DOE/NV/26383-08

FINAL REPORT

HYDRAULIC CONDUCTIVITY WITH DEPTH FOR UNDERGROUND TEST AREA (UGTA) WELLS

prepared by

Phil L. Oberlander, David McGraw, and Charles E. Russell
Division of Hydrologic Sciences
Desert Research Institute
Nevada System of Higher Education

submitted to

Nevada Site Office
National Nuclear Security Administration
U.S. Department of Energy
Las Vegas, Nevada

October 2007

Publication No. 45228

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The work upon which this report is based was supported by the U.S. Department of Energy under Contract #DE-AC52-06NA26383. Approved for public release; further dissemination unlimited.

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ABSTRACT

Hydraulic conductivity with depth has been calculated for Underground Test Area (UGTA) wells in volcanic tuff and carbonate rock. The following wells in volcanic tuff are evaluated: ER-EC-1, ER-EC-2a, ER-EC-4, ER-EC-5, ER-5-4#2, ER-EC-6, ER-EC-7, and ER-EC-8. The following wells in carbonate rock are evaluated: ER-7-1, ER-6-1, ER-6-1#2, and ER-12-3.

There are a sufficient number of wells in volcanic tuff and carbonate rock to associate the conductivity values with the specific hydrogeologic characteristics such as the stratigraphic unit, hydrostratigraphic unit, hydrogeologic unit, lithologic modifier, and alteration modifier used to describe the hydrogeologic setting. Associating hydraulic conductivity with hydrogeologic characteristics allows an evaluation of the data range and the statistical distribution of values. These results are relevant to how these units are considered in conceptual models and represented in groundwater models.

The wells in volcanic tuff illustrate a wide range of data values and data distributions when associated with specific hydrogeologic characteristics. Hydraulic conductivity data within a hydrogeologic characteristic can display normal distributions, lognormal distributions, semi-uniform distribution, or no identifiable distribution. There can be multiple types of distributions within a hydrogeologic characteristic such as a single stratigraphic unit. This finding has implications for assigning summary hydrogeologic characteristics to hydrostratigraphic and hydrogeologic units. The results presented herein are specific to the hydrogeologic characteristic and to the wells used to describe hydraulic conductivity.

The wells in carbonate rock are associated with a fewer number of hydrogeologic characteristics. That is, UGTA wells constructed in carbonate rock have tended to be in similar hydrogeologic materials, and show a wide range in hydraulic conductivity values and data distributions. Associations of hydraulic conductivity and hydrogeologic characteristics are graphically presented even when there are only a few data. This approach benchmarks what is currently known about the association of depth-specific hydraulic conductivity and hydrogeologic characteristics.

EXECUTIVE SUMMARY

Background and Purpose

The U.S. Department of Energy (DOE), National Nuclear Security Administration Nevada Site Office (NNSA/NSO) constructed a series of deep characterization and monitoring wells as part of the Underground Test Area (UGTA) Program in southern Nevada. These wells have been characterized with a borehole flow meter that measures flow in the well under ambient and pumping conditions. Based on the changes in borehole flow rate, the depth-specific amount of groundwater inflow is calculated. The groundwater contributions to the well are combined with other information to calculate the depth-specific hydraulic conductivity. These values are important when evaluating the association of aquifer permeability to hydrogeologic features in tuff and carbonate rock such as the:

- Stratigraphic unit,
- Lithologic description,

- Lithologic alteration,
- Hydrogeologic unit, and
- Hydrostratigraphic unit.

The association of hydraulic conductivity with hydrogeologic characteristics provides important information on how the physical characteristics of the Nevada Test Site (NTS) are summarized and represented in numeric models. The UGTA project has conducted borehole flow logging in eight wells in volcanic tuff and four wells in carbonate rock. Figure 1 illustrates these wells located at the Nevada Test Site, and the Nevada Test and Training Range in Nye County, Nevada. Wells presented in this report in volcanic tuff are: ER-EC-1, ER-EC-2A, ER-EC-4, ER-EC-5, ER-EC-6, ER-EC-7, ER-EC-8, and ER- 5-4#2, and those in carbonate rock are: ER-6-1, ER-6-1#2, ER-7-1, and ER-12-3.

The borehole flow logging has obtained a substantial amount of information on groundwater flow into the wells. The total vertical length of the flow-logged boreholes exceeds 1,067 meters (m) in volcanic tuff and 1,194 m in carbonate rock. Interpretation of these flow-logs has produced high-resolution, depth-specific borehole hydraulic conductivities for vertical intervals as small as 1.5 m. This information provides insight into aquifer vertical heterogeneity at previously unavailable spatial scales.

Hydraulic conductivity as evidenced by groundwater flow into the well was detected for 22.2 percent of the screened intervals in volcanic tuff and 65 percent of the open borehole accessible in carbonate rock. This finding is important because wells in tuff are screened based on an assumed relationships between geologic classification and the expected hydraulic properties. The findings of this study suggest that these assumed relationships are often tenuous. No general trend of lower hydraulic conductivity with depth is identified based on these data.

Tuff Bedrock

The results of the analysis are summarized in a series of tables providing the average of the detected hydraulic conductivity and estimated statistical distribution for each of the hydrostratigraphic characteristics. Average hydraulic conductivity values detected for the various hydrogeologic characteristics should not be viewed as the average hydraulic conductivity for the entire thickness of the unit. The purpose of evaluating hydraulic conductivity is to understand the range and statistical characteristics of the permeability underlying the transmissivity of the major hydrogeologic units.

Table S-1 summarizes the hydraulic conductivity for stratigraphic units in tuff. The table indicates that many of the stratigraphic units have unknown or too few values to describe the statistical distribution of data. Comparing data for the same stratigraphic unit among wells indicates that the values may be similar such as for the unit Tfb (Tertiary Beatty Wash Formation) in wells ER-EC-7 and ER-EC-8 or may have very different values such as the stratigraphic unit Tfbw (Tertiary Rhyolite of Beatty Wash Formation) in wells ER-EC-2a and ER-EC-7 and for the unit Tmar (Tertiary Mafic-rich Ammonia Tanks Tuff) in wells ER-EC-2a and ER-EC-5. There seems to be no identifiable trends in the average hydraulic conductivity based on stratigraphic unit. In general, well ER-EC-2a seems to have much lower hydraulic conductivity than the other wells. This aspect may be related to the specific fracture domain at that well.

Table S-2 summarizes the hydraulic conductivity for lithologic units in tuff. The table indicates that almost all of the units have unknown statistical distribution of data. An interesting observation is that the average hydraulic conductivity seems unaffected by the degree of welding in tuff. The nonwelded tuff, partly welded tuff, moderately welded tuff, and moderately to densely welded tuff have values over similar ranges. The average hydraulic conductivity values for lava (LA) are generally greater than for other lithologic units.

The summary of results for association of average hydraulic conductivity with alteration modifier for tuff is presented in Table S-3. There are too few data to describe the statistical distributions or trends for most wells. The statistical distribution is unknown for nearly all of the remaining wells. There are no identifiable trends associating average hydraulic conductivity with alteration modifier.

The summary of hydrogeologic units in tuff and average hydraulic conductivity is presented in Table S-4. Well ER-EC-2a has lower average hydraulic conductivity values for all hydrogeologic classifications. Evaluation of the average values for the welded tuff aquifer (WTA) and lava flow aquifer (LFA) shows similarity to those for tuff confining units (TCU). This observation should be viewed with caution because these are average detectable hydraulic conductivity values and do not reflect the many nondetects within each type of hydrogeologic unit. The table is possibly indicating that the permeability of fractures is similar in welded tuff aquifers and tuff confining units and that it is the frequency of fractures that determines whether the unit is an aquifer or a confining unit.

Table S-5 presents the average hydraulic conductivity for the various hydrostratigraphic units in tuff. Well ER-EC-2a is again unique in that the average values are lower than the other wells. Only three hydrostratigraphic units are found in more than one well (e.g., FCCM – Fortymile Canyon Composite Unit, TMCM – Timber Mountain Composite Unit, and BA – Benham Aquifer). Most of the hydrostratigraphic units do not have an identifiable statistical distribution. The average values do not indicate an association with hydrostratigraphic unit.

Table S-1. Average hydraulic conductivity by stratigraphic unit in tuff.

Well	Summary Properties	Stratigraphic Unit												
		Tfbw	**Tfb**	**Tf**	**Ttc**	**Tpb**	**Tmaw**	**Tmar**	**Tmap**	**Tcb**	**Tpcm**	**Tptm**	**Tcpe**	**Tmrp**
ER-EC-1	Ave K (m/d)					**27.6**					**2.3**	**8.4**	**11.1**	
	Distribution					ln					unk	unk	unk	
ER-EC-2a	Ave K (m/d)	**0.18**		**0.17**			**0.17**	**0.04**						
	Distribution	ln		few			unk	few						
ER-EC-4	Ave K (m/d)				**27.6**									**16.4**
	Distribution				unk									few
ER-EC-5	Ave K (m/d)							**21.9**	**18.2**					
	Distribution							n-s	ln					
ER-5-4#2	Ave K (m/d)									**5.2**				
	Distribution									unk				
ER-EC-6	Ave K (m/d)					**5.1**								
	Distribution					unk								
ER-EC-7	Ave K (m/d)	**28.2**	**13.0**											
	Distribution	few	n											
ER-EC-8	Ave K (m/d)		**15.3**						**5.6**					
	Distribution		n						unk					

Estimated statistical distribution types n = normal, n-s = normal skewed, ln = log normal, few = too few values to estimate, unk = unknown

Table S-2. Average hydraulic conductivity by lithologic modifiers in tuff.

Well	Summary Properties	Lithologic Unit										
		NWT	**PWT**	**PWT-MWT**	**MWT**	**MWT-DWT**	**LA**	**BED**	**TSLT**	**RWT**	**CL**	**FB**
ER-EC-1	Ave K (m/d)		**2.3**	**8.4**			**33.4**	**4.3**				**10.7**
	Distribution		unk	unk			unk	few				unk
ER-EC-2a	Ave K (m/d)	**0.14**			**0.04**			**0.2**	**0.11**	**0.24**		
	Distribution	ln			few			ln	unk	unk		
ER-EC-4	Ave K (m/d)		**16.4**				**28.8**				**8.5**	
	Distribution		unk				unk				unk	
ER-EC-5	Ave K (m/d)				**21.9**	**18.2**						
	Distribution				n-s							
ER-5-4#2	Ave K (m/d)	**5.2**										
	Distribution	unk										
ER-EC-6	Ave K (m/d)						**5.1**					
	Distribution						unk					
ER-EC-7	Ave K (m/d)						**18.0**					
	Distribution						few					
ER-EC-8	Ave K (m/d)	**14.6**										
	Distribution	ln										

Estimated statistical distribution types n = normal, n-s = normal skewed, ln = log normal, few = too few values to estimate, unk = unknown

Table S-3. Average hydraulic conductivity by alteration modifiers in tuff.

Well	Summary Properties	Alteration Modifier					
		DV	GL	ZE	QZ	QF	VAR
ER-EC-1	Ave K (m/d)	29.9		4.3	10.6	11.1	
	Distribution	unk		few	few	few	
ER-EC-2a	Ave K (m/d)			0.4		0.2	
	Distribution			few		unk	
ER-EC-4	Ave K (m/d)	28.8				16.4	
	Distribution	unk				few	
ER-EC-5	Ave K (m/d)					21.5	
	Distribution					n-s	
ER-5-4#2	Ave K (m/d)			5.2			
	Distribution			ln			
ER-EC-6	Ave K (m/d)	1.6	10.9				
	Distribution	few	unk				
ER-EC-7	Ave K (m/d)					28.2	13.0
	Distribution					few	unk
ER-EC-8	Ave K (m/d)				15.3	5.6	
	Distribution				unk	few	

Estimated statistical distribution types n = normal, n-s = normal skewed, ln = log normal, few = too few values to estimate, unk = unknown

Table S-4. Average hydraulic conductivity by hydrogeologic units in tuff.

Well	Summary Properties	Hydrogeologic Unit			
		WTA	TCU	LFA	AA
ER-EC-1	Ave K (m/d)	5.4	4.3	28.4	
	Distribution	few	few	unk	
ER-EC-2a	Ave K (m/d)	0.04	0.2		0.1
	Distribution	few	unk		few
ER-EC-4	Ave K (m/d)	16.4		28.8	8.5
	Distribution	few		unk	few
ER-EC-5	Ave K (m/d)	21.5			
	Distribution	n-s			
ER-5-4#2	Ave K (m/d)		5.2		
	Distribution		ln		
ER-EC-6	Ave K (m/d)			5.1	
	Distribution			unk	
ER-EC-7	Ave K (m/d)			18.0	
	Distribution			ln	
ER-EC-8	Ave K (m/d)		14.6		
	Distribution		ln		

Estimated statistical distribution types n = normal, n-s = normal skewed, ln = log normal, few = too few values to estimate, unk = unknown

Table S-5. Average hydraulic conductivity by hydrostratigraphic unit in tuff.

Well	Summary Properties	Hydrostratigraphic Unit									
		FCCM	**TMCM**	**TCVA**	**TMA**	**LTCU**	**BA**	**UPCU**	**TCA**	**TSA**	**CFCM**
ER-EC-1	Ave K (m/d)						**30.6**	**4.3**	**2.3**	**8.4**	**11.1**
	Distribution						**ln**	**unk**	**unk**	**unk**	**unk**
ER-EC-2a	Ave K (m/d)	**0.2**	**0.2**								
	Distribution	**ln**	**unk**								
ER-EC-4	Ave K (m/d)			**27.6**	**16.4**						
	Distribution			**unk**	**unk**						
ER-EC-5	Ave K (m/d)		**21.5**								
	Distribution		**ln**								
ER-5-4#2	Ave K (m/d)					**5.2**					
	Distribution					**unk**					
ER-EC-6	Ave K (m/d)						**5.1**				
	Distribution						**unk**				
ER-EC-7	Ave K (m/d)	**18.0**									
	Distribution	**ln**									
ER-EC-8	Ave K (m/d)	**15.3**	**5.6**								
	Distribution	**ln**	**few**								

Estimated statistical distribution types n = normal, n-s = normal skewed, ln = log normal, few = too few values to estimate, unk = unknown

Carbonate Bedrock

Wells in carbonate exhibit only two variations in hydrostratigraphic characteristics: the stratigraphic unit and the lithologic unit. These hydraulic conductivity values are based, in part, on a linearization of the borehole flow rates that produces an average value over distances greater than the nominal 1.5-m vertical calculation interval used in screened wells. Therefore, short intervals containing nondetectable hydraulic conductivity are incorporated into the average values.

Table S-6 presents the average hydraulic conductivity data for each stratigraphic unit in carbonate. The statistical distributions of hydraulic conductivity within each stratigraphic unit are generally unknown. The close similarity of values of ER-6-1 and ER-6-1#2 is the result of these wells being located only 64 m apart.

Table S-7 presents the average hydraulic conductivity associated with lithologic unit. The values in dolomite (Dol) appear to be more similar than those in limestone (Ls). The statistical distributions in carbonate are generally lognormal. This is in contrast to tuff which apparently have more variability in the statistical distributions.

Table S-6. Average hydraulic conductivity by stratigraphic units in carbonate.

Well	Summary Properties	Stratigraphic Unit			
		DSs	**DSl**	**Oes**	**Puz**
ER-6-1	Ave K (m/d)	**1.1**	**4.3**	**6.7**	
	Distribution	unk	ln	unk	
ER-6-1#2	Ave K (m/d)		**3.3**	**6.7**	
	Distribution		unk	unk	
ER-7-1	Ave K (m/d)				**33.1**
	Distribution				unk
ER-12-3	Ave K (m/d)				**0.4**
	Distribution				unk

Estimated statistical distribution types n = normal, n-s = normal skewed, ln = log normal, few = too few values to estimate, unk = unknown

Table S-7. Average hydraulic conductivity by lithologic modifiers in carbonate.

Well	Summary Properties	Lithologic Unit	
		Dol	**Ls**
ER-6-1	Ave K (m/d)	**3.2**	
	Distribution	ln	
ER-6-1#2	Ave K (m/d)	**3.5**	
	Distribution	unk	
ER-7-1	Ave K (m/d)		**33.1**
	Distribution		ln
ER-12-3	Ave K (m/d)	**0.8**	**0.02**
	Distribution	few	ln

Estimated statistical distribution types n = normal, n-s = normal skewed, ln = log normal, few = too few values to estimate, unk = unknown

Alternative Analysis Using Censored Data

The hydraulic conductivity data collected from the well logging contains many values reported as 'less than' some minimum detectable K. In the first stage of this study, these data were either discarded or averaged with detected Ks to produce a composite K for each well at each measured depth. An alternative method to analyze these data was also performed in stage 2 of this study. The 'less-than,' or censored data, were retained for analysis and no averaging of K was performed. Though this results in a significantly larger data set to analyze, analysis is complicated by the presence of the censored data.

Robust, nonparametric methods for statistical analysis of censored data sets were employed in the stage 2 of this study. The Kendall-Tau test was performed to determine correlations between K and depth. This test was motivated by previous groundwater models in this area that assume an exponential decay of K with depth. Also, the Peto-Peto modification of the Wilcoxon test was used to test for differences in populations. This test is a nonparametric alternative to the paired Student's t-test and is appropriate for censored data sets. As applied to this study, the test statistic is used to determine differences between two survival curves.

In this stage of the study, the purpose of the analysis was to describe the data, determine trends in the data, and evaluate heterogeneity. These tasks are similar to those described in the first stage of the study, the difference being a different representation of the raw data was used in stage 2.

The following questions were addressed:

- What are typical values for K?
- Does K follow any trend within a well? Does K decrease with depth?
- Are rock characteristics homogeneous? For example, do the K values for an HSU of BA in one location differ from the K values for an HSU of BA in another location?
- Are there differences in K within rock classifications? Or, which rock classifications best describe variability in K?
- Are Ks affected by fractures?

In summary, the following conclusions were reached:

- Approximately one-quarter of the units exhibit a decrease in K with depth. However, many of these units are relatively thin and extrapolation to thicknesses greater than 100 m may not be appropriate.
- Over 90 percent of the rock classifications exhibit some spatial heterogeneity.
- For each rock classification (HSU, HGU, LITH, STRAT, or ALTERATION) there is significant overlap among their respective characteristics, implying that rock classification is a poor method of describing K. However, of the five rock classifications, stratigraphic unit was the best descriptor of K, while lithology was the worst.
- Though fracture analysis was not part of the original scope, it was discovered that the presence of fractures may be correlated to high values of conductivity.

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LIST OF ACRONYMS

ANOVA	analysis of variance
DOE	U.S. Department of Energy
EDA	Expoloratory Data Analysis
HGU	hydrogeologic unit
HSU	hydrostratigraphic unit
IQR	interquartile range
LITH	lithology
NNSA	National Nuclear Security Administration
NSO	Nevada Site Office
STRAT	stratigraphic unit
UGTA	Underground Test Area

INTRODUCTION

Background

The U.S. Department of Energy (DOE), National Nuclear Security Administration Nevada Site Office (NNSA/NSO) constructed a series of deep characterization and monitoring wells as part of the Underground Test Area (UGTA) Program in southern Nevada. The Desert Research Institute has performed borehole flow logging at many of these wells as part of the hydrogeologic characterization. The borehole flow logging is conducted to:

- Understand the quantity and depth of groundwater inflow to the well under ambient and pumping conditions,
- Select target depths for geochemical sampling of discrete inflow zones, and
- Calculate the depth-specific hydraulic conductivity at the smallest spatial scale as practical.

The UGTA project has conducted borehole flow logging in eight wells in volcanic tuff and four wells in carbonate rock. Figure 1 illustrates these wells located at the Nevada Test Site, and the Nevada Test and Training Range in Nye County, Nevada. Wells presented in this report in volcanic tuff are: ER-EC-1, ER-EC-2A, ER-EC-4, ER-EC-5, ER-EC-6, ER-EC-7, ER-EC-8, and ER- 5-4#2, and those in carbonate rock are: ER-6-1, ER-6-1#2, ER-7-1, and ER-12-3.

The borehole flow logging has obtained a substantial amount of information on groundwater flow into the wells. The total vertical length of the flow-logged boreholes exceeds 1,067 meters (m) in volcanic tuff and 1,194 m in carbonate rock. These vertical intervals include only the length of screened intervals or open well bores and do not include cased sections of the wells.

Interpretation of these flow-logs has produced high-resolution, depth-specific borehole hydraulic conductivities for vertical intervals as small as 1.5 m. This information provides insight into aquifer vertical heterogeneity at previously unavailable spatial scales. Hydraulic conductivity as evidenced by groundwater flow into the well was detected for 22.2 percent of the screened intervals in volcanic tuff and 65 percent of the open borehole accessible in carbonate rock. The results of borehole flow logging have been reported previously to DOE in reports that focus on the depth-specific hydraulic conductivity at individual wells. The hydraulic conductivity data at depth for each well are provided in the Appendix.

Purpose

Associating the hydraulic conductivity data with other hydrogeologic information is an important next step to understanding the area's hydrogeology. Of value to the site characterization and groundwater modeling are association of depth-specific hydraulic conductivities to other characterization data commonly used to describe the hydrogeology such as the results of single-well hydraulic tests, geologic descriptors, hydrogeologic classifications, and degree of fracturing.

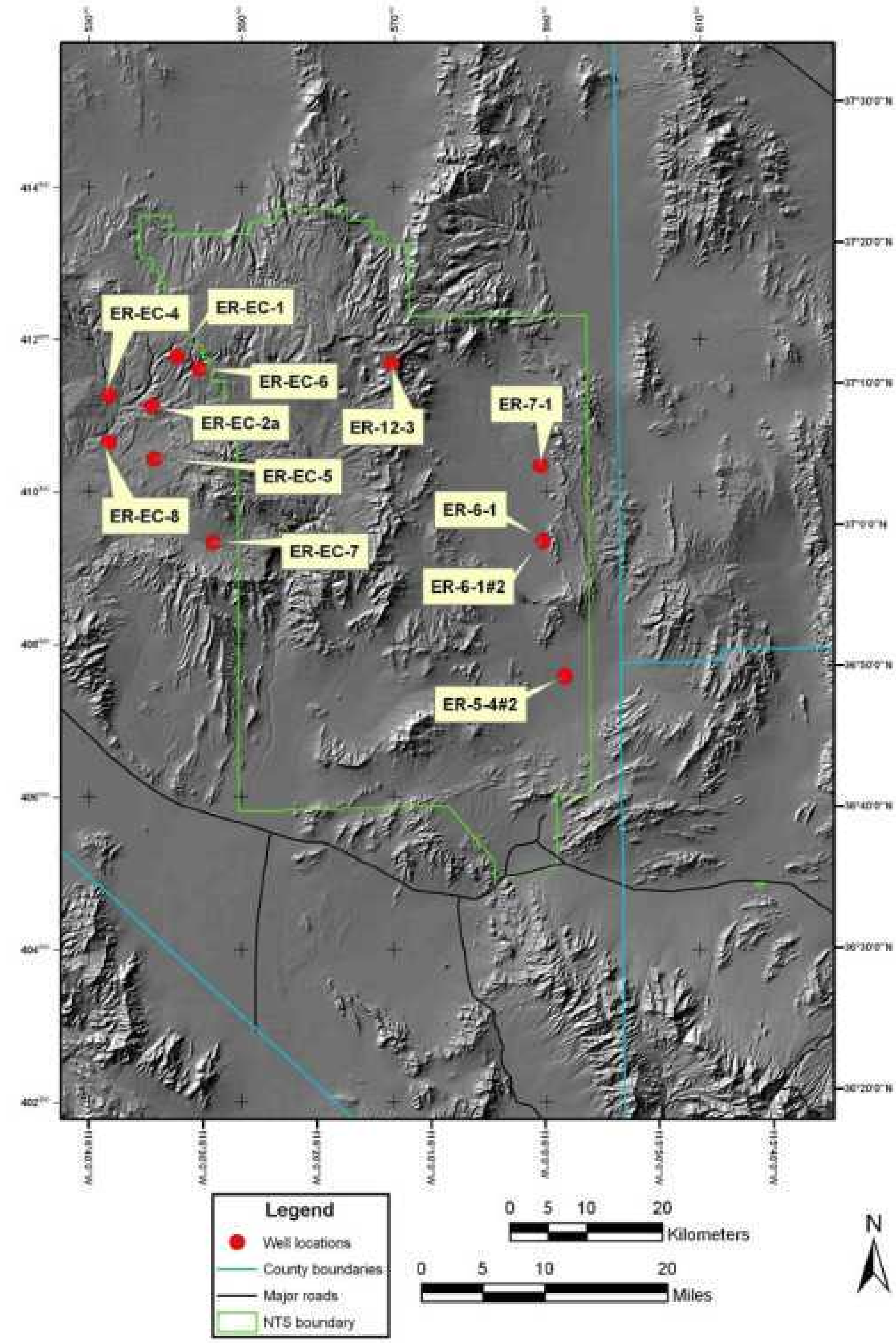


Figure 1. Location map showing the eight wells in volcanic tuff and four wells in carbonate rock where borehole flow logging was conducted for the UGTA project.

This report examines depth-specific hydraulic conductivity data at multiple wells and identifies the major statistical trends, or lack of trends, within the hydrogeologic classifications. The hydrogeologic classifications that describe the geologic conditions at depth are taken from DOE NNSA/NSO Well Completion reports (DOE, 2000a,b,c,d,e; DOE, 2006b), and through personal communication (William Fryer, Stoller Navarro, 2006). The hydrostratigraphic designations for specific depth intervals are taken from DOE NNSA/NSO hydrostratigraphic framework model reports (DOE 2002b, 2005b, 2006a). All of the major hydrogeologic descriptors reported in those studies are used in this analysis.

Site interpretation relies on rock descriptions and context. Five separate classification systems are applied to the rock at any single point within the borehole. For the purposes of this report, a terminology is used to distinguish among the various rock description systems. The first and highest level system is referred to as the hydrogeologic classification. The second and next lowest system of subsequent descriptors within a hydrogeologic **classification** is referred to as a hydrogeologic **characteristic**.

The five major hydrogeologic classifications used to describe the rock in UGTA wells are:

- Stratigraphic unit,
- Lithologic description,
- Lithologic alteration,
- Hydrogeologic unit, and
- Hydrostratigraphic unit.

Each of the hydrogeologic classifications has several characteristics to designate the particular stratigraphic unit, lithology, alteration, etc. The Appendix includes the hydrogeologic classification and assigned characteristic for each hydraulic conductivity value. This information is provided for the reader that wants to examine the data in greater detail than presented in this report. The number of hydrogeologic characteristics that were borehole flow logged and those that have detectable hydraulic conductivity for each hydrogeologic classification are presented in Table 1. The hydrogeologic characteristics flow logged for tuff are populated with more designations than for carbonate.

Table 1. The number of hydrogeologic characteristics available for association with hydraulic conductivity.

Hydrogeologic Classification	Number of Hydrogeologic Characteristics Adjacent to Well Screen or Open Borehole	Number of Hydrogeologic Characteristics with Detected Permeability
Tuff Stratigraphic Unit	15	11
Tuff Lithologic Description	16	10
Tuff Lithologic Alteration	7	6
Tuff Hydrogeologic Unit	4	4
Tuff Hydrostratigraphic Unit	14	8
Carbonate Stratigraphic Unit	4	4
Carbonate Lithologic Description	2	2
Carbonate Lithologic Alteration	1	1
Carbonate Hydrogeologic Unit	1	1
Carbonate Hydrostratigraphic Unit	1	1

Approach

Evaluation of hydraulic conductivity and hydrogeologic classifications is challenged by the many possible data associations and the many possible data applications. There are tens of thousands of possible statistical associations between hydraulic conductivity and combinations of the many hydrogeologic characteristics. This analysis seeks a balance between presenting an evaluation of hydraulic conductivity in relation to the many possible combinations of hydrogeologic characteristics and presenting only the most obvious relationships. An evaluation is made of hydrogeologic conductivity within each hydrogeologic characteristic, even if there is only one hydraulic conductivity value that can be associated with that characteristic. The purpose of presenting these limited data is to benchmark what is known about the association of hydraulic conductivity and hydrogeology. This can be considered a "brute force" technique for presenting the data graphically and fulfills the objective of documenting associations of hydraulic conductivity with the hydrogeologic characteristics. Presenting figures that show no trend to the data distributions are included. That is, analyses that show null results are presented so that the topic (i.e., do the log-transformed hydraulic conductivity data have an identifiable frequency trend) can be dismissed. It is also necessary to present sophisticated analyses of the data within the hydrogeologic characteristics and to address the importance of nondetections.

To accomplish these goals, the analysis is presented using two complementary stages. The first-stage analysis is the most basic and is intended for the reader who is mainly interested in a graphical review of hydraulic conductivity at specific wells or for specific hydrogeologic characteristics.

The second-stage analysis conducts a more in-depth statistical evaluation of hydraulic conductivity, depth, and hydrogeologic classifications. This includes relating hydraulic conductivity to fractures geophysically logged in the wells. Each of these approaches is described in more detail below. The report is divided into separate sections for volcanic tuff and carbonate aquifers.

Stage-one Analysis

The first-stage analysis is the most basic and presents the data from two perspectives: 1) the well-by-well detection of hydraulic conductivity within multiple hydrogeologic characteristics, and 2) the statistical distribution of hydraulic conductivity for each hydrogeologic characteristic at multiple wells. In other words, the first perspective examines one well having multiple hydrogeologic characteristics and the second perspective examines one hydrogeologic characteristic at many wells.

Three metrics are used for the well-specific first-stage analysis:

1. Detected hydraulic conductivity plotted versus depth independent of hydrogeologic characteristics.
2. Vertical extent of the well screen (where there is the potential to detect hydraulic conductivity) within each hydrogeologic characteristic compared to the length within the screen where hydraulic conductivity was detected.
3. Average hydraulic conductivity for each of the hydrogeologic characteristics.

The specific graphs for each well are paired with their intended application in Table 2. A nomenclature convention related to the placement of well screen is used within this report. Sections of a well where well screen in placed are referenced herein as "screened." In actuality, this means that well screen was placed adjacent to the rock unit. The term does not infer that a statistical selection has been made regarding the unit or that the unit was physically changed by being screened. In providing an analysis that is as complete as possible, there is no attempt to economize the number of associations of hydraulic conductivity with hydrogeologic characteristics. This approach generates many figures that sometimes contain minimal (but important) information.

Table 2. Well-specific analysis of hydraulic conductivity and hydrogeologic characteristics.

Presentation Graph	Analysis Application
Hydraulic conductivity with depth	Overview of depths and screened intervals where hydraulic conductivity was detected. Number of vertical intervals where hydraulic conductivity was detected. Identification of any obvious trends of hydraulic conductivity with depth.
Length of screened interval and aquifer thickness containing detectable hydraulic conductivity for hydrogeologic characteristic within each hydrogeologic classification	Hydrogeologic characteristics encountered by well construction and which characteristics were completed with well screen. Identification of which characteristics had detectable hydraulic conductivity. Efficacy of selecting intervals for screening at most permeable locations. Depiction of the amount of screened interval with nondetects.
Average hydraulic conductivity for hydrogeologic characteristic within each hydrogeologic classification	Association of hydrogeologic characteristics and hydraulic conductivity to identify overall permeability for each characteristic.

The second part of the stage-one analysis presents the same basic hydraulic conductivity information at multiple wells for each hydrogeologic characteristic. Where there is only one well with detectable hydraulic conductivity for that characteristic, the information is not presented in a separate figure because the information is identical to that presented for the individual well.

Five metrics are used for the hydrogeologic-characteristic-specific first-stage evaluation:

1. Detected hydraulic conductivity plotted versus depth independent of hydrogeologic characteristics.
2. Binned hydraulic conductivity values where each well is presented individually.
3. Binned hydraulic conductivity values where all values are presented in composite.
4. Binned logarithmic hydraulic conductivity values where each well is presented individually.

5. Binned logarithmic hydraulic conductivity values where all values are presented in composite.

The specific graphs for each hydrogeologic characteristic and the intended application are presented in Table 3.

Table 3. Hydrogeologic characteristics specific analysis of hydraulic conductivity.

Presentation Graph	Analysis Application
Hydraulic conductivity with depth for all of the wells with that hydrogeologic characteristic	Overview of depths and screened intervals where hydraulic conductivity is detected. Comparison of hydraulic conductivity at various wells within same hydrogeologic characteristic
Number of detected hydraulic conductivity values at each well within linear statistical bins	Examination of whether a particular hydrogeologic characteristic results in similar hydraulic conductivity values and similar statistical distributions for different wells
Combined number of detected hydraulic conductivity values for all wells within linear statistical bins	Examination of whether, in composite, a particular hydrogeologic characteristic results in similar hydraulic conductivity values and the statistical distribution of all values forms a recognizable statistical distribution
Number of detected hydraulic conductivity values at each well within logarithmic statistical bins	Examination of whether a particular hydrogeologic characteristic at different wells results in similar hydraulic conductivity values and recognizable statistical distributions when the values are logarithmically transformed
Combined number of detected hydraulic conductivity values at each well within logarithmic statistical bins	Examination of whether, in composite, a particular hydrogeologic characteristic at different wells results in similar hydraulic conductivity values and recognizable statistical distributions when the values are logarithmically transformed

Stage-two Analysis

The purpose of this stage is to explore the data at a more detailed level using exploratory data analysis with censored data. The data are evaluated without prior assumptions of distribution or other behavior.

The hydraulic conductivity values (K) were obtained with more than one pumping rate, resulting in up to three values of K at each measured depth in a well. In the previous stage of this study, low values, or values less than the assigned minimum value, were evaluated qualitatively and either averaged or discarded to produce a composite hydraulic conductivity. This results in one value of K for each depth in a well.

In this stage, all measured values of K were analyzed, regardless of whether or not the value was below its minimum acceptable value. Data identified only by a range, or a 'less-than' value, are called censored data.

Limitations of the Borehole Flowmeter and Data Reduction

Borehole flow logging was performed while the wells were being pumped and the flowmeter instrument was moved upward and downward. Pumping rates were increased stepwise between discrete sets of logging runs. The selected pumping rates typically represented the maximum, intermediate, and minimum flow rates at which the well could be continuously pumped based on water level drawdown and the motor capacity. Flow logging was conducted at nominal line speeds (e.g., the speed at which the geophysical tools are raised or lowered in the well) of 6, 12, and 18 meters per minute (m min^{-1}). The different combinations of logging speeds and pumping rates typically provide nine unique flow logs for each well.

The borehole flowmeter records the impeller revolution rate as counts per second. These readings are processed with other information to calculate the borehole flow rate at the various locations in the well. Although simple in concept, calibration involves incorporating many factors to determine the best representation of borehole flow rate. Specifically, the effects of well diameter, minor variations in vertical trolling speed (cable line speed), direction of trolling the flowmeter, impeller response to changing fluid density, and the instrument's mechanical condition are considered in calculating the borehole flow rate. The borehole flowmeter records the impeller rotation rate every 6.1 centimeters of logging depth. The relatively short recording distance also causes the logging system to base the impeller rotation rate on a limited number of rotations. At the slowest logging line speed of about six m min^{-1}, there are 0.6 seconds of impeller rotation available to calculate the average rotation rate. Logging at higher travel speeds of 9.1 to 12.2 m min^{-1} reduces the recording interval to every 0.4 to 0.3 seconds, respectively. The short time period available for data collection limits the number of impeller rotations (or partial rotations) before data recording. Therefore, apparent short-term flow rate variations are embedded in the raw data as noise.

It is important to reduce the small-scale flow rate variations caused by measurement noise so that they are not attributed to changes in borehole flow rate or hydraulic conductivity. The borehole flowmeter readings are also subject to other influences including flow turbulence, changes in the alignment of the borehole flowmeter within the well casing, impeller jarring, and occasional debris impacts. This is accomplished by data processing of the borehole flow logs by averaging, filtering, and censoring Oberlander and Russell (2003) and Oberlander and Russell (2006).

There are three primary considerations concerning flowmeter data processing that are important to understanding the data presented in this report. First, the flowmeter precision is a function of the borehole flow rate. Therefore, the instrument precision of the flowmeter varies as it encounters differing flow rates within the borehole and the well is logged at different line speeds. Therefore, not all of the borehole flow rate measurements and the subsequent hydraulic conductivity estimates have the same confidence.

Second, borehole flow rates are abstracted by vertically averaging over regular vertical intervals. The length of the vertical calculation interval is important to this analysis because it is used to estimate the change in borehole flow rate for subsequent calculation of horizontal hydraulic conductivity with depth. There are two important and competing objectives when vertically averaging flow rate data, preserving spatial resolution and reducing uncertainty. Long vertical calculation intervals will average more data and reduce the amount of uncertainty in the average borehole flow rates. However, long calculation intervals limit detection of relatively small changes in borehole flow rate that can be attributed to groundwater inflow. Long calculation intervals reduce the capability to locate discrete hydraulic features with the end-member on this condition being the standard aquifer test. In the UGTA wells, characterization of fracture flow locations is an important objective, dictating that the vertical calculation interval be as small as practical. When the borehole flowmeter was used in large diameter wells (i.e., greater than 12 cm internal diameter) or in uncased carbonate wells, the flowmeter exhibited a high degree of variation in reading over short vertical distances. These data sets were vertically averaged over long intervals of 10's of meters to estimate the average change in flow rate. These borehole flow logs were essentially linearized over the intervals corresponding to the major changes in flow rates. Although this process reflects the average flow conditions within the well, it also produces the analysis artifact of having adjacent locations within the well having very similar hydraulic conductivity values. This aspect of data analysis is recognizable in the reported hydraulic conductivity values provided in the Appendix.

Third, the borehole flow rates at each pumping rate are averaged to calculate a hydraulic conductivity for each at each pumping rate. The three calculated hydraulic conductivity measurements are averaged (if they agree) to produce the best estimate of hydraulic conductivity for that location. Compositing data from nine borehole flow logs are used to produce one estimate of hydraulic conductivity. Therefore, compositing the flow logs carries various sources and levels of uncertainty into each final hydraulic conductivity estimate.

Comparisons of the summed hydraulic conductivity values derived from the borehole flowmeter method do not precisely reproduce the transmissivity calculated from aquifer tests for the entire well. There are several reasons for this:

- The borehole flowmeter is unable to detect small changes in flow rate and subsequently calculate low amounts of groundwater inflow that can be attributed to groundwater inflow. The lowest change in flow rate (e.g., a lower quantification limit for hydraulic conductivity) is a function of borehole fluid velocity, instrument condition, turbulence, and borehole diameter. The lower quantification limit for groundwater inflow and the associated hydraulic conductivity varies for each screen section and is accounted for in the analysis by censoring values below the quantification threshold.
- There are sections of the well where the borehole flowmeter cannot reliably detect hydraulic conductivity whereas the aquifer test of the entire well includes these minor groundwater inflow zones in the determination of transmissivity. This results in the summed hydraulic conductivities producing a transmissivity less than the transmissivity determined by an aquifer test for the entire well.
- Interpretation of the aquifer tests for entire wells are often based on sophisticated techniques that include additional processes (such as dual porosity) not considered in the analysis of the nominal 1.5 m calculation intervals used for the borehole flow method. The borehole flowmeter methodology is similar to the methods for

interpreting the transmissivity for a well at steady state flow. The aquifer tests for entire wells are based on methods for transient water level drawdown while the well is not at steady state flow. Use of differing assumptions in the analysis methods and the well being tested at different states (e.g., steady state vs. transient flow) contributes to the different transmissivity results.

The borehole flowmeter provides greater spatial information concerning where hydraulic conductivity occurs and the statistical properties of hydraulic conductivity in a single well. This information is gained at the cost of not being able to detect reliably relatively low values of hydraulic conductivity. Therefore, the borehole flow meter methodology and aquifer testing of entire wells provide complementary, but not the same, information.

Uncertainty in the borehole flow rates could be reduced by changing the well design to include a section of blank casing below the lowest screened interval. This blank section would serve as a catchment for well detritus and ensure the entire length of well screen was open to the aquifer. A blank section of casing at the bottom of the well would also allow recalibration of the flow meter in the no flow zone. Currently, the flow meter is recalibrated only at the top of each logged section were the borehole flow rate is known to be equal to the flow at flow meter located at land surface. A second calibration location for the borehole would allow two calibrations; one at the start and one at the finish of each flow log. These additional calibrations would reduce uncertainty in the measured flow rates and provide better correspondence of flow rate readings among the various logs. The ultimate outcome would be detection of smaller changes in borehole flow rates, detection of lower values of hydraulic conductivity, and greater certainty in the reported values of hydraulic conductivity.

STAGE-ONE ANALYSIS

Wells Constructed in Volcanic Tuff

Overview

Eight wells logged in volcanic tuff provided a total of 1,067 m of screened borehole. Table 4 presents a summary of the detection of hydraulic conductivity in tuff. The length of logged well screen reflects the accessible well depth. Some wells contained fill material at the bottom of the well that limited the depth of well logging and the effective screen length.

Detection of hydraulic conductivity in only 22.2 percent of the screened length may seem a modest accomplishment. It should be noted that permeability in tuff is often associated with discrete fractures and that well intervals having nondetectable permeability is expected. Another way to view the depth-specific hydraulic conductivity in tuff is that borehole flow logging provides 237 values of hydraulic conductivity and 833 nondetects instead of only the eight hydraulic conductivity values provided by the single-well aquifer tests. These data represent a 30-fold increase in information about the well permeability. Most important is that these values also provide the depth dependence and the statistical distribution of hydraulic conductivity as described later in this report.

Table 4. Detection of hydraulic conductivity in tuff.

Well	Min. Pumping Rate (L/min)	Max. Pumping Rate (L/min)	Screened Length (m)	Vertical Evaluation Interval Length (m)	Possible Hydraulic Conductivity Detection (m)	Hydraulic Conductivity Detection (m)	Intervals with Detectible Hydraulic Conductivity (percent)
ER-EC-1	244	480	151.9	1.5	151.9	32.8	21.6
ER-EC-2a	269	648	377.7	1.5	377.7	88.8	23.5
ER-EC-4	231	692	135.3	1.5	135.3	27.1	20.0
ER-EC-5	230	612	85.9	0.6	85.9	31.8	37.1
ER-5-4#2	287	668	46.8	0.6	46.8	20.3	43.4
ER-EC-6	238	260	124.2	0.6	124.2	4.8	3.8
ER-EC-7	249	671	67.4	1.5	67.4	8.2	12.2
ER-EC-8	250	670	77.6	0.6	77.6	23.0	29.7
TOTAL	n.a.	n.a.	1,066.8	n.a.	1066.8	236.8	22.2

The hydraulic conductivity with depth is presented in Figures 2 through 9. The position of the well screen, where detection of hydraulic conductivity is possible, is indicated on the left-hand side of the figure.

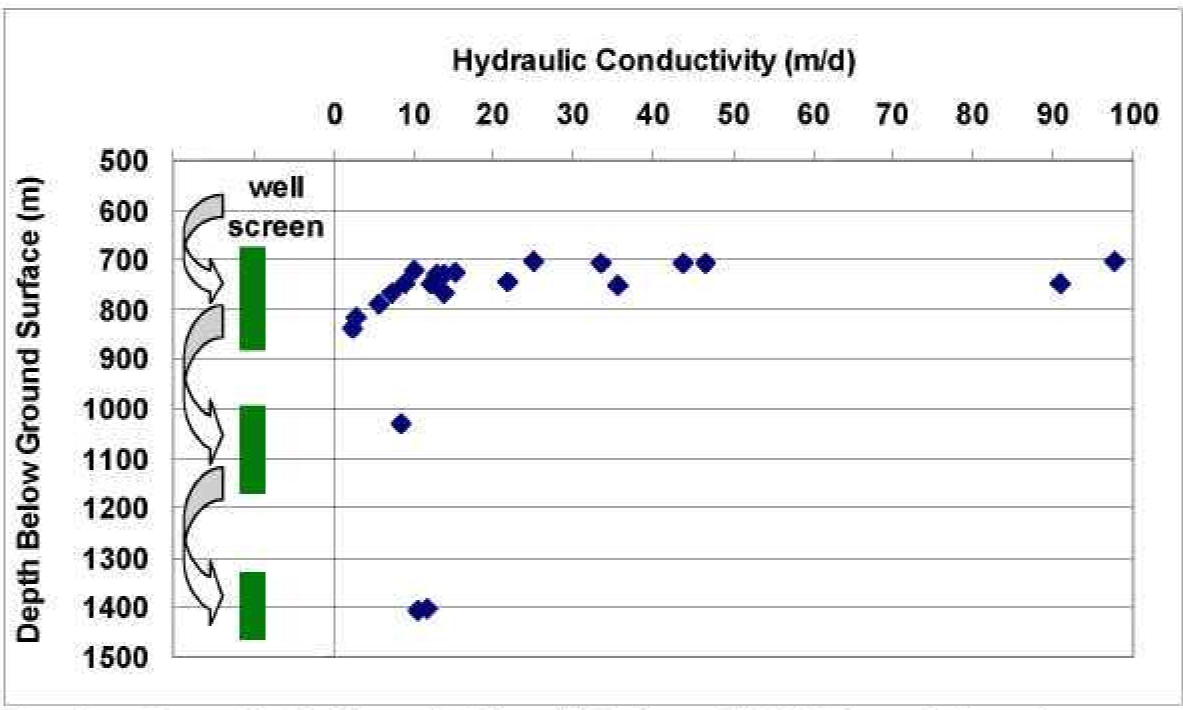


Figure 2. Detected hydraulic conductivity with depth at well ER-EC-1, vertical green bars on left-hand side of figure indicate position of well screen.

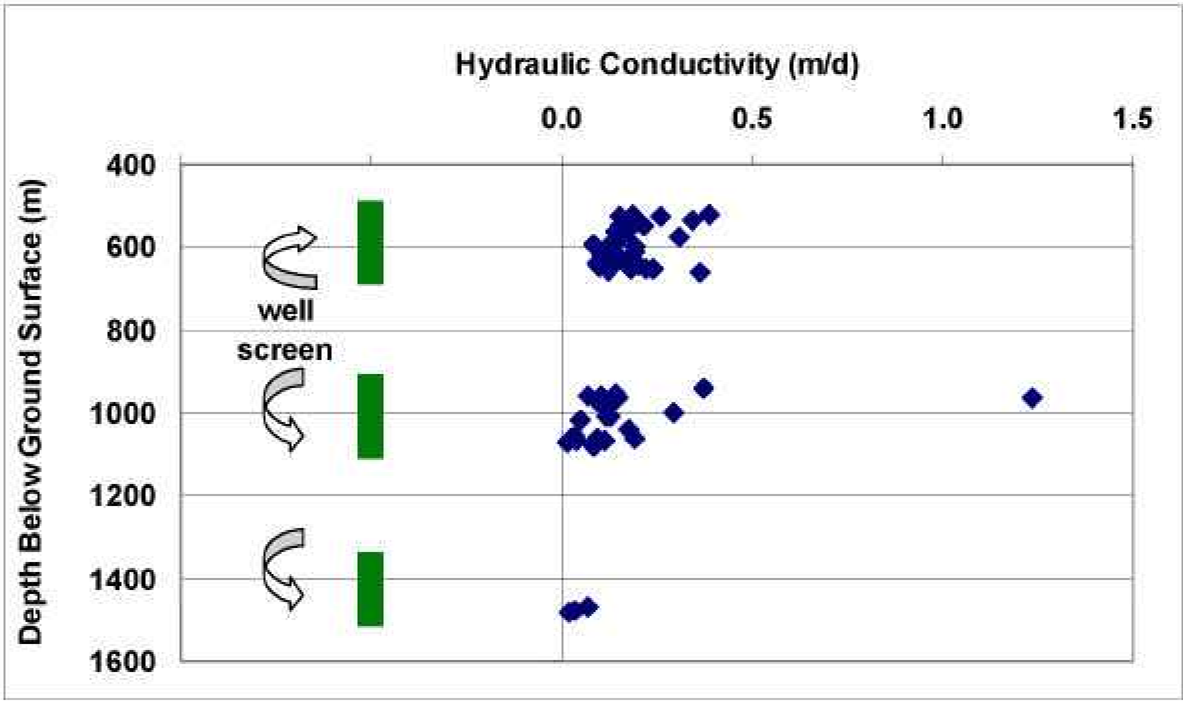


Figure 3. Detected hydraulic conductivity with depth at well ER-EC-2a, vertical green bars on left-hand side of figure indicate position of well screen.

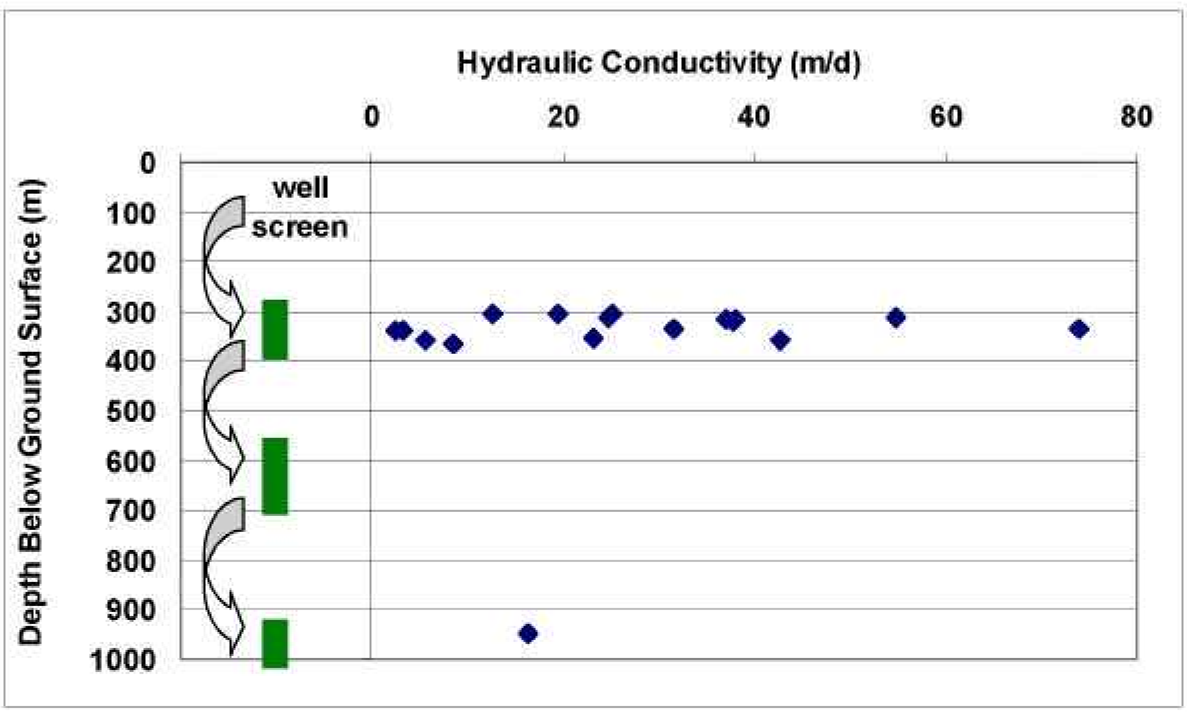


Figure 4. Detected hydraulic conductivity with depth at well ER-EC-4, vertical green bars on left-hand side of figure indicate position of well screen.

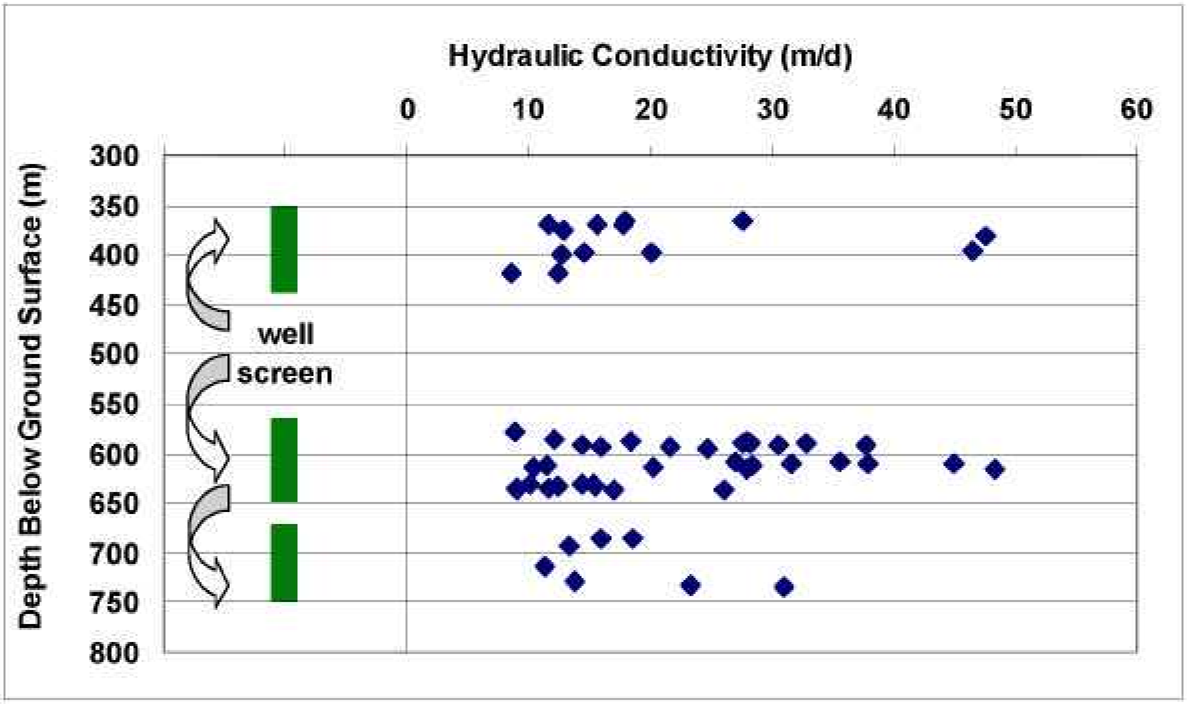


Figure 5. Detected hydraulic conductivity with depth at well ER-EC-5, vertical green bars on left-hand side of figure indicate position of well screen.

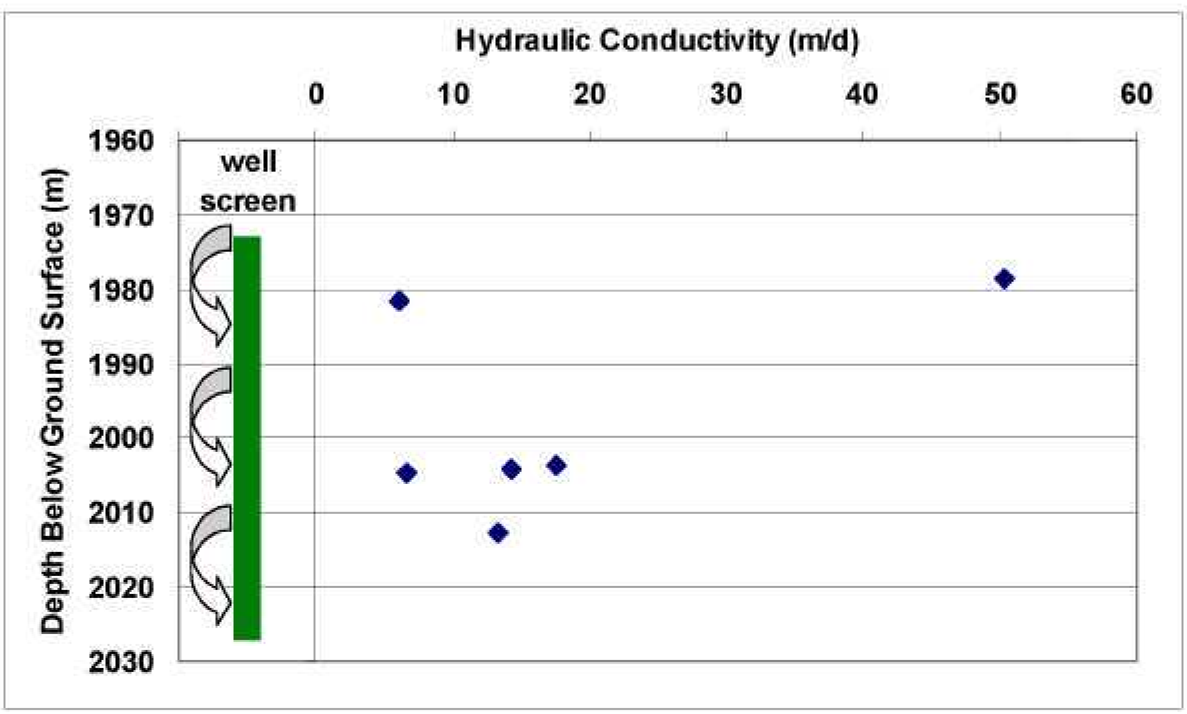


Figure 6. Detected hydraulic conductivity with depth at well ER-5-4#2, vertical green bars on left-hand side of figure indicate position of well screen.

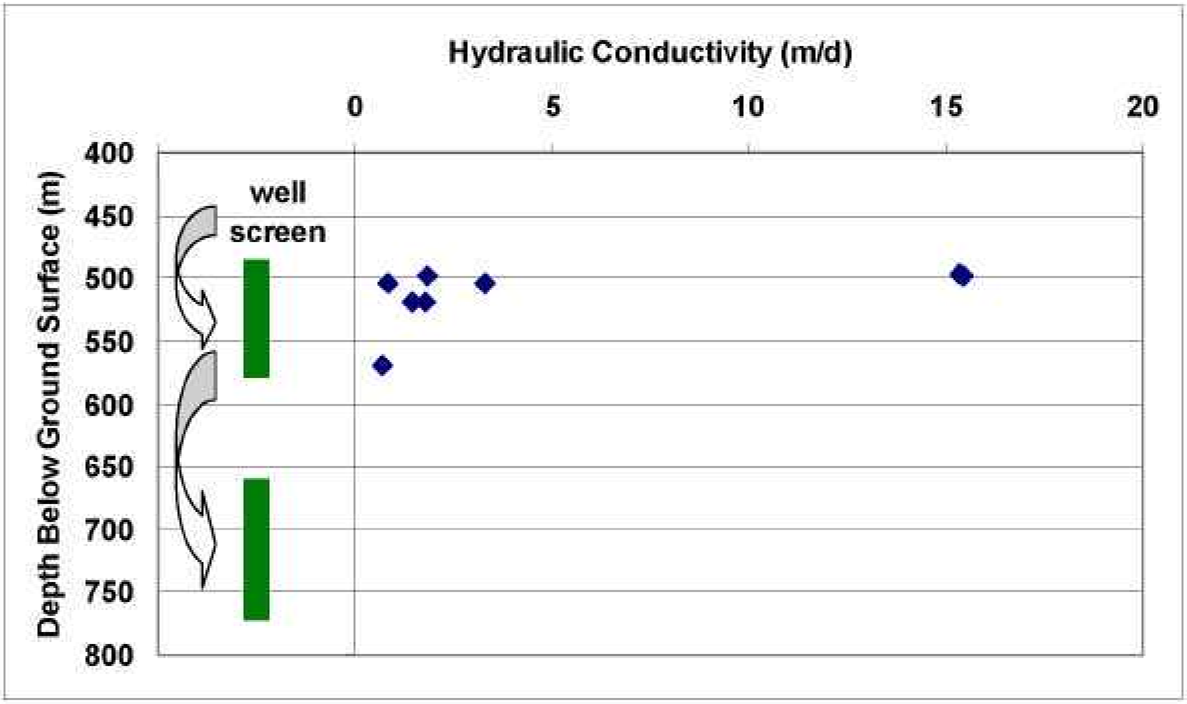


Figure 7. Detected hydraulic conductivity with depth at well ER-EC-6, vertical green bars on left-hand side of figure indicate position of well screen.

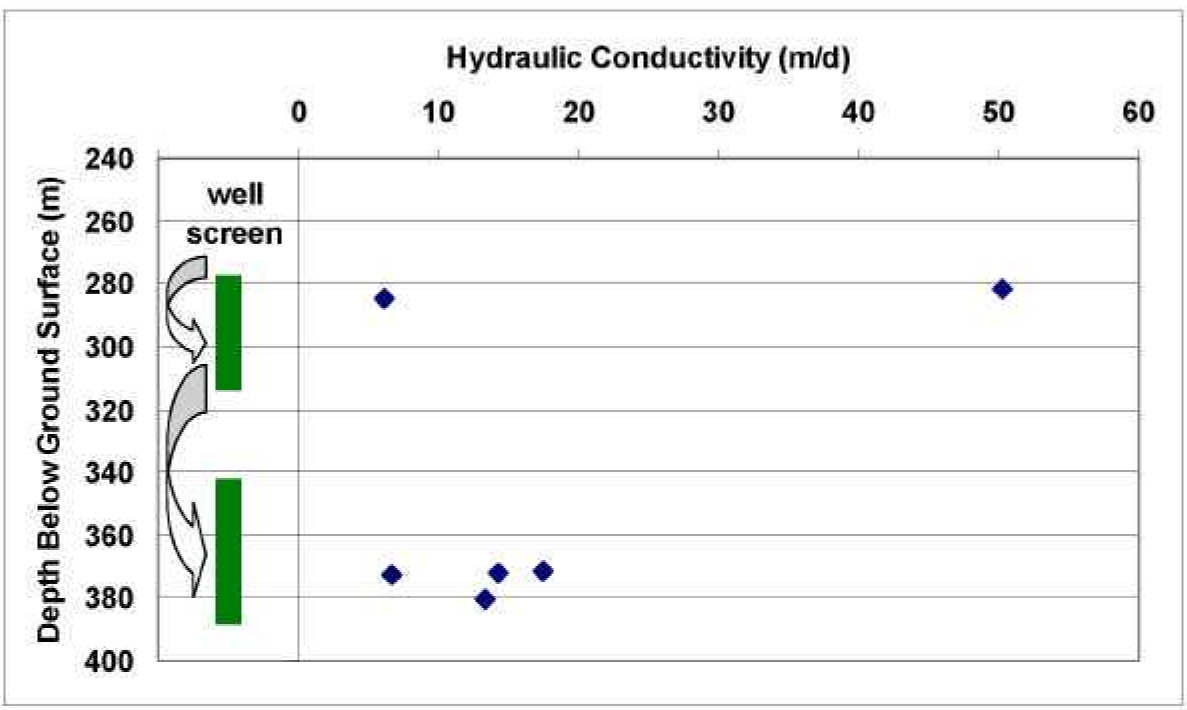


Figure 8. Detected hydraulic conductivity with depth at well ER-EC-7, vertical green bars on left-hand side of figure indicate position of well screen.

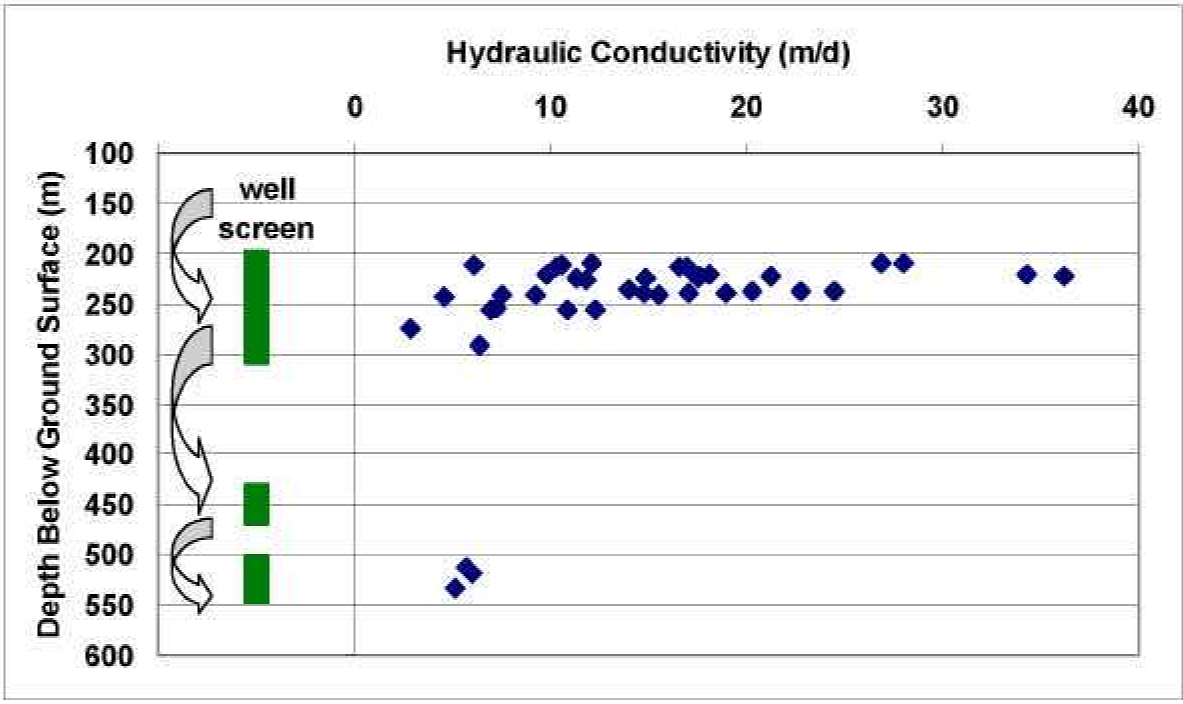


Figure 9. Detected hydraulic conductivity with depth at well ER-EC-8, vertical green bars on left-hand side of figure indicate position of well screen.

Examination of Figures 2 through 9 indicates that for most wells, the highest conductivity values were found in the upper-most portions of the well. That said, this does not mean that low values were only found at deeper depths. Rather, low values were also found mixed in with the high values in the upper-most portions of the wells. From these data alone, it would be difficult to quantify the dependence of hydraulic conductivity with depth as a general function based on multiple wells.

Wells ER-EC-5, ER-EC-7, and possibly ER-EC-2a are the exceptions to having the most hydraulic conductivity in the upper portions of the screened intervals. The graphical depiction of hydraulic conductivity with depth does not indicate any clearly identifiable trends and these data are examined in detail in the stage-two analyses.

The analysis continues by examining hydraulic conductivity for each hydrogeologic classification. The five major hydrogeologic classifications are:

- Stratigraphic unit,
- Lithologic description,
- Lithologic alteration,
- Hydrogeologic unit, and
- Hydrostratigraphic unit.

Each of the hydrogeologic classifications has several characteristics to designate the particular stratigraphic unit, lithology, etc. The hydrogeologic characteristics are defined at the beginning of each report section.

Association of Hydraulic Conductivity with Well-specific Hydrogeologic Characteristics

The following sections describe the association of hydraulic conductivity with each hydrogeologic characteristic. The analysis goals of the figures are described in Table 2. These results are intended for the reader interested in the characteristics of a specific well. Each well is discussed in a separate section below. The value of these tables is that they provide a quick review of the stratigraphic units containing detectable hydraulic conductivity without the reader needing to examine each of the well-specific figures.

Hydraulic Conductivity and Stratigraphy

Well construction in tuff encountered 34 different stratigraphic units. Each of the units encountered is presented in the tables and figures to aid the reader in understanding the stratigraphic section at each well and the context of well screening and the detection of hydraulic conductivity. Table 5 presents the stratigraphic abbreviations for the stratigraphic units encountered in each well. Table 6 presents a summary of the stratigraphic units associated with well screen and the detection of hydraulic conductivity. Sixteen stratigraphic units had well screen placed adjacent to the unit and hydraulic conductivity was detected in 12 of these stratigraphic units.

The vertical length of well screen in each stratigraphic unit and the length over which hydraulic conductivity was detected are presented for each well in Figures 10 through 17. The figures include tuff stratigraphic units that were encountered during drilling but not screened, to aid the reader in understanding the stratigraphic context. This is especially important where there are intervening stratigraphic units between the screened units.

The numerical average detected hydraulic conductivity within each stratigraphic unit is presented in Figures 18 through 25. This analysis demonstrates an interesting finding. Although there are differences in average detected hydraulic conductivity values, the values within each well are of similar order of magnitude. The largest difference in average values within a well are less than an order of magnitude. Readers interested in performing additional evaluations of the data are referred to the Appendix.

Table 5. Stratigraphic units for wells in tuff.

Stratigraphic Abbreviation	Stratigraphic Unit Name
ER-EC-1	
Ttt	Trail Ridge Tuff
Ttp/Ttr	Pahute Mesa and Rocket Wash Tuff
Tmap	Mafic-poor Ammonia Tanks Tuff
Tmat	Rhyolite of Tannenbaum Hill
Tmrp	Mafic-poor Rainier Mesa Tuff
Tmrf	Rhyolite of Fluorspar Canyon
Tpb	Rhyolite of Benham
Tpcm	Pahute Mesa Lobe of Tiva Canyon Tuff
Thr	Calico Hills Formation
Tptm	Pahute Mesa Lobe of Topopah Spring Tuff
Tcpe	Prow Pass Tuff
ER-EC-2a	
Tfbw	Rhyolite of Beatty Wash
Tfb	Beatty Wash Formation
Tf	Volcanics of Fortymile Canyon
Tmaw	Tuff of Button Hook Wash
Tmar	Mafic-rich Ammonia Tanks Tuff

Table 5. Stratigraphic units for wells in tuff (continued).

Stratigraphic Abbreviation	Stratigraphic Unit Name
ER-EC-4	
Typ	Pliocene Basalt
Ttg	Gold Flat Tuff
Ttt	Trail Ridge Tuff
Ttp	Pahute Mesa Tuff
Ttr	Rocket Wash Tuff
Ttc	Trachyte of Ribbon Cliff
Tfbr	Rhyolite of Chukkar Canyon
Tfbw	Rhyolite of Beatty Wash
Tmay	Trachyte of East Cat Canyon
Tmap	Mafic-poor Ammonia Tanks Tuff
Tmab	Bedded Ammonia Tanks Tuff
Tmrb	Bedded Rainier Mesa Tuff
Tmrp	Mafic-poor Rainier Mesa Tuff
ER-EC-5	
Ttp	Pahute Mesa Tuff
Ttr	Rocket Wash Tuff
Tgc	Caldera Moat-Filling Sedimentary Deposits
Tfbw	Rhyolite of Beatty Wash
Tmx	Timber Mountain Landslide Breccia
Tmar	Mafic-rich Ammonia Tanks Tuff
Tmap	Mafic-poor Ammonia Tanks Tuff
ER-5-4#2	
Ttp	Pahute Mesa Tuff
QTp	Quaternary-Tertiary Playa
QTa	Quaternary-Tertiary Alluvium
Tma	Ammonia Tanks Tuff
Tmab	Bedded Ammonia Tanks Tuff
Tmr	Rainier Mesa Tuff
Tmr/Tw	Rainier Mesa Tuff/Wahmonie Formation
Tw	Wahmonie Formation
Tcb	Bullfrog Tuff
ER-EC-6	
Tmat	Rhyolite of Tannenbaum Hill
Tmrf	Rhyolite of Fluorspar Canyon
Tpb	Rhyolite of Benham
Tpcm	Pahute Mesa Lobe of Tiva Canyon Tuff
Thr	Mafic-rich Calico Hills Formation
Tptm	Pahute Mesa Lobe of Topopah Spring Tuff
Tcpe	Prow Pass Tuff
Tcpk	Prow Pass Tuff
ER-EC-7	
Tfbw	Rhyolite of Beatty Wash
Tfbr	Rhyolite of Chukkar Canyon
Tfb	Beatty Wash Formation
Tfl	Tuff of Leadfield Road
ER-EC-8	
Tt	Thirsty Canyon Group
Tfb	Beatty Wash Formation
Tmaw	Tuff of button Hook Wash
Tmap	Mafic-poor Ammonia Tanks Tuff

Table 6. Stratigraphic units encountered in drilling. Units that are screened are shaded gray and units with detectable hydraulic conductivity are in bold type.

Well	Stratigraphic Unit												
ER-EC-1	Ttt	Ttp/Ttr	Tmap	Tmat	Tmrp	Tmrf	**Tpb**	**Tpcm**	Thr	**Tptm**	**Tcpe**		
ER-EC-2a	**Tfbw**	Tfb	**Tf**	**Tmaw**	**Tmar**								
ER-EC-4	Typ	Ttg	Ttt	Ttp	Ttr	**Ttc**	Tfbr	Tfbw	Tmay	Tmap	Tmab	Tmrb	**Tmrp**
ER-EC-5	Ttp	Ttr	Tgc	Tfbw	Tmx	**Tmar**	**Tmap**						
ER-5-4#2	Ttp	QTp	QTa	Tma	Tmab	Tmr	Tmr/Tw	Tw	**Tcb**				
ER-EC-6	Tmat	Tmrf	**Tpb**	Tpcm	Thr	Tptm	Tcpe	Tcpk					
ER-EC-7	**Tfbw**	Tfbr	**Tfb**	Tfl									
ER-EC-8	Tt	**Tfb**	Tmaw	**Tmap**									

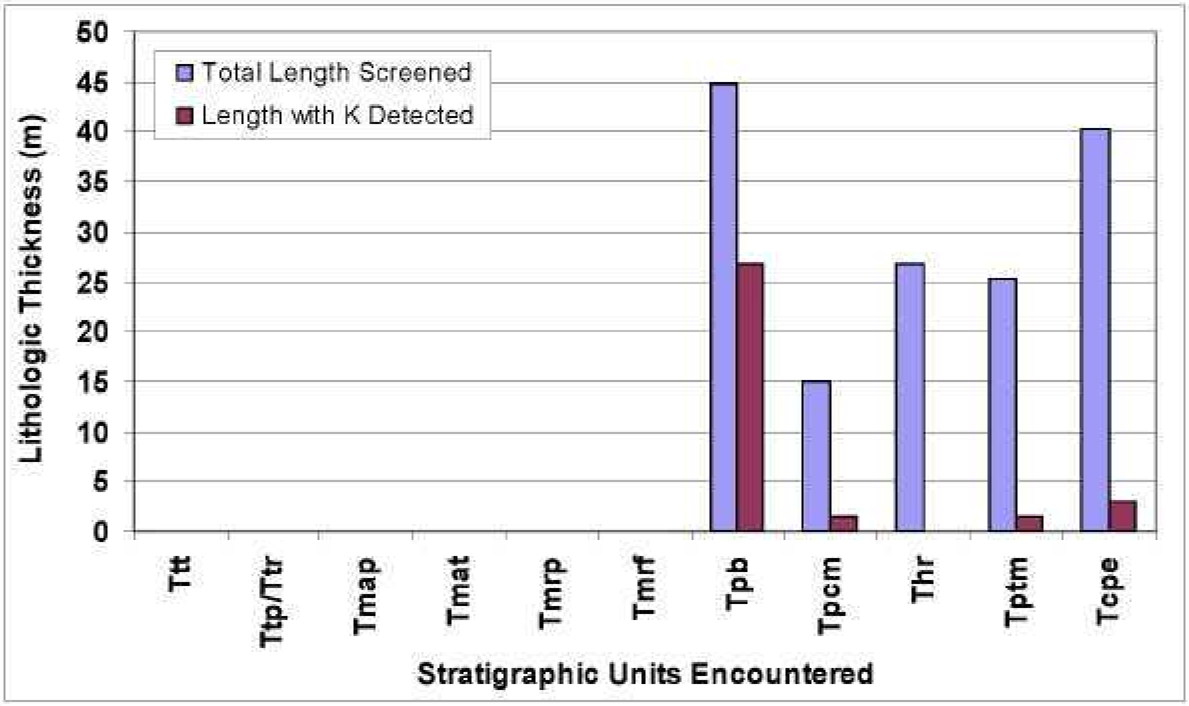


Figure 10. Stratigraphic units adjacent to well screen and detectable hydraulic conductivity at well ER-EC-1.

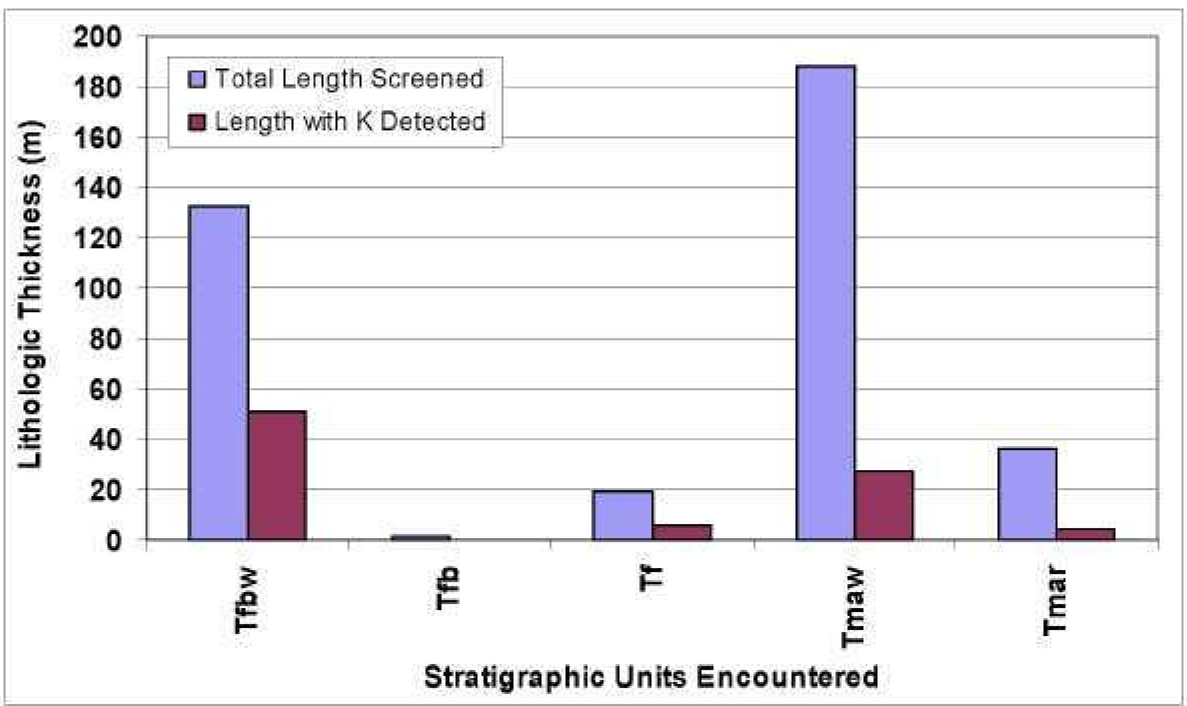


Figure 11. Stratigraphic units adjacent to well screen and detectable hydraulic conductivity at well ER-EC-2a.

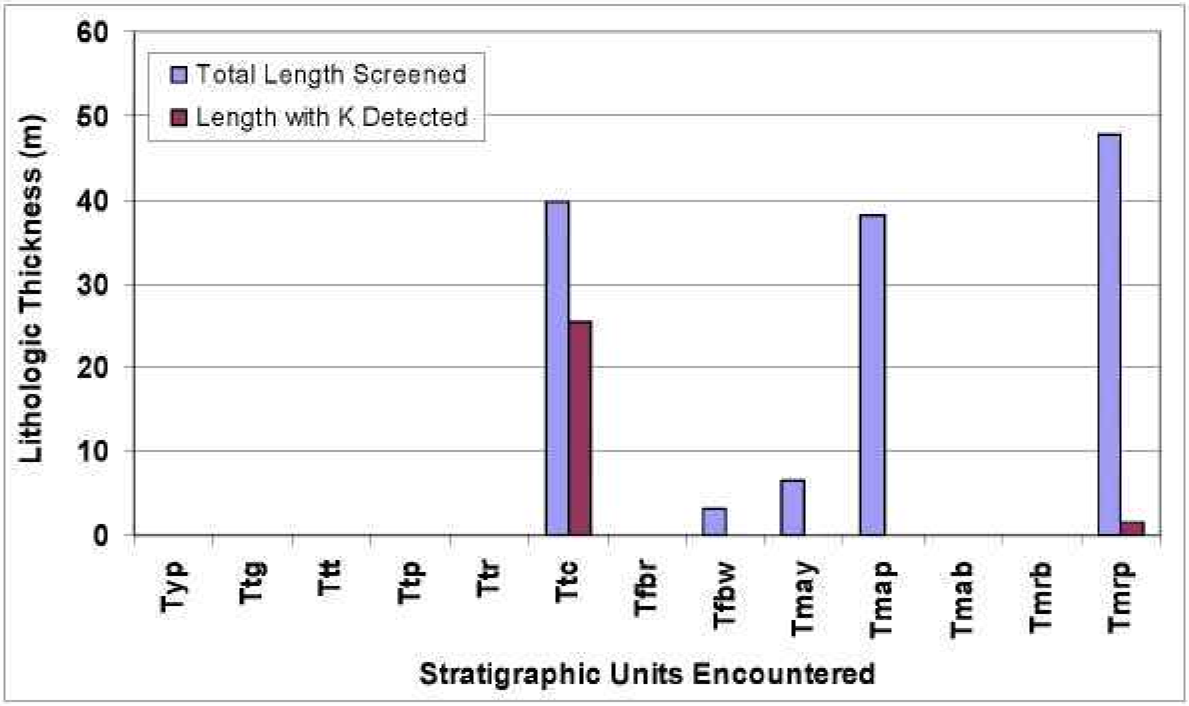


Figure 12. Stratigraphic units adjacent to well screen and detectable hydraulic conductivity at well ER-EC-4.

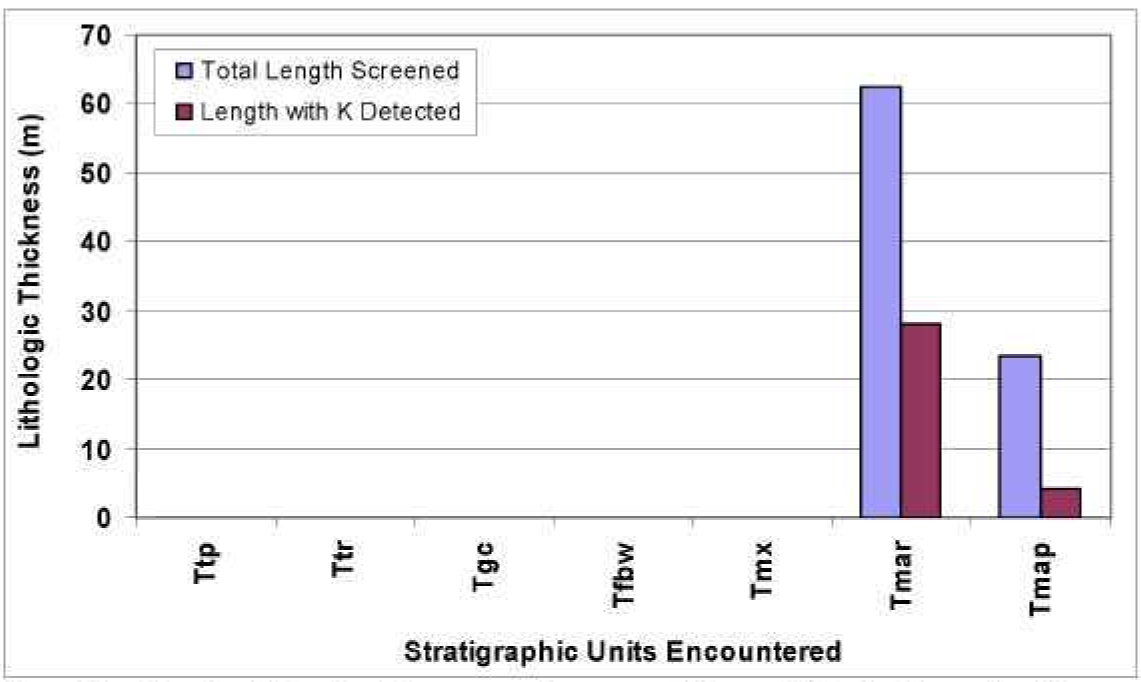


Figure 13. Stratigraphic units adjacent to well screen and detectable hydraulic conductivity at well ER-EC-5.

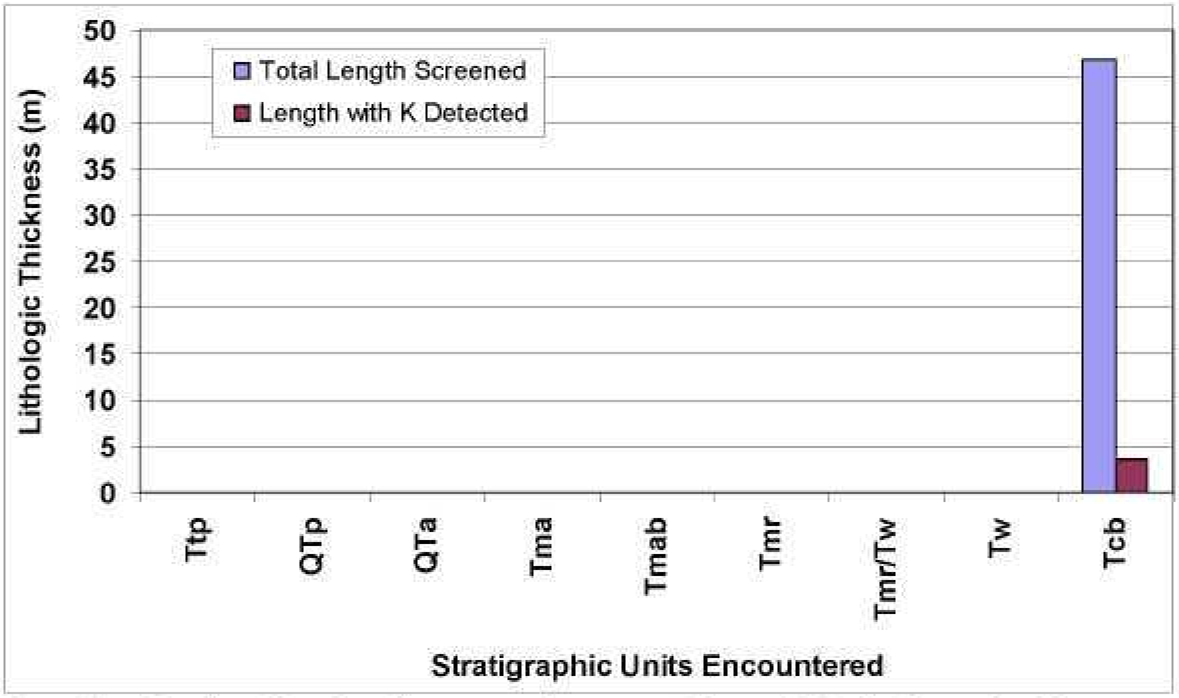


Figure 14. Stratigraphic units adjacent to well screen and detectable hydraulic conductivity at well ER-5-4#2.

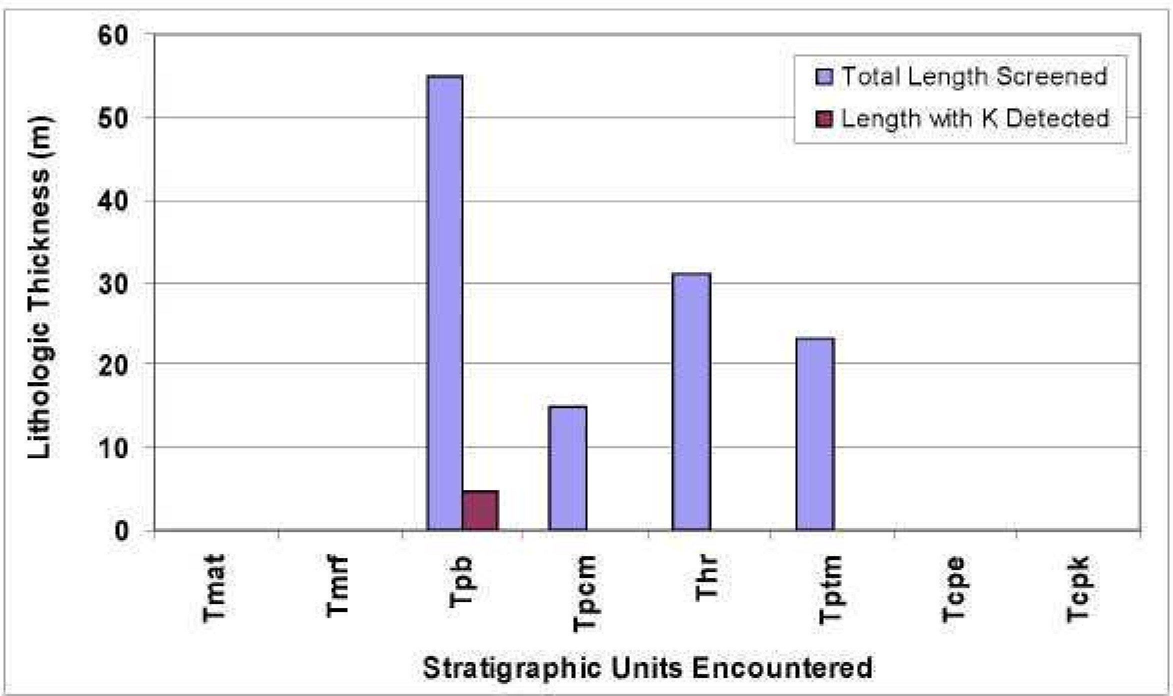


Figure 15. Stratigraphic units adjacent to well screen and detectable hydraulic conductivity at well ER-EC-6.

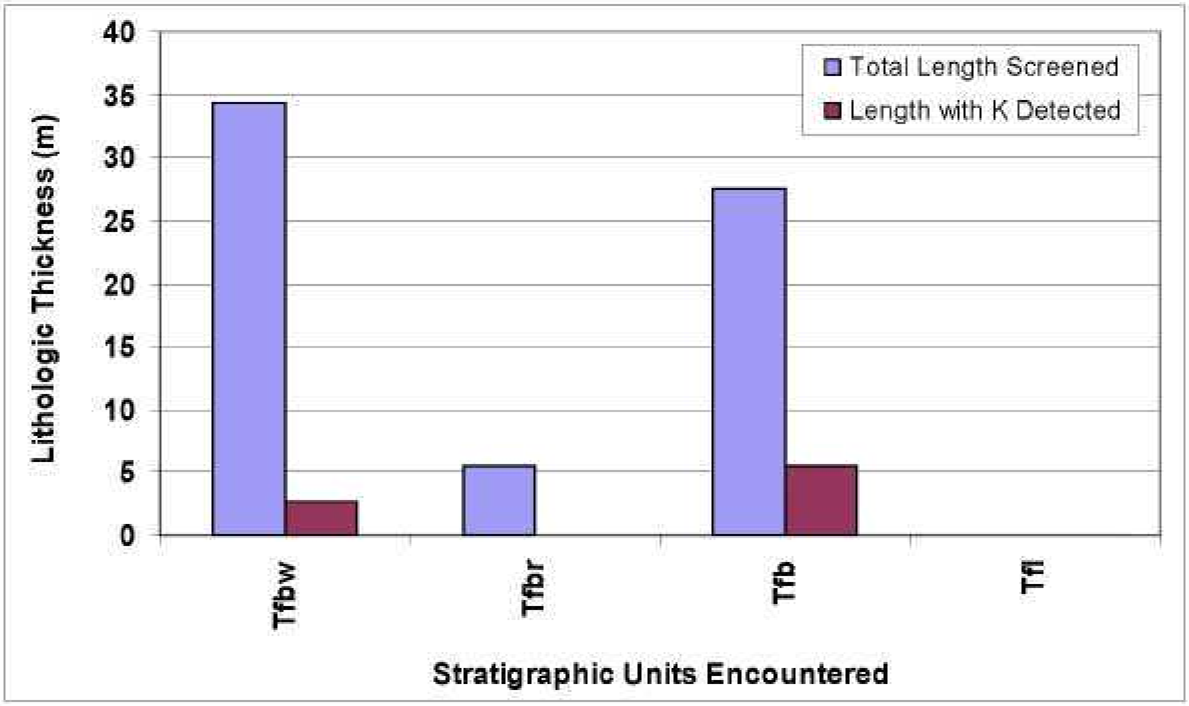


Figure 16. Stratigraphic units adjacent to well screen and detectable hydraulic conductivity at well ER-EC-7.

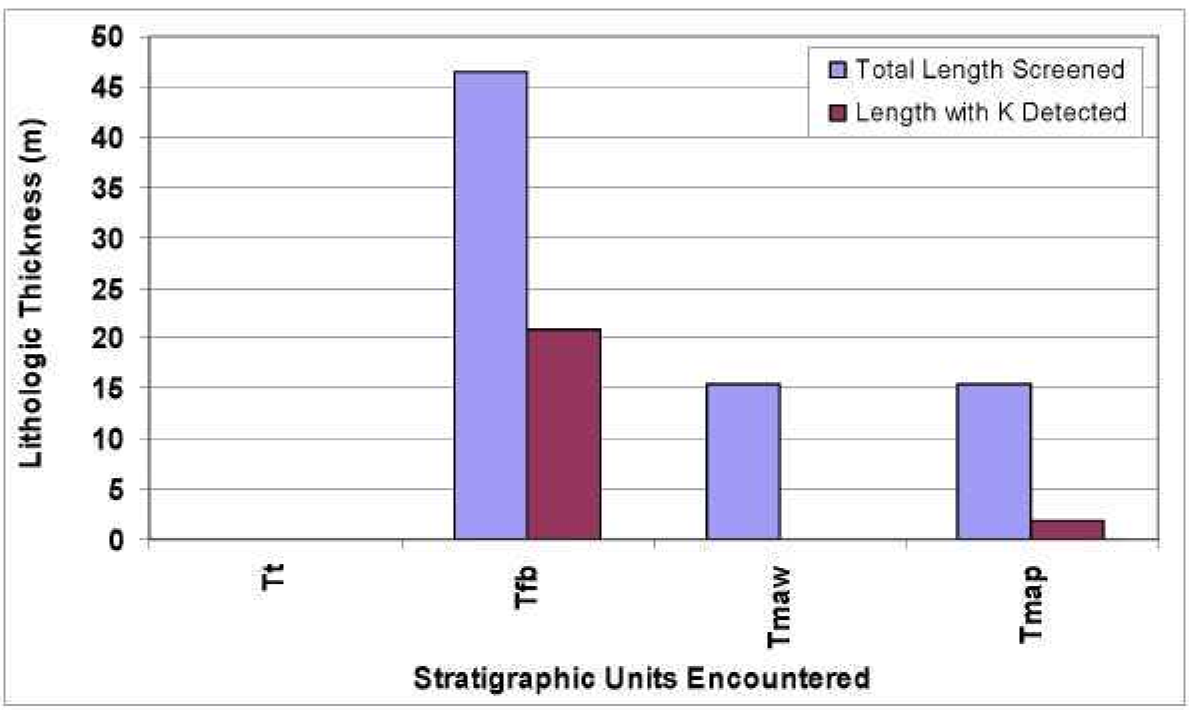


Figure 17. Stratigraphic units adjacent to well screen and detectable hydraulic conductivity at well ER-EC-8.

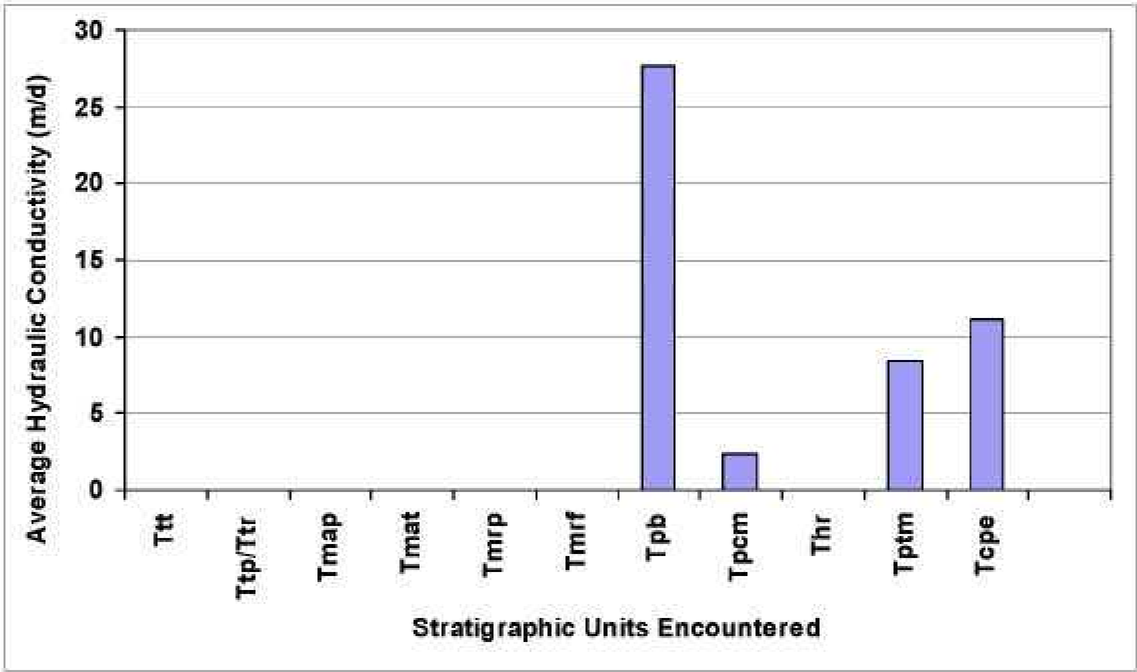


Figure 18. Average detected hydraulic conductivity in stratigraphic units at well ER-EC-1.

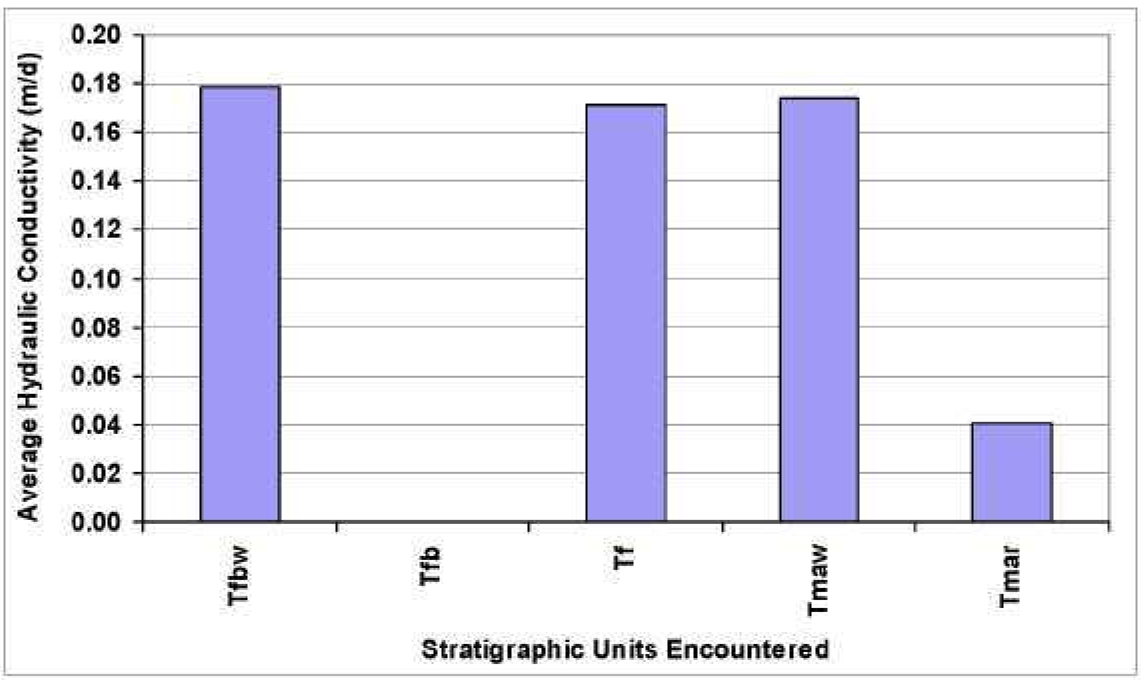


Figure 19. Average detected hydraulic conductivity in stratigraphic units at well ER-EC-2a.

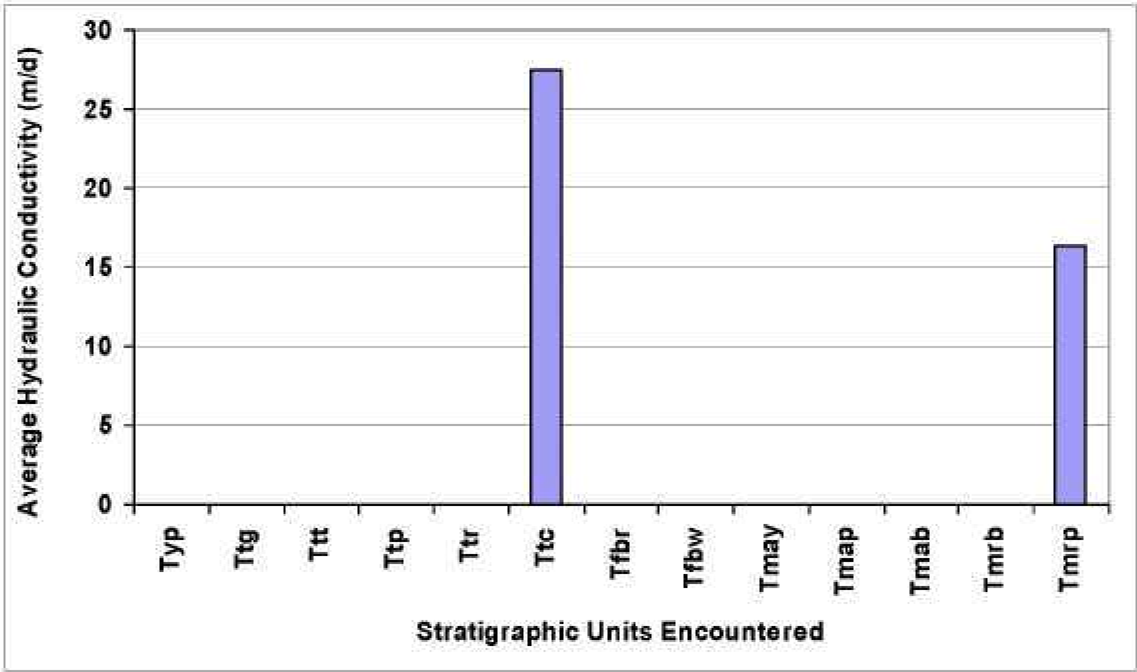


Figure 20. Average detected hydraulic conductivity in stratigraphic units at well ER-EC-4.

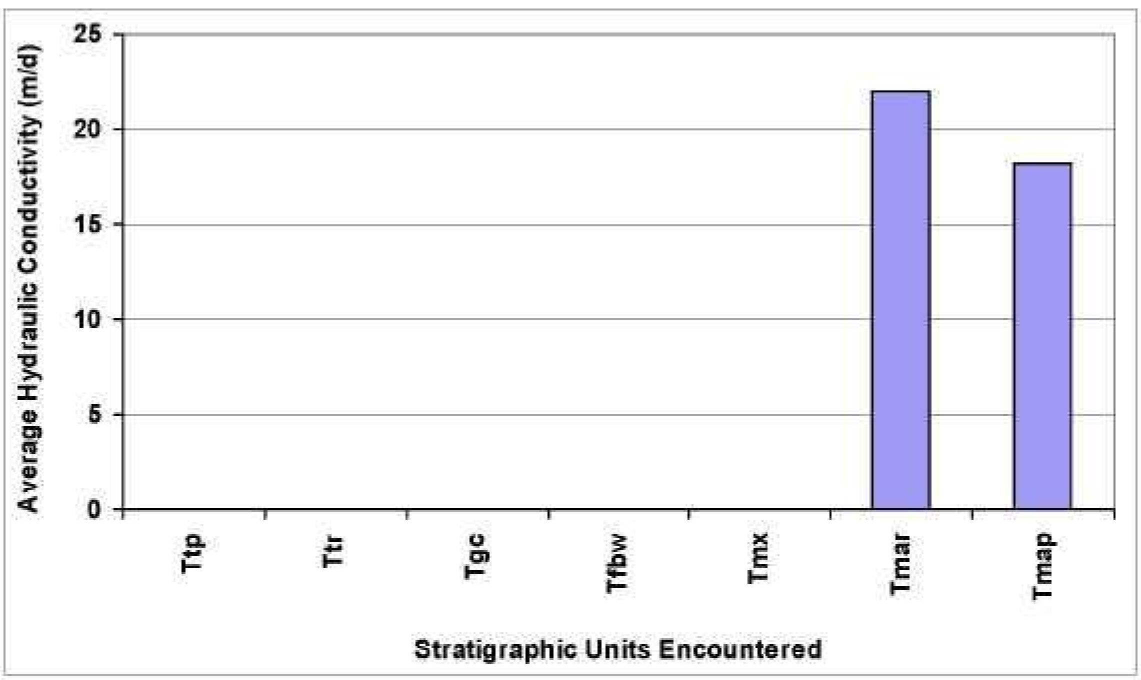


Figure 21. Average detected hydraulic conductivity in stratigraphic units at well ER-EC-5.

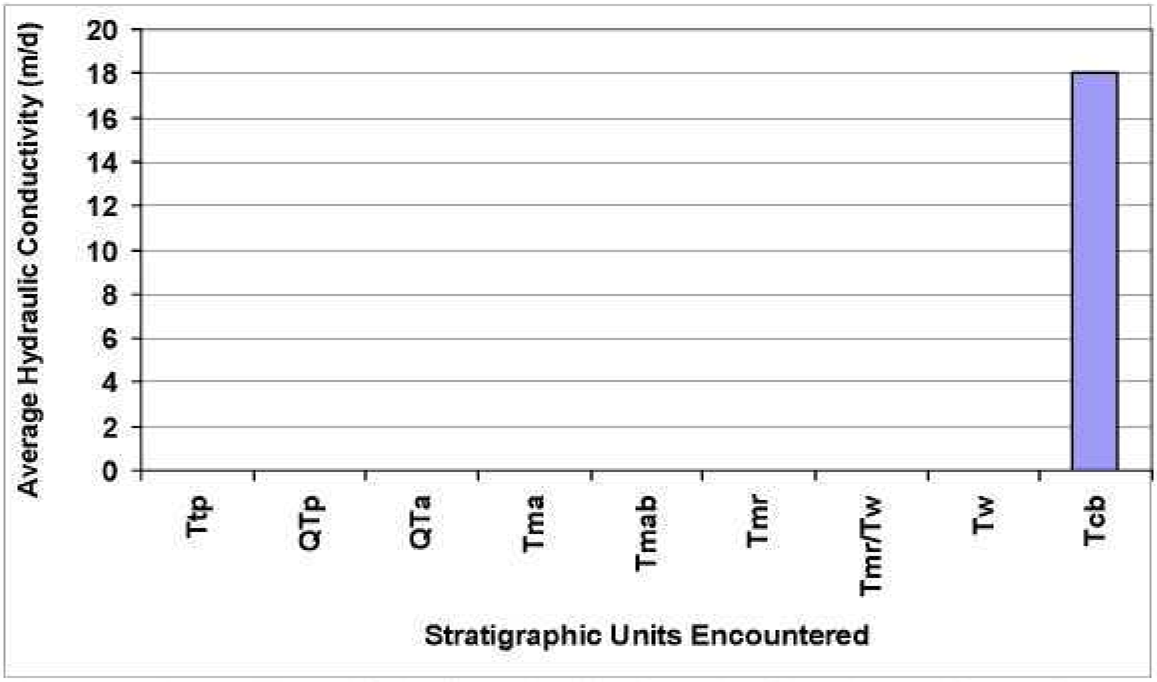


Figure 22. Average detected hydraulic conductivity in stratigraphic units at well ER-5-4#2.

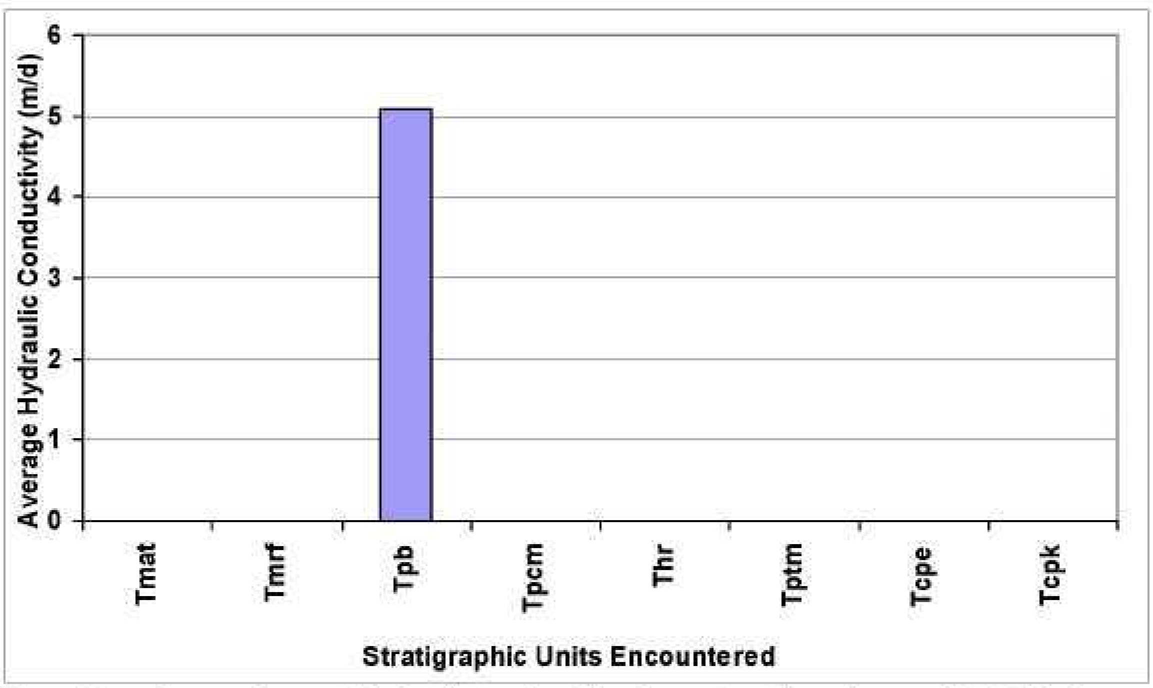


Figure 23. Average detected hydraulic conductivity in stratigraphic units at well ER-EC-6.

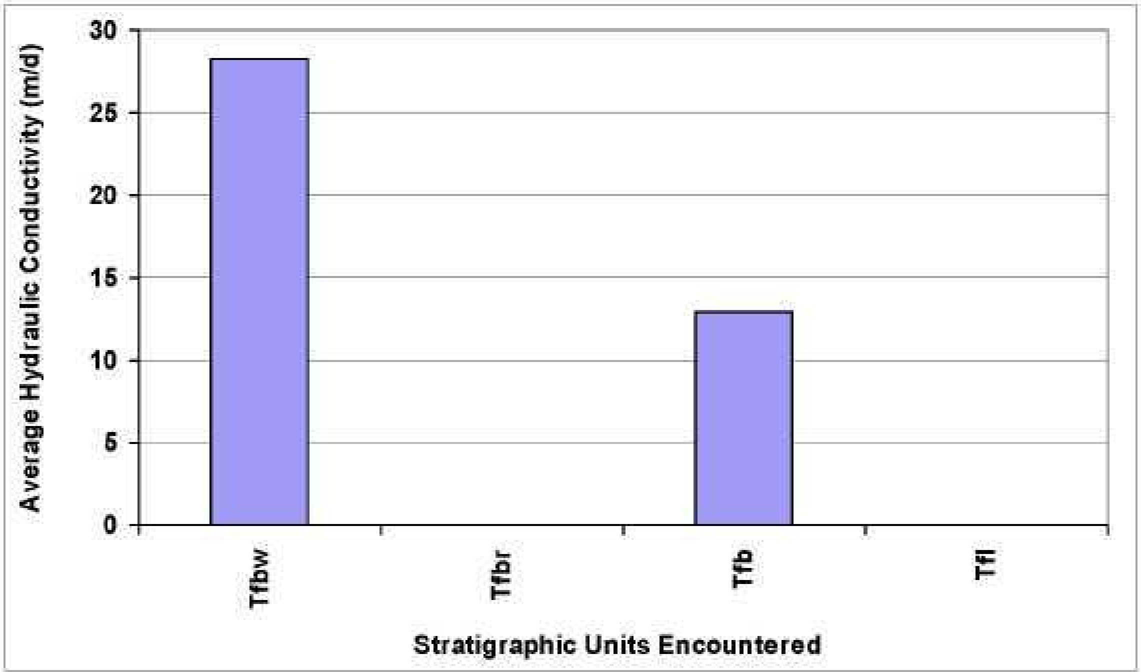


Figure 24. Average detected hydraulic conductivity in stratigraphic units at well ER-EC-7.

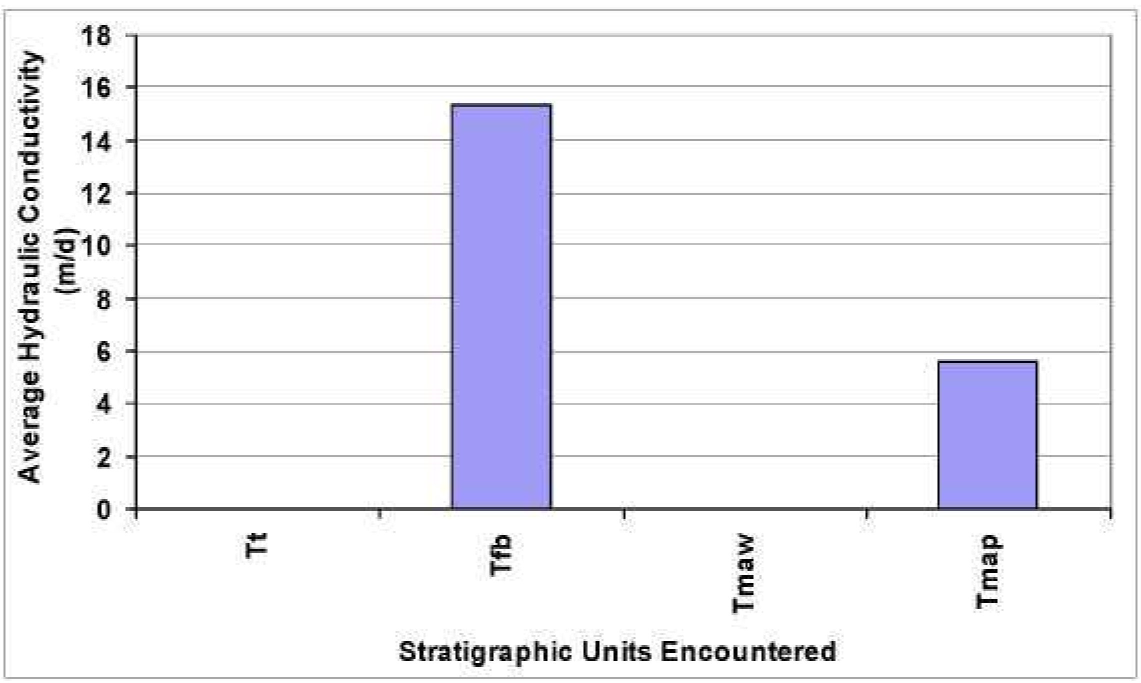


Figure 25. Average detected hydraulic conductivity in stratigraphic units at well ER-EC-8.

Hydraulic Conductivity and Lithologic Modifier

Well construction in tuff placed well screen adjacent to units containing 16 different lithologic modifiers. Each of the modifiers encountered during well construction is presented in the tables and figures to aid the reader in understanding the context of well screening and the detection of hydraulic conductivity. Table 7 presents abbreviations for the lithologic modifiers encountered in the wells. Table 8 presents a summary of the lithologic modifiers associated with well screen and the detection of hydraulic conductivity. Well screen was placed adjacent to 16 unique lithologic modifiers in tuff. Ten of these lithologic modifiers are associated with detectable hydraulic conductivity. Lithologic modifiers have the second highest number of associations among the hydrogeologic characteristic.

The vertical length of well screen placed adjacent to each lithologic modifier and the length over which hydraulic conductivity was detected are presented for each well in Figures 26 through 33. The figures include only the lithologic modifiers that were screened. Units described as nonwelded tuff and lava most often had detectable hydraulic conductivity. The average detected hydraulic conductivity for the lithologic modifiers is presented in Figures 34 through 41. The higher values of average hydraulic conductivity are associated with lava where it is present.

Hydraulic Conductivity and Alteration Modifier

Well construction in tuff placed well screen adjacent to units containing seven different alteration modifiers. Each of the modifiers that were encountered during well construction is presented in the tables and figures to aid the reader in understanding the context of well screening and the detection of hydraulic conductivity. Table 9 presents abbreviations for the alteration modifiers encountered in the wells. Table 10 presents a summary of the alteration modifiers associated with well screen and the detection of hydraulic conductivity. Well screen was placed adjacent to seven unique alteration modifiers in tuff. Six of these alteration modifiers are associated with detectable hydraulic conductivity.

Table 7. Lithologic modifiers for wells in tuff.

Lithologic Abbreviation	Lithologic Unit Name
NWT	Nonwelded Tuff
NWT-PWT	Nonwelded - Partially Welded Tuff
PWT	Partially Welded Tuff
PWT-MWT	Partially Welded - Moderately Welded Tuff
MWT	Moderately Welded Tuff
DWT	Densely Welded Tuff
VT	Vitrified Tuff
BED	Bedded Tuff
PL	Pumiceous Lava
LA	Lava
VL	Vitrified Lava
FB	Flow Base
RWT	Rhylolitic Welded Tuff
TSLT	Tuff reworked with Silt
CL	Paleocolluvium mixed with Lava

Table 8. Lithologic units that are adjacent to well screened. Lithologic modifiers with detectable hydraulic conductivity are shaded gray.

Well	Lithologic Unit									
ER-EC-1	NWT-PWT	**PWT**	**PWT-MWT**	MWT	VT	**BED**	PL	**LA**	VL	**FB**
ER-EC-2a	**NWT**	**MWT**	**BED**	**TSLT**	**RWT**					
ER-EC-4	NWT	**PWT**	MWT	DWT	VT	BED	**LA**	**CL**		
ER-EC-5	**MWT**	**MWT-DWT**								
ER-5-4#2	**NWT**									
ER-EC-6	NWT	PWT	MWT	**LA**	BED					
ER-EC-7	**LA**	BED	VL	FB						
ER-EC-8	**NWT**	PWT	PWT-MWT	VT						

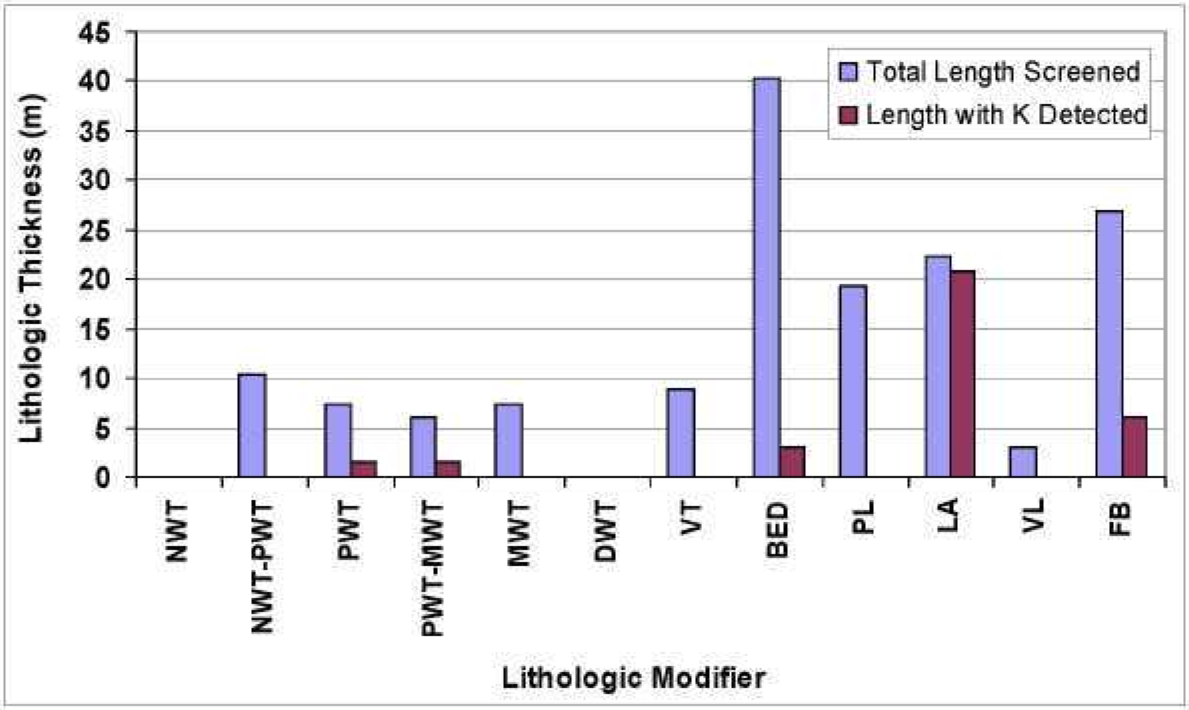


Figure 26. Lithologic modifiers adjacent to well screen and detectable hydraulic conductivity at well ER-EC-1.

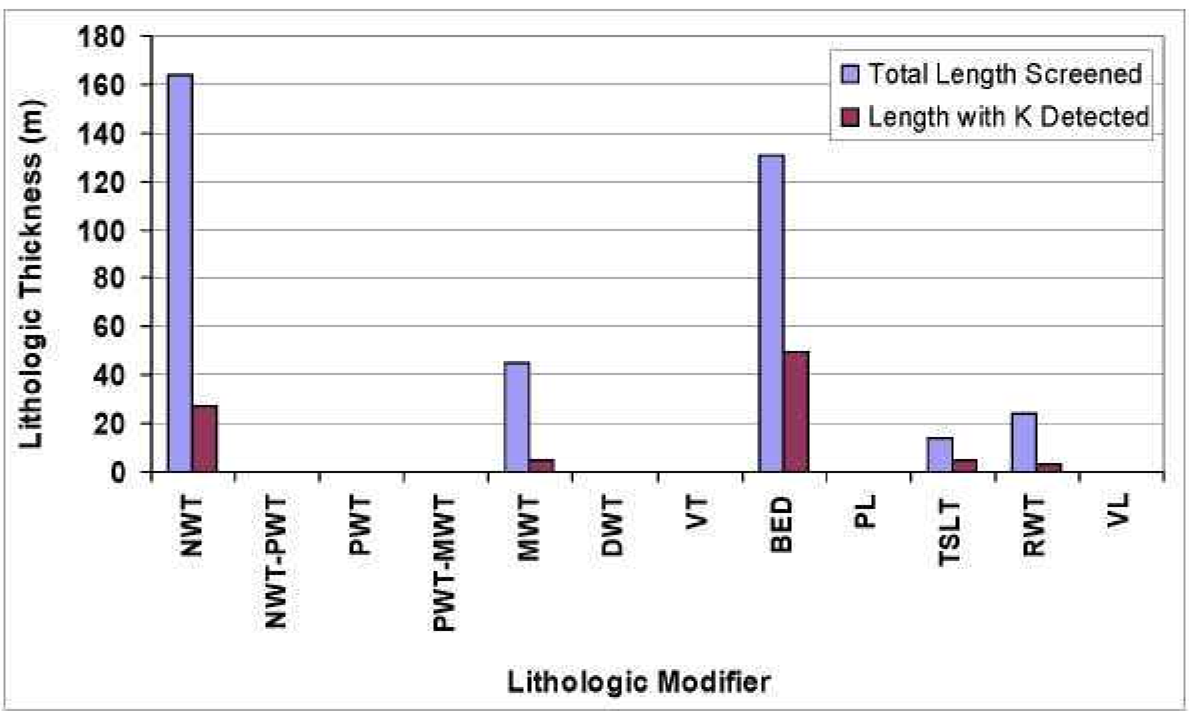


Figure 27. Lithologic modifiers adjacent to well screen and detectable hydraulic conductivity at well ER-EC-2a.

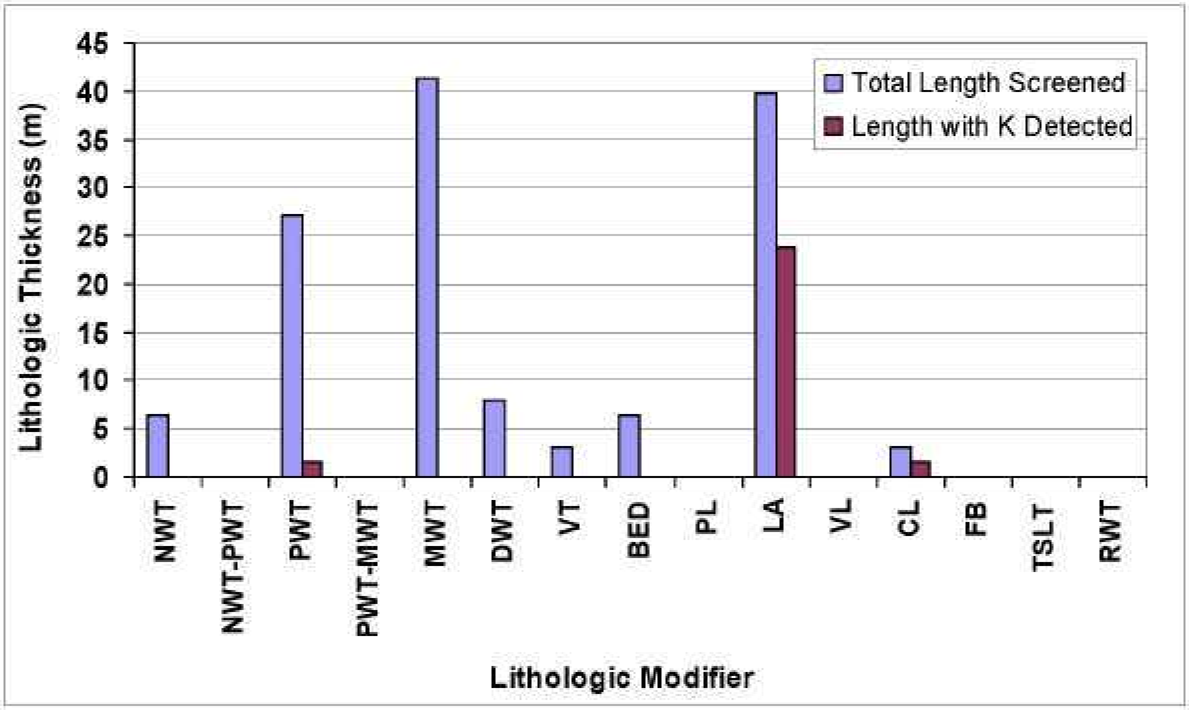


Figure 28. Lithologic modifiers adjacent to well screen and detectable hydraulic conductivity at well ER-EC-4.

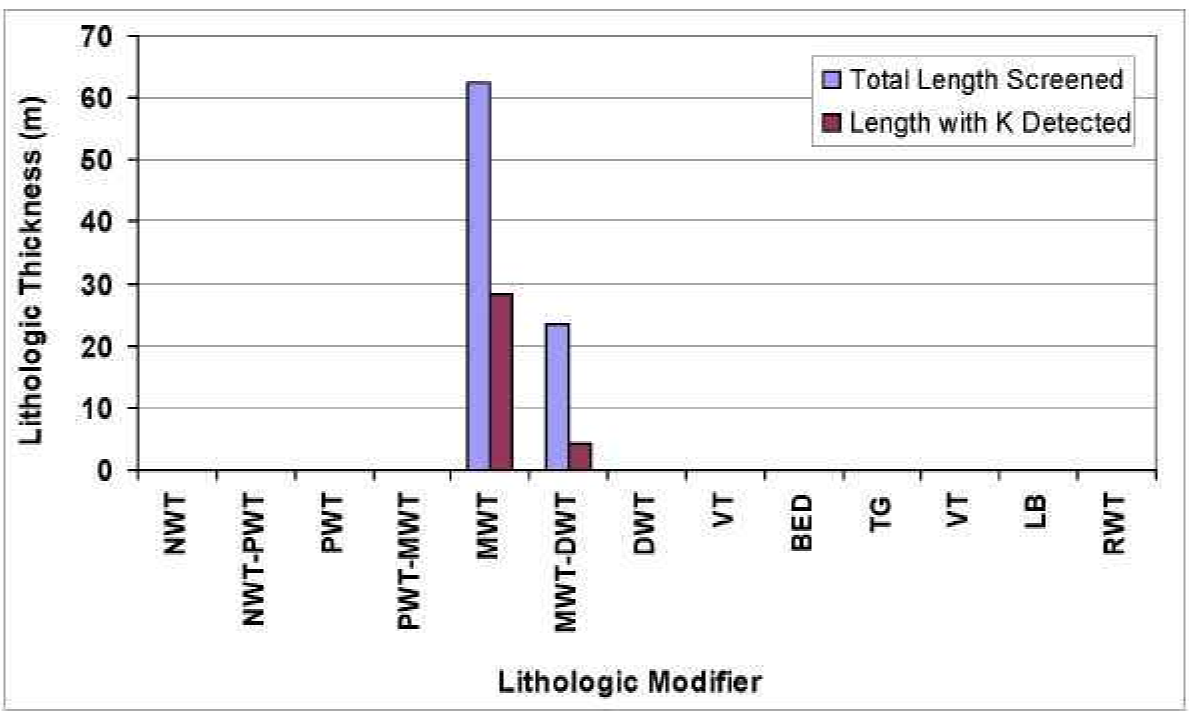


Figure 29. Lithologic modifiers adjacent to well screen and detectable hydraulic conductivity at well ER-EC-5.

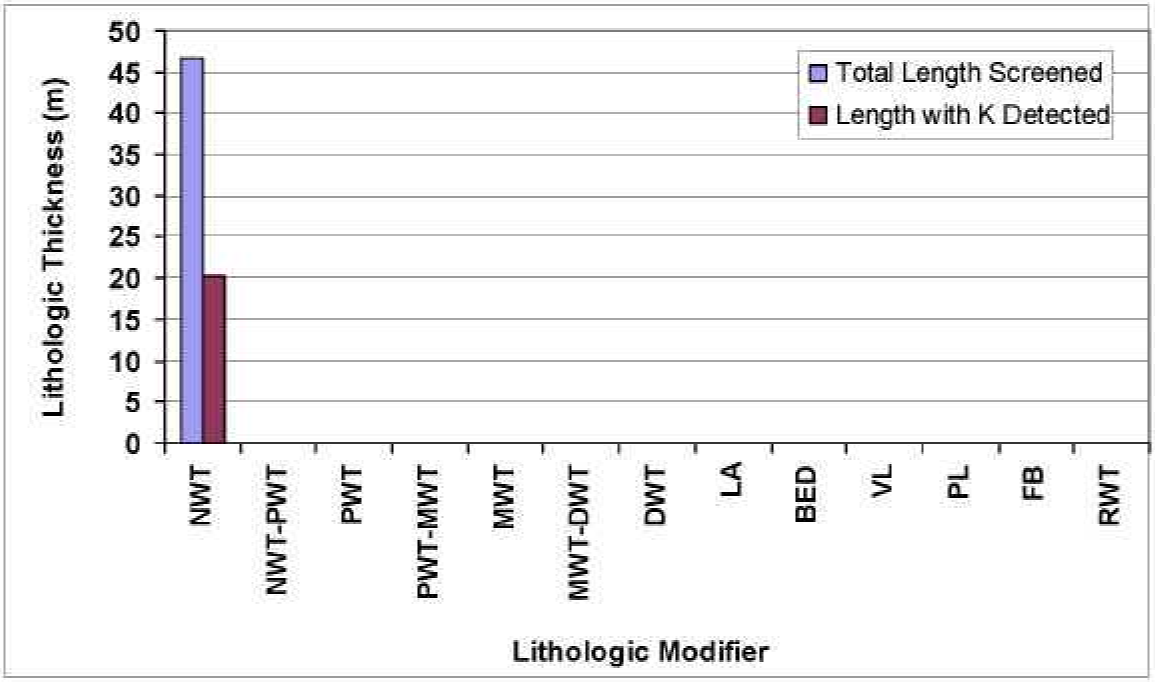


Figure 30. Lithologic modifiers adjacent to well screen and detectable hydraulic conductivity at well ER-5-4#2.

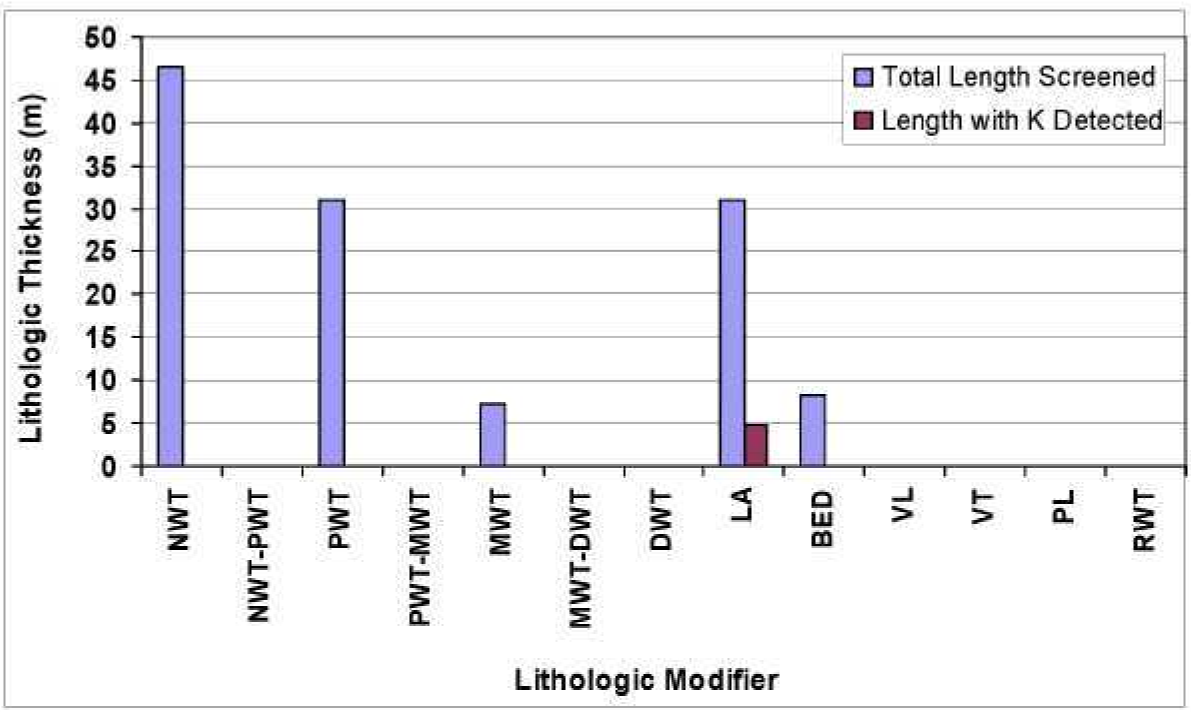


Figure 31. Lithologic modifiers adjacent to well screen and detectable hydraulic conductivity at well ER-EC-6.

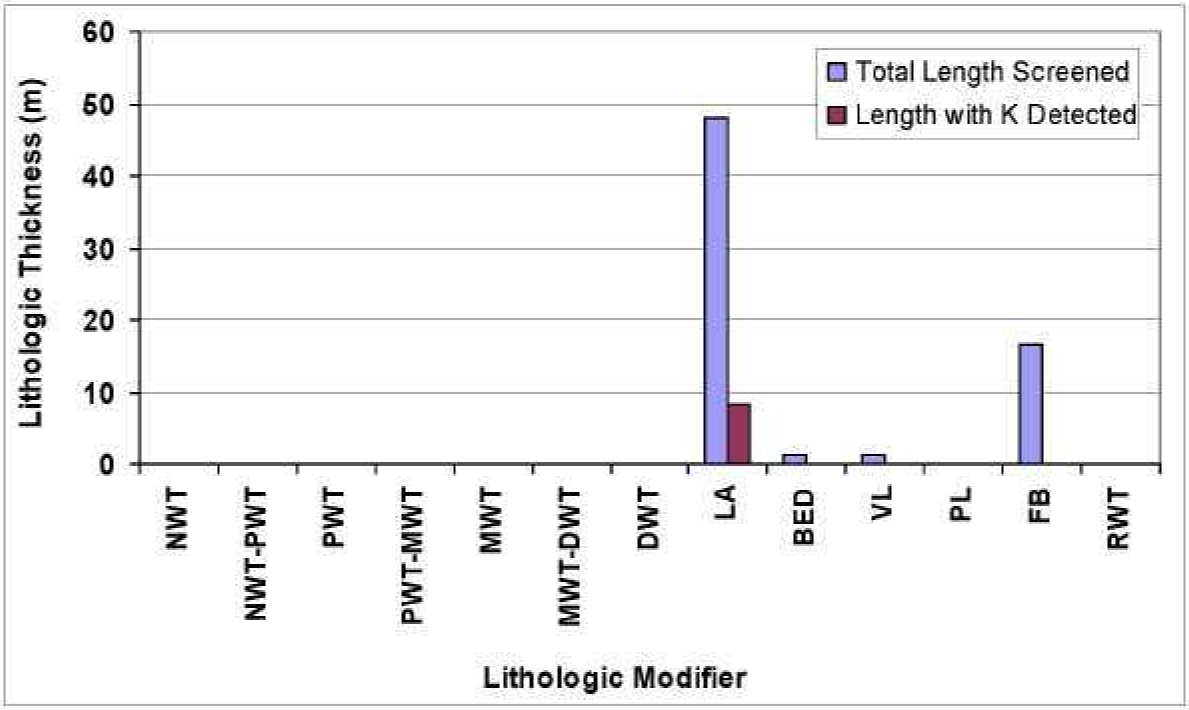


Figure 32. Lithologic modifiers adjacent to well screen and detectable hydraulic conductivity at well ER-EC-7.

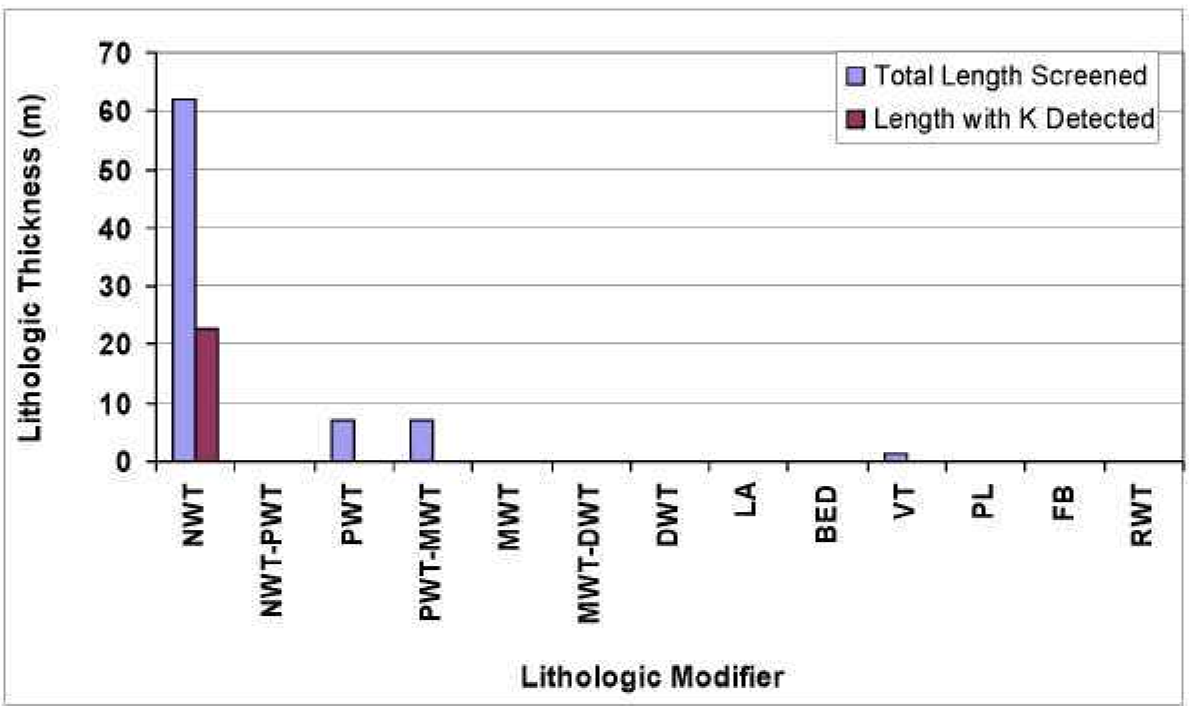


Figure 33. Lithologic modifiers adjacent to well screen and detectable hydraulic conductivity at well ER-EC-8.

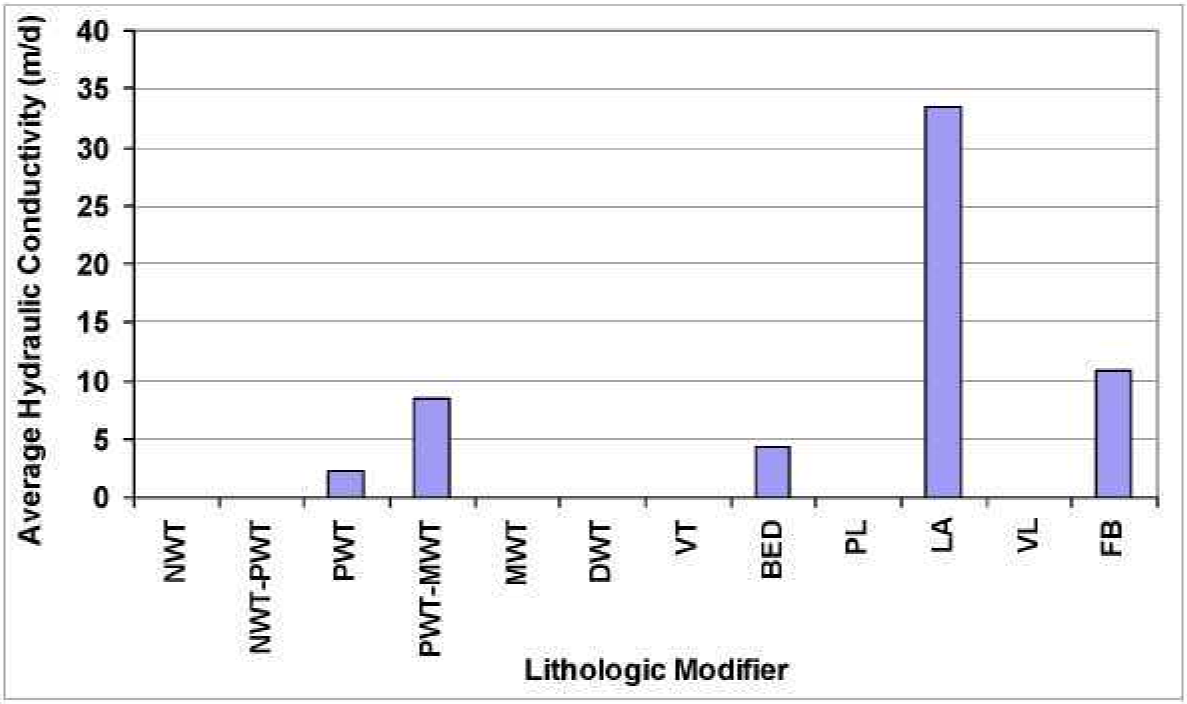


Figure 34. Average detected hydraulic conductivity for lithologic modifiers at well ER-EC-1.

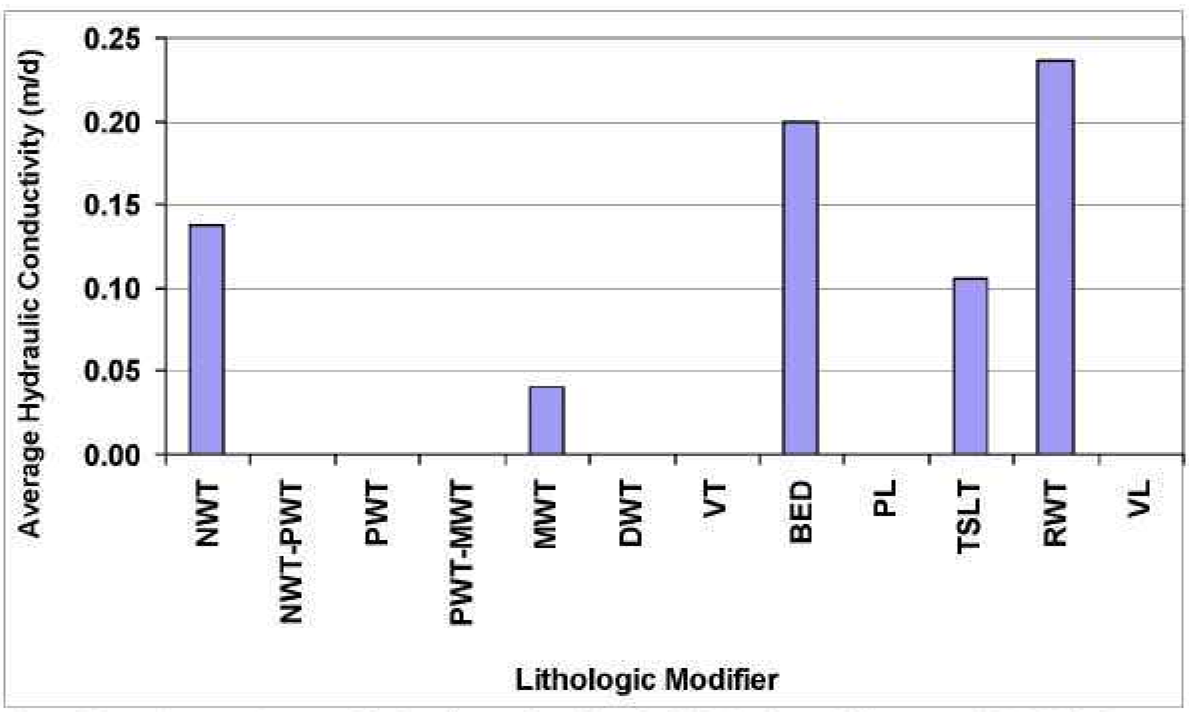


Figure 35. Average detected hydraulic conductivity for lithologic modifiers at well ER-EC-2a.

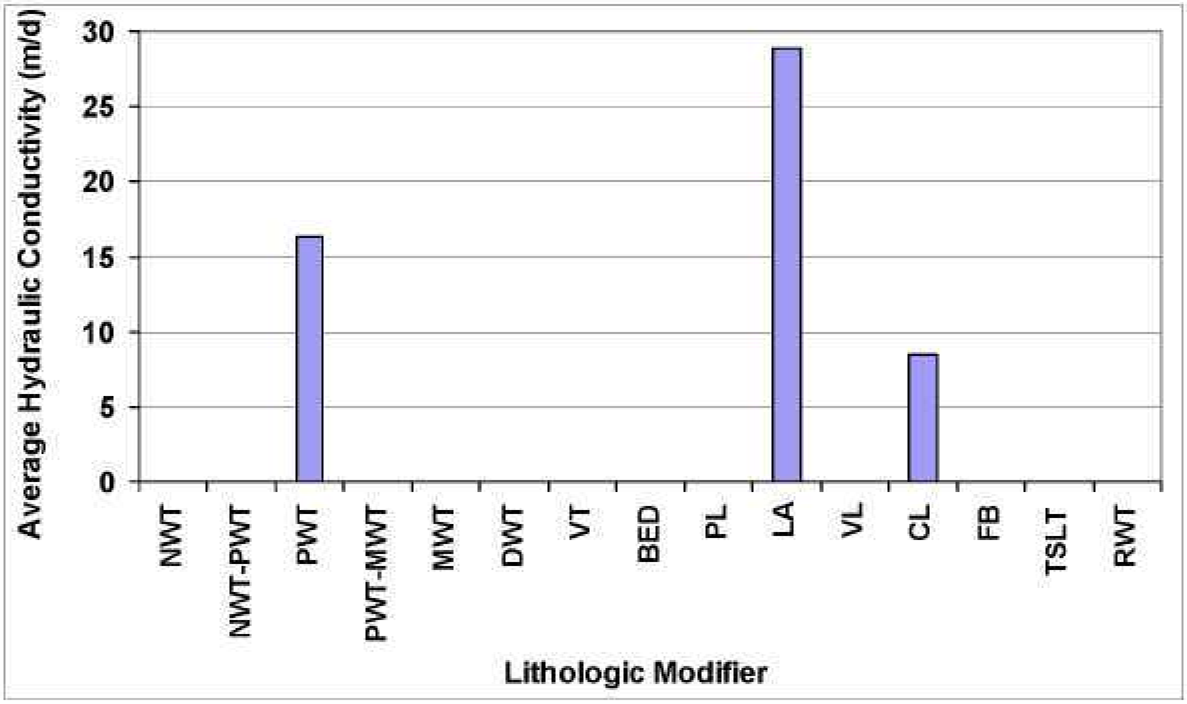


Figure 36. Average detected hydraulic conductivity for lithologic modifiers at well ER-EC-4.

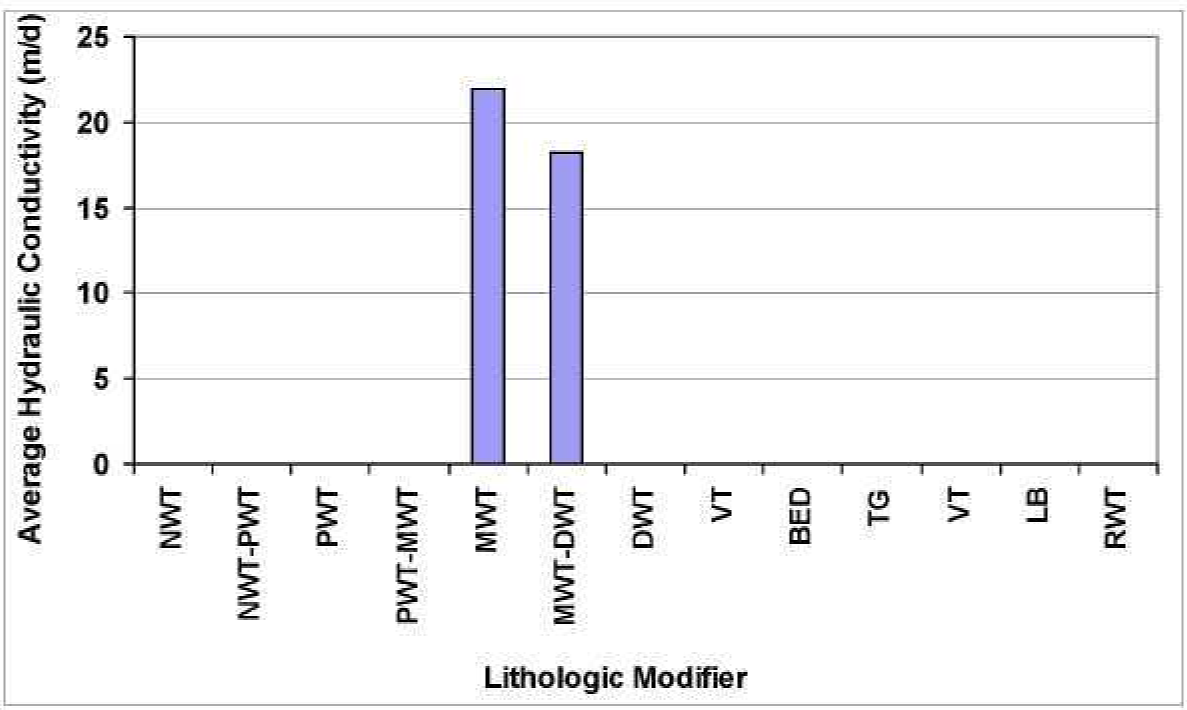


Figure 37. Average detected hydraulic conductivity for lithologic modifiers at well ER-EC-5.

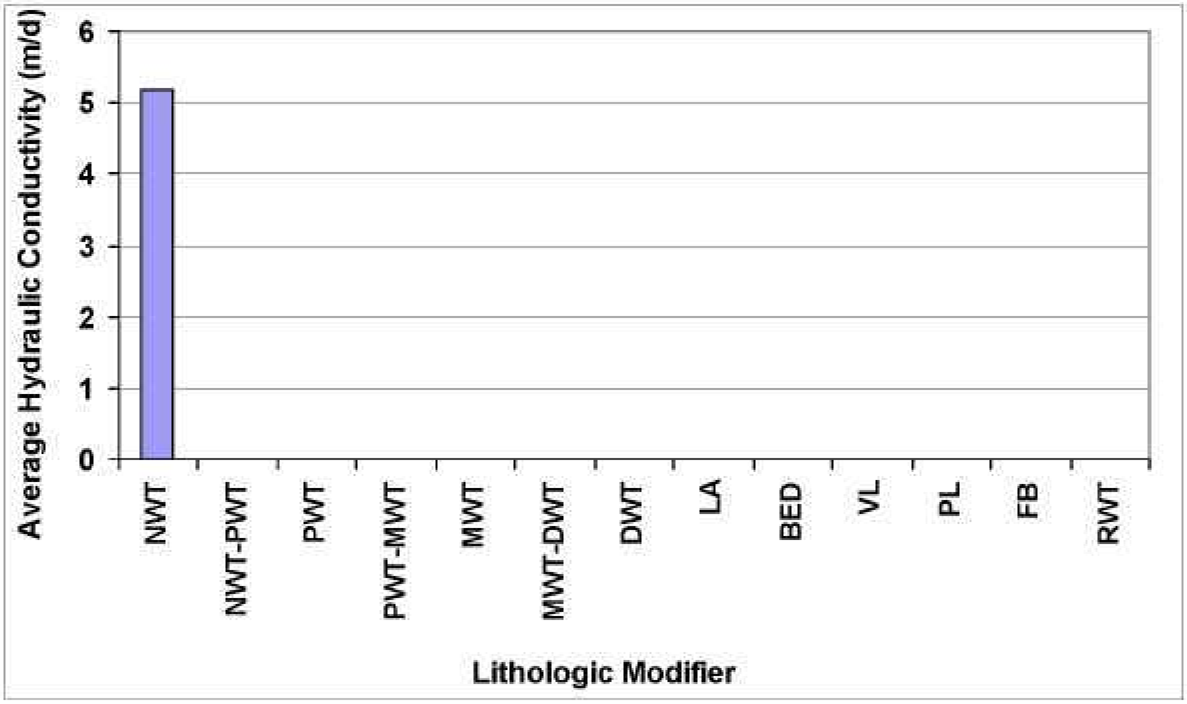


Figure 38. Average detected hydraulic conductivity for lithologic modifiers at well ER-5-4#2.

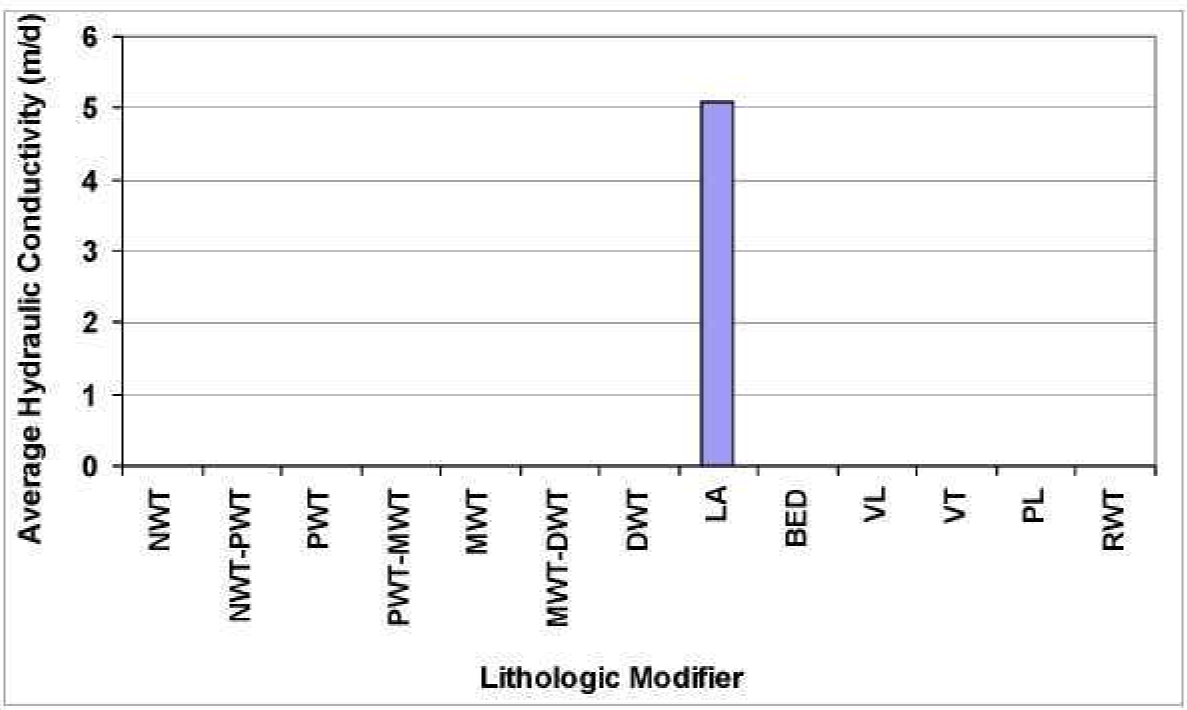


Figure 39. Average detected hydraulic conductivity for lithologic modifiers at well ER-EC-6.

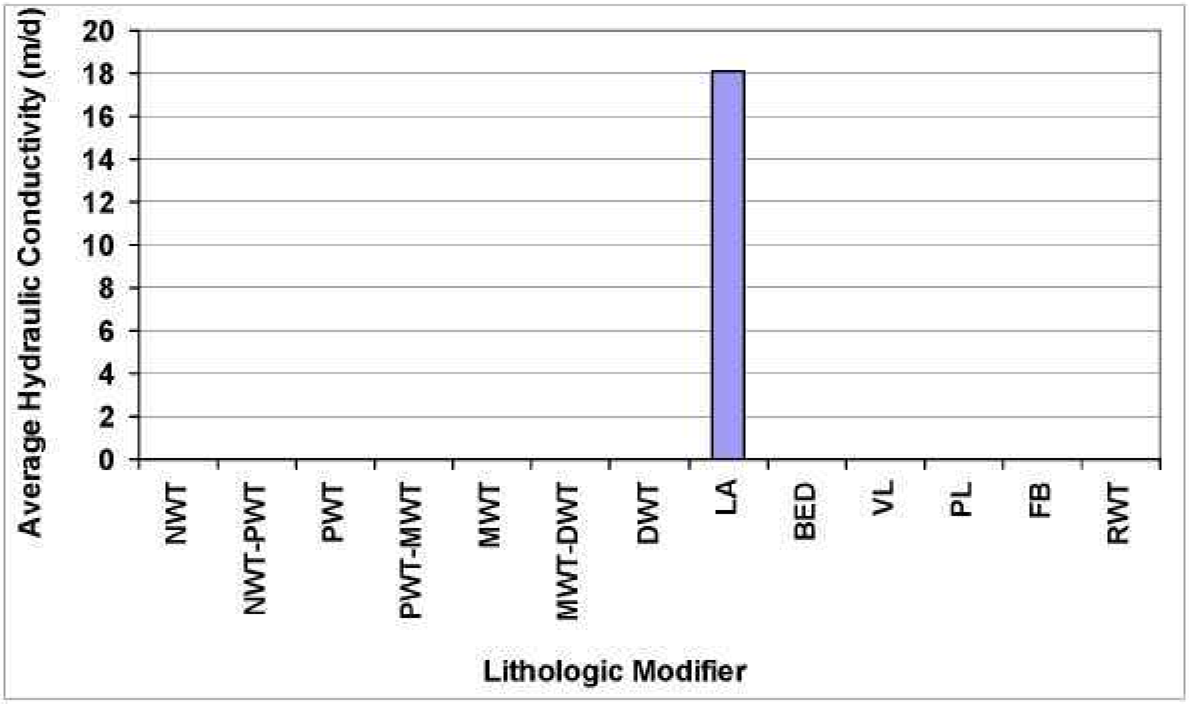


Figure 40. Average detected hydraulic conductivity for lithologic modifiers at well ER-EC-7.

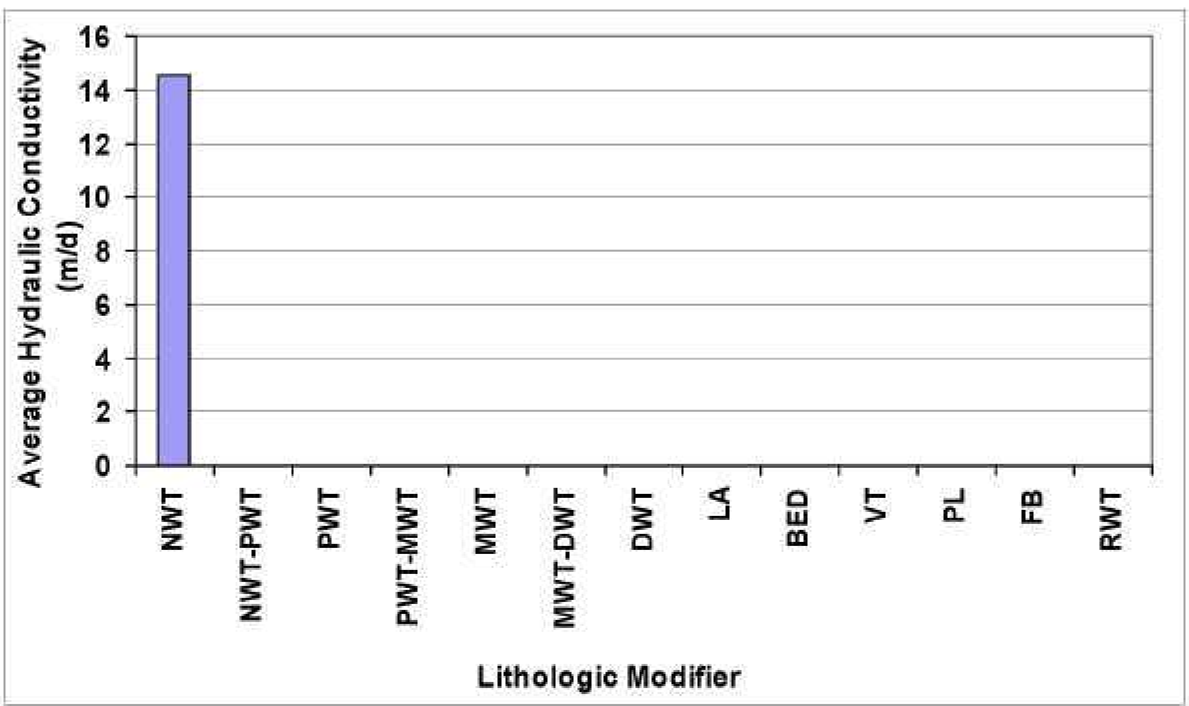


Figure 41. Average detected hydraulic conductivity for lithologic modifiers at well ER-EC-8.

Table 9. Alteration modifiers for wells in tuff.

Lithologic Alteration Abbreviation	Lithologic Unit Name
DV	Devitrified
GL	Glass Vitrophyre
VP	Vapor Phase Mineralization
ZE	Zeolitic
QZ	Quartz
QF	Quartz Feldspathoidic

Table 10. Alteration modifiers that are screened. Modifiers with detectable hydraulic conductivity are shaded gray.

Well	Alteration Modifier						
ER-EC-1	**DV**	GL		**ZE**	**QZ**	**QF**	
ER-EC-2a				**ZE**	QZ	**QF**	
ER-EC-4	**DV**	GL		ZE		**QF**	
ER-EC-5						**QF**	
ER-5-4#2				**ZE**			
ER-EC-6	**DV**	**GL**				QF	
ER-EC-7	DV	GL				**QF**	**VAR**
ER-EC-8	DV		VP		**QZ**	**QF**	

The vertical length of well screen placed adjacent to each alteration modifier and the length over which hydraulic conductivity was detected are presented for each well in Figures 42 through 49. The figures include only the alteration modifiers that were screened. Units described as devitrified and quartzo-feldspathoidic modifiers most often had detectable hydraulic conductivity.

The average detected hydraulic conductivity for the alteration modifiers is presented in Figures 50 through 57. Trends in the average hydraulic conductivity are difficult to ascertain from the data plots.

Hydraulic Conductivity and Hydrogeologic Unit

Well construction in tuff placed well screen adjacent to four different hydrogeologic units. The hydrogeologic units that were screened are presented in the tables and figures to aid the reader in understanding the context of well screening and the detection of hydraulic conductivity. Table 11 presents abbreviations for the hydrogeologic units adjacent to well screen. Table 12 presents a summary of the hydrogeologic units associated with well screen and the detection of hydraulic conductivity. Well screen was placed adjacent to four unique hydrogeologic units in tuff. All four of these hydrogeologic units are associated with detectable hydraulic conductivity.

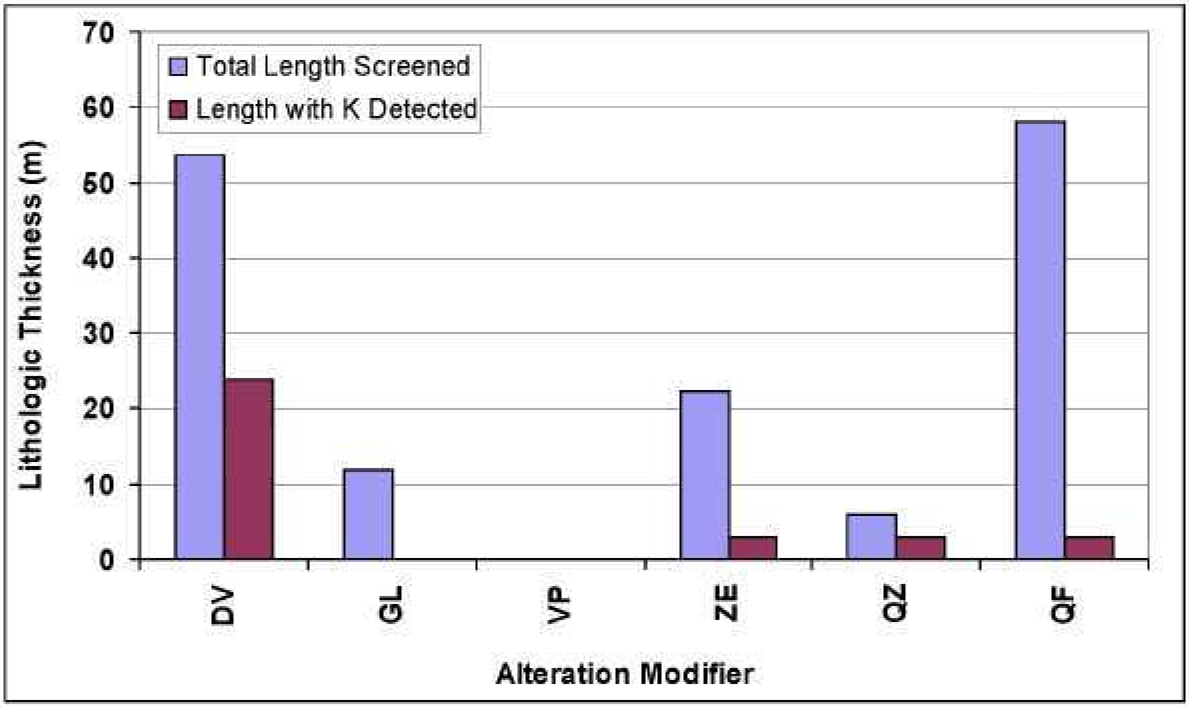


Figure 42. Alteration modifiers adjacent to well screen and detectable hydraulic conductivity at well ER-EC-1.

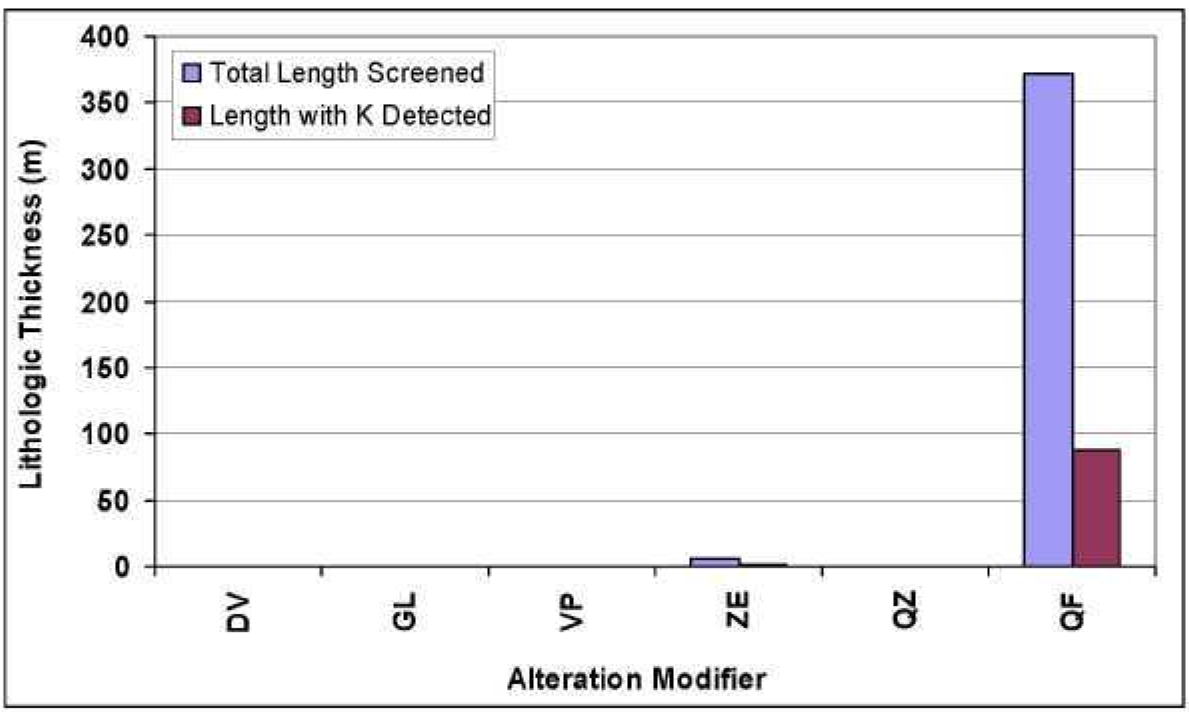


Figure 43. Alteration modifiers adjacent to well screen and detectable hydraulic conductivity at well ER-EC-2a.

Figure 44. Alteration modifiers adjacent to well screen and detectable hydraulic conductivity at well ER-EC-4.

Figure 45. Alteration modifiers adjacent to well screen and detectable hydraulic conductivity at well ER-EC-5.

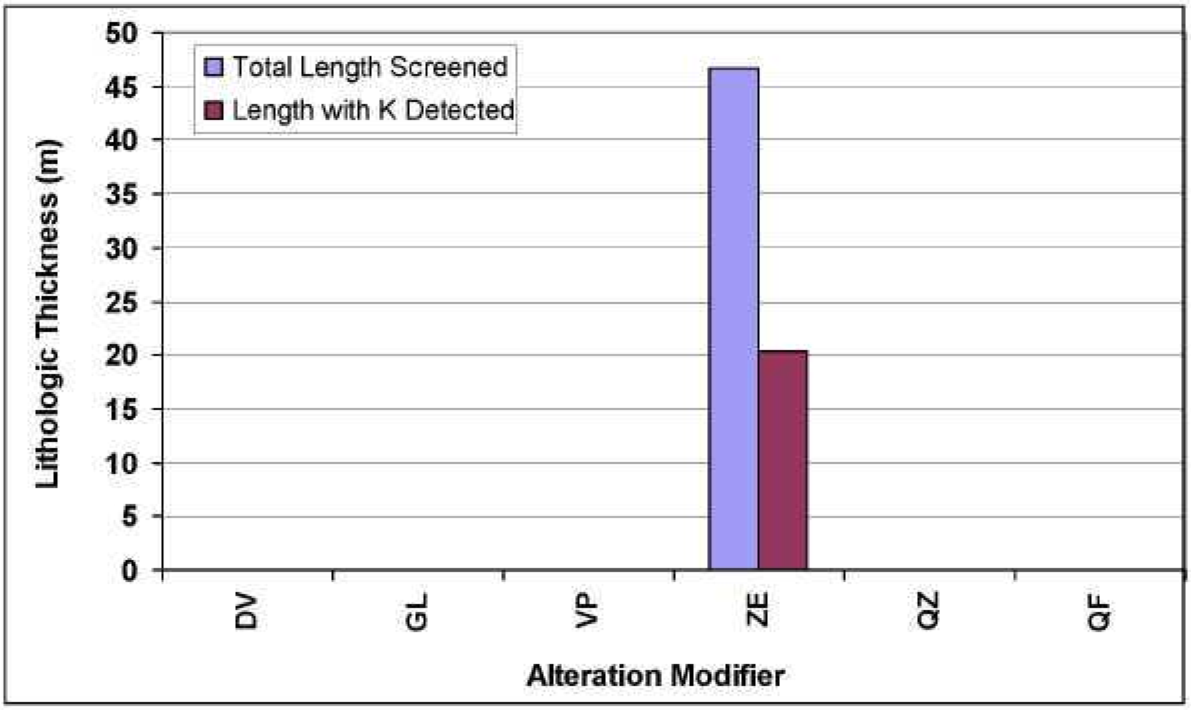


Figure 46. Alteration modifiers adjacent to well screen and detectable hydraulic conductivity at well ER-5-4#2.

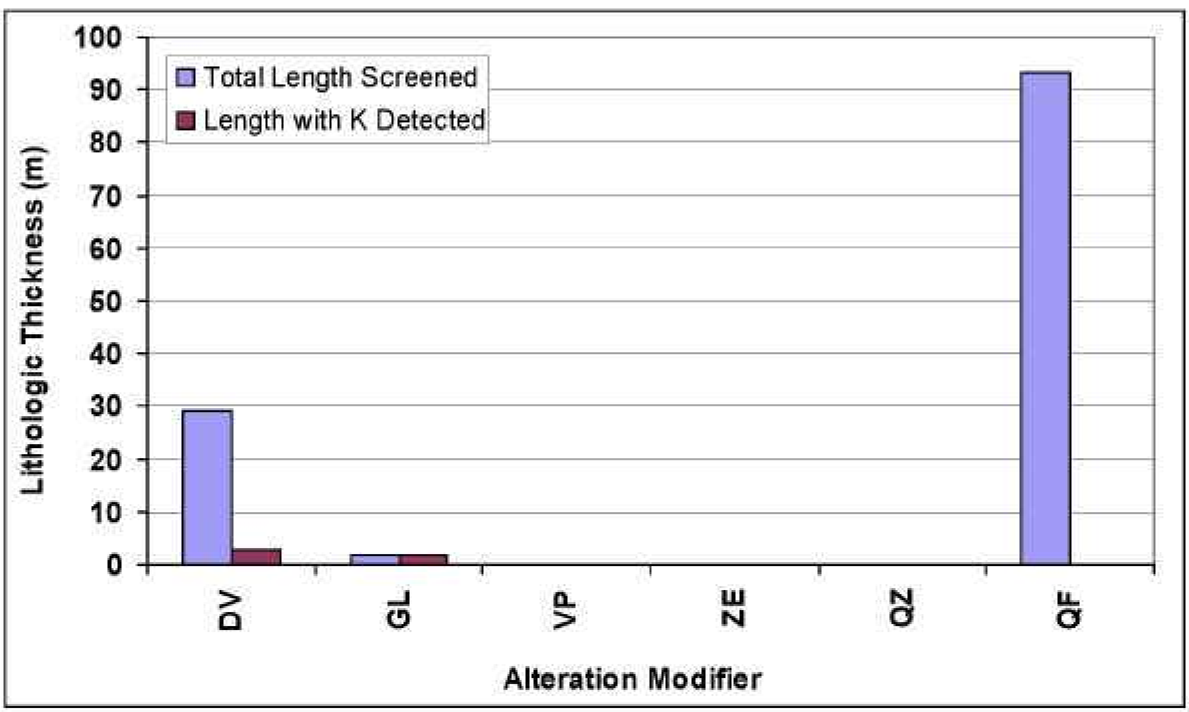


Figure 47. Alteration modifiers adjacent to well screen and detectable hydraulic conductivity at well ER-EC-6.

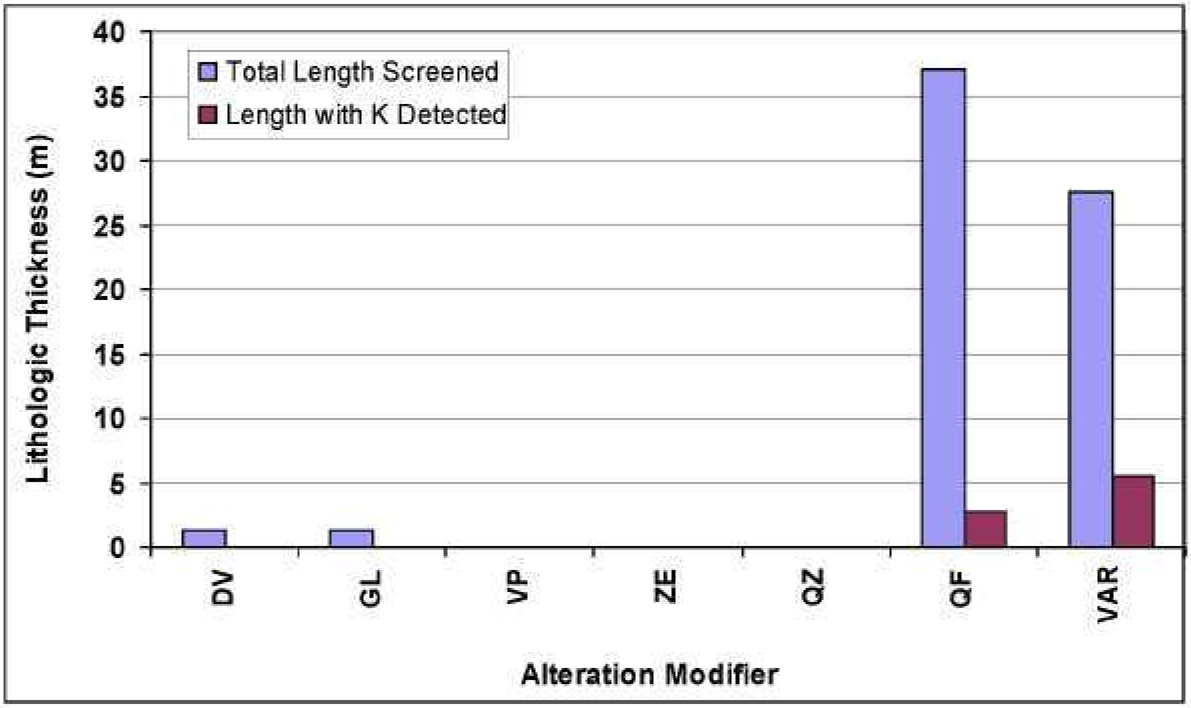


Figure 48. Alteration modifiers adjacent to well screen and detectable hydraulic conductivity at well ER-EC-7.

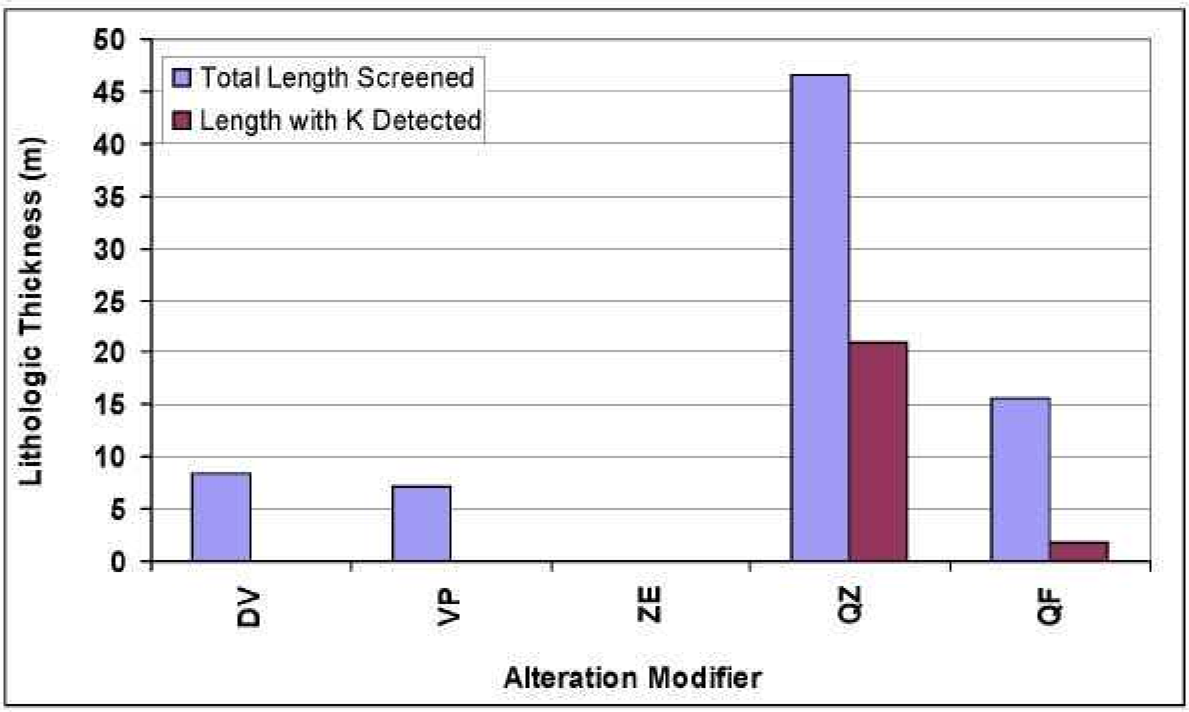


Figure 49. Alteration modifiers adjacent to well screen and detectable hydraulic conductivity at well ER-EC-8.

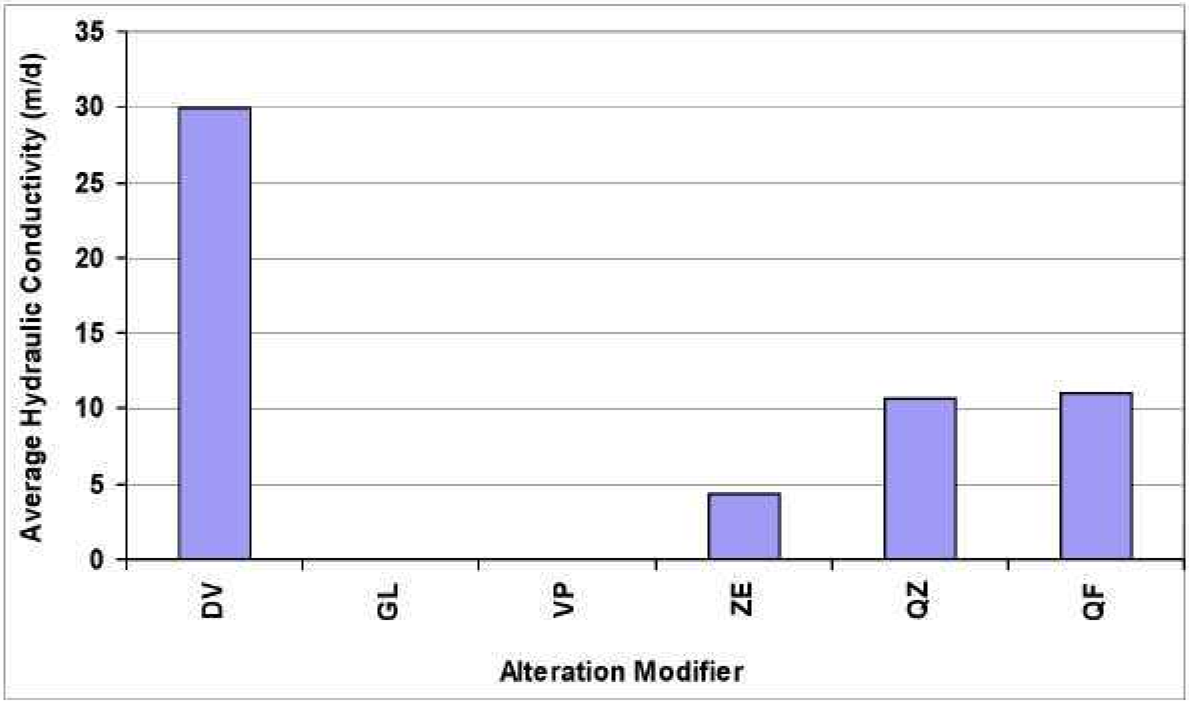


Figure 50. Average detected hydraulic conductivity for alteration modifiers at well ER-EC-1.

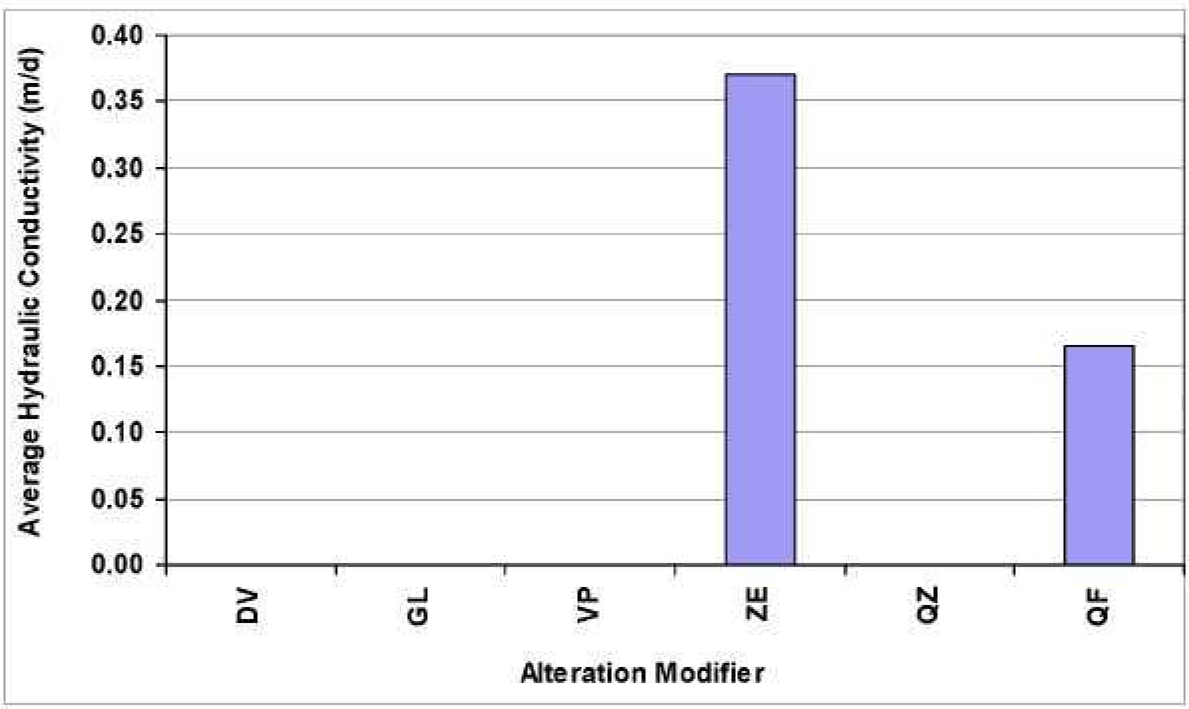


Figure 51. Average detected hydraulic conductivity for alteration modifiers at well ER-EC-2a.

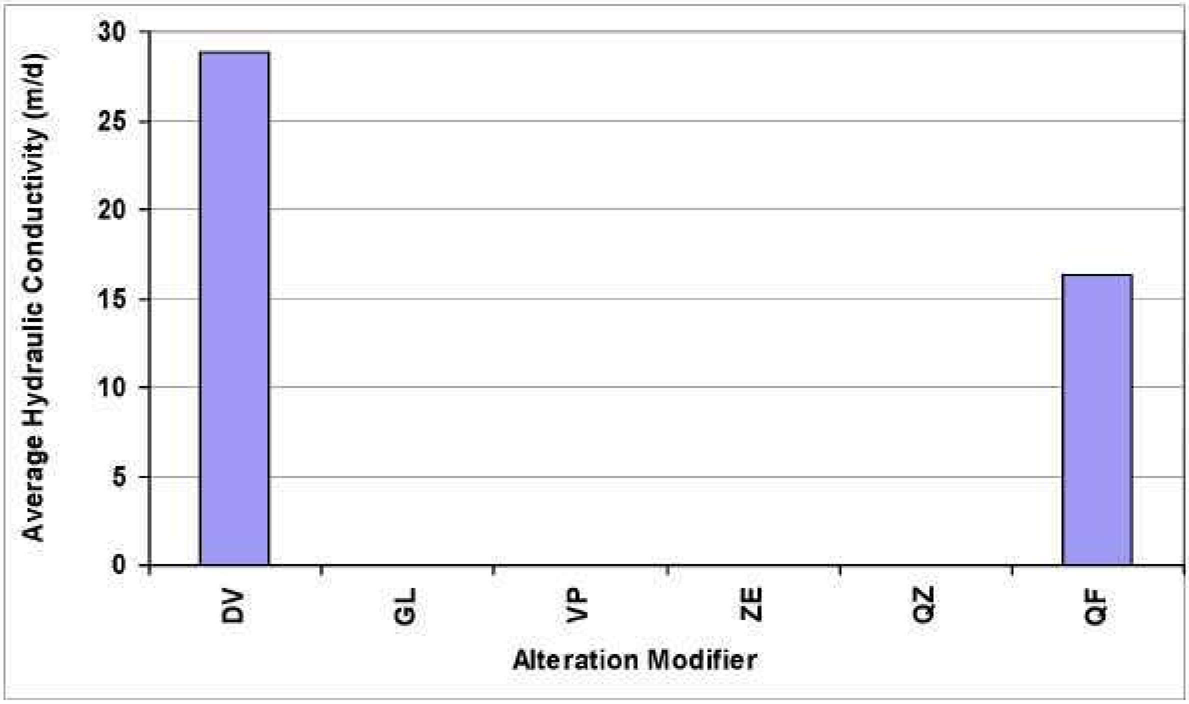


Figure 52. Average detected hydraulic conductivity for alteration modifiers at well ER-EC-4.

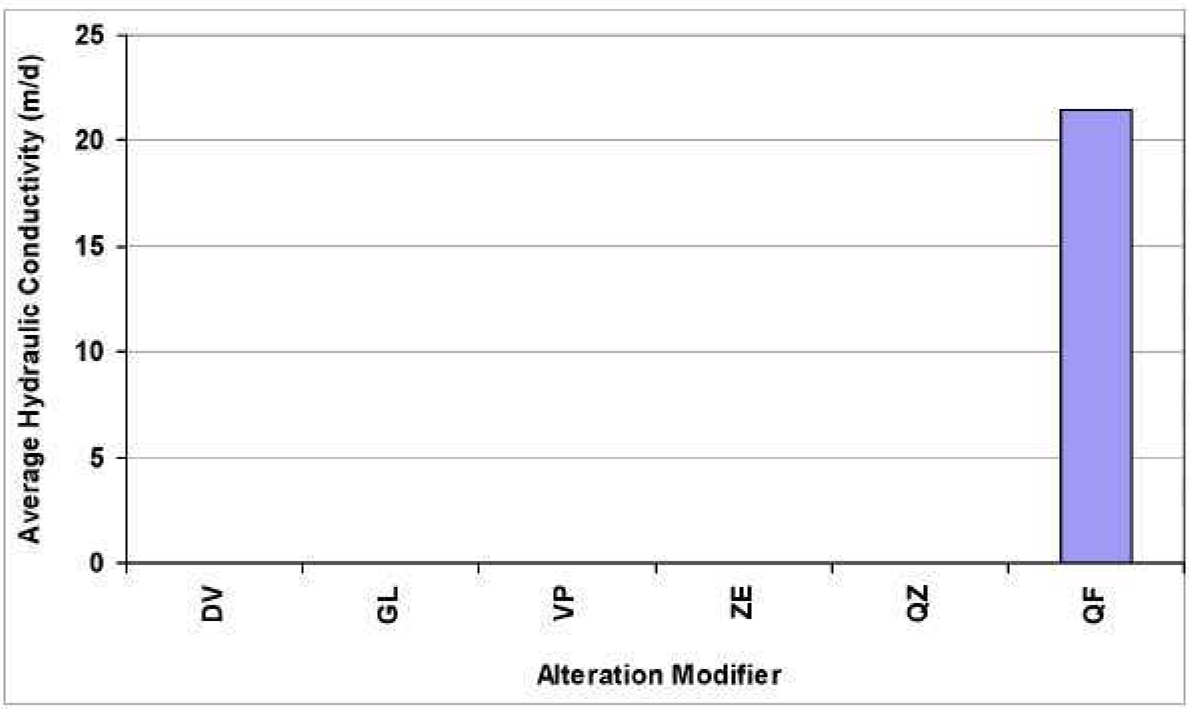


Figure 53. Average detected hydraulic conductivity for alteration modifiers at well ER-EC-5.

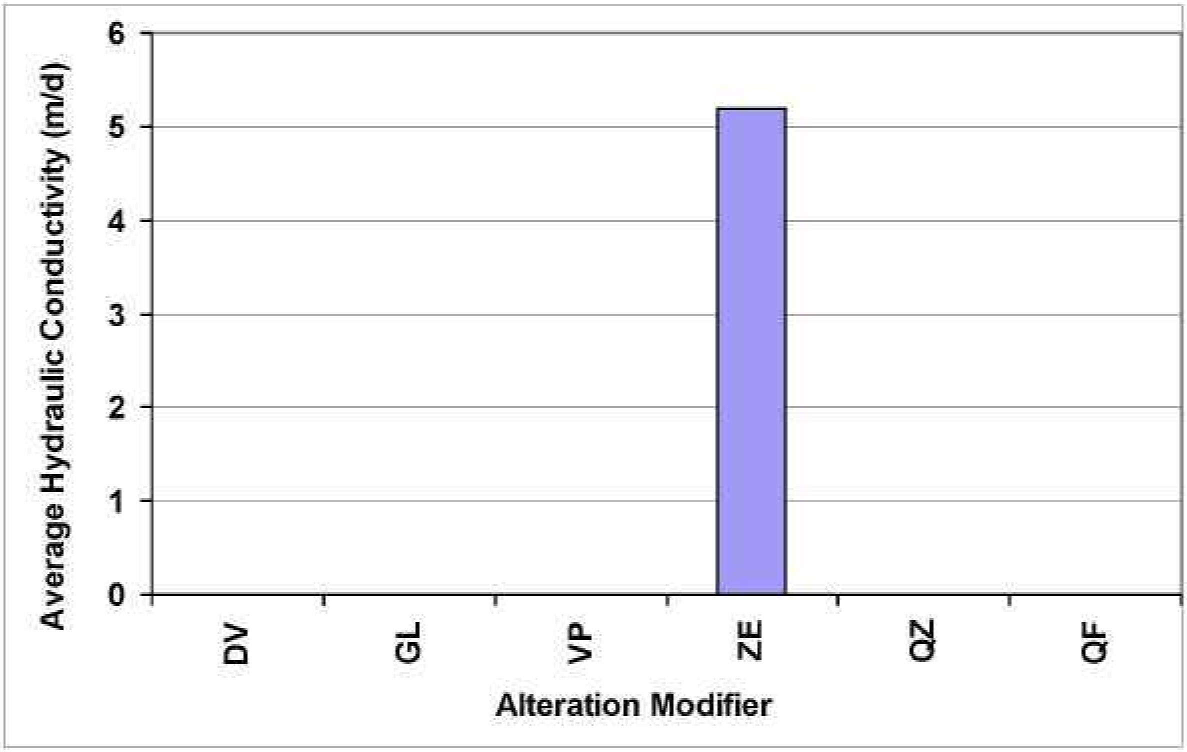


Figure 54. Average detected hydraulic conductivity for alteration modifiers at well ER-5-4#2.

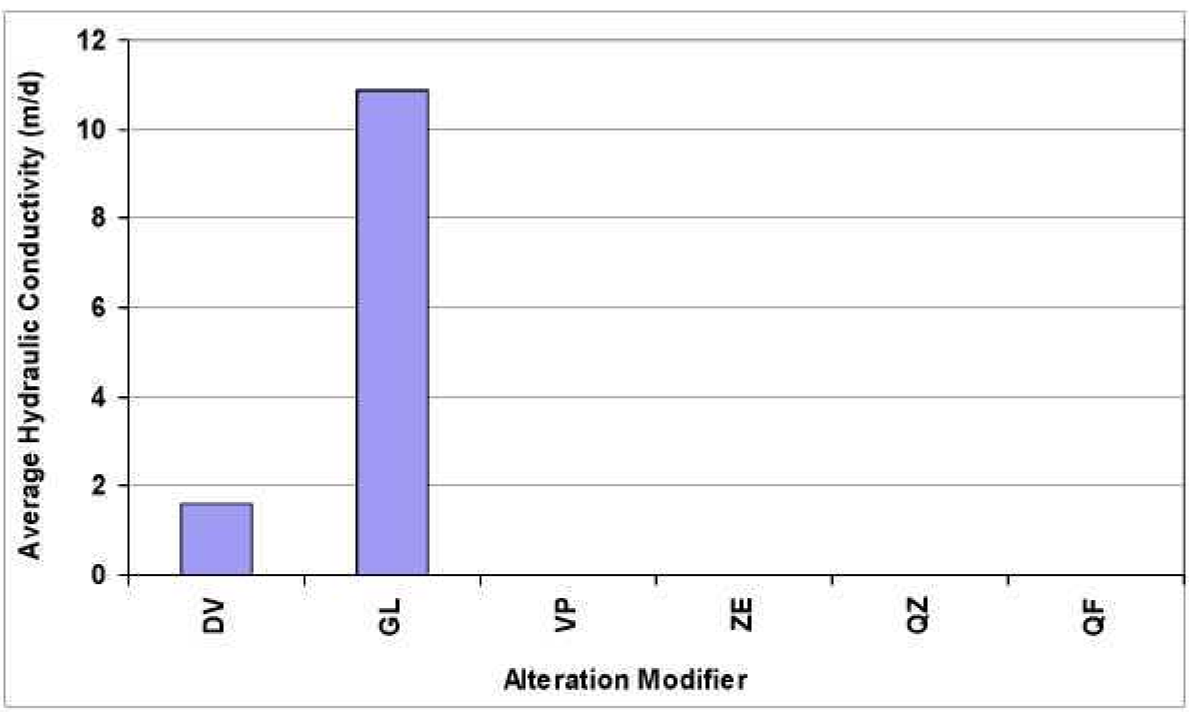


Figure 55. Average detected hydraulic conductivity for alteration modifiers at well ER-EC-6.

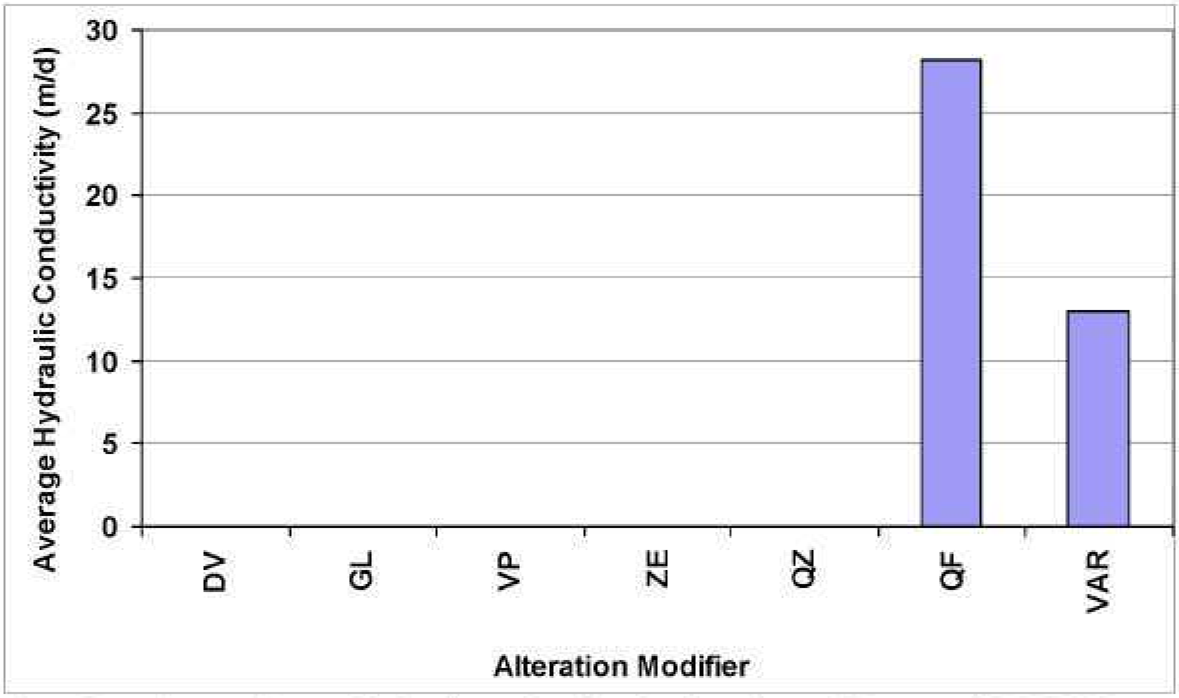


Figure 56. Average detected hydraulic conductivity for alteration modifiers at well ER-EC-7.

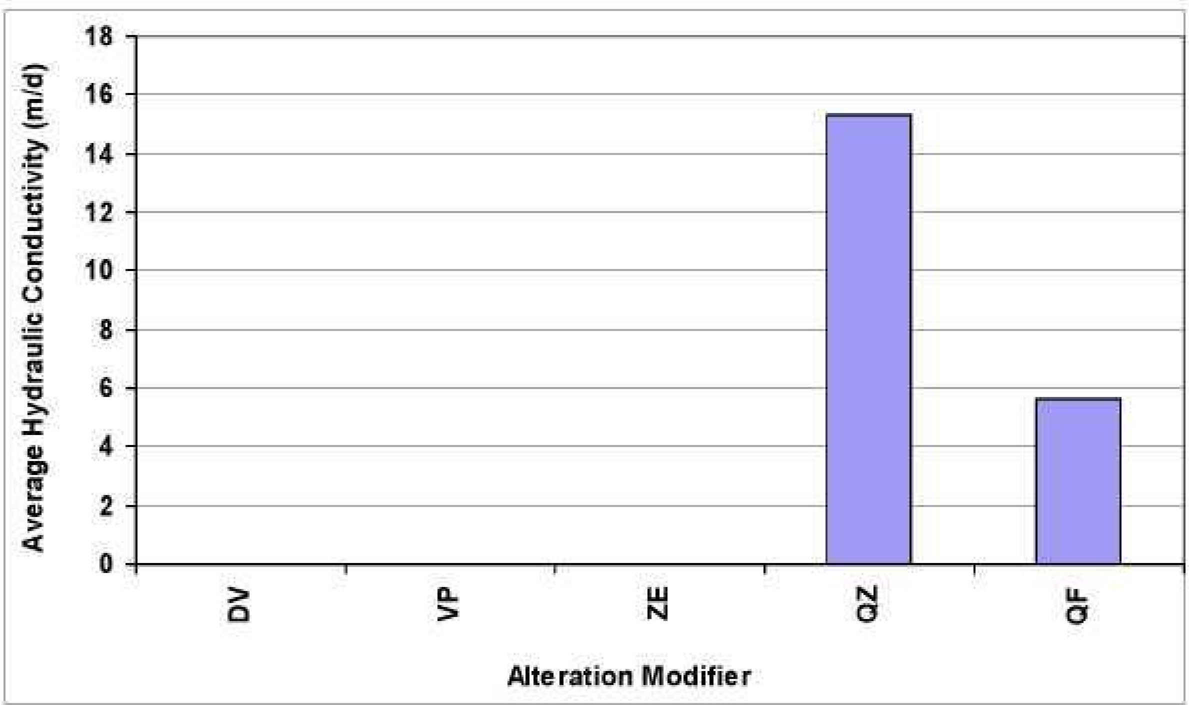


Figure 57. Average detected hydraulic conductivity for alteration modifiers at well ER-EC-8.

Table 11. Hydrogeologic units for wells in tuff.

Hydrogeologic Unit Abbreviation	Hydrogeologic Unit Name
AA	Alluvial Aquifer
WTA	Welded Tuff Aquifer
TCU	Tuff Confining Unit
LFA	Lava Flow Aquifer

Table 12. Hydrogeologic units that are screened. Units with detectable hydraulic conductivity are shaded gray.

Well	Hydrogeologic Unit			
ER-EC-1	**WTA**	**TCU**	**LFA**	
ER-EC-2a	**WTA**	**TCU**		**AA**
ER-EC-4	**WTA**	TCU	**LFA**	**AA**
ER-EC-5	**WTA**			
ER-5-4#2		**TCU**		
ER-EC-6	WTA	TCU	**LFA**	
ER-EC-7		TCU	**LFA**	
ER-EC-8	WTA	**TCU**		

The vertical length of well screen placed adjacent to each hydrogeologic unit and the length over which hydraulic conductivity was detected are presented for each well in Figures 58 through 65. The figures include only the hydrogeologic units that were screened. The figures indicate that slightly less vertical thickness described as welded tuff aquifer were screened compared to intervals described as tuff confining units. The probability of detecting hydraulic conductivity is nearly equal in welded tuff aquifers and tuff confining units.

The average detected hydraulic conductivity for the hydrogeologic units is presented in Figures 66 through 73. Average hydraulic conductivities are similar for all hydrogeologic units within a particular well with the range of values among units within an order of magnitude.

Hydraulic Conductivity and Hydrostratigraphic Unit

Well construction in tuff encountered 23 hydrostratigraphic units. Well screen was placed adjacent to 12 different hydrostratigraphic units and hydraulic conductivity was detected in eight units. Each of the hydrostratigraphic units that were encountered is presented in the tables and figures to aid the reader in understanding the context of well screening and the detection of hydraulic conductivity. Table 13 presents abbreviations for the hydrostratigraphic units encountered. Table 14 presents a summary of the hydrostratigraphic units and the detection of hydraulic conductivity.

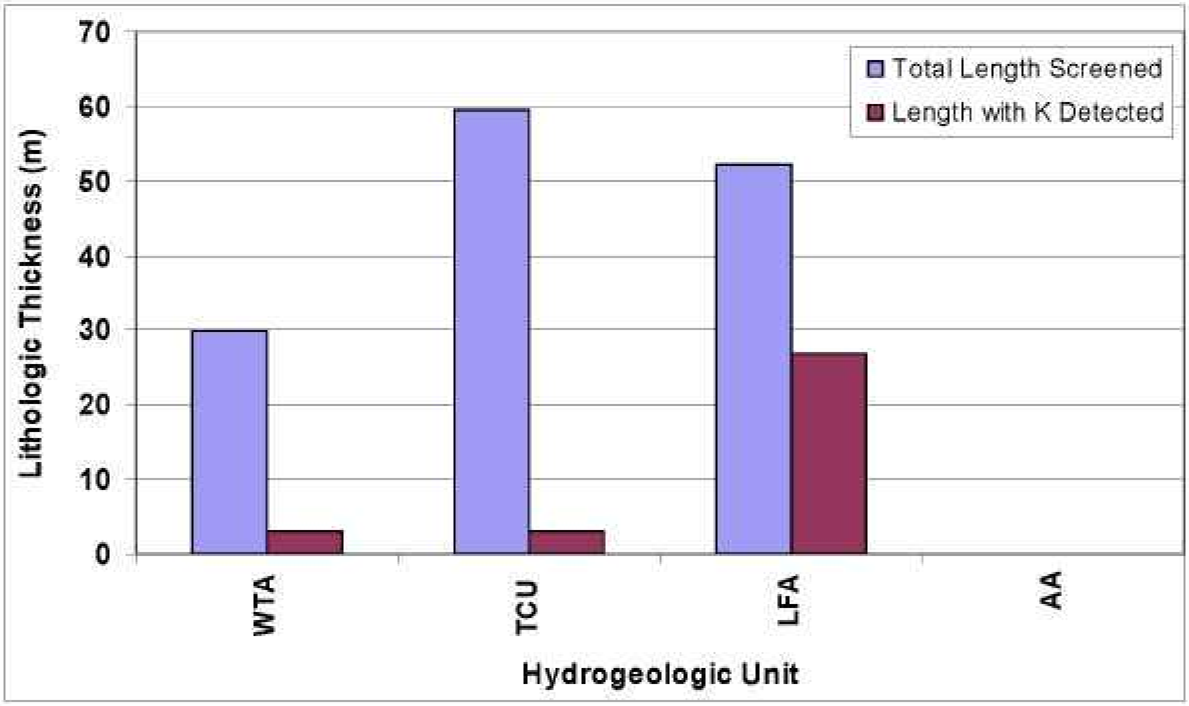


Figure 58. Hydrogeologic units adjacent to well screen and detectable hydraulic conductivity at well ER-EC-1.

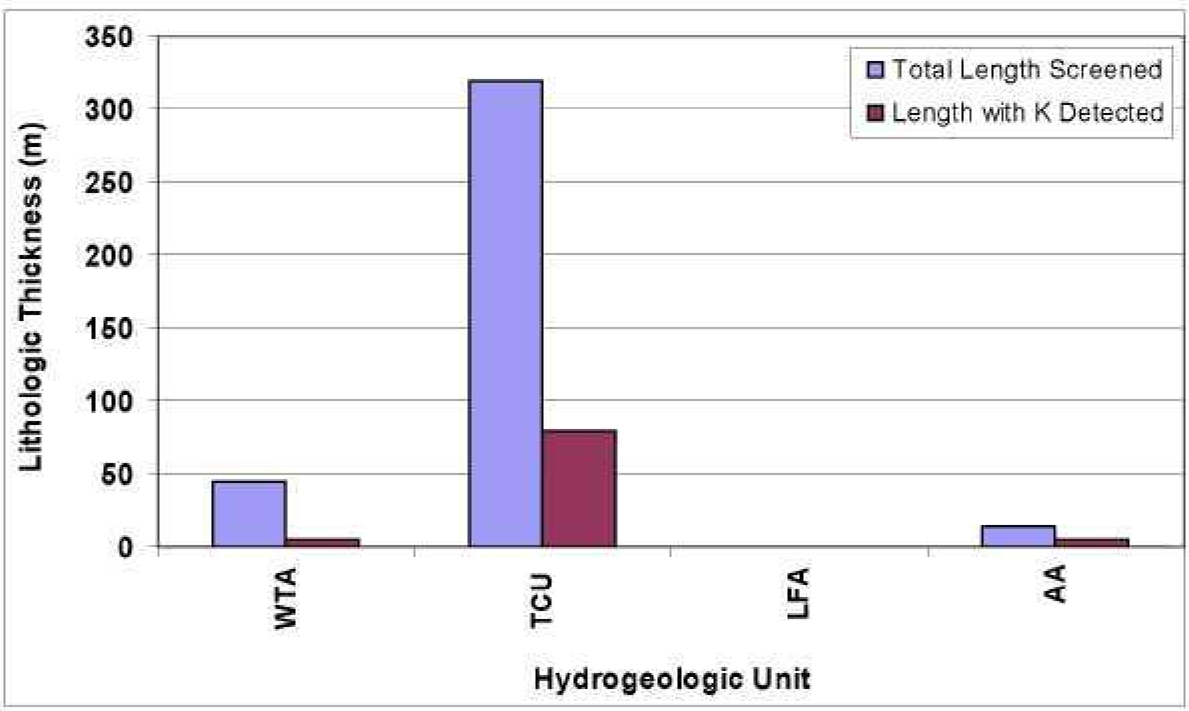


Figure 59. Hydrogeologic units adjacent to well screen and detectable hydraulic conductivity at well ER-EC-2a.

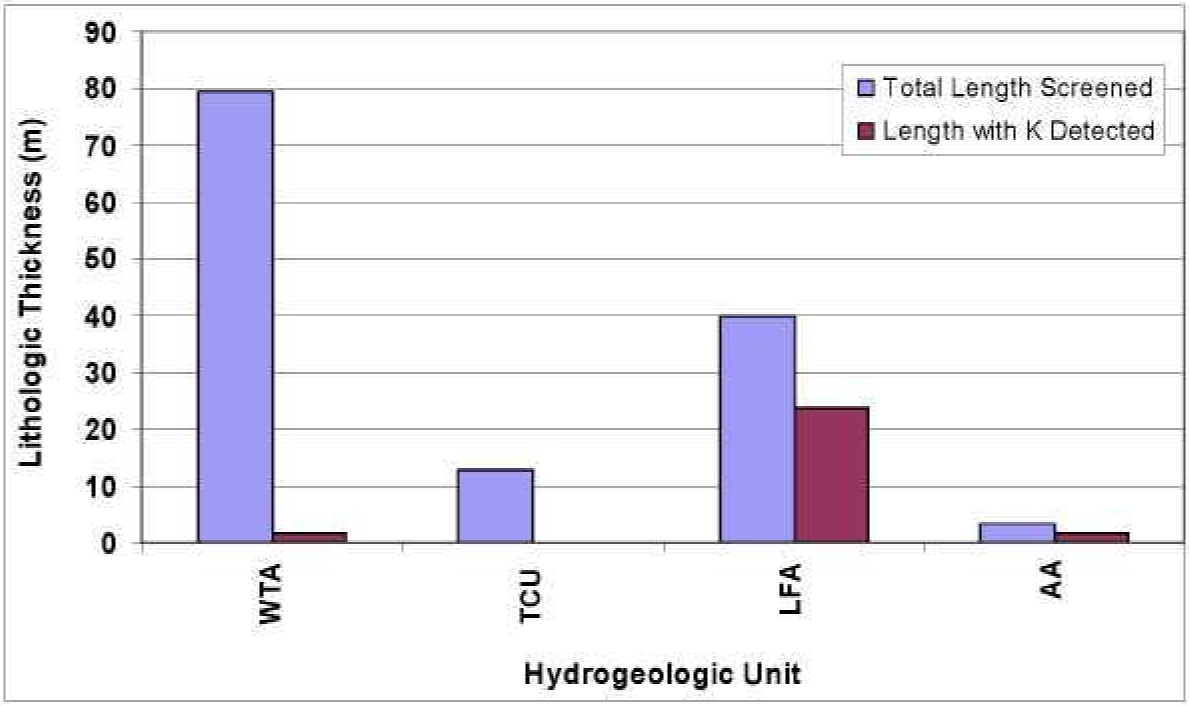


Figure 60. Hydrogeologic units adjacent to well screen and detectable hydraulic conductivity at well ER-EC-4.

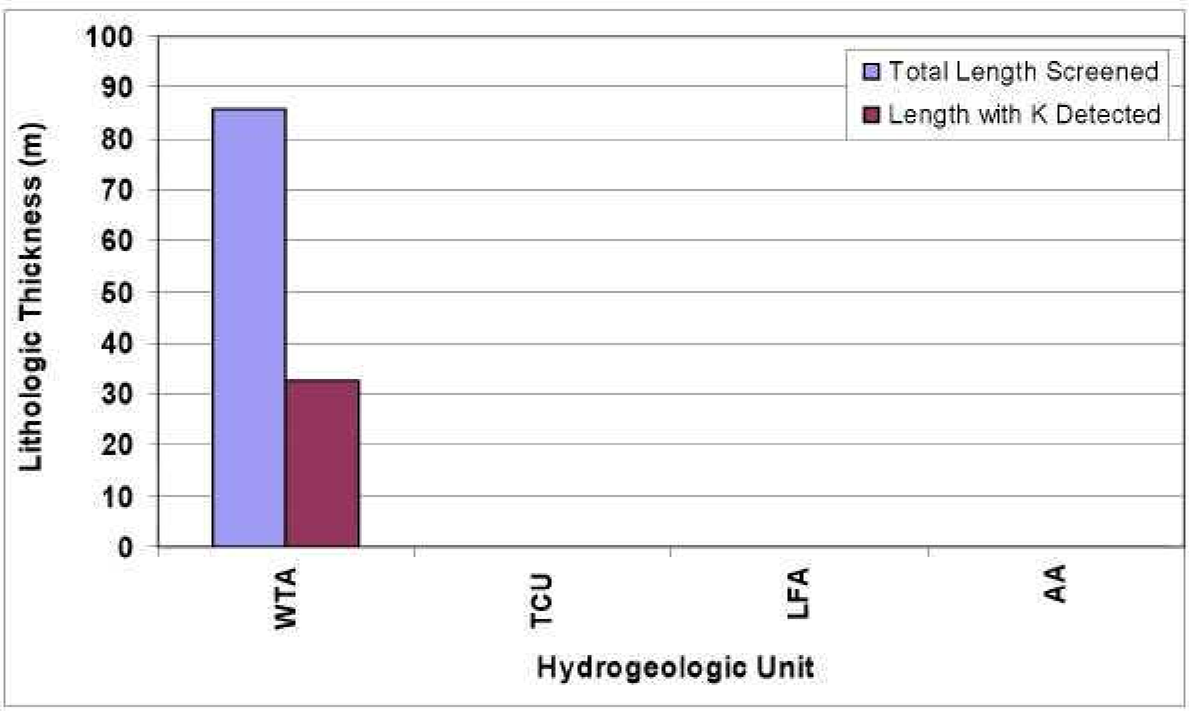


Figure 61. Hydrogeologic units adjacent to well screen and detectable hydraulic conductivity at well ER-EC-5.

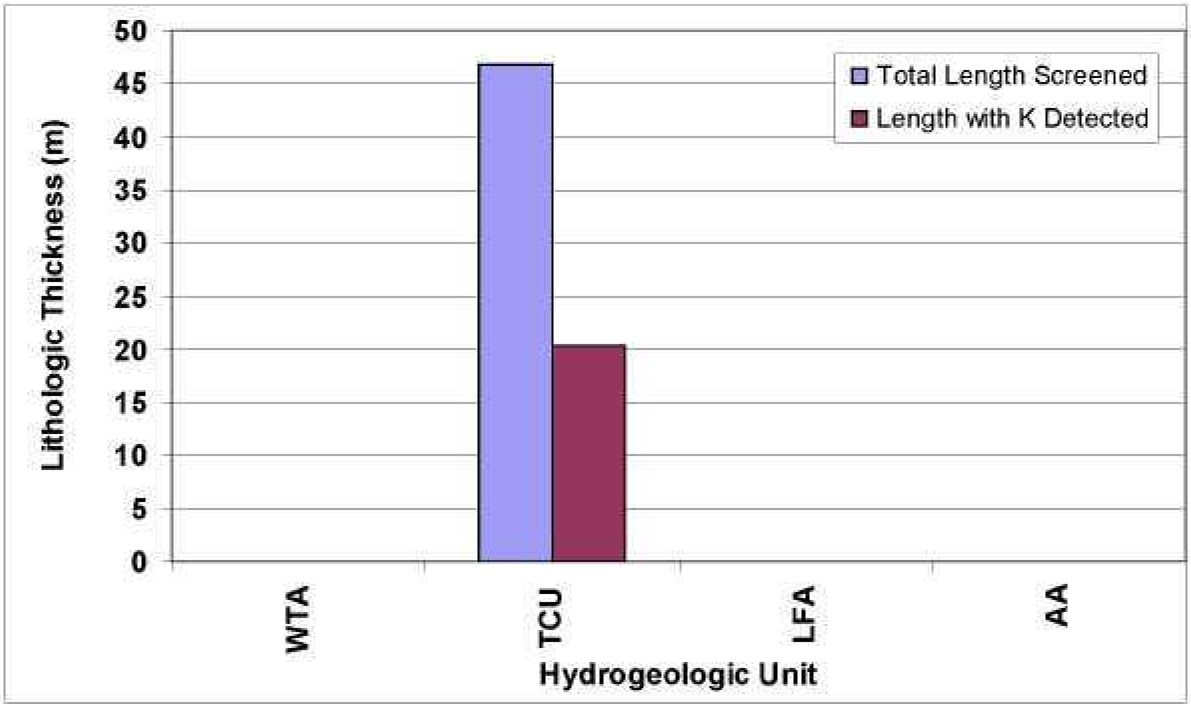


Figure 62. Hydrogeologic units adjacent to well screen and detectable hydraulic conductivity at well ER-5-4#2.

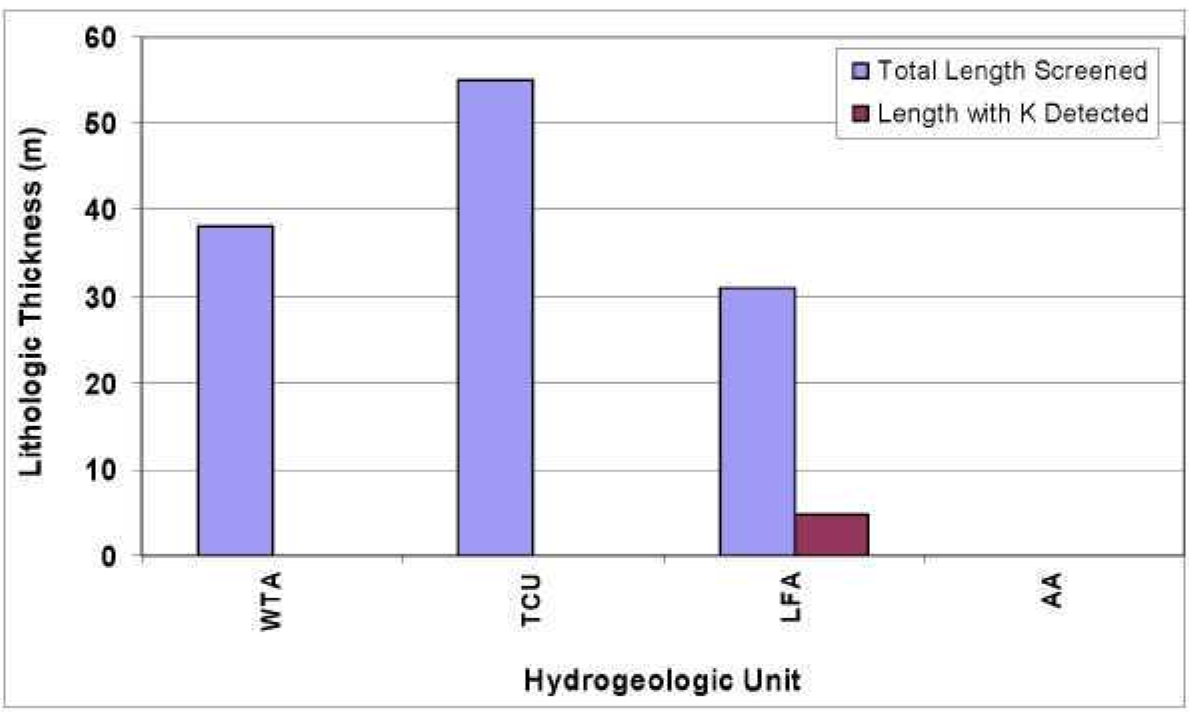


Figure 63. Hydrogeologic units adjacent to well screen and detectable hydraulic conductivity at well ER-EC-6.

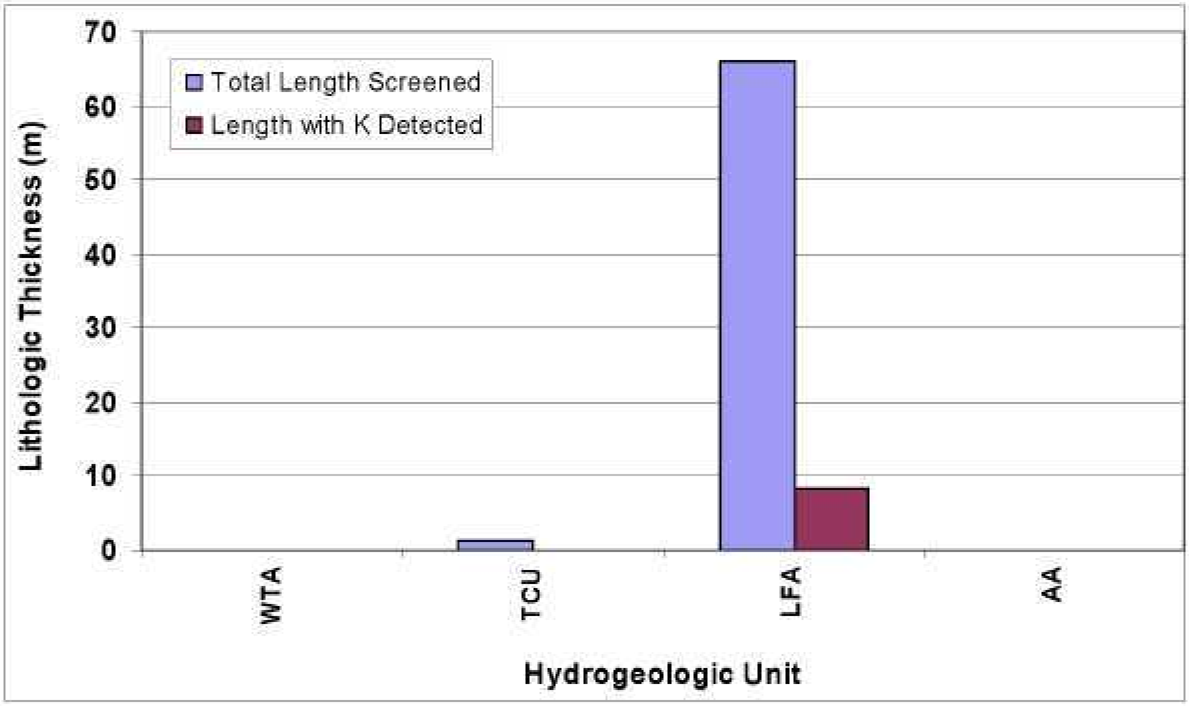


Figure 64. Hydrogeologic units adjacent to well screen and detectable hydraulic conductivity at well ER-EC-7.

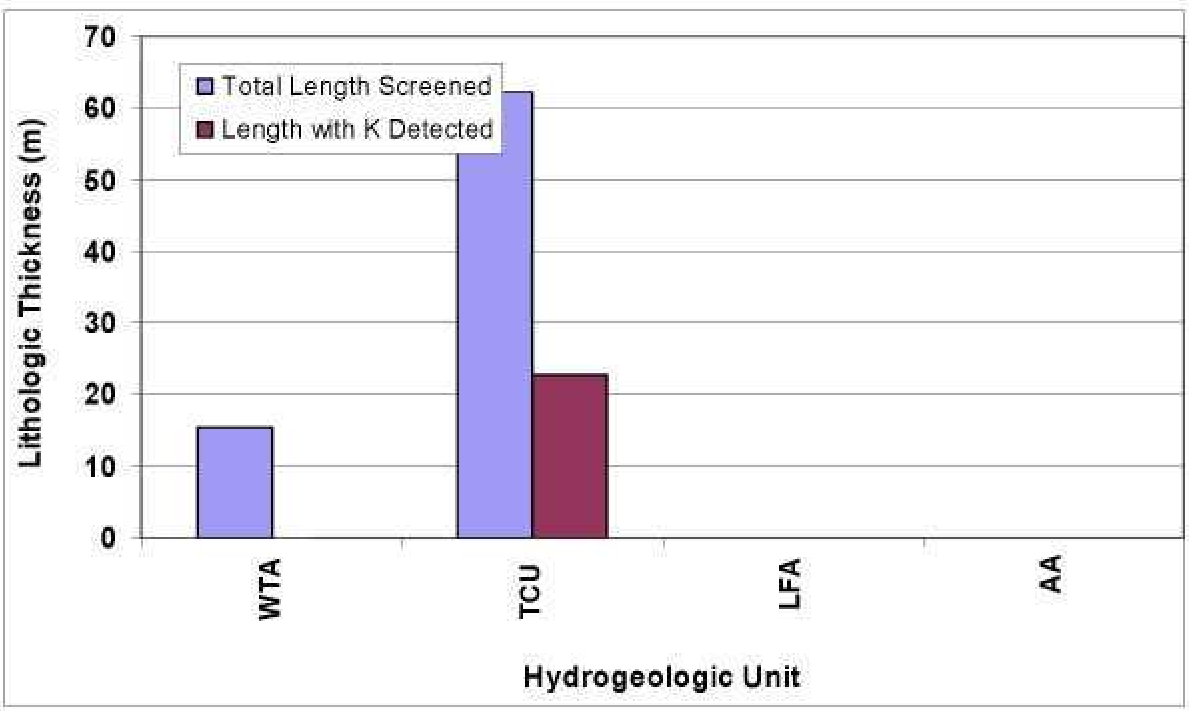


Figure 65. Hydrogeologic units adjacent to well screen and detectable hydraulic conductivity at well ER-EC-8.

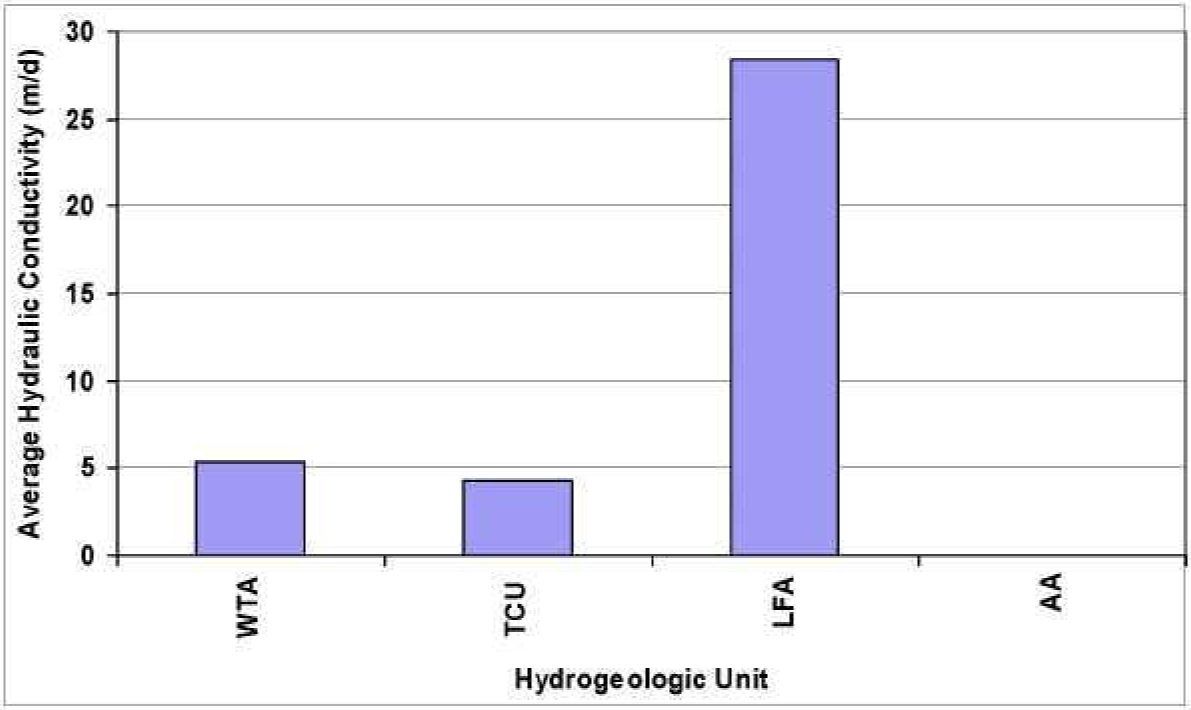


Figure 66. Average detected hydraulic conductivity for hydrogeologic units at well ER-EC-1.

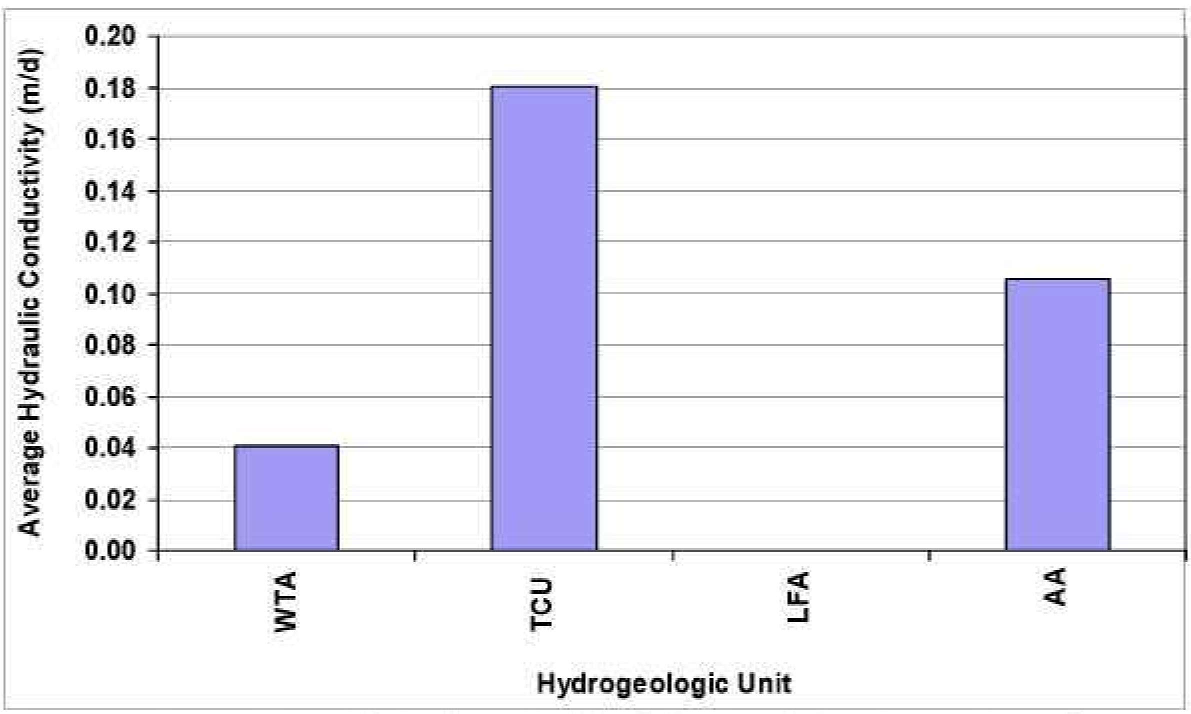


Figure 67. Average detected hydraulic conductivity for hydrogeologic units at well ER-EC-2a.

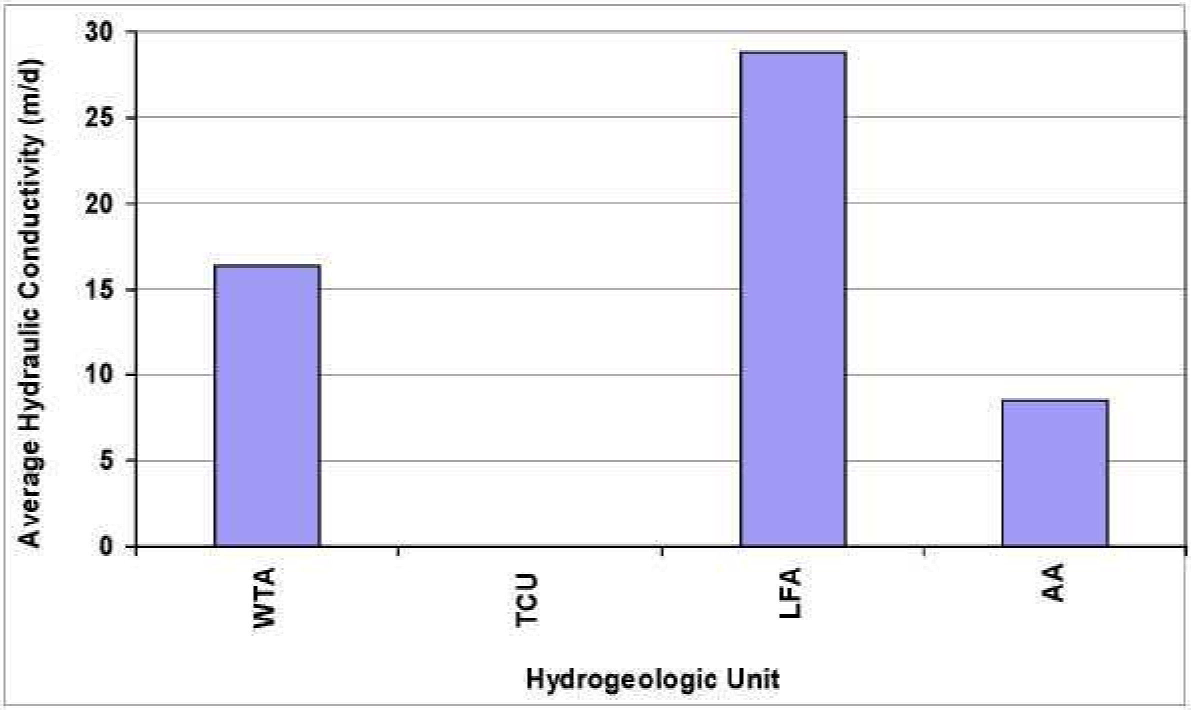


Figure 68. Average detected hydraulic conductivity for hydrogeologic units at well ER-EC-4.

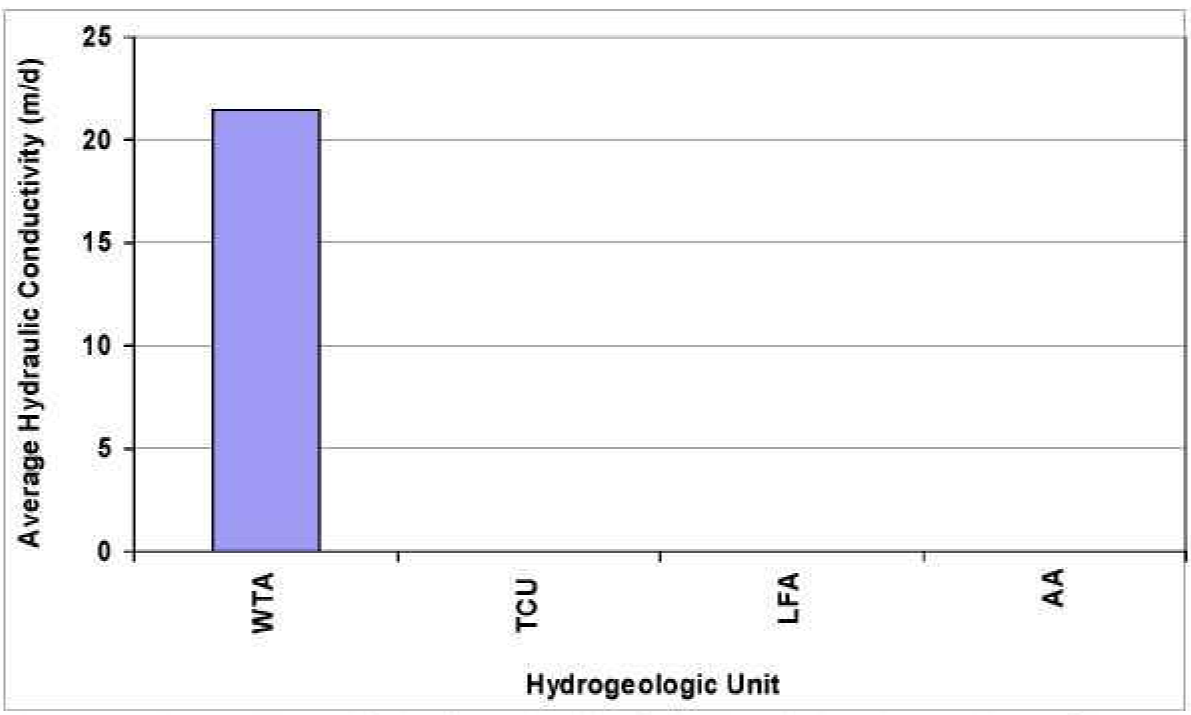


Figure 69. Average detected hydraulic conductivity for hydrogeologic units at well ER-EC-5.

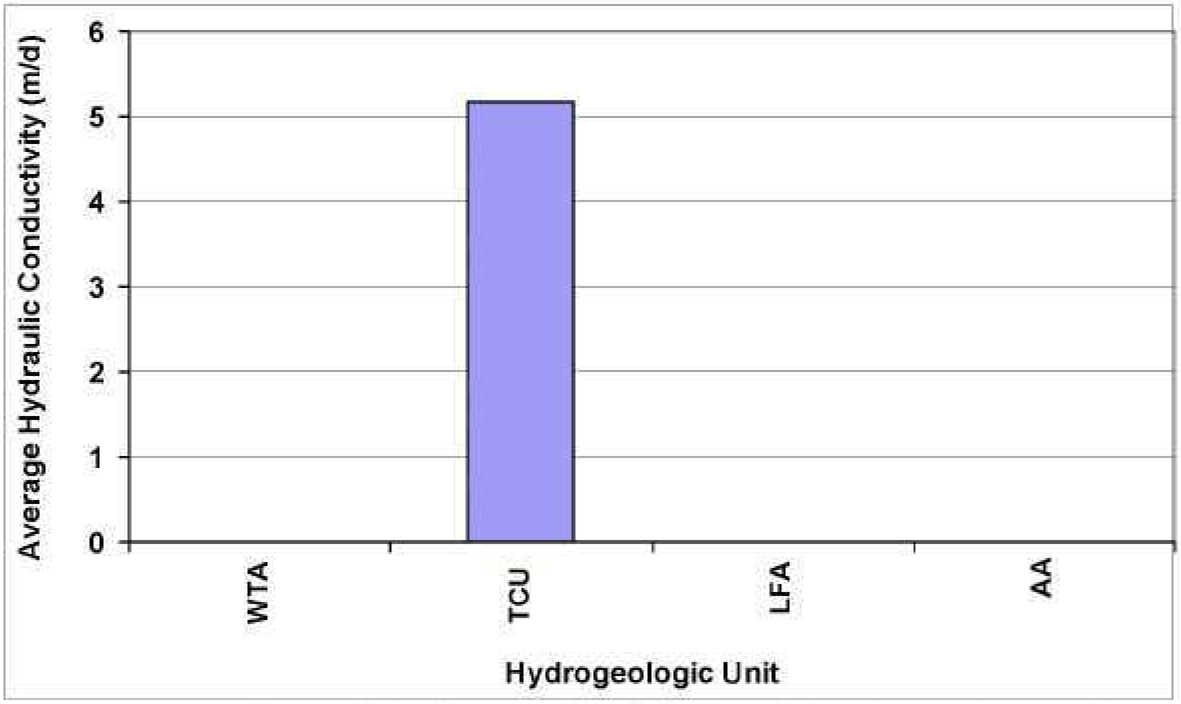


Figure 70. Average detected hydraulic conductivity for hydrogeologic units at well ER-5-4#2.

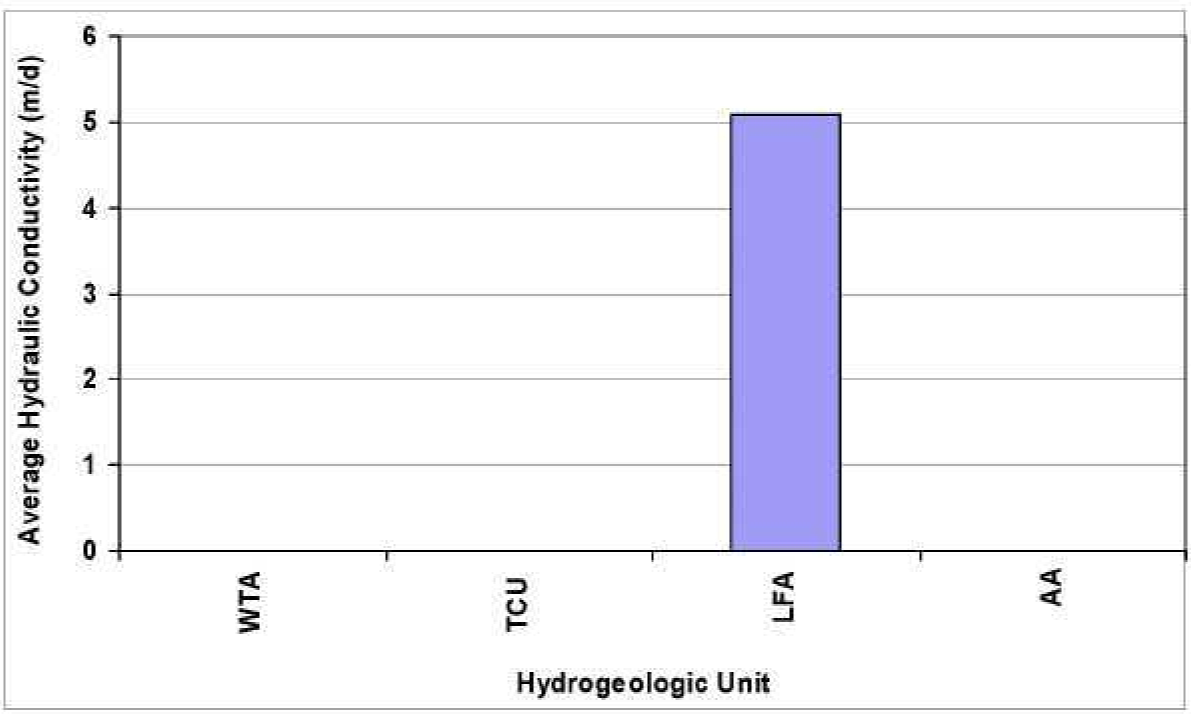


Figure 71. Average detected hydraulic conductivity for hydrogeologic units at well ER-EC-6.

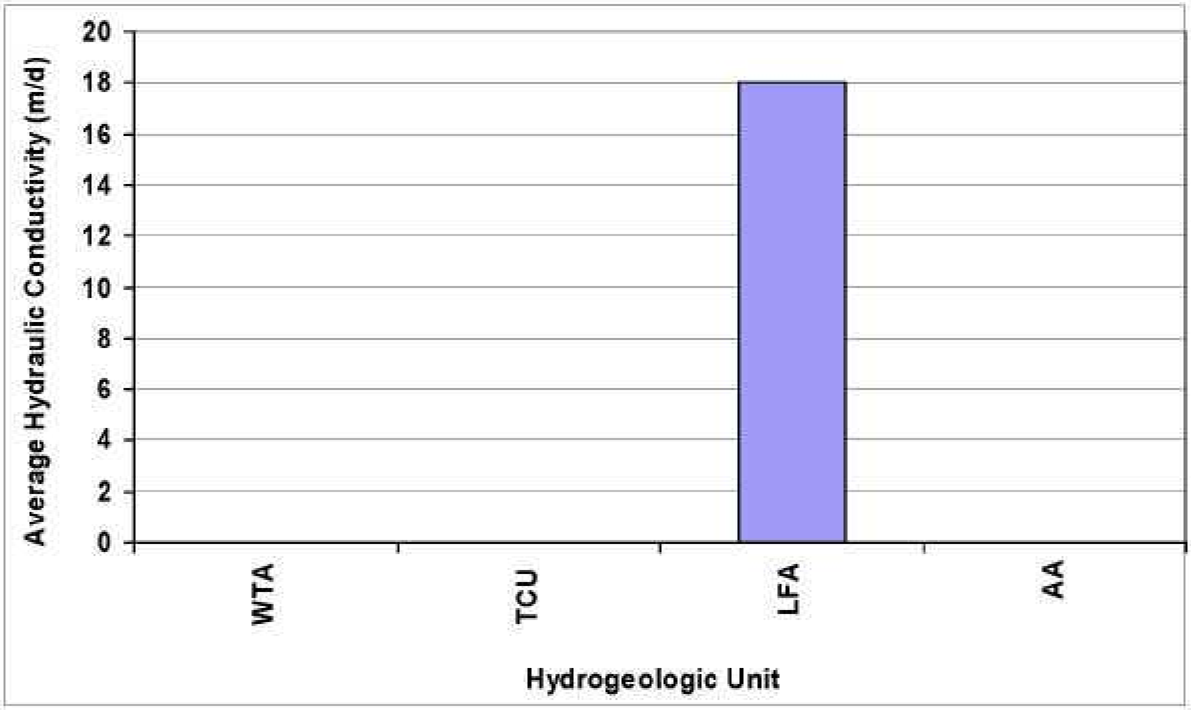


Figure 72. Average detected hydraulic conductivity for hydrogeologic units at well ER-EC-7.

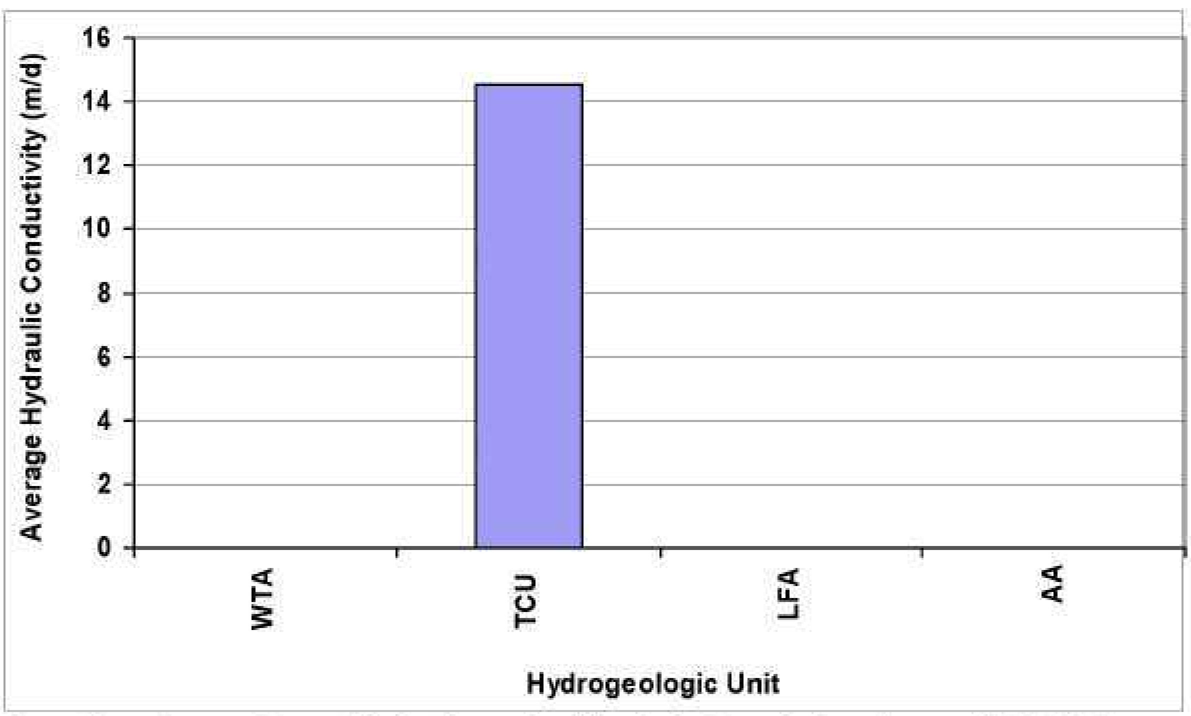


Figure 73. Average detected hydraulic conductivity for hydrogeologic units at well ER-EC-8.

Table 13. Hydrostratigraphic units for wells in tuff.

Hydrostratigraphic Abbreviation		Hydrostratigraphic Unit Name
ER-EC-1		
	TCVA	Thirsty Canyon Volcanic Aquifer
	THLFA	Tannenbaum Hill Lava-Flow Aquifer
	THCM	Tannenbaum Hill Composite Unit
	TMA	Timber Mountain Aquifer
	FCCU	Fluorspar Canyon Confining Unit
	BA	Benham Aquifer
	UPCU	Upper Paintbrush Confining Unit
	TCA	Tiva Canyon Aquifer
	LPCU	Lower Paintbrush Confining Unit
	TSA	Topopah Spring Aquifer
	CHCU	Calico Hills Confining Unit
	CFCM	Crater Flat Composite Unit
ER-EC-2a		
	FCCM	Fortymile Canyon Composite Unit
	TMCM	Timber Mountain Composite Unit
ER-EC-4		
	YVCM	Younger Volcanics Composite Unit
	TCVA	Thirsty Canyon Volcanic Aquifer
	FCCM	Fluorspar Canyon Composite Unit
	TMA	Timber Mountain Aquifer
ER-EC-5		
	TCVA	Thirsty Canyon Volcanic Aquifer
	FCCM	Fluorspar Canyon Composite Unit
	TMCM	Timber Mountain Composite Unit
ER-5-4#2		
	AA3	Alluvial Aquifer No. 3
	PCU1U	Poorly Consolidated Alluvial Aquifer
	AA1	Alluvial Aquifer No. 1
	TM-WTA	Timber Mountain Welded Tuff Aquifer
	TM-LVTA	Timber Mountain Lava and Tuff Aquifer
	LTCU	Lower Tuff Confining Unit
ER-EC-6		
	THLFA	Tannenbaum Hill Lava-Flow Aquifer
	THCM	Tannenbaum Hill Composite Unit
	FCCU	Fortymile Canyon Confining Unit
	BA	Benham Aquifer
	UPCU	Upper Paintbrush Confining Unit
	TCA	Tiva Canyon Aquifer
	LPCU	Lower Paintbrush Confining Unit
	TSA	Topopah Spring Aquifer
	CHCU	Calico Hills Intrusive Confining Unit
	CFCM	Crater Flat Composite Unit
ER-EC-7		
	FCCM	Fortymile Canyon Composite Unit
ER-EC-8		
	TCVA	Thirsty Canyon Volcanic Aquifer
	FCCM	Fortymile Canyon Composite Unit
	TMCM	Timber Mountain Composite Unit

Table 14. Hydrostratigraphic units encountered in drilling that were screened are shaded gray and units with detectable hydraulic conductivity are in bold type.

Well	Hydrostratigraphic Unit										
ER-EC-1	TCVA	THLFA	THCM	TMA	FCCU	**BA**	**UPCU**	**TCA**	LPCU	**TSA**	CHCU	**CFCM**
ER-EC-2a	**FCCM**	**TMCM**										
ER-EC-4	YVCM	**TCVA**	FCCM	**TMA**								
ER-EC-5	TCVA	FCCM	**TMCM**									
ER-5-4#2	AA3	PCU1U	AA1	TM-WTA	TM-LVTA	**LTCU**						
ER-EC-6	THLFA	THCM	FCCU	**BA**	UPCU	TCA	LPCU	TSA	CHCU	CFCM		
ER-EC-7	**FCCM**											
ER-EC-8	TCVA	**FCCM**	**TMCM**									

The vertical length of well screen placed adjacent to each hydrostratigraphic unit and the length over which hydraulic conductivity was detected are presented for each well in Figures 74 through 81. The figures include all hydrostratigraphic units that were encountered during drilling to provide a hydrostratigraphic context for well screening. The figures indicate that the Benham Aquifer and the Fluorspar Canyon Composite Unit are likely to have detectable hydraulic conductivity.

The average detected hydraulic conductivity for the hydrostratigraphic units is presented in Figures 82 through 89. Average hydraulic conductivities are highest for the Benham Aquifer, Thirsty Canyon Volcanic Aquifer, and Fortymile Canyon Composite Unit.

Association of Hydrogeologic Characteristics with Well-specific Hydraulic Conductivity

The following sections describe the hydraulic conductivity for each hydrogeologic characteristic that occurs within multiple wells. When a hydrogeologic characteristic is found in only one well, the information is identical to that presented above. The analysis goals of the figures are described in Table 3. Each hydrogeologic classification is discussed in a separate section below. The figures in this section show the detected hydraulic conductivity data for each well plotted both separately and displayed as if all the values are at the same location.

Hydraulic Conductivity and Stratigraphy

There are five stratigraphic units with detected hydraulic conductivity in more than one well. The names of the stratigraphic units and their abbreviations are provided in Table 5. The stratigraphic association of screened intervals and hydraulic conductivity for all wells in tuff is presented in Table 15.

There are more stratigraphic units than any other hydrogeologic characteristic. This tends to reduce the number of detected hydraulic conductivity values within any particular stratigraphic characteristic. Data associations with other hydrogeologic classifications exhibit more heavily populated data sets.

The detected hydraulic conductivity with depth for the Rhyolite of Beatty Wash is presented in Figure 90. Well ER-EC-2a has much lower hydraulic conductivity values than well ER-EC-7. Figures 91 through 94 present the detected hydraulic conductivity for the wells individually and in composite for normal and log-transformed values. Because the ranges of values for the two wells do not overlap, the figures for the wells individually and in composite are identical. The sparse data for this unit prevent interpretation of data trends.

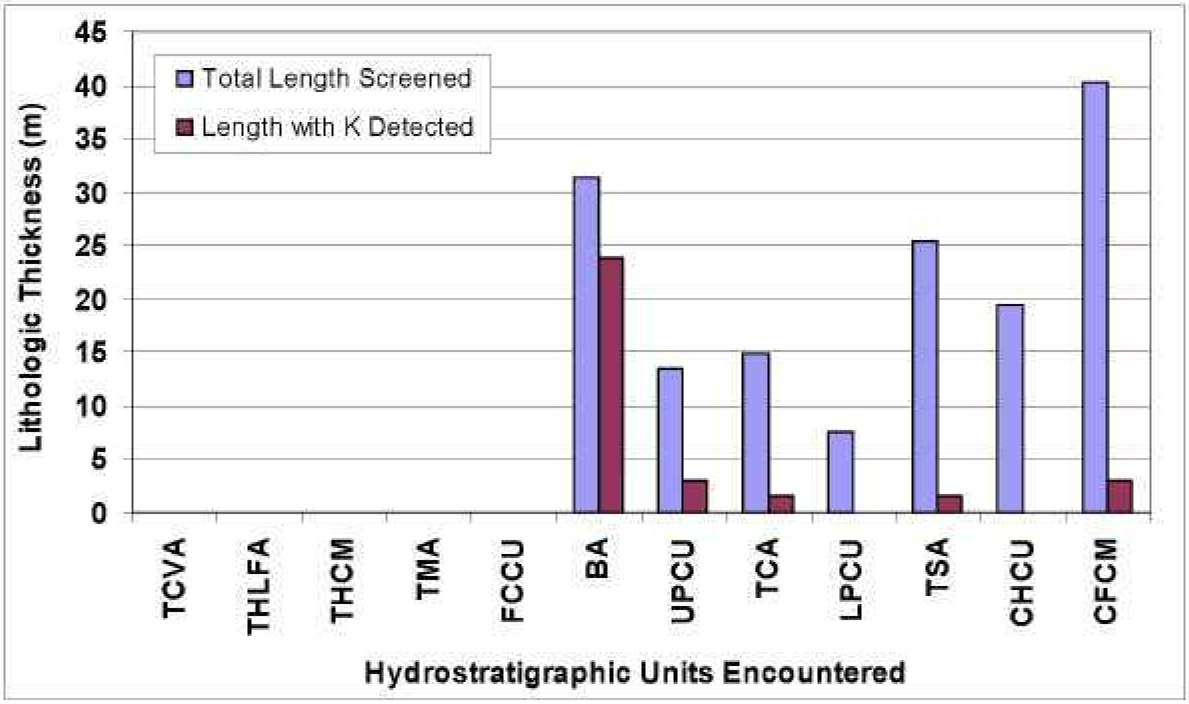


Figure 74. Hydrostratigraphic units adjacent to well screen and detectable hydraulic conductivity at well ER-EC-1.

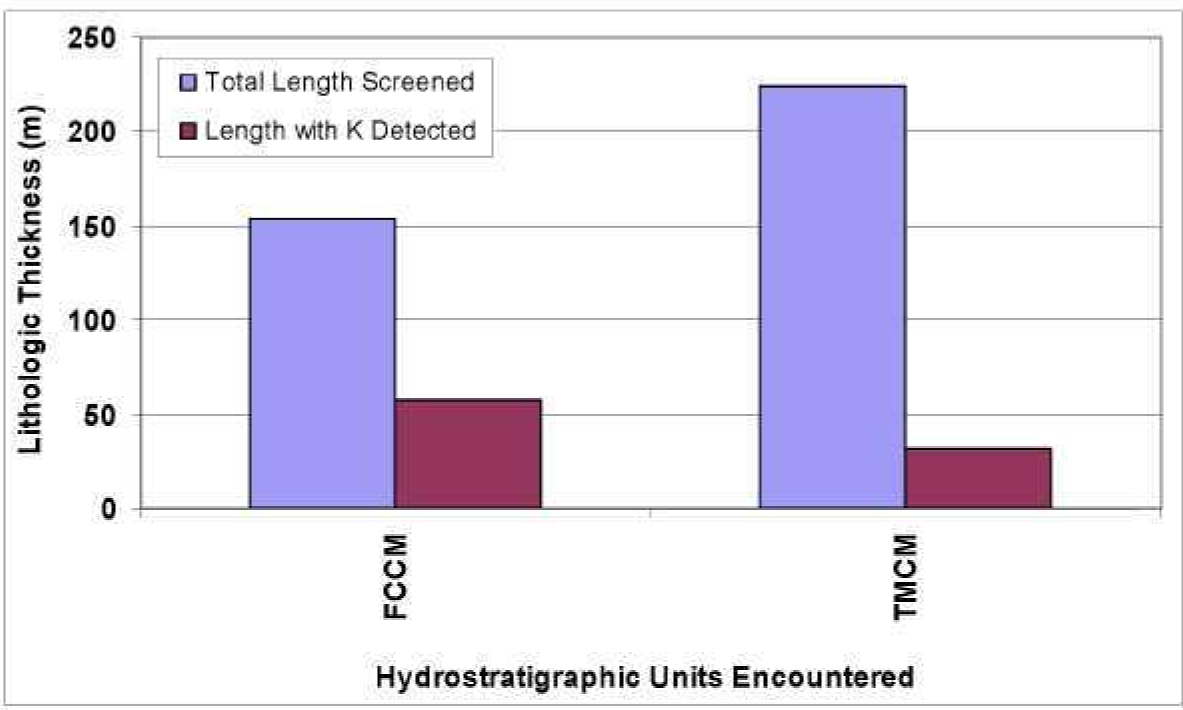


Figure 75. Hydrostratigraphic units adjacent to well screen and detectable hydraulic conductivity at well ER-EC-2a.

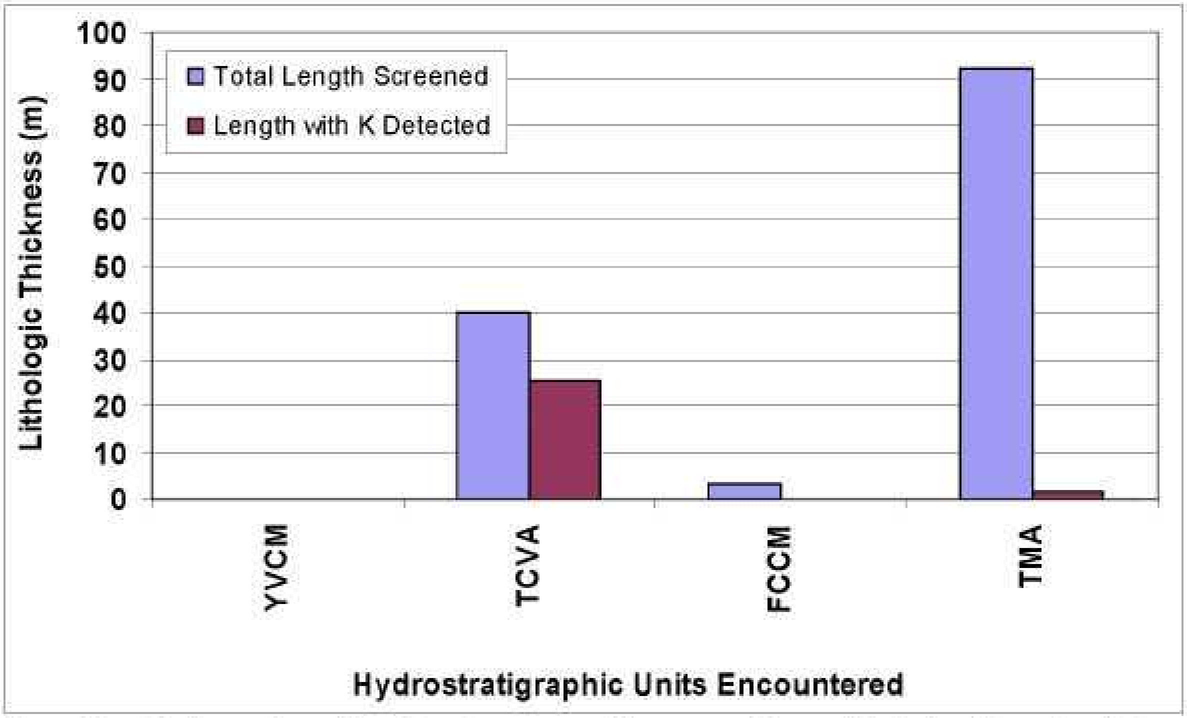


Figure 76. Hydrostratigraphic units adjacent to well screen and detectable hydraulic conductivity at well ER-EC-4.

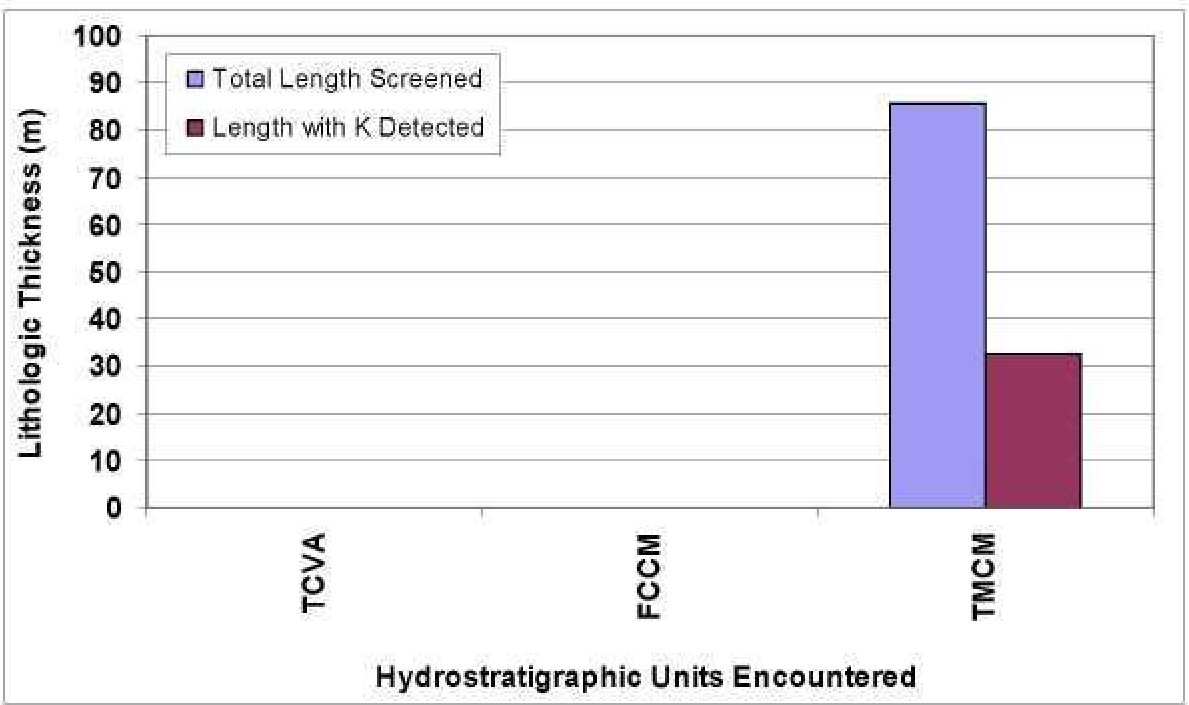


Figure 77. Hydrostratigraphic units adjacent to well screen and detectable hydraulic conductivity at well ER-EC-5.

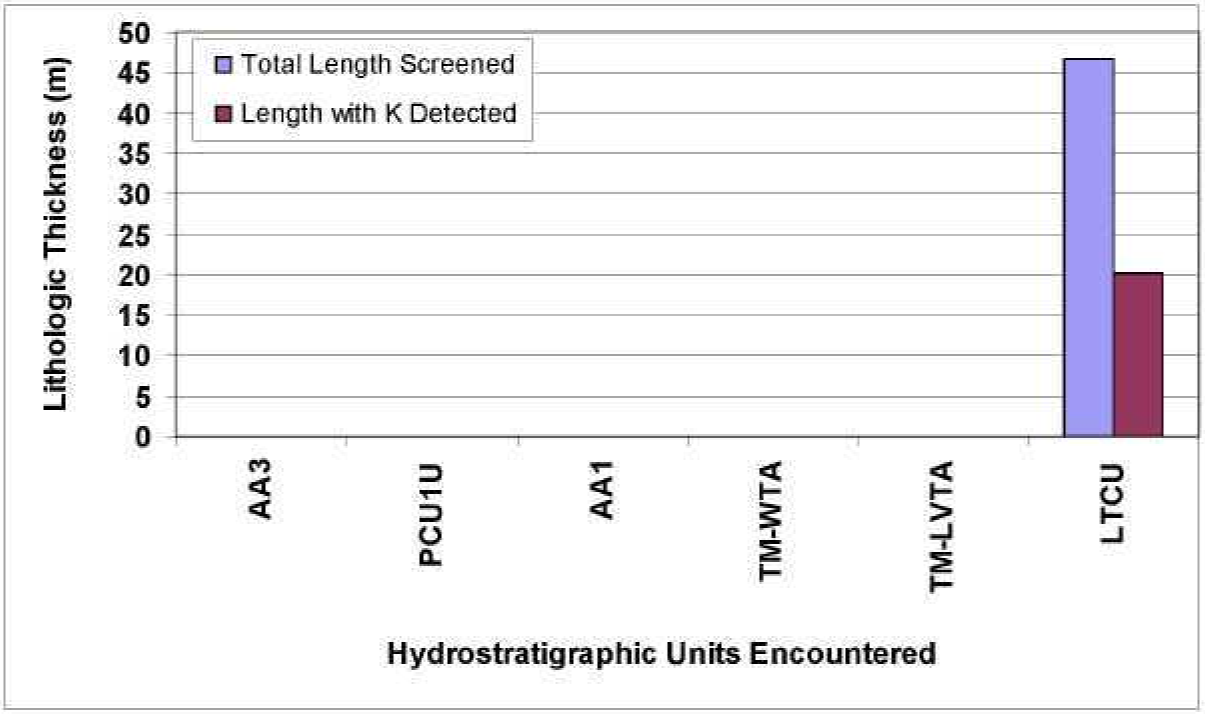


Figure 78. Hydrostratigraphic units adjacent to well screen and detectable hydraulic conductivity at well ER-5-4#2.

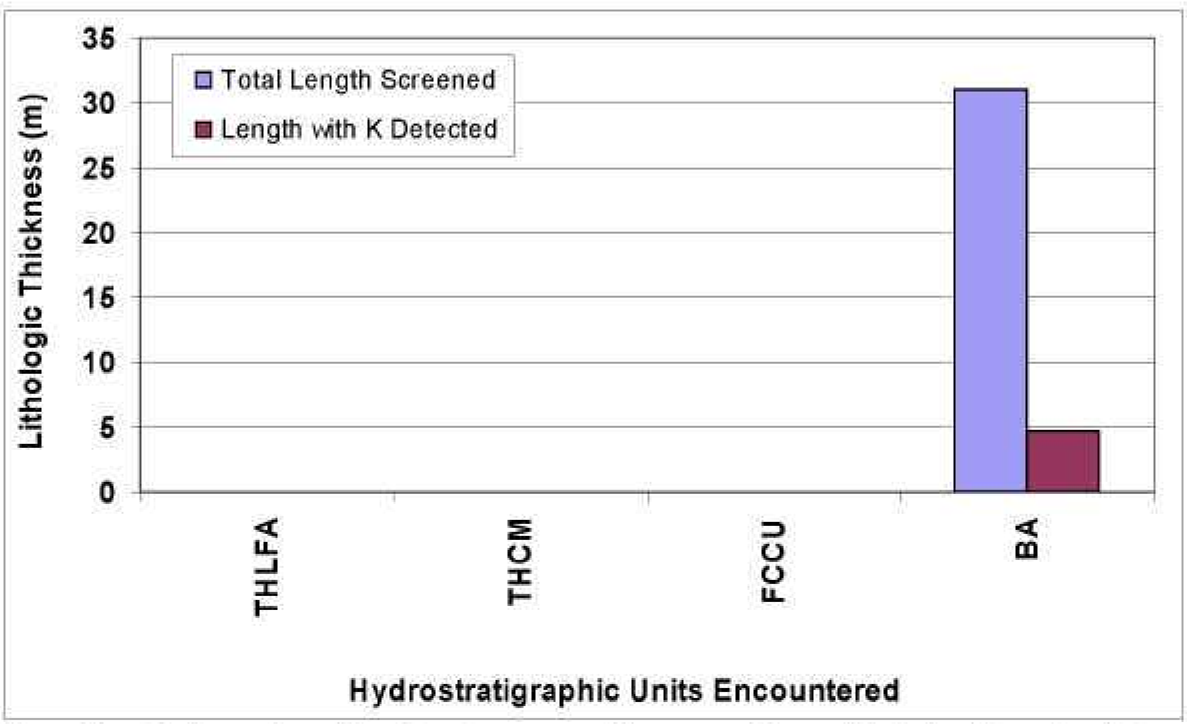


Figure 79. Hydrostratigraphic units adjacent to well screen and detectable hydraulic conductivity at well ER-EC-6.

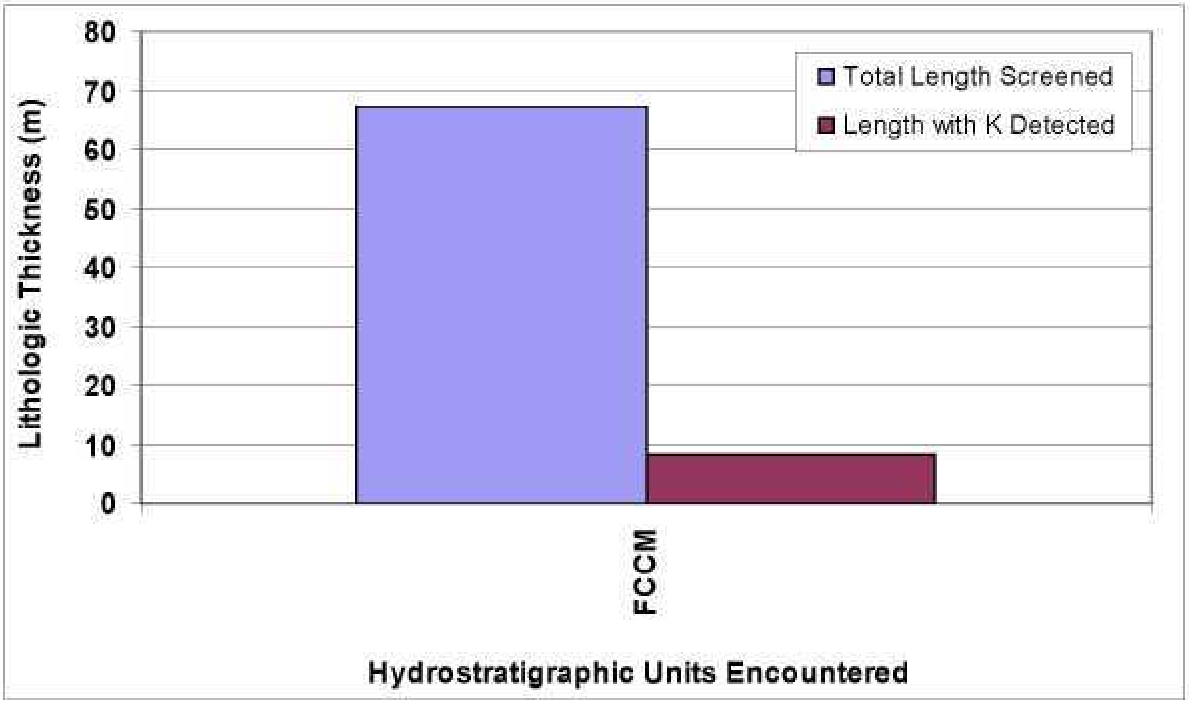


Figure 80. Hydrostratigraphic units adjacent to well screen and detectable hydraulic conductivity at well ER-EC-7.

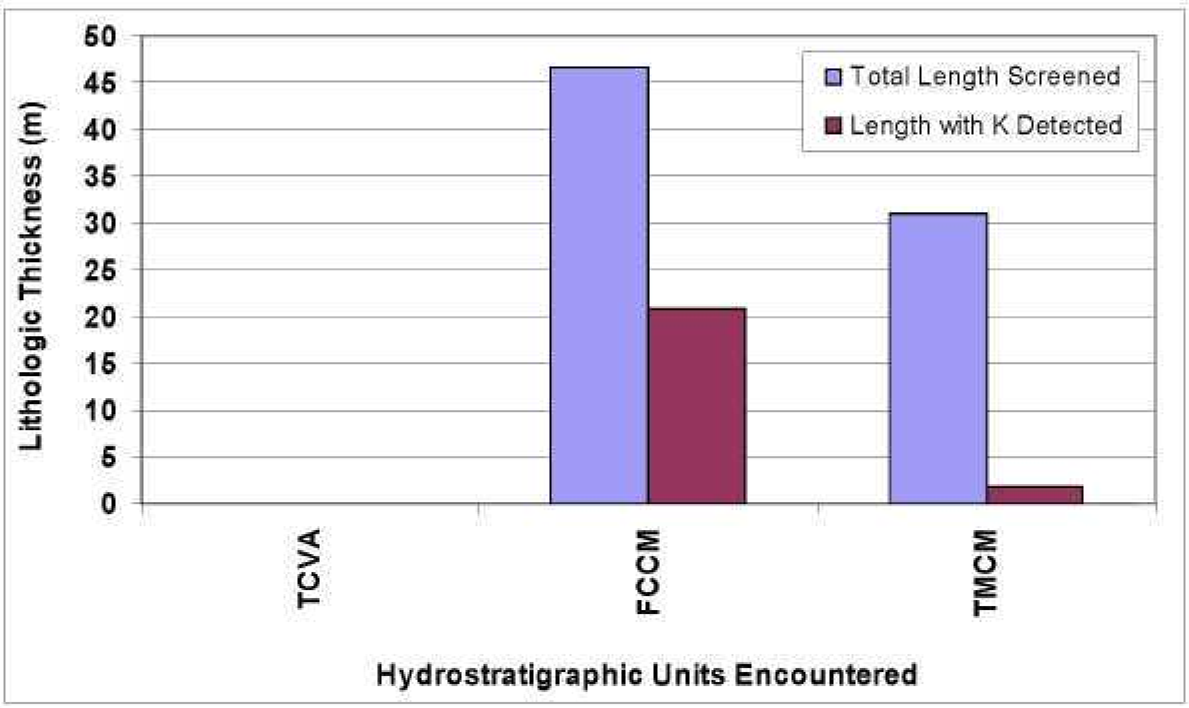


Figure 81. Hydrostratigraphic units adjacent to well screen and detectable hydraulic conductivity at well ER-EC-8.

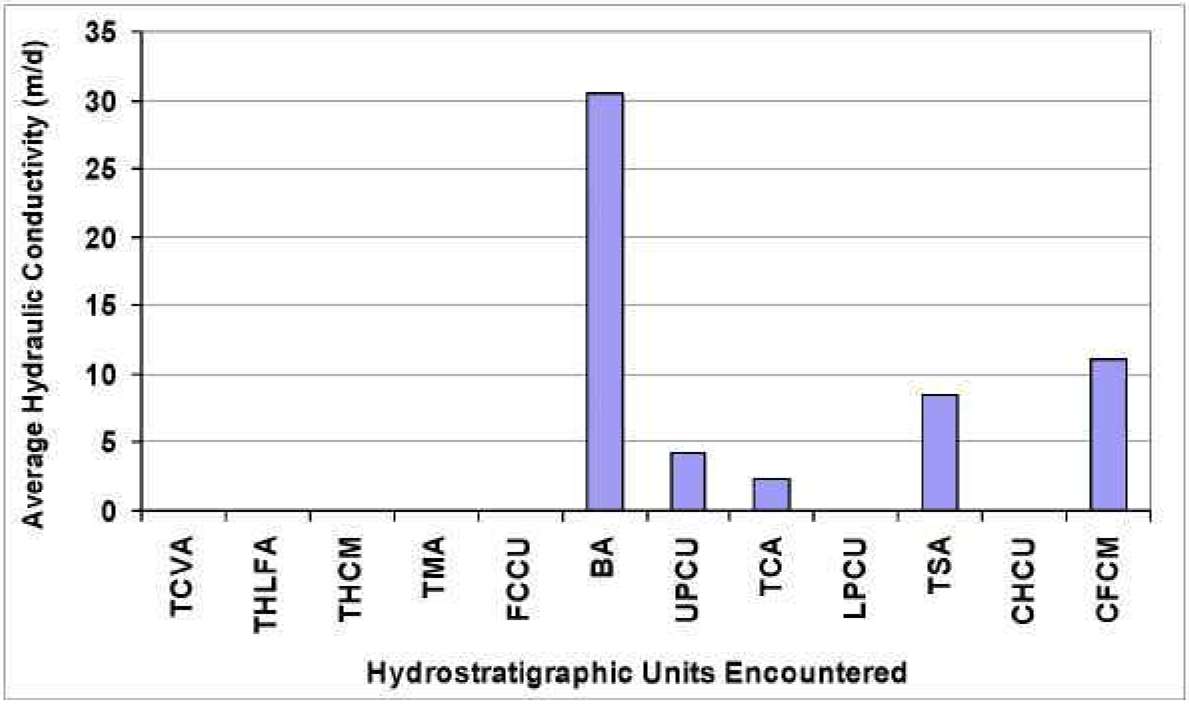


Figure 82. Average detected hydraulic conductivity for hydrostratigraphic units at well ER-EC-1.

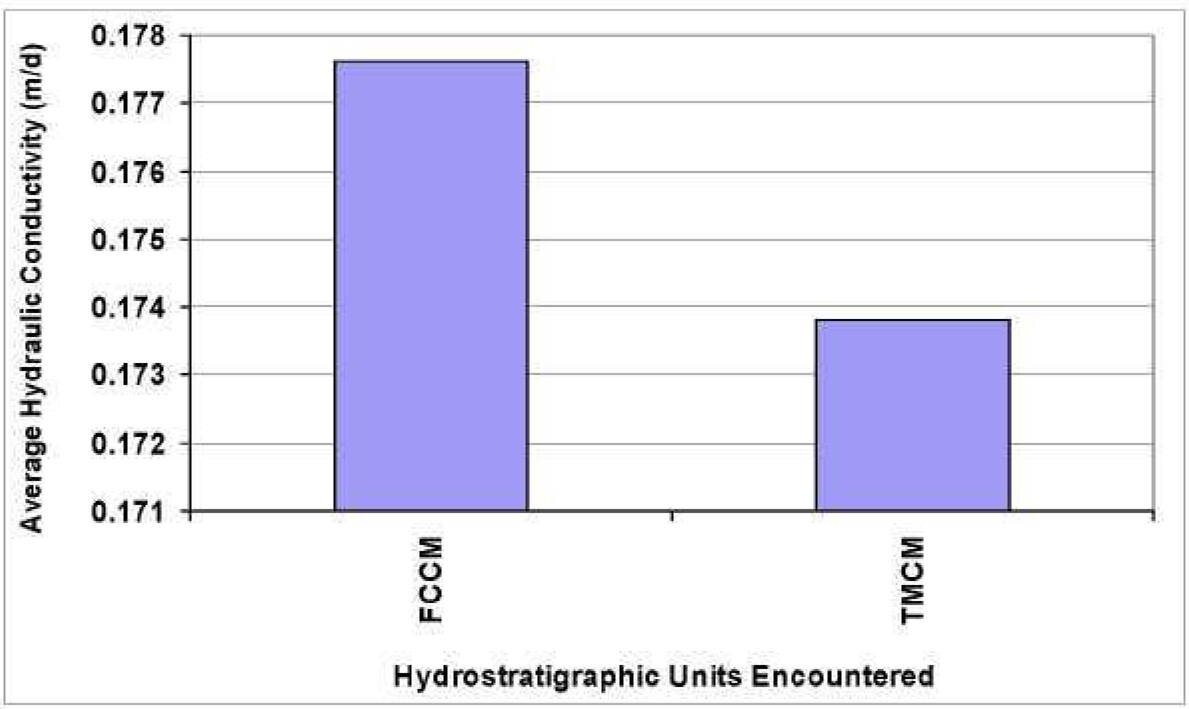


Figure 83. Average detected hydraulic conductivity for hydrostratigraphic units at well ER-EC-2a.

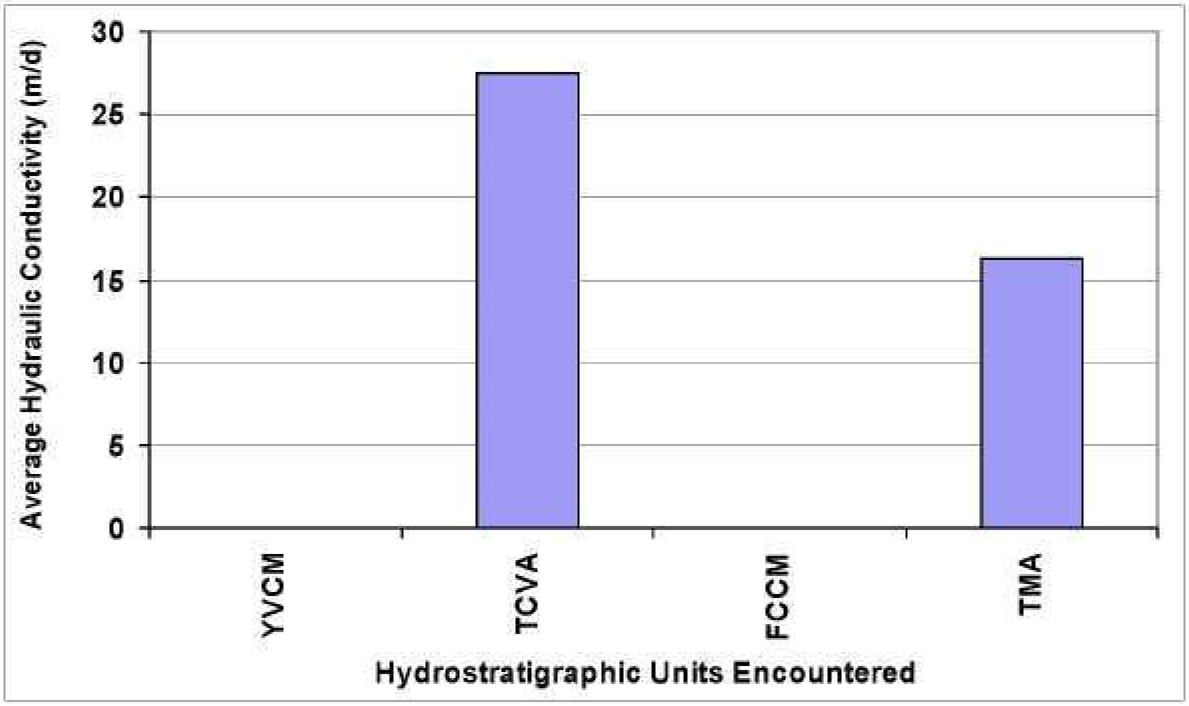


Figure 84. Average detected hydraulic conductivity for hydrostratigraphic units at well ER-EC-4.

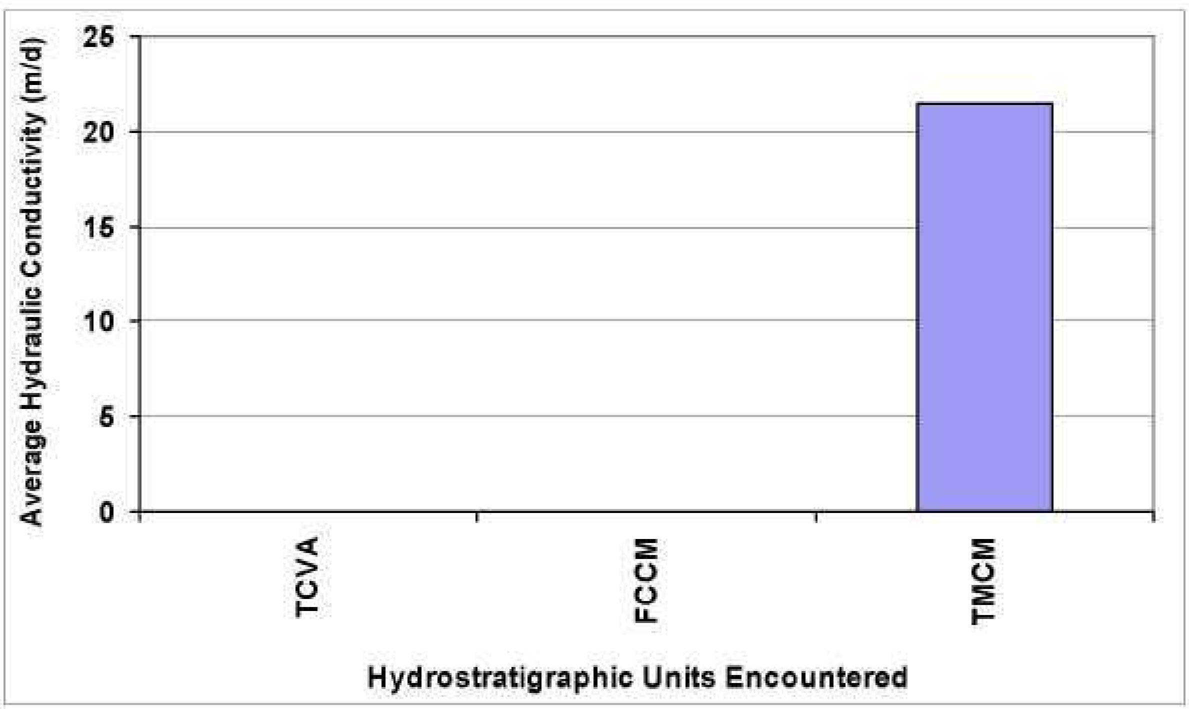


Figure 85. Average detected hydraulic conductivity for hydrostratigraphic units at well ER-EC-5.

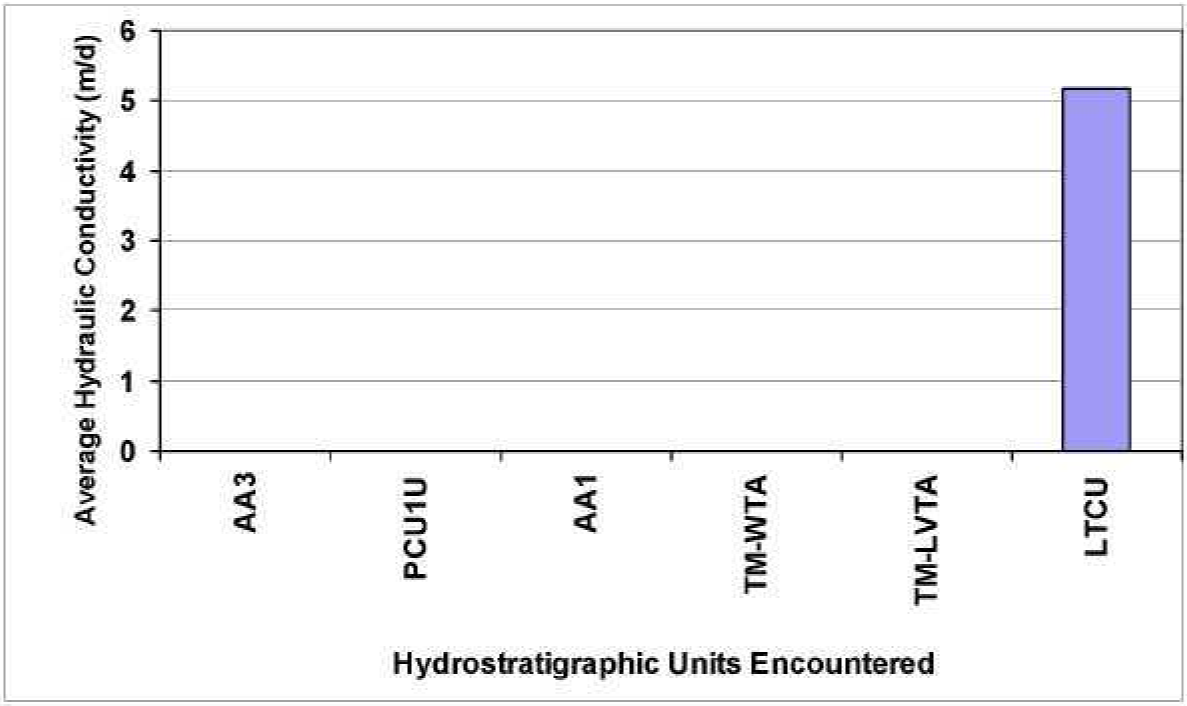


Figure 86. Average detected hydraulic conductivity for hydrostratigraphic units at well ER-5-4#2.

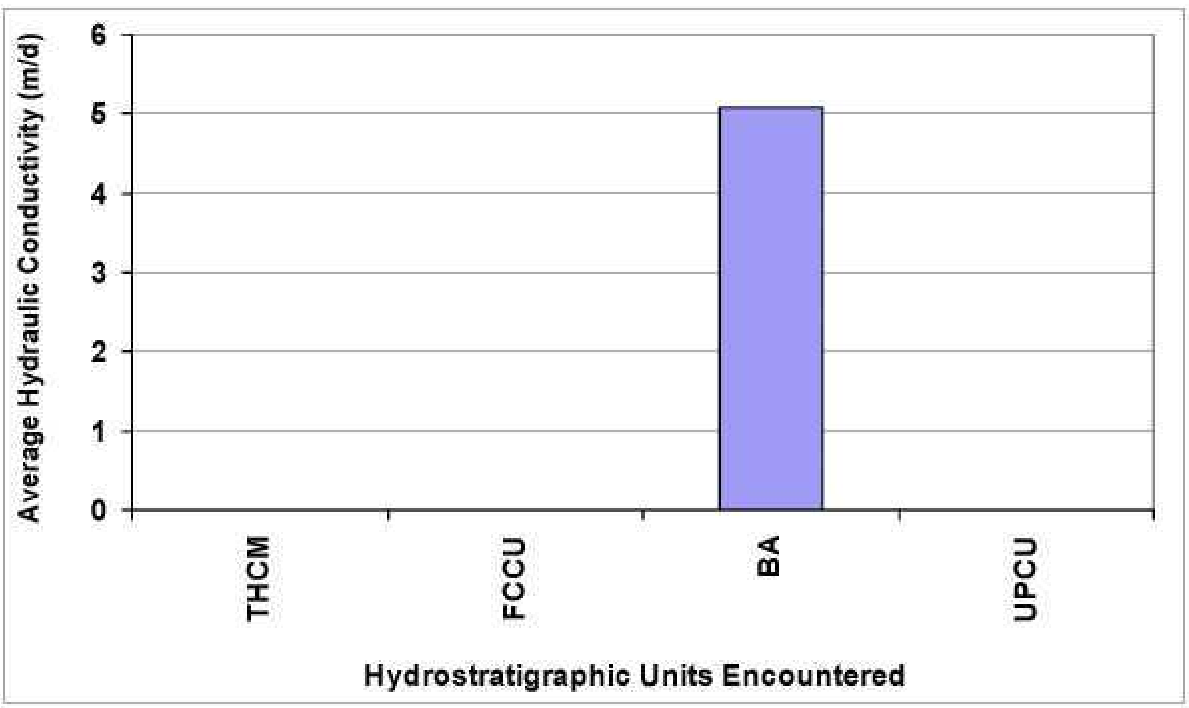


Figure 87. Average detected hydraulic conductivity for hydrostratigraphic units at well ER-EC-6.

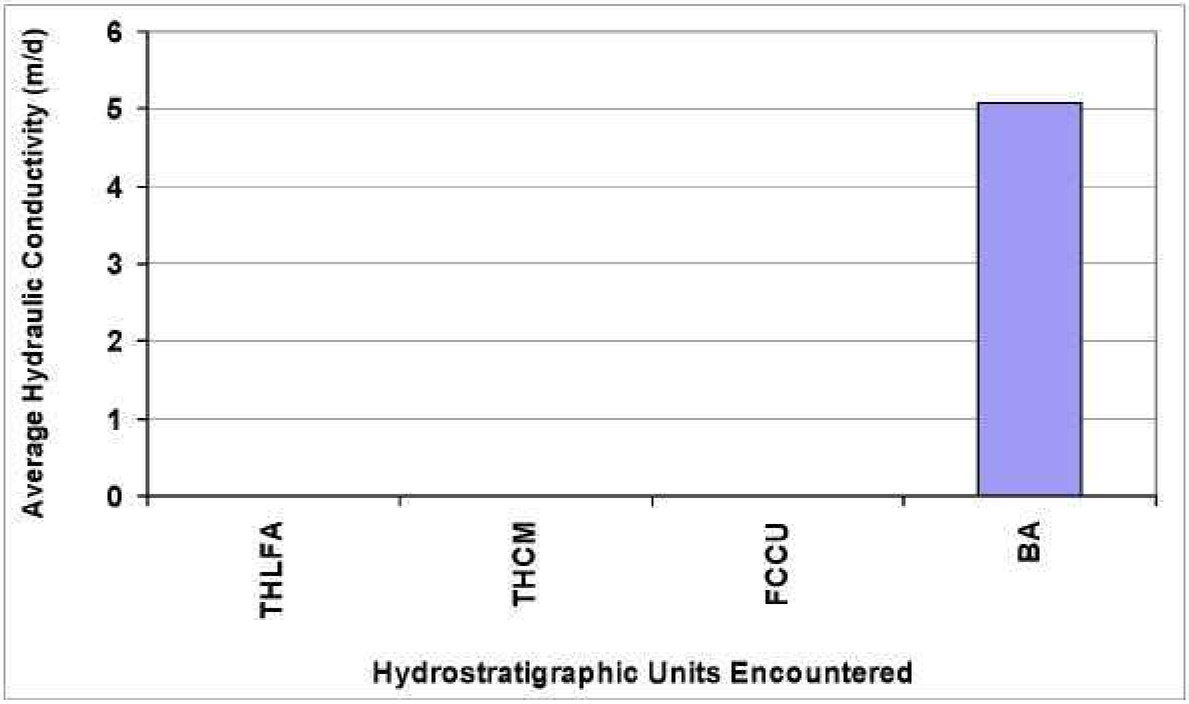


Figure 88. Average detected hydraulic conductivity for hydrostratigraphic units at well ER-EC-7.

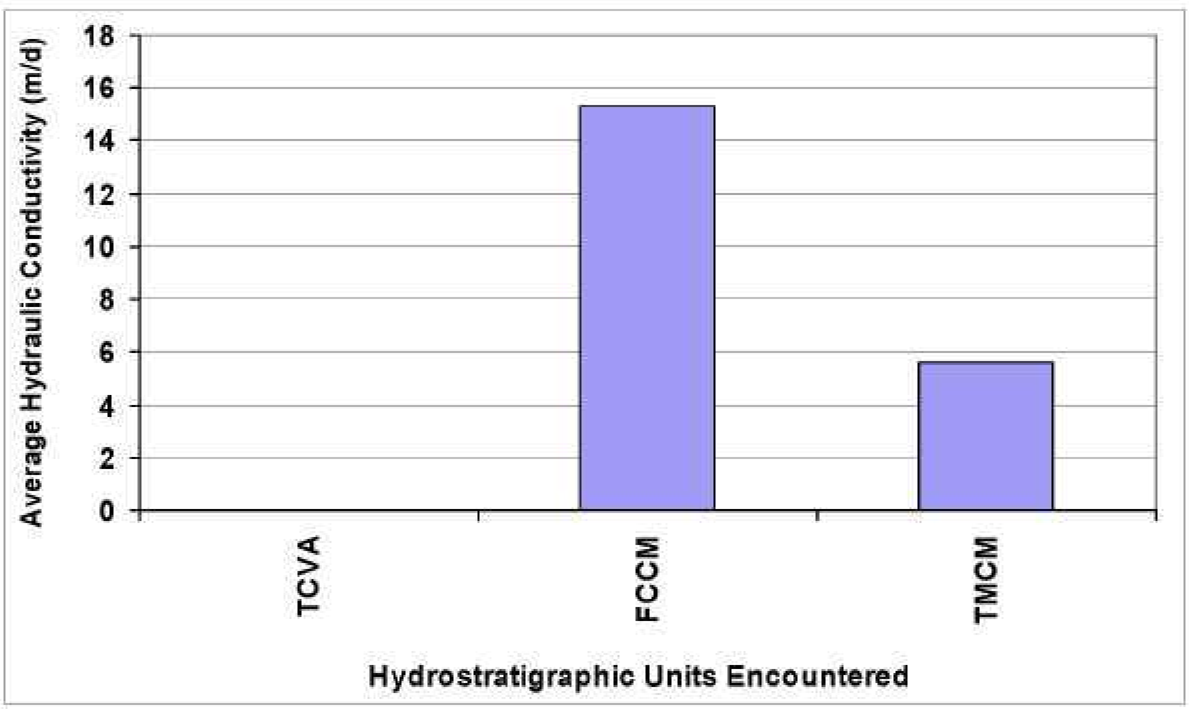


Figure 89. Average detected hydraulic conductivity for hydrostratigraphic units at well ER-EC-8.

Table 15. Stratigraphic units encountered at multiple wells in tuff.

Stratigraphic Unit	ER-EC-1		ER-EC-2a		ER-EC-4		ER-EC-5		ER-5-4#2		ER-EC-6		ER-EC-7		ER-EC-8	
	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)
Tpb	44.7	**26.8**	0	0	0	0	0	0	0	0	54.9	**4.8**	0	0	0	0
Tpcm	14.9	1.5	0	0	0	0	0	0	0	0	14.9	0	0	0	0	0
Thr	26.8	0	0	0	0	0	0	0	0	0	31.0	0	0	0	0	0
Tptm	25.3	1.5	0	0	0	0	0	0	0	0	23.3	0	0	0	0	0
Tcpe	40.2	3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tfbw	0	0	132.4	**51.2**	3.2	0	0	0	0	0	0	0	34.4	**2.7**	0	0
Tfb	0	0	1.5	0	0	0	0	0	0	0	0	0	27.5	**5.5**	46.6	**20.9**
Tf	0	0	19.6	6.0	0	0	0	0	0	0	0	0	0	0	0	0
Tmaw	0	0	188.1	27.1	0	0	0	0	0	0	0	0	0	0	15.5	0
Tmar	0	0	36.1	**4.5**	0	0	62.5	**28.2**	0	0	0	0	0	0	0	0
Ttc	0	0	0	0	39.8	25.5	0	0	0	0	0	0	0	0	0	0
Tfbr	0	0	0	0	0	0	0	0	0	0	0	0	5.5	0	0	0
Tmay	0	0	0	0	6.4	0	0	0	0	0	0	0	0	0	0	0
Tmrp	0	0	0	0	47.8	1.6	0	0	0	0	0	0	0	0	0	0
Tmap	0	0	0	0	38.2	0	23.4	**4.2**	0	0	0	0	0	0	15.5	**1.8**
Tcb	0	0	0	0	0	0	0	0	46.8	20.3	0	0	0	0	0	0

Stratigraphic units are not presented in stratigraphic sequence
Gray shading indicates a stratigraphic unit that occurs in multiple wells.
Bold type indicates length of detectable hydraulic conductivity for stratigraphic units with detectable hydraulic conductivity in more than one well

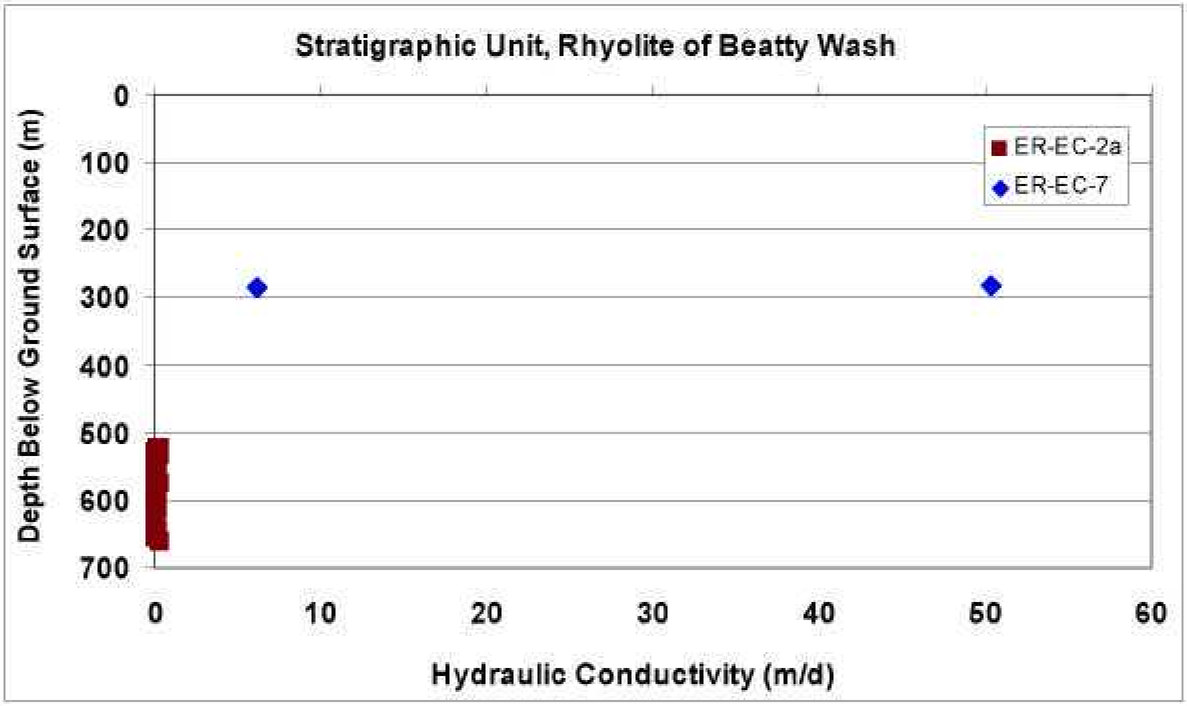


Figure 90. Detected hydraulic conductivity with depth for the stratigraphic unit Rhyolite of Beatty Wash.

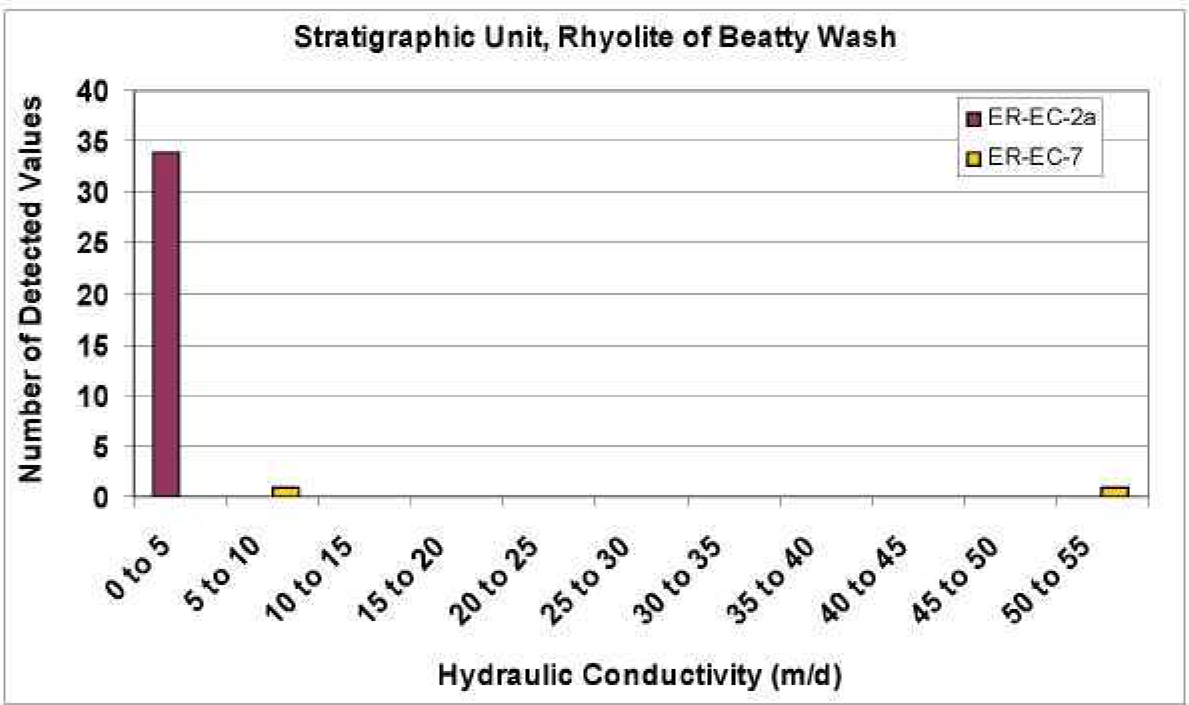


Figure 91. Detected hydraulic conductivity for individual wells for the stratigraphic unit Rhyolite of Beatty Wash.

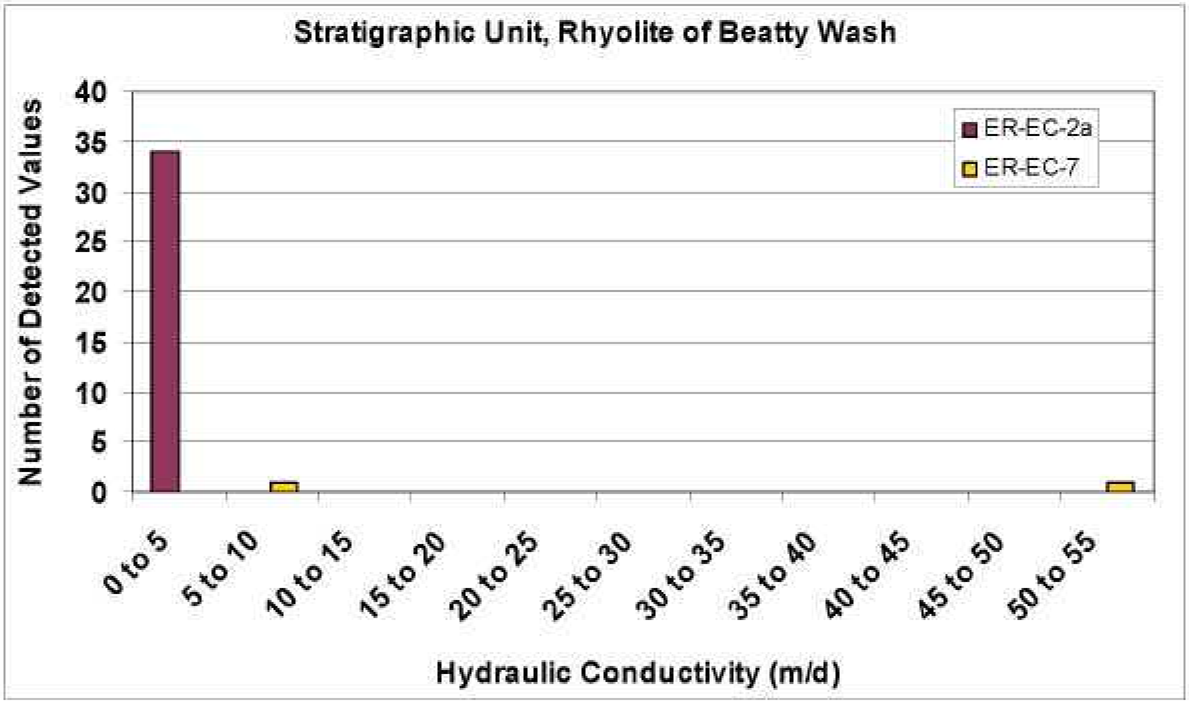


Figure 92. Detected hydraulic conductivity for wells in composite for the stratigraphic unit Rhyolite of Beatty Wash.

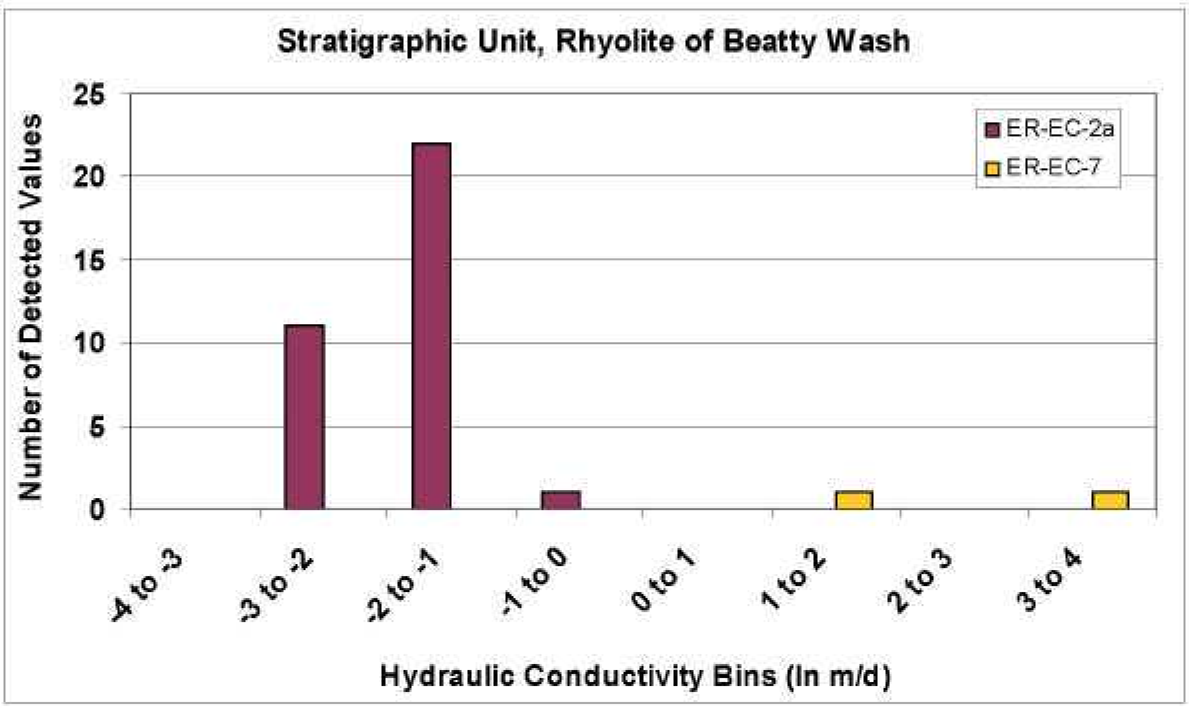


Figure 93. Detected natural logarithm hydraulic conductivity for individual wells for the stratigraphic unit Rhyolite of Beatty Wash.

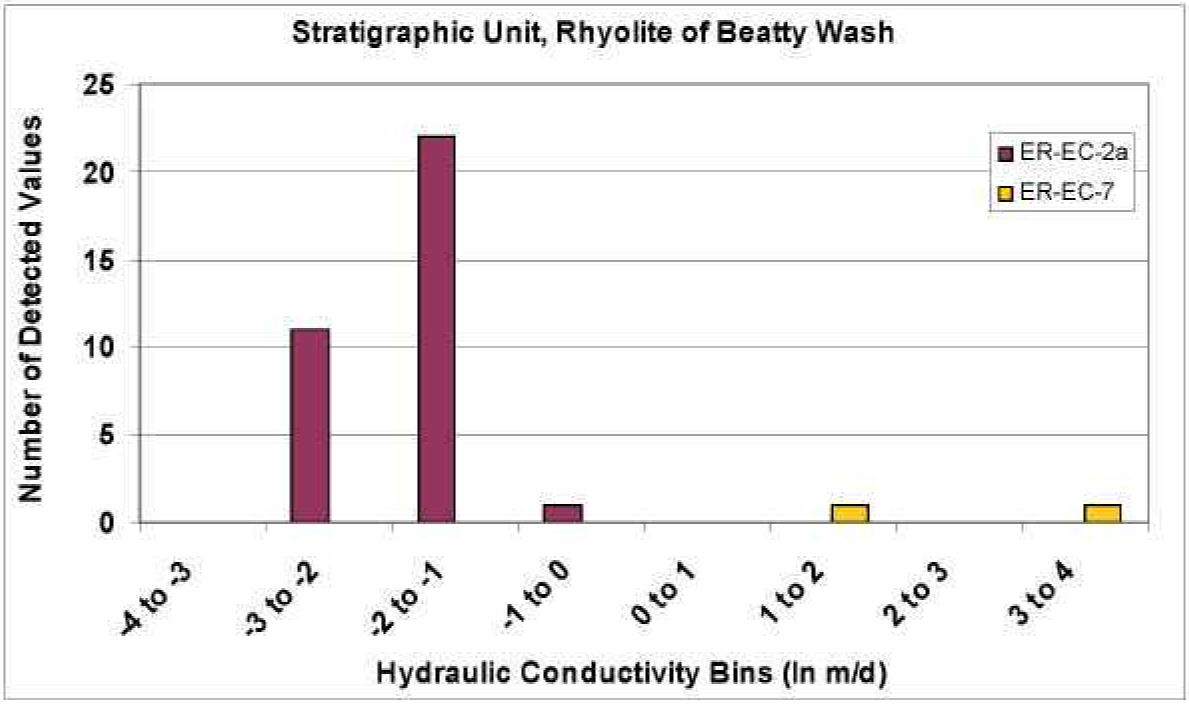


Figure 94. Detected natural logarithm hydraulic conductivity for wells in composite for the stratigraphic unit Rhyolite of Beatty Wash.

The detected hydraulic conductivity with depth for the Beatty Wash Formation is presented in Figure 95. Wells ER-EC-7 and ER-EC-8 have similar hydraulic conductivity values. Figures 96 through 99 present detected hydraulic conductivity for the wells individually and in composite for normal and log-transformed values. The distributions in Figures 96 and 99 indicate a strong similarity to the data sets. Figures 97 and 98 indicate a nearly lognormal statistical distribution.

The detected hydraulic conductivity with depth for the mafic-rich Ammonia Tanks Tuff is presented in Figure 100. Wells ER-EC-2a and ER-EC-5 have dissimilar hydraulic conductivity values. Figures 101 through 104 present detected hydraulic conductivity for the wells individually and in composite for normal and log-transformed values. Because the ranges of values for the two wells do not overlap, the figures for the wells individually and in composite are identical. The distributions in Figures 101 through 104 indicate that the hydraulic values for well ER-EC-2a are much lower than in well ER-EC-5. The hydraulic conductivity values in Figures 101 and 102 appear to have a normal distribution, with the few values for ER-EC-2a as the low-end member. Log-transformation of the data in Figures 103 and 104 does not aid in interpretation.

The detected hydraulic conductivity with depth for the mafic-poor Ammonia Tanks Tuff is presented in Figure 105. Wells ER-EC-5 and ER-EC-8 have dissimilar hydraulic conductivity values. Figures 106 through 109 present detected hydraulic conductivity for the wells individually and in composite for normal and log-transformed values. Because the ranges of values for the two wells do not overlap, the figures for the wells individually and in composite are identical. The distributions in Figures 106 and 107 do not display a regular trend. Log-transformation of the values in Figures 108 and 109 may indicate a lognormal distribution for ER-EC-5 and a separate distribution for ER-EC-8.

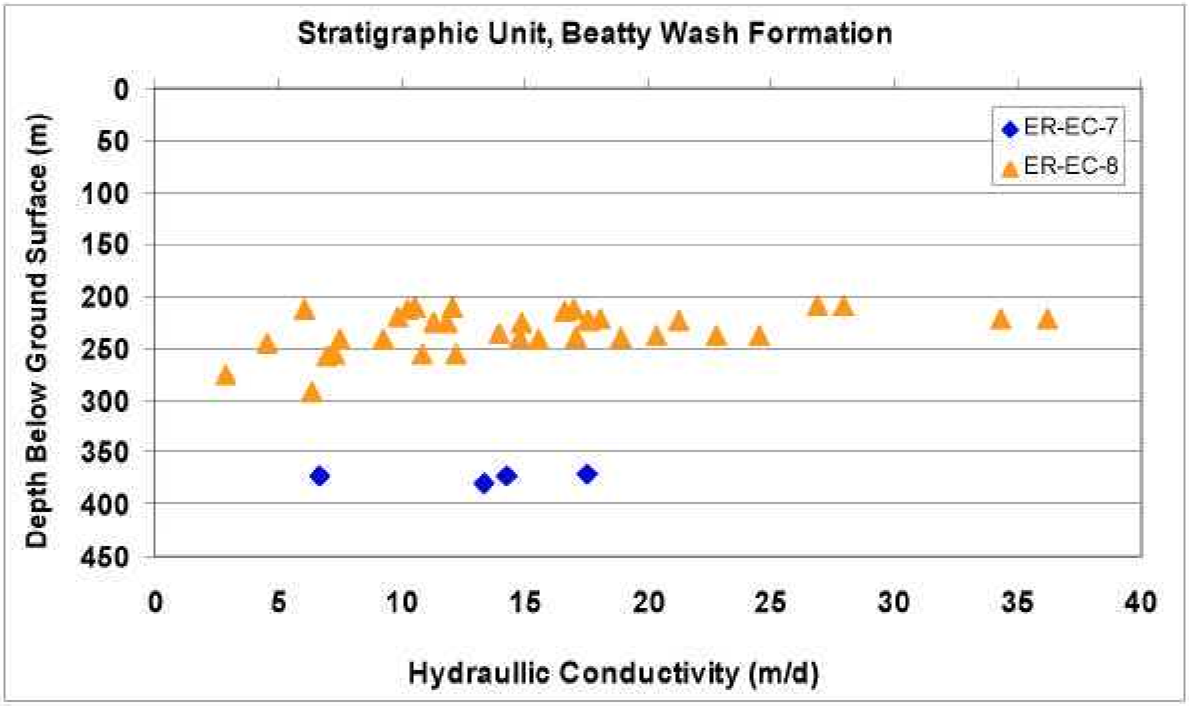


Figure 95. Detected hydraulic conductivity with depth for the stratigraphic unit Beatty Wash Formation.

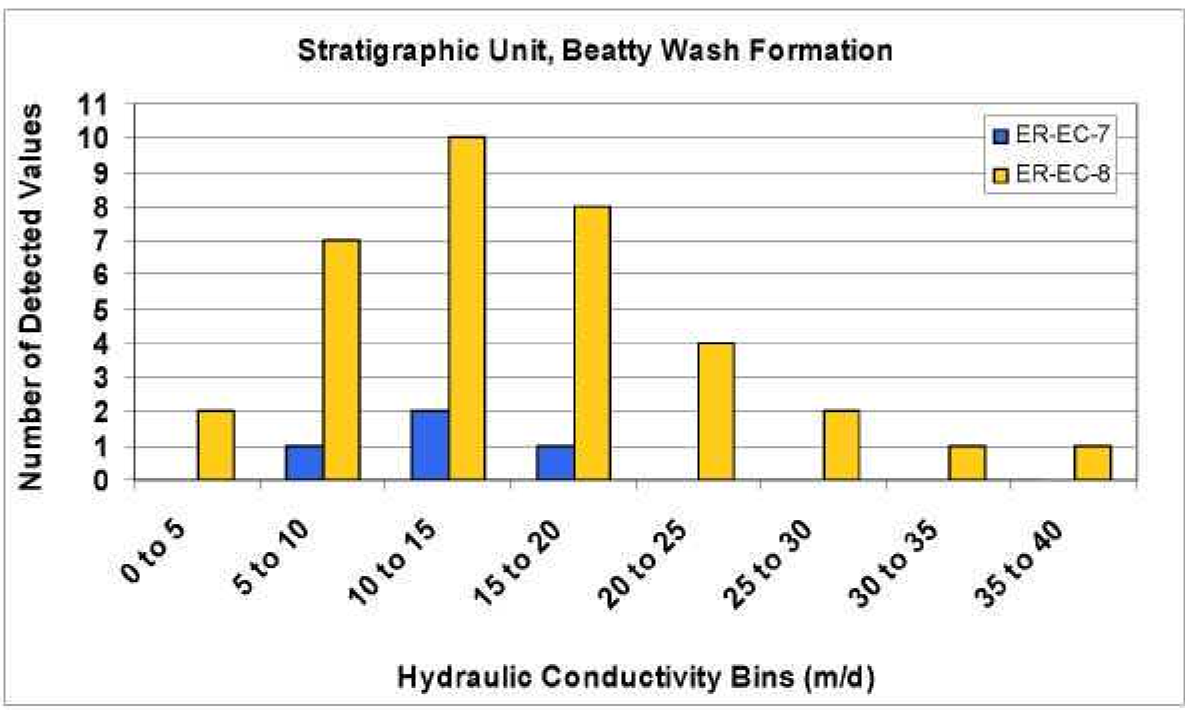


Figure 96. Detected hydraulic conductivity for individual wells for the stratigraphic unit Beatty Wash Formation.

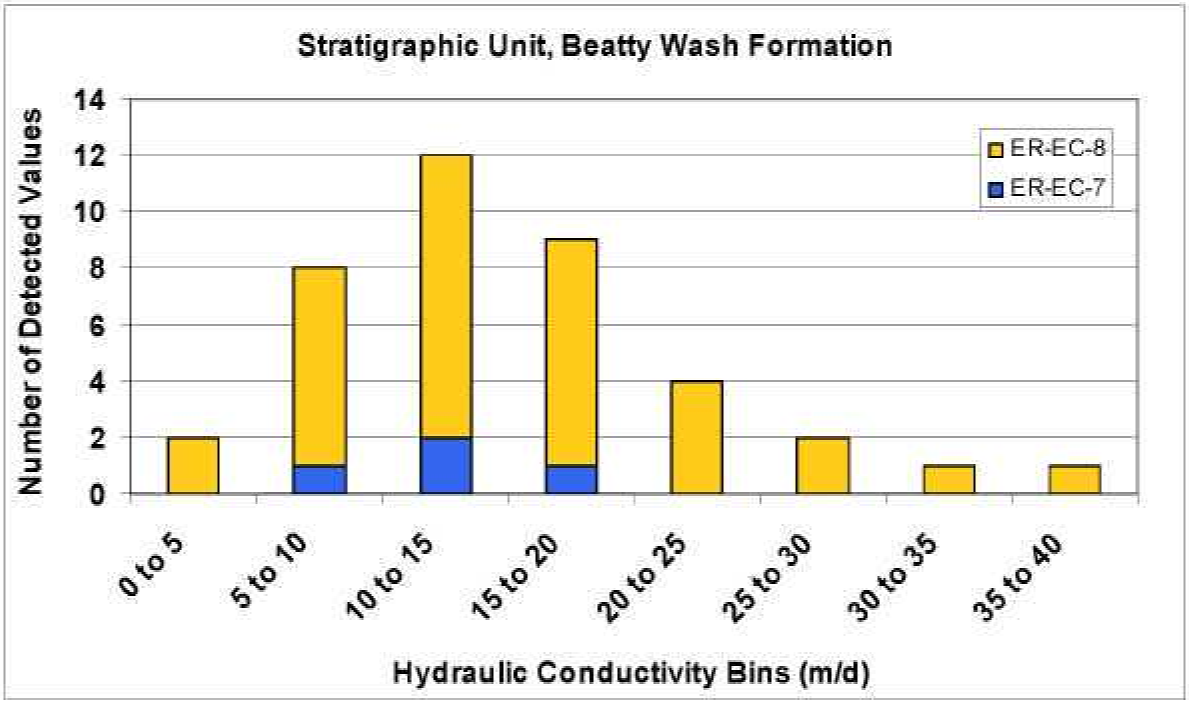


Figure 97. Detected hydraulic conductivity for wells in composite for the stratigraphic unit Beatty Wash Formation.

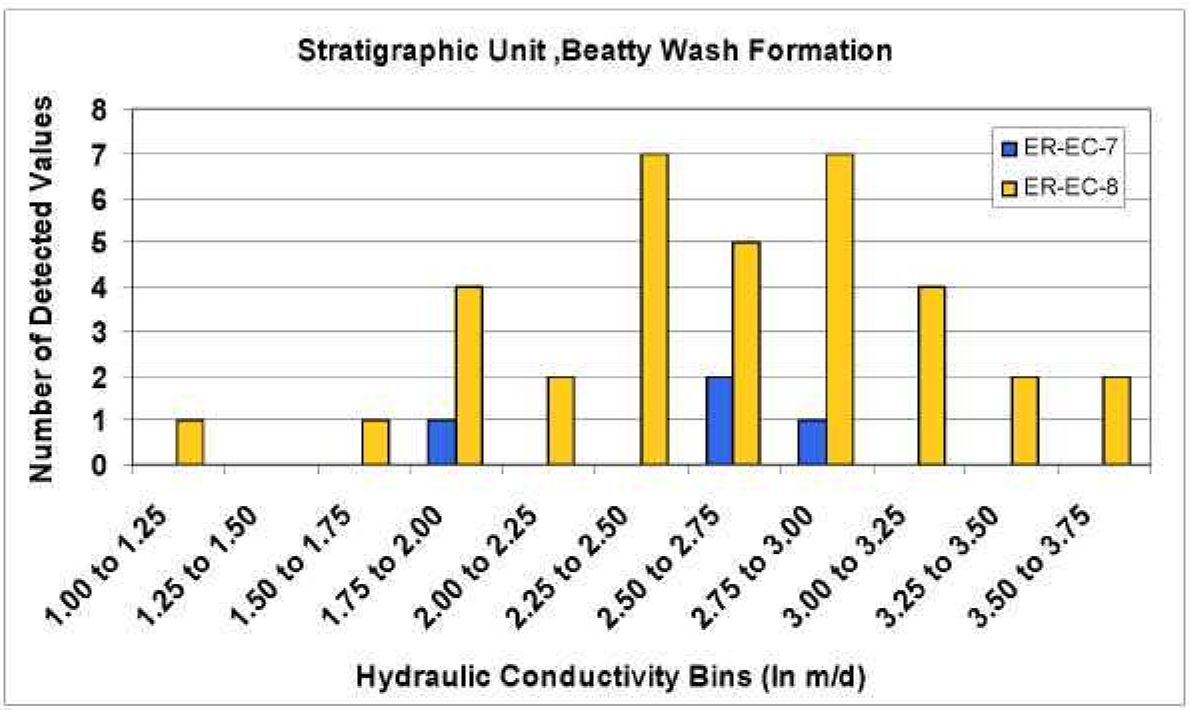


Figure 98. Detected natural logarithm hydraulic conductivity for individual wells for the stratigraphic unit Beatty Wash Formation.

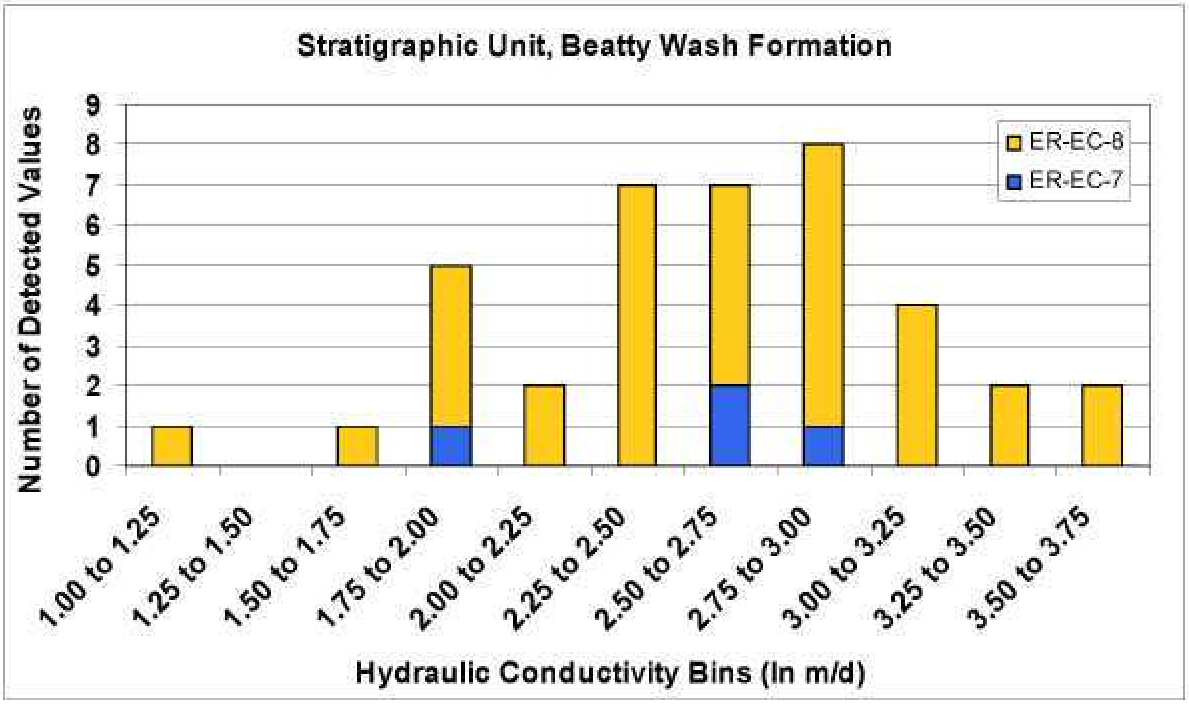


Figure 99. Detected natural logarithm hydraulic conductivity for wells in composite for the stratigraphic unit Beatty Wash Formation.

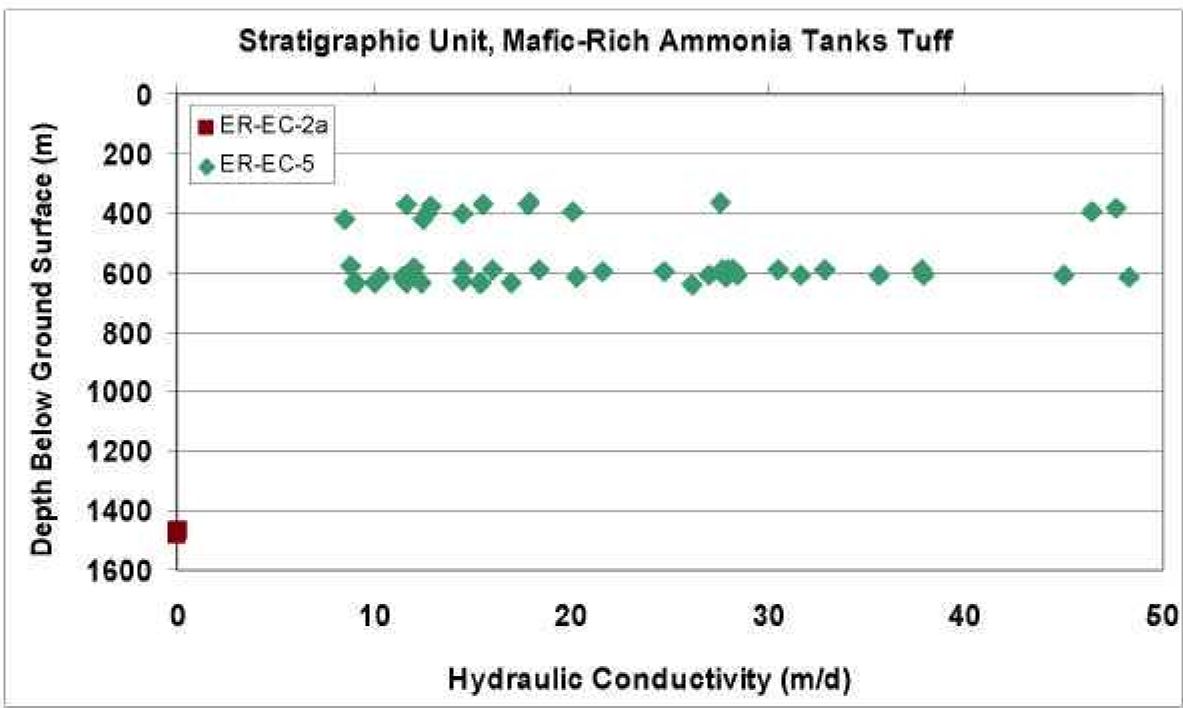


Figure 100. Detected hydraulic conductivity with depth for the stratigraphic unit mafic-rich Ammonia Tanks Tuff.

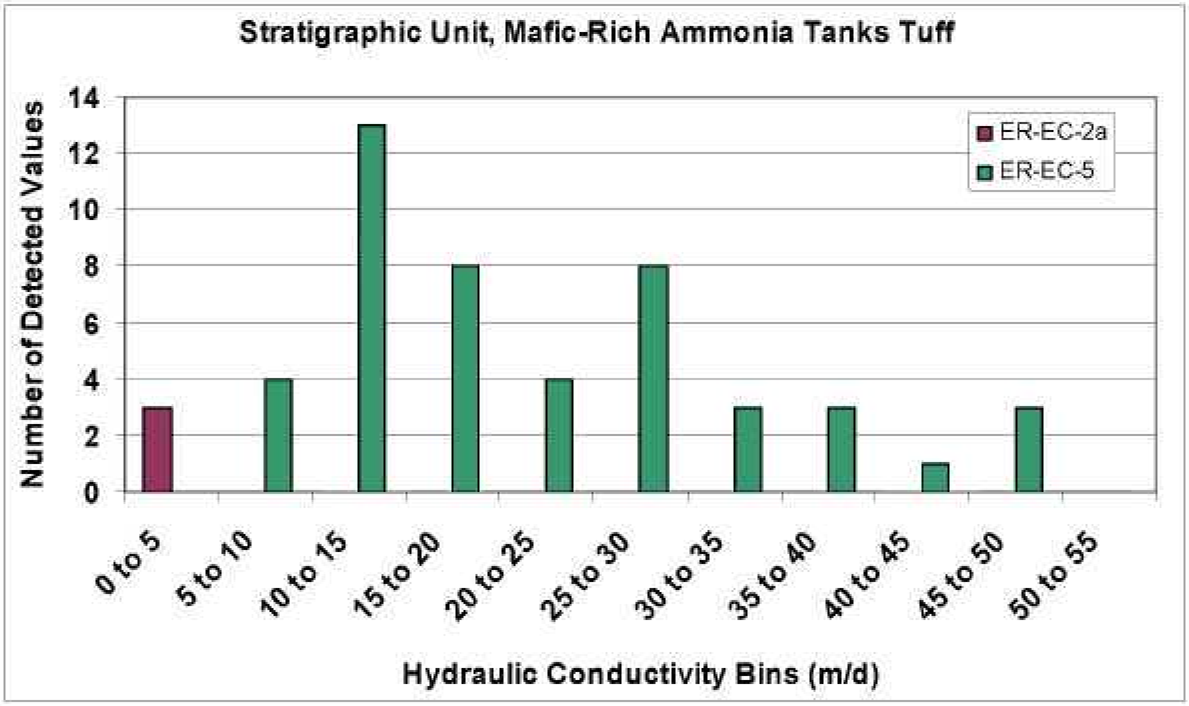


Figure 101. Detected hydraulic conductivity for individual wells for the stratigraphic unit mafic-rich Ammonia Tanks Tuff.

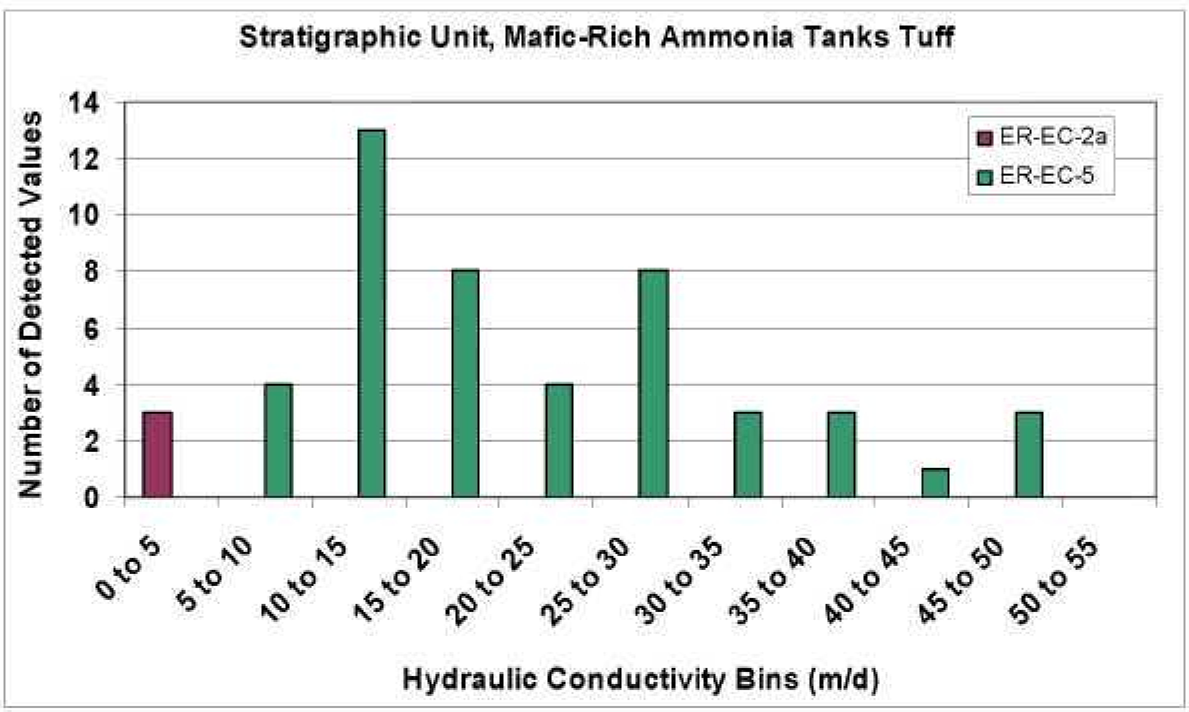


Figure 102. Detected hydraulic conductivity for wells in composite for the stratigraphic unit mafic-rich Ammonia Tanks Tuff.

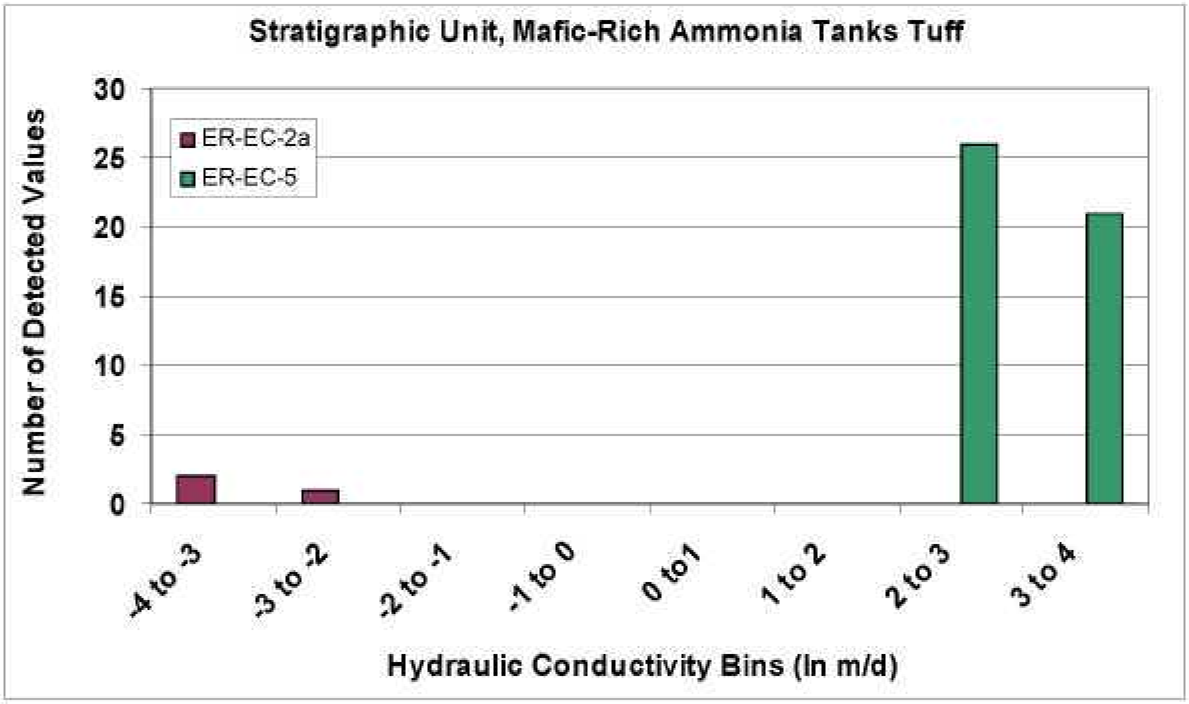


Figure 103. Detected natural logarithm hydraulic conductivity for individual wells for the stratigraphic unit mafic-rich Ammonia Tanks Tuff.

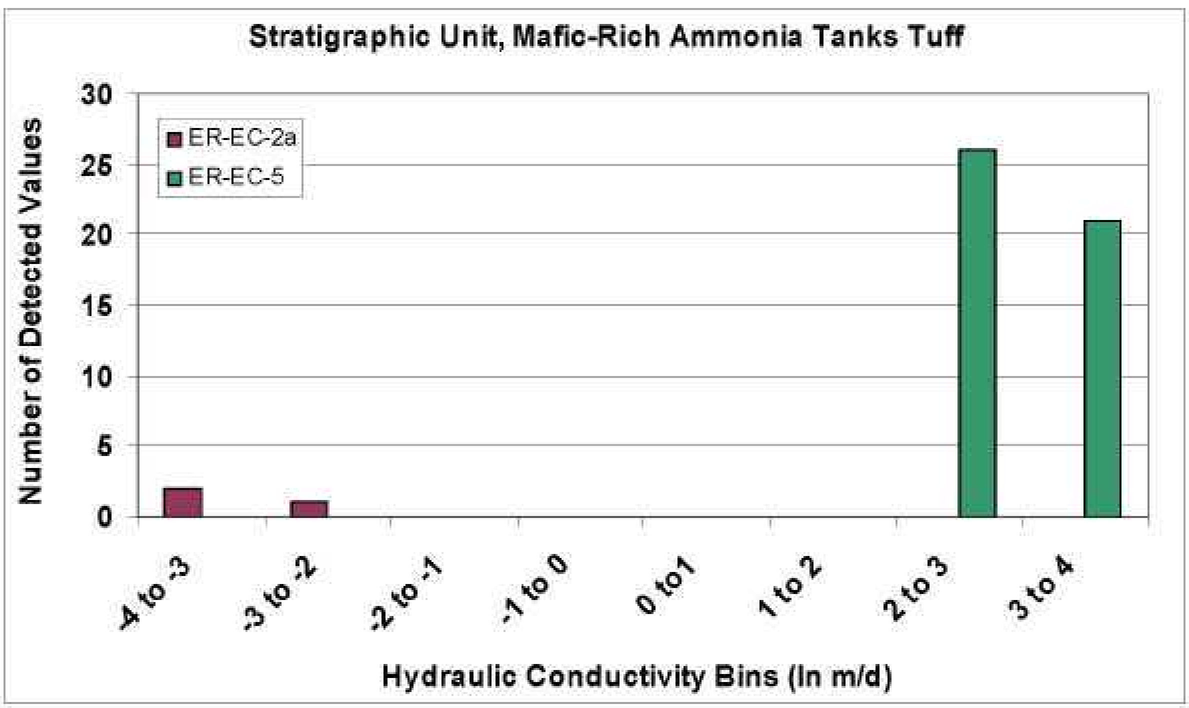


Figure 104. Detected natural logarithm hydraulic conductivity for wells in composite for the stratigraphic unit mafic-rich Ammonia Tanks Tuff.

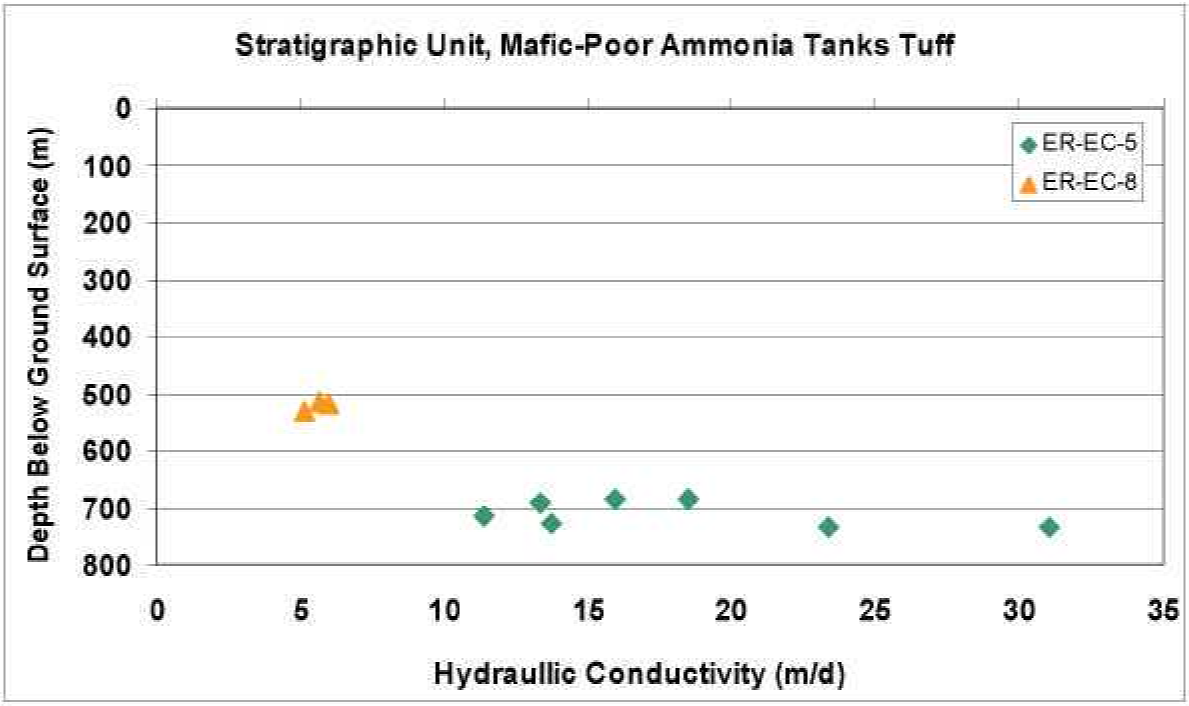


Figure 105. Detected hydraulic conductivity with depth for the stratigraphic unit mafic-poor Ammonia Tanks Tuff.

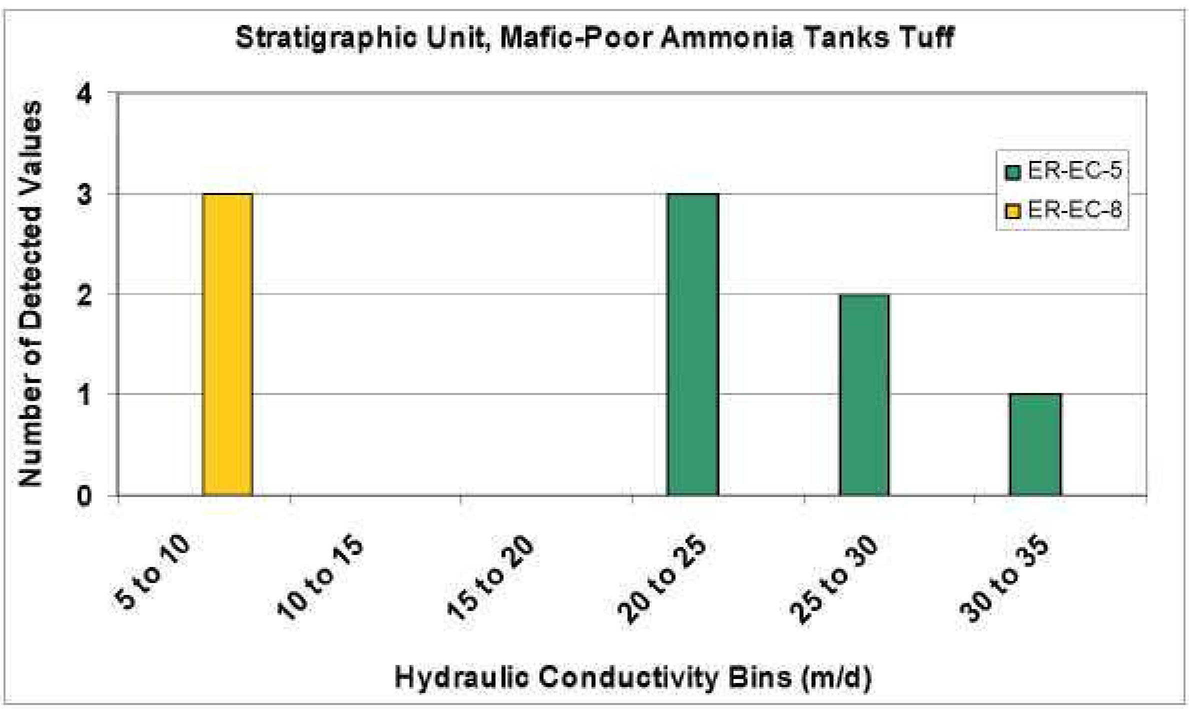


Figure 106. Detected hydraulic conductivity for individual wells for the stratigraphic unit mafic-poor Ammonia Tanks Tuff.

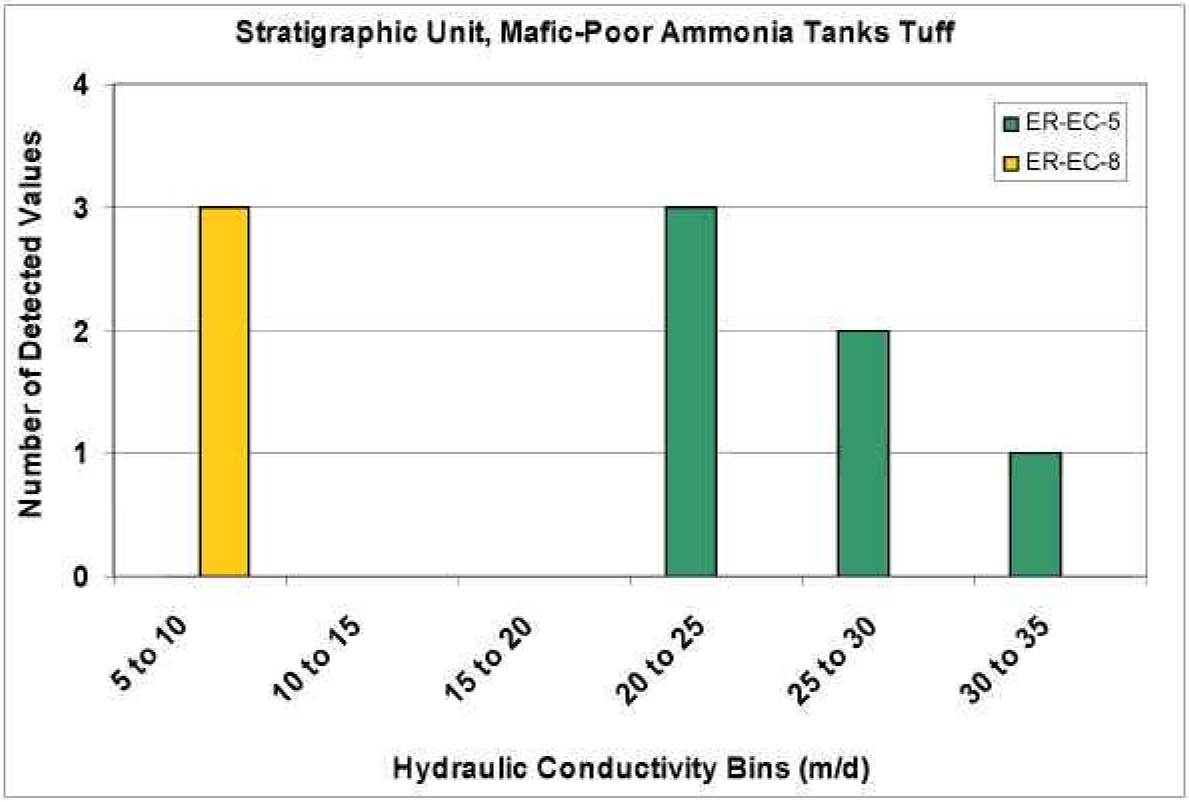


Figure 107. Detected hydraulic conductivity for wells in composite for the stratigraphic unit mafic-poor Ammonia Tanks Tuff.

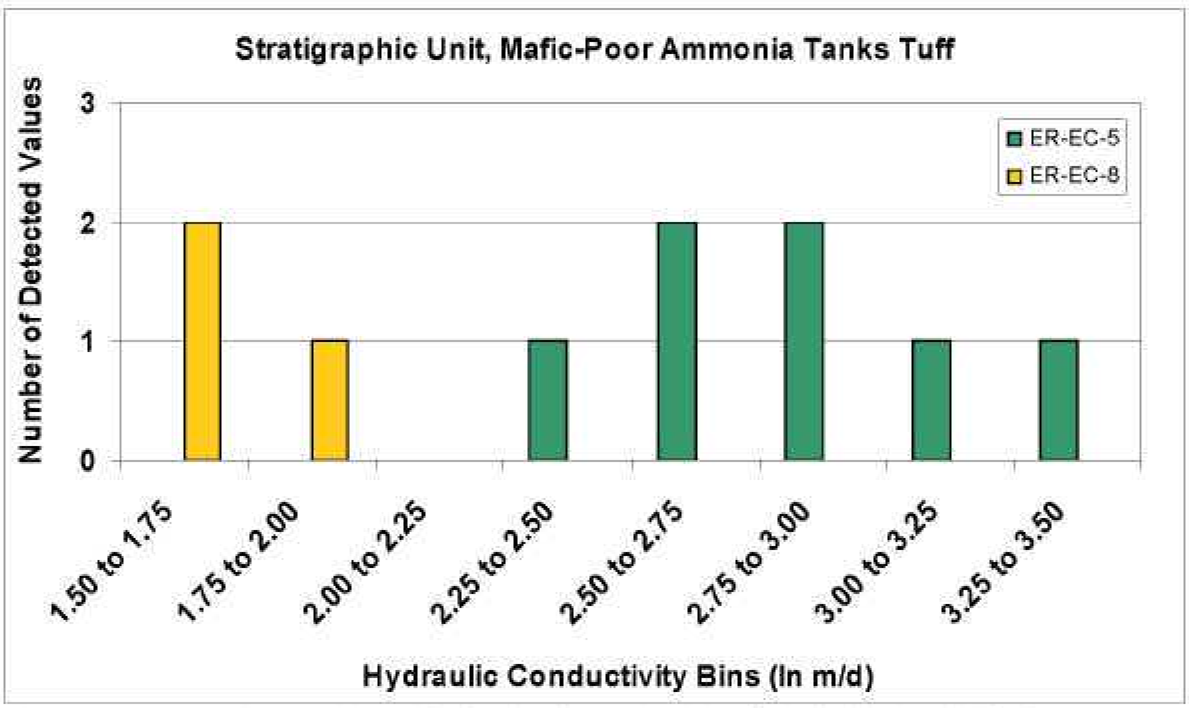


Figure 108. Detected natural logarithm hydraulic conductivity for individual wells for the stratigraphic unit mafic-poor Ammonia Tanks Tuff.

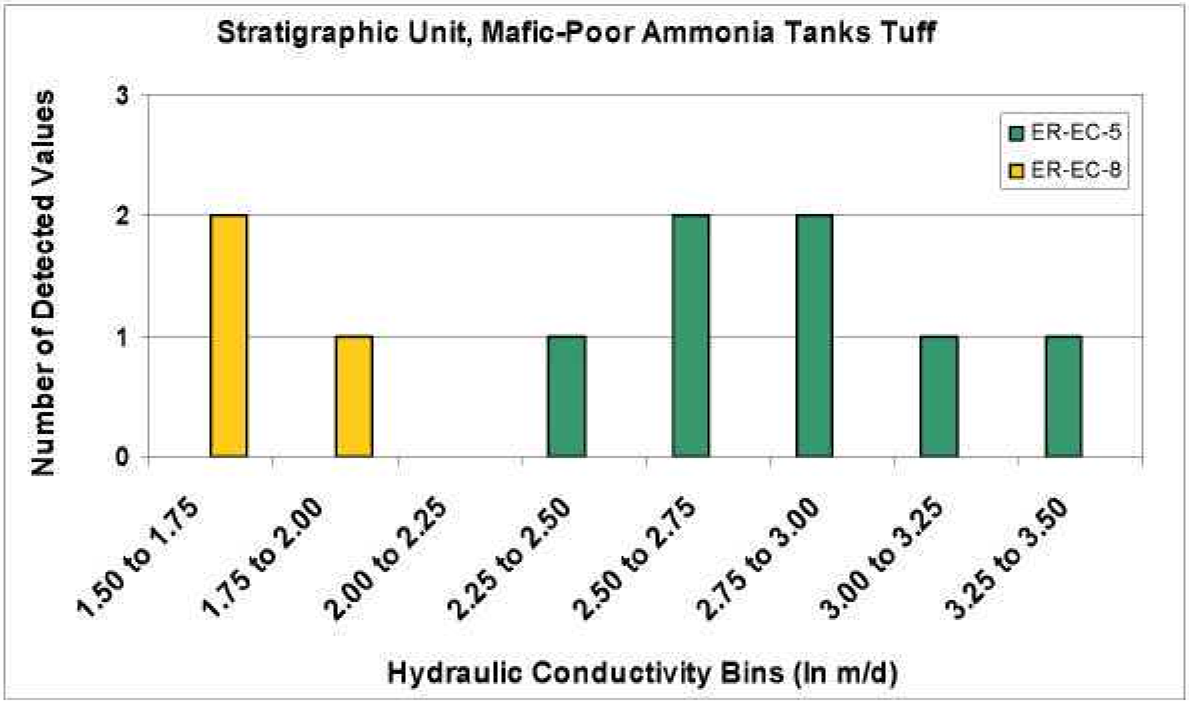


Figure 109. Detected natural logarithm hydraulic conductivity for wells in composite for the stratigraphic unit mafic-poor Ammonia Tanks Tuff.

The detected hydraulic conductivity with depth for the Rhyolite of Benham is presented in Figure 110. Wells ER-EC-1 and ER-EC-6 have dissimilar hydraulic conductivity values. Figures 111 through 114 present detected hydraulic conductivity for the wells individually and in composite for normal and log-transformed values. The distributions in Figures 111 and 112 display a weak trend for more low values than high values. Log-transformation of the values in Figure 113 suggests that the values for each well form a separate lognormal distribution with the values for well ER-EC-1 slightly higher than well ER-EC-6. Figure 114 indicates that the values are sufficiently similar to form a composite lognormal distribution with the values for well ER-EC-1 slightly higher than well ER-EC-6.

Hydraulic Conductivity and Lithologic Modifier

There are five lithologic modifier units with detected hydraulic conductivity in more than one well. The names of the lithologic modifier units and their abbreviations are provided in Table 7. The lithologic modifier association with screened intervals and hydraulic conductivity for all wells in tuff is presented in Table 16. The lithologic modifier partially welded tuff (PWT) is a special case where each of the two wells with detected hydraulic conductivity (e.g., ER-EC-1 and ER-EC-4) has only one value.

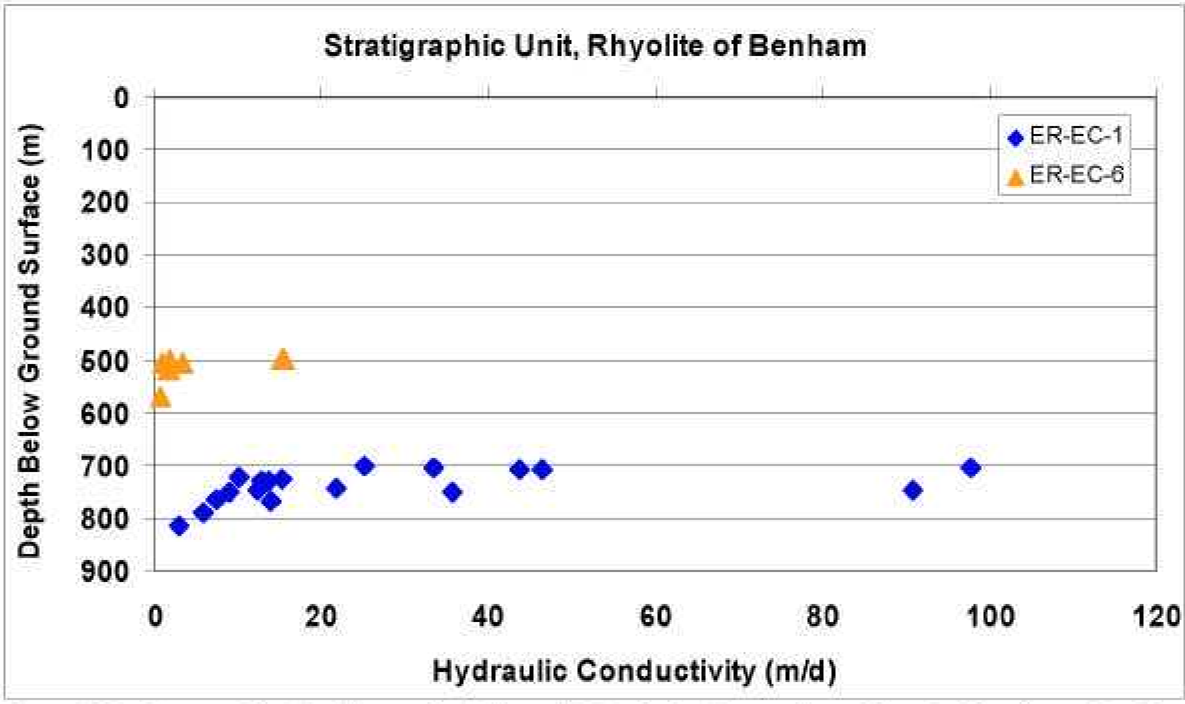


Figure 110. Detected hydraulic conductivity with depth for the stratigraphic unit Rhyolite of Benham Tuff.

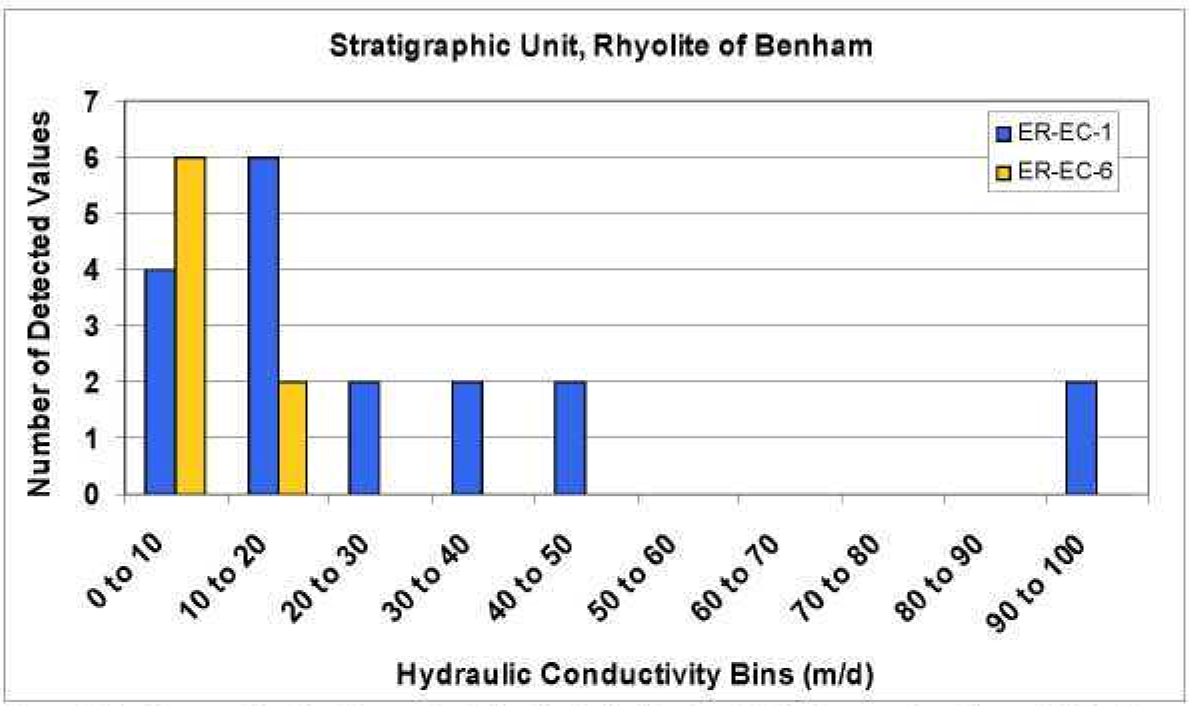


Figure 111. Detected hydraulic conductivity for individual wells for the stratigraphic unit Rhyolite of Benham Tuff.

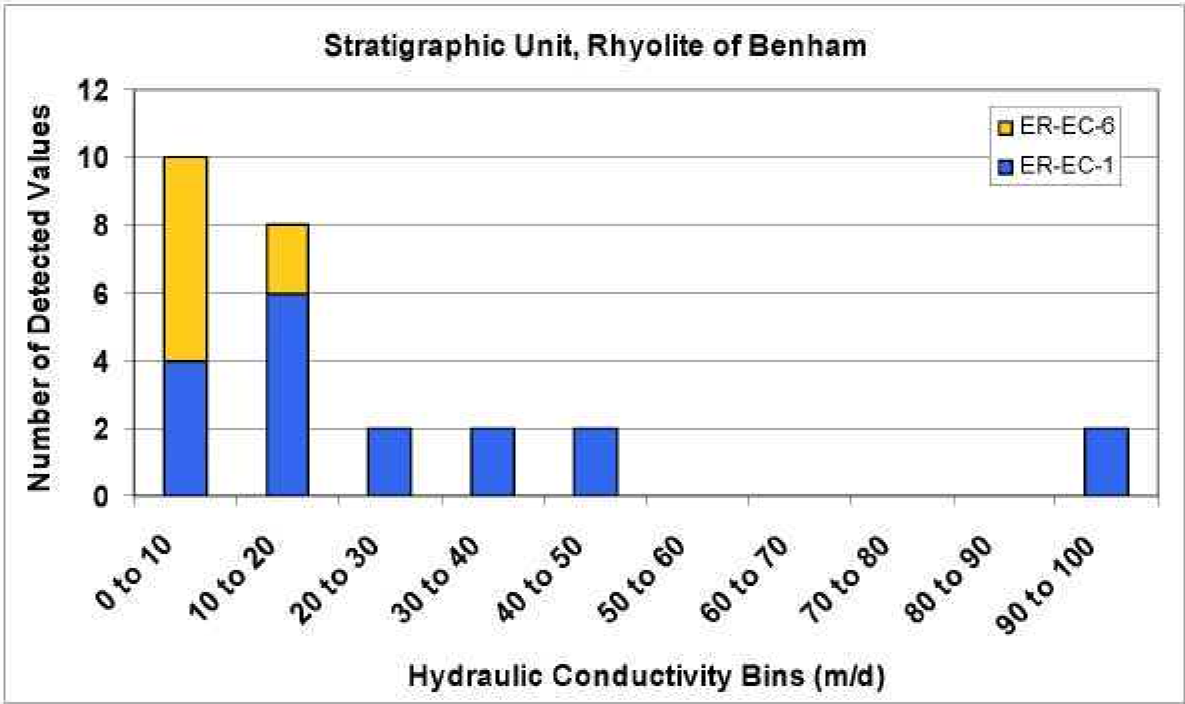


Figure 112. Detected hydraulic conductivity for wells in composite for the stratigraphic unit Rhyolite of Benham Tuff.

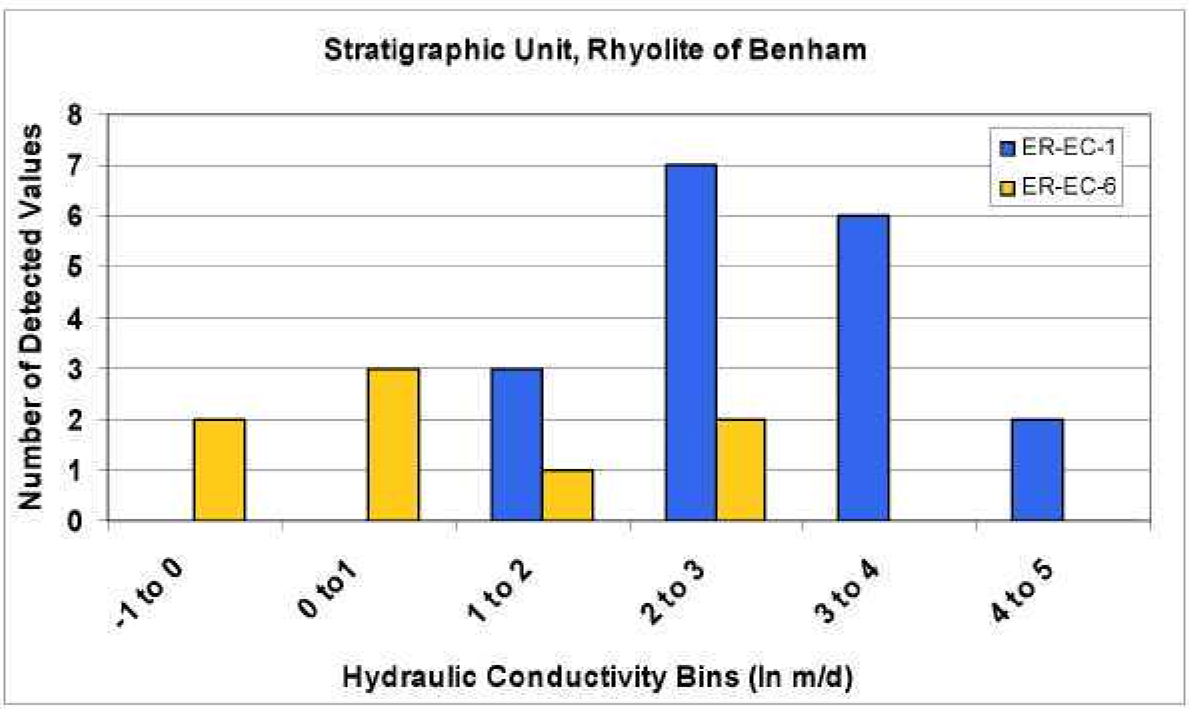


Figure 113. Detected natural logarithm hydraulic conductivity for individual wells for the stratigraphic unit Rhyolite of Benham Tuff.

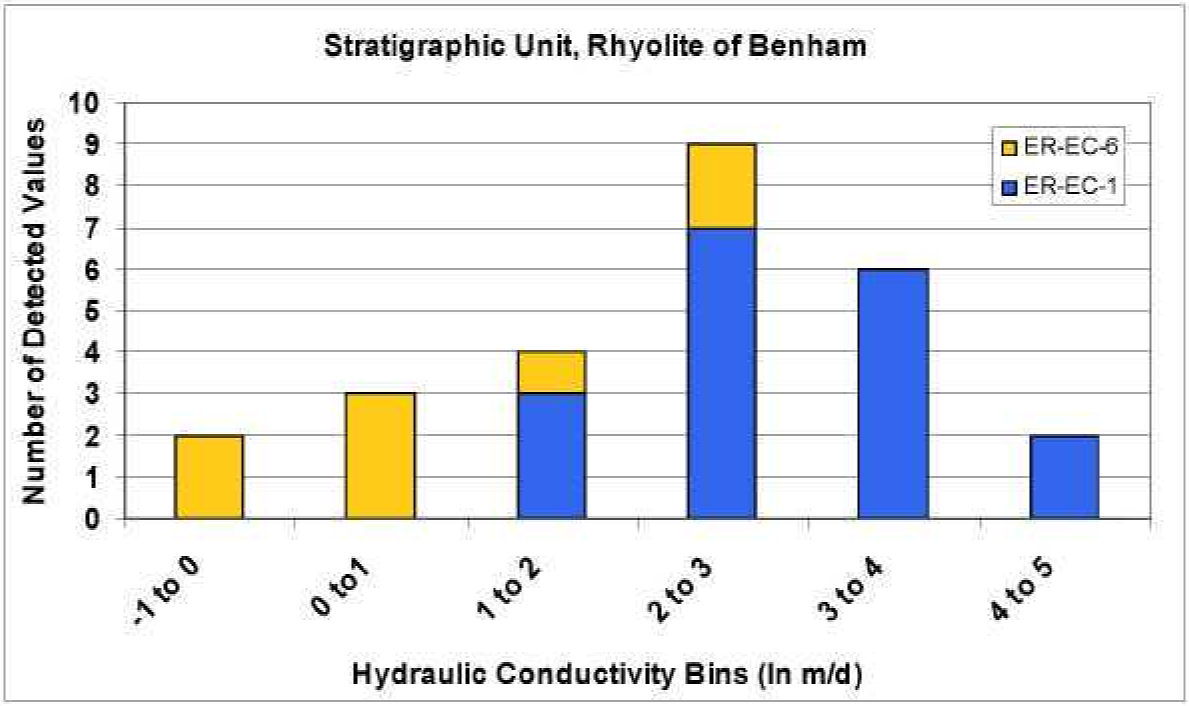


Figure 114. Detected natural logarithm hydraulic conductivity for wells in composite for the stratigraphic unit Rhyolite of Benham Tuff.

Table 16. Lithologic units encountered at multiple wells in tuff.

Lithologic Modifier	ER-EC-1		ER-EC-2a		ER-EC-4		ER-EC-5		ER-5-4#2		ER-EC-6		ER-EC-7		ER-EC-8	
	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)
NWT	0	0	164.0	**27.1**	6.4	0	0	0	46.8	**20.3**	46.6	0	0	0	62.1	**22.7**
NWT-PWT	10.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PWT	7.4	**1.5**	0	0	27.1	**1.6**	0	0	0	0	31.0	0	0	0	7.2	0
PWT-MWT	6.0	**1.5**	0	0	0	0	0	0	0	0	0	0	0	0	7.2	0
MWT	7.4	0	45.1	**4.5**	41.4	0	62.5	**28.2**	0	0	7.2	0	0	0	0	0
MWT-DWT	0	0	0	0	0	0	23.4	**4.2**	0	0	0	0	0	0	0	0
DWT	0	0	0	0	8.0	0	0	0	0	0	0	0	0	0	0	0
VT	8.9	0	0	0	3.2	0	0	0	0	0	0	0	0	0	0	0
BED	40.2	**3.0**	130.9	**49.7**	6.4	0	0	0	0	0	8.4	0	1.4	0	0	0
PL	19.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LA	22.3	**20.9**	0	0	39.8	**23.9**	0	0	0	0	31.0	**4.8**	48.1	**8.2**	0	0
VL	3.0	0.0	0	0	0	0	0	0	0	0	0	0	1.4	0	0	0
FB	26.8	**6.0**	0	0	0	0	0	0	0	0	0	0	16.5	0	0	0
TSLT	0	0	13.5	**4.5**	0	0	0	0	0	0	0	0	0	0	0	0
RWT	0	0	24.1	**3.0**	0	0	0	0	0	0	0	0	0	0	0	0
CL	0	0	0	0	3.2	**1.6**	0	0	0	0	0	0	0	0	0	0
TG	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Stratigraphic units are not presented in stratigraphic sequence

Gray shading indicates a stratigraphic unit that occurs in multiple wells

Bold type indicates length of detectable hydraulic conductivity for stratigraphic units with detectable hydraulic conductivity in more than one well

The detected hydraulic conductivity with depth for nonwelded tuff is presented in Figure 115. Well ER-EC-2a has much lower hydraulic conductivity values than wells ER-5-4#2 or ER-EC-8. Figures 116 through 119 present the detected hydraulic conductivity for the wells individually and in composite for normal and log-transformed values. Figures 118 and 119 show essentially two separate lognormal distributions with well ER-EC-2a having much lower values and ER-5-4#2 and ER-EC-8 sharing a similar distribution. The visual interpretation is that well ER-EC-2a forms a separate population from ER-5-4#2 and ER-EC-8.

The detected hydraulic conductivity with depth for moderately welded tuff is presented in Figure 120. Well ER-EC-2a has much lower hydraulic conductivity values than well ER-EC-5. Figures 121 through 124 present the detected hydraulic conductivity for the wells individually and in composite for normal and log-transformed values. Because the ranges of values for the two wells do not overlap, the figures for the wells individually and in composite are identical. Figure 123 indicates the wells have two separate distributions with well ER-EC-2a having much lower values than ER-EC-5. There are too few values (i.e., three) to characterize the distribution for ER-EC-2a, but it appears to form a separate population from ER-EC-5. The data for ER-EC-5 appear to form a lognormal distribution.

The detected hydraulic conductivity with depth for bedded tuff is presented in Figure 125. Well ER-EC-2a has somewhat lower hydraulic conductivity values than well ER-EC-1. Figures 126 through 129 present the detected hydraulic conductivity for the wells individually and in composite for normal and log-transformed values. Because the ranges of values for the two wells do not overlap, the figures for the wells individually and in composite are identical. Figure 128 indicates that well ER-EC-2a has much lower values than ER-EC-1. The data for ER-EC-2a appear to form a lognormal distribution. There are too few values (i.e., two) to characterize the distribution for ER-EC-1.

The detected hydraulic conductivity with depth for lava is presented in Figure 130. There are four wells with detectable hydraulic conductivity and this forms the most populated data set for the hydrogeologic characteristic of lithologic modifier. The wells have overlapping data ranges. Figures 131 through 134 present the detected hydraulic conductivity for the wells individually and in composite for normal and log-transformed values. Figure 131 demonstrates that no individual well has a unique distribution. The wells are considered in composite in Figure 132 and demonstrate that low values are much more prevalent in lava and may represent a "heavy tailed" distribution. Log-transformed data for individual wells in Figure 133 are difficult to interpret for all of the wells. The wells in composite are presented in Figure 134 and visually suggest that the values are of the same population.

<u>Hydraulic Conductivity and Alteration Modifier</u>

There are four alteration modifier units with detected hydraulic conductivity in more than one well. The names of the alteration modifier units and their abbreviations are provided in Table 9. The alteration modifier association with screened intervals and hydraulic conductivity for all wells in tuff is presented in Table 17.

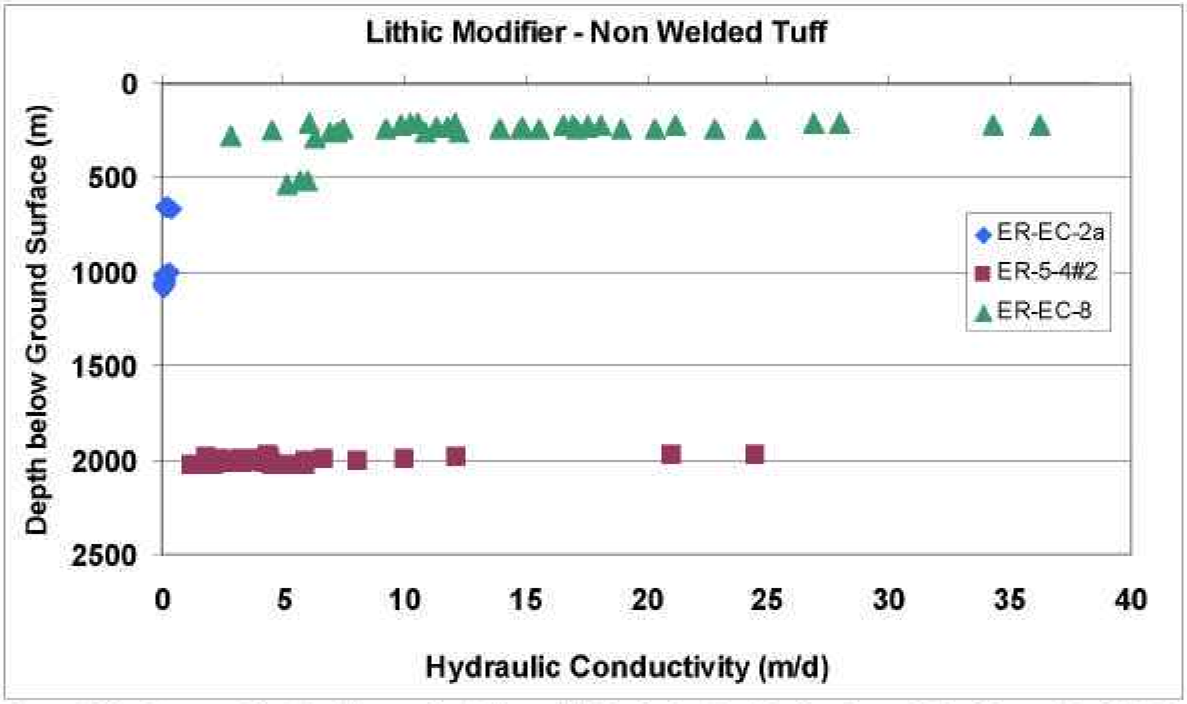


Figure 115. Detected hydraulic conductivity with depth for the lithologic modifier Nonwelded Tuff.

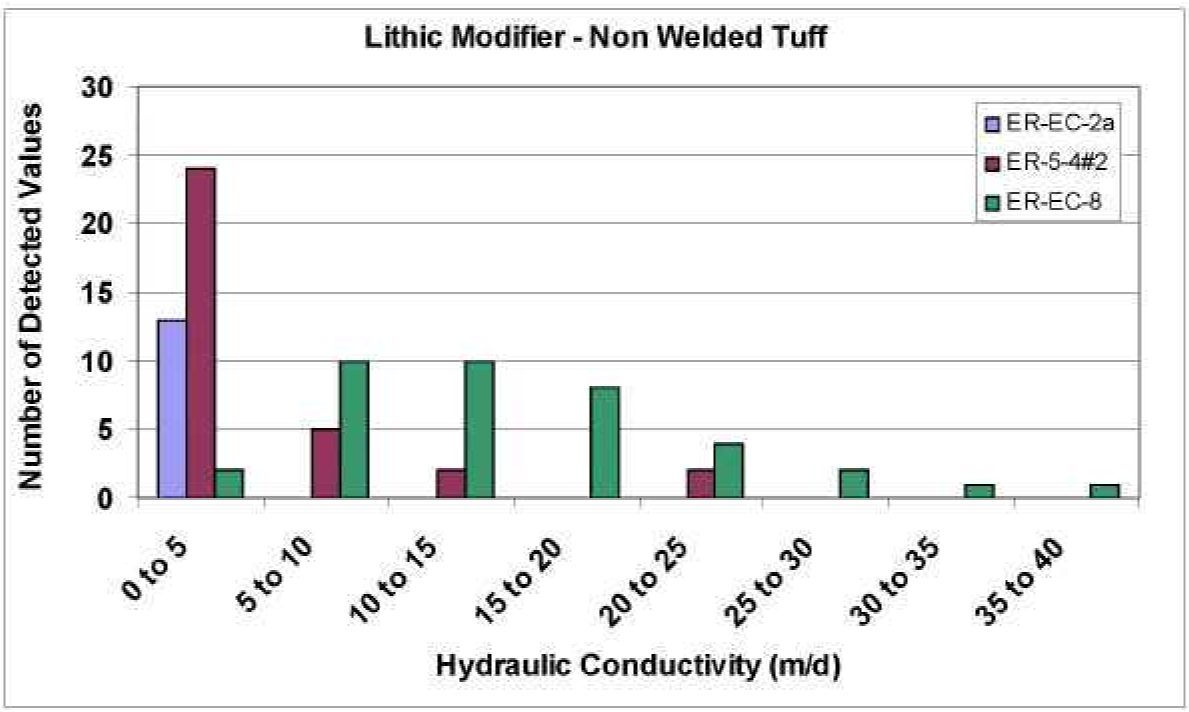


Figure 116. Detected hydraulic conductivity for individual wells for the lithologic modifier Nonwelded Tuff.

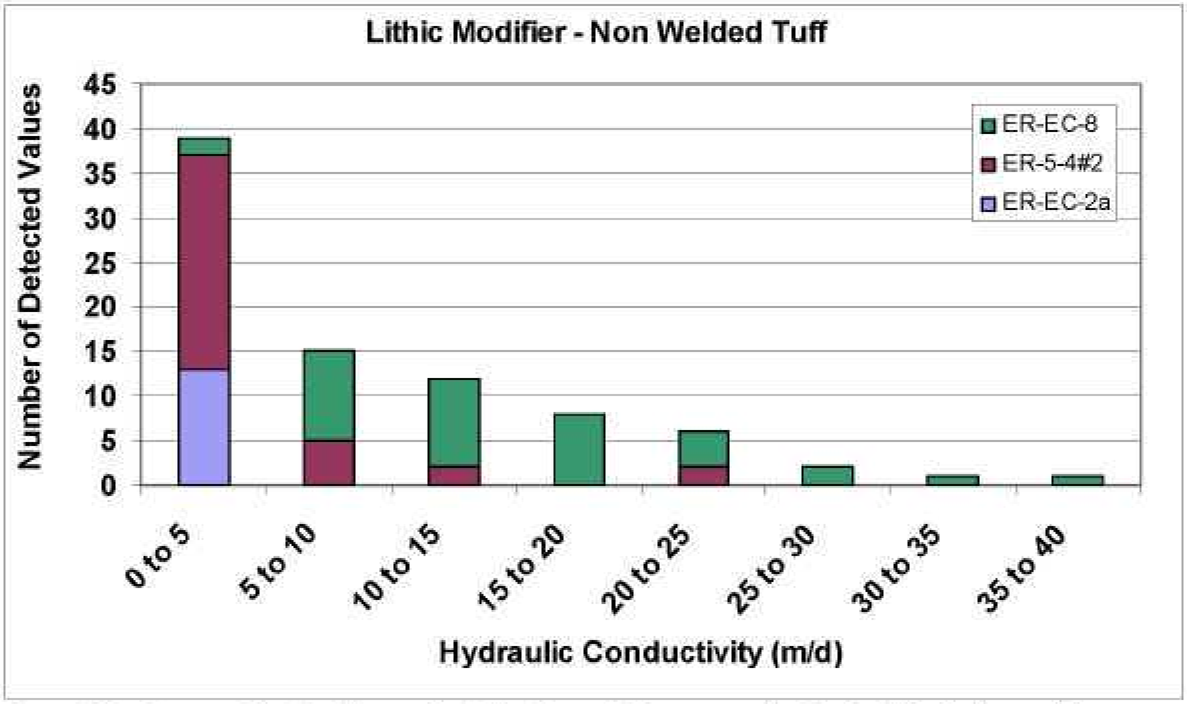


Figure 117. Detected hydraulic conductivity for wells in composite for the lithologic modifier Nonwelded Tuff.

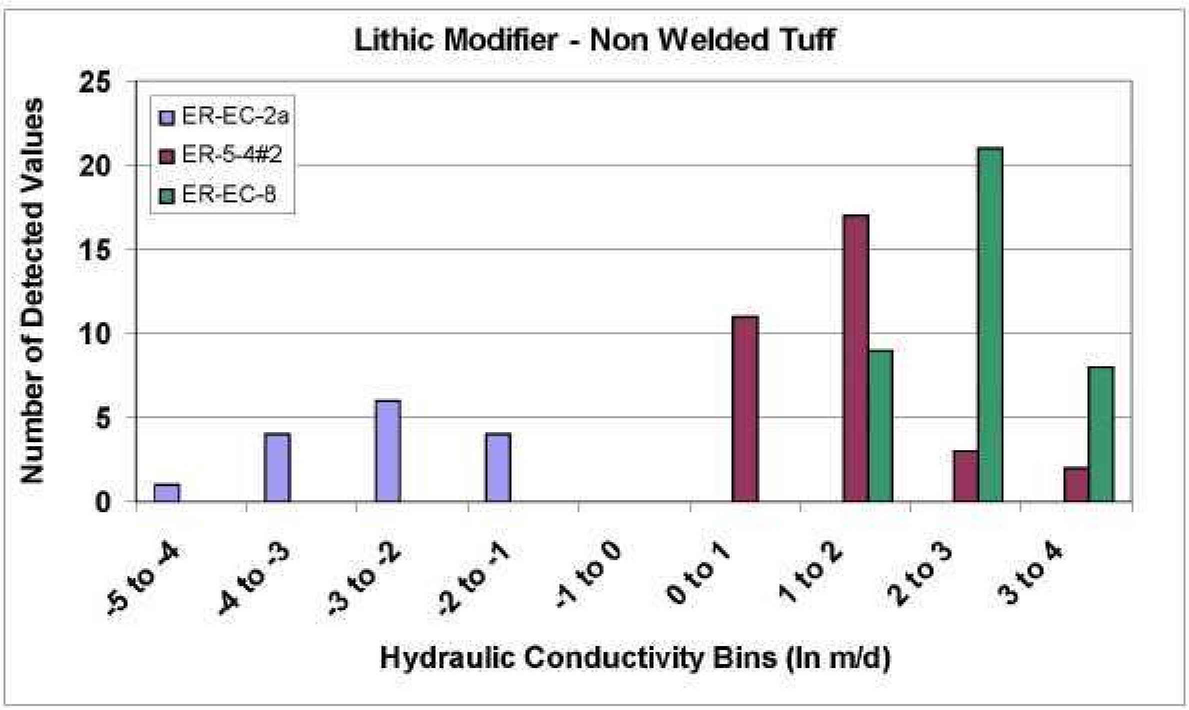


Figure 118. Detected natural logarithm hydraulic conductivity for individual wells for the lithologic modifier Nonwelded Tuff.

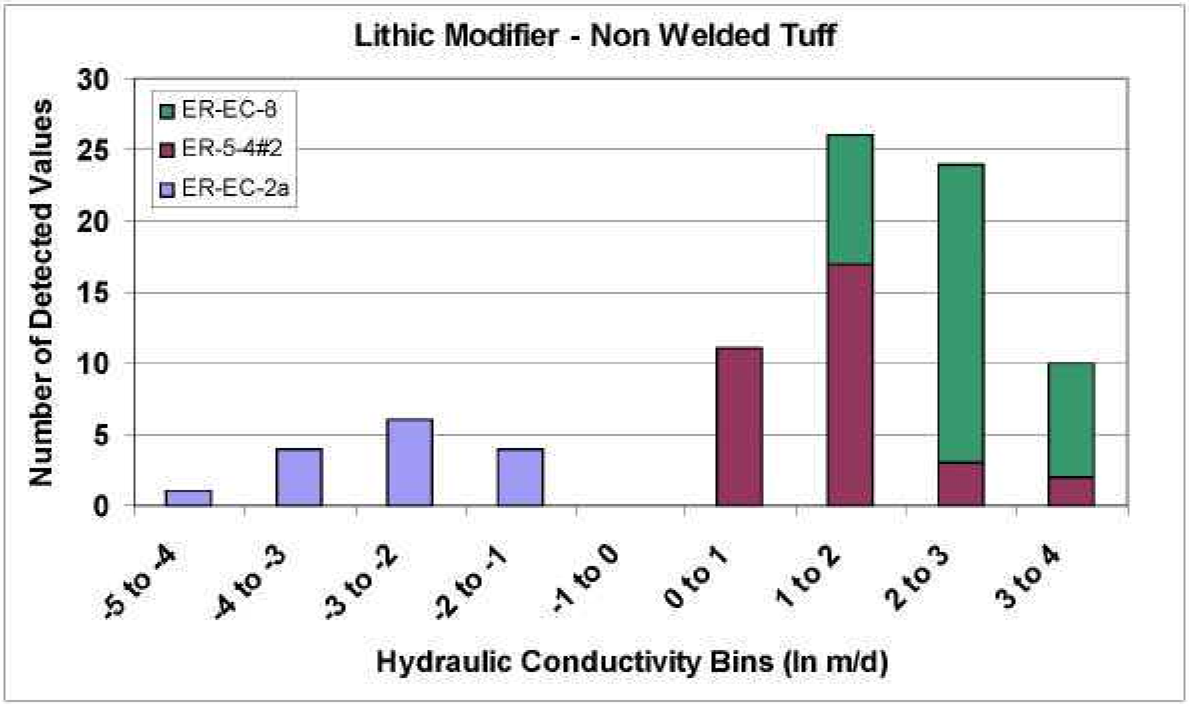


Figure 119. Detected natural logarithm hydraulic conductivity for wells in composite for the lithologic modifier Nonwelded Tuff.

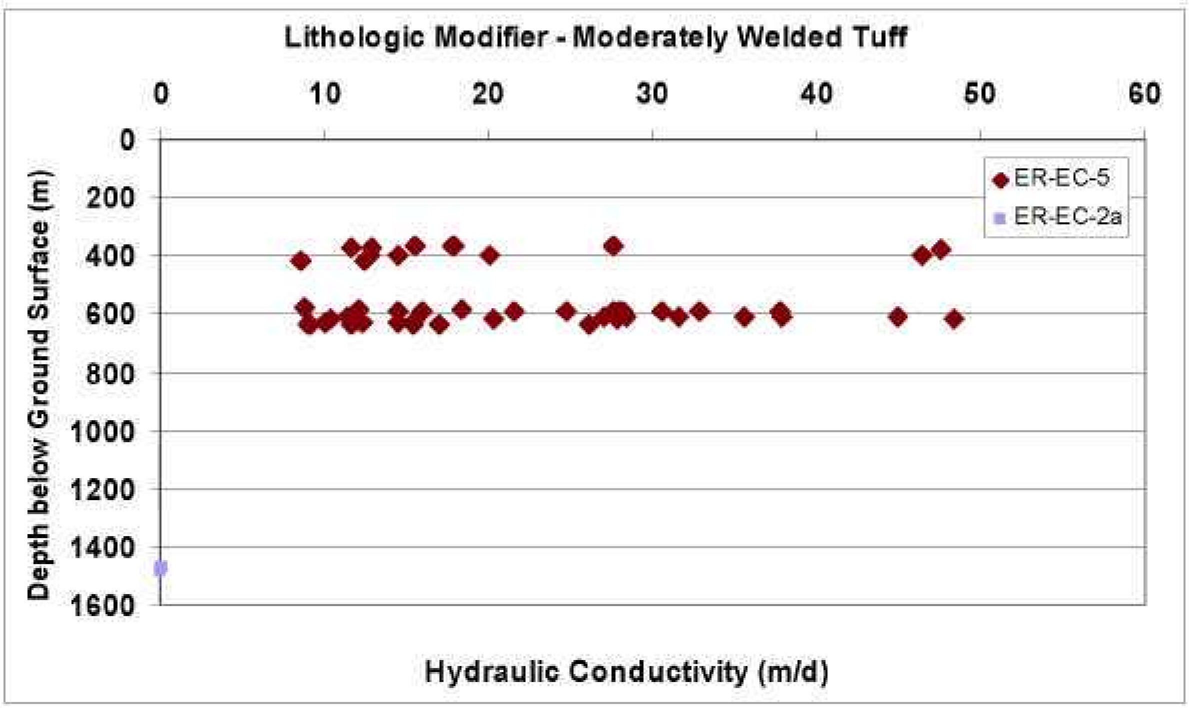


Figure 120. Detected hydraulic conductivity with depth for the lithologic modifier Moderately Welded Tuff.

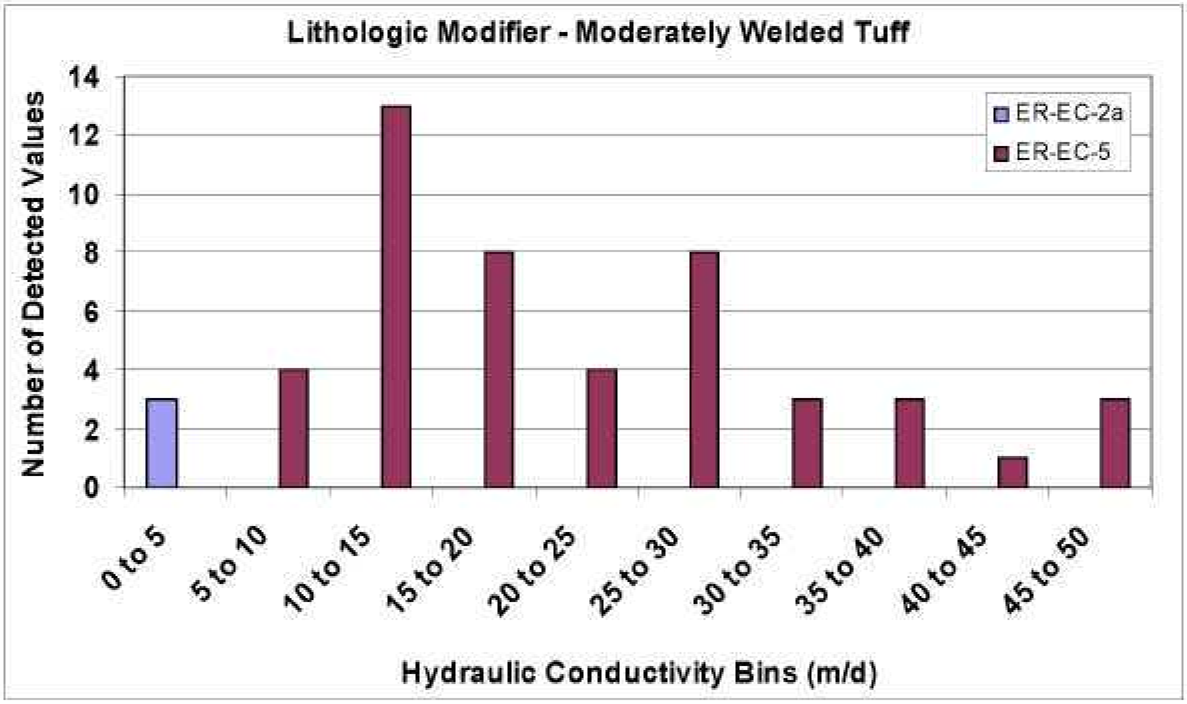


Figure 121. Detected hydraulic conductivity for individual wells for the lithologic modifier Moderately Welded Tuff.

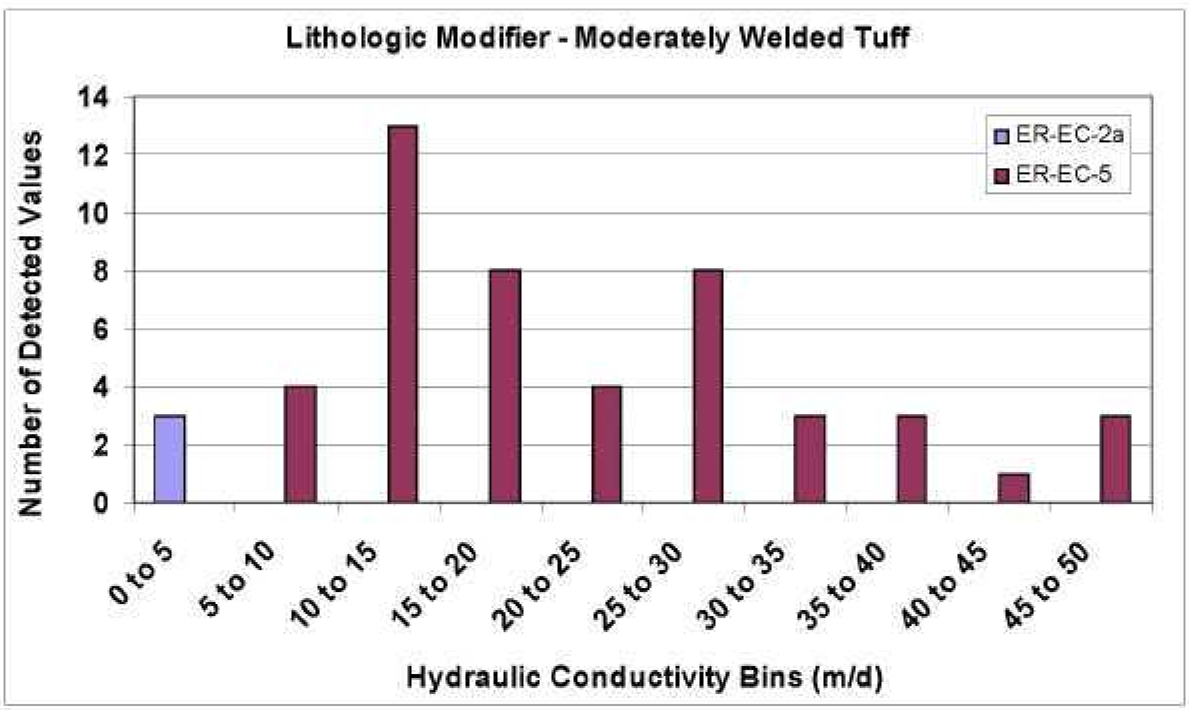


Figure 122. Detected hydraulic conductivity for wells in composite for the lithologic modifier Moderately Welded Tuff.

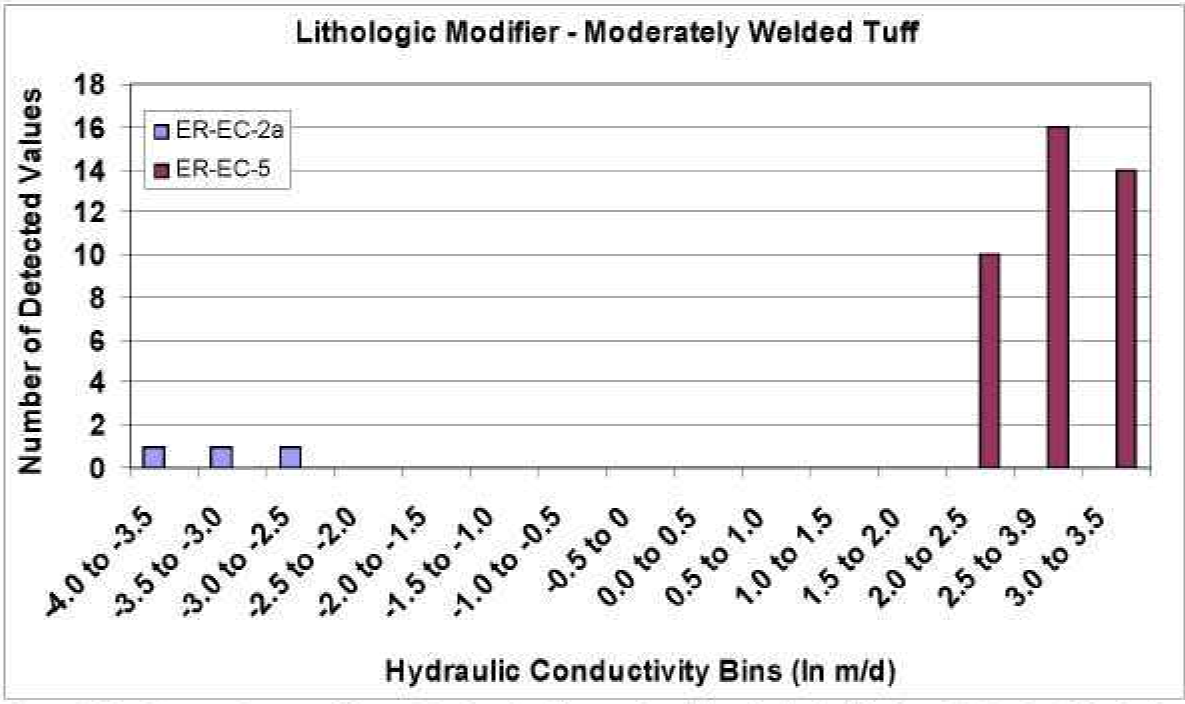


Figure 123. Detected natural logarithm hydraulic conductivity for individual wells for the lithologic modifier Moderately Welded Tuff.

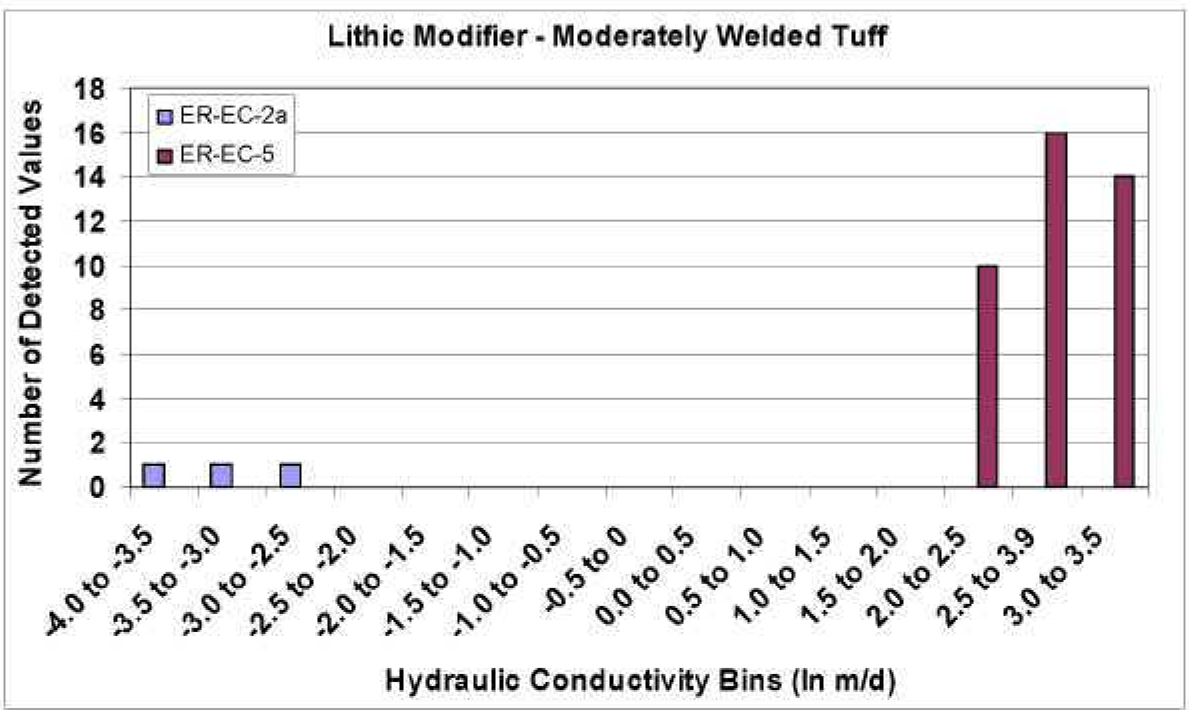


Figure 124. Detected natural logarithm hydraulic conductivity for wells in composite for the lithologic modifier Moderately Welded Tuff.

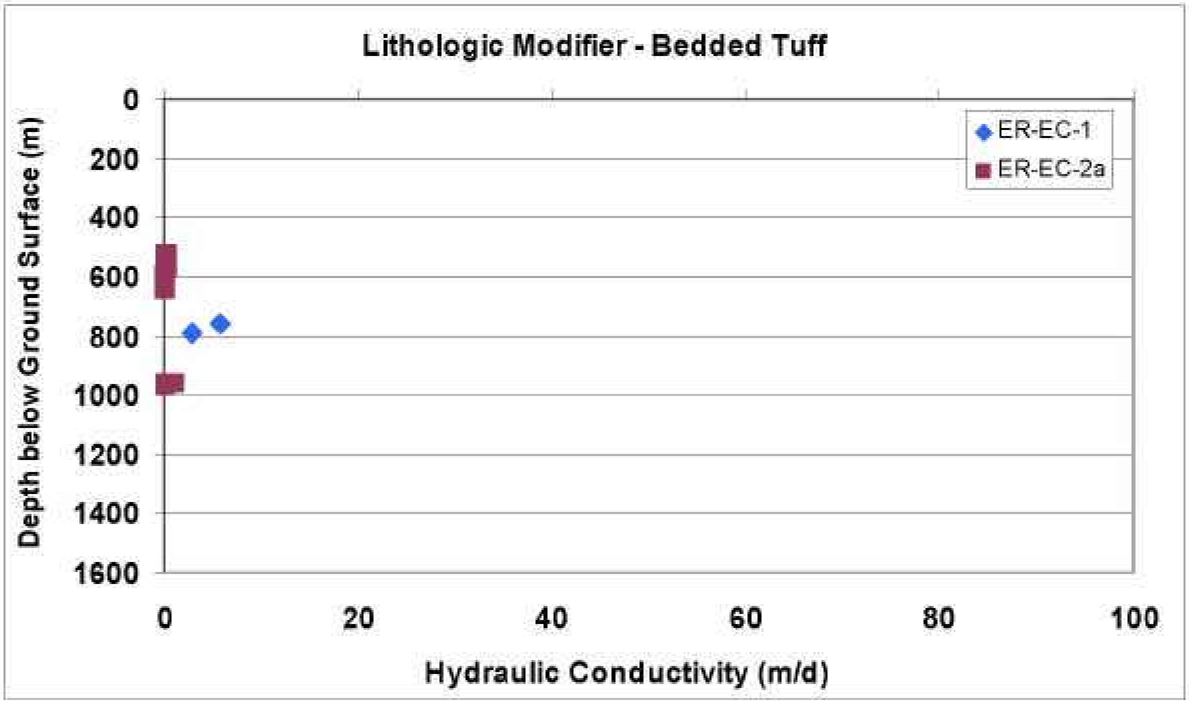


Figure 125. Detected hydraulic conductivity with depth for the lithologic modifier Bedded Tuff.

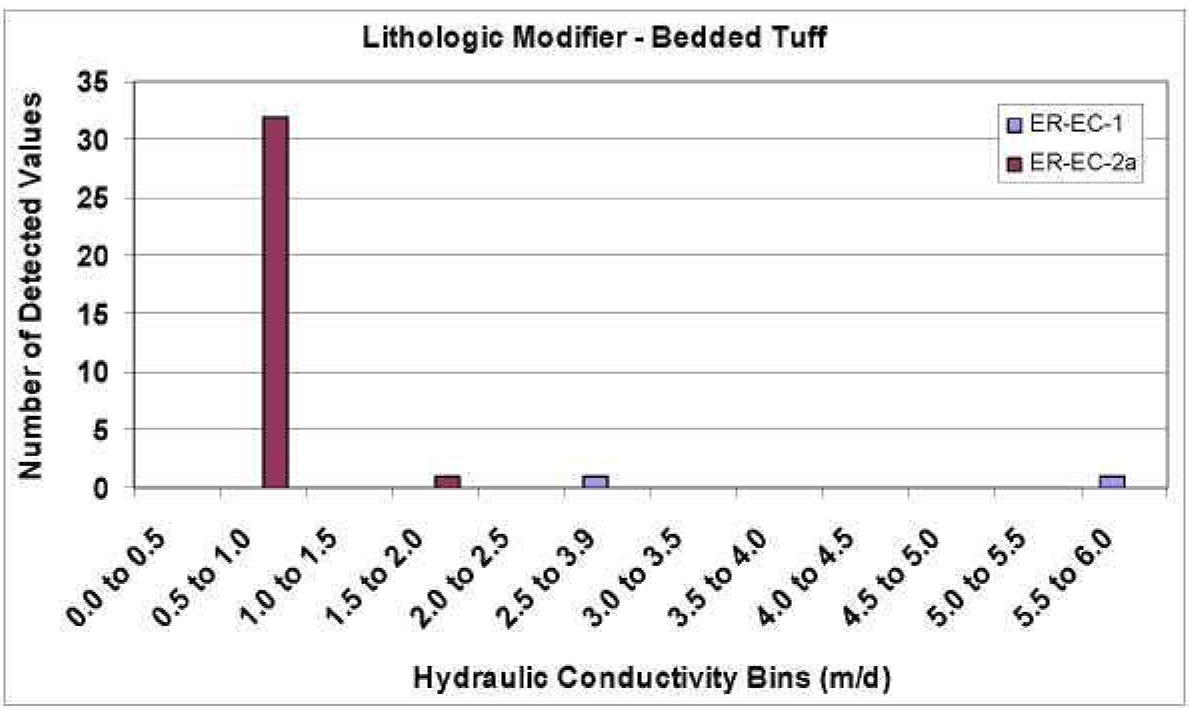


Figure 126. Detected hydraulic conductivity for individual wells for the lithologic modifier Bedded Tuff.

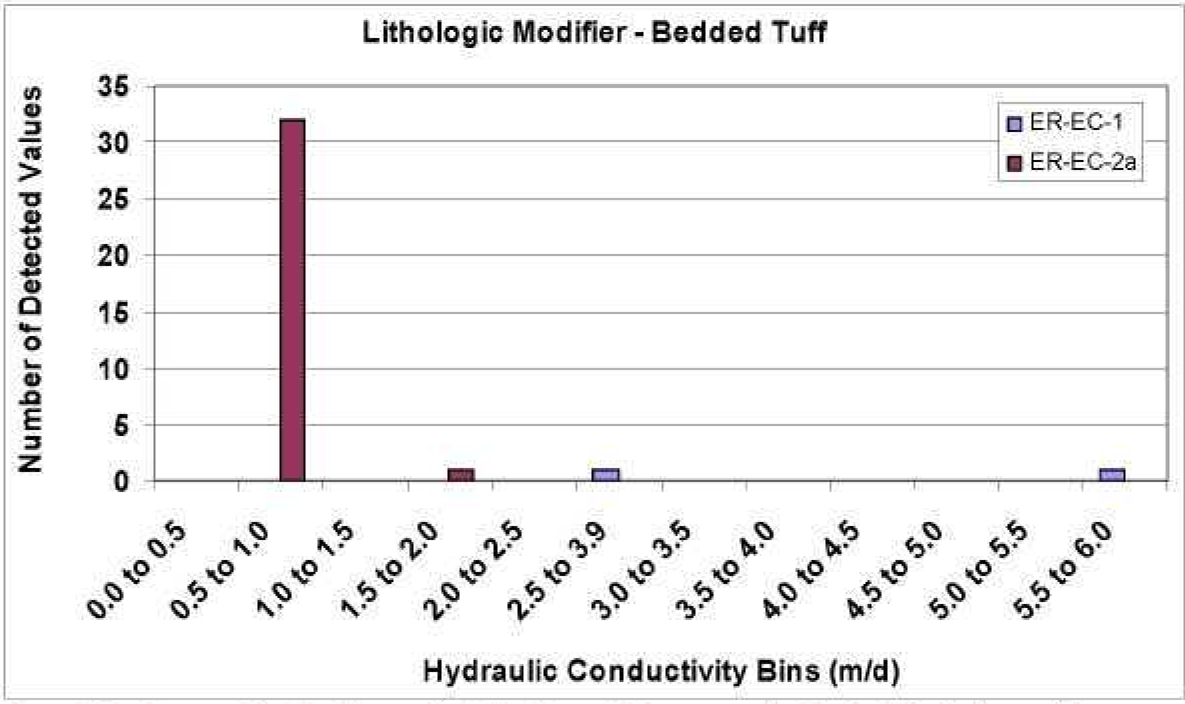


Figure 127. Detected hydraulic conductivity for wells in composite for the lithologic modifier Bedded Tuff.

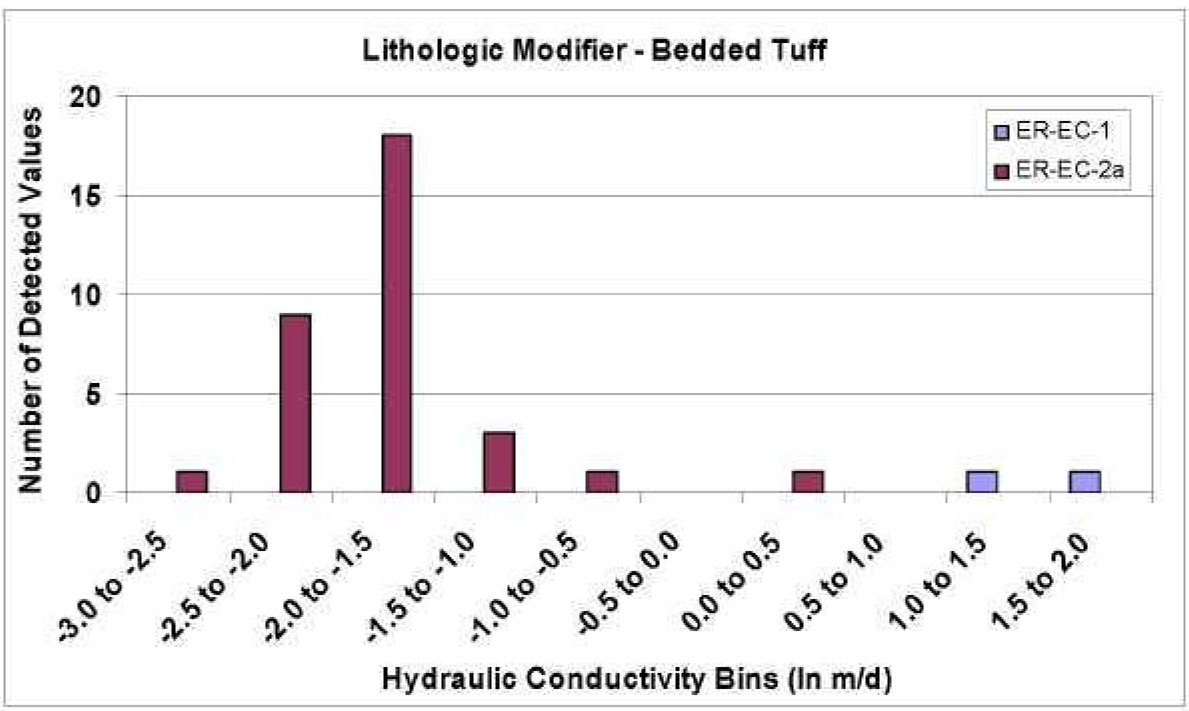


Figure 128. Detected natural logarithm hydraulic conductivity for individual wells for the lithologic modifier Bedded Tuff.

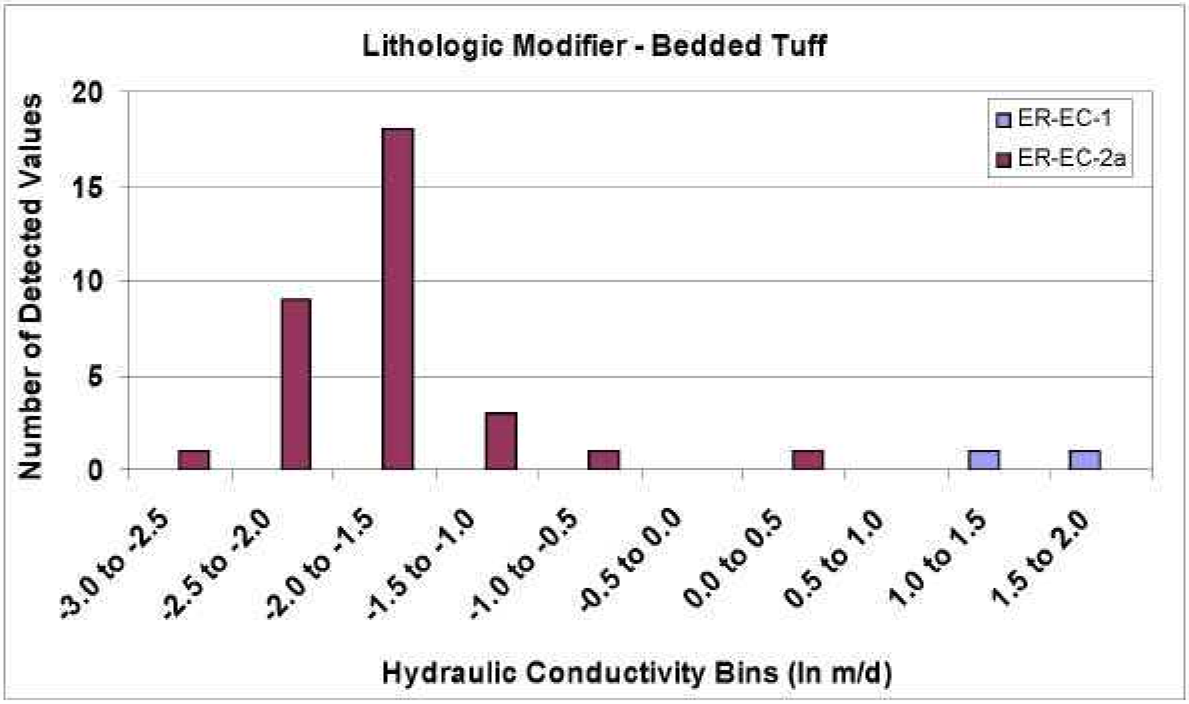


Figure 129. Detected natural logarithm hydraulic conductivity for wells in composite for the lithologic modifier Bedded Tuff.

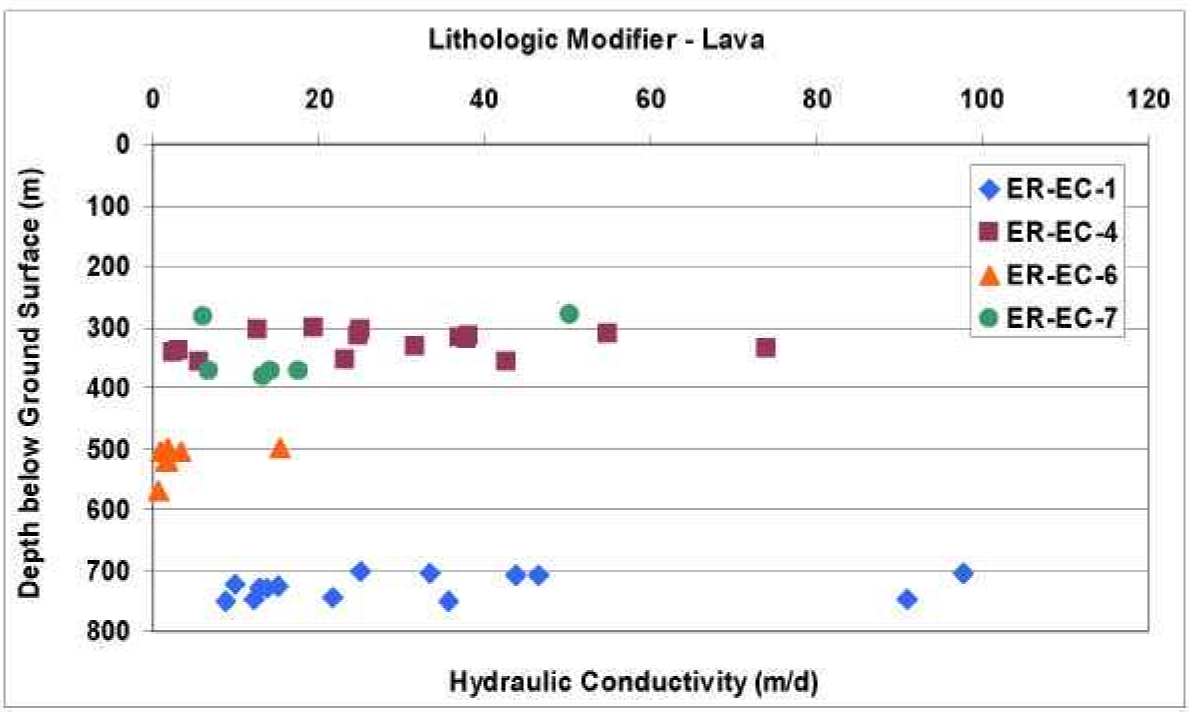


Figure 130. Detected hydraulic conductivity with depth for the lithologic modifier lava.

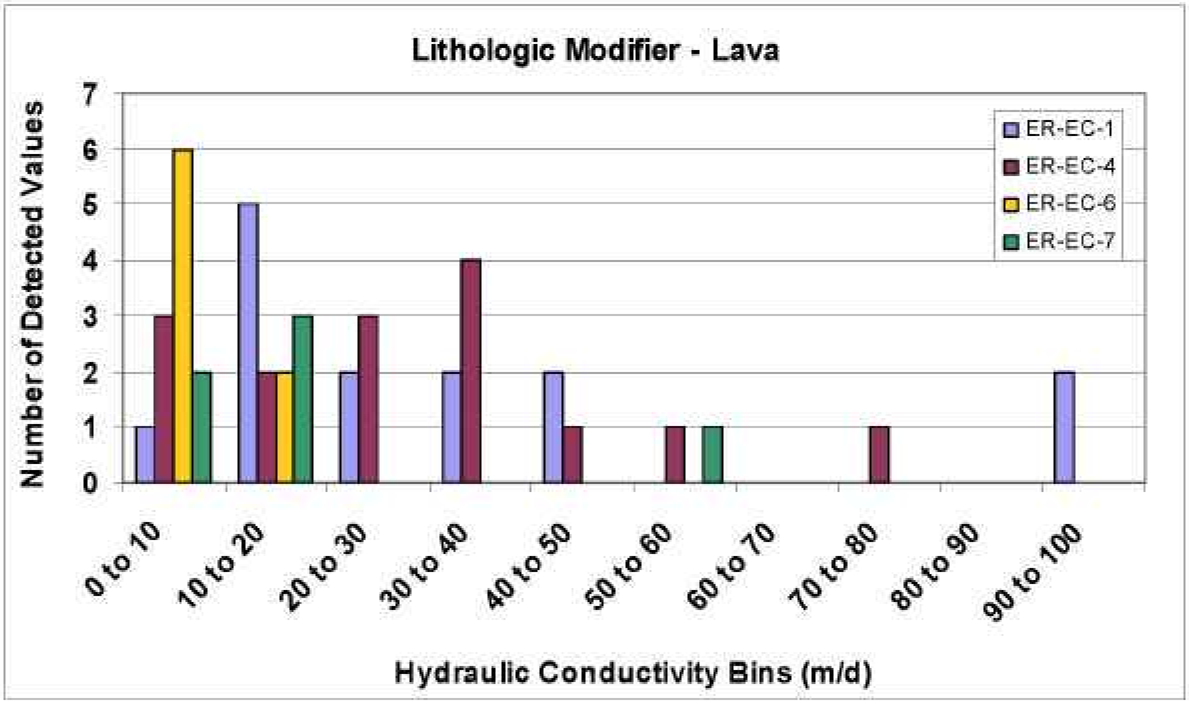


Figure 131. Detected hydraulic conductivity for individual wells for the lithologic modifier lava.

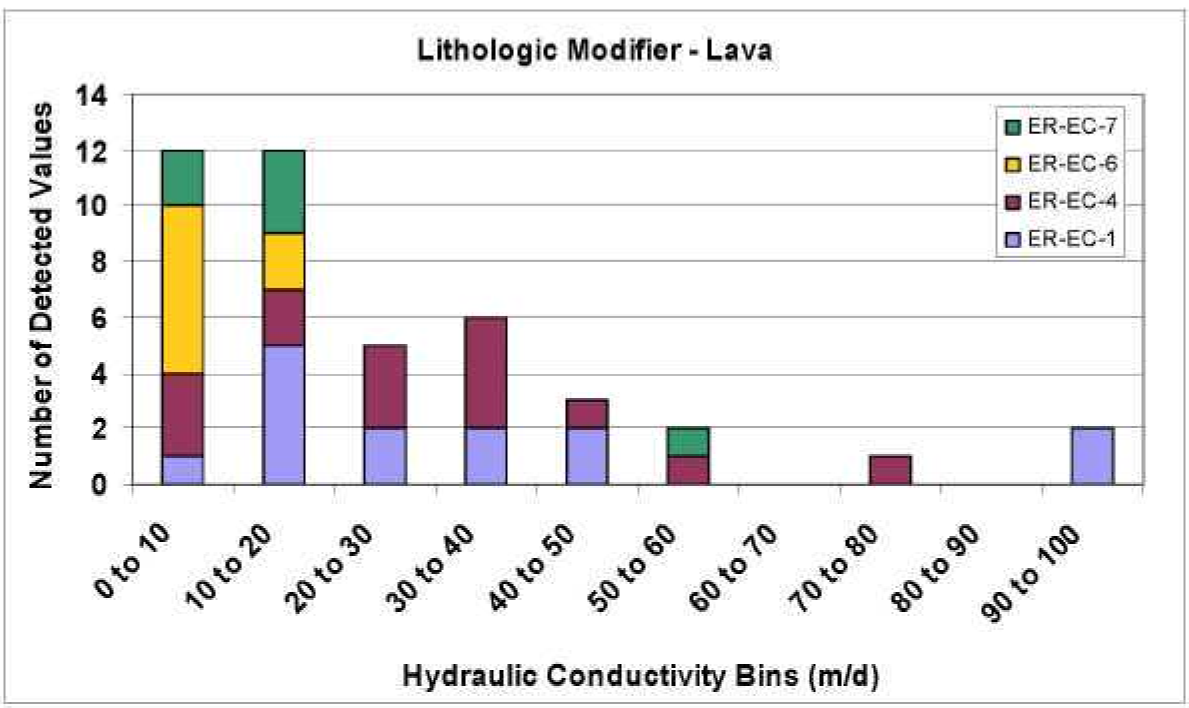


Figure 132. Detected hydraulic conductivity for wells in composite for the lithologic modifier lava.

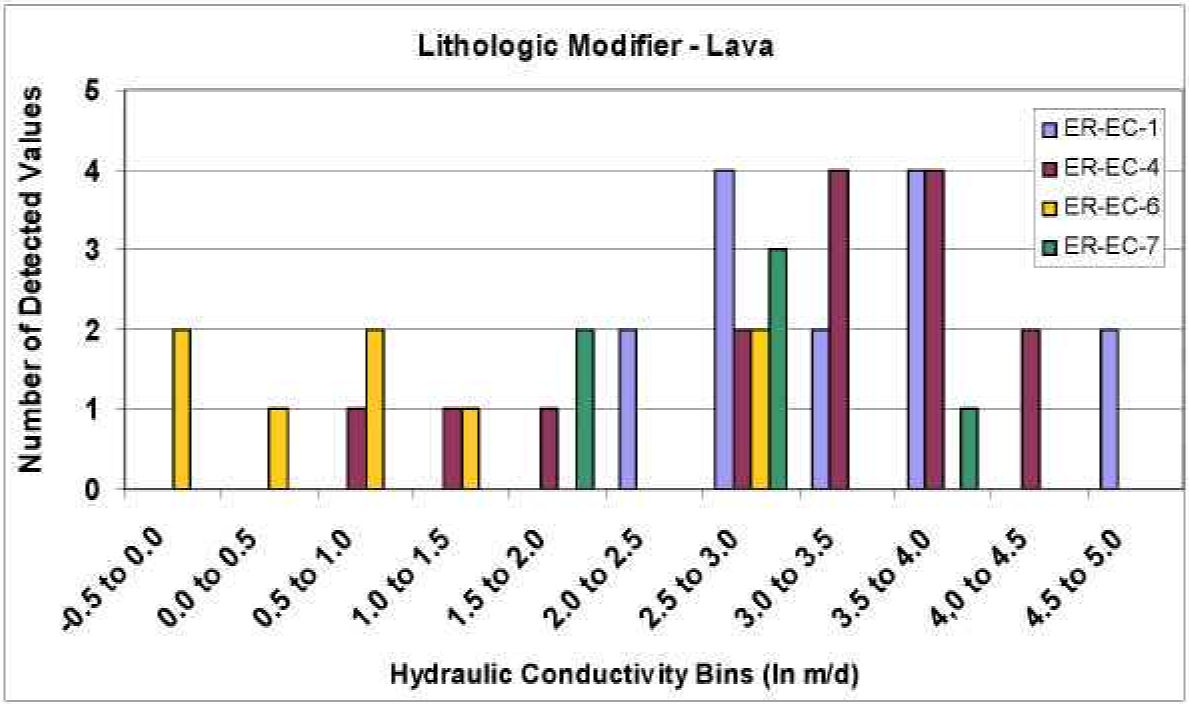


Figure 133. Detected natural logarithm hydraulic conductivity for individual wells for the lithologic modifier lava.

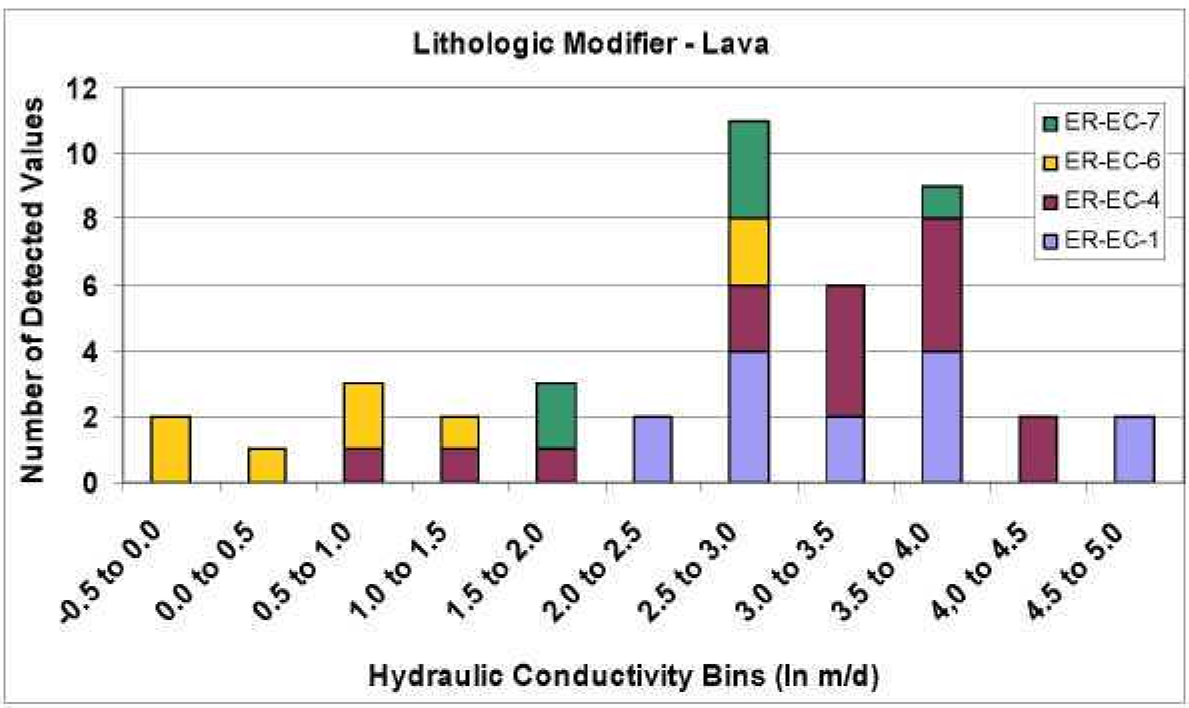


Figure 134. Detected natural logarithm hydraulic conductivity for wells in composite for the lithologic modifier lava.

Table 17. Alteration modifiers encountered at multiple wells in tuff.

Alteration Modifier	ER-EC-1		ER-EC-2a		ER-EC-4		ER-EC-5		ER-5-4#2		ER-EC-6		ER-EC-7		ER-EC-8	
	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)
DV	53.6	**23.8**	0	0	39.8	**23.9**	0	0	0	0	29.3	**3.0**	1.4	0	8.4	0
GL	11.9	0	0	0	3.2	0	0	0	0	0	1.8	**1.8**	1.4	0	0	0
VP	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.2	0
ZE	22.3	**3.0**	6.0	**1.5**	3.2	0	0	0	46.8	**20.3**	0	0	0	0	0	0
QZ	6.0	**3.0**	0	0	0	0	0	0	0	0	0	0	0	0	46.6	**20.9**
QF	58.1	**3.0**	371.7	**87.3**	86.0	**1.6**	85.9	**32.4**	0	0	93.1	0	37.1	2.7	15.5	**1.8**

Gray shading indicates an alteration modifier that occurs in multiple wells

Bold type indicates length of detectable hydraulic conductivity for alteration modifiers with detectable hydraulic conductivity in more than one well

The detected hydraulic conductivity with depth for devitrified tuff is presented in Figure 135. Well ER-EC-6 has slightly lower hydraulic conductivity values than wells ER-EC-1 or ER-EC-4. Figures 136 through 139 present the detected hydraulic conductivity for the wells individually and in composite for normal and log-transformed values. Figure 136 shows that the individual wells have no visually discernible distributions. Figure 137 shows that in composite, there is a general trend of progressively fewer values of higher hydraulic conductivity. Figures 138 shows that wells ER-EC-1 and ER-EC-4 have similar distributions of log hydraulic conductivity. Well ER-EC-6 has much lower log hydraulic conductivities. Figure 139 shows that devitrified tuff for wells in composite does not indicate a visually interpretable trend.

The detected hydraulic conductivity with depth for zeolitic tuff is presented in Figure 140. There are few values of detected hydraulic conductivity in wells ER-EC-1 and ER-EC-2a. Well ER-EC-2a has much lower hydraulic conductivity values than wells ER-EC-1 and ER-5-4#2. Figures 141 through 144 present the detected hydraulic conductivity for the wells individually and in composite for normal and log-transformed values. Most of the information for zeolitic alteration is based on well ER- 5-4#2. The data in Figures 141 through 144 do not indicate a recognizable statistical distribution.

The detected hydraulic conductivity with depth for quartzitic tuff is presented in Figure 145. Figures 146 through 149 present the detected hydraulic conductivity for the wells individually and in composite for normal and log-transformed values. Figures 146 and 147 indicate that well ER-EC-8 has detected hydraulic conductivity values forming an approximately normal distribution. There are too few data from ER-EC-1 to demonstrate an independent distribution. Figures 148 and 149 indicate a lognormal distribution of values.

The detected hydraulic conductivity with depth for quartz feldspathoidic tuff is presented in Figure 150. There are six wells with detectable hydraulic conductivity and this forms the most populated data set for the hydrogeologic characteristic of alteration modifier. Well ER-EC-2a again has the lowest values of hydraulic conductivity within the data set. Figures 151 through 154 present the detected hydraulic conductivity for the wells individually and in composite for normal and log-transformed values. Figure 151 demonstrates that no individual well has a discernible distribution except perhaps ER-EC-5. The wells are considered in composite in Figure 152 and appear to demonstrate that the low values of ER-EC-2a are not part of a continuous distribution. Log-transformed data for individual wells in Figure 153 are difficult to interpret. The distribution for well ER-EC-2a shows a decreasing number of values at low log hydraulic conductivity while well ER-EC-5 shows fewer values with increasing log hydraulic conductivity. The wells in composite are presented in Figure 154 and visually suggest that the values are of different distributions and that there is no overarching trend for quartz feldspathoidic tuff.

<u>Hydraulic Conductivity and Hydrogeologic Unit</u>

There are four hydrogeologic units with detected hydraulic conductivity in more than one well. The names of the hydrogeologic units and their abbreviations are provided in Table 11. The hydrogeologic unit association with screened intervals and hydraulic conductivity for all wells in tuff is presented in Table 18.

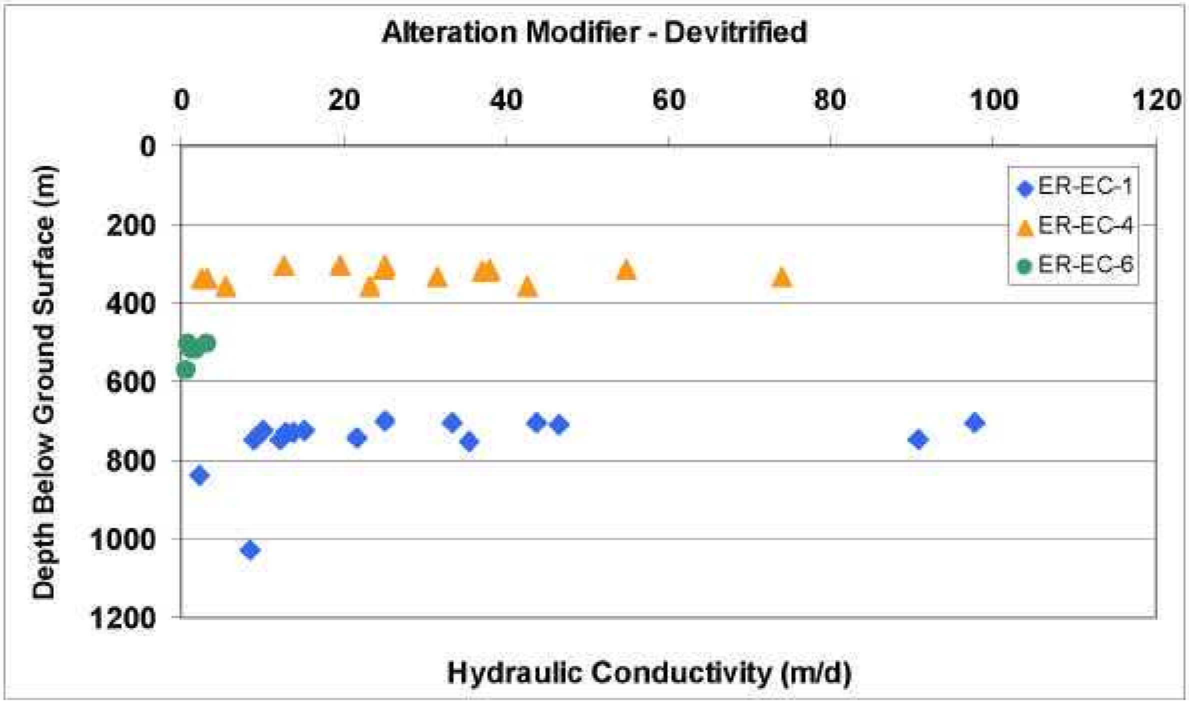


Figure 135. Detected hydraulic conductivity with depth for the alteration modifier Devitrified.

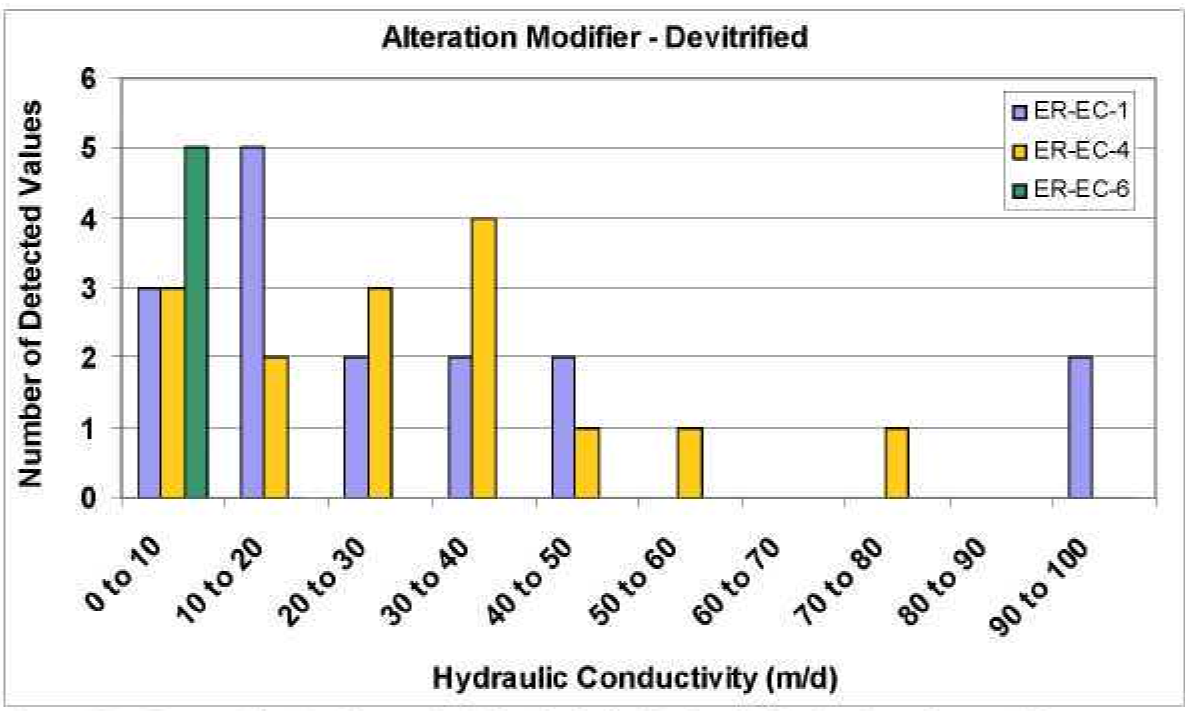


Figure 136. Detected hydraulic conductivity for individual wells for the alteration modifier Devitrified.

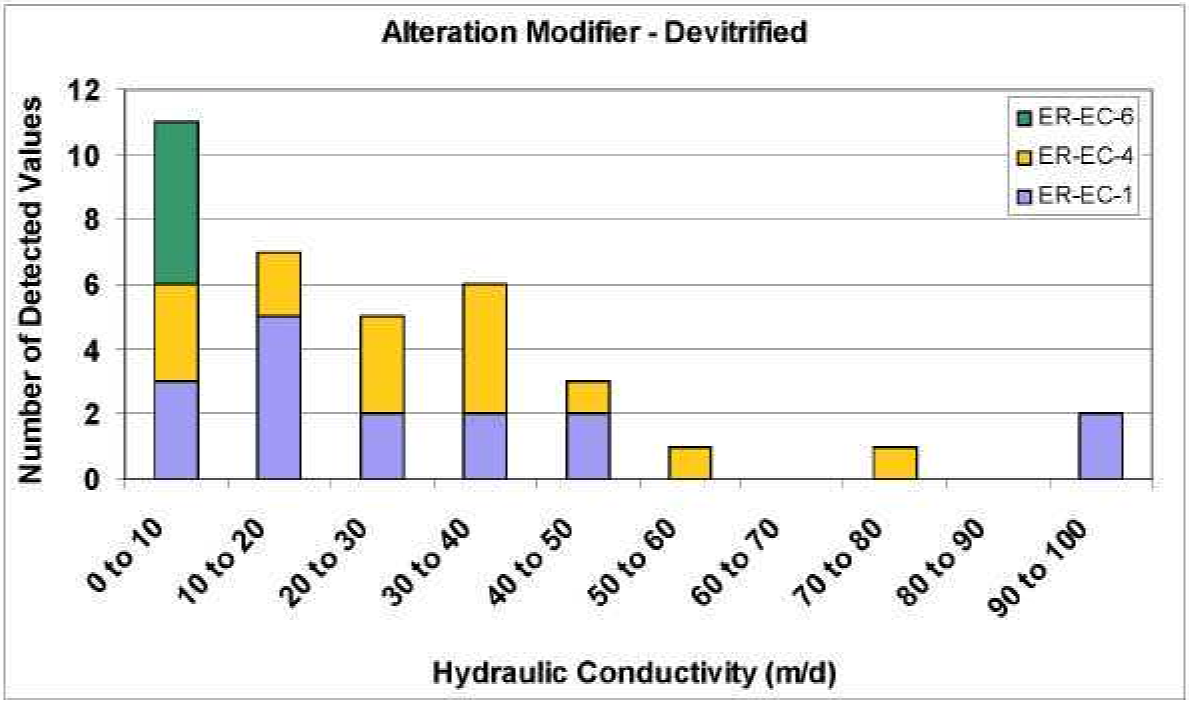


Figure 137. Detected hydraulic conductivity for wells in composite for the alteration modifier Devitrified.

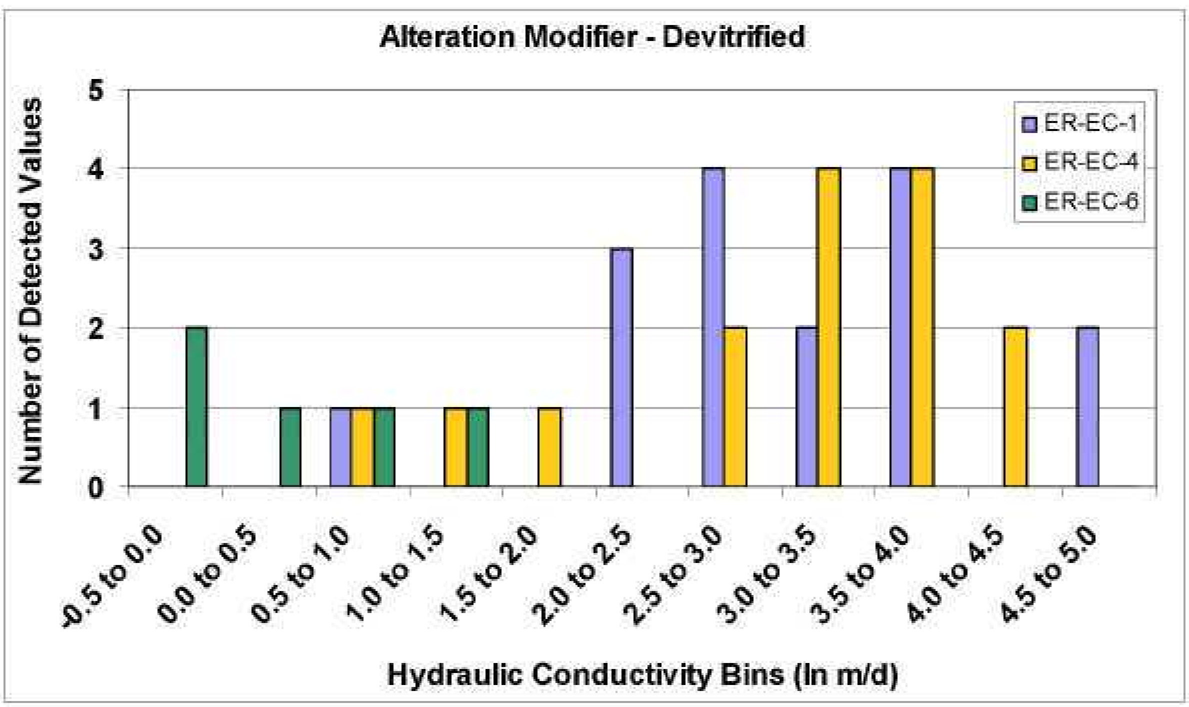


Figure 138. Detected natural logarithm hydraulic conductivity for individual wells for the alteration modifier Devitrified.

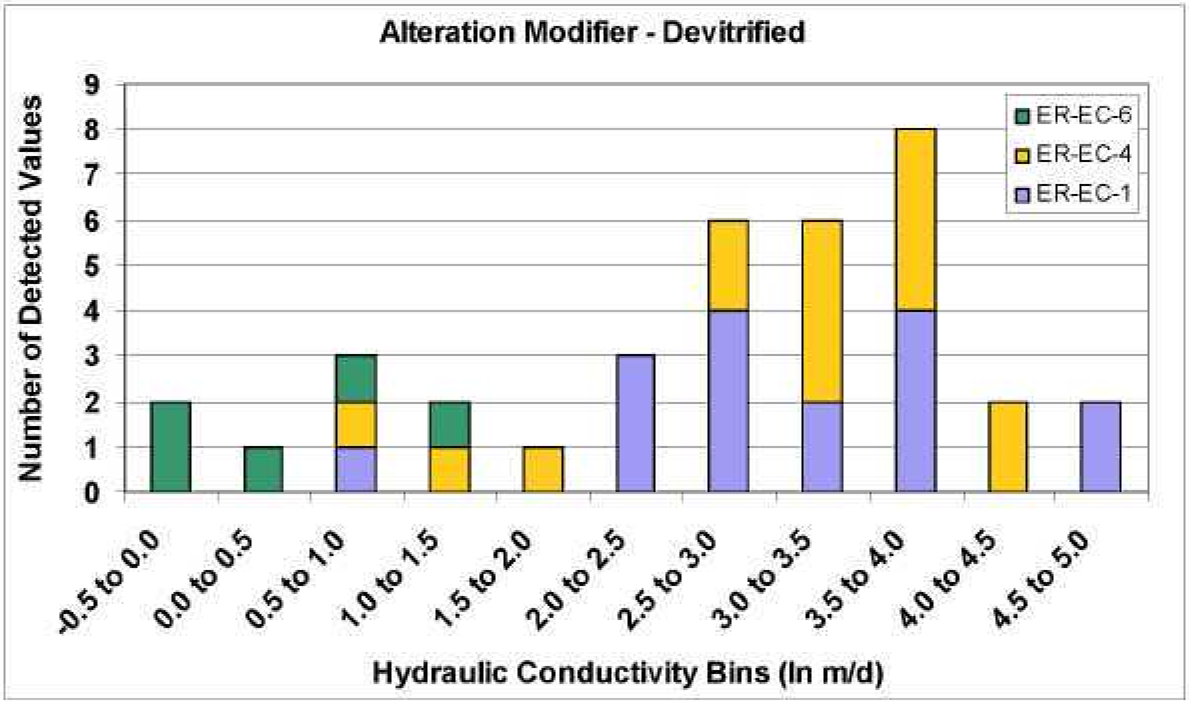


Figure 139. Detected natural logarithm hydraulic conductivity for wells in composite for the alteration modifier Devitrified.

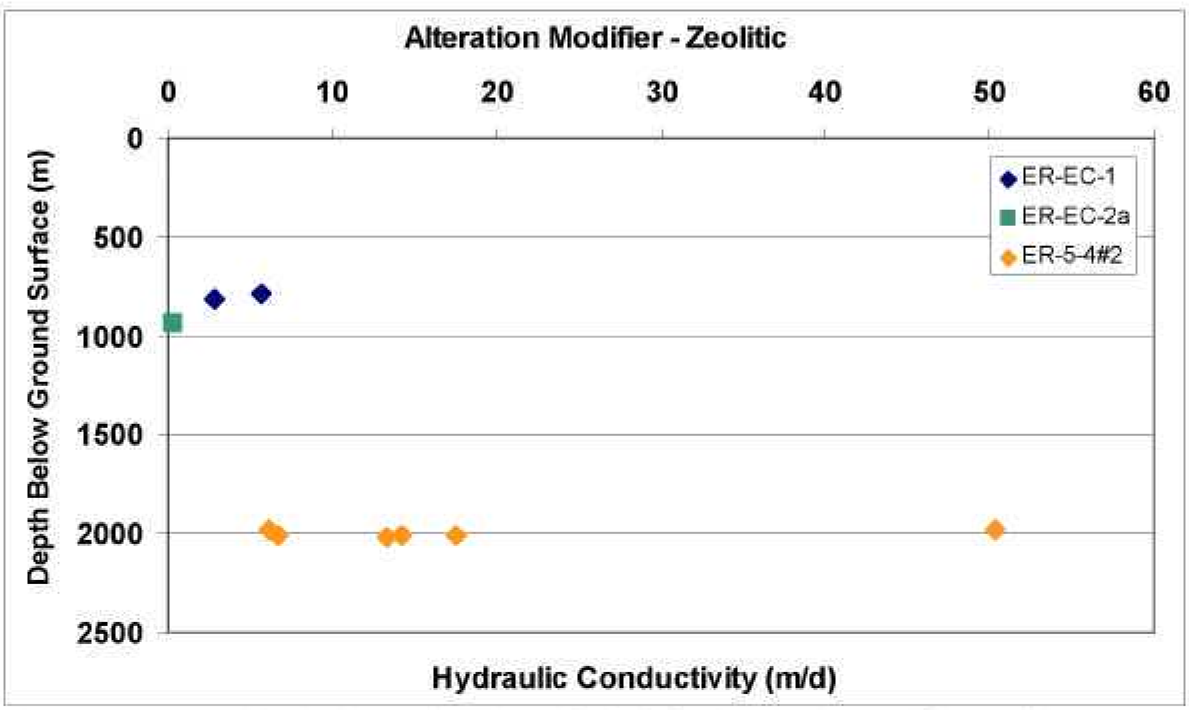


Figure 140. Detected hydraulic conductivity with depth for the alteration modifier Zeolitic.

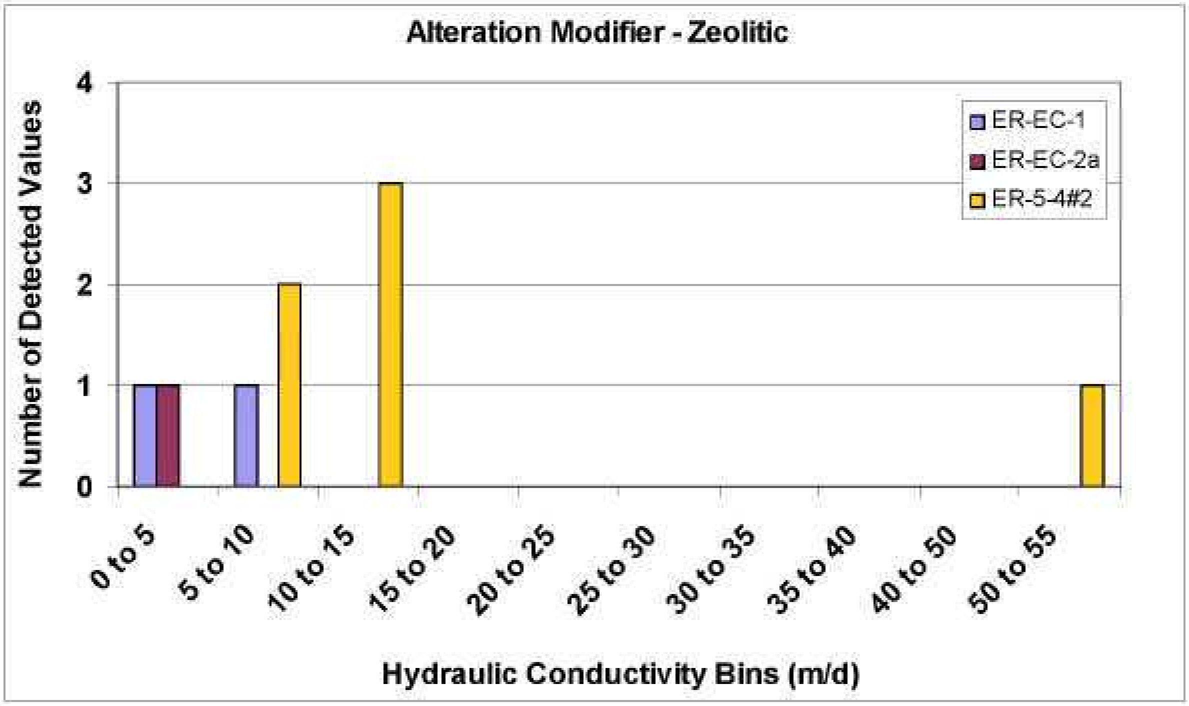


Figure 141. Detected hydraulic conductivity for individual wells for the alteration modifier Zeolitic.

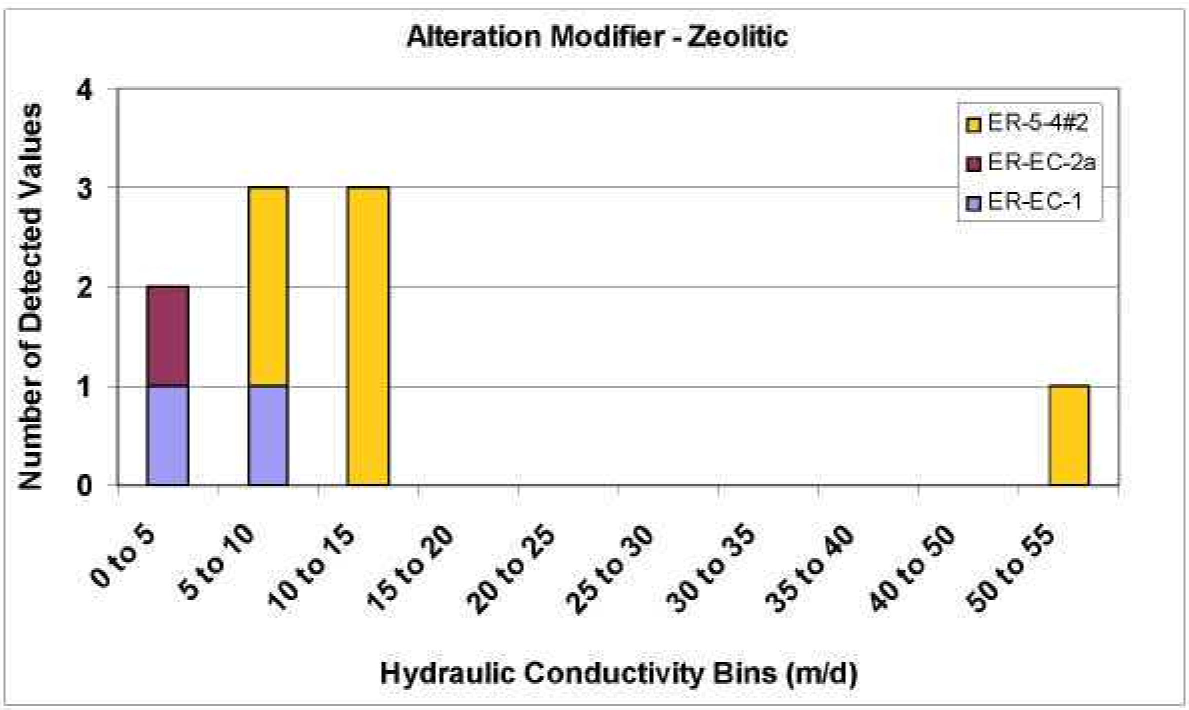


Figure 142. Detected hydraulic conductivity for wells in composite for the alteration modifier Zeolitic.

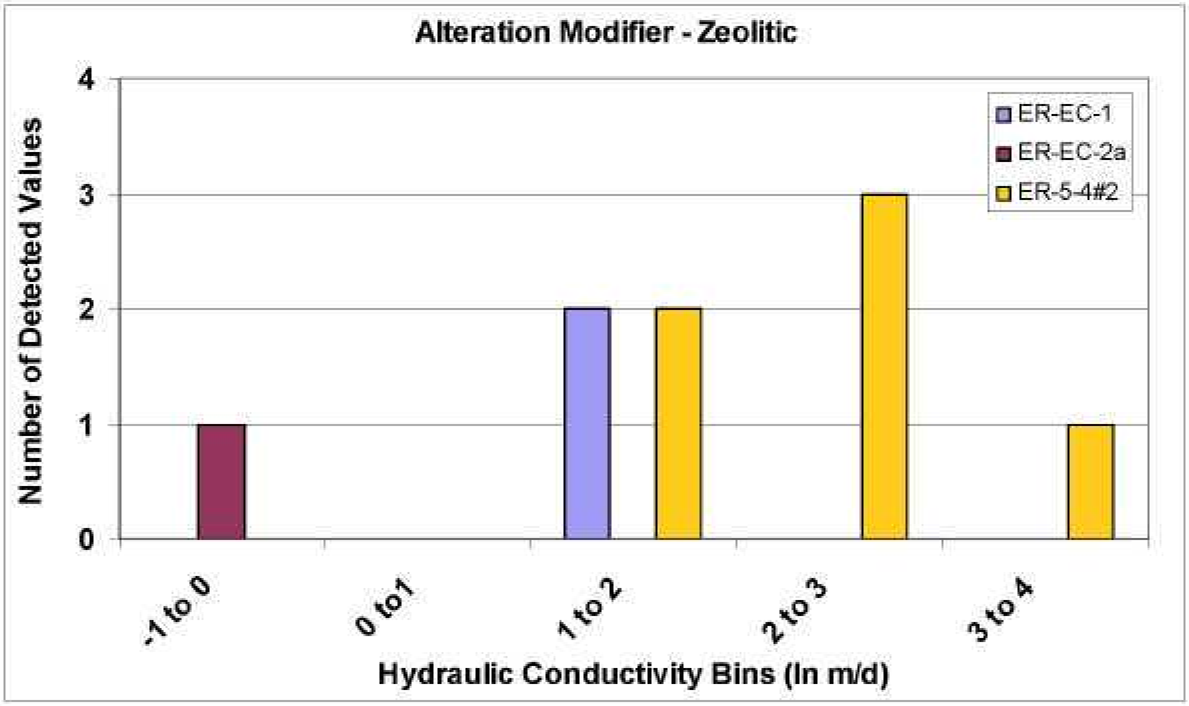


Figure 143. Detected natural logarithm hydraulic conductivity for individual wells for the alteration modifier Zeolitic.

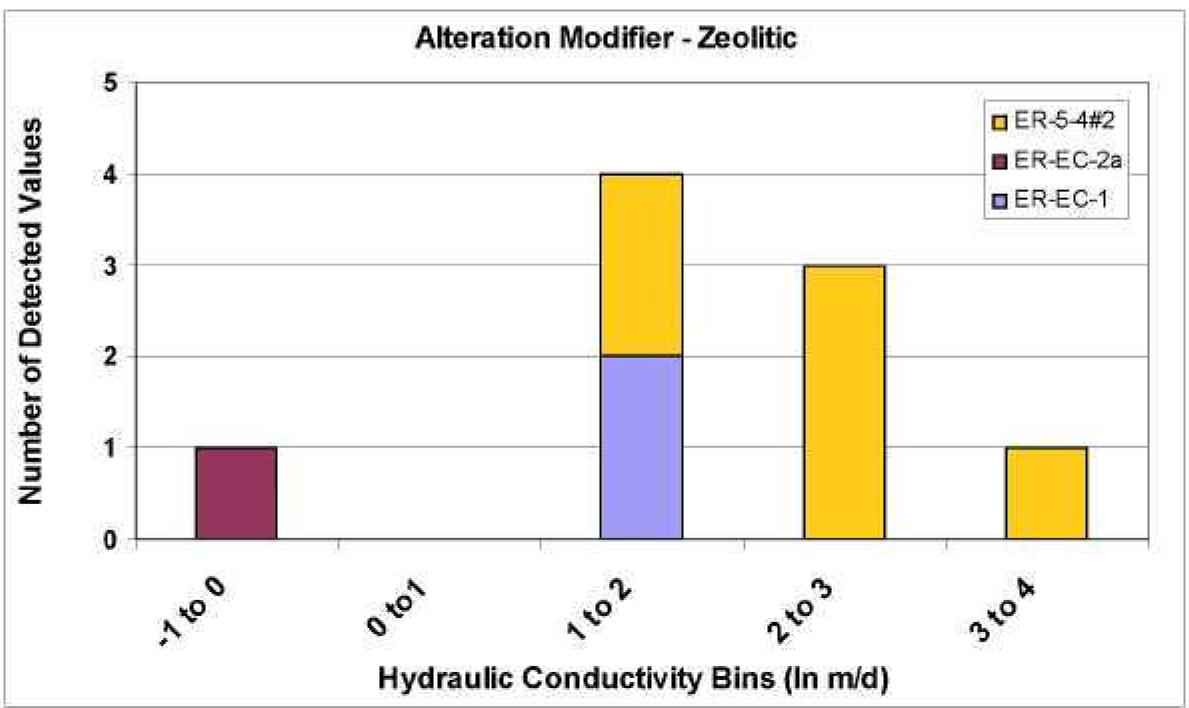


Figure 144. Detected natural logarithm hydraulic conductivity for wells in composite for the alteration modifier Zeolitic.

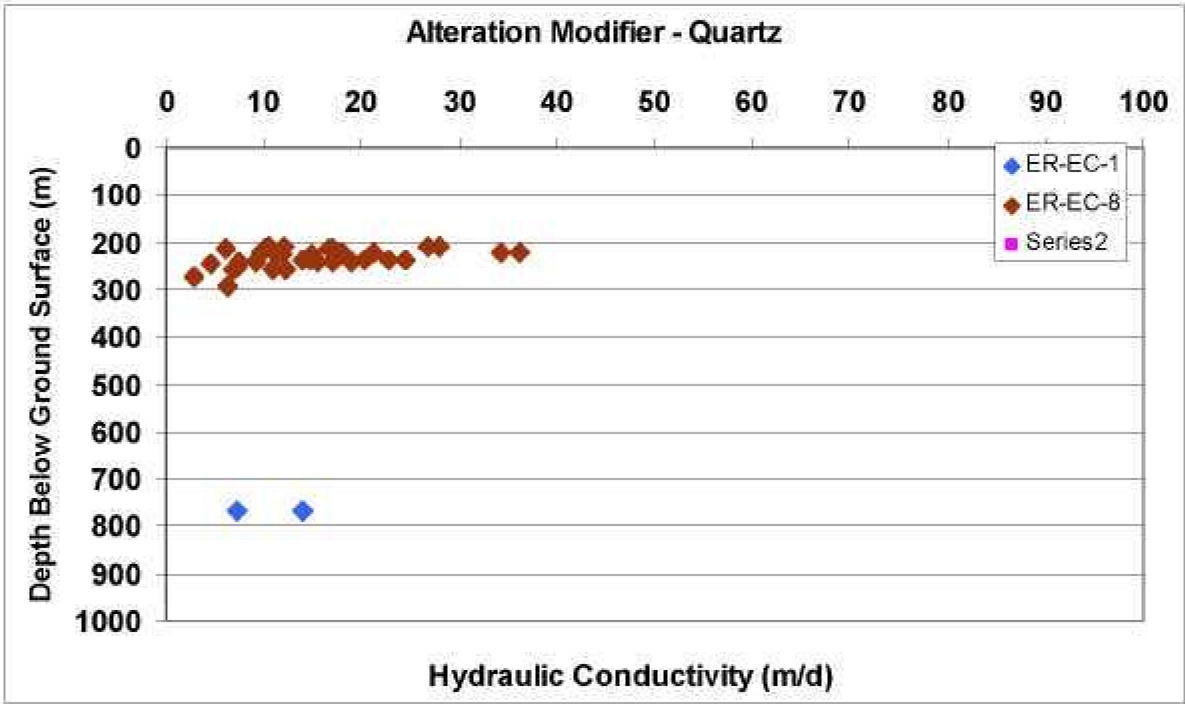


Figure 145. Detected hydraulic conductivity with depth for the alteration modifier Quartz.

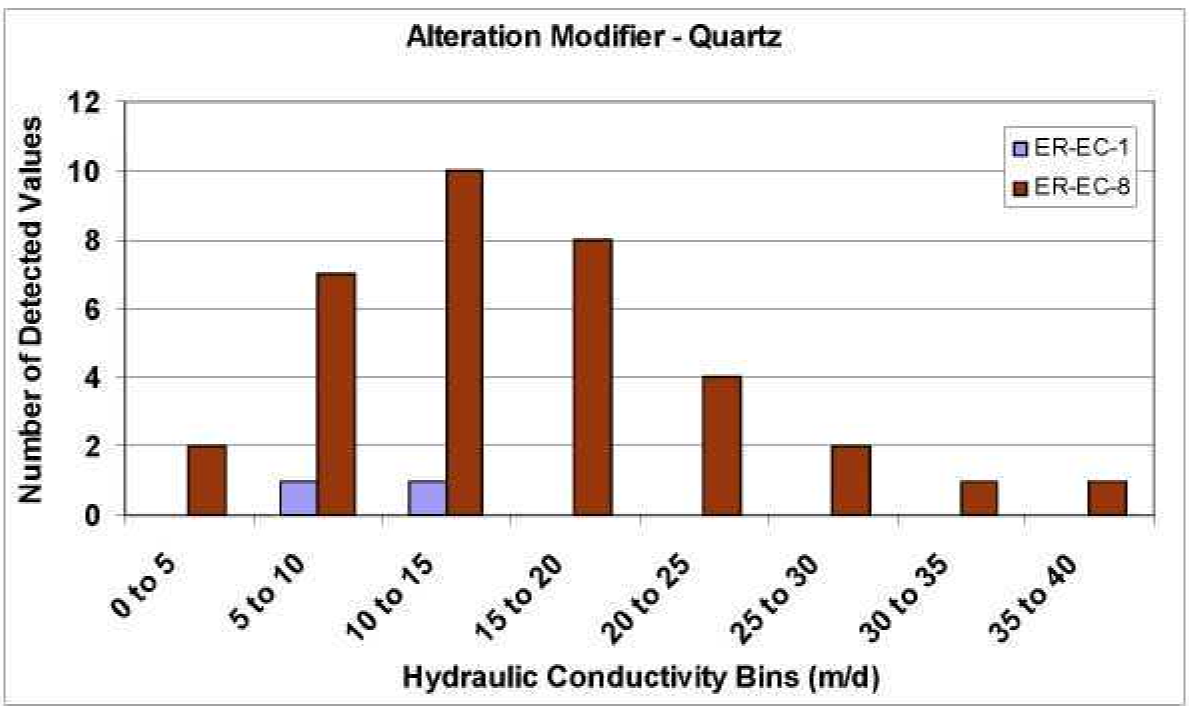


Figure 146. Detected hydraulic conductivity for individual wells for the alteration modifier Quartz.

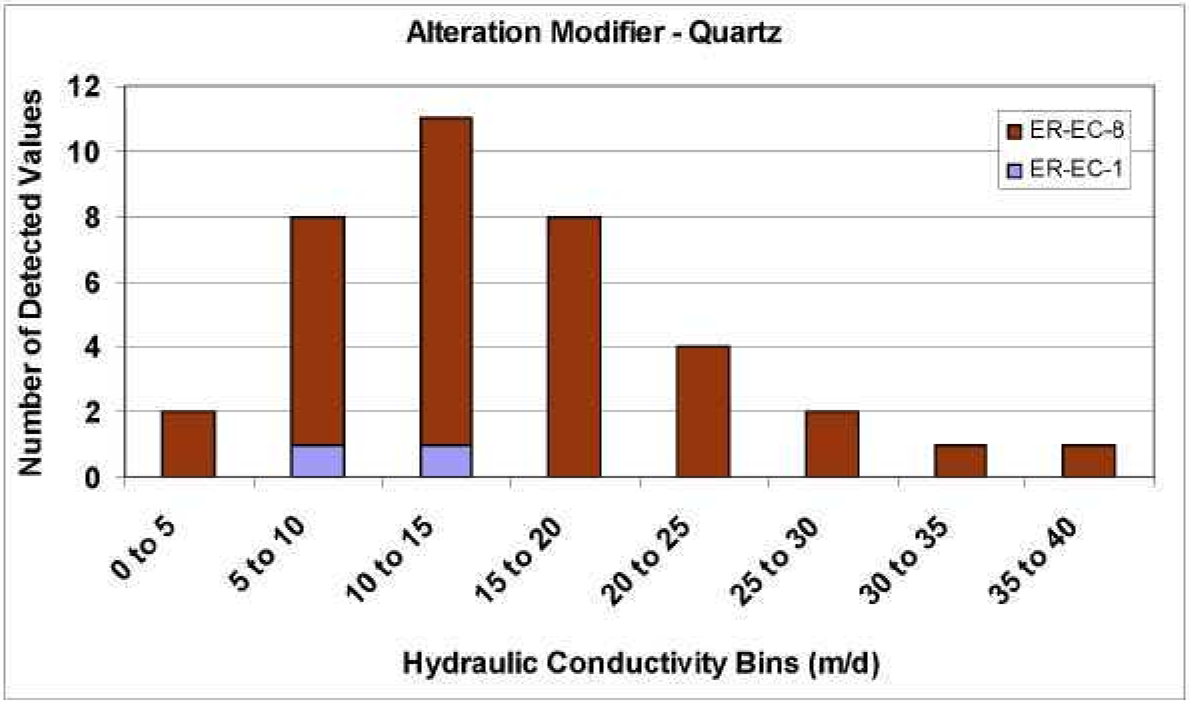


Figure 147. Detected hydraulic conductivity for wells in composite for the alteration modifier Quartz.

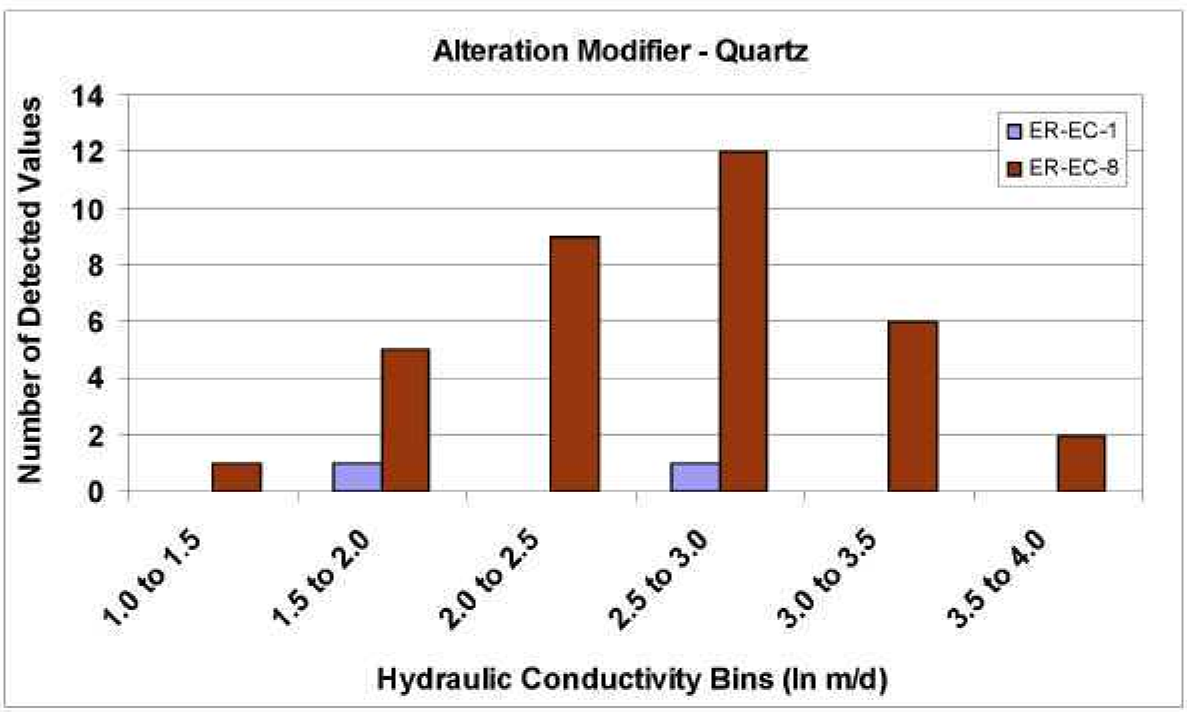


Figure 148. Detected natural logarithm hydraulic conductivity for individual wells for the alteration modifier Quartz.

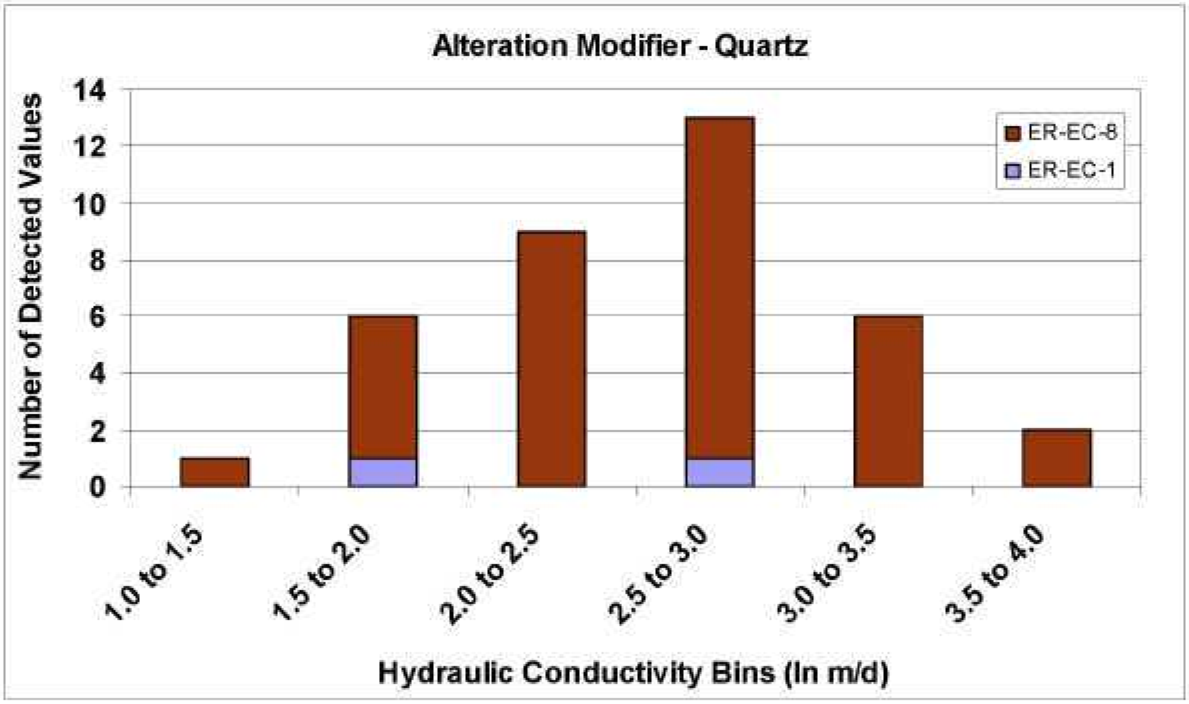


Figure 149. Detected natural logarithm hydraulic conductivity for wells in composite for the alteration modifier Quartz.

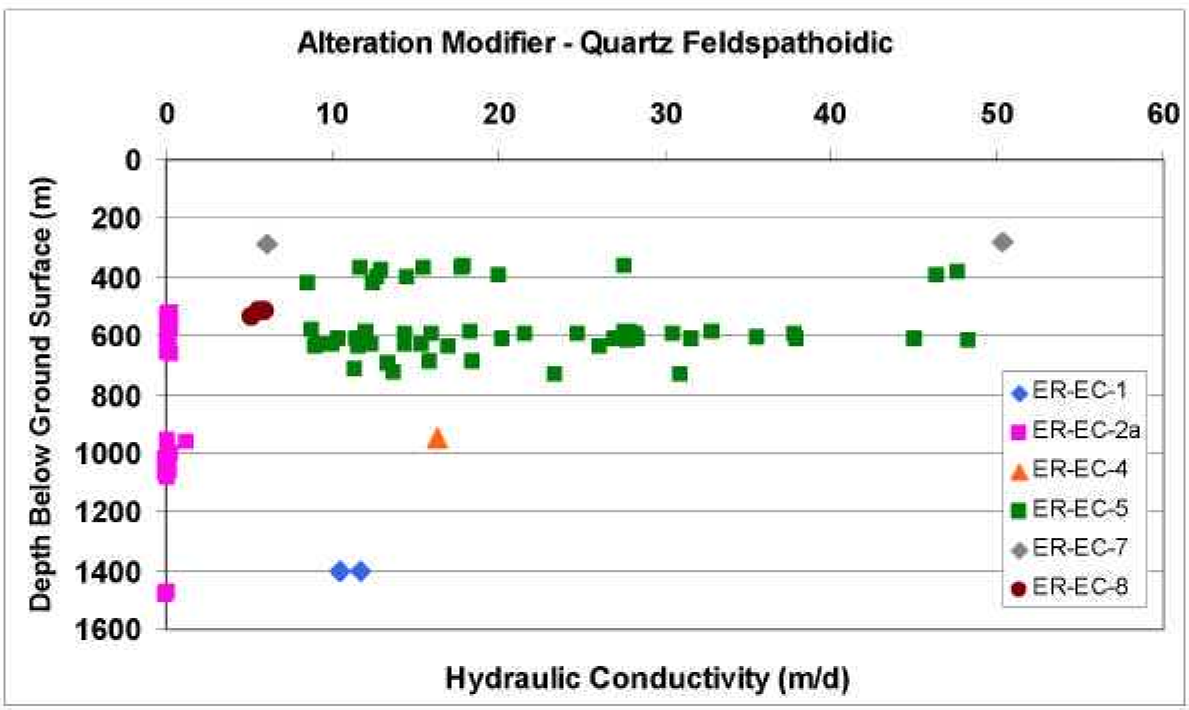


Figure 150. Detected hydraulic conductivity with depth for the alteration modifier Quartz Feldspathoidic.

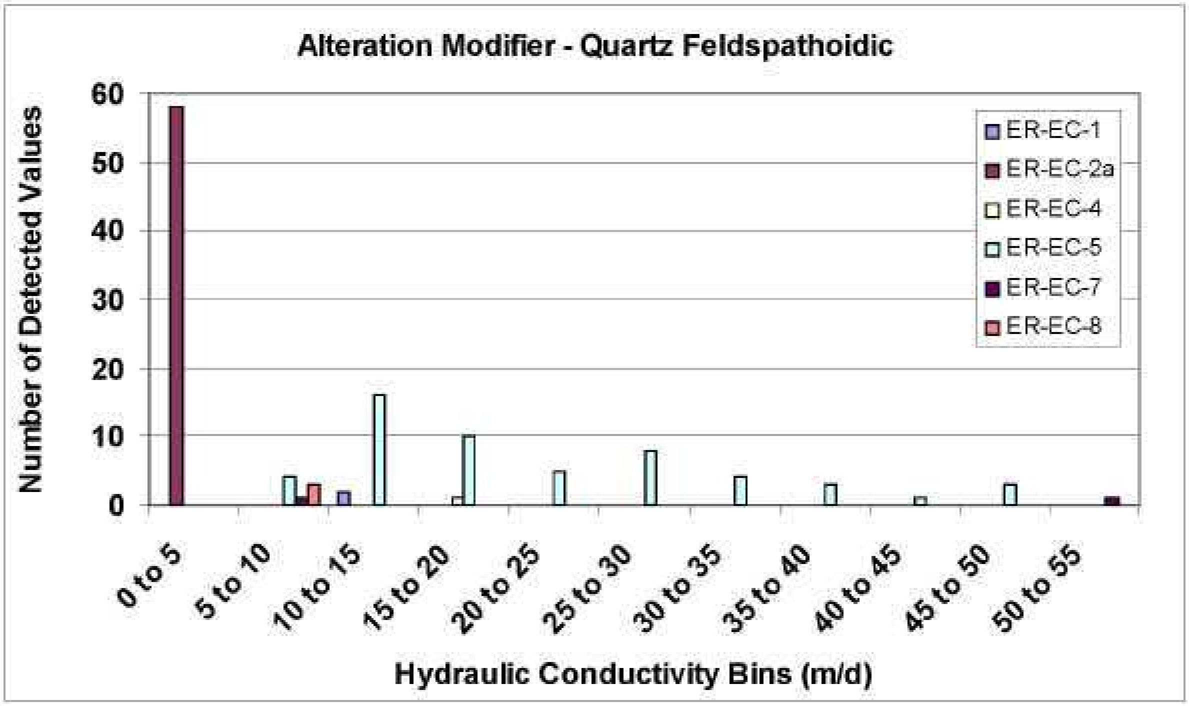


Figure 151. Detected hydraulic conductivity for individual wells for the alteration modifier Quartz Feldspathoidic.

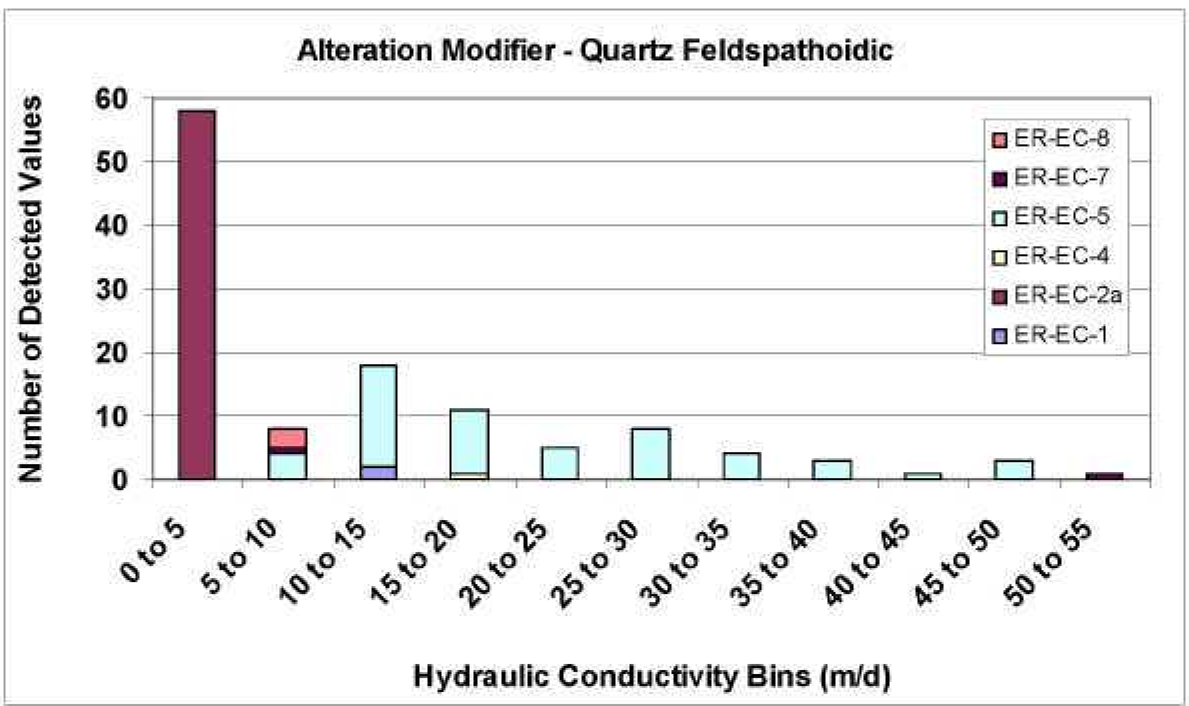


Figure 152. Detected hydraulic conductivity for wells in composite for the alteration modifier Quartz Feldspathoidic.

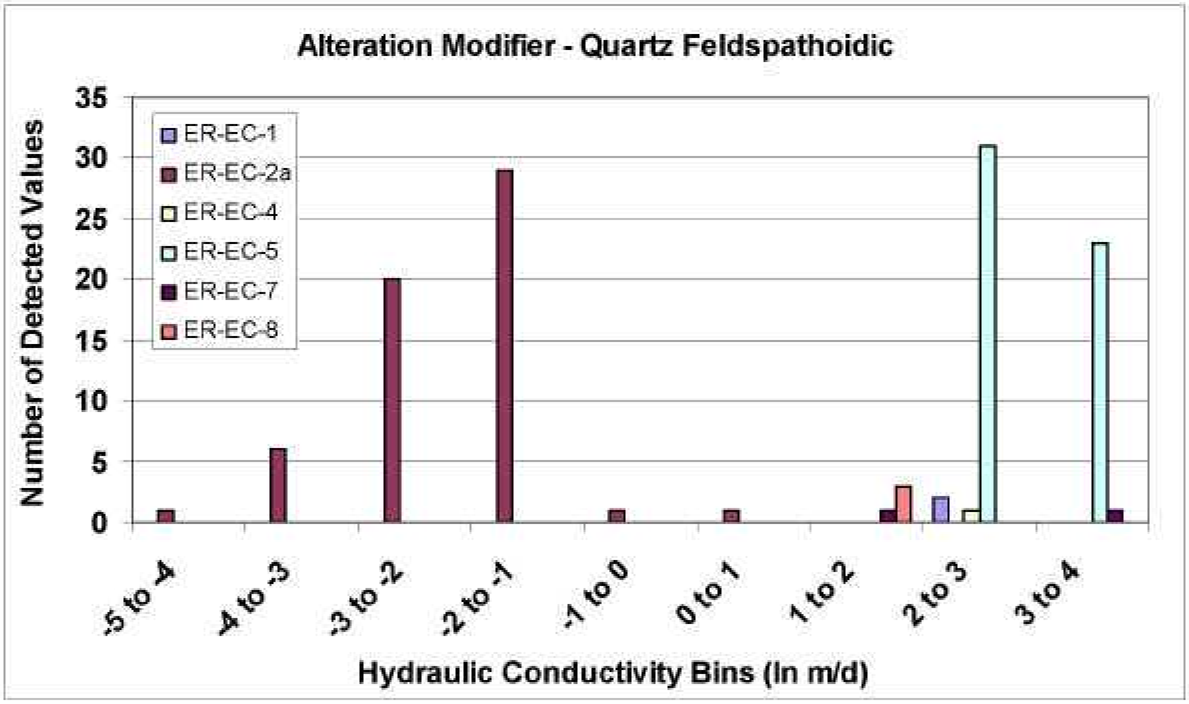


Figure 153. Detected natural logarithm hydraulic conductivity for individual wells for the alteration modifier Quartz Feldspathoidic.

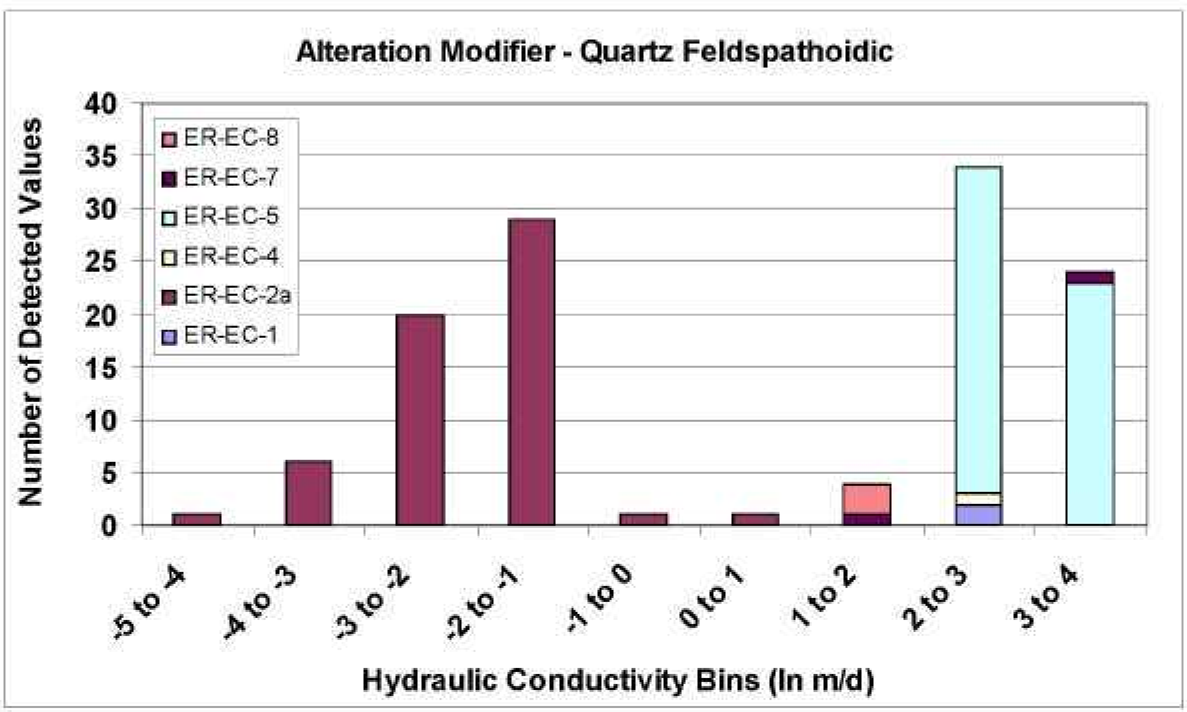


Figure 154. Detected natural logarithm hydraulic conductivity for wells in composite for the alteration modifier Quartz Feldspathoidic.

Table 18. Hydrogeologic units encountered at multiple wells in tuff.

Hydrogeologic Unit	ER-EC-1		ER-EC-2a		ER-EC-4		ER-EC-5		ER-5-4#2		ER-EC-6		ER-EC-7		ER-EC-8	
	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)
Welded Tuff Aquifer	29.8	**3.0**	45.1	**4.5**	79.6	**1.6**	85.9	**32.4**	0	0	38.2	0	0	0	15.5	0
Tuff Confining Unit	59.6	**3.0**	319.0	**79.8**	12.7	0	0	0	46.8	**20.3**	54.9	0	1.4	0	62.1	**22.7**
Lava Flow Aquifer	52.1	**26.8**	0	0	39.8	**23.9**	0	0	0	0	31.0	**4.8**	66.0	**8.2**	0	0
Alluvial Aquifer	0	0	13.5	**4.5**	3.2	**1.6**	0	0	0	0	0	0	0	0	0	0

Gray shading indicates an alteration modifier that occurs in multiple wells

Bold type indicates length of detectable hydraulic conductivity for alteration modifiers with detectable hydraulic conductivity in more than one well

The detected hydraulic conductivity with depth for welded tuff aquifer units is presented in Figure 155. Well ER-EC-2a has lower hydraulic conductivity values than wells ER-EC-1, ER-EC-4, or ER-EC-5. Figures 156 through 159 present the detected hydraulic conductivity for the wells individually and in composite for normal and log-transformed values. Figure 156 shows that the individual wells have no visually discernible distributions except for ER-EC-5. This is caused by the sparse data for the wells other than ER-EC-5. Figure 157 shows that in composite, there is a general trend of a distribution to the data. Figures 158 and 159 show no visually discernible distribution of log hydraulic conductivity.

The detected hydraulic conductivity with depth for Tuff Confining Units is presented in Figure 160. Well ER-EC-2a has much lower hydraulic conductivity values than wells ER-EC-1, ER-5-4#2, and ER-EC-8. Figures 161 through 164 present the detected hydraulic conductivity for the wells individually and in composite for normal and log-transformed values. The distributions of detected hydraulic conductivity for the wells individually are presented in Figure 161 and indicate that only well ER-EC-8 has a discernible data distribution. Figure 162 presents the data for each well in composite and suggests a trend of a decreasing number of values for higher values of hydraulic conductivity. Logarithm transformation of the data for individual wells in Figure 163 indicates that well ER-EC-2a has a data distribution centered on much lower values than the other wells. Wells ER-EC-1, ER-5-4#2, and ER-EC-8 have a similar range of values. Figure 164 indicates that there is a unique distribution of data for ER-EC-2a and that the other wells in composite form an approximately lognormal distribution.

The detected hydraulic conductivity with depth for lava flow aquifer units is presented in Figure 165. Figures 166 through 169 present the detected hydraulic conductivity for the wells individually and in composite for normal and log-transformed values. Figure 166 indicates that well ER-EC-6 has detected hydraulic conductivity values that are somewhat lower than the other wells. There are no discernible data distributions for the wells when plotted individually. Figure 167 presents the detected hydraulic conductivity values plotted in composite. Figure 168 demonstrates no visually discernible distribution to the data. Figure 169 for data values in composite indicates a distribution of values that is weighted toward higher values.

The detected hydraulic conductivity with depth for alluvial aquifer units is presented in Figure 170. There are only four values of detected hydraulic conductivity in alluvial aquifer units. Well ER-EC-2a again has the lower values of hydraulic conductivity within the data set. Figures 171 through 174 present the detected hydraulic conductivity for the wells individually and in composite for normal and log-transformed values. Because the ranges of values for the two wells do not overlap, the plots for the wells individually and in composite are identical. The sparse data for this unit prevent interpretation of data trends.

Hydraulic Conductivity and Hydrostratigraphic Unit

There are three hydrostratigraphic units with detected hydraulic conductivity in more than one well. The names of the hydrogeologic units and their abbreviations are provided in Table 13. The hydrostratigraphic unit association with screened intervals and hydraulic conductivity for all wells in tuff is presented in Table 19.

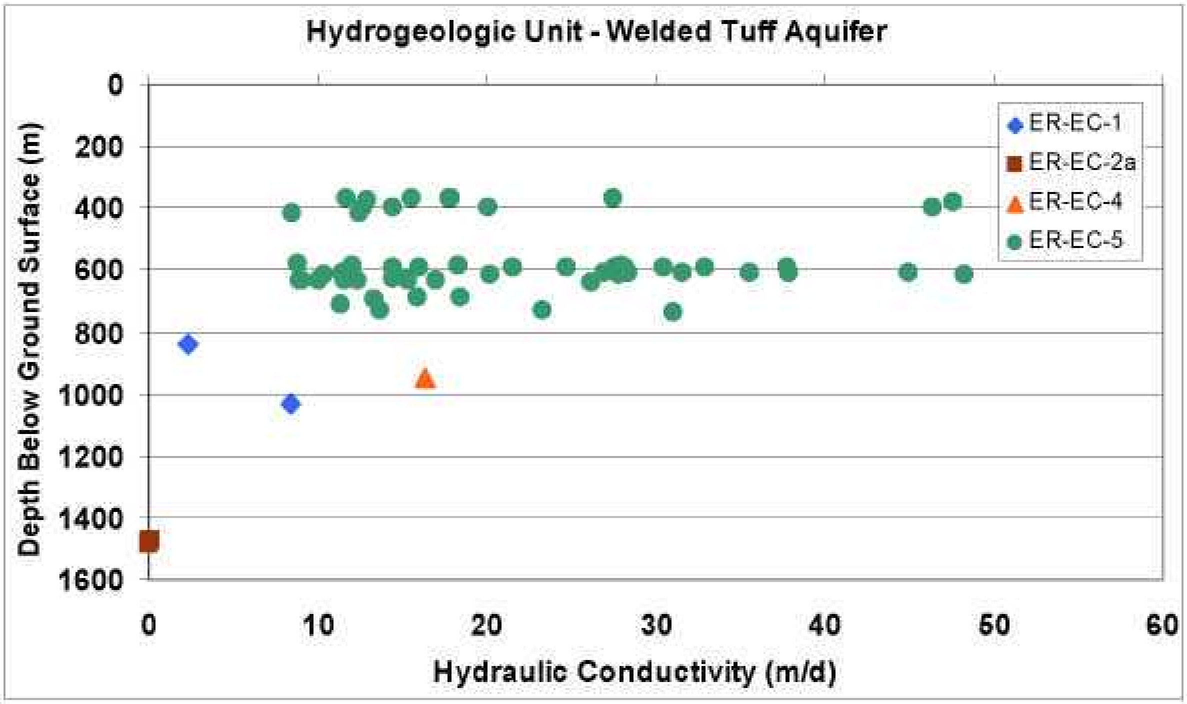


Figure 155. Detected hydraulic conductivity with depth for the hydrogeologic unit Welded Tuff Aquifer.

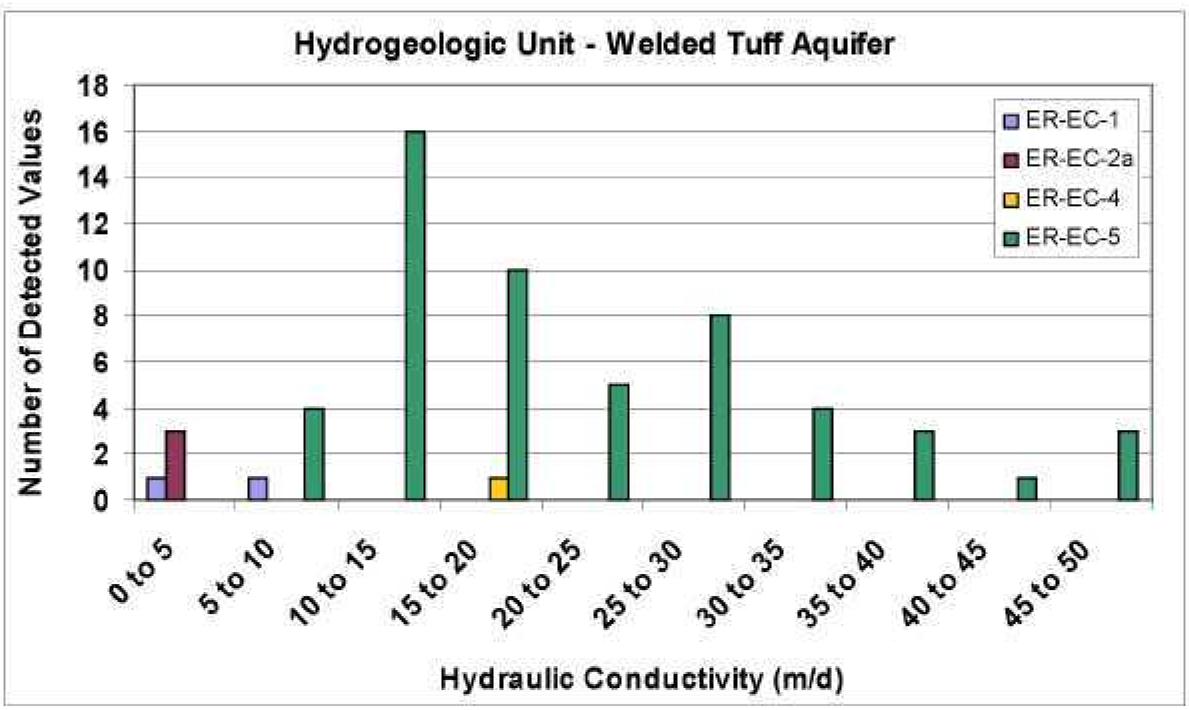


Figure 156. Detected hydraulic conductivity for individual wells for the hydrogeologic unit Welded Tuff Aquifer.

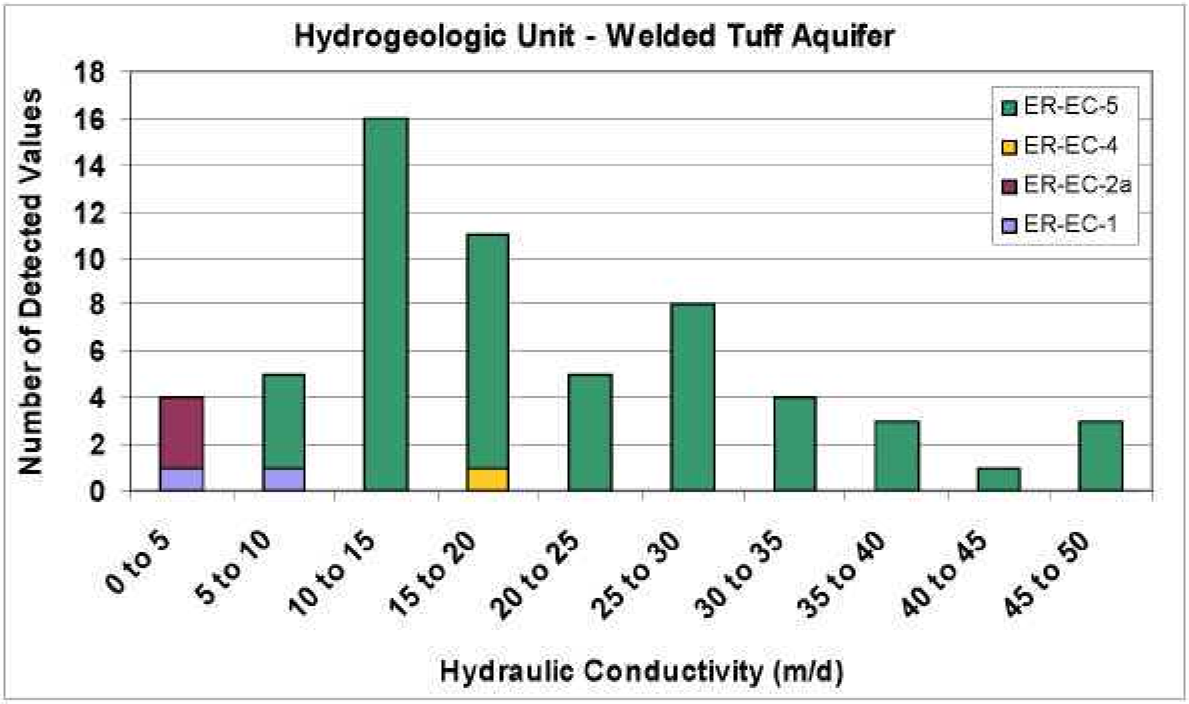


Figure 157. Detected hydraulic conductivity for wells in composite for the hydrogeologic unit Welded Tuff Aquifer.

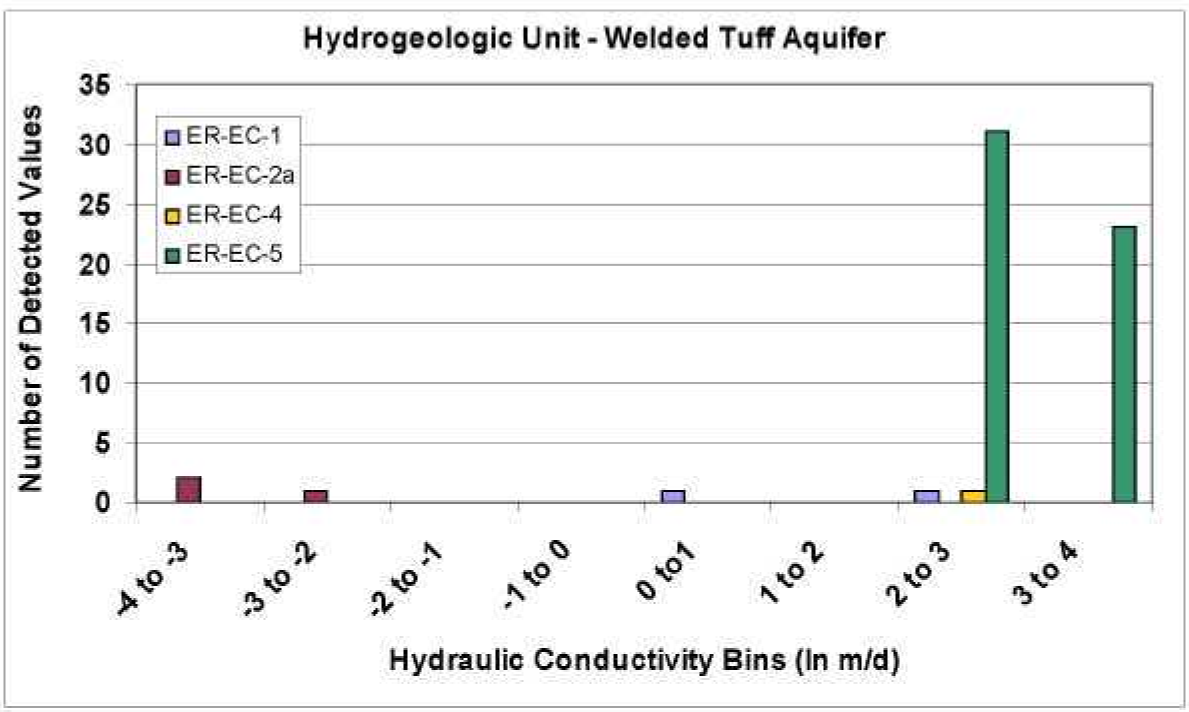


Figure 158. Detected natural logarithm hydraulic conductivity for individual wells for the hydrogeologic unit Welded Tuff Aquifer.

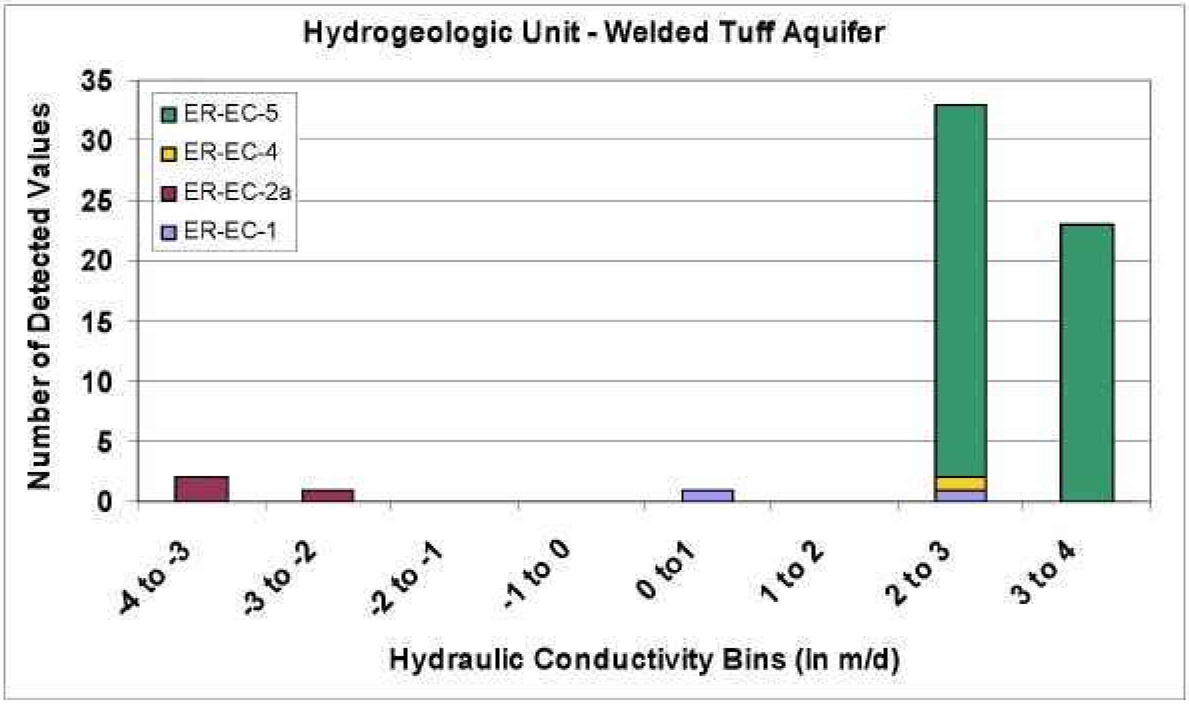


Figure 159. Detected natural logarithm hydraulic conductivity for wells in composite for the hydrogeologic unit Welded Tuff Aquifer.

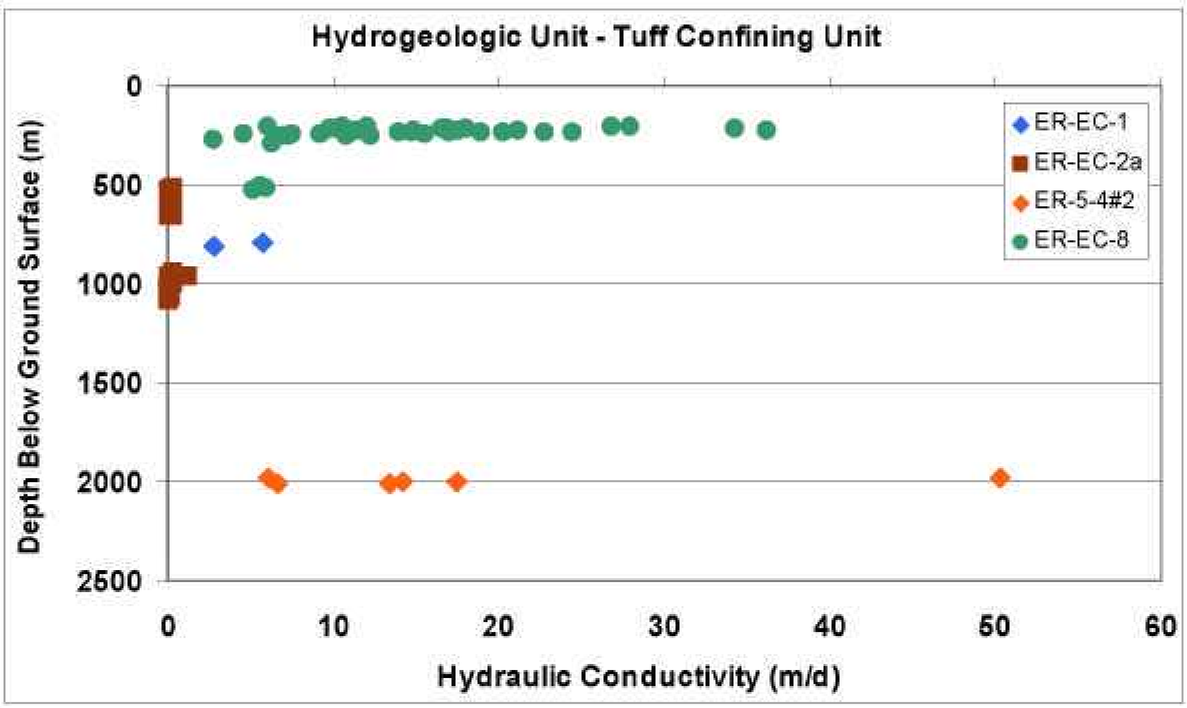


Figure 160. Detected hydraulic conductivity with depth for the hydrogeologic unit Tuff Confining Unit.

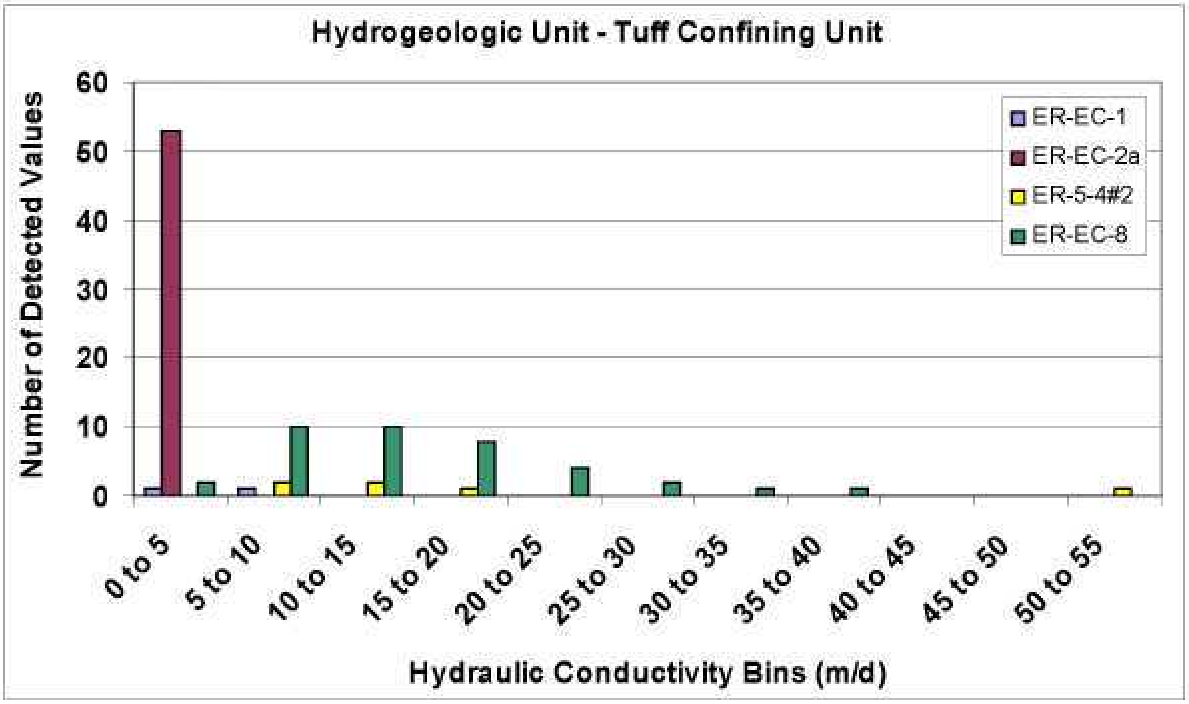


Figure 161. Detected hydraulic conductivity for individual wells for the hydrogeologic unit Tuff Confining Unit.

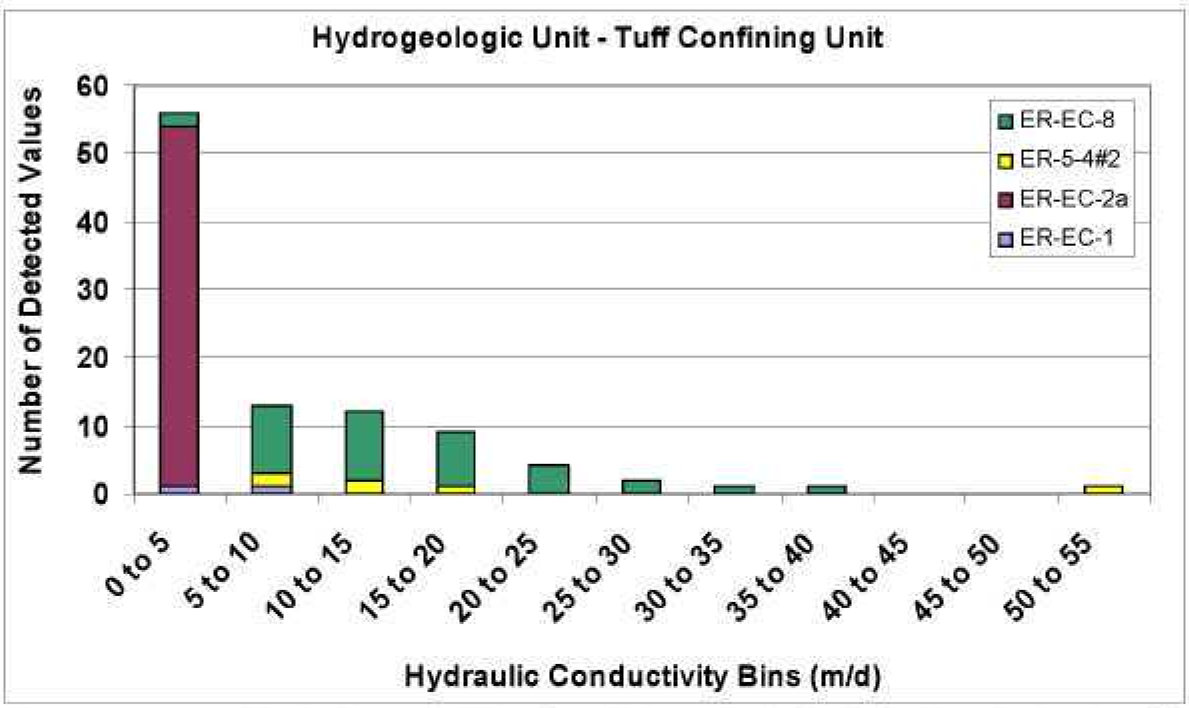


Figure 162. Detected hydraulic conductivity for wells in composite for the hydrogeologic unit Tuff Confining Unit.

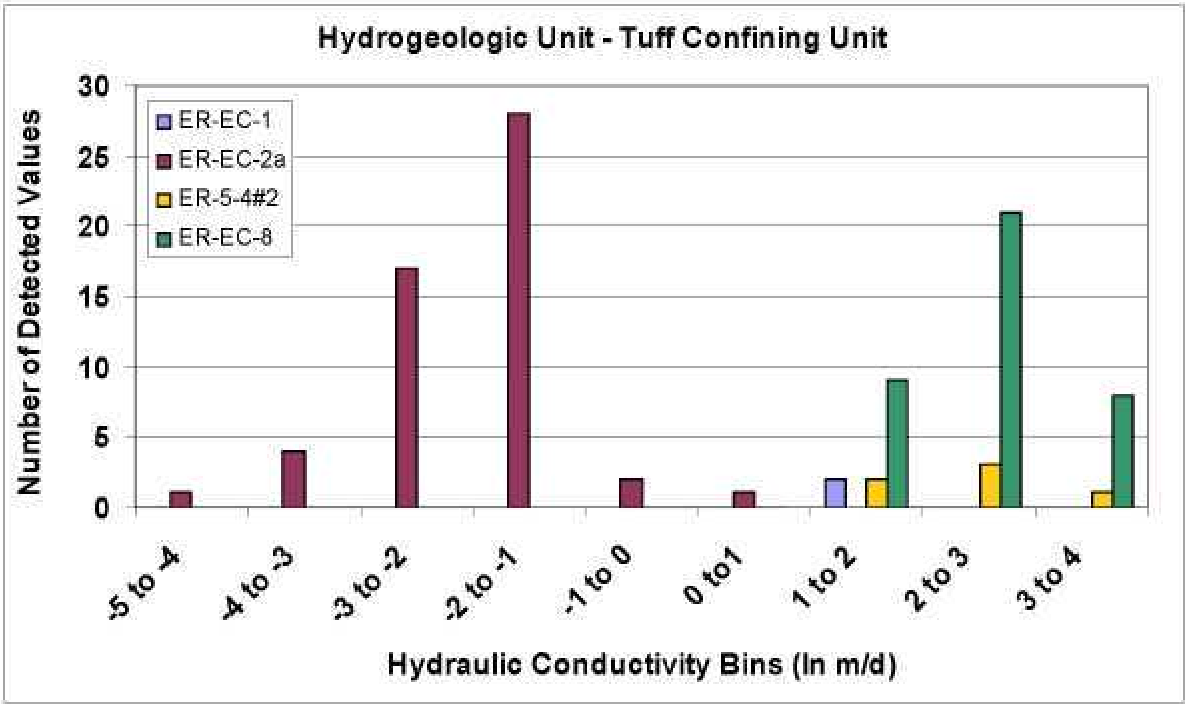


Figure 163. Detected natural logarithm hydraulic conductivity for individual wells for the hydrogeologic unit Tuff Confining Unit.

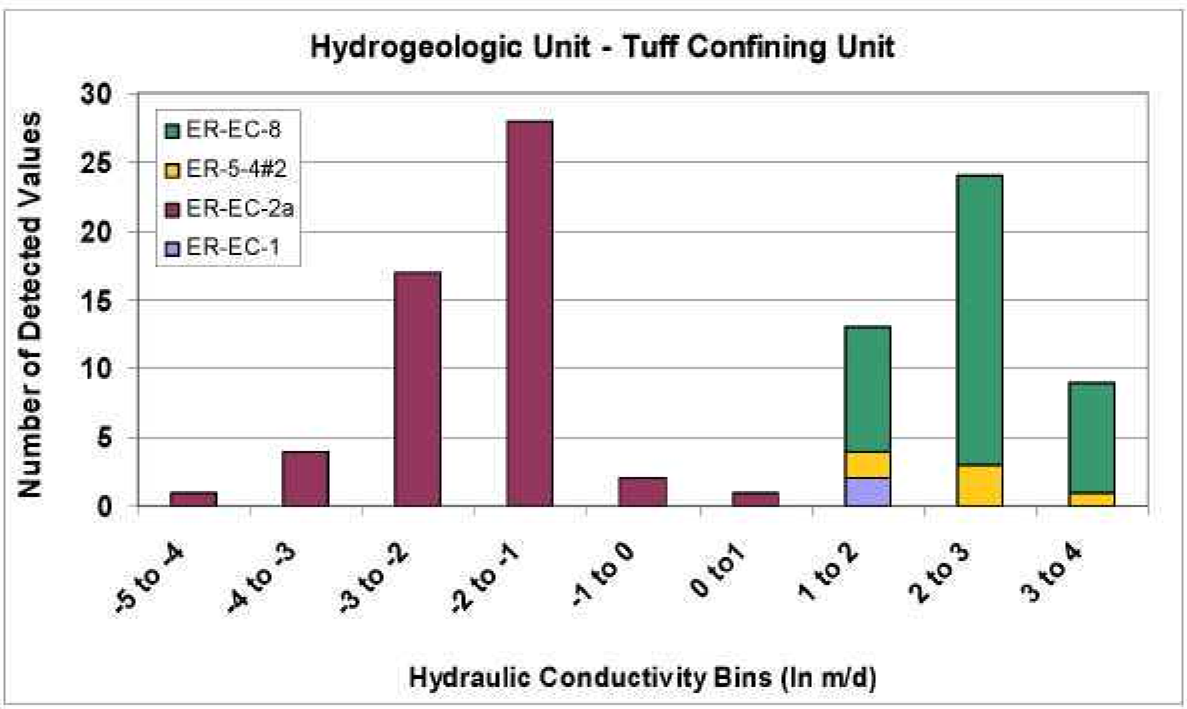


Figure 164. Detected natural logarithm hydraulic conductivity for wells in composite for the hydrogeologic unit Tuff Confining Unit.

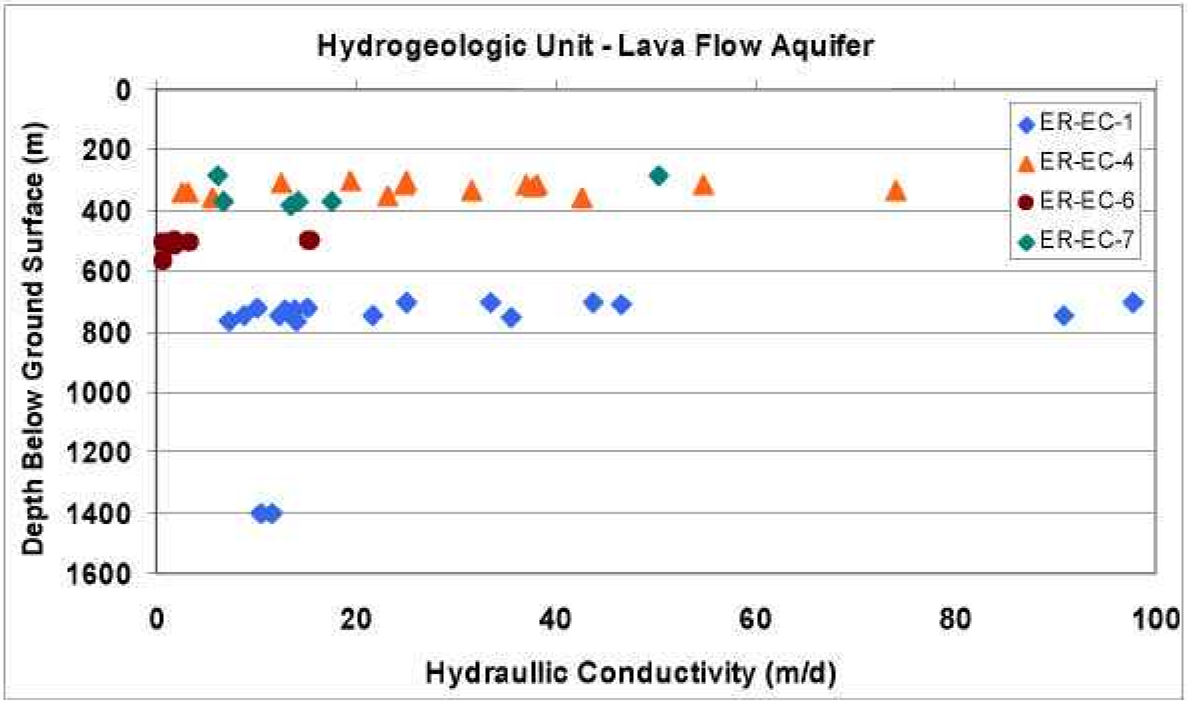


Figure 165. Detected hydraulic conductivity with depth for the hydrogeologic unit Lava Flow Aquifer.

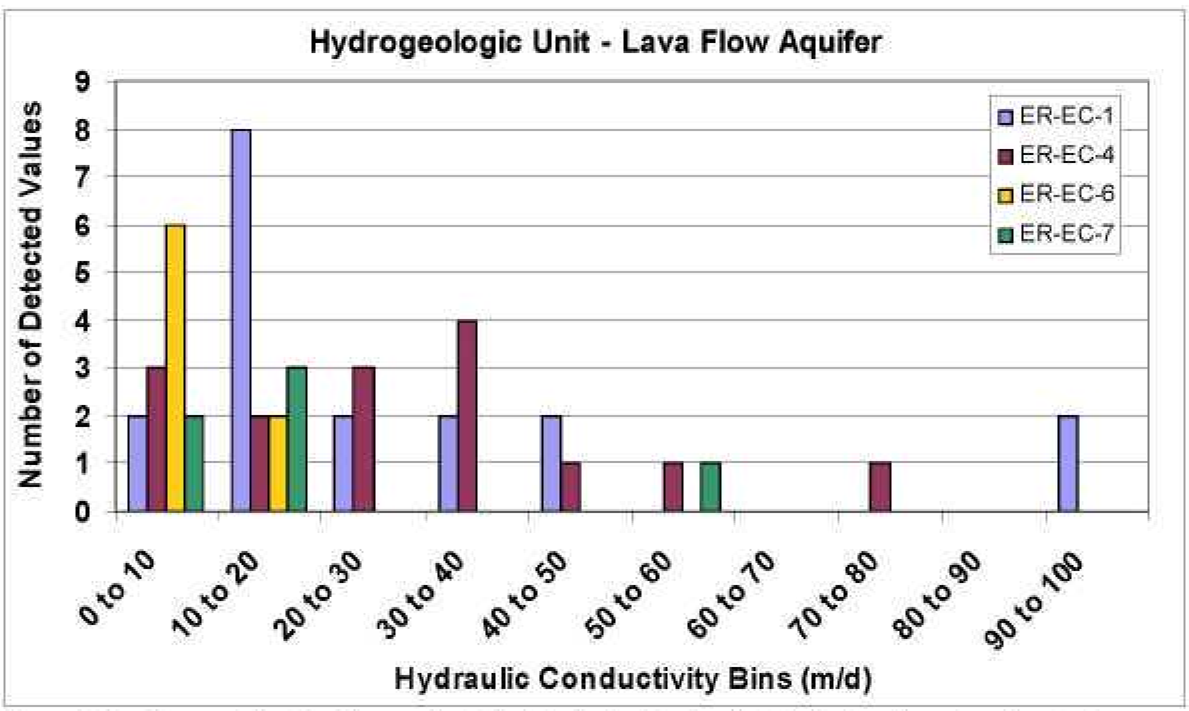


Figure 166. Detected hydraulic conductivity for individual wells for the hydrogeologic unit Lava Flow Aquifer.

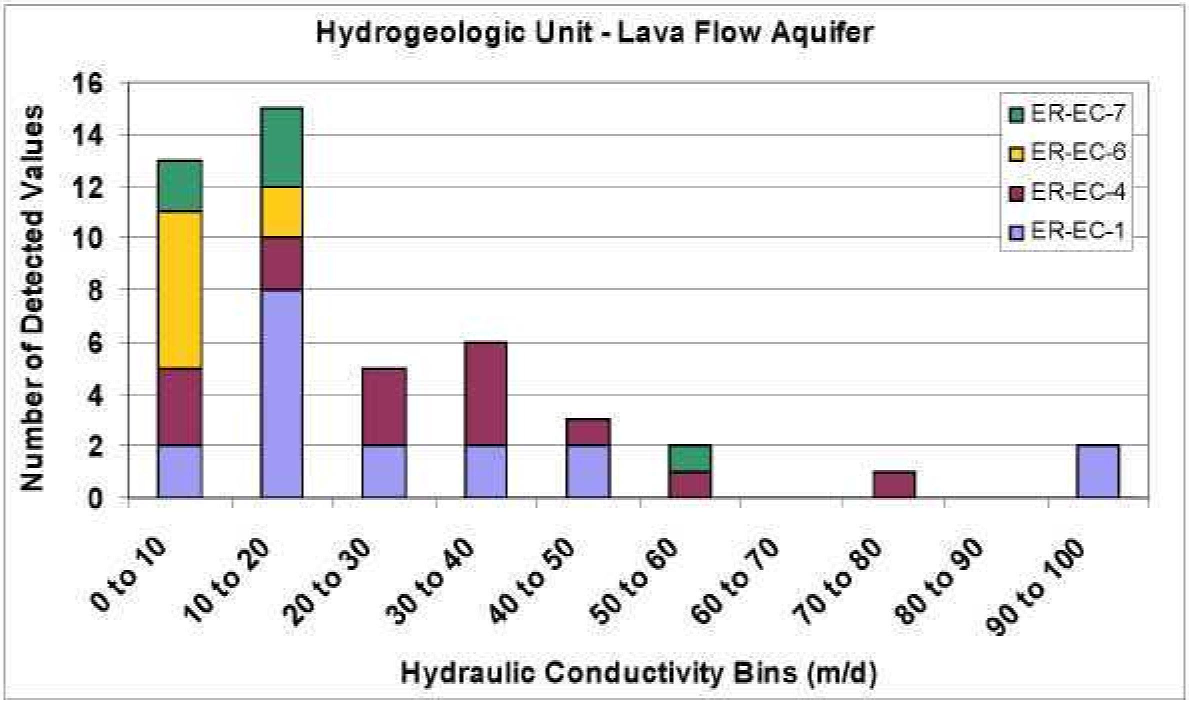


Figure 167. Detected hydraulic conductivity for wells in composite for the hydrogeologic unit Lava Flow Aquifer.

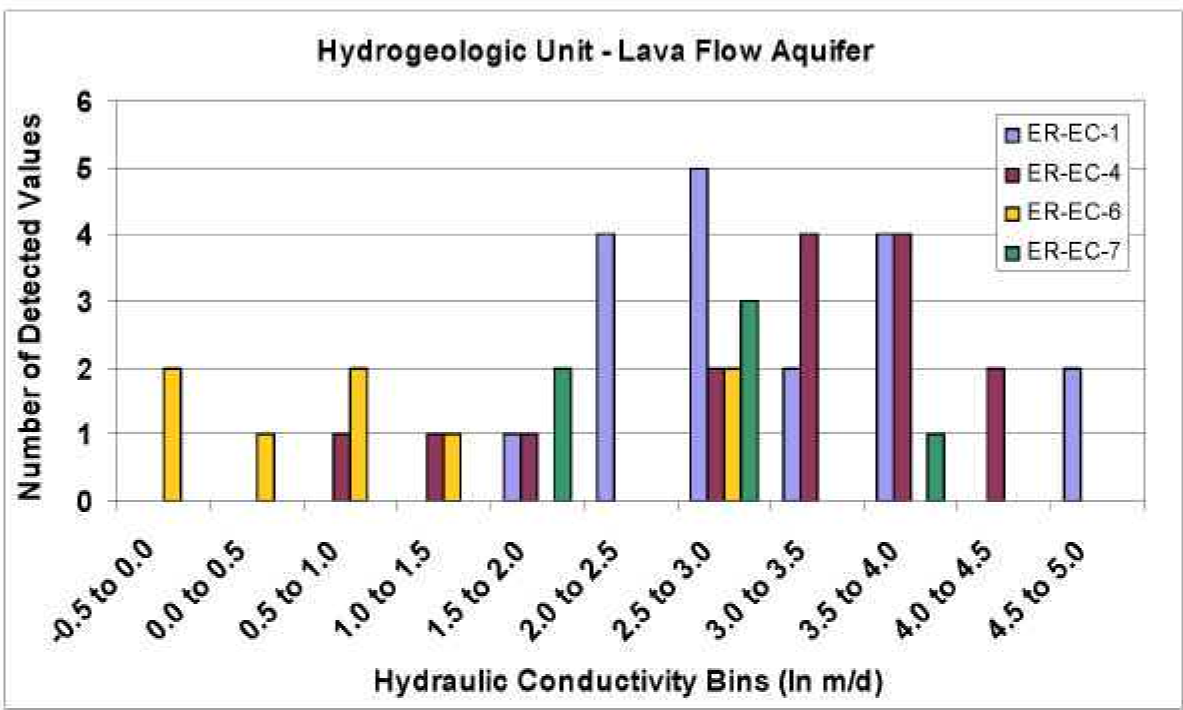


Figure 168. Detected natural logarithm hydraulic conductivity for individual wells for the hydrogeologic unit Lava Flow Aquifer.

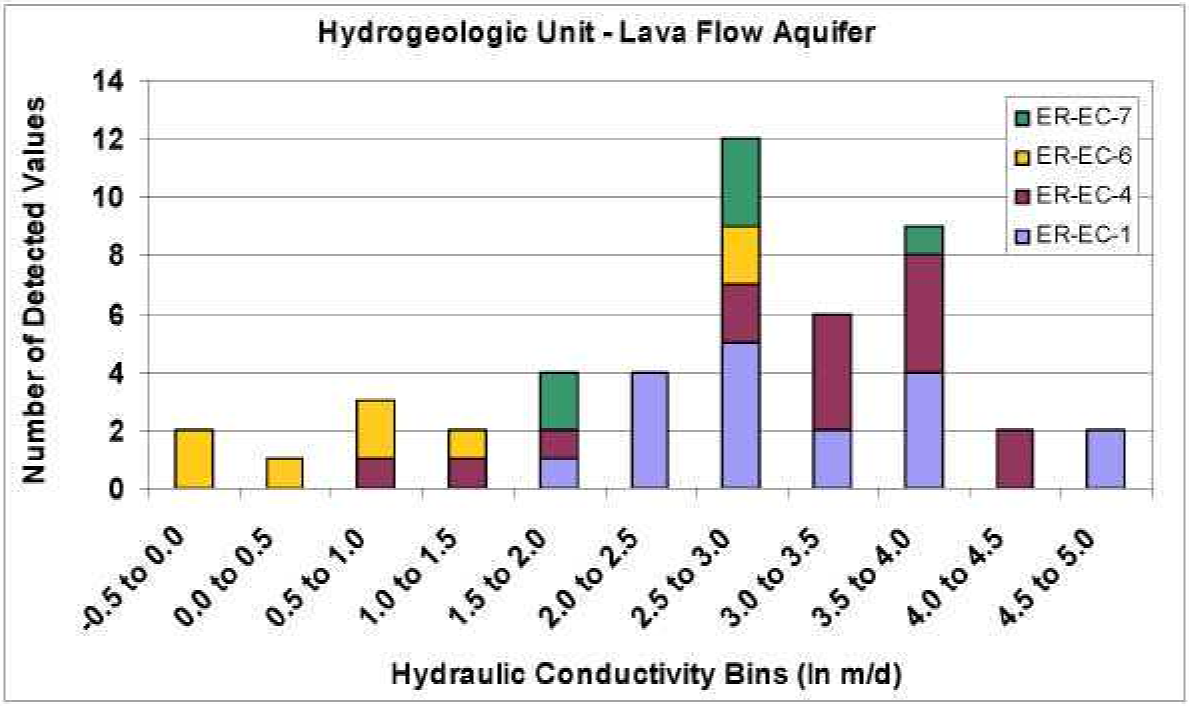


Figure 169. Detected natural logarithm hydraulic conductivity for wells in composite for the hydrogeologic unit Lava Flow Aquifer.

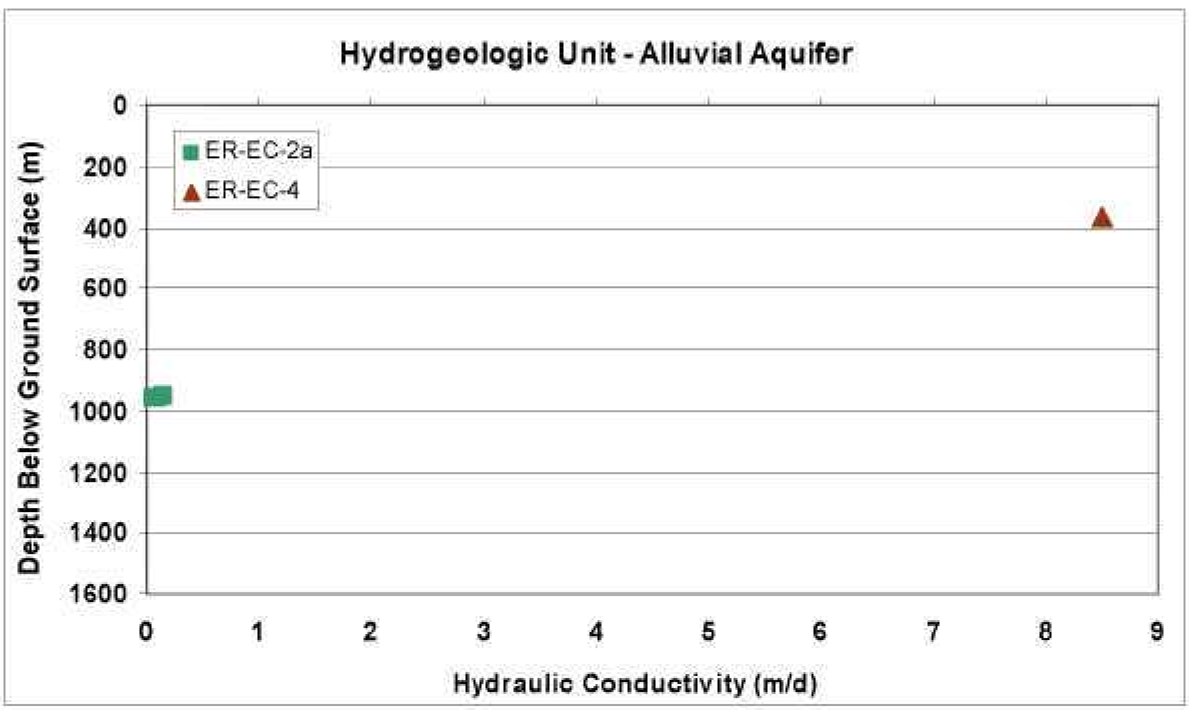


Figure 170. Detected hydraulic conductivity with depth for the hydrogeologic unit Alluvial Aquifer.

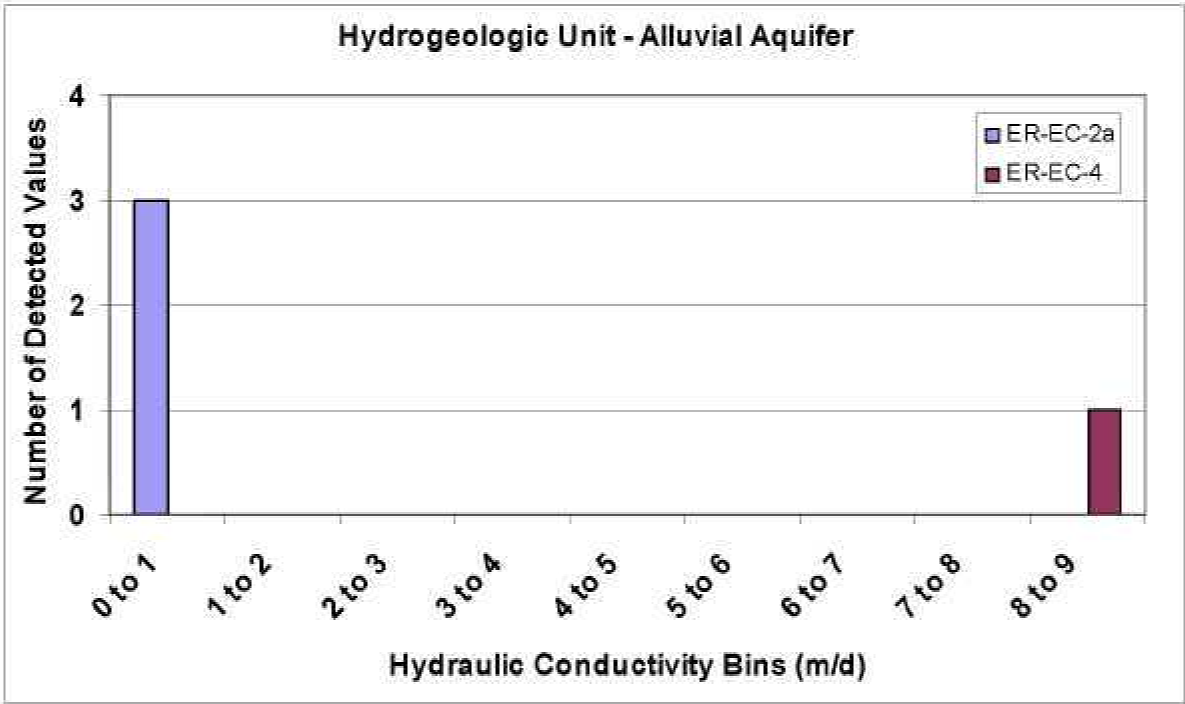


Figure 171. Detected hydraulic conductivity for individual wells for the hydrogeologic unit Alluvial Aquifer.

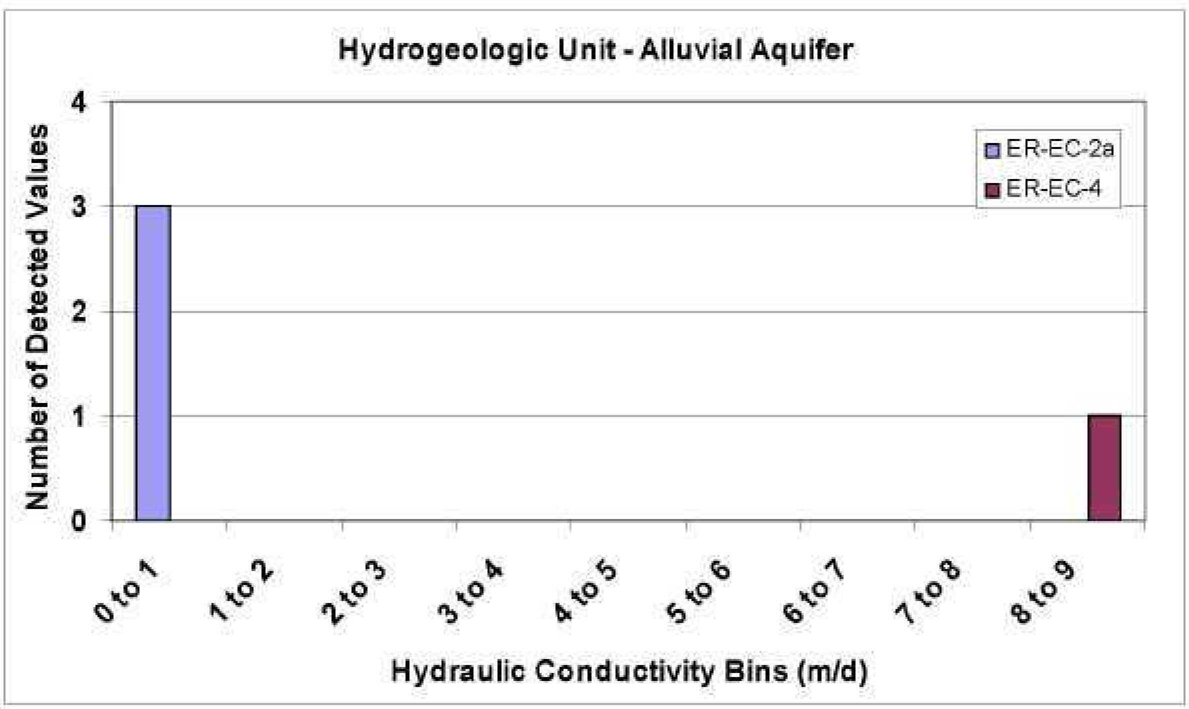


Figure 172. Detected hydraulic conductivity for wells in composite for the hydrogeologic unit Alluvial Aquifer.

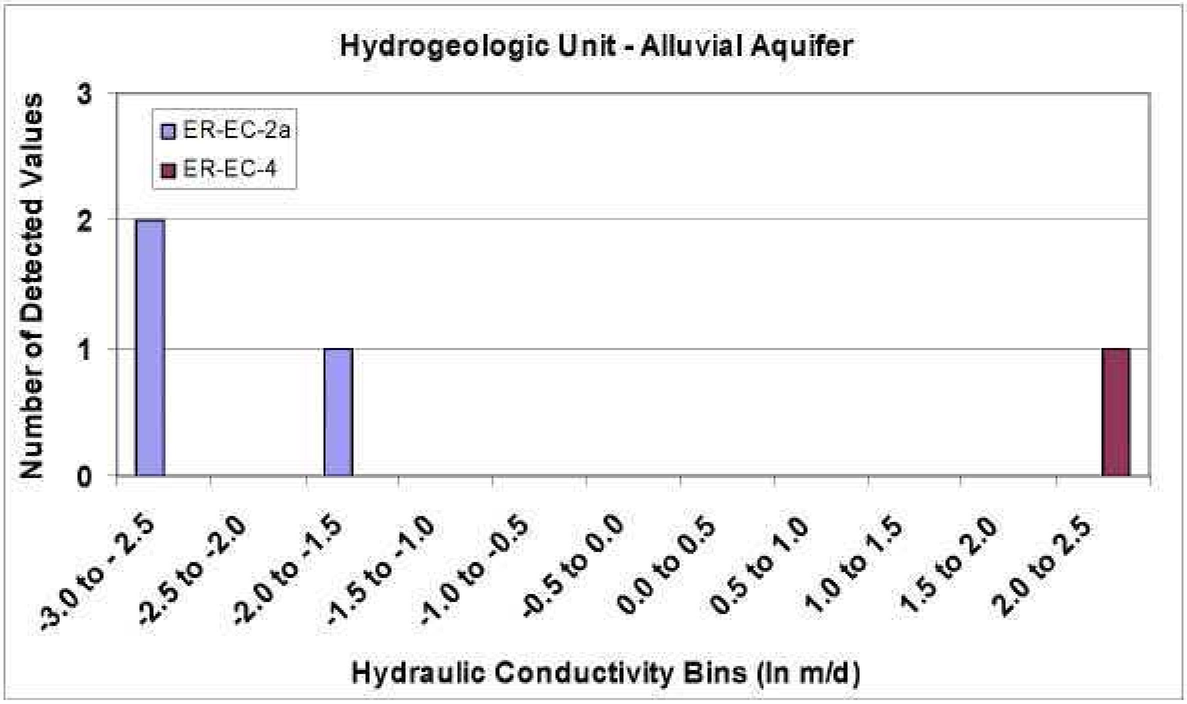


Figure 173. Detected natural logarithm hydraulic conductivity for individual wells for the hydrogeologic unit Alluvial Aquifer.

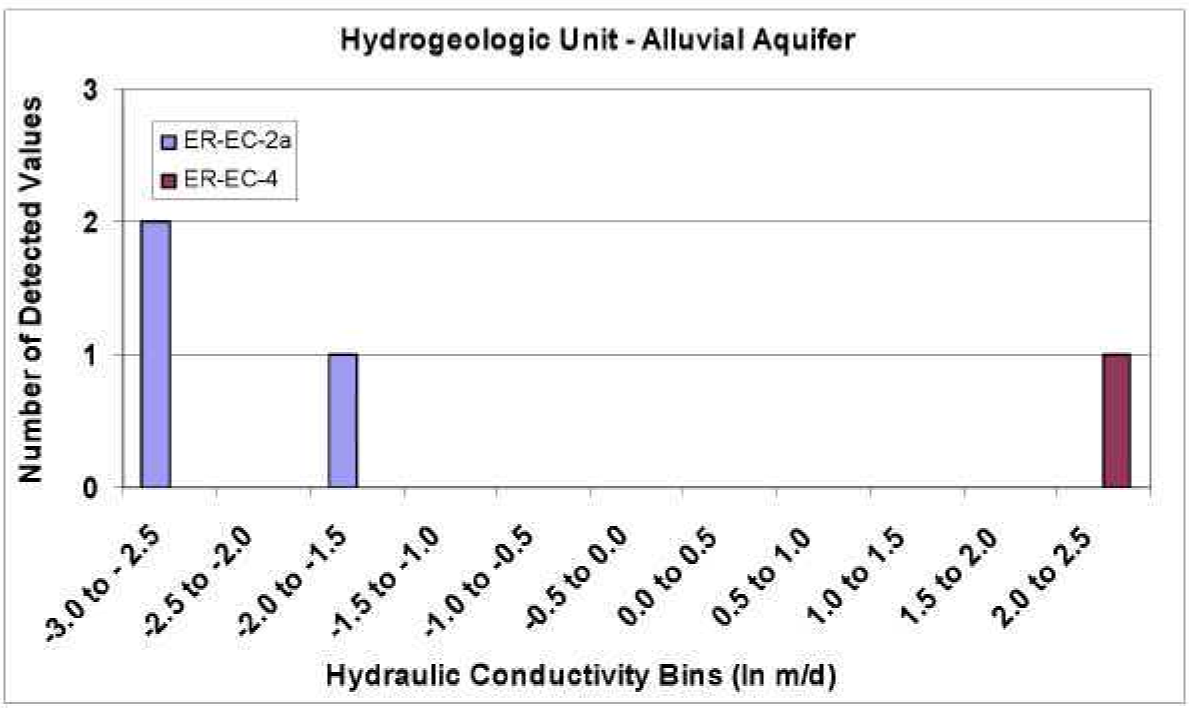


Figure 174. Detected natural logarithm hydraulic conductivity for wells in composite for the hydrogeologic unit Alluvial Aquifer.

Table 19. Hydrostratigraphic units encountered at multiple wells in tuff.

Hydrostratigraphic	ER-EC-1		ER-EC-2a		ER-EC-4		ER-EC-5		ER-5-4#2		ER-EC-6		ER-EC-7		ER-EC-8	
Unit	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)	Screened Length (m)	Detected K Length (m)
TCVA	0	0			39.8	25.5	0	0	0	0	0	0	0	0	0	0
FCCM	0	0	153.5	**57.2**	3.2	0.0	0	0	0	0	0	0	67.4	**8.2**	46.6	**20.9**
TMCM	0	0	224.2	**31.6**	0	0	85.9	**32.4**	0	0	0	0	0	0	31.0	**1.8**
TMA	0	0	0	0	92.3	1.6	0	0	0	0	0	0	0	0	0	0
BA	31.3	**23.8**	0	0	0	0	0	0	0	0	31.0	**4.8**	0	0	0	0
UPCU	13.4	3.0	0	0	0	0	0	0	0	0	23.9	0	0	0	0	0
TCA	14.9	1.5	0	0	0	0	0	0	0	0	14.9	0	0	0	0	0
LPCU	7.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TSA	25.3	1.5	0	0	0	0	0	0	0	0	23.3	0	0	0	0	0
CHCU	19.4	0	0	0	0	0	0	0	0	0	31.0	0	0	0	0	0
CFCM	40.2	3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LTCU	0	0	0	0	0	0	0	0	46.8	20.3	0	0	0	0	0	0

Gray shading indicates an alteration modifier that occurs in multiple wells
Bold type indicates length of detectable hydraulic conductivity for alteration modifiers with detectable hydraulic conductivity in more than one well

The detected hydraulic conductivity with depth for the Fortymile Canyon Composite Unit is presented in Figure 175. Well ER-EC-2a has lower hydraulic conductivity values than wells ER-EC-7 or ER-EC-8. Figures 176 through 179 present the detected hydraulic conductivity for the wells individually and in composite for normal and log-transformed values. Figure 176 shows a similar range for wells ER-EC-7 and ER-EC-8. The data for ER-EC-8 appear to approximate a normal distribution. Figure 177 shows that in composite, the data from ER-EC-2a have a different distribution from the other wells. Figures 178 and 179 show the log transform of the hydraulic conductivity data results in two distinct statistical distributions, with well ER-EC-2a having the lower values.

The detected hydraulic conductivity with depth for the Timber Mountain Composite Unit is presented in Figure 180. Well ER-EC-2a has much lower hydraulic conductivity values than wells ER-EC-5 and ER-EC-8. Figures 181 through 184 present the detected hydraulic conductivity for the wells individually and in composite for normal and log-transformed values. The distributions of detected hydraulic conductivity for the wells individually are presented in Figure 181 and indicate that only well ER-EC-5 has a discernible data distribution. Figure 182 presents the data for each well in composite and suggests a trend of a decreasing number of values for higher values of hydraulic conductivity. Logarithm transformation of the data for individual wells in Figure 183 indicates that well ER-EC-2a has a data distribution centered on much lower values than the other wells. Figure 184 indicates that there is a unique distribution of data for ER-EC-2a and that the other wells in composite form an approximately normal distribution.

The detected hydraulic conductivity with depth for the Benham Aquifer is presented in Figure 185. Figures 186 through 189 present the detected hydraulic conductivity for the wells individually and in composite for normal and log-transformed values. Figure 186 indicates no discernible data distributions for the wells when plotted individually. Figure 187 presents the detected hydraulic conductivity values plotted in composite. Figure 188 demonstrates no visually discernible distribution to the data for well ER-EC-6 and an approximately normal distribution for well ER-EC-1. Figure 189 showing data values for wells in composite indicates a distribution of values that is weighted toward lower values.

Wells Constructed in Carbonate Rock

Overview

Four wells logged in carbonate provided a total of 1,194 m of open borehole. Table 20 presents a summary of the detection of hydraulic conductivity in carbonate rock. Detection of hydraulic conductivity occurred in 65 percent of the open borehole. It should be noted that permeability in carbonate rock can be associated with discrete fractures and that well intervals having nondetectable permeability is expected. The percentage of hydraulic conductivity detection in carbonate rock cannot be directly compared with detection in tuff. The boreholes in carbonate rock were not always screened to the full depth of the well. Wells ER-6-1 and ER-6-1#2 were open boreholes at the logging depths. Wells ER-7-1 and ER-12-3 were screened but did not contain filter pack and provided an open conduit behind the well screen. The borehole flow data were linearized along vertical intervals of various lengths to remove instrument noise for calculation of hydraulic conductivity.

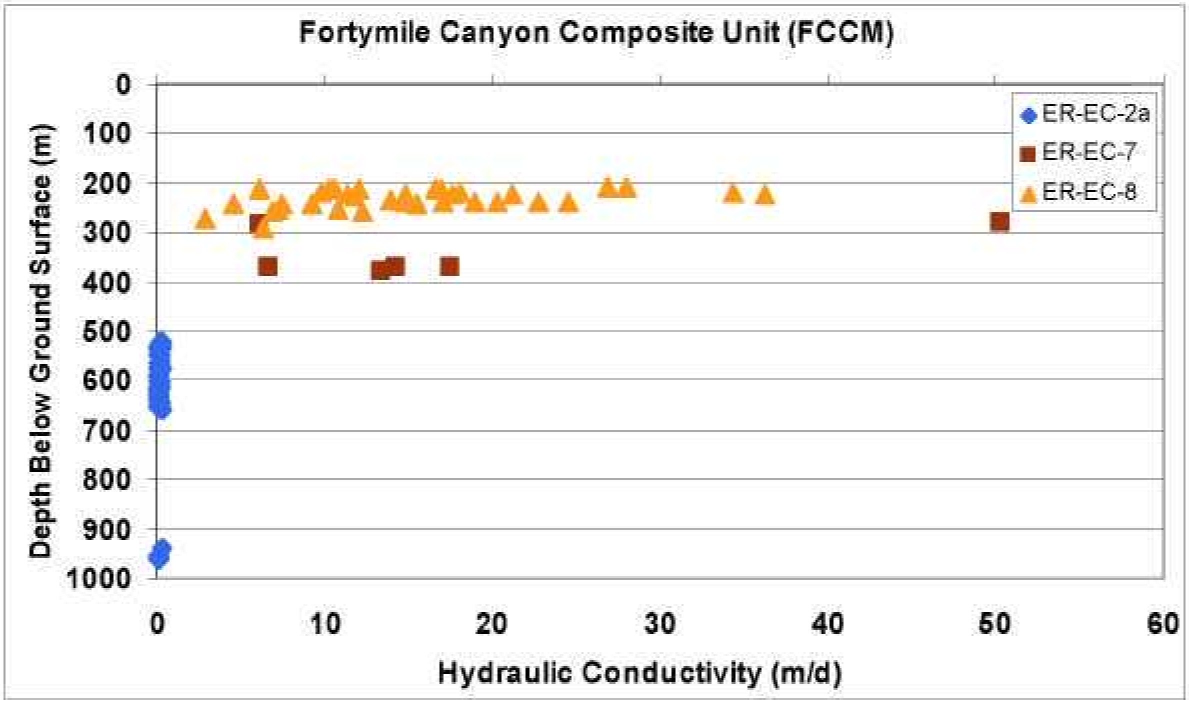


Figure 175. Detected hydraulic conductivity with depth for the hydrostratigraphic unit Fortymile Canyon Composite Unit.

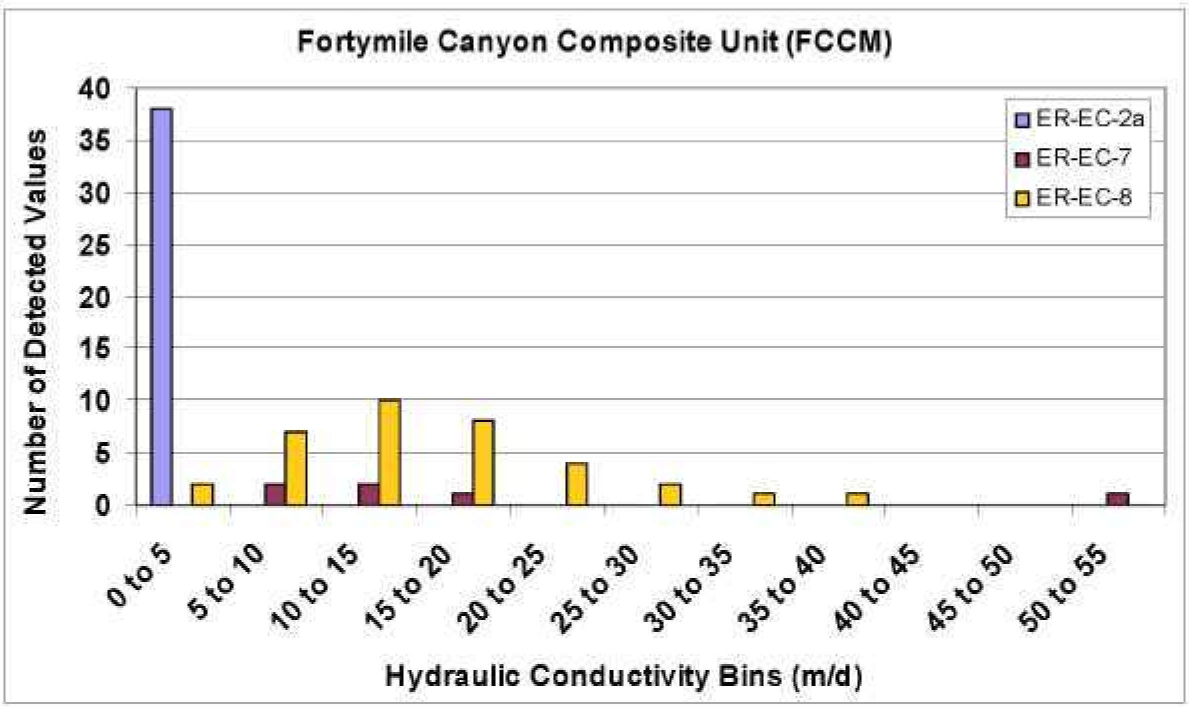


Figure 176. Detected hydraulic conductivity for individual wells for the hydrostratigraphic unit Fortymile Canyon Composite Unit.

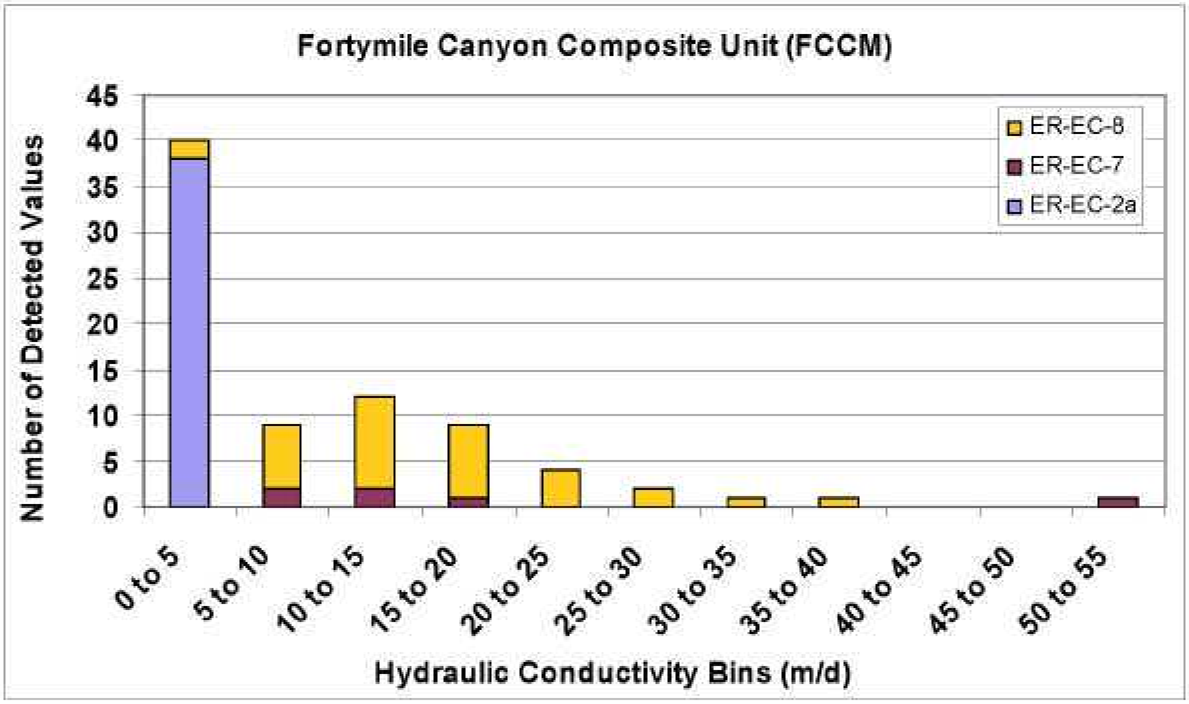


Figure 177. Detected hydraulic conductivity for wells in composite for the hydrostratigraphic unit Fortymile Canyon Composite Unit.

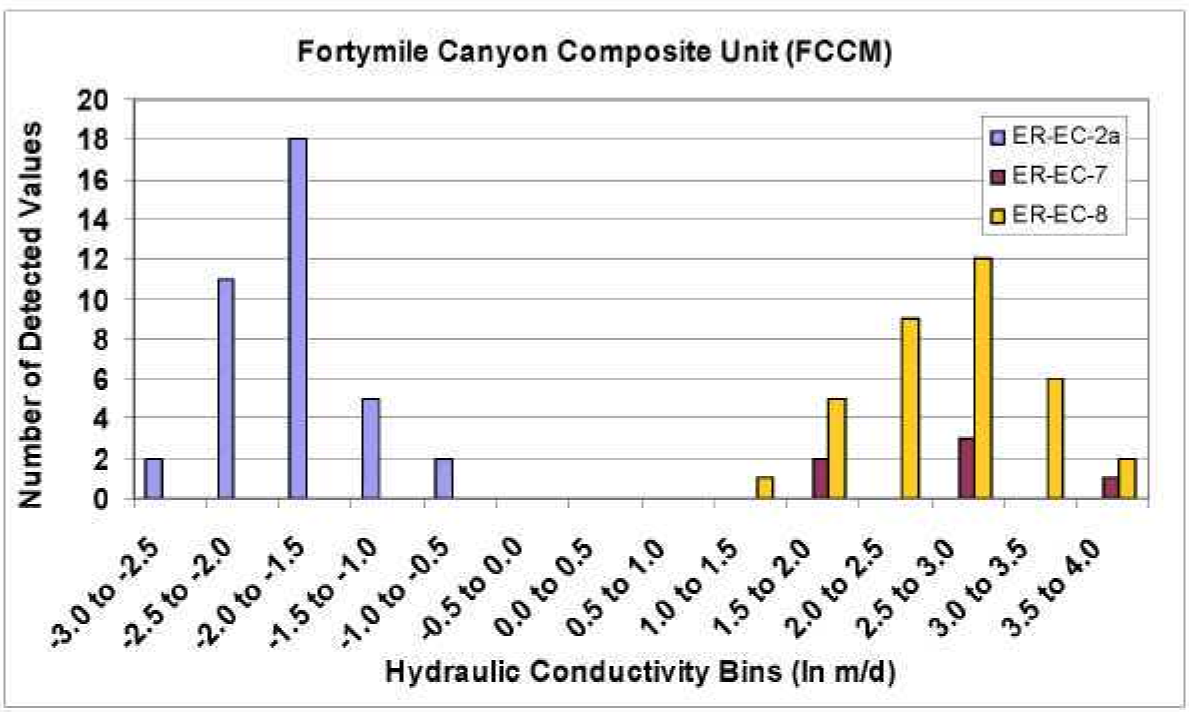


Figure 178. Detected natural logarithm hydraulic conductivity for individual wells for the hydrostratigraphic unit Fortymile Canyon Composite Unit.

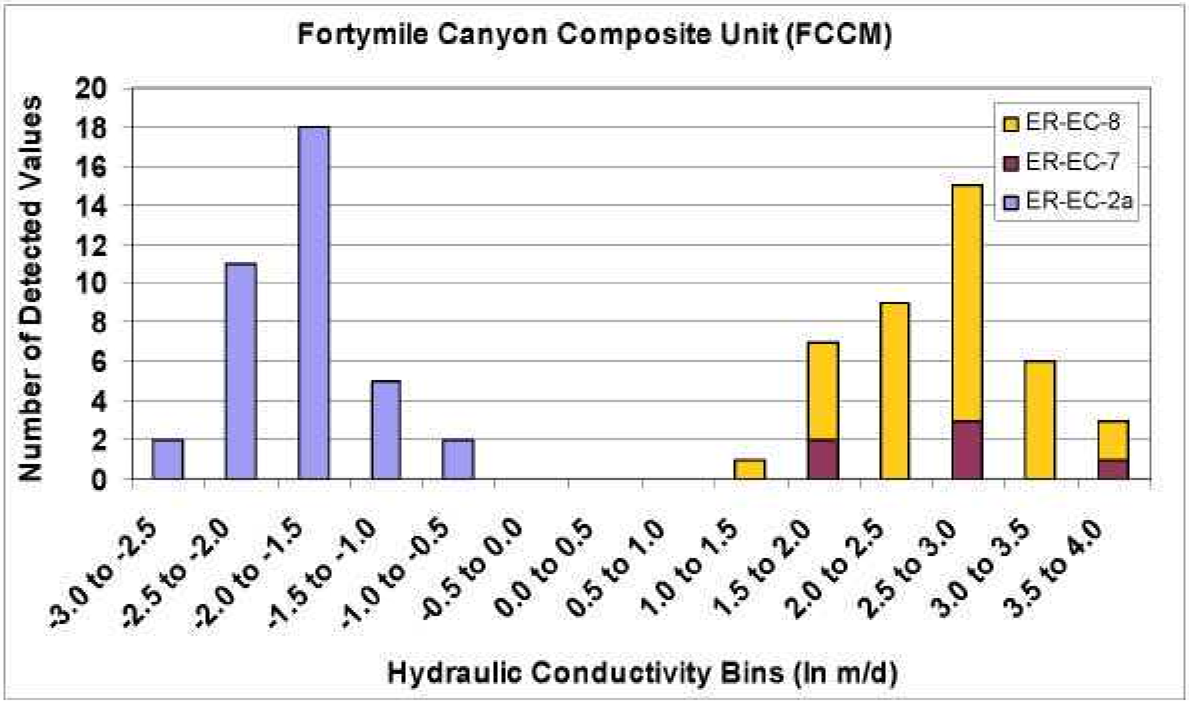


Figure 179. Detected natural logarithm hydraulic conductivity for wells in composite for the hydrostratigraphic unit Fortymile Canyon Composite Unit.

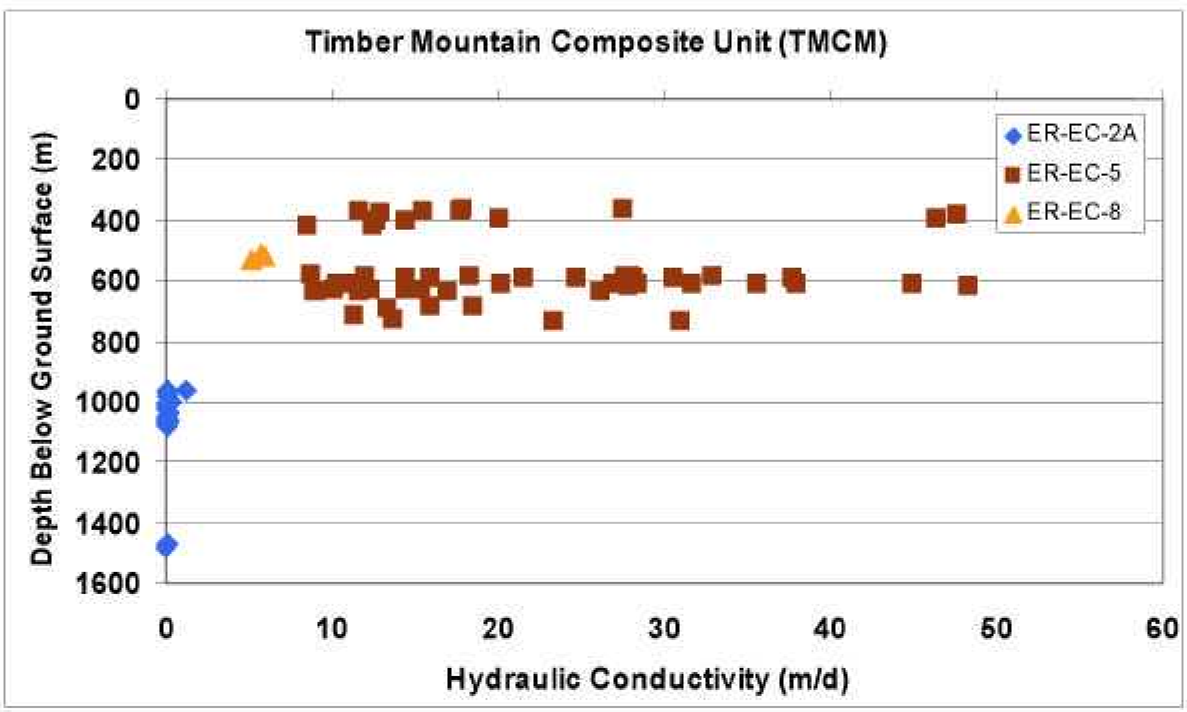


Figure 180. Detected hydraulic conductivity with depth for the hydrostratigraphic unit Timber Mountain Composite Unit.

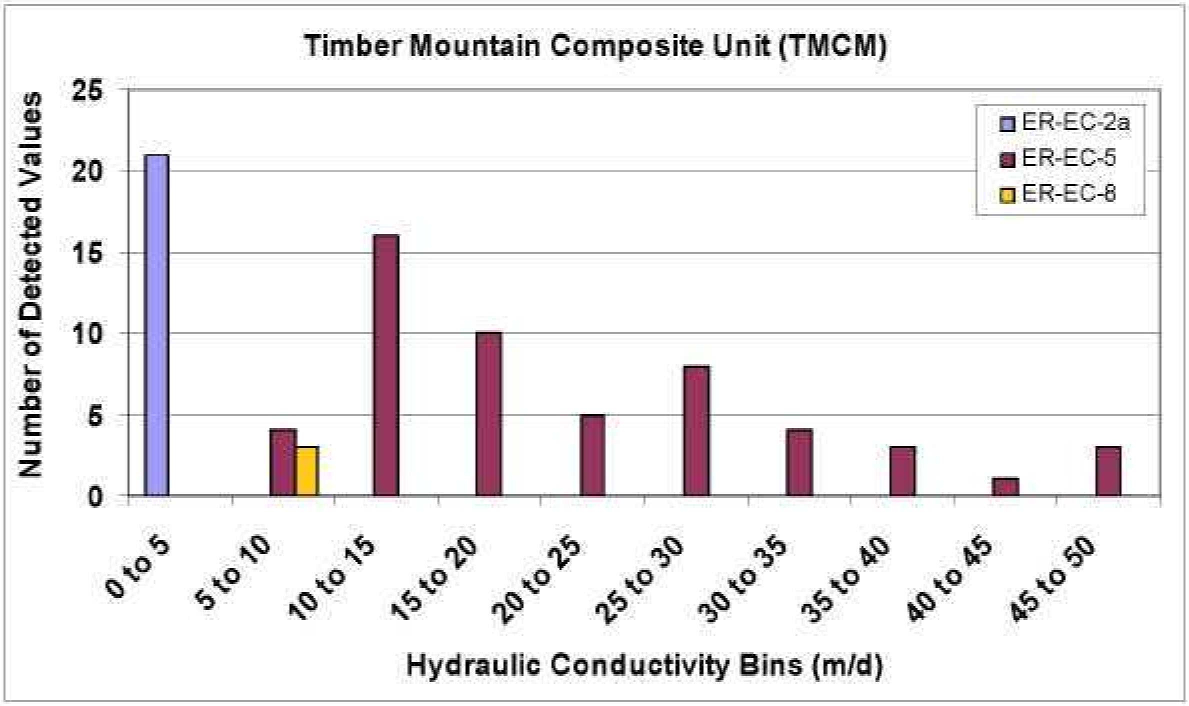


Figure 181. Detected hydraulic conductivity for individual wells for the hydrostratigraphic unit Timber Mountain Composite Unit.

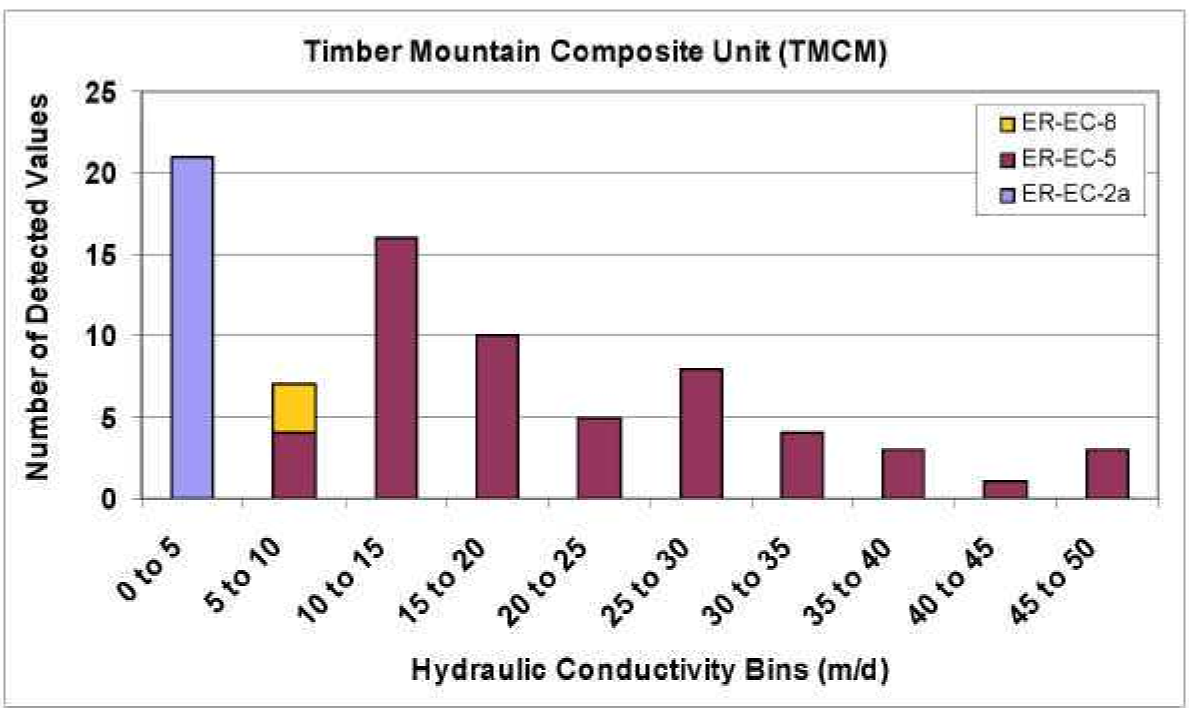


Figure 182. Detected hydraulic conductivity for wells in composite for the hydrostratigraphic unit Timber Mountain Composite Unit.

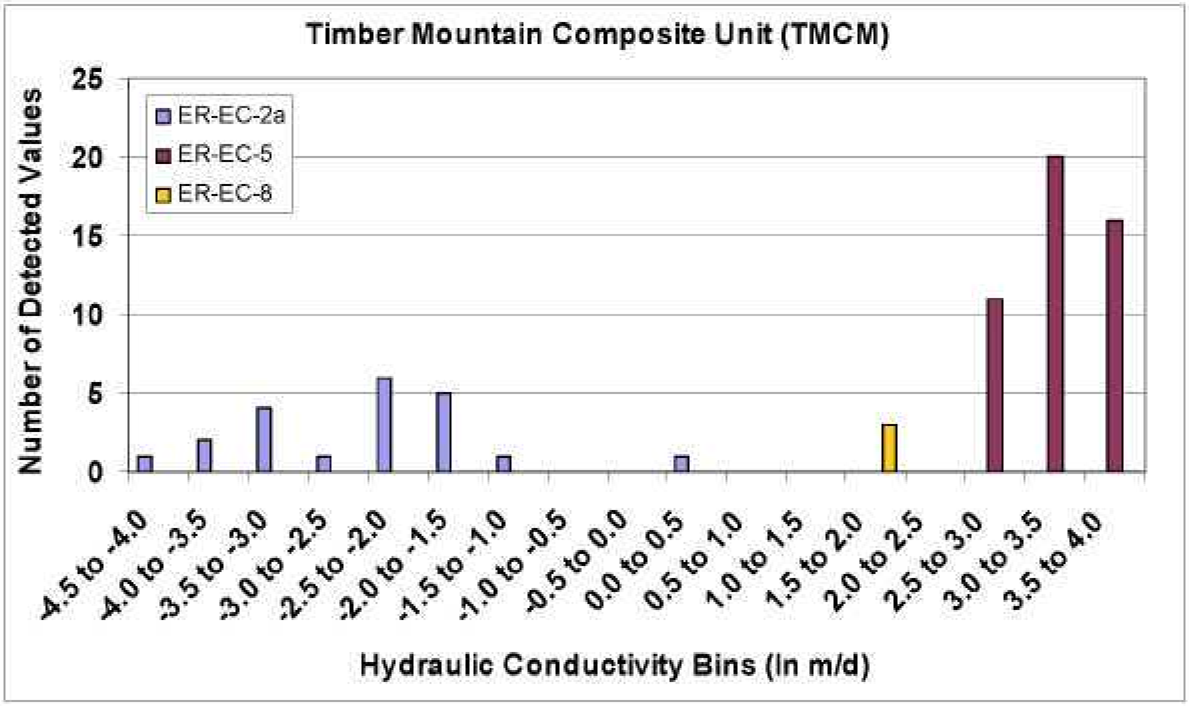


Figure 183. Detected natural logarithm hydraulic conductivity for individual wells for the hydrostratigraphic unit Timber Mountain Composite Unit.

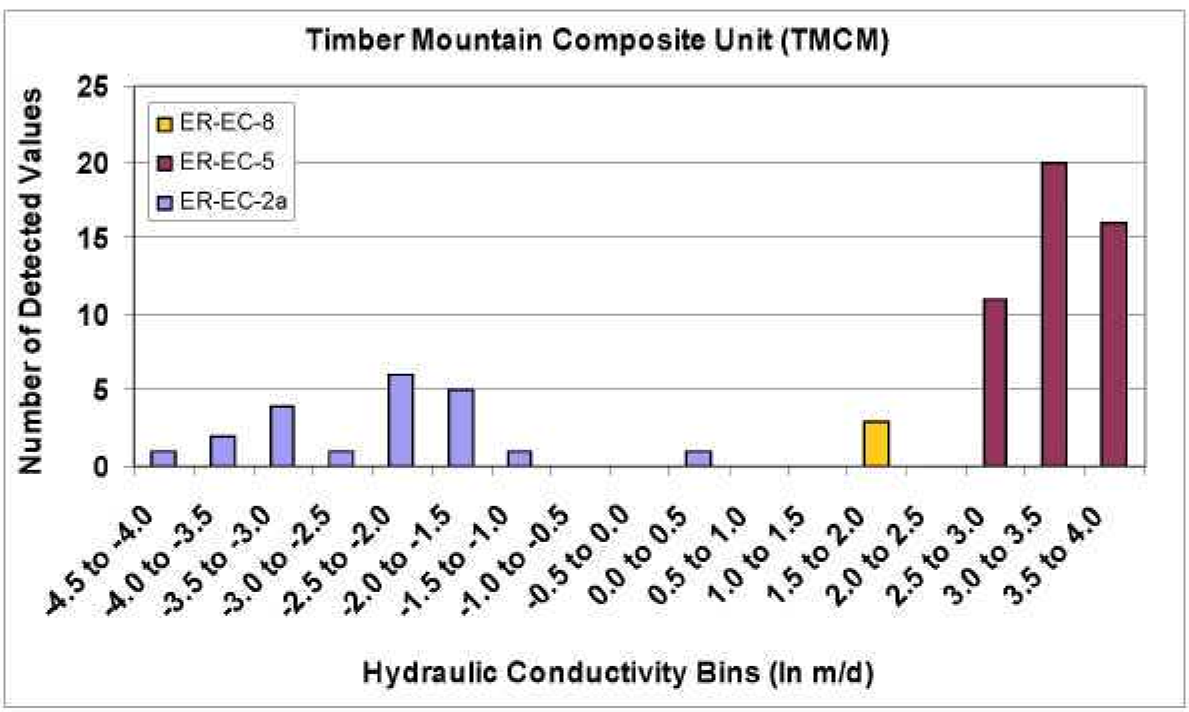


Figure 184. Detected natural logarithm hydraulic conductivity for wells in composite for the hydrostratigraphic unit Timber Mountain Composite Unit.

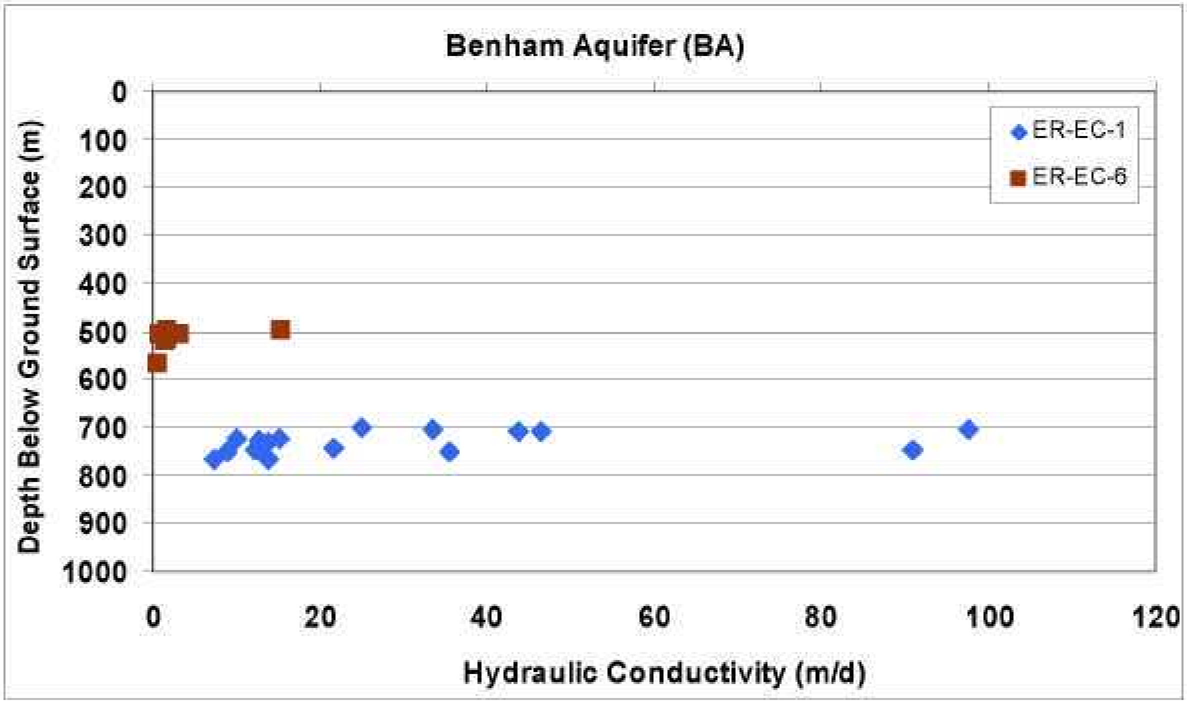


Figure 185. Detected hydraulic conductivity with depth for the hydrostratigraphic unit Benham Aquifer.

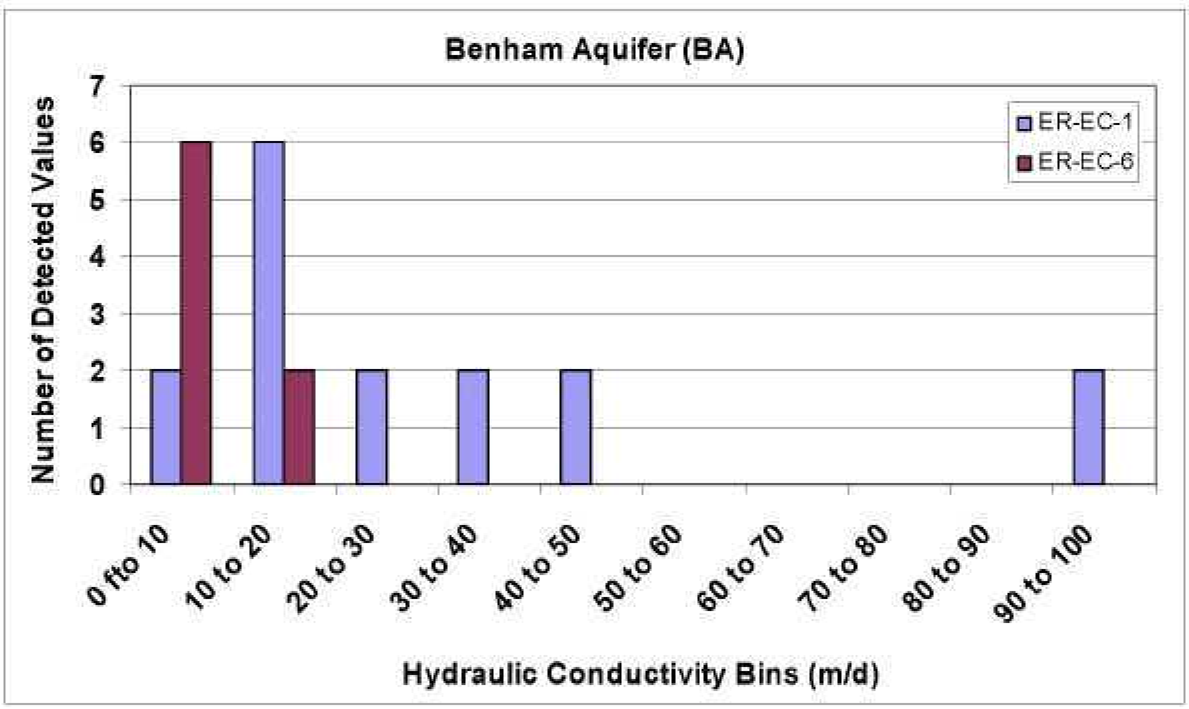


Figure 186. Detected hydraulic conductivity for individual wells for the hydrostratigraphic unit Benham Aquifer.

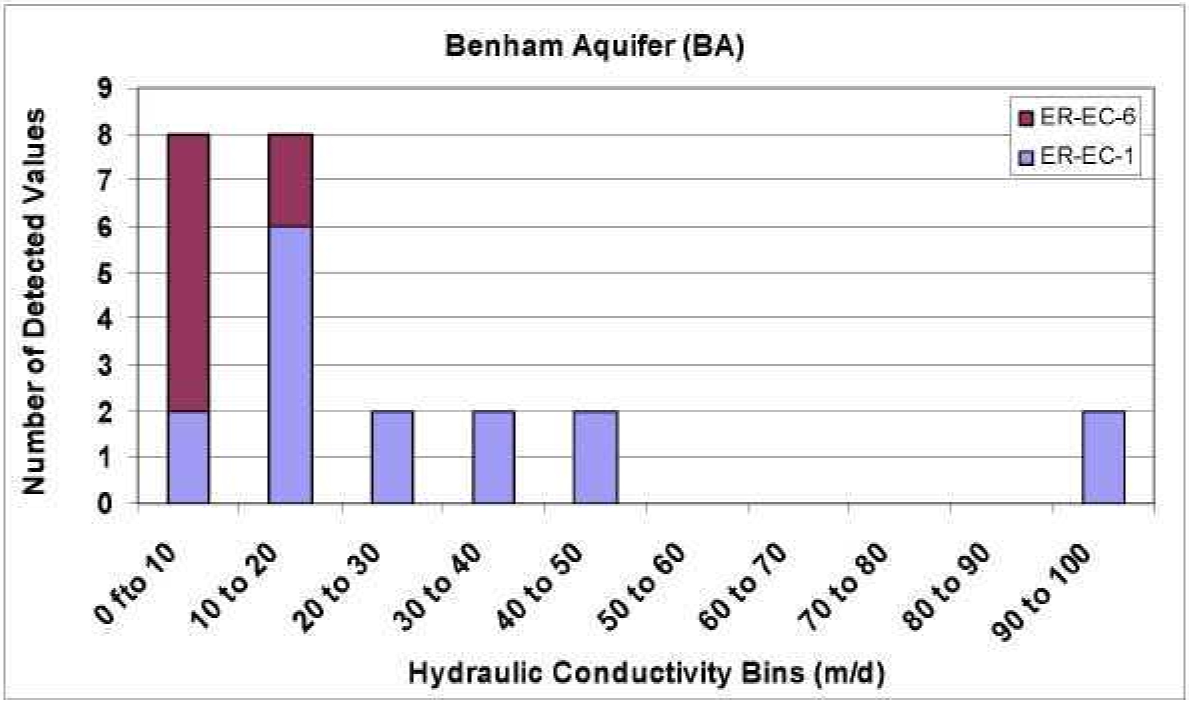


Figure 187. Detected hydraulic conductivity for wells in composite for the hydrostratigraphic unit Benham Aquifer.

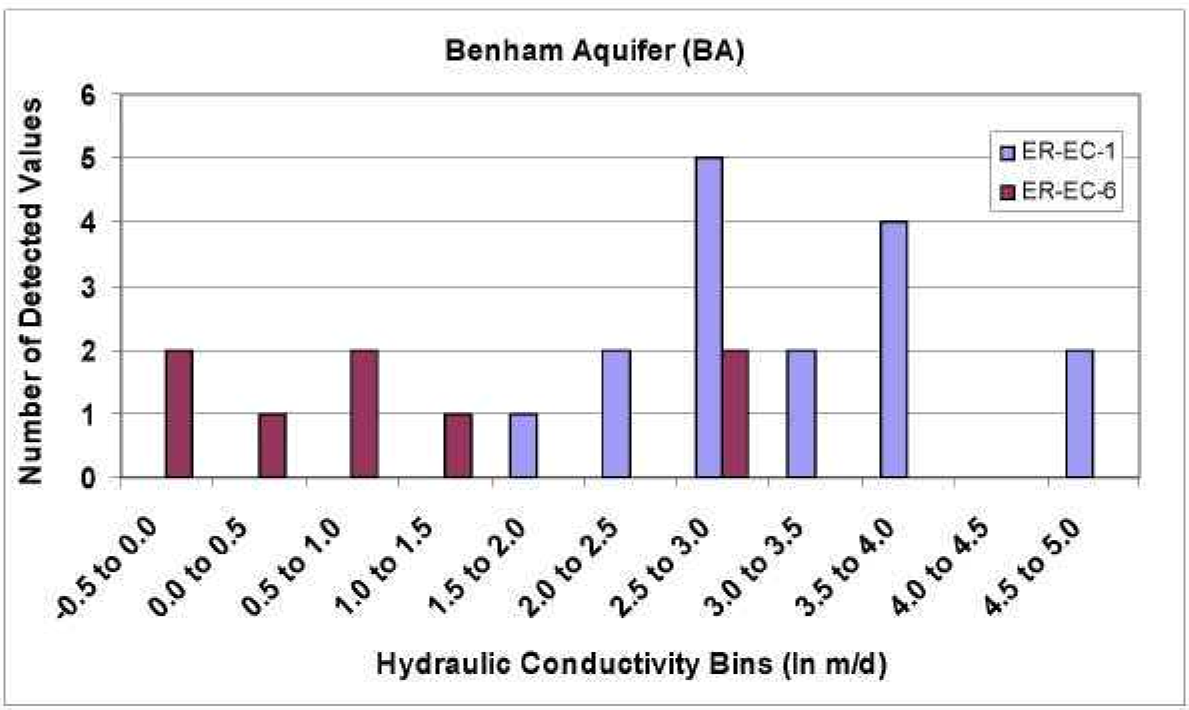


Figure 188. Detected natural logarithm hydraulic conductivity for individual wells for the hydrostratigraphic unit Benham Aquifer.

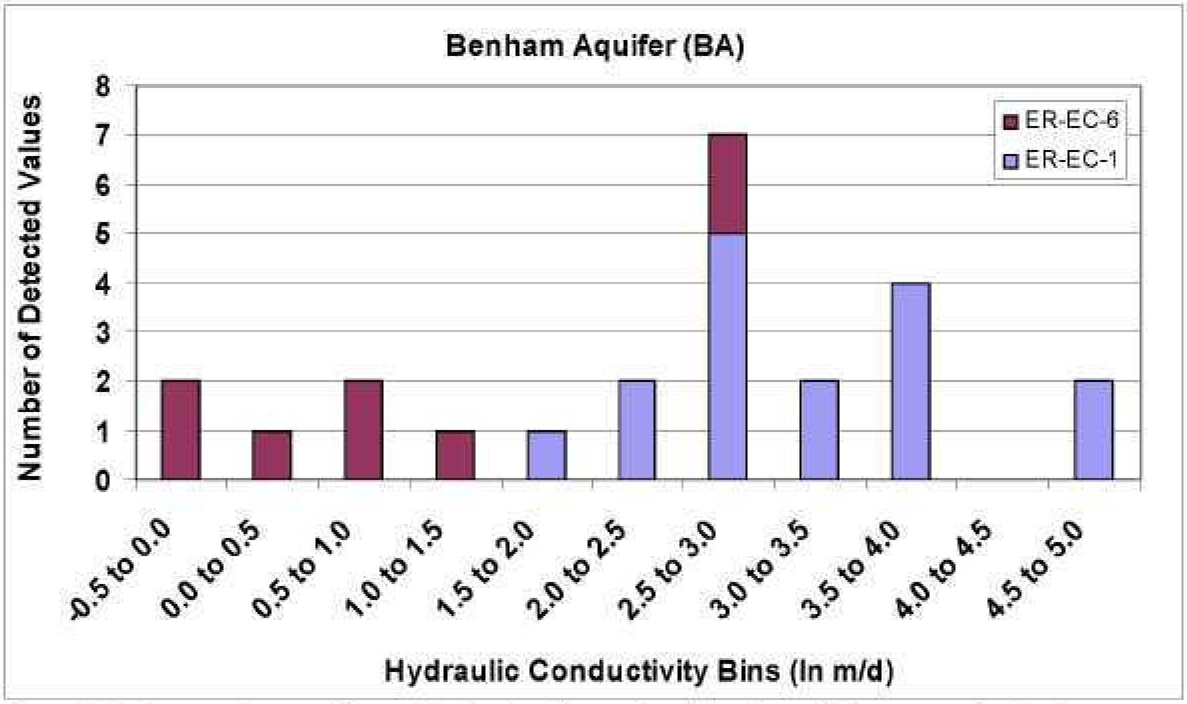


Figure 189. Detected natural logarithm hydraulic conductivity for wells in composite for the hydrostratigraphic unit Benham Aquifer.

Table 20. Detection of hydraulic conductivity in carbonate rock.

Well	Min. Pumping Rate (L/min)	Max. Pumping Rate (L/min)	Open Bore Length (m)	Vertical Evaluation Interval Length (m)	Possible Hydraulic Conductivity Detection (m)	Hydraulic Conductivity Detection (m)
ER-6-1	1,053	2,140	373.4	1.5	373.4	342.9
ER-6-1#2	1,050	2,072	353.6	1.5	353.6	234.7
ER-7-1	461	595	87.3	1.5	87.3	67.5
ER-12-3	79	112	379.4	9.5	379.4	132.8
TOTAL	n.a.	n.a.	1,193.7	n.a.	1,193.7	778.0

The hydraulic conductivity with depth is presented in Figures 190 through 193. The position of the well screen or open borehole, where detection of hydraulic conductivity is possible, is indicated on the left-hand side of the figure.

Examination of Figures 190 through 193 indicates that hydraulic conductivity is detected in all portions of the well. Wells ER-7-1 and ER-12-3 have the highest values of hydraulic conductivity in the upper portions of the screened interval. The reader is referred to the Appendix to access the depths and hydraulic conductivity values if alternative data presentations are viewed as being valuable to their analysis needs.

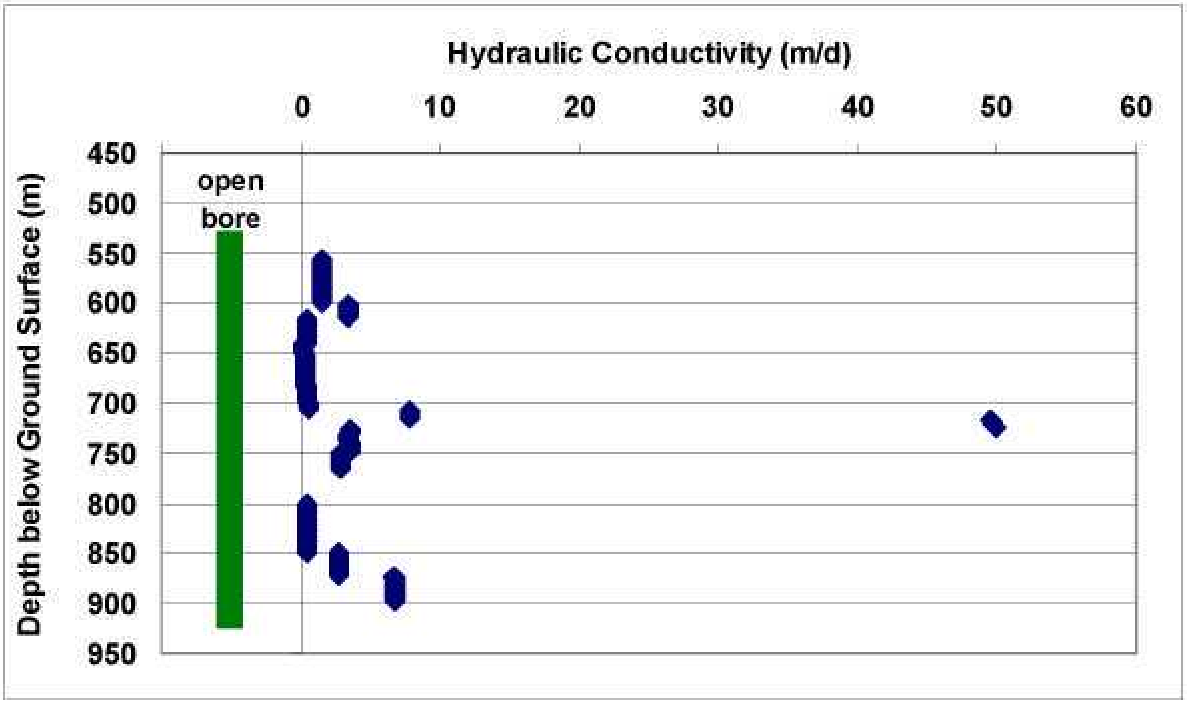


Figure 190. Detected hydraulic conductivity with depth at well ER-6-1.

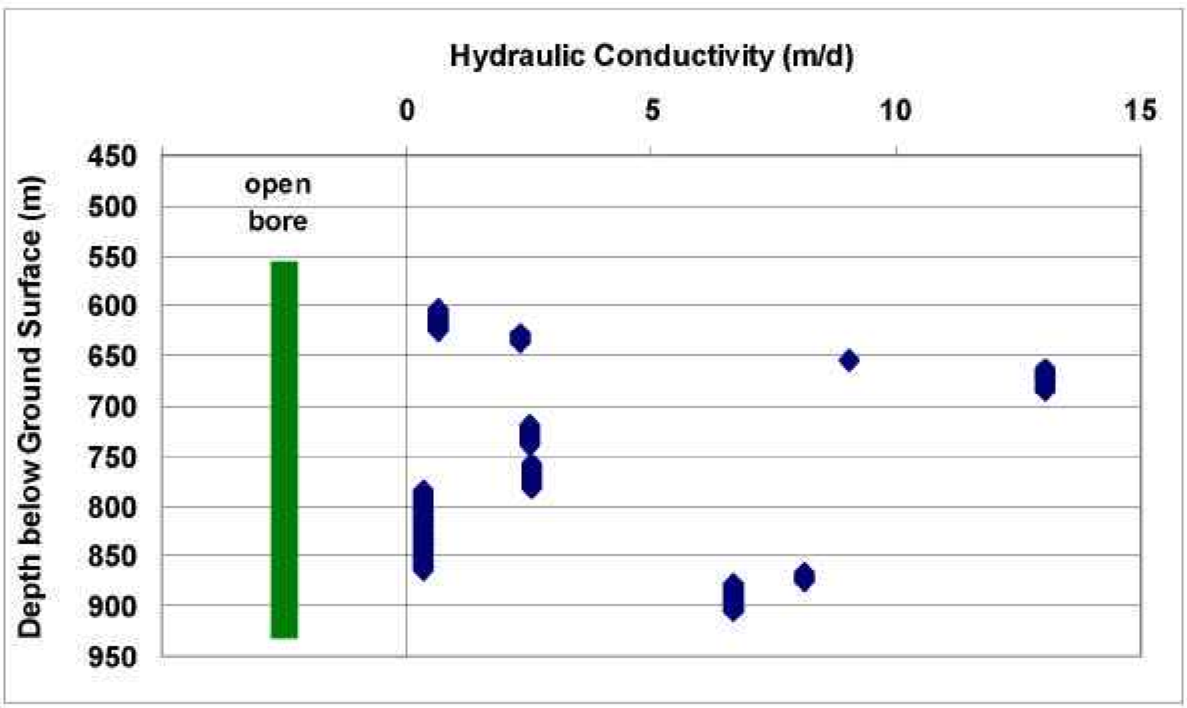


Figure 191. Detected hydraulic conductivity with depth at well ER-6-1#2.

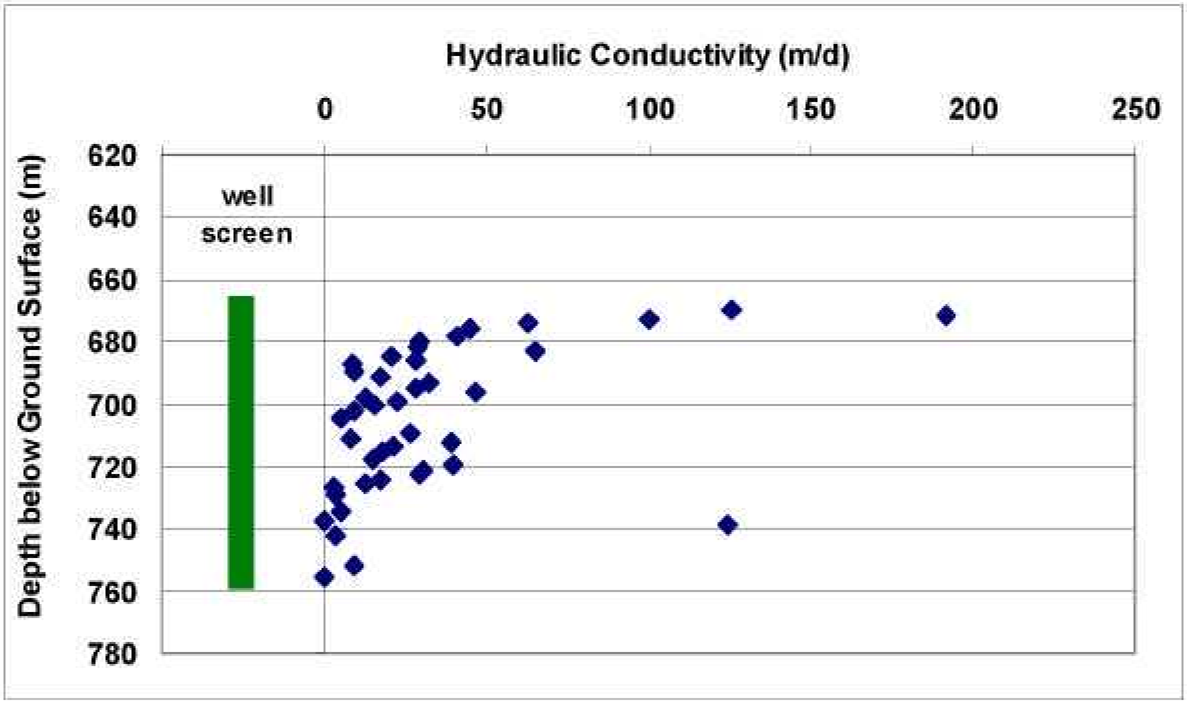


Figure 192. Detected hydraulic conductivity with depth at well ER-7-1.

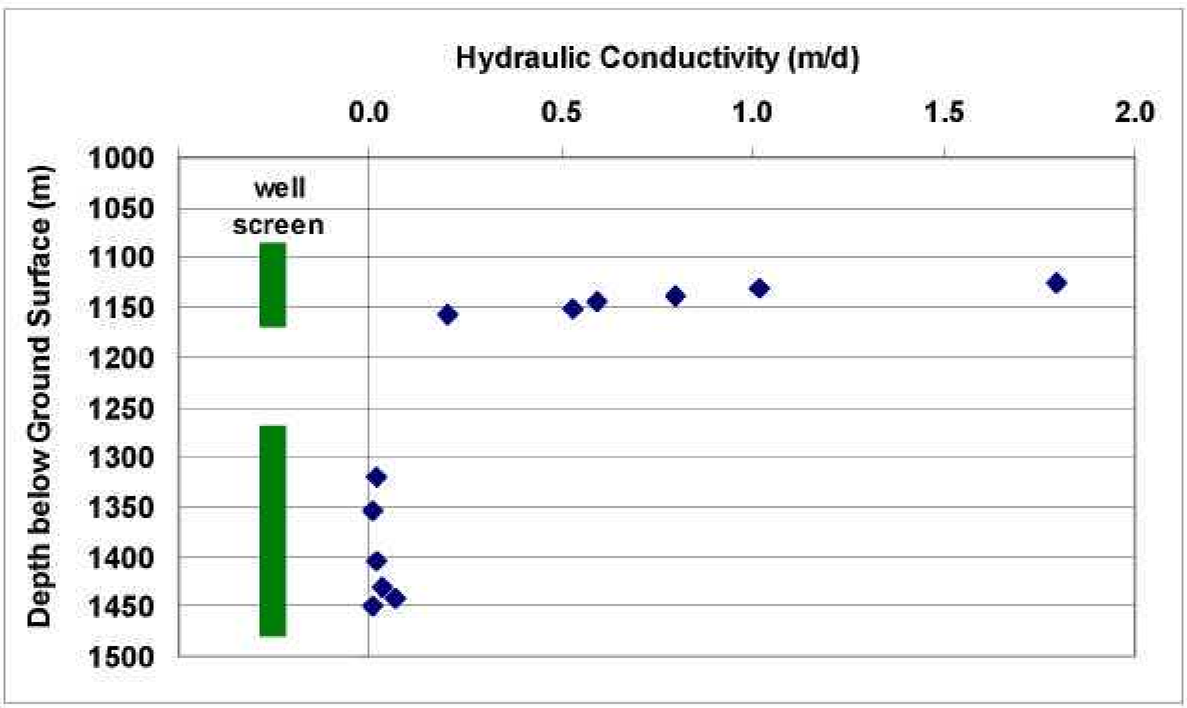


Figure 193. Detected hydraulic conductivity with depth at well ER-12-3.

The analysis continues by examining hydraulic conductivity for the hydrogeologic classifications:

- stratigraphic unit,
- lithologic modifier, and
- hydrogeologic / hydrostratigraphic / alteration modifier.

The hydrogeologic unit, hydrostratigraphic unit, and alteration modifier do not vary within the hydrogeologic classifications. The hydrogeologic characteristics for all of the wells are carbonate aquifer, lower carbonate aquifer, and unaltered, respectively. Each of the other hydrogeologic classifications has several characteristics to designate the particular stratigraphic unit or lithologic modifier. Therefore, the data are not plotted for these hydrogeologic characteristics. The hydrogeologic characteristics are defined at the beginning of each report section.

Association of Hydraulic Conductivity with Well-specific Hydrogeologic Characteristics

The following sections describe the association of hydraulic conductivity with each hydrogeologic characteristic. The analysis goals of the figures are described in Table 2. These results are intended for the reader interested in the characteristics of a specific well. Wells ER-6-1 and ER-6-1#2 are located about 64 m apart (210 ft) and have similar lithologic and hydraulic characteristics. Each well is discussed in a separate section below.

Hydraulic Conductivity and Stratigraphy

Well construction in carbonate encountered eight different stratigraphic units. Each of the units encountered is presented in the tables and figures to aid the reader in understanding the stratigraphic section at each well and the context of well screening and the detection of hydraulic conductivity. Table 21 presents the stratigraphic abbreviations for the stratigraphic units encountered in each well. Table 22 presents a summary of the stratigraphic units associated with well screen and the detection of hydraulic conductivity. The value of these tables is that they provide a quick review of the stratigraphic units containing detectable hydraulic conductivity without the reader needing to examine each of the well-specific figures. Four stratigraphic units had well screen placed adjacent to the unit and hydraulic conductivity was detected in all of these stratigraphic units.

The vertical length of well screen in each stratigraphic unit and the length over which hydraulic conductivity was detected are presented for each well in Figures 194 through 197. The figures include carbonate stratigraphic units that were encountered during drilling but not screened, to aid the reader in understanding the stratigraphic context. This is especially important where there are intervening stratigraphic units between the screened units.

The average detected hydraulic conductivity within each stratigraphic unit is presented in Figures 198 through 201. This analysis demonstrates a range in hydraulic conductivity of about two orders of magnitude with wells ER-6-1, ER-6-1#2, and ER-12-3 having relatively low values and well ER-7-1 having higher values.

Table 21. Stratigraphic units for wells in carbonate rock.

Stratigraphic Abbreviation	Stratigraphic Unit Name
ER-6-1	
Al	Alluvium
Tuff	Tuff
DSs	Sevy Dolomite
DSl	Laketown Dolomite
Oes	Ely Springs Dolomite
Oe	Eureka Quartzite
ER-6-1#2	
Al	Alluvium
Tuff	Tuff
Col	Coluvium
DSl	Laketown Dolomite
Oes	Ely Springs Dolomite
Oe	Eureka Quartzite
ER-7-1	
Al	Alluvium
Tuff	Tuff
Col	Colluvium
Pzu	Paleozoic Undifferentiated
ER-12-3	
Al	Alluvium
Tuff	Tuff
Pzu	Paleozoic Undifferentiated

Table 22. Stratigraphic units encountered in drilling. Stratigraphic units that are screened are shaded gray and units with detectable hydraulic conductivity are in bold type.

Well	Stratigraphic Unit					
ER-6-1	Al	Tuff	**DSs**	**DSl**	**Oes**	Oe
ER-6-1#2	Al	Tuff	Col	**DSl**	**Oes**	Oe
ER-7-1	Al	Tuff	Col	**Pzu**		
ER-12-3	Al	Tuff		**Pzu**		

Hydraulic Conductivity and Lithologic Modifier

Well construction in carbonate placed well screen adjacent to units containing seven different lithologic modifiers. Each of the modifiers encountered during well construction is presented in the tables and figures to aid the reader in understanding the context of well screening and the detection of hydraulic conductivity. Table 23 presents abbreviations for the lithologic modifiers encountered in the wells. Table 24 presents a summary of the lithologic modifiers associated with well screen and the detection of hydraulic conductivity. Well screen was placed adjacent to two unique lithologic modifiers in carbonate. Both of these lithologic modifiers are associated with detectable hydraulic conductivity. Lithologic modifiers have the lowest number of associations among the hydrogeologic characteristic.

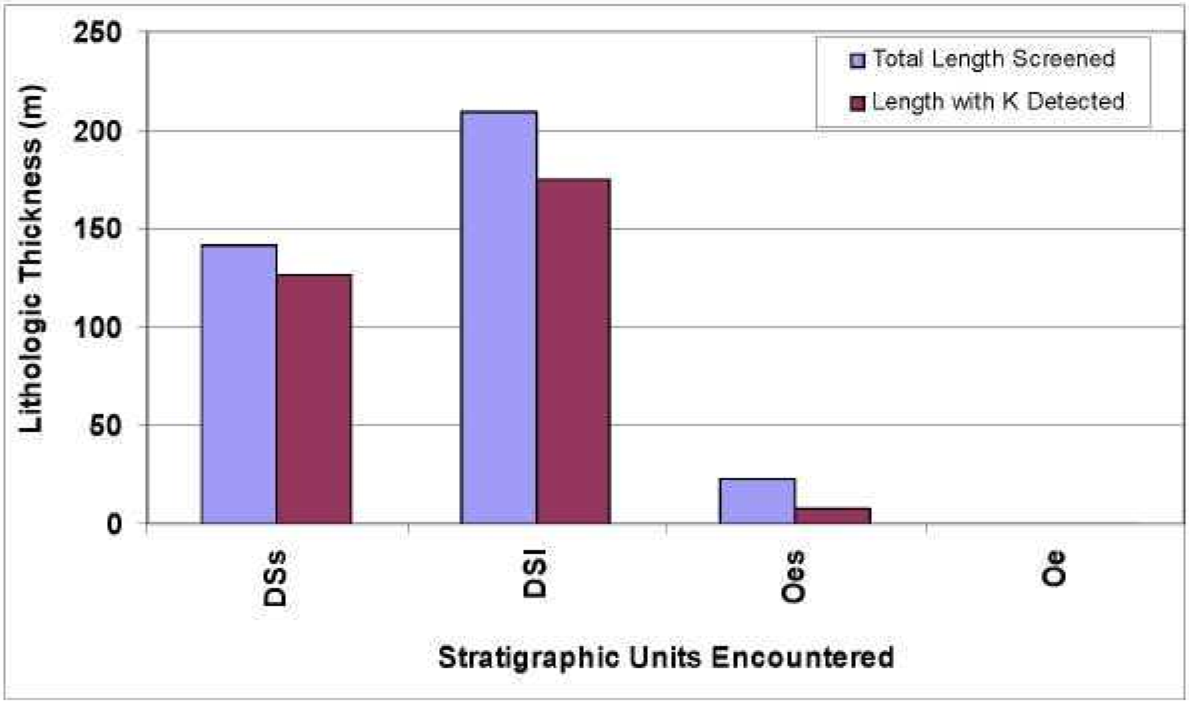


Figure 194. Stratigraphic units adjacent to well screen and detectable hydraulic conductivity at well ER-6-1.

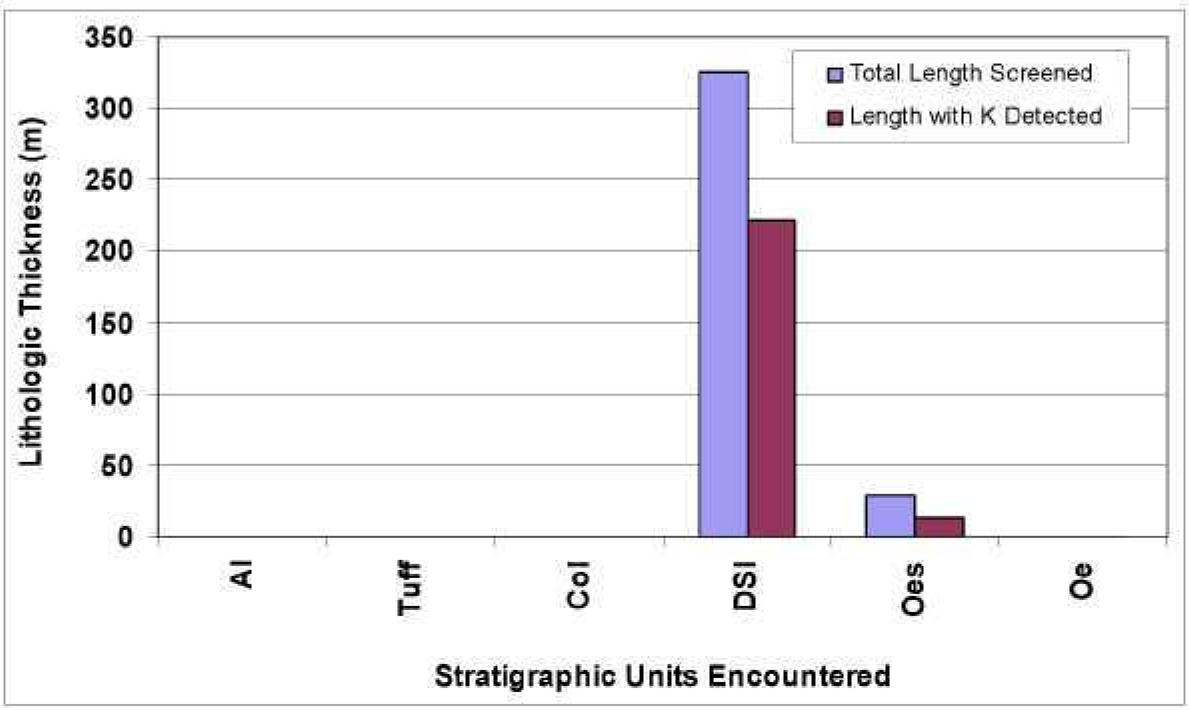


Figure 195. Stratigraphic units adjacent to well screen and detectable hydraulic conductivity at well ER-6-1#2.

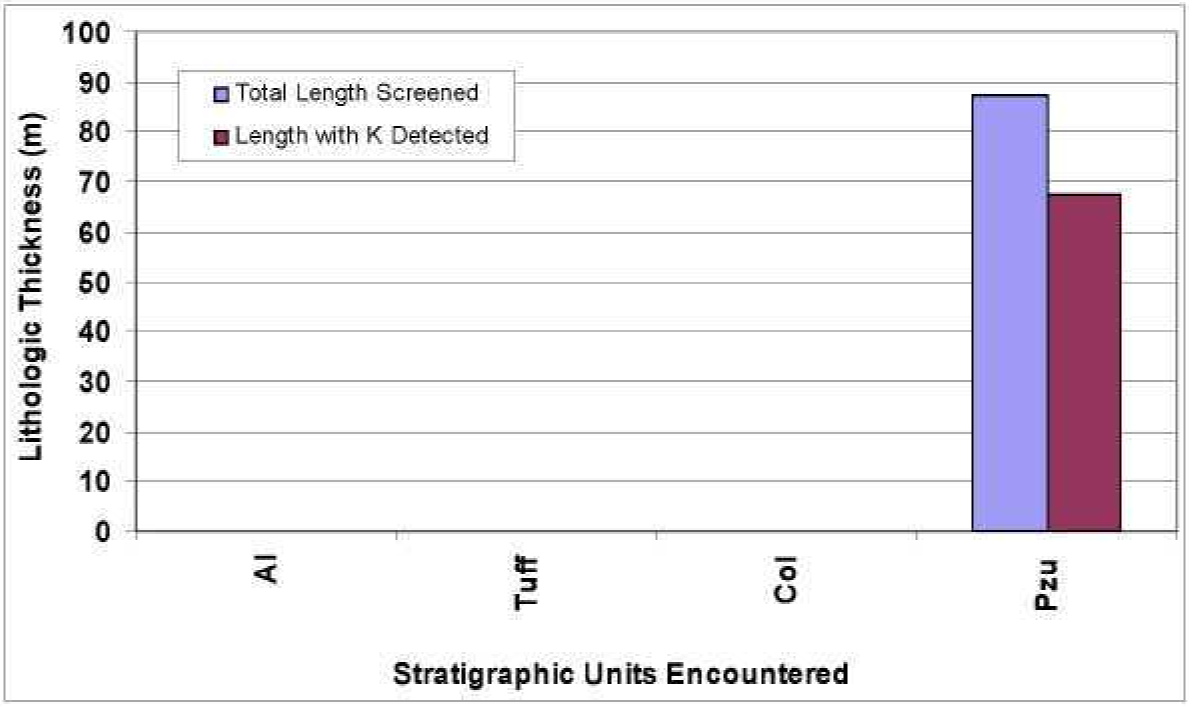


Figure 196. Stratigraphic units adjacent to well screen and detectable hydraulic conductivity at well ER-7-1.

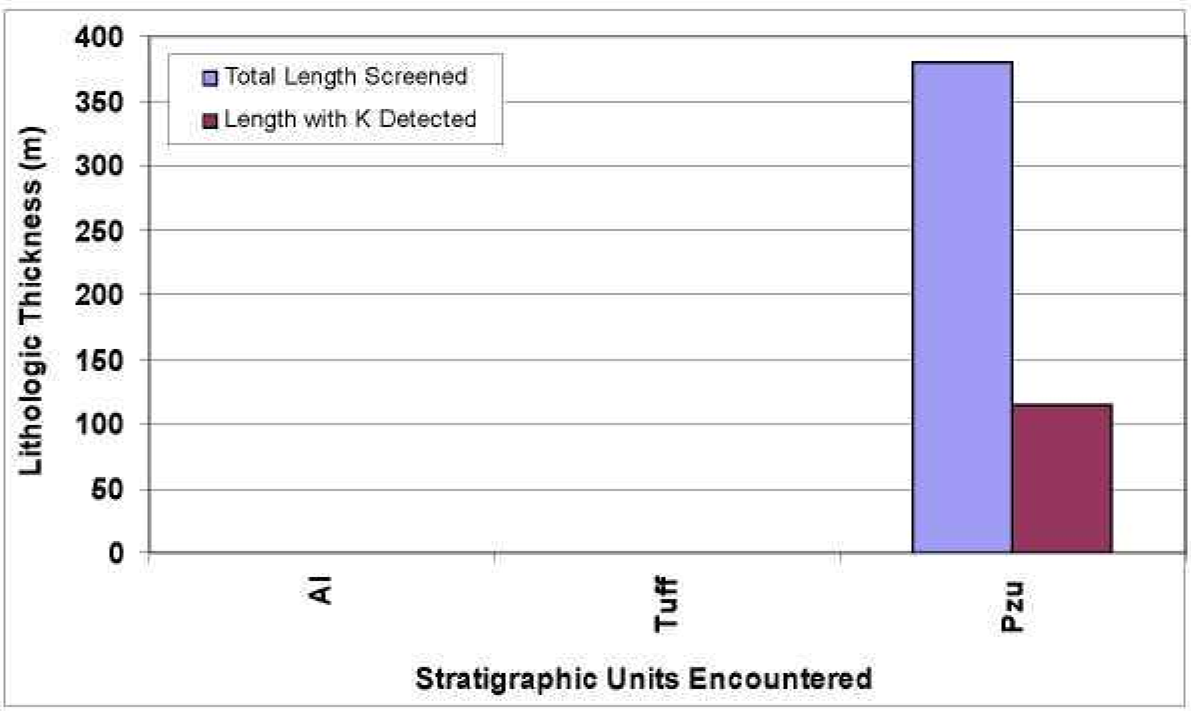


Figure 197. Stratigraphic units adjacent to well screen and detectable hydraulic conductivity at well ER-12-3.

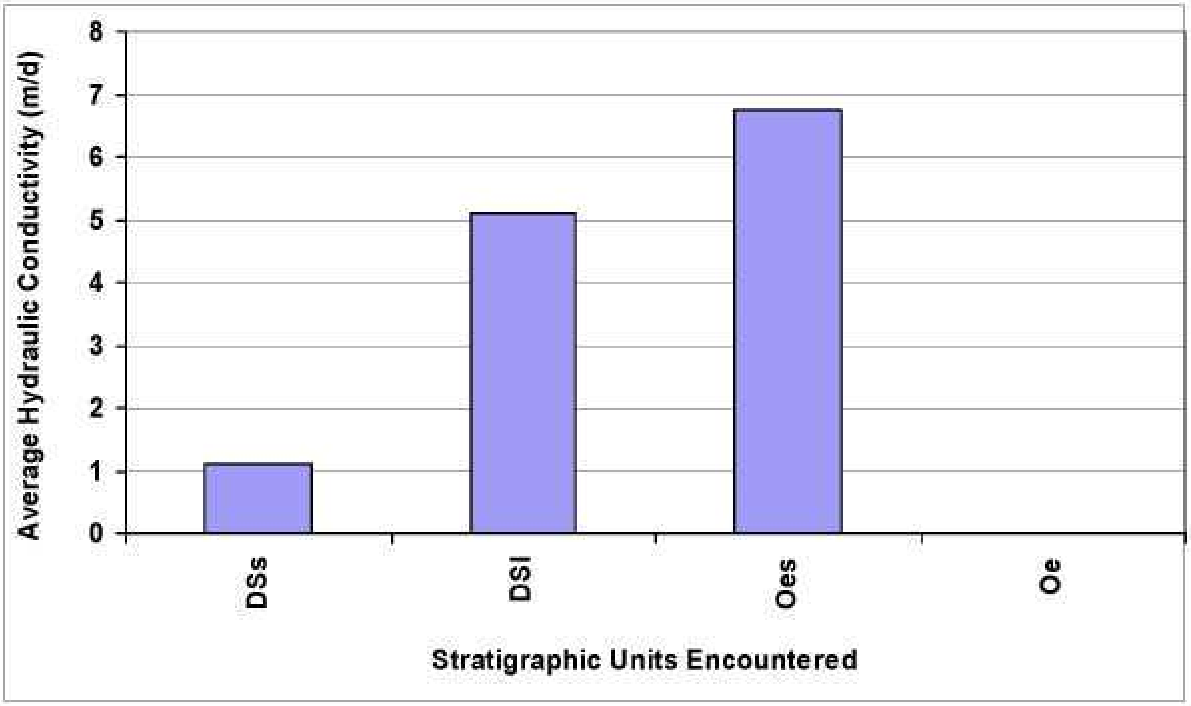


Figure 198. Average detected hydraulic conductivity in stratigraphic units at well ER-6-1.

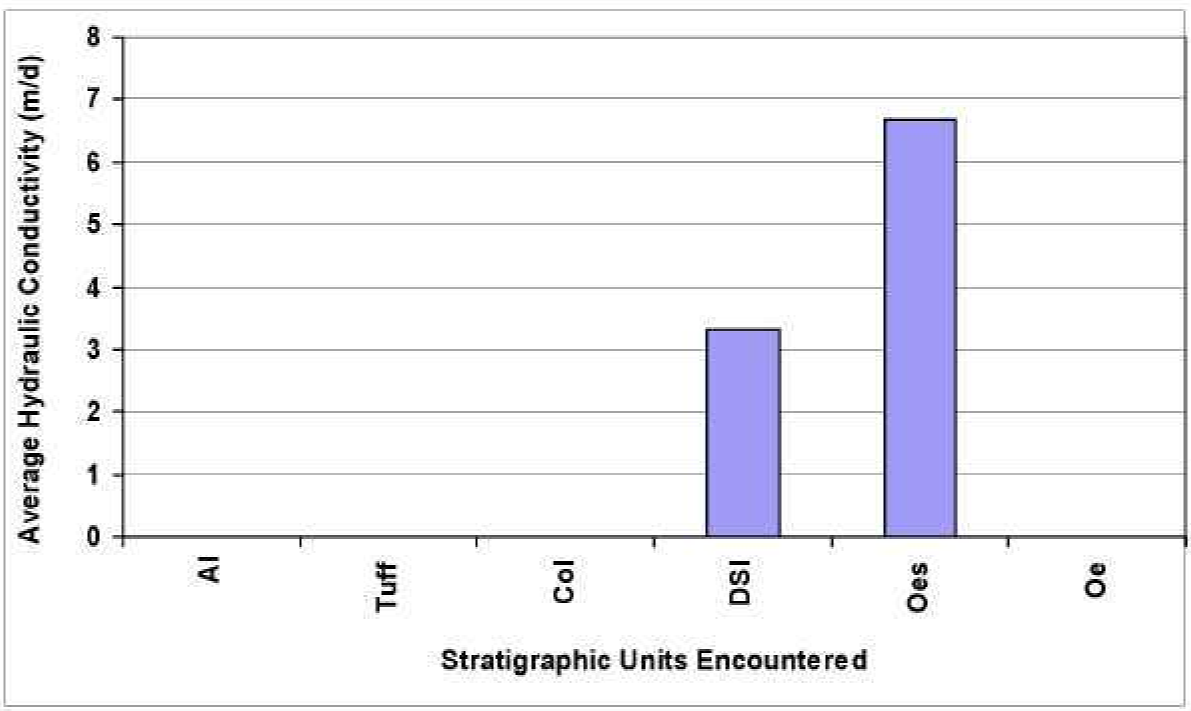


Figure 199. Average detected hydraulic conductivity in stratigraphic units at well ER-6-1#2.

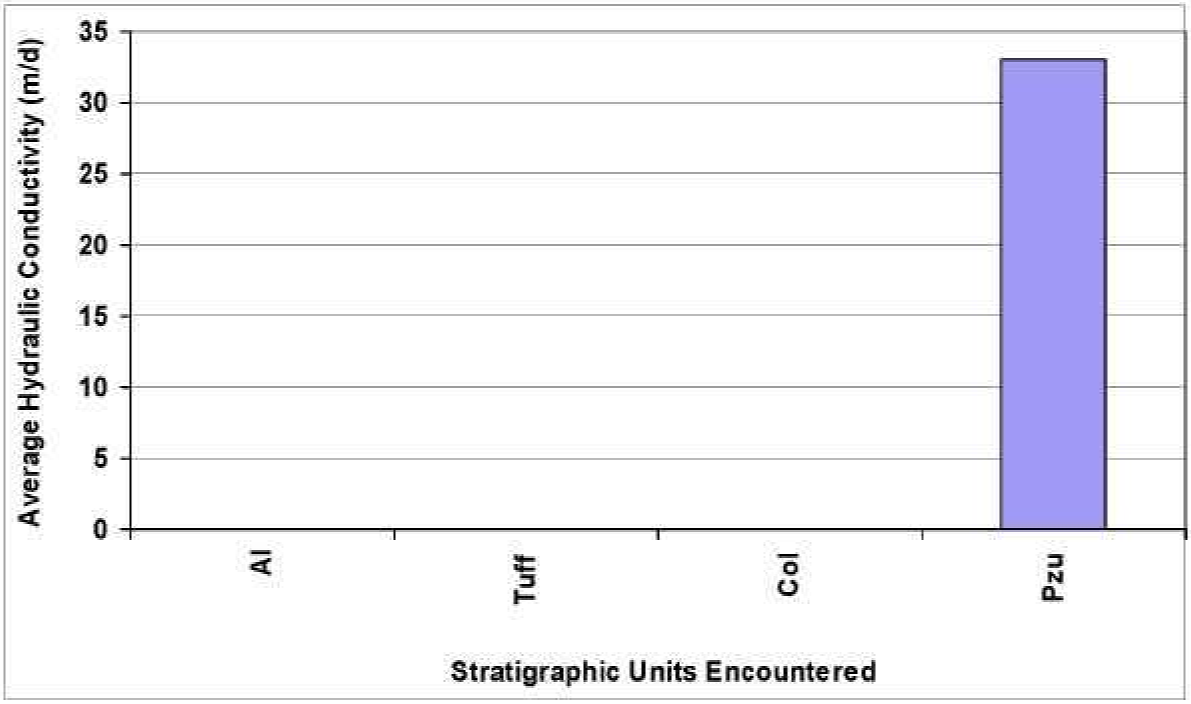


Figure 200. Average detected hydraulic conductivity in stratigraphic units at well ER-7-1.

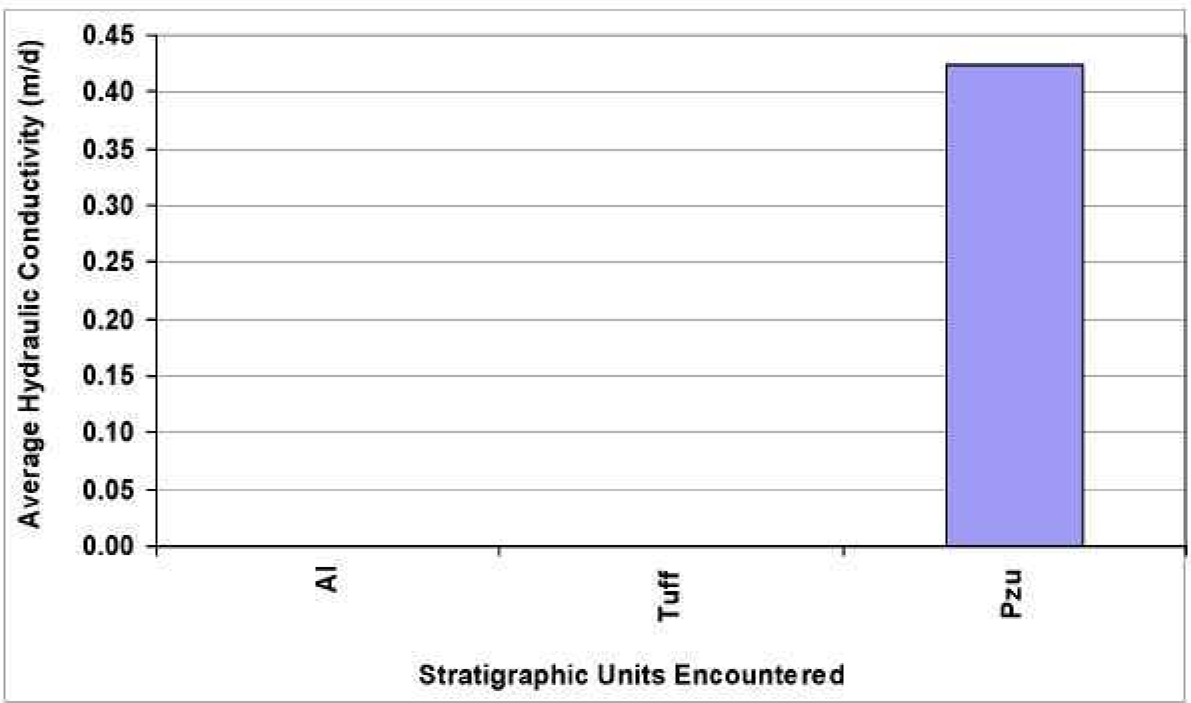


Figure 201. Average detected hydraulic conductivity in stratigraphic units at well ER-12-3.

Table 23. Lithologic modifiers for wells in carbonate rock.

Lithologic Abbreviation	Lithologic Unit Name
At	Tuffaceous alluvium
Tuff	Tuff
Dol	Dolomite
Ls	Limestone
QTZT	Quartzite
Col	Coluvium
SS	Sandstone

Table 24. Lithologic modifiers that are screened. Lithologic modifiers with detectable hydraulic conductivity are shaded gray.

Well	Lithologic Unit				
ER-6-1	At	Tuff	**Dol**	SS	QTZT
ER-6-1#2	At	Tuff	Col	**Dol**	QTZT
ER-7-1	At	Tuff	Col	**Ls**	
ER-12-3	At	Tuff	**Dol**	**Ls**	

The vertical length of well screen placed adjacent to each lithologic modifier and the length over which hydraulic conductivity was detected are presented for each well in Figures 202 through 205. Hydraulic conductivity was detected for each lithologic modifier that was screened or that was open borehole. Dolomite and limestone provide similar likelihood of detecting hydraulic conductivity. The average detected hydraulic conductivity for the lithologic modifiers is presented in Figures 206 through 209. No data trends are identified as being associated with lithologic modifiers.

Association of Hydrogeologic Characteristics with Well-specific Hydraulic Conductivity

The following sections describe the hydraulic conductivity for each hydrogeologic characteristic that occurs within multiple wells. When a hydrogeologic characteristic is found in only one well, the information is identical to that presented above. The analysis goals of the figures are described in Table 3. Each hydrogeologic classification is discussed in a separate section below. The figures in this section show the detected hydraulic conductivity data for each well plotted both separately and displayed as if all the values are at the same location.

Hydraulic Conductivity and Stratigraphy

There are three stratigraphic units with detected hydraulic conductivity in more than one well (e.g., the data for each well are plotted separately, and the data are displayed as if all the values are at the same location). The names of the stratigraphic units and their abbreviations are provided in Table 21. The stratigraphic association of screened intervals and hydraulic conductivity for all wells in carbonate rock is presented in Table 25.

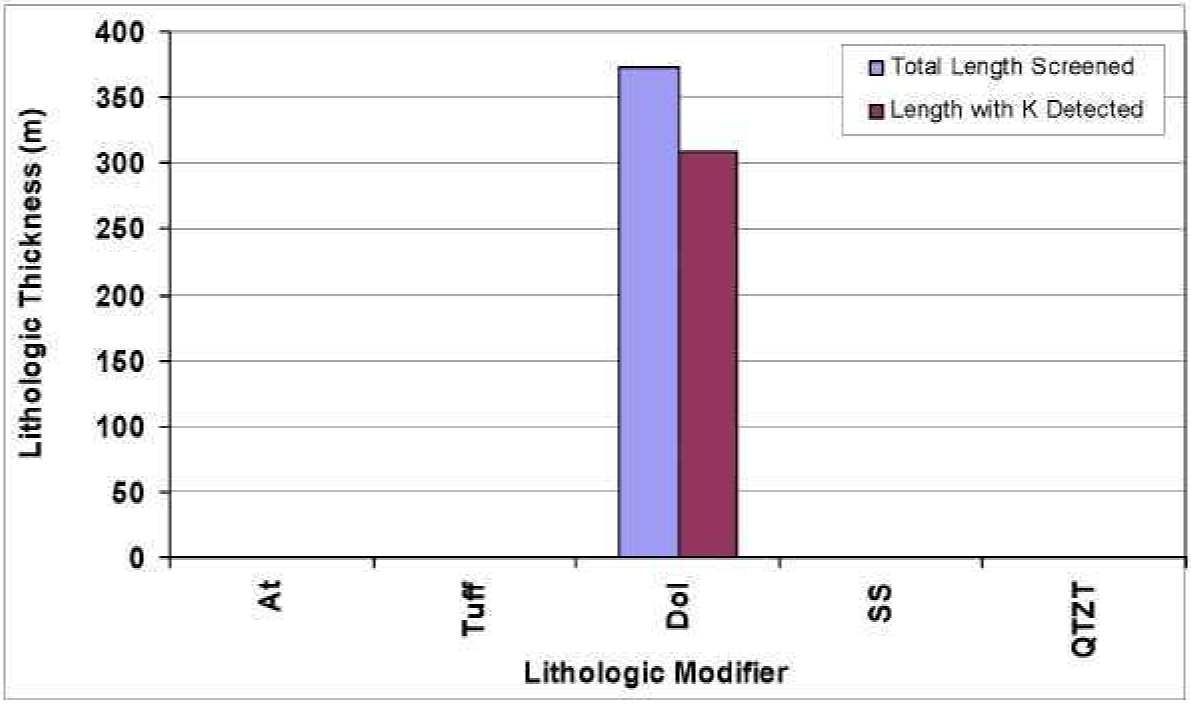


Figure 202. Lithologic modifiers adjacent to well screen and detectable hydraulic conductivity at well ER-6-1.

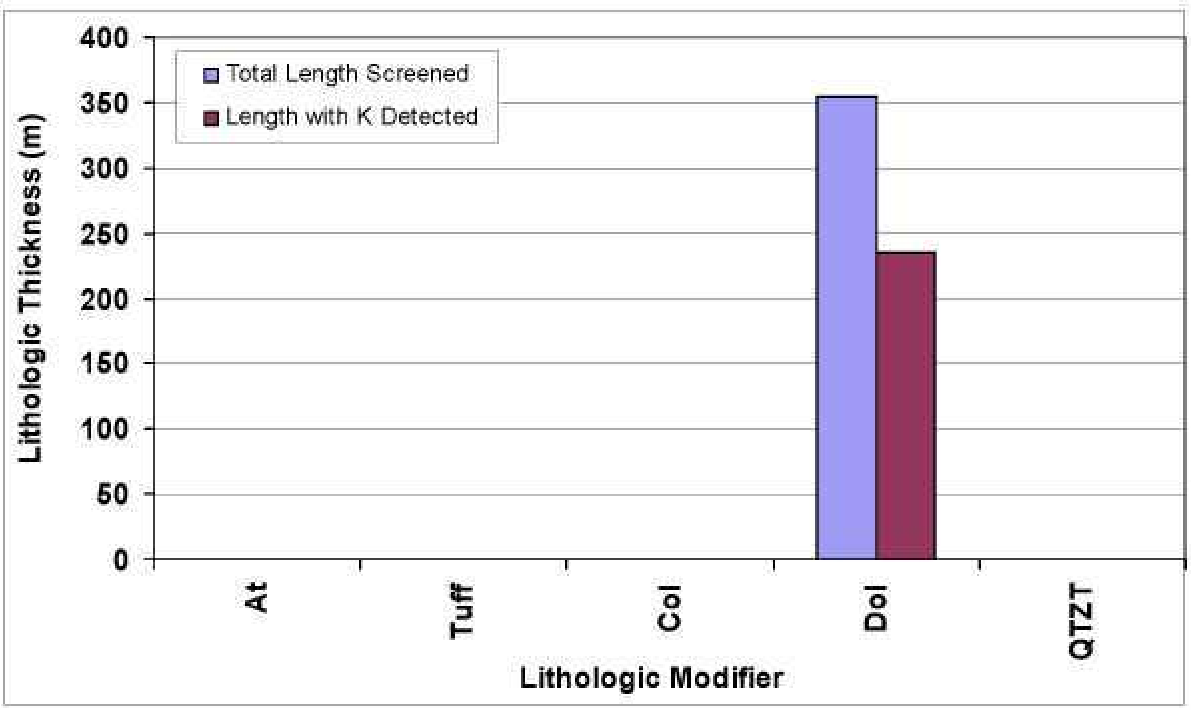


Figure 203. Lithologic modifiers adjacent to well screen and detectable hydraulic conductivity at well ER-6-1#2.

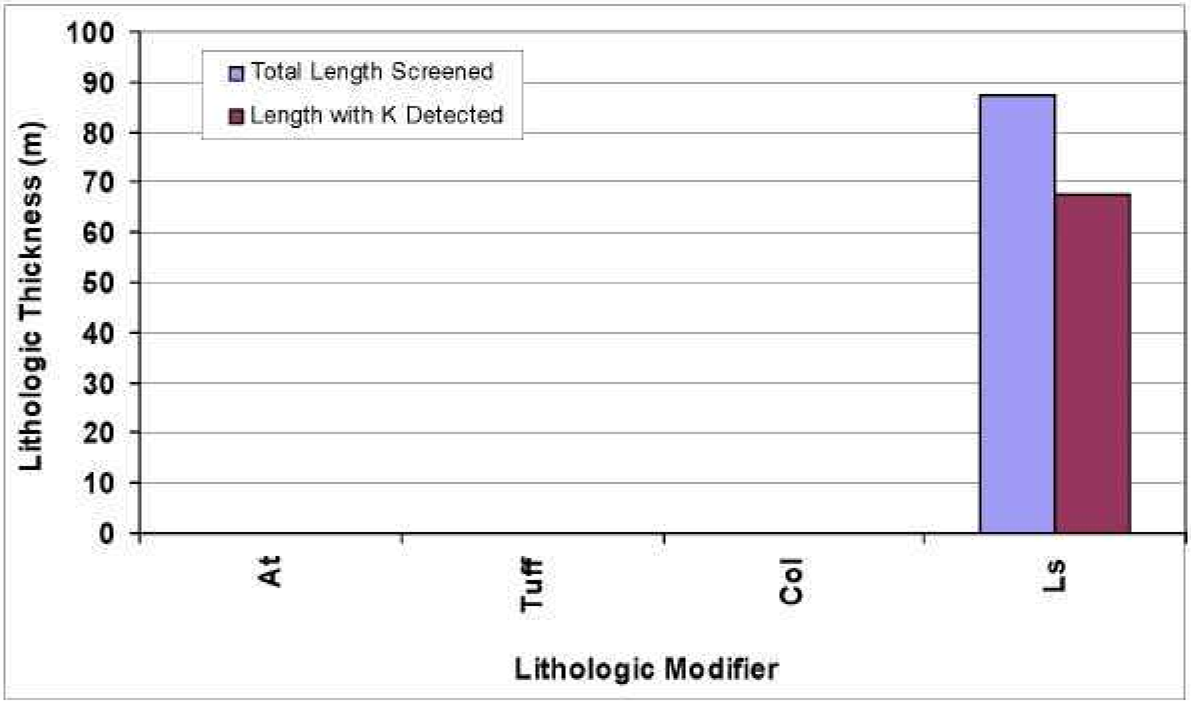


Figure 204. Lithologic modifiers adjacent to well screen and detectable hydraulic conductivity at well ER-7-1.

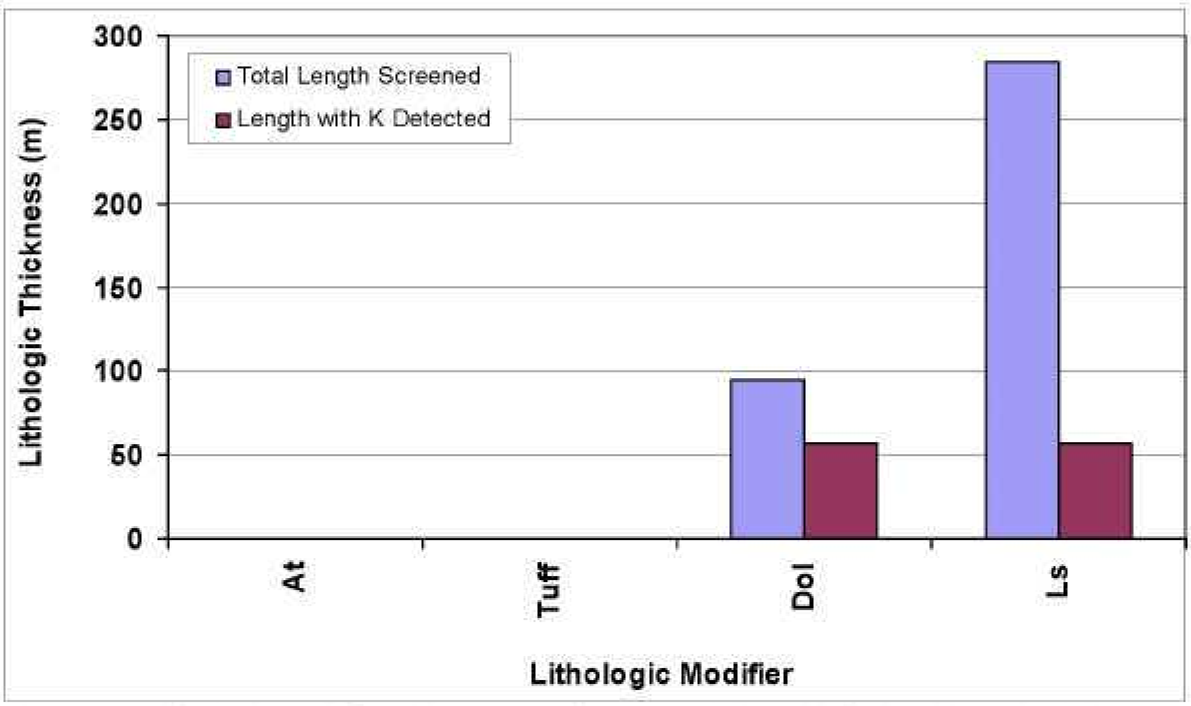


Figure 205. Lithologic modifiers adjacent to well screen and detectable hydraulic conductivity at well ER-12-3.

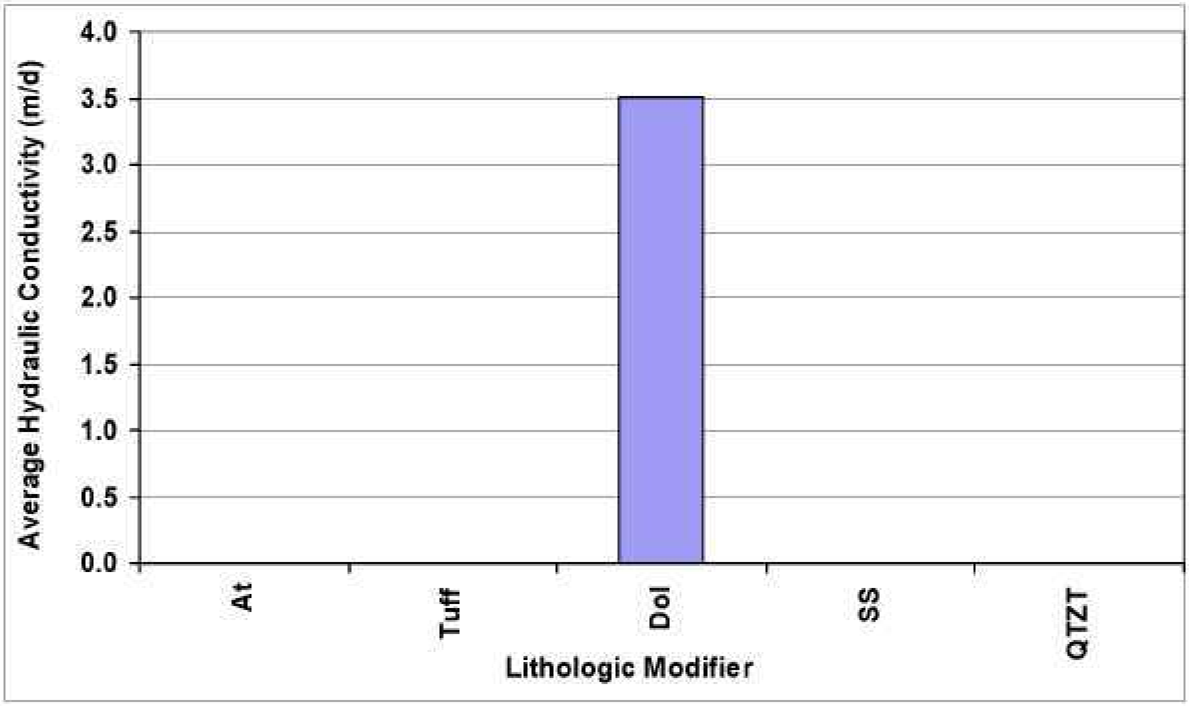


Figure 206. Average detected hydraulic conductivity for lithologic modifiers at well ER-6-1.

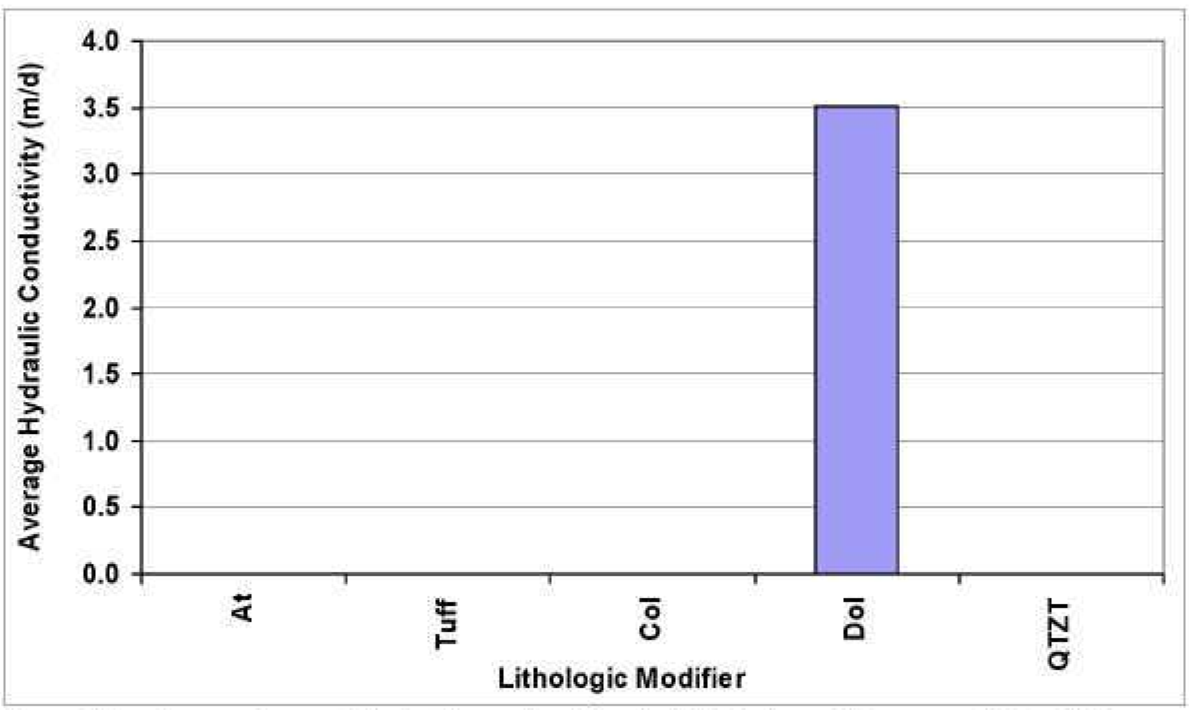


Figure 207. Average detected hydraulic conductivity for lithologic modifiers at well ER-6-1#2.

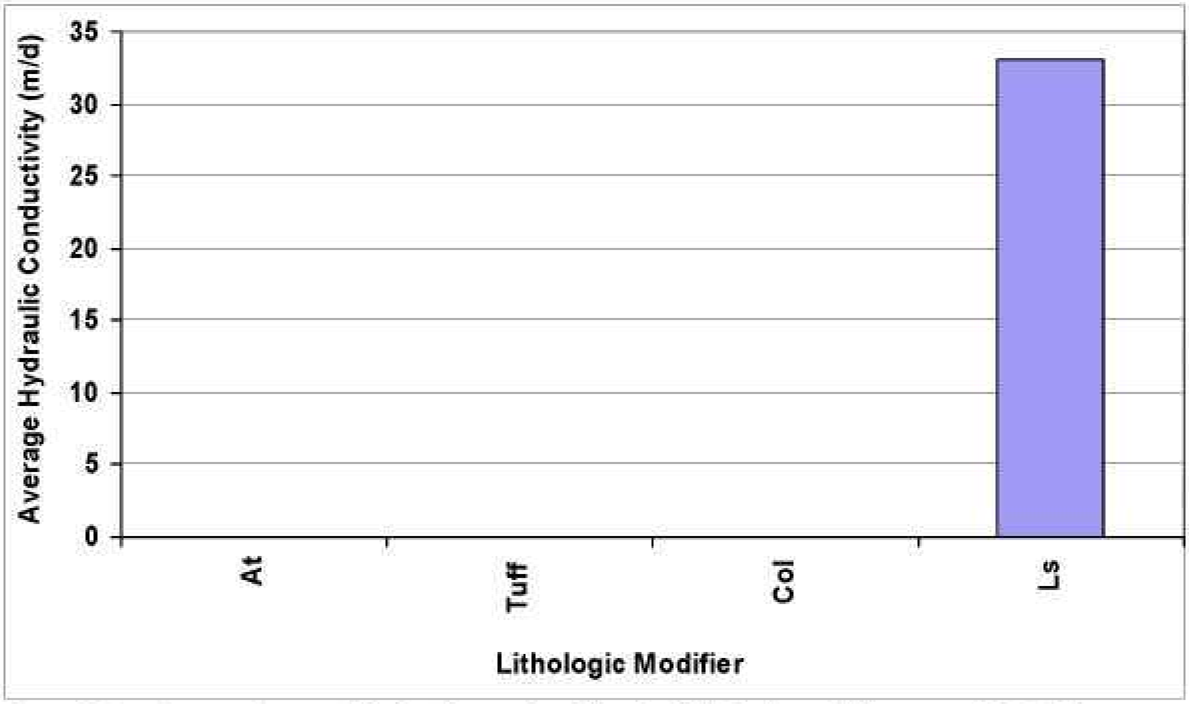


Figure 208. Average detected hydraulic conductivity for lithologic modifiers at well ER-7-1.

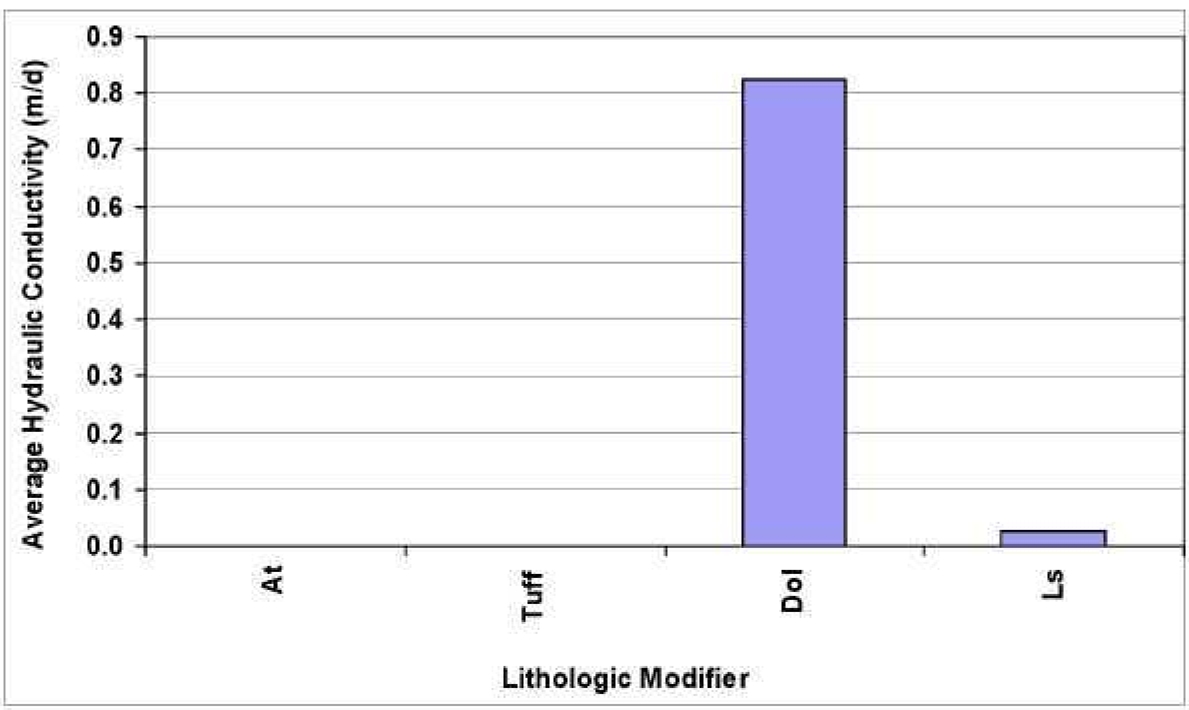


Figure 209. Average detected hydraulic conductivity for lithologic modifiers at well ER-12-3.

Table 25. Stratigraphic units encountered at multiple wells in carbonate rock.

Stratigraphic Unit	ER-6-1 Logged Length (m)	ER-6-1 Detected K Length (m)	ER-6-1#2 Logged Length (m)	ER-6-1#2 Detected K Length (m)	ER-7-1 Logged Length (m)	ER-7-1 Detected K Length (m)	ER-12-3 Logged Length (m)	ER-12-3 Detected K Length (m)
DSs	141.7	126.5						
DSl	208.8	**208.8**	324.6	**221.0**				
Oes	22.86	**7.62**	29.0	**13.7**				
Pzu					87.3	**67.5**	379.4	**132.8**

Stratigraphic units are not presented in stratigraphic sequence
Gray shading indicates a stratigraphic unit that occurs in multiple wells
Bold type indicates length of detectable hydraulic conductivity for stratigraphic units with detectable hydraulic conductivity in more than one well

There are more stratigraphic units in carbonate rock than any other hydrogeologic characteristic. This tends to reduce the number of detected hydraulic conductivity values within any particular stratigraphic characteristic. Data associations with other hydrogeologic classifications exhibit more heavily populated data sets.

The detected hydraulic conductivity with depth for the Laketown Dolomite is presented in Figure 210. The results for wells ER-6-1 and ER-6-1#2 are similar as may be expected for wells located 64 m apart. Figures 211 through 214 present the detected hydraulic conductivity for the wells individually and in composite for normal and log-transformed values. The data trends are similar for these wells.

The detected hydraulic conductivity with depth for the Ely Springs Dolomite is presented in Figure 215. Wells ER-6-1 and ER-6-1#2 are essentially identical. Figures 216 through 219 present detected hydraulic conductivity for the wells individually and in composite for normal and log-transformed values. Because the ranges of values for the two wells are essentially the same, the figures for the wells individually and in composite are identical. No data trends can be identified by these data.

The detected hydraulic conductivity with depth for the Paleozoic Undifferentiated Carbonate is presented in Figure 220. Wells ER-7-1 and ER-12-3 have dissimilar hydraulic conductivity values, with the detected values for well ER-12-3 being much lower. Figures 221 through 224 presents the detected hydraulic conductivity for the wells individually and in composite for normal and log-transformed values. The distributions in Figures 221 through 224 indicate that the hydraulic values for well ER-12-3 are much lower than in well ER-7-1. The hydraulic conductivity values in Figure 222 visually appear to have a data trend of many low values with a decreasing number of higher values. Log transforming the data in Figures 223 and 224 does not aid in interpretation.

Hydraulic Conductivity and Lithologic Modifier

There are two stratigraphic units with detected hydraulic conductivity in more than one well. The names of the lithologic modifiers and their abbreviations are provided in Table 23. The lithologic association of screened intervals and hydraulic conductivity for all wells in carbonate rock is presented in Table 26.

The detected hydraulic conductivity with depth for the lithologic modifier Limestone is presented in Figure 225. Wells ER-7-1 and ER-12-3 have dissimilar hydraulic conductivity values, with the detected values for well ER-12-3 being much lower. Figures 226 through 229 present detected hydraulic conductivity for the wells individually and in composite for normal and log-transformed values. The distributions in Figures 221 through 224 indicate that the hydraulic values for well ER-12-3 are much lower than in well ER-7-1. The hydraulic conductivity values in Figure 227 visually appear to have a data trend of many low values with a decreasing number of higher values. Log transforming the data in Figures 228 and 229 appears to indicate two distinct data distributions for wells ER-7-1 and ER-12-3.

The detected hydraulic conductivity with depth for the lithologic modifier Dolomite is presented in Figure 230. The results for wells ER-6-1, ER-6-1#2, and ER-12-3 are similar. Figures 231 through 234 present the detected hydraulic conductivity for the wells individually and in composite for normal and log-transformed values. The data trends are similar for these wells. Figures 231 and 232 illustrate a trend of higher occurrences of low hydraulic conductivity values. Figures 233 and 234 illustrate no identifiable trends to the data.

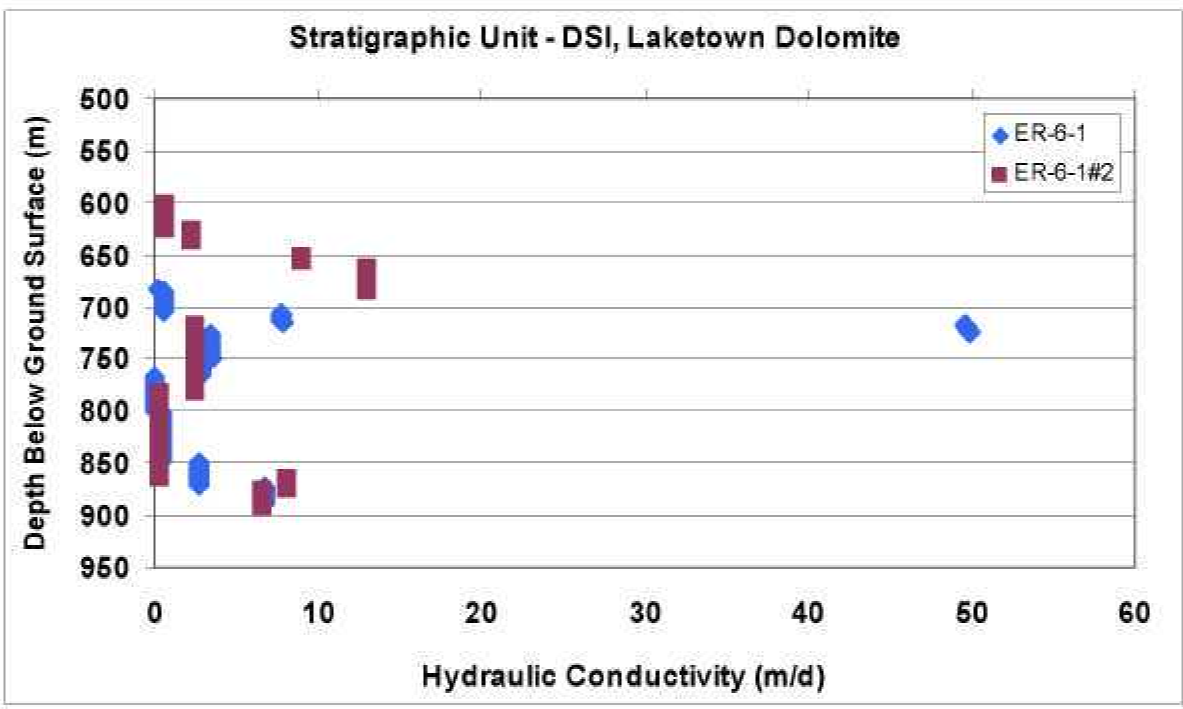


Figure 210. Detected hydraulic conductivity with depth for the stratigraphic unit Laketown Dolomite.

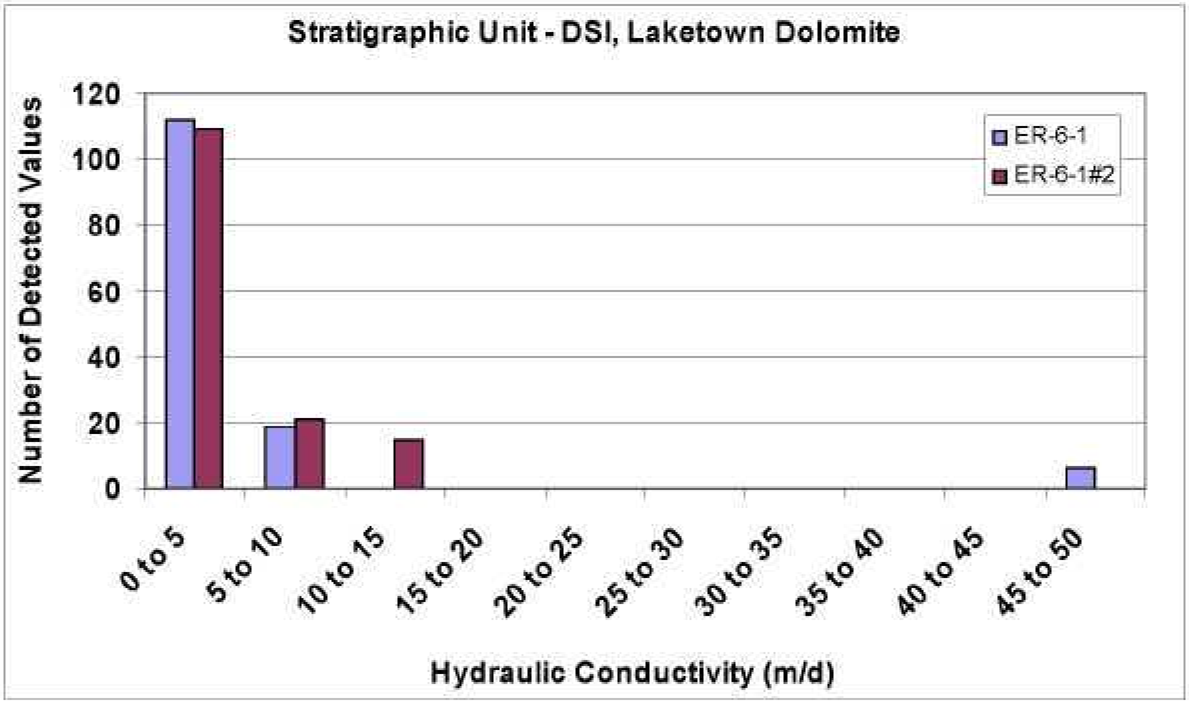


Figure 211. Detected hydraulic conductivity for individual wells for the stratigraphic unit Laketown Dolomite.

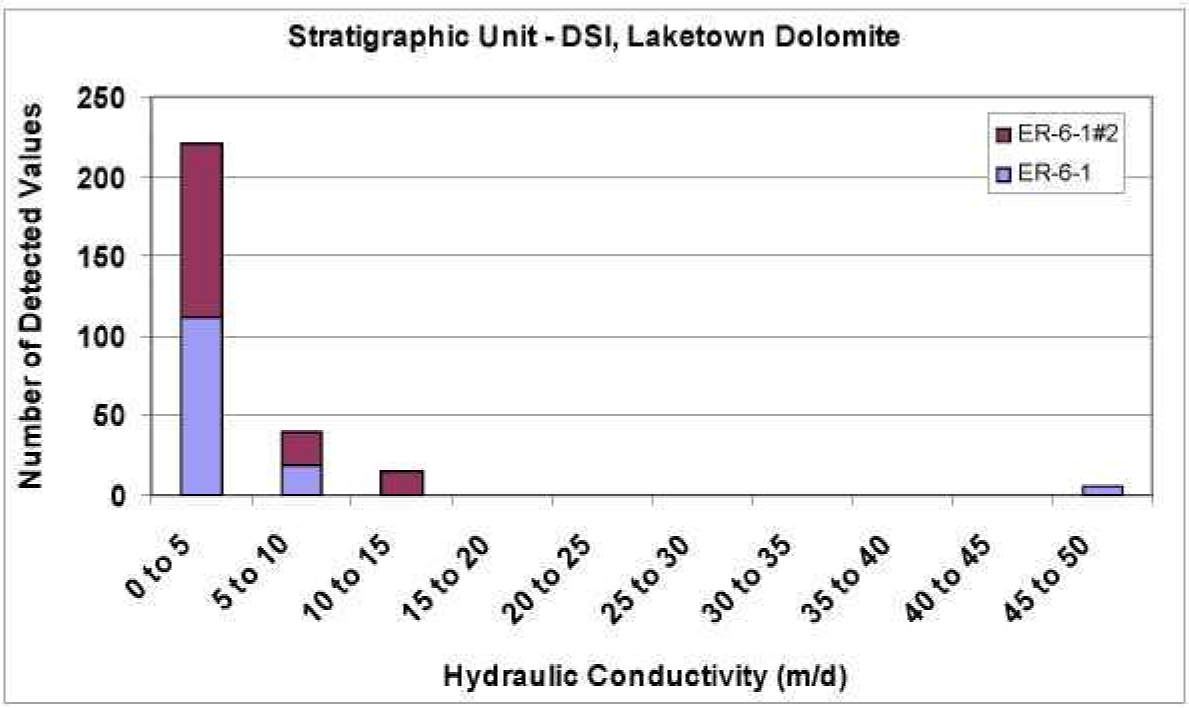


Figure 212. Detected hydraulic conductivity for wells in composite for the stratigraphic unit Laketown Dolomite.

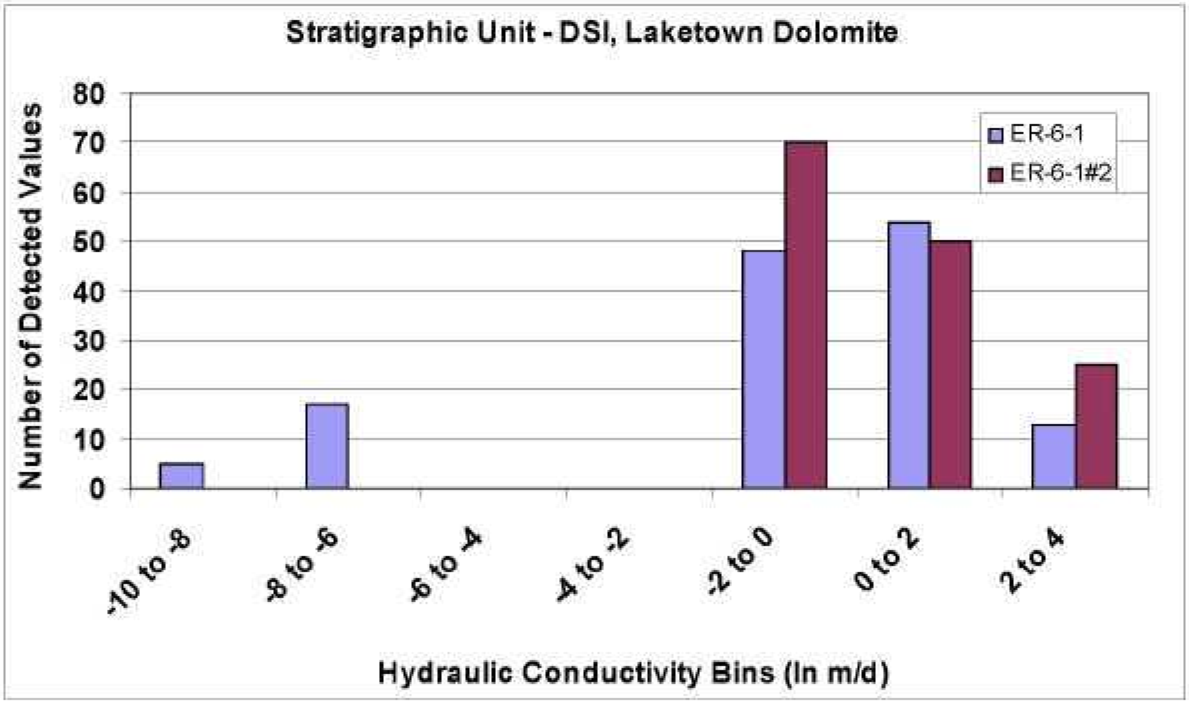


Figure 213. Detected natural logarithm hydraulic conductivity for individual wells for the stratigraphic unit Laketown Dolomite.

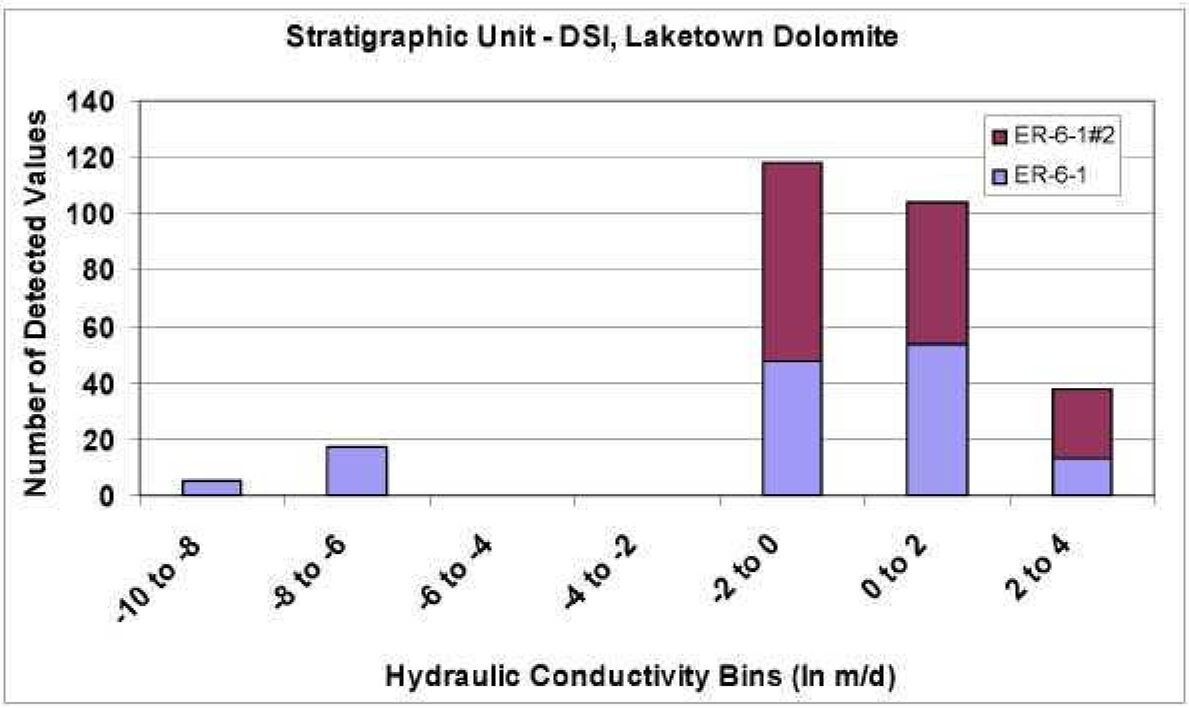


Figure 214. Detected natural logarithm hydraulic conductivity for wells in composite for the stratigraphic unit Laketown Dolomite.

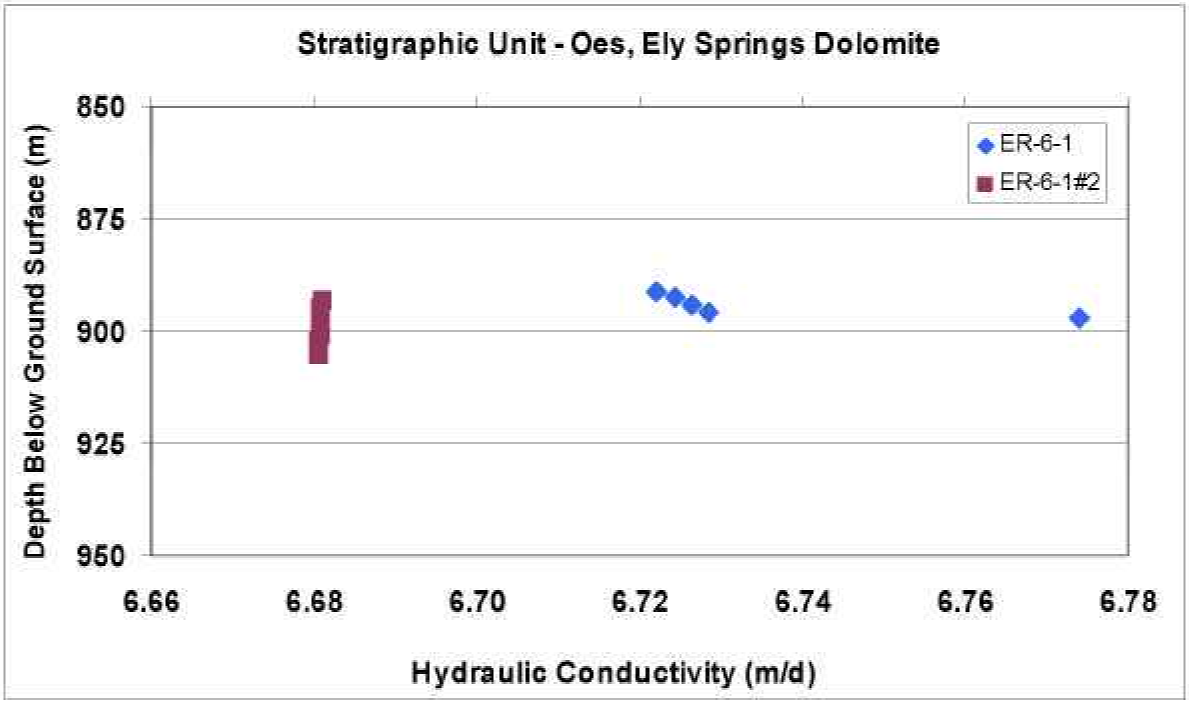


Figure 215. Detected hydraulic conductivity with depth for the stratigraphic unit Ely Springs Dolomite.

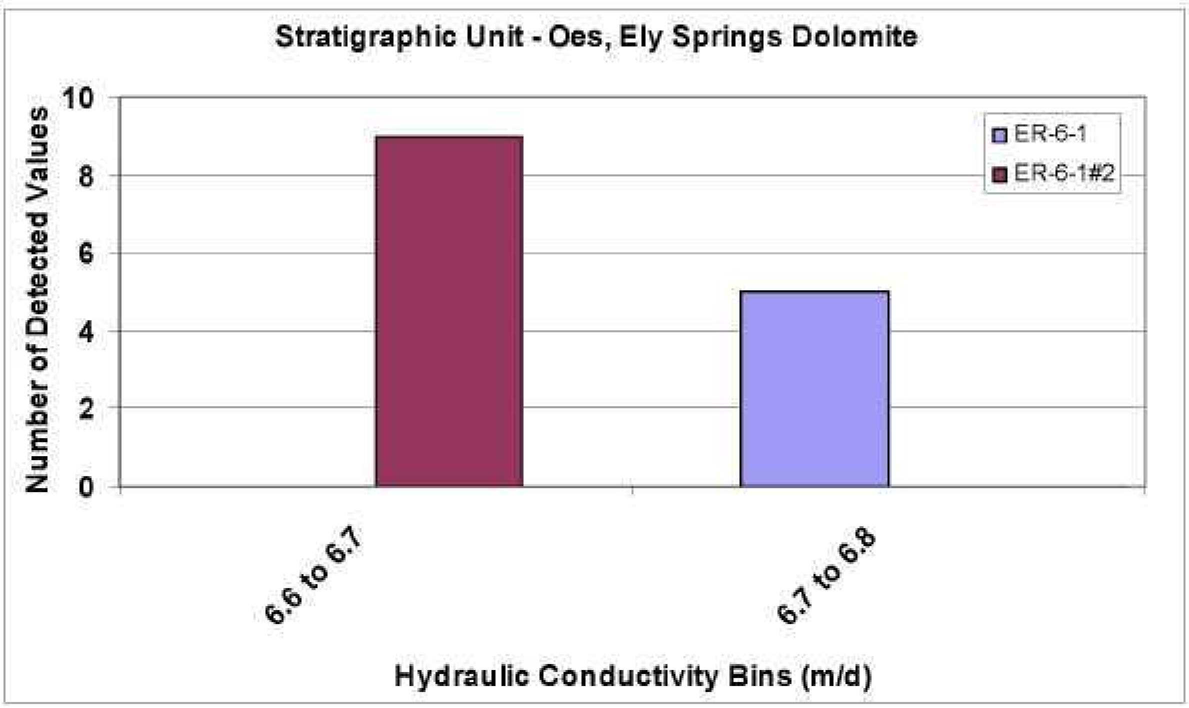


Figure 216. Detected hydraulic conductivity for individual wells for the stratigraphic unit Ely Springs Dolomite.

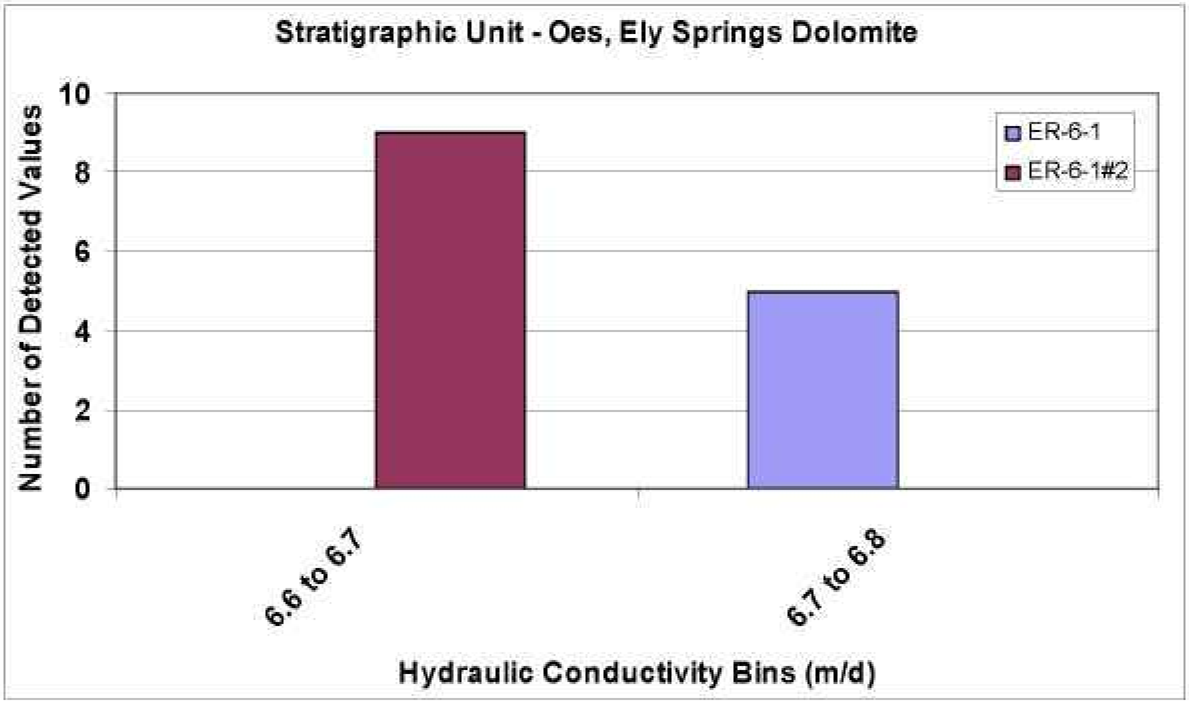


Figure 217. Detected hydraulic conductivity for wells in composite for the stratigraphic unit Ely Springs Dolomite.

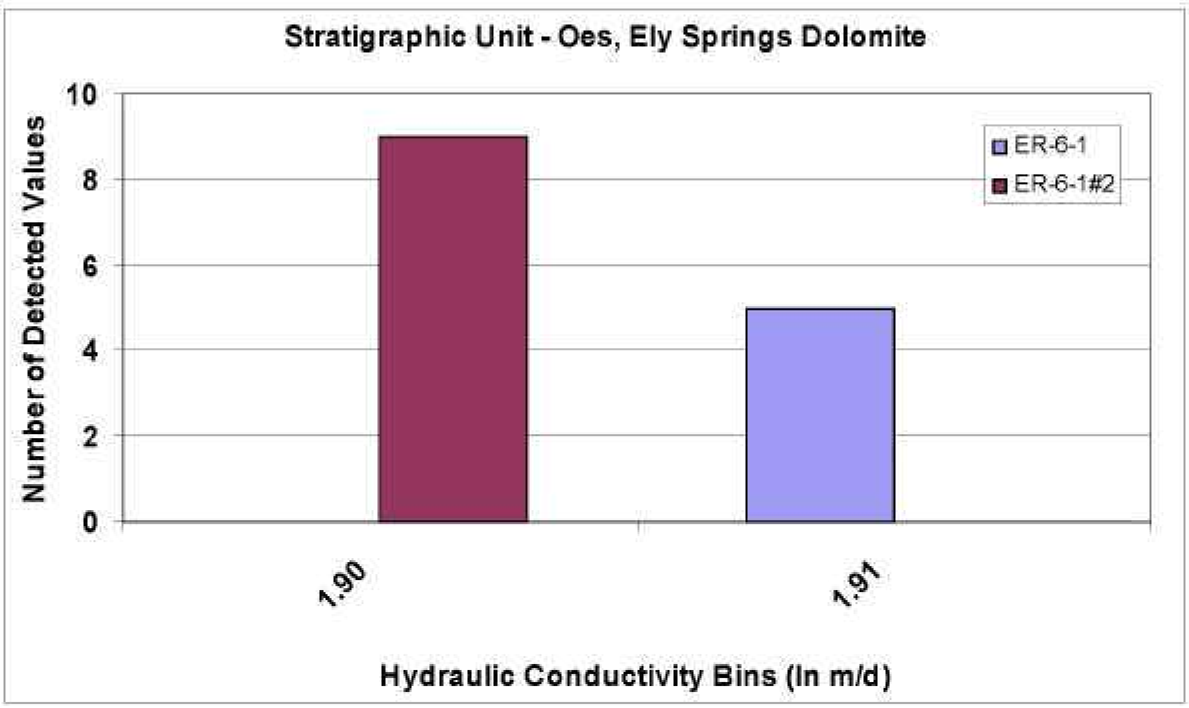


Figure 218. Detected natural logarithm hydraulic conductivity for individual wells for the stratigraphic unit Ely Springs Dolomite.

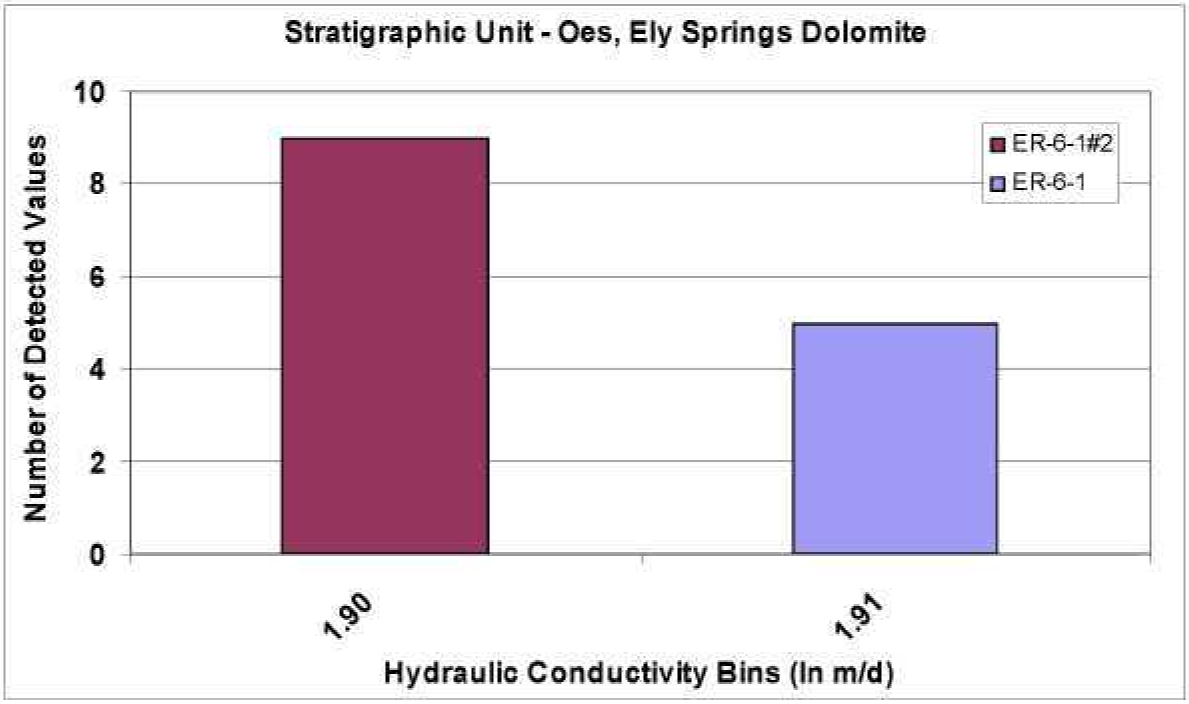


Figure 219. Detected natural logarithm hydraulic conductivity for wells in composite for the stratigraphic unit Ely Springs Dolomite.

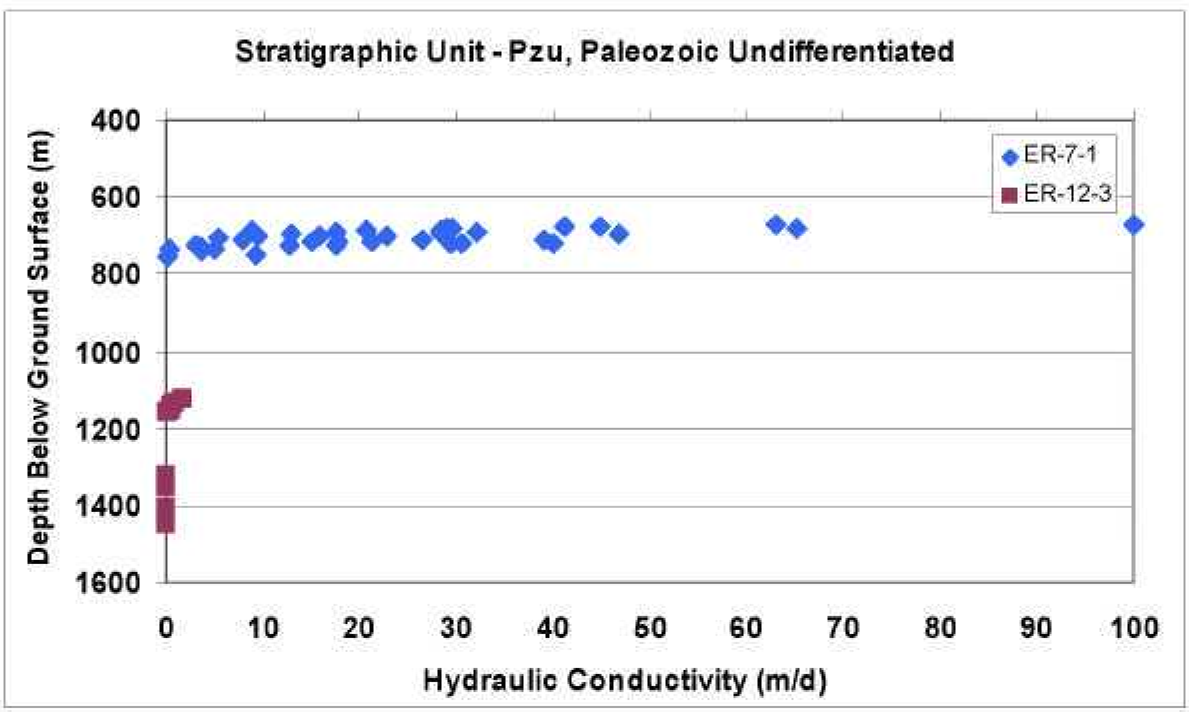


Figure 220. Detected hydraulic conductivity with depth for the stratigraphic unit Paleozoic Undifferentiated.

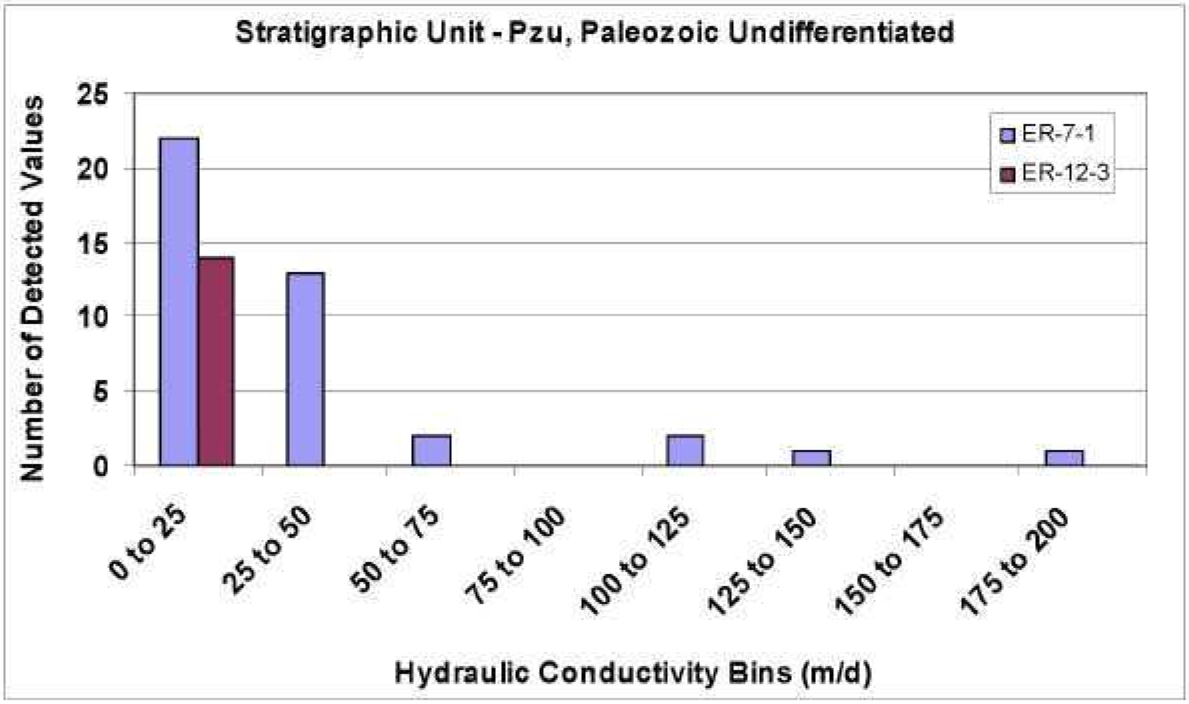


Figure 221. Detected hydraulic conductivity for individual wells for the stratigraphic unit Paleozoic Undifferentiated.

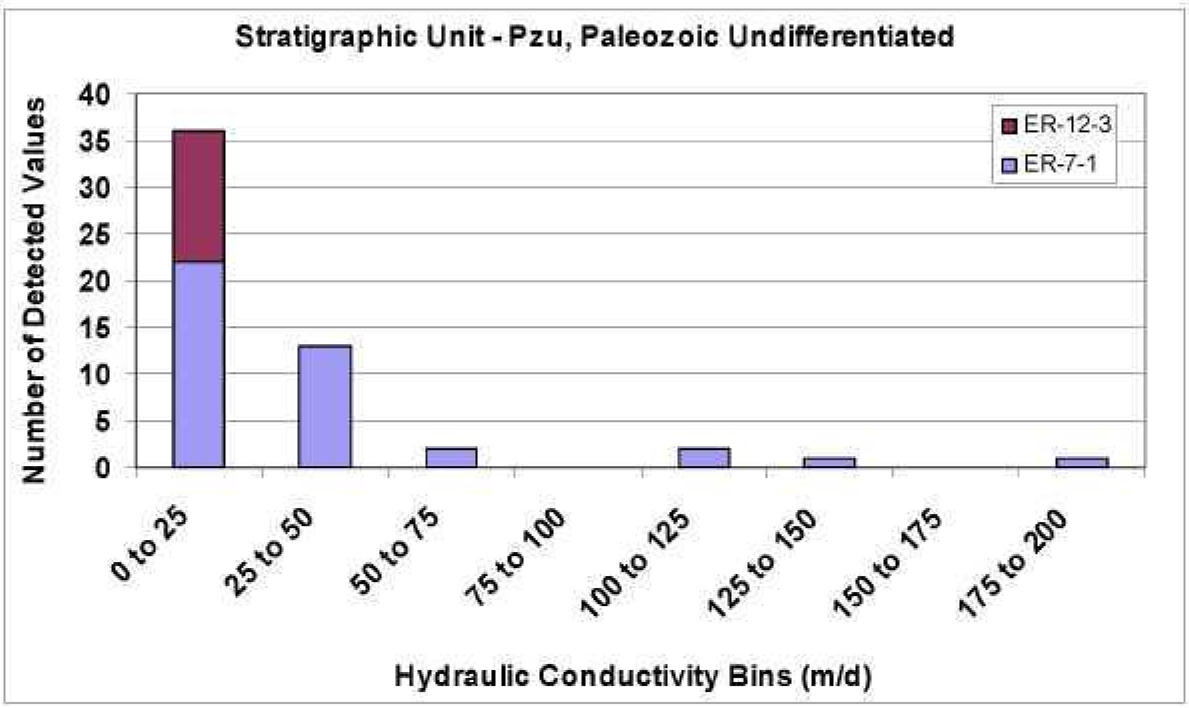


Figure 222. Detected hydraulic conductivity for wells in composite for the stratigraphic unit Paleozoic Undifferentiated.

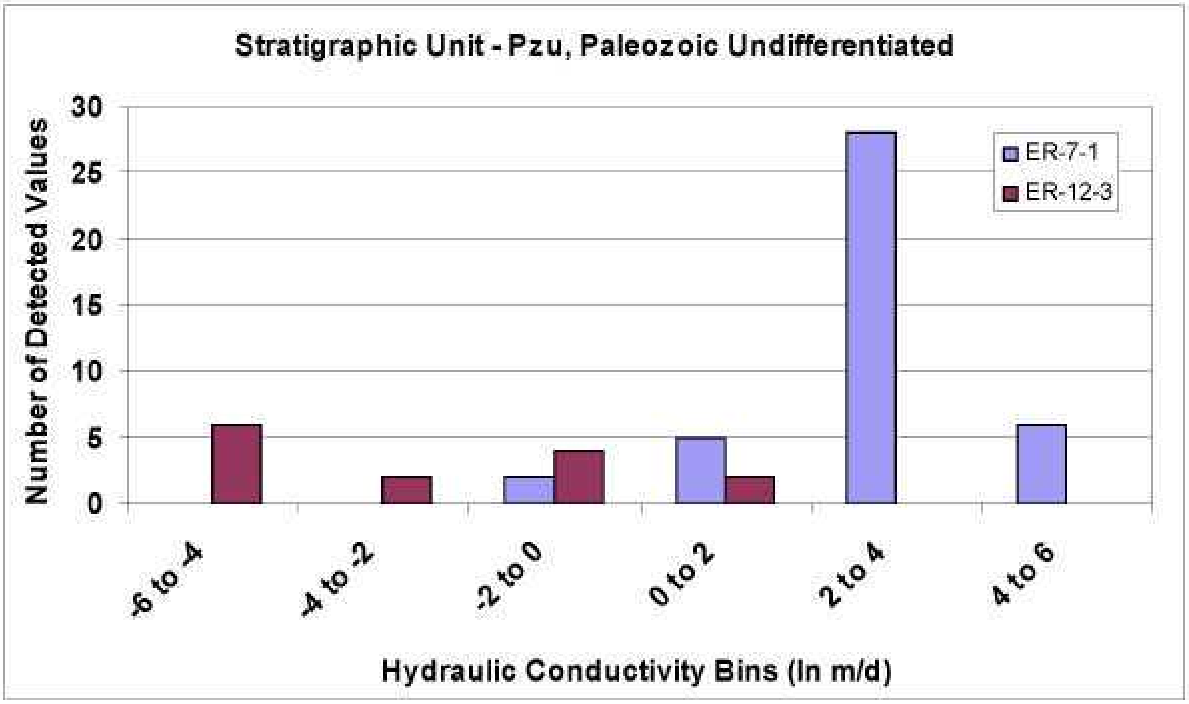


Figure 223. Detected natural logarithm hydraulic conductivity for individual wells for the stratigraphic unit Paleozoic Undifferentiated.

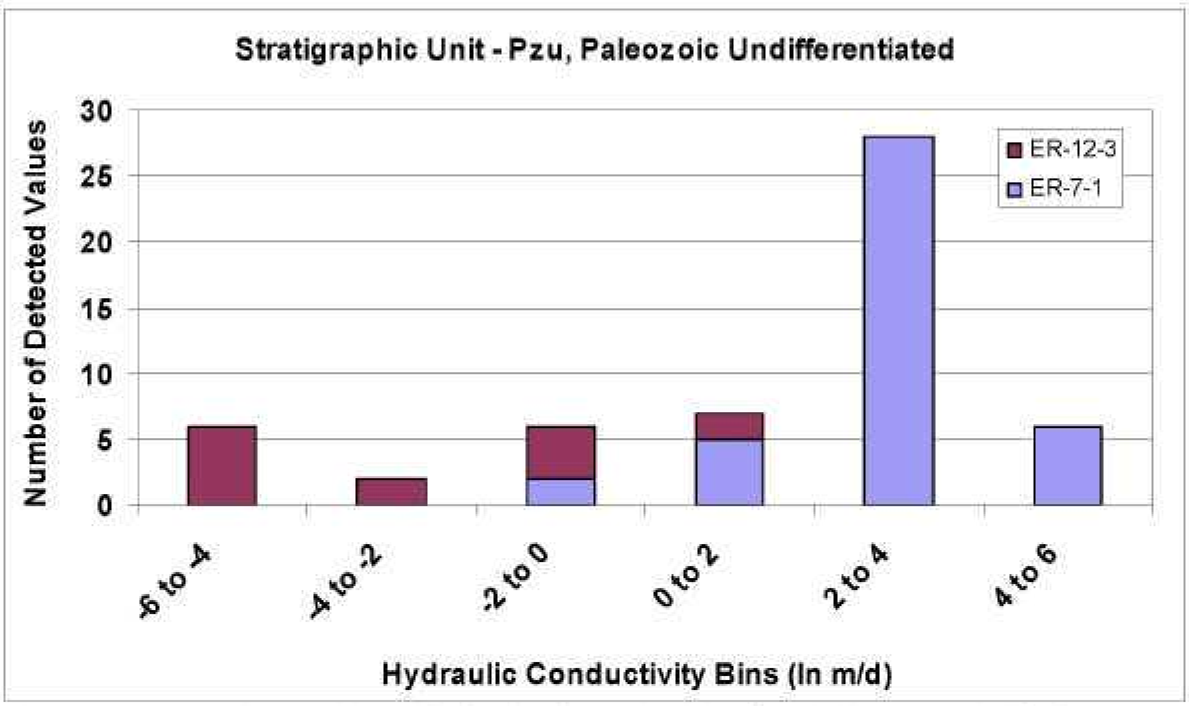


Figure 224. Detected natural logarithm hydraulic conductivity for wells in composite for the stratigraphic unit Paleozoic Undifferentiated.

Table 26. Lithic modifier units encountered at multiple wells in carbonate.

Lithic Modifier	ER-6-1 Logged Length (m)	ER-6-1 Detected K Length (m)	ER-6-1#2 Logged Length (m)	ER-6-1#2 Detected K Length (m)	ER-7-1 Logged Length (m)	ER-7-1 Detected K Length (m)	ER-12-3 Logged Length (m)	ER-12-3 Detected K Length (m)
Ls					87.3	**67.5**	284.6	**75.9**
Dol	342.9	**342.9**	353.6	**234.7**			94.9	**56.9**

Lithologic units are not presented in stratigraphic sequence
Gray shading indicates a stratigraphic unit that occurs in multiple wells
Bold type indicates length of detectable hydraulic conductivity for stratigraphic units with detectable hydraulic conductivity in more than one well

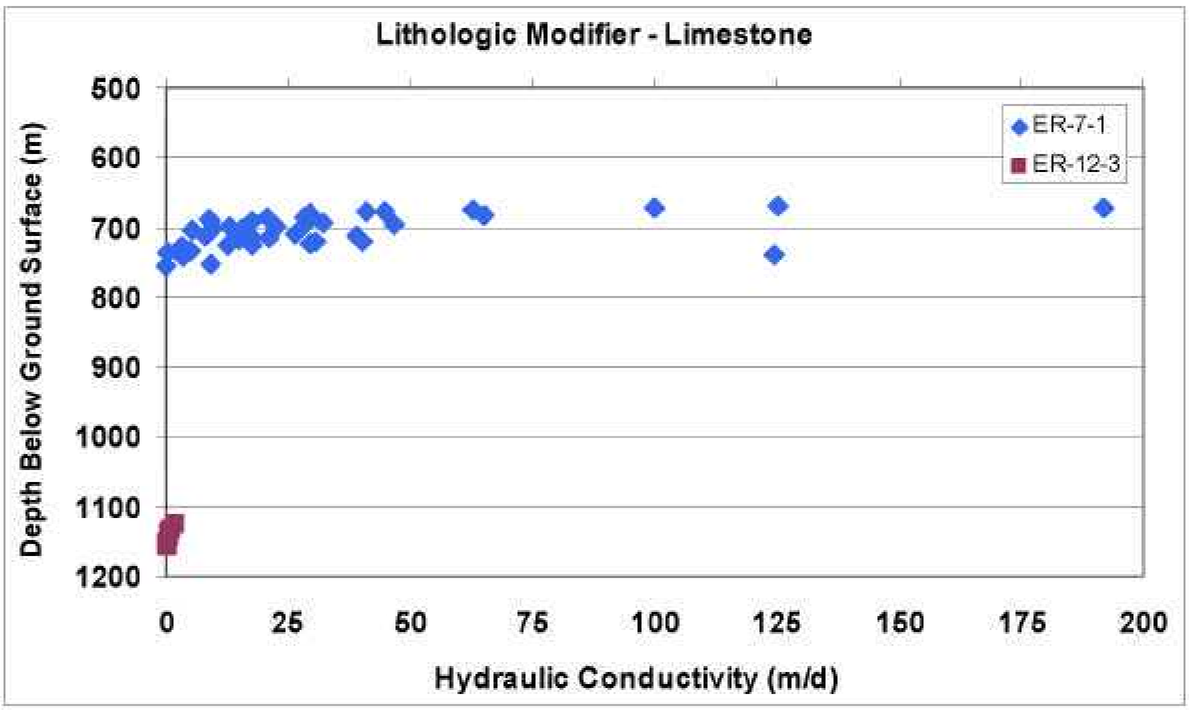


Figure 225. Detected hydraulic conductivity with depth for the lithologic modifier Limestone.

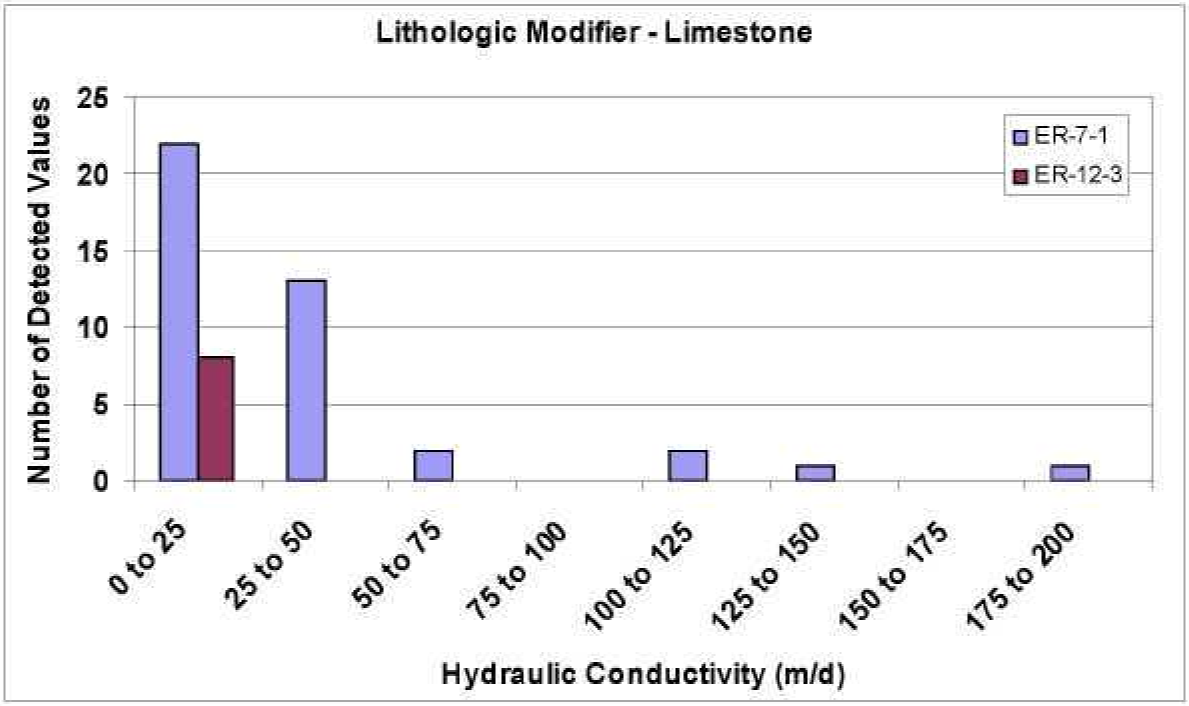


Figure 226. Detected hydraulic conductivity for individual wells for the lithologic modifier Limestone.

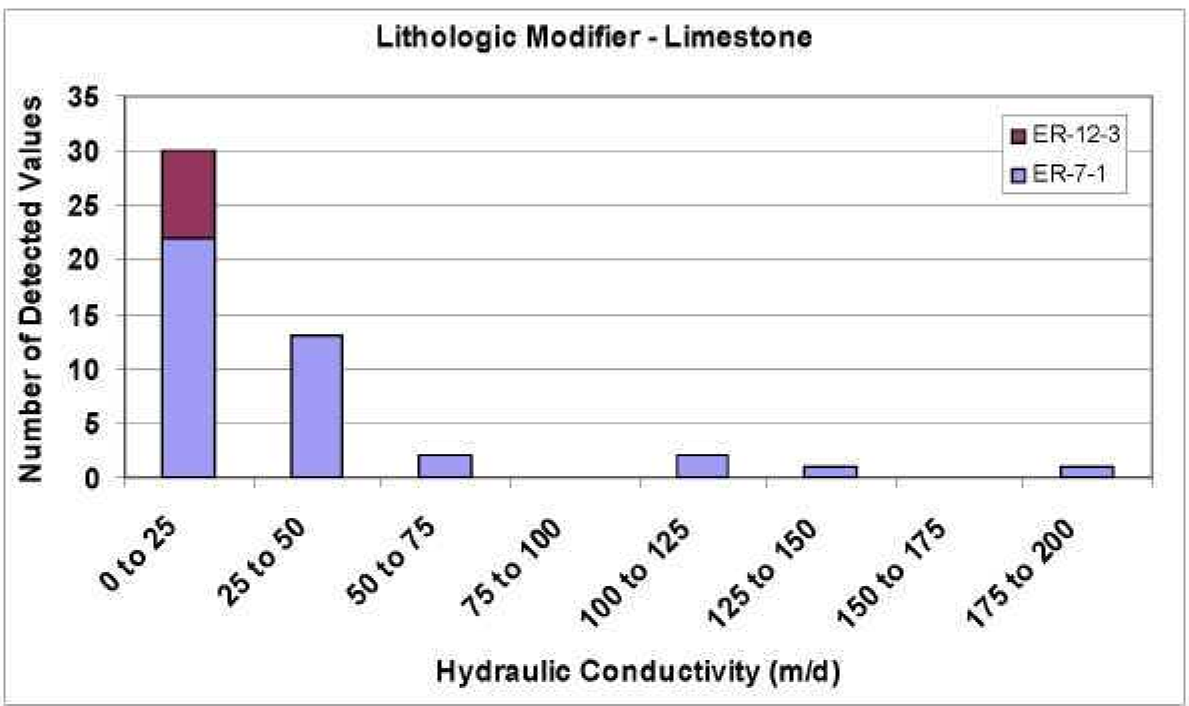


Figure 227. Detected hydraulic conductivity for wells in composite for the lithologic modifier Limestone.

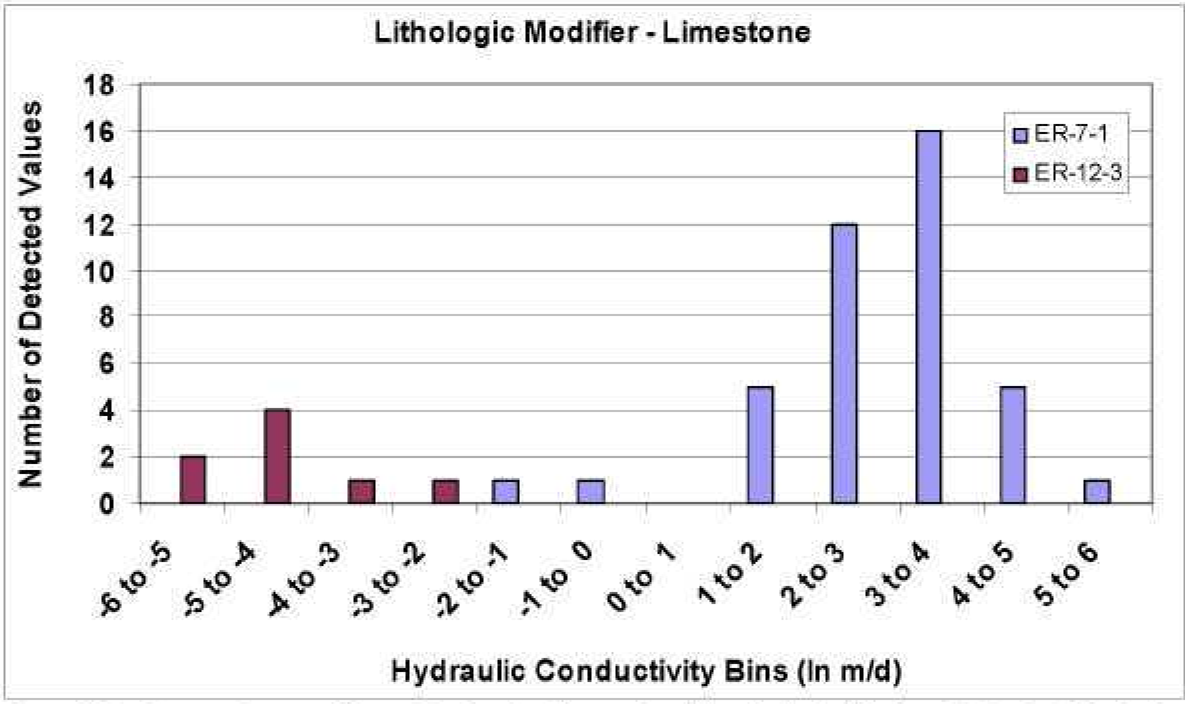


Figure 228. Detected natural logarithm hydraulic conductivity for individual wells for the lithologic modifier Limestone.

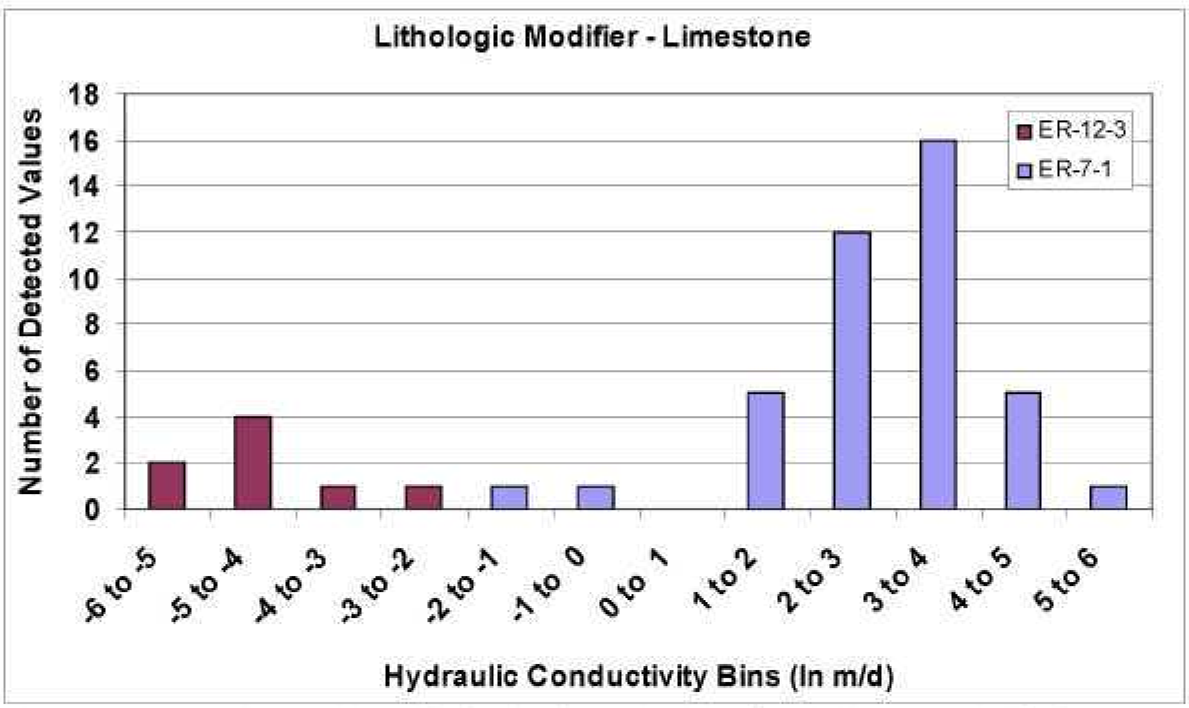


Figure 229. Detected natural logarithm hydraulic conductivity for wells in composite for the lithologic modifier Limestone.

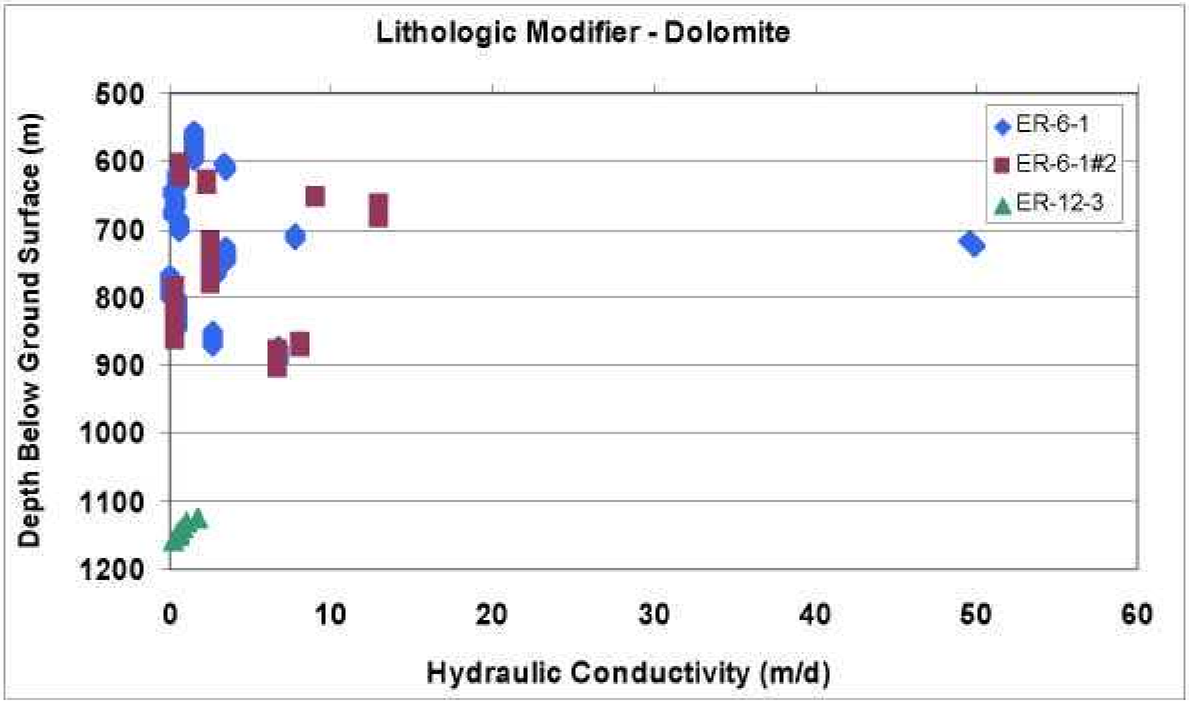


Figure 230. Detected hydraulic conductivity with depth for the lithologic modifier Dolomite.

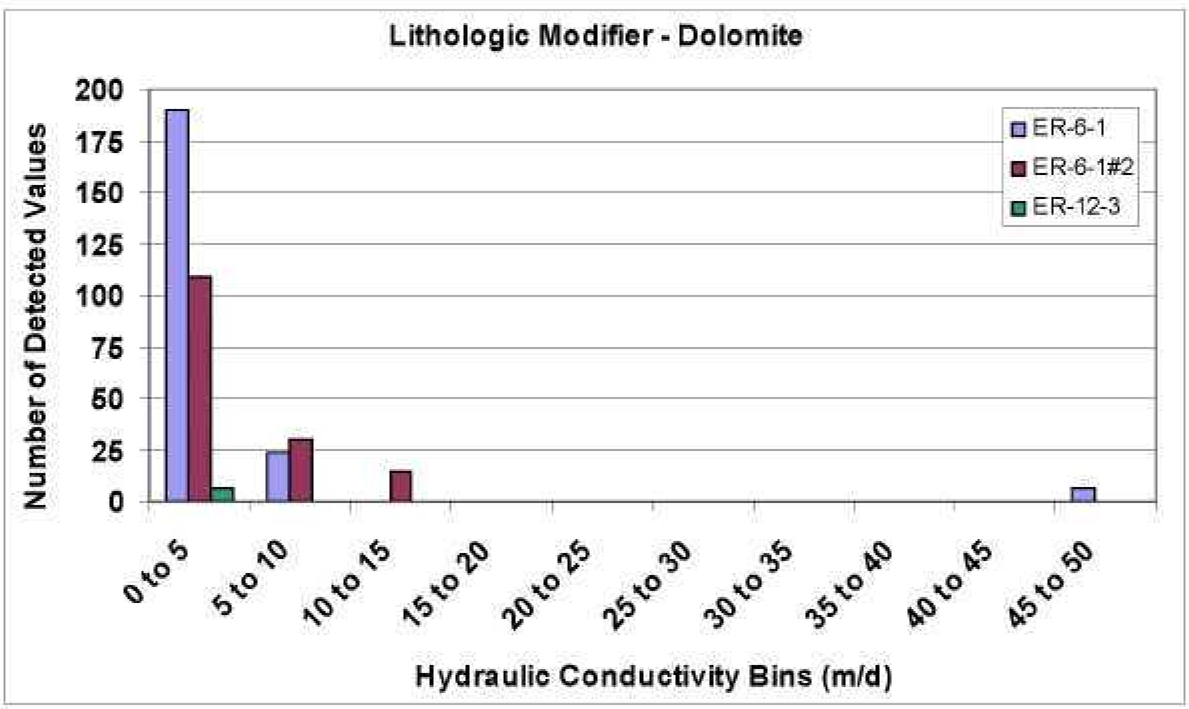


Figure 231. Detected hydraulic conductivity for individual wells for the lithologic modifier Dolomite.

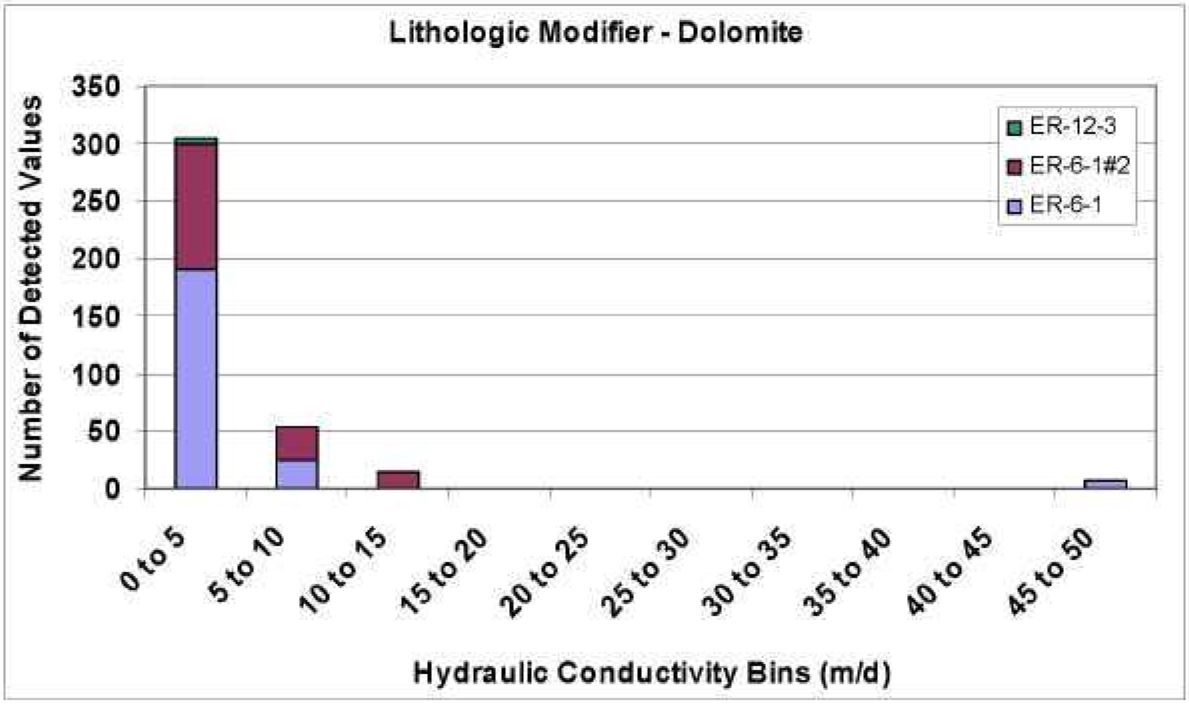


Figure 232. Detected hydraulic conductivity for wells in composite for the lithologic modifier Dolomite.

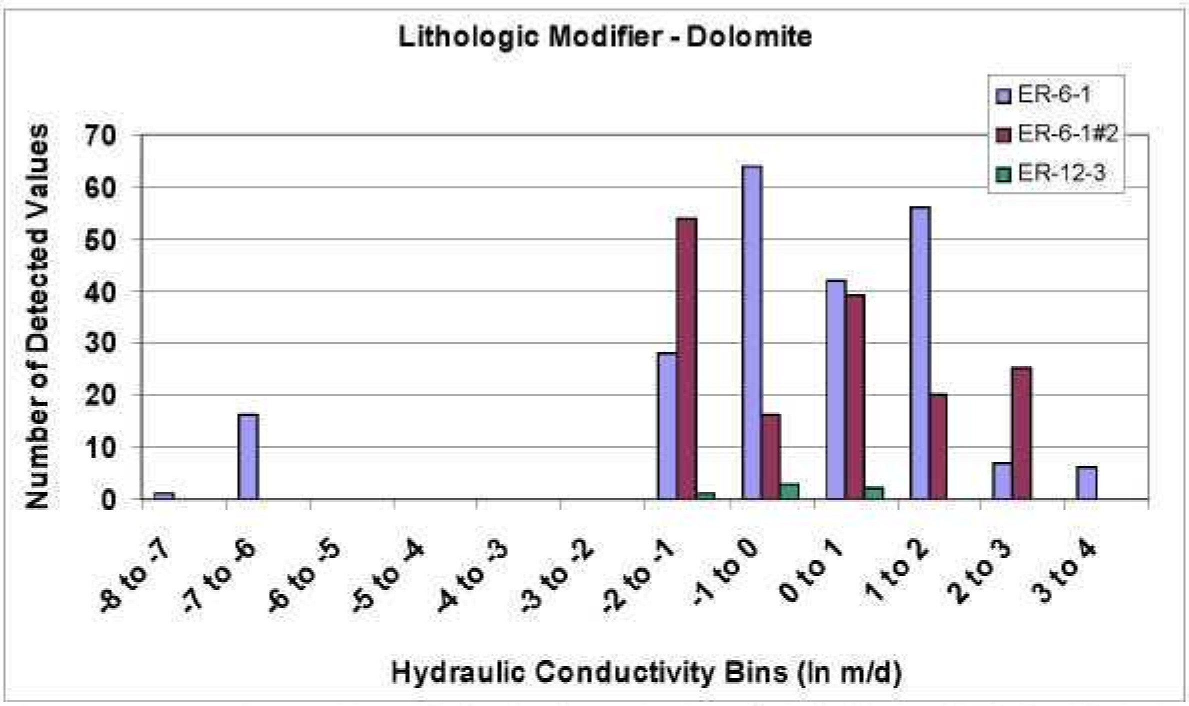


Figure 233. Detected natural logarithm hydraulic conductivity for individual wells for the lithologic modifier Dolomite.

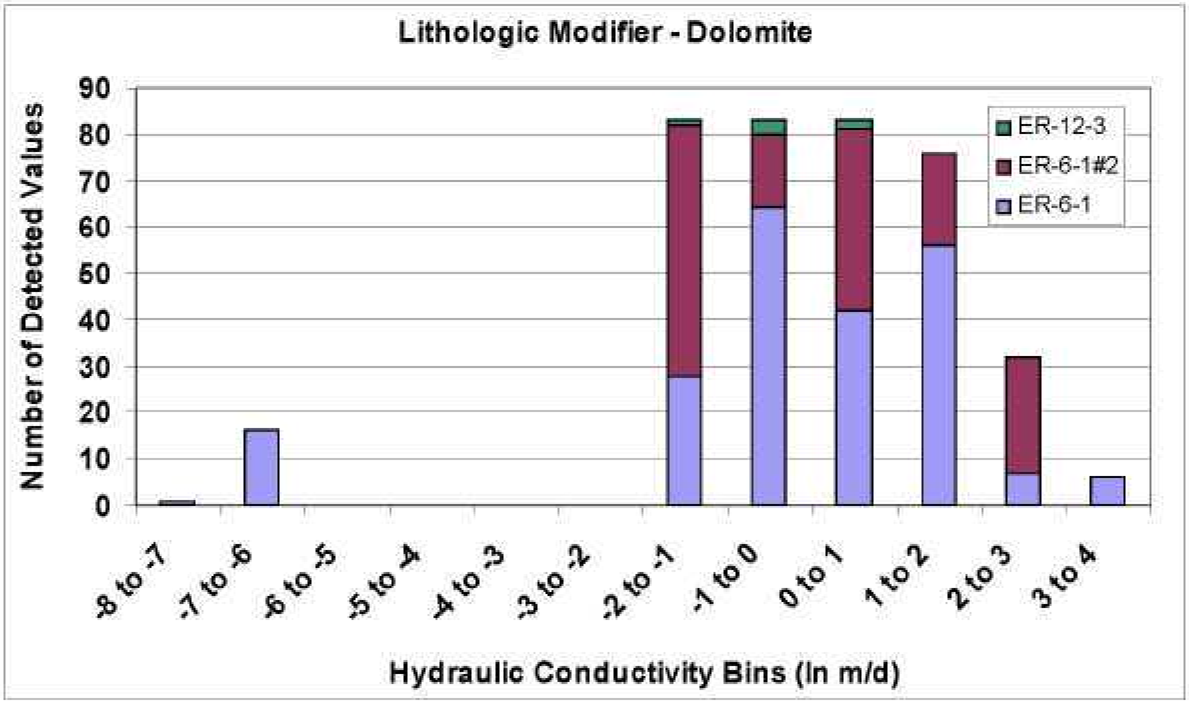


Figure 234. Detected natural logarithm hydraulic conductivity for wells in composite for the lithologic modifier Dolomite.

Hydraulic Conductivity and Hydrogeologic Unit / Hydrostratigraphic Unit / Alteration Modifier

The hydrogeologic unit, hydrostratigraphic unit, and alteration modifier do not vary within the hydrogeologic classifications and are carbonate aquifer, lower carbonate aquifer, and unaltered, respectively. The hydraulic conductivity values are presented in composite for all carbonate wells.

The detected hydraulic conductivity with depth for all carbonate wells in composite is presented in Figure 235. The results for wells ER-6-1, ER-6-1#2, and ER-12-3 are similar. Well ER-7-1 has notably higher values. Figures 236 through 239 present the detected hydraulic conductivity for the wells individually and in composite for normal and log-transformed values. Figures 236 and 237 illustrate a trend of higher occurrences of low hydraulic conductivity values. Figures 238 and 239 illustrate no identifiable trends to the data.

Summary of Phase One Analysis

The results of the Phase One analysis are summarized in a series of tables providing the average hydraulic conductivity and estimated statistical distribution for each of the hydrostratigraphic characteristics. The reader is reminded that these values are the average of the *detected* hydraulic conductivities. Nondetects are not included in the Stage One analysis and are addressed in the Stage Two analysis presented later in this report. Average hydraulic conductivity values detected for the various hydrogeologic characteristics should not be viewed as the average hydraulic conductivity for the entire thickness of the unit. The purpose of evaluating hydraulic conductivity is to understand the range and statistical characteristics of the permeability underlying the transmissivity of the major hydrogeologic units. These characteristics are particularly important for numerical simulation of radionuclide groundwater transport in calculating arrival times and concentrations.

Table 27 summarizes the hydraulic conductivity for stratigraphic units in tuff. The table indicates that many of the stratigraphic units have unknown or too few values to describe the statistical distribution of data. Comparing data for the same stratigraphic unit among wells indicates that the values may be similar such as for the unit Tfb (Tertiary Beatty Wash Formation) in wells ER-EC-7 and ER-EC-8 or may have very different values such the stratigraphic unit Tfbw (Tertiary Rhyolite of Beatty Wash Formation) in wells ER-EC-2a and ER-EC-7 and for the unit Tmar (Tertiary Mafic-Rich Ammonia tanks Tuff) in wells ER-EC-2a and ER-EC-5. There seems to be no identifiable trends in the average hydraulic conductivity based on stratigraphic unit. In general, well ER-EC-2a seems to have much lower hydraulic conductivity than the other wells. This aspect may be related to the specific fracture domain at that well.

Table 28 summarizes the hydraulic conductivity for lithologic units in tuff. The table indicates that almost all of the units have unknown statistical distribution of data. An interesting observation is that the average hydraulic conductivity seems unaffected by the degree of welding in tuff. The nonwelded tuff, partly welded tuff, moderately welded tuff and moderately to densely welded tuff have values over similar ranges. The average hydraulic conductivity values for lava (LA) are generally greater than for other lithologic units.

The summary of results for association of average hydraulic conductivity with alteration modifier for tuff is presented in Table 29. There are too few data to describe the statistical distributions for most wells. The statistical distribution is unknown nearly all of the remaining wells. There are no identifiable trends associating average hydraulic conductivity with alteration modifier.

The summary of hydrogeologic units in tuff and average hydraulic conductivity is presented in Table 30. Well ER-EC-2a has lower average hydraulic conductivity values for all hydrogeologic classifications. Evaluation of the average values for welded tuff aquifer (WTA), and lava flow aquifer (LFA) are similar to those for tuff confining units (TCU). This observation should be viewed with caution because these are average detectable hydraulic conductivity values and does not reflect the many nondetects within each type of hydrogeologic unit. The table is possibly indicating that the permeability of fractures is similar in welded tuff aquifers and tuff confining units and that it is the frequency of fractures that determines whether the unit is an aquifer or a confining unit.

Table 31 presents the average hydraulic conductivity for the various hydrostratigraphic units in tuff. Well ER-EC-2a is again unique in that the average values are lower than the other wells. Only three hydrostratigraphic units are found in more than one well (e.g., FCCM – Fortymile Canyon Composite Unit, TMCM – Timber Mountain Composite Unit, and BA – Benham Aquifer. Most of the hydrostratigraphic units do not have an identifiable statistical distribution. The average values do not indicate an association with hydrostratigraphic unit.

Wells in carbonate exhibit only two variations in hydrostratigraphic characteristics: the stratigraphic unit and the lithologic unit. These hydraulic conductivity values are based, in part, on a linearization of the borehole flow rates that produces an average value over distances greater than the nominal 1.5 m vertical calculation interval used in screened wells. Therefore, short intervals containing nondetectable hydraulic conductivity are incorporated into the average values.

Table 32 presents the average hydraulic conductivity data for each stratigraphic unit in carbonate. The statistical distributions of hydraulic conductivity within each stratigraphic unit are generally unknown. The close similarity of values of ER-6-1 and ER-6-1#2 is the result of these wells being located only 64 m apart.

Table 33 presents the average hydraulic conductivity associated with lithologic unit. The values in dolomite (Dol) appear to be more similar than those in limestone (Ls). The statistical distributions in carbonate are generally lognormal. This is in contrast to tuff which apparently have more variability in the statistical distributions.

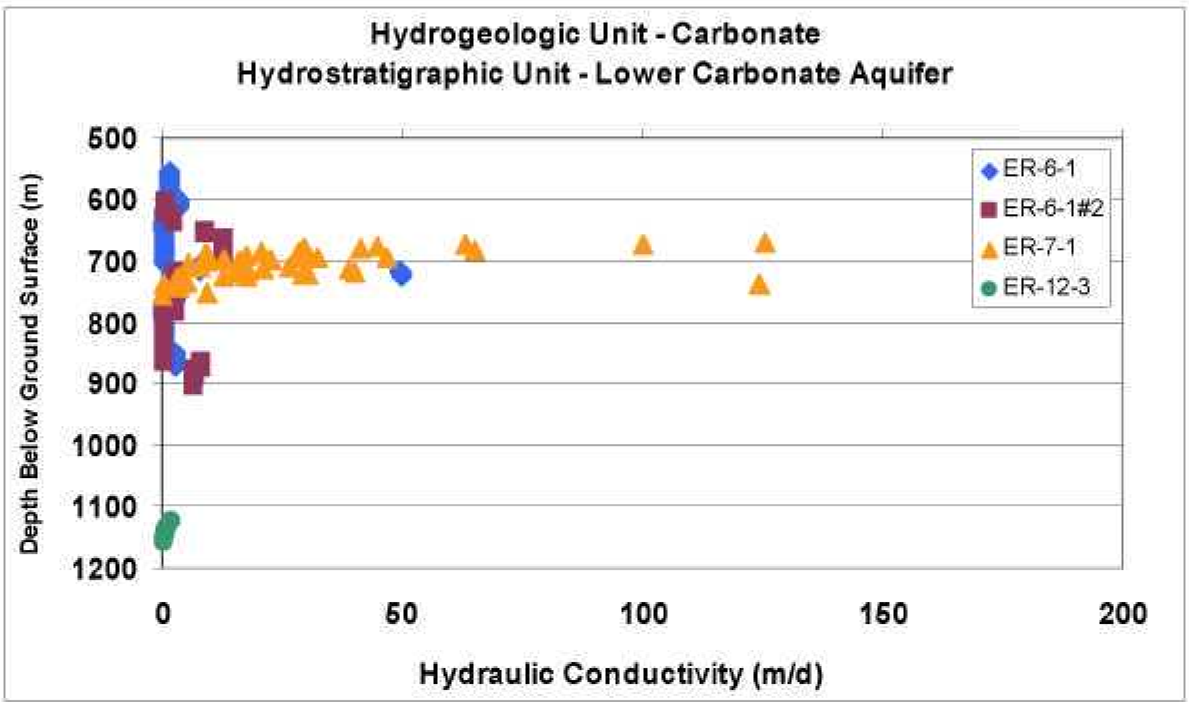


Figure 235. Detected hydraulic conductivity with depth for the hydrogeologic unit Carbonate and hydrostratigraphic unit Lower Carbonate Aquifer.

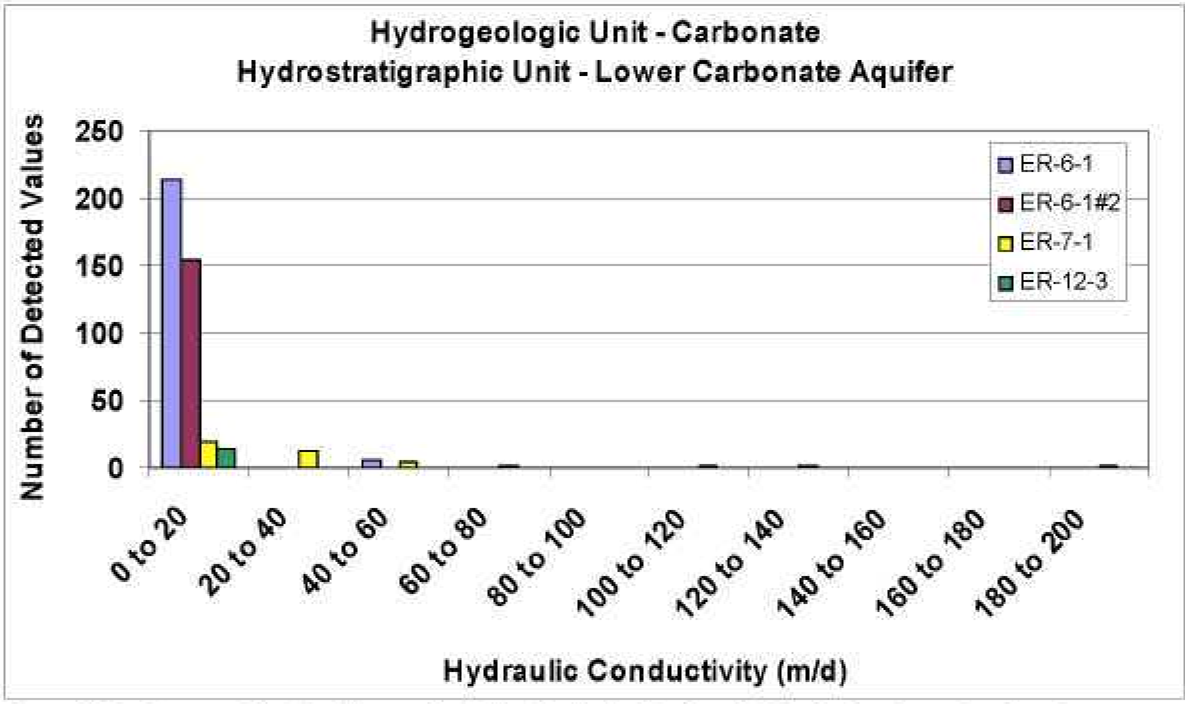


Figure 236. Detected hydraulic conductivity for individual wells for the hydrogeologic unit Carbonate and hydrostratigraphic unit Lower Carbonate Aquifer.

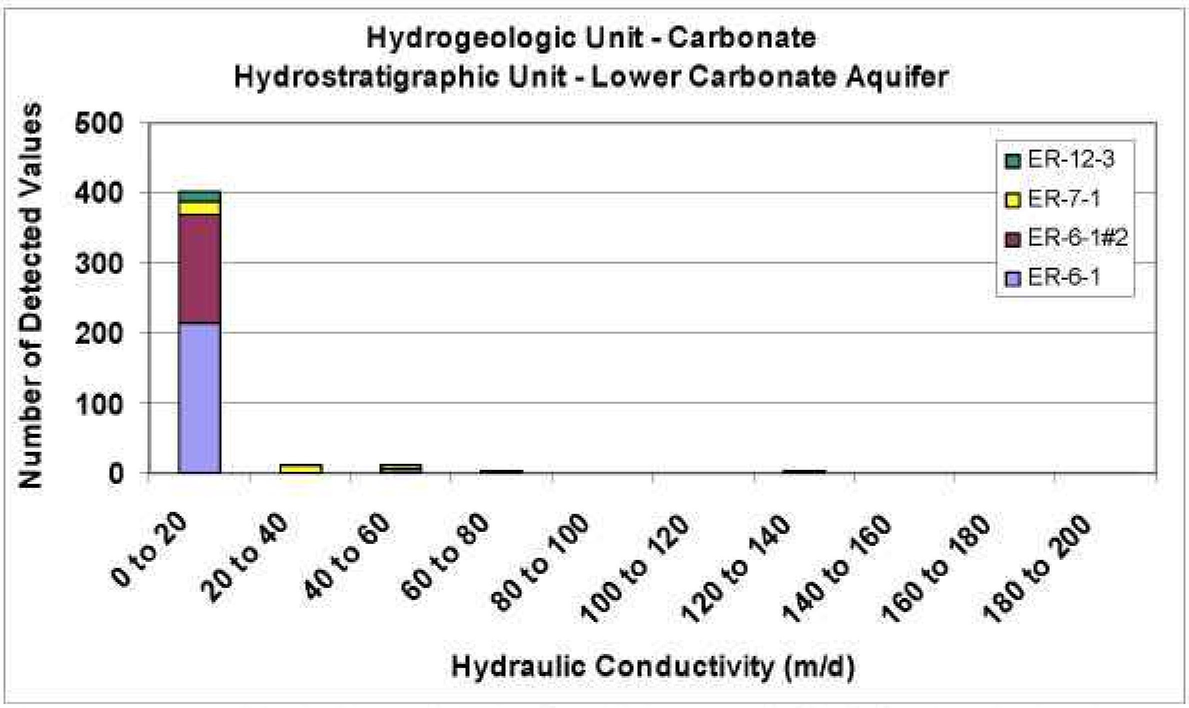


Figure 237. Detected hydraulic conductivity for wells in composite for the hydrogeologic unit Carbonate and hydrostratigraphic unit Lower Carbonate Aquifer.

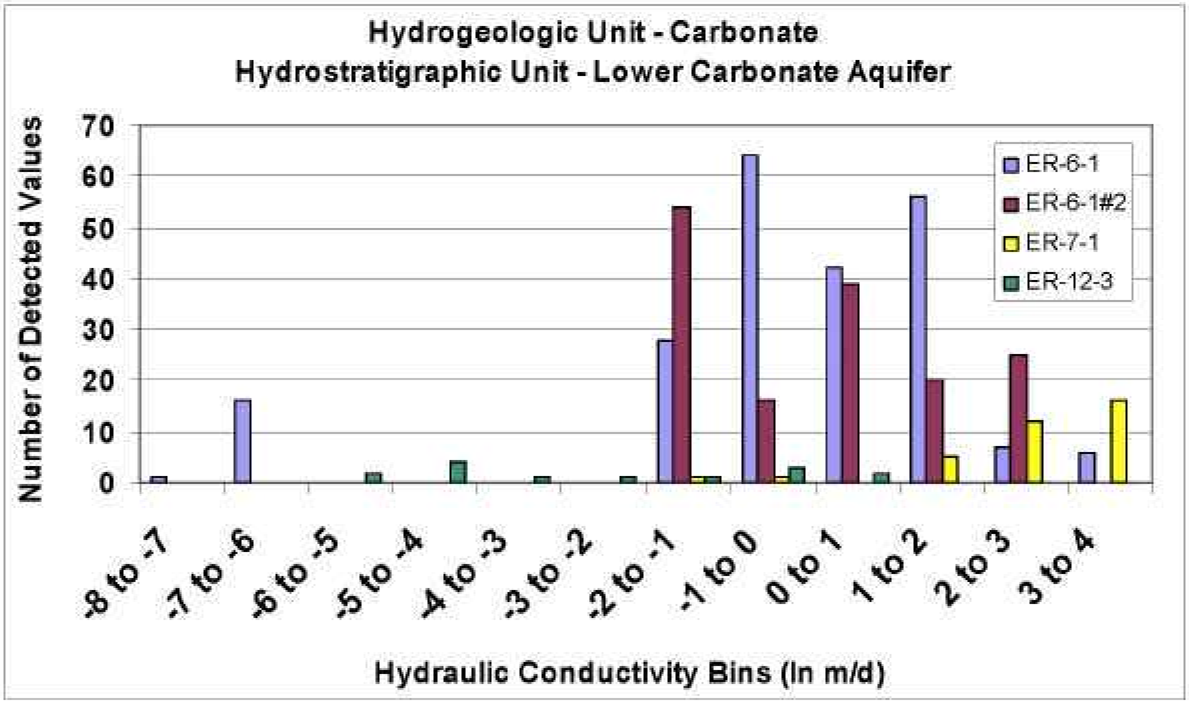


Figure 238. Detected natural logarithm hydraulic conductivity for individual wells for the hydrogeologic unit Carbonate and hydrostratigraphic unit Lower Carbonate Aquifer.

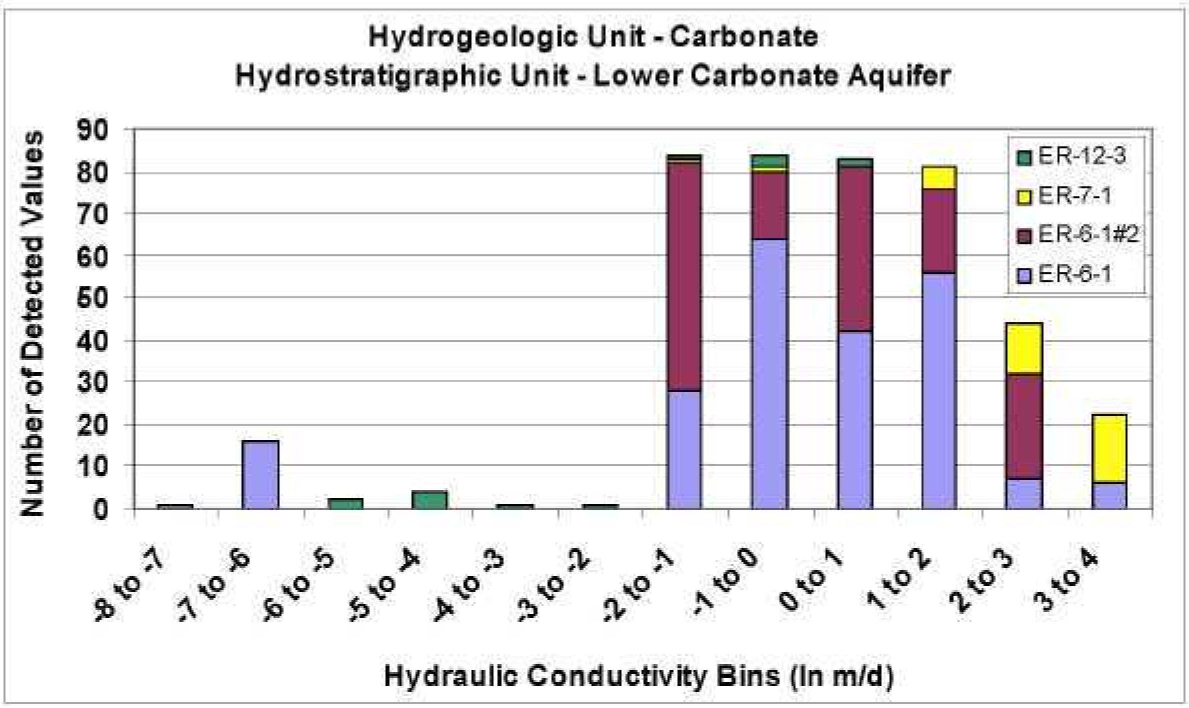


Figure 239. Detected natural logarithm hydraulic conductivity for wells in composite for the hydrogeologic unit Carbonate and hydrostratigraphic unit Lower Carbonate Aquifer.

Table 27. Tuff stratigraphic units property summary.

Well	Summary Properties	Stratigraphic Unit												
		Tfbw	**Tfb**	**Tf**	**Ttc**	**Tpb**	**Tmaw**	**Tmar**	**Tmap**	**Tcb**	**Tpcm**	**Tptm**	**Tcpe**	**Tmrp**
ER-EC-1	Ave K (m/d)					**27.6**					**2.3**	**8.4**	**11.1**	
	Distribution					ln					unk	unk	unk	
ER-EC-2a	Ave K (m/d)	**0.18**		**0.17**			**0.17**	**0.04**						
	Distribution	ln		few			unk	few						
ER-EC-4	Ave K (m/d)				**27.6**									**16.4**
	Distribution				unk									few
ER-EC-5	Ave K (m/d)							**21.9**	**18.2**					
	Distribution							n-s	ln					
ER-5-4#2	Ave K (m/d)									**5.2**				
	Distribution									unk				
ER-EC-6	Ave K (m/d)					**5.1**								
	Distribution					unk								
ER-EC-7	Ave K (m/d)	**28.2**	**13.0**											
	Distribution	few	n											
ER-EC-8	Ave K (m/d)		**15.3**						**5.6**					
	Distribution		n						unk					

Estimated statistical distribution types n = normal, n-s = normal skewed, ln = log normal, few = too few values to estimate, unk = unknown

Table 28. Tuff lithologic modifiers property summary.

Well	Summary Properties	Lithologic Unit										
		NWT	PWT	PWT-MWT	MWT	MWT-DWT	LA	BED	TSLT	RWT	CL	FB
ER-EC-1	Ave K (m/d)		**2.3**	**8.4**			**33.4**	**4.3**				**10.7**
	Distribution		unk	unk			unk	few				unk
ER-EC-2a	Ave K (m/d)	**0.14**			**0.04**			**0.2**	**0.11**	**0.24**		
	Distribution	ln			few			ln	unk	unk		
ER-EC-4	Ave K (m/d)		**16.4**				**28.8**				**8.5**	
	Distribution		unk				unk				unk	
ER-EC-5	Ave K (m/d)				**21.9**	**18.2**						
	Distribution				n-s							
ER-5-4#2	Ave K (m/d)	**5.2**										
	Distribution	unk										
ER-EC-6	Ave K (m/d)						**5.1**					
	Distribution						unk					
ER-EC-7	Ave K (m/d)						**18.0**					
	Distribution						few					
ER-EC-8	Ave K (m/d)	**14.6**										
	Distribution	ln										

Estimated statistical distribution types n = normal, n-s = normal skewed, ln = log normal, few = too few values to estimate, unk = unknown

Table 29. Tuff alteration modifiers property summary.

Well	Summary Properties	Alteration Modifier					
		DV	GL	ZE	QZ	QF	VAR
ER-EC-1	Ave K (m/d)	29.9		4.3	10.6	11.1	
	Distribution	unk		few	few	few	
ER-EC-2a	Ave K (m/d)			0.4		0.2	
	Distribution			few		unk	
ER-EC-4	Ave K (m/d)	28.8				16.4	
	Distribution	unk				few	
ER-EC-5	Ave K (m/d)					21.5	
	Distribution					n-s	
ER-5-4#2	Ave K (m/d)			5.2			
	Distribution			ln			
ER-EC-6	Ave K (m/d)	1.6	10.9				
	Distribution	few	unk				
ER-EC-7	Ave K (m/d)					28.2	13.0
	Distribution					few	unk
ER-EC-8	Ave K (m/d)				15.3	5.6	
	Distribution				unk	few	

Estimated statistical distribution types n = normal, n-s = normal skewed, ln = log normal, few = too few values to estimate, unk = unknown

Table 30. Tuff hydrogeologic units summary properties.

Well	Summary Properties	Hydrogeologic Unit			
		WTA	TCU	LFA	AA
ER-EC-1	Ave K (m/d)	5.4	4.3	28.4	
	Distribution	few	few	unk	
ER-EC-2a	Ave K (m/d)	0.04	0.2		0.1
	Distribution	few	unk		few
ER-EC-4	Ave K (m/d)	16.4		28.8	8.5
	Distribution	few		unk	few
ER-EC-5	Ave K (m/d)	21.5			
	Distribution	n-s			
ER-5-4#2	Ave K (m/d)		5.2		
	Distribution		ln		
ER-EC-6	Ave K (m/d)			5.1	
	Distribution			unk	
ER-EC-7	Ave K (m/d)			18.0	
	Distribution			ln	
ER-EC-8	Ave K (m/d)		14.6		
	Distribution		ln		

Estimated statistical distribution types n = normal, n-s = normal skewed, ln = log normal, few = too few values to estimate, unk = unknown

Table 31. Tuff hydrostratigraphic units summary properties.

Well	Summary Properties	Hydrostratigraphic Unit									
		FCCM	TMCM	TCVA	TMA	LTCU	BA	UPCU	TCA	TSA	CFCM
ER-EC-1	Ave K (m/d)						30.6	4.3	2.3	8.4	11.1
	Distribution						ln	unk	unk	unk	unk
ER-EC-2a	Ave K (m/d)	0.2	0.2								
	Distribution	ln	unk								
ER-EC-4	Ave K (m/d)			27.6	16.4						
	Distribution			unk	unk						
ER-EC-5	Ave K (m/d)		21.5								
	Distribution		ln								
ER-5-4#2	Ave K (m/d)					5.2					
	Distribution					unk					
ER-EC-6	Ave K (m/d)						5.1				
	Distribution						unk				
ER-EC-7	Ave K (m/d)	18.0									
	Distribution	ln									
ER-EC-8	Ave K (m/d)	15.3	5.6								
	Distribution	ln	few								

Estimated statistical distribution types n = normal, n-s = normal skewed, ln = log normal, few = too few values to estimate, unk = unknown

Table 32. Carbonate stratigraphic units property summary.

Well	Summary Properties	Stratigraphic Unit			
		DSs	DSl	Oes	Pzu
ER-6-1	Ave K (m/d)	1.1	4.3	6.7	
	Distribution	unk	ln	unk	
ER-6-1#2	Ave K (m/d)		3.3	6.7	
	Distribution		unk	unk	
ER-7-1	Ave K (m/d)				33.1
	Distribution				unk
ER-12-3	Ave K (m/d)				0.4
	Distribution				unk

Estimated statistical distribution types n = normal, n-s = normal skewed, ln = log normal, few = too few values to estimate, unk = unknown

Table 33. Carbonate lithologic modifiers property summary.

Well	Summary Properties	Lithologic Unit	
		Dol	Ls
ER-6-1	Ave K (m/d)	3.2	
	Distribution	ln	
ER-6-1#2	Ave K (m/d)	3.5	
	Distribution	unk	
ER-7-1	Ave K (m/d)		33.1
	Distribution		ln
ER-12-3	Ave K (m/d)	0.8	0.02
	Distribution	few	ln

Estimated statistical distribution types n = normal, n-s = normal skewed, ln = log normal, few = too few values to estimate, unk = unknown

STAGE-TWO ANALYSIS

Introduction

The purpose of this stage of the study is to explore the data at a more detailed level using exploratory data analysis with censored data. The data are evaluated without prior assumptions of distribution or other behavior.

Recall that conductivity values (K) were obtained under more than one flow rate, resulting in up to three values of K at each measured depth in a well. In the previous stage of this study, low values, or values less than the assigned minimum value, were evaluated qualitatively and either averaged or discarded to produce a composite K. This results in one value of K for each depth in a well.

In this stage, all measured values of K were analyzed, regardless of whether or not the value was below its minimum acceptable value. Data identified only by a range, or a 'less-than' value, is called censored data. A detailed explanation of censored data and methods of analysis is included below.

Also, only the wells in tuff are analyzed in this stage. As noted above, wells in carbonate rock exhibit very little variation in rock type and it was decided that, for this stage, the analysis would be performed only on the characteristics of tuff.

As an example using fictitious data, table 34 illustrates the difference in data sets used for the previous stage and this one.

Table 34. Comparison of data sets between stage one and stage two.

	Raw Data						Raw Data used in Stage 2			Raw Data used in Stage 1
depth	K for Q1	min K	K for Q2	min K	K for Q3	min K	K1	K2	K3	composite K
110	3	4	4	3	6	6	<4	4	6	5
111	3	4	4	3	6	6	<4	4	6	5
112	2	4	4	3	6	6	<4	4	6	5
113	2	2	3	3	5	6	2	3	<6	3.7
114	3	2	4	3	6	6	3	4	6	4.3
115	4	4	5	4	4	6	4	5	<6	4.5
116	5	4	6	4	2	6	5	6	<6	5.5

In the table above, if the minimum **K** is greater than the measured **K**, the value used in the analysis would be "<(minK)." For example, using the fictitious data in Table 34, at depth 110 under flow Q1 the measured K is 3, while the minimum K is 4; this results in a data point of <4. Using a composite method, the first tier analysis would have 7 values to analyze and the second-tier analysis would have 21 values. Even though the presence of censored data complicates any statistical analysis, their values are retained in this stage.

Exploratory Data Analysis

Exploratory Data Analysis (EDA) is an approach to analyzing data described in Tukey (1977). This approach uses mostly graphical techniques to maximize use of our natural pattern recognition abilities. Typically, the data are not assumed to follow any model or distribution and are used to develop models and hypotheses rather than test assumptions about the data.

This part of the study relies heavily on EDA methods, particularly graphical and summary techniques. Typically, after the initial analysis (usually graphical), standard statistical tests can be performed. In this study, nonparametric tests are used whenever possible. As described below, the presence of censored data lends itself well to a nonparametric approach.

Among the many graph styles used in EDA, boxplots are often considered most useful. However, using boxplots with censored data presents a problem—specifically, how to present the 'less-than' values. Censored data can be thought of as a value in a range, rather than a discrete point. In the case of environmental data, that range is usually between zero and the censoring/detection limit. Boxplots in this report will use the maximum value for display. For example, a value of less than 4 will plot as 4. The effect of this technique is a misleading plot, one where data are skewed toward higher values. This compromise was necessary to compare data sets, but one should be aware that these plots do not represent actual data. Any statistical tests will use robust nonparametric techniques on the original censored dataset; the presentation of the maximum possible value for the censored data points is only for visual analysis.

The National Institute of Science and Technology e-Handbook of Statistics (2006) summarizes well the purpose and methods of EDA:

> *"The primary goal of EDA is to maximize the analyst's insight into a data set and into the underlying structure of a data set, while providing all of the specific items that an analyst would want to extract from a data set.*

"Insight implies detecting and uncovering underlying structure in the data. Such underlying structure may not be encapsulated in the list of items above; such items serve as the specific targets of an analysis, but the real insight and "feel" for a data set comes as the analyst judiciously probes and explores the various subtleties of the data. The "feel" for the data comes almost exclusively from the application of various graphical techniques, the collection of which serves as the window into the essence of the data. Graphics are irreplaceable--there are no quantitative analogues that will give the same insight as well-chosen graphics.

"To get a "feel" for the data, it is not enough for the analyst to know what is in the data; the analyst also must know what is not in the data, and the only way to do that is to draw on our own human pattern-recognition and comparative abilities in the context of a series of judicious graphical techniques applied to the data."

In this study, the following methods are used extensively:

- Graphical/survival curves
- Description using nonparametric methods
- Nonparametric analysis of variance (ANOVA) to describe differences in populations

Approach

In this portion of the study, the following questions will be addressed:

- What are typical values for K?
- Does K follow any trend within a well? Does K decrease with depth?
- Are rock characteristics homogeneous? For example, do the K values for an HSU of BA in one location differ from the K values for an HSU of BA in another location?
- Are there differences in K within rock classifications? Or, which rock classifications best describe variability in K?
- Are Ks affected by fractures?

Note: Throughout the Stage 2 analysis, the following abbreviations for rock characteristics are used extensively: Hydrostratigraphic Unit (HSU), Hydrogeologic Unit (HGU), Stratigraphic Unit (STRAT), and Lithology (LITH).

OVERVIEW OF CENSORED DATA METHODS

There are several methods available to deal with censored data. Sometimes, nondetects are eliminated from the data set. This results in a data set skewed toward higher values and does not provide a random sample of the population. Often, one-half of the detection limit is substituted for the actual (albeit unknown) value. This method is sometimes recommended in manuals by federal agencies (EPA [1998]; U.S. Army Corps of Engineers [1998]). A third common practice is to assume the data follow a distribution (with environmental data, the log-normal distribution is often used) and replace the censored data with data that follow the assumed distribution.

Helsel (2005) provides an overview of these techniques and describes the problems and errors associated with them. Helsel also recommends statistically rigorous methods to deal with censored data without fabricating or discarding values, or assuming the data belong to a distribution. The nonparametric techniques described in Helsel are used in this stage of the study.

Correlation

The Kendall Tau rank correlation coefficient is used in this analysis to measure to correspondence between two rankings. This non-parametric method is commonly-used in the environmental sciences to determine trends (correspondence between a measured value and time) and, in this study, to determine correspondence between hydraulic conductivity and depth. The correlation coefficient (τ) is an intuitively simple measure of the strength of relationship between two variables (Noether, 1986).

The Kendall Tau is defined below:

$$\tau = \frac{4P}{[n(n-1)]}$$

where n is the number of samples and P is the number of concordant pairs—or data pairs where X increases as Y increases, or X decreases while Y decreases. The Kendall-Tau test was used below to identify a relationship between K and depth.

Comparison of Populations

The Peto-Peto generalization of the Wilcoxon statistic is used in this study to test for the differences in populations. It is a non-parametric alternative to the paired Student's t-test. As applied to this study, the test statistic is used to determine if there is a difference between two survival curves. Example survival curves are shown in Figure 240.

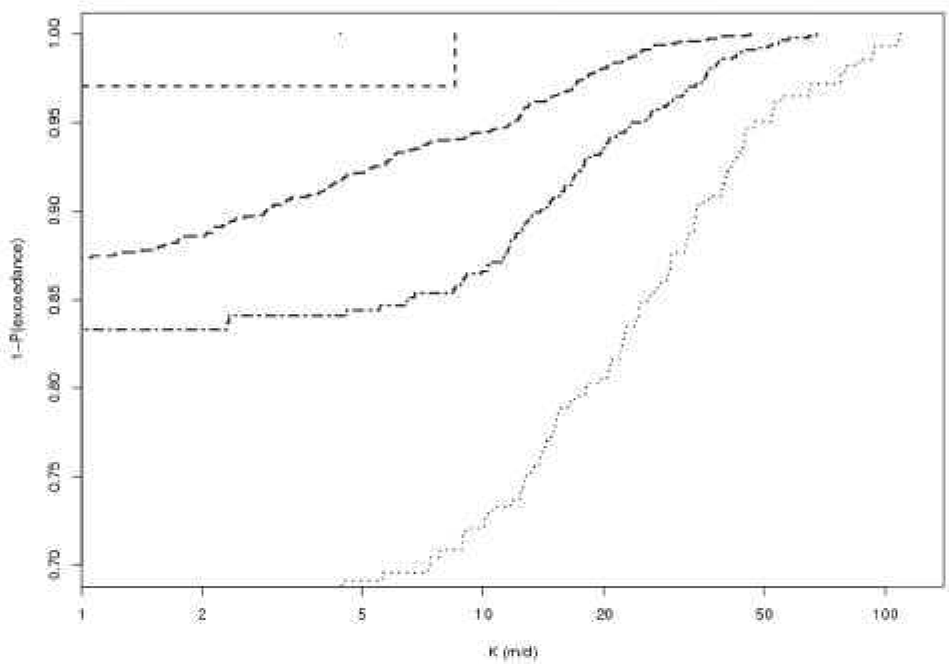
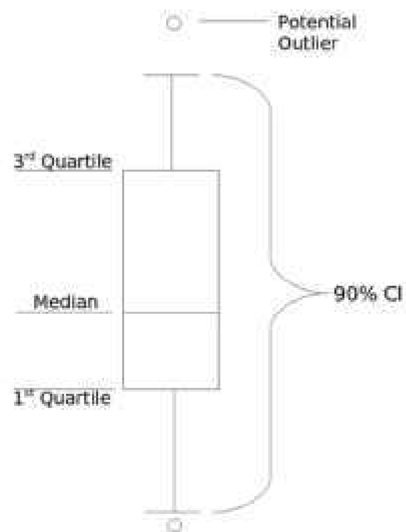


Figure 240. Example of survival curves.

Survival curves, commonly used in medical statistics, plot percent survival as a function of some variable. Modified for the left-censored data in this study, survival curves plot the probability of non-exceedance—or the probability that the true K is less than K computed by the survival function. A survival curve can be thought of as a non-parametric q-q plot; when several survival curves are plotted together, differences in the populations become apparent. Survival curves are also appropriate for censored data (Helsel, 2005). Differences between the curves are then computed using the Peto-Peto generalization of the Wilcoxon signed-rank test. In this study, the significance of the test statistic is computed at p=0.05.

In this study, survival curves and the Peto-Peto Wilcoxon test are used extensively to evaluate differences in populations.

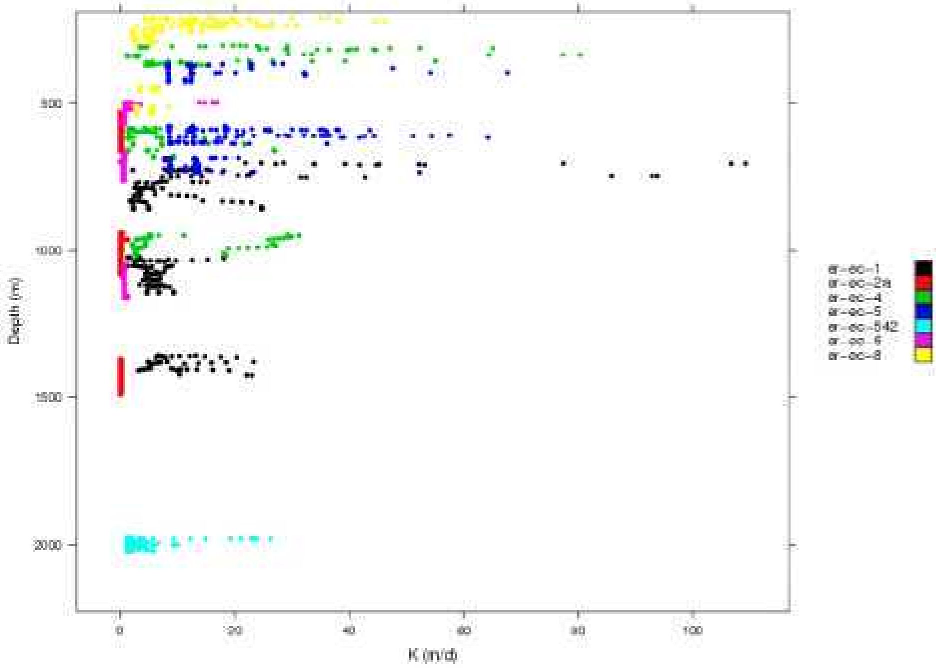
Visual comparison of populations can also be done with boxplots. Boxplots (see the figure below) are used extensively in this study to highlight differences in populations. Please note, however, the difficulty in representing censored values in any plot. The boxplots used in this study were used for visual comparison only.



SUMMARY OF ENTIRE DATASET

First, to get an overview, the entire dataset is summarized below:

- All values lie between 0 and 109 m/d. The smallest value for K is unknown, since any of the censored values could be the smallest, but the smallest uncensored value is 0.0011 m/d. The largest value is 109 m/d. The plot below shows all values of K plotted against depth and grouped by well.



- Eighty-one percent of the values are censored. Since more than half are censored, a median or interquartile range (IQR) cannot be computed.
- The density of the data set (using maximum values in the case of censored data) is given below in Figure 241.

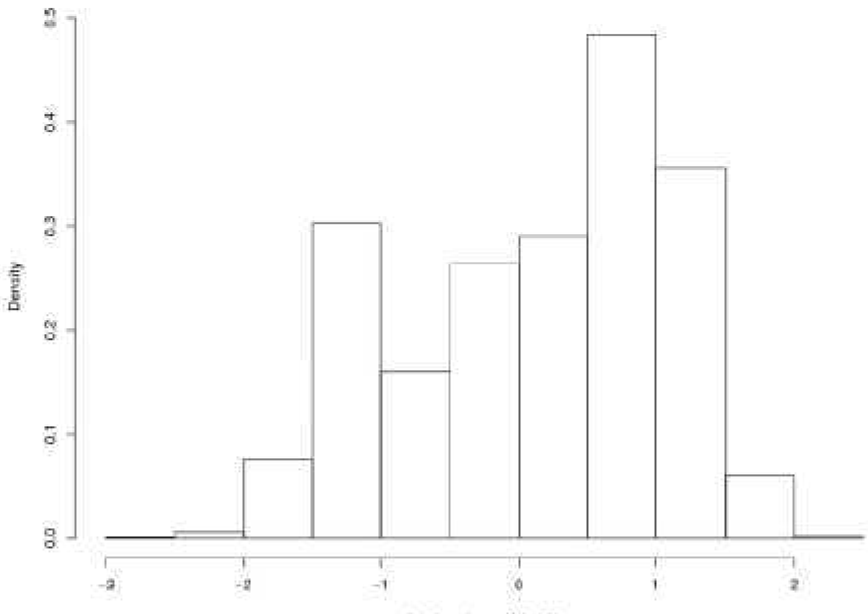


Figure 241. Density of all Ks.

DESCRIPTION OF K WITHIN EACH WELL

In this section, conductivity within a well is described and analyzed. Data are isolated according to their rock classification and characteristic and Kendall's tau is computed.

In each well, a test for a trend with depth was performed for every rock characteristic present (Table 35). For example, in well ER-EC-1 there are seven classifications of HSU, four HGUs, 10 LITHs, five ALTERATIONs, and five STRATs, for a total of 31 tests. Only those tests that resulted in a statistically significant (at the 0.05 level) correlation of K with depth are presented below.

The purpose of this section is to determine if K varies with depth within a rock characteristic. The detected correlation between K and depth may be due to several underlying factors such as: increased lithostatic pressure with depth, correlation of K to occurrence of fractures, or friction loss impeding flow from lower intervals. The determination of the causal factors is beyond the scope of this report, though the section below, titled "Compare K with Fractures," gives a brief discussion of a possible correlation between the presence of fractures and high hydraulic conductivity.

Also, many of the significant correlations between K and depth are the result of analysis on populations spanning less than 100 meters in depth. Extrapolation of these results to greater depths, or generalizing these results for use in large-scale models, may not be appropriate.

Table 35. Characteristics and classifications of intervals within wells in which a statistically-significant correlation of depth and K were detected.

Well	Characteristic	Classification
ER-EC-1	HSU	BA
	HGU	LFA
	ALTERATION	DV
	STRAT	Tpb
ER-EC-2a	HGU	TCU
	ALTERATION	QF
	LITH	NWT
ER-EC-4	HSU	TCVA
	HGU	LFA
	ALTERATION	DV
	LITH	LA
	STRAT	Ttc
ER-EC-5 and ER-5-4#2	none	
ER-EC-6	HSU	BA
	HGU	LFA
	LITH	LA
	STRAT	Tpb
ER-EC-8	HSU	FCCM
	HGU	TCU
	ALTERATION	QZ
	LITH	NWT
	STRAT	Tfb

K versus Depth: Well ER-EC-1

HSU:BA

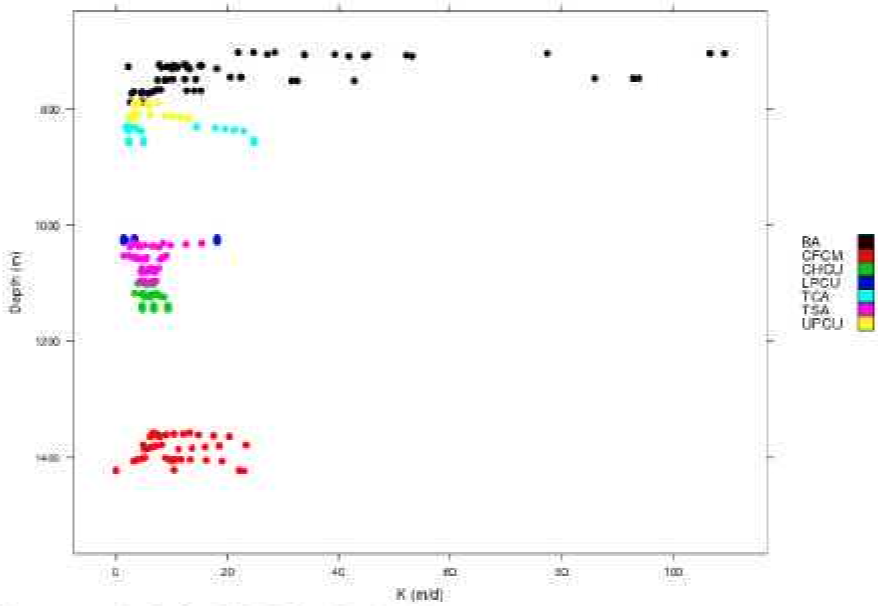


Figure 242. K versus depth for ER-EC-1 by HSU.

HGU:LFA

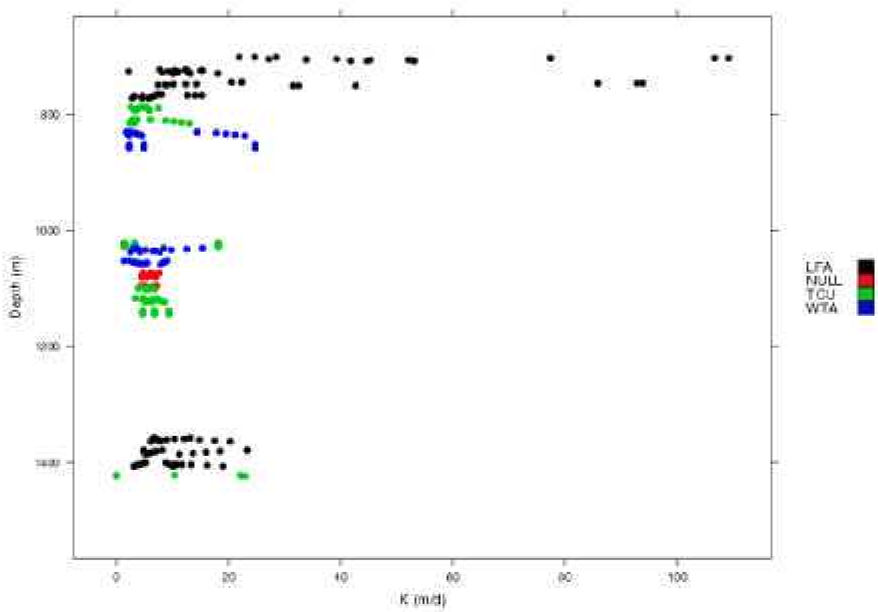


Figure 243. K versus depth for ER-EC-1 by HGU.

ALTERATION:DV

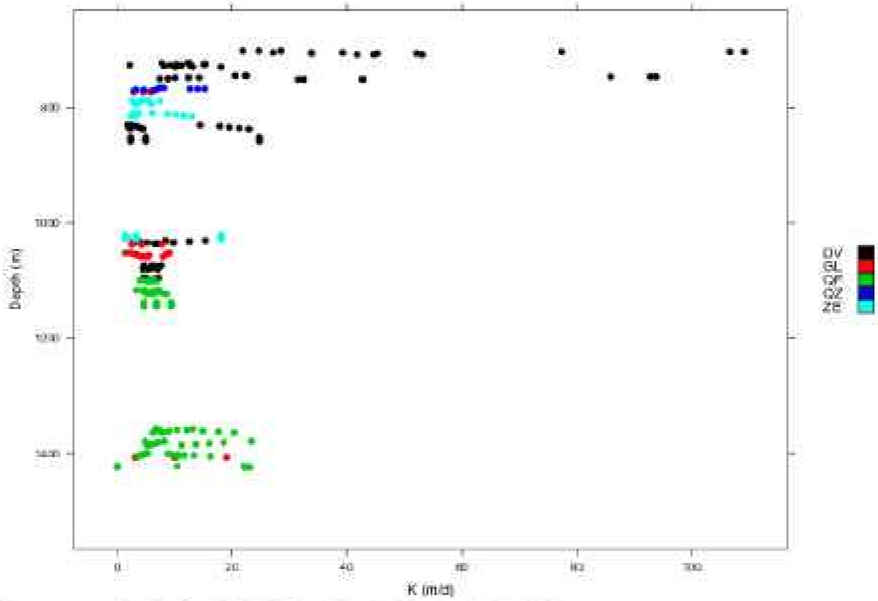


Figure 244. K versus depth for ER-EC-1 by ALTERATION.

STRAT:Tpb

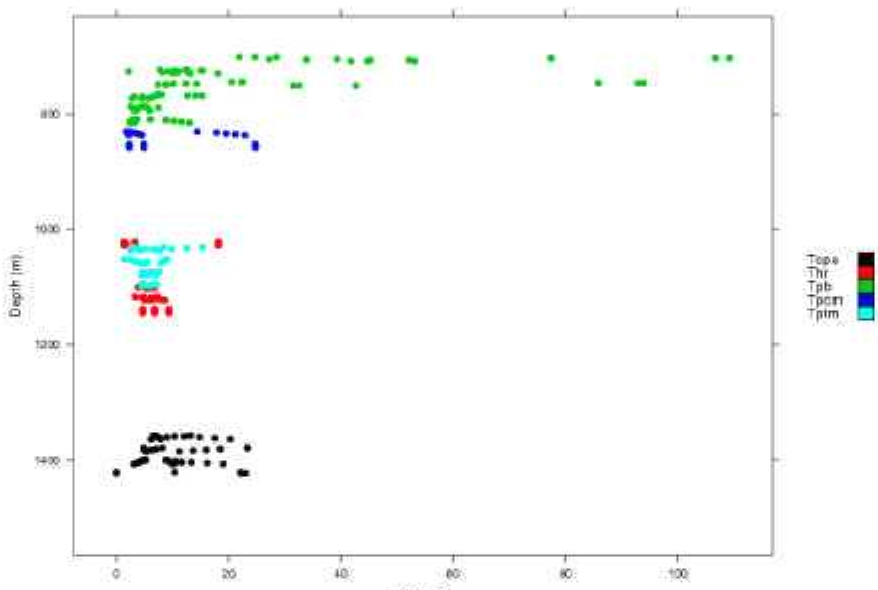


Figure 245. K versus depth for ER-EC-1 by STRAT.

K versus Depth: Well ER-EC-2a

HGU:TCU

In well ER-EC-2a, there is a slight decrease in K with depth for an HGU of TCU, though the highest values occur in the middle screened section.

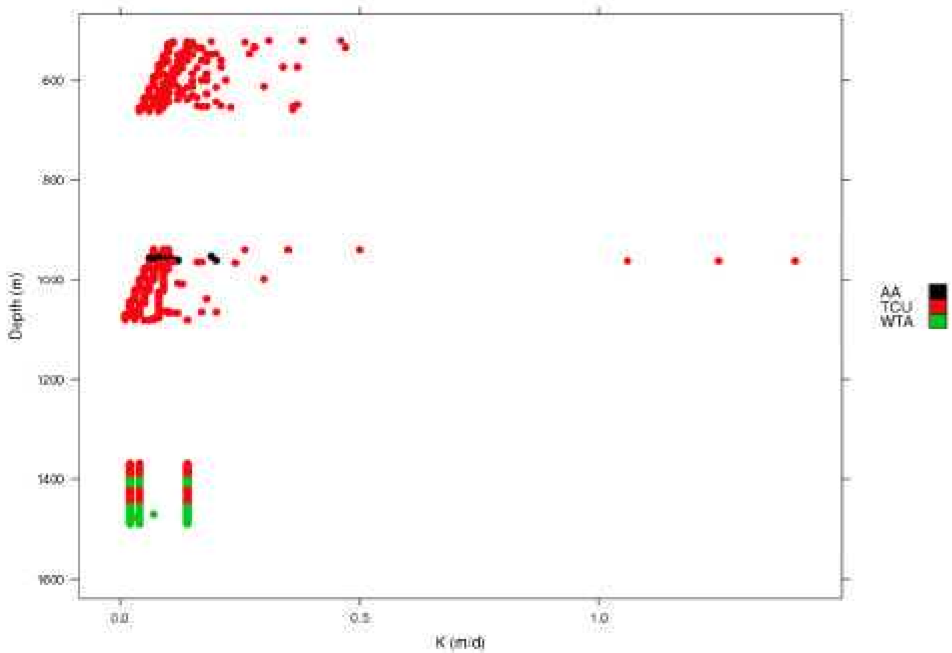


Figure 246. K versus depth for ER-EC-2A by HGU.

ALTERATION:QF

K decreases slightly with depth in ALTERATION QF.

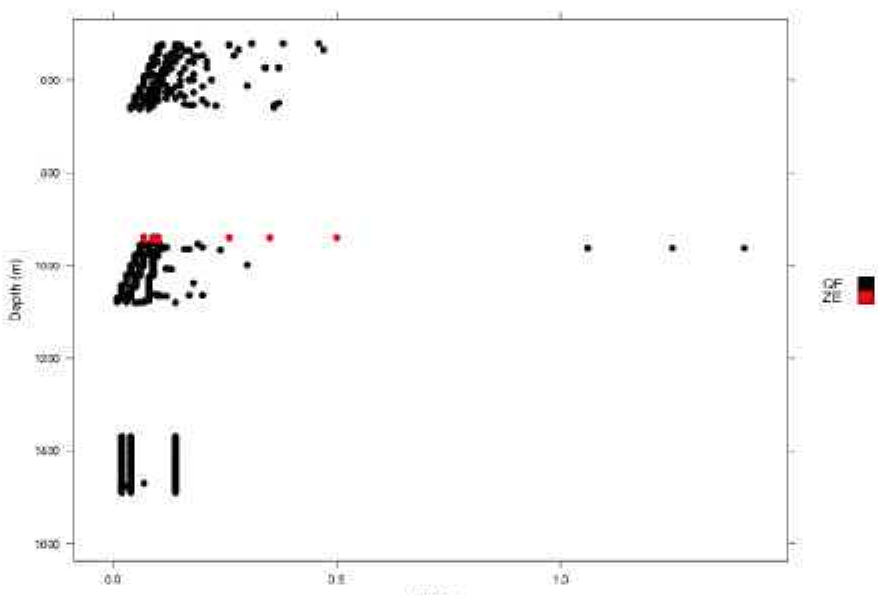


Figure 247. K versus depth for ER-EC-2A by ALTERATION.

LITH:NWT

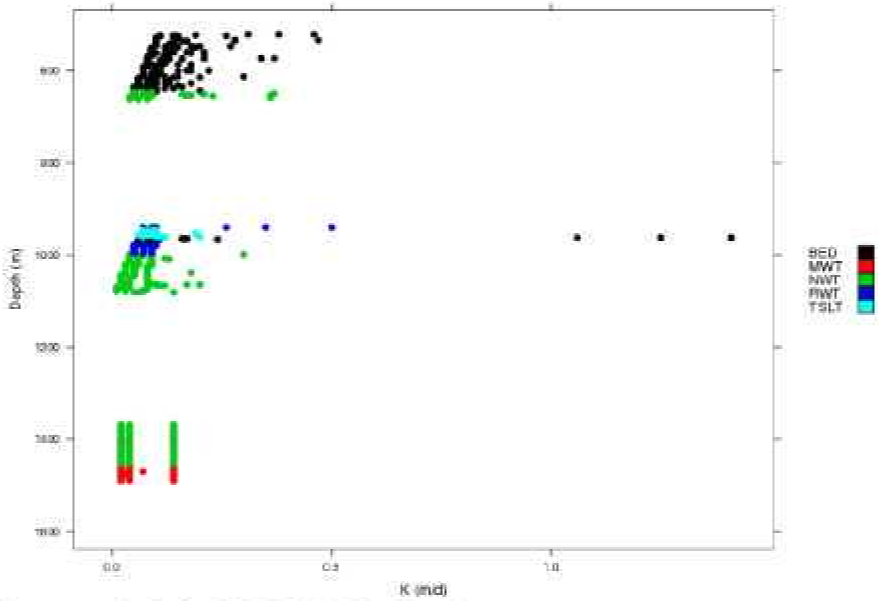


Figure 248. K versus depth for ER-EC-2A by LITH.

K versus Depth: Well ER-EC-4

HSU:TCVA

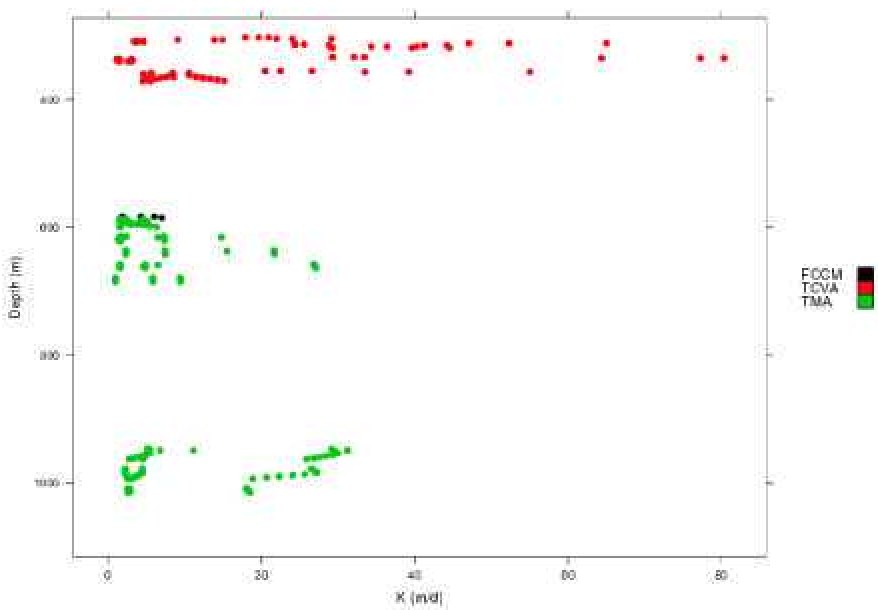


Figure 249. K versus depth for ER-EC-4 by HSU.

HGU:LFA

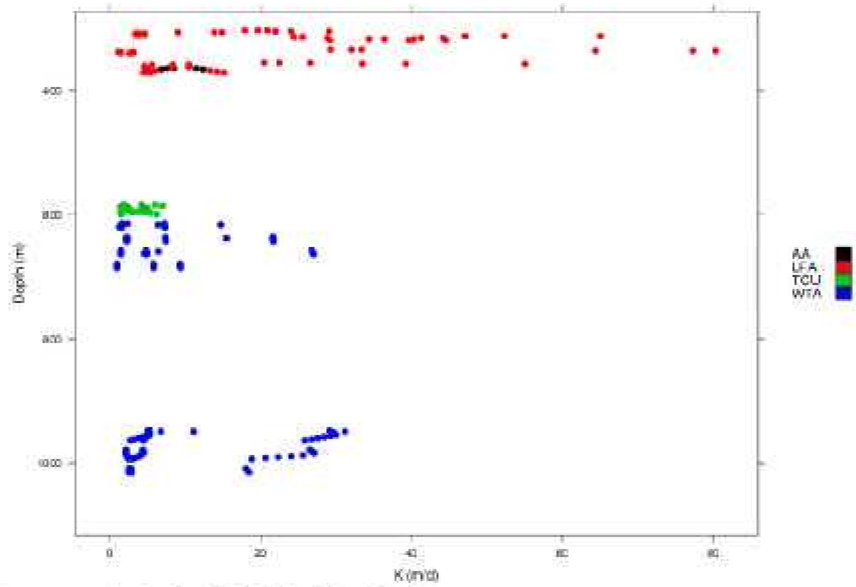


Figure 250. K versus depth for ER-EC-4 by HGU.

ALTERATION:DV

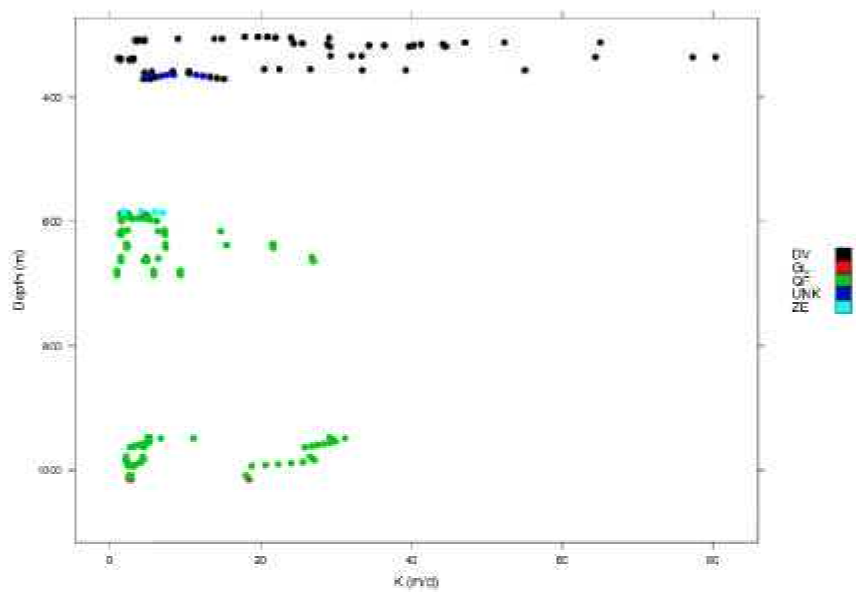


Figure 251. K versus depth for ER-EC-4 by ALTERATION.

LITH:LA

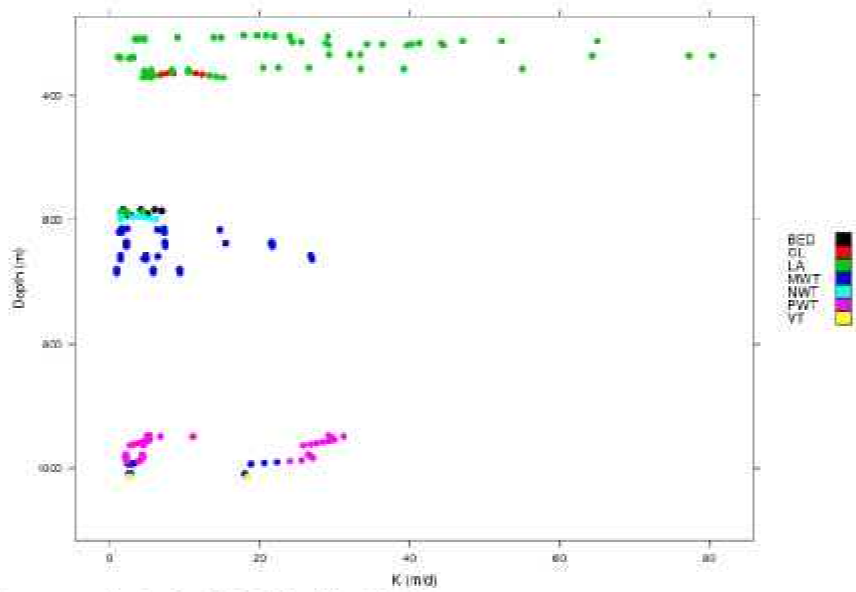


Figure 252. K versus depth for ER-EC-4 by LITH.

STRAT:Ttc

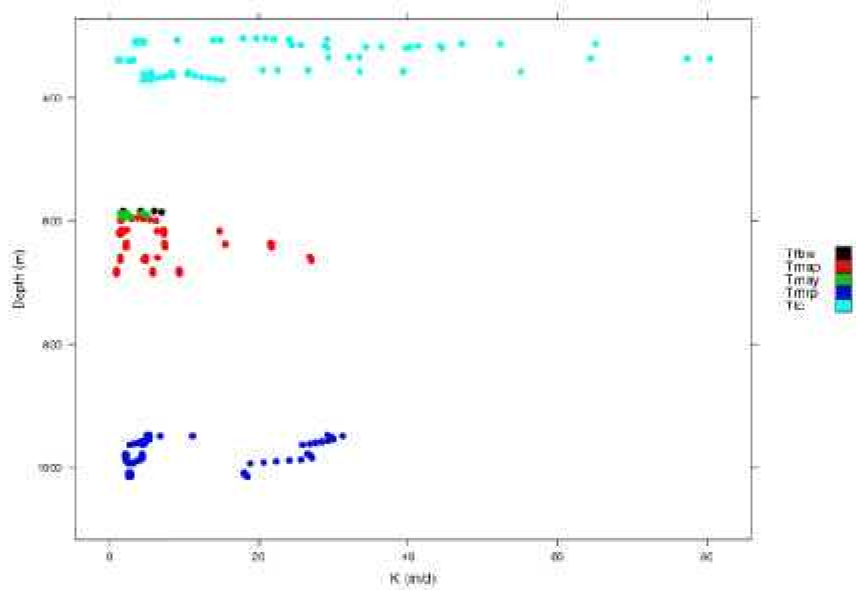


Figure 253. K versus depth for ER-EC-4 by STRAT.

K versus Depth: Wells ER-EC-5, ER-5-4#2

There are no significant correlations between depth and K for wells ER-EC-5 and ER-5-4#2.

K versus Depth: Well ER-EC-6

<u>HSU:BA</u>

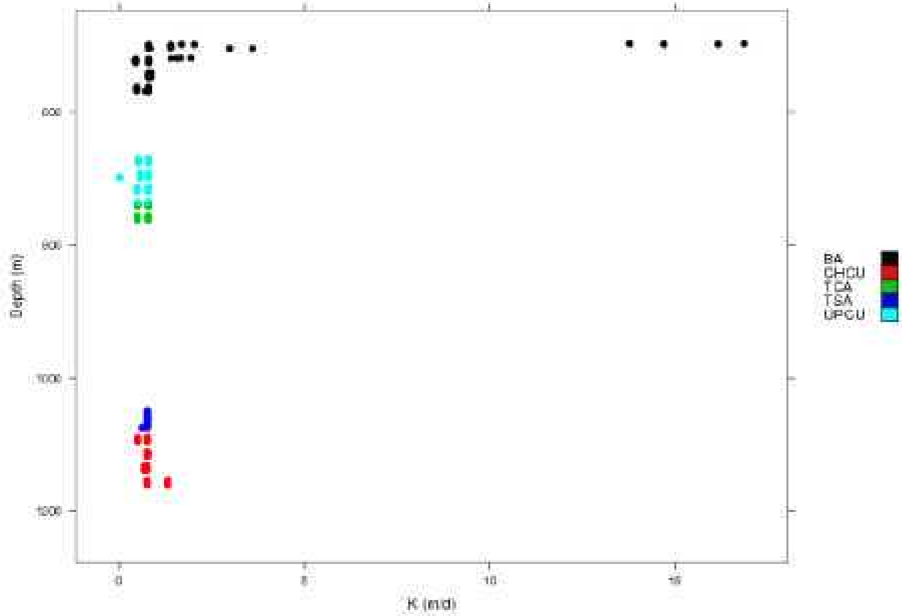


Figure 254. K versus depth for ER-EC-6 by HSU.

<u>HGU:LFA</u>

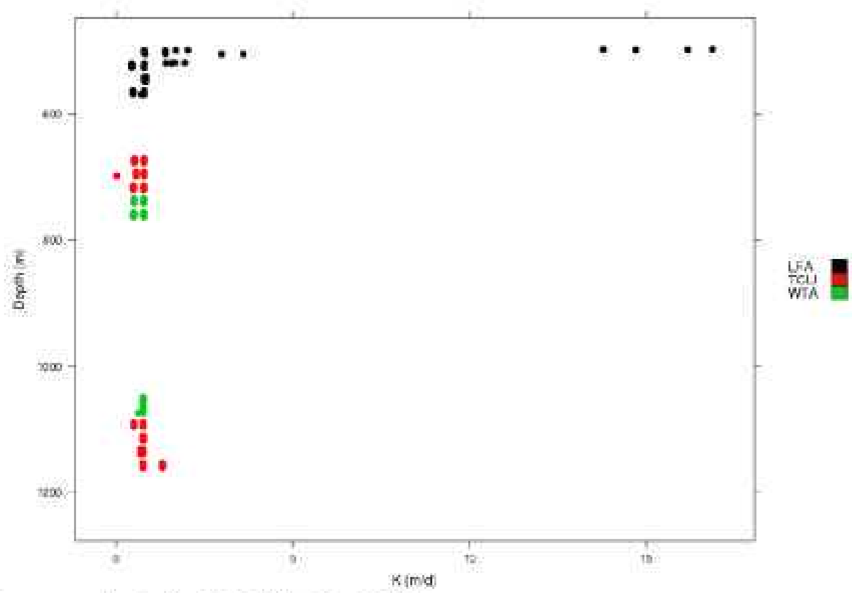


Figure 255. K versus depth for ER-EC-6 by HGU.

LITH:LA

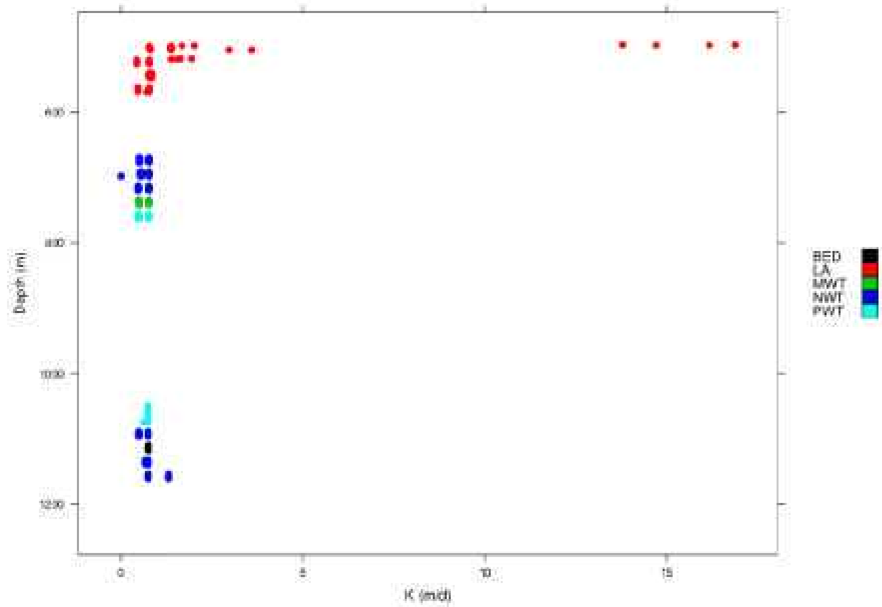


Figure 256. K versus depth for ER-EC-6 by LITH.

STRAT:Tpb

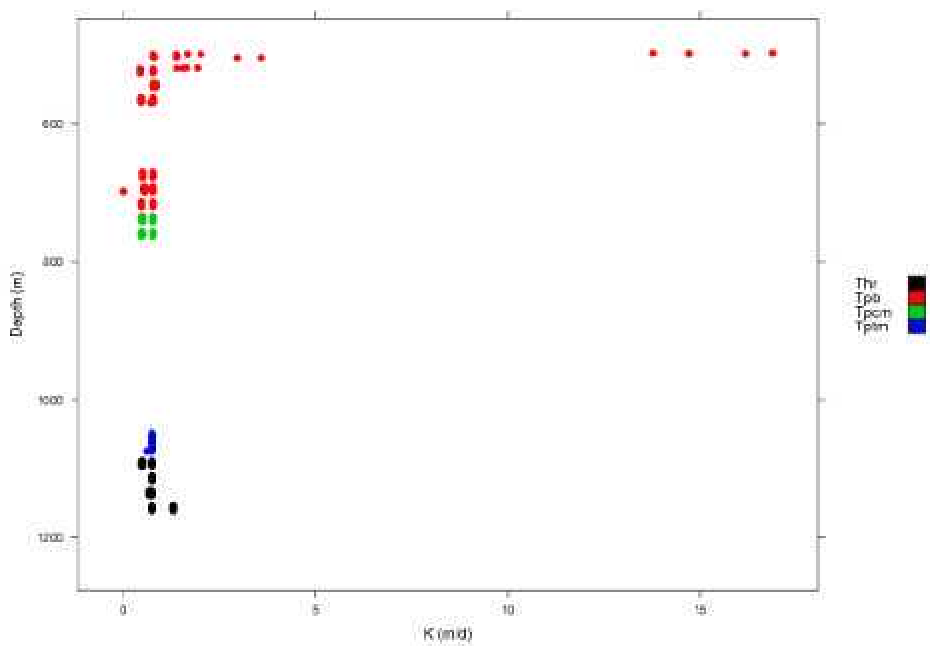


Figure 257. K versus depth for ER-EC-6 by STRAT.

K versus Depth: Well ER-EC-8

HSU:FCCM

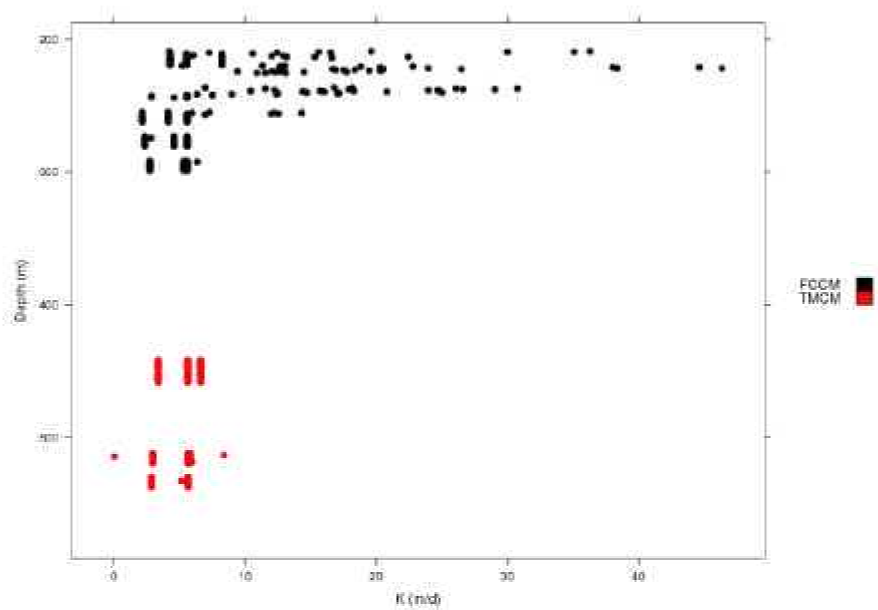


Figure 258. K versus depth for ER-EC-8 by HSU.

HGU:TCU

Though there is a significant correlation between depth and K for an HGU of TCU, nearly all K values greater than 10 m/d are associated with fractures. However, the presence of only low values (<10 m/d) below 500 m depth suggest the correlation between K and depth may indeed exist.

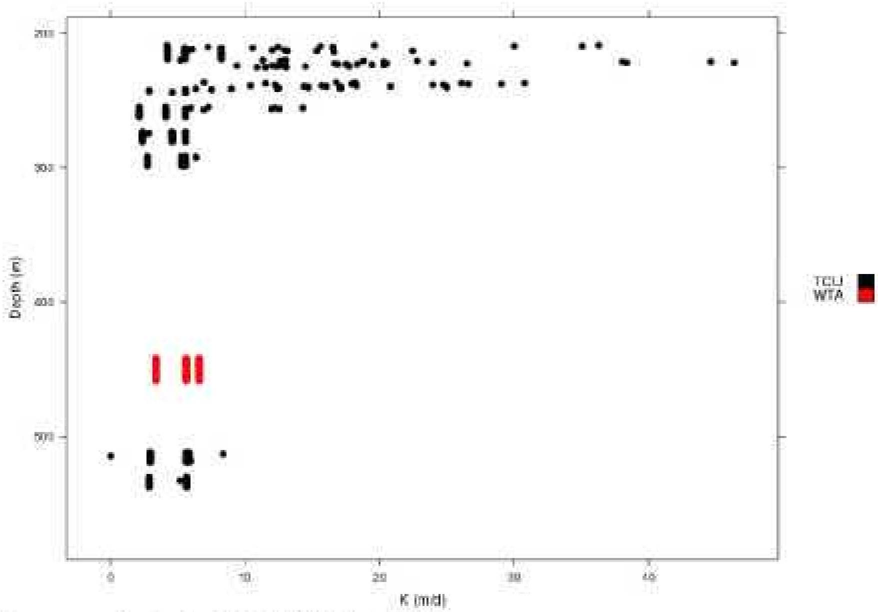


Figure 259. K versus depth for ER-EC-8 by HGU.

ALTERATION:QZ

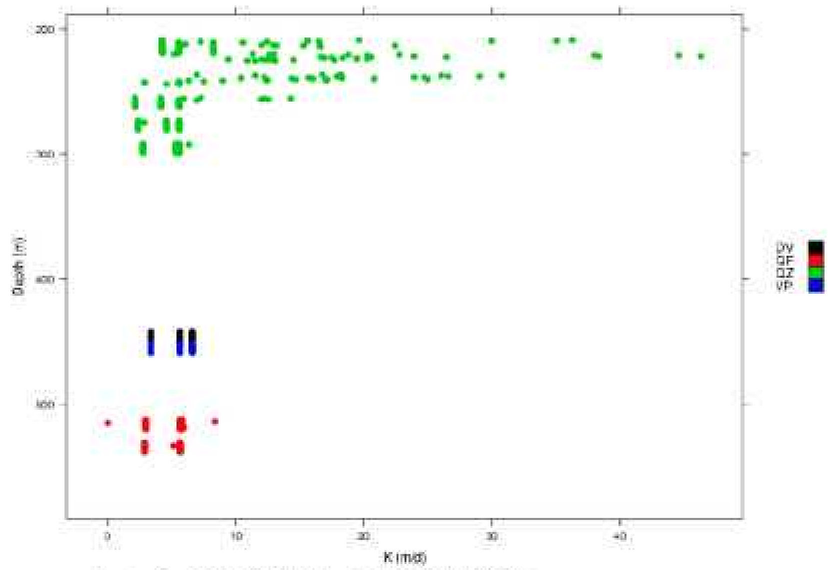


Figure 260. K versus depth for ER-EC-8 by ALTERATION.

LITH:NWT

Though there is a significant correlation between depth and K for a LITH of NWT, nearly all K values greater than 10 m/d are associated with fractures. However, the presence of only low values (<10 m/d) below 500 m depth suggest the correlation between K and depth may indeed exist.

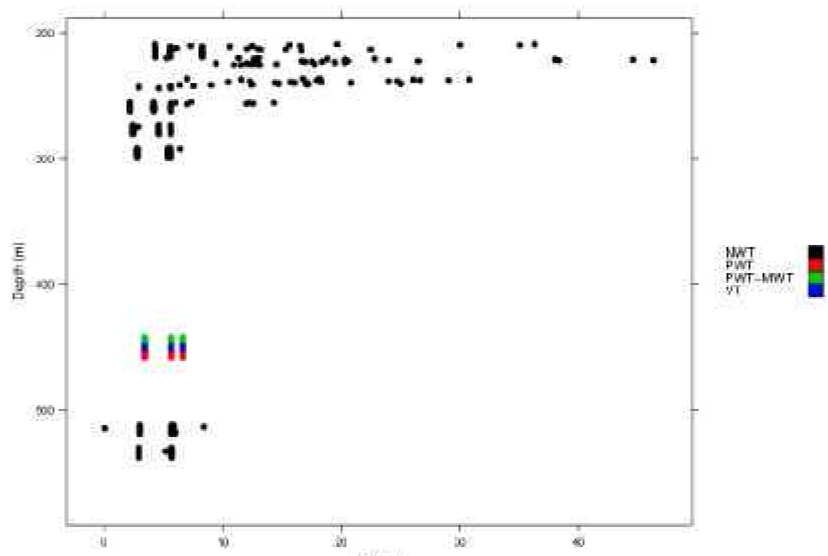


Figure 261. K versus depth for ER-EC-8 by LITH.

STRAT:Tfb

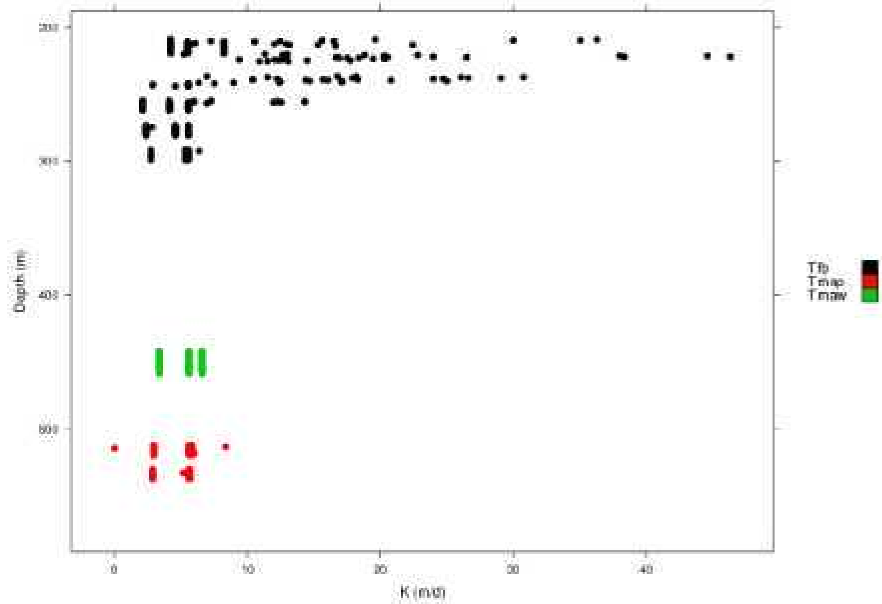


Figure 262. K versus depth for ER-EC-8 by STRAT.

Summary

Twenty-one of 88 classifications have decreasing K with depth at the 95-percent confidence level. The cause of this phenomenon is not explored in this study. However, a preliminary and qualitative analysis of fracture location suggests many of the high Ks are associated with fractures, which occur primarily in the shallower depths.

HETEROGENEITY OF ROCK CHARACTERISTICS

In this section, the heterogeneity of rock characteristics is explored to investigate if Ks from a rock characteristic in one well come from the same population as those in another well. For example, do the Ks from an HSU of BA in one well look the same as those from an HSU of BA in another well?

In addition to a visual analysis, samples will be compared to see if they are statistically different. In this case, 'statistically different' is defined as the difference between two or more empirical cumulative distribution functions using the Peto and Peto modification of the Gehan-Wilcoxon test (Lee, 2006), a nonparametric test of equivalence of populations. This test was performed at the 95-percent confidence level.

For each rock characteristic that occurs in multiple wells, the Gehan-Wilcoxon test was performed. The results of the multiple comparison statistical test for each two-well combination are presented below.

Heterogeneity of HSUs

The following HSU characteristics occur in multiple wells: BA, CHCU, FCCM, TCA, TMCM, TSA, and UPCU.

Table 36. HSU characteristic two-well comparison by rock classification.

Classification	Wells Compared		p-value
BA	ER-EC-1	ER-EC-6	0.0
CHCU	ER-EC-1	ER-EC-6	0.0
FCCM	ER-EC-2a	ER-EC-4	0.0
FCCM	ER-EC-2a	ER-EC-8	0.0
FCCM	ER-EC-4	ER-EC-8	No significant difference
TCA	ER-EC-1	ER-EC-6	0.0
TMCM	ER-EC-2a	ER-EC-5	0.0
TMCM	ER-EC-2a	ER-EC-8	0.0
TMCM	ER-EC-5	ER-EC-8	2.4E-05
TSA	ER-EC-1	ER-EC-6	0.0
UPCU	ER-EC-1	ER-EC-6	0.0

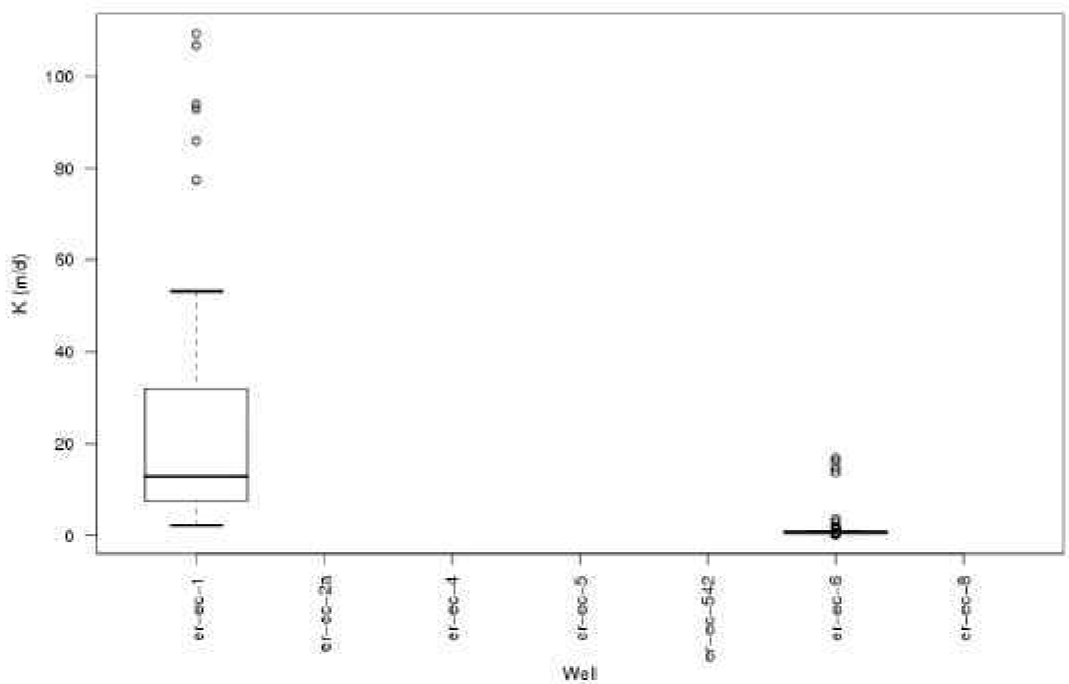


Figure 263. Heterogeneity of HSU: BA.

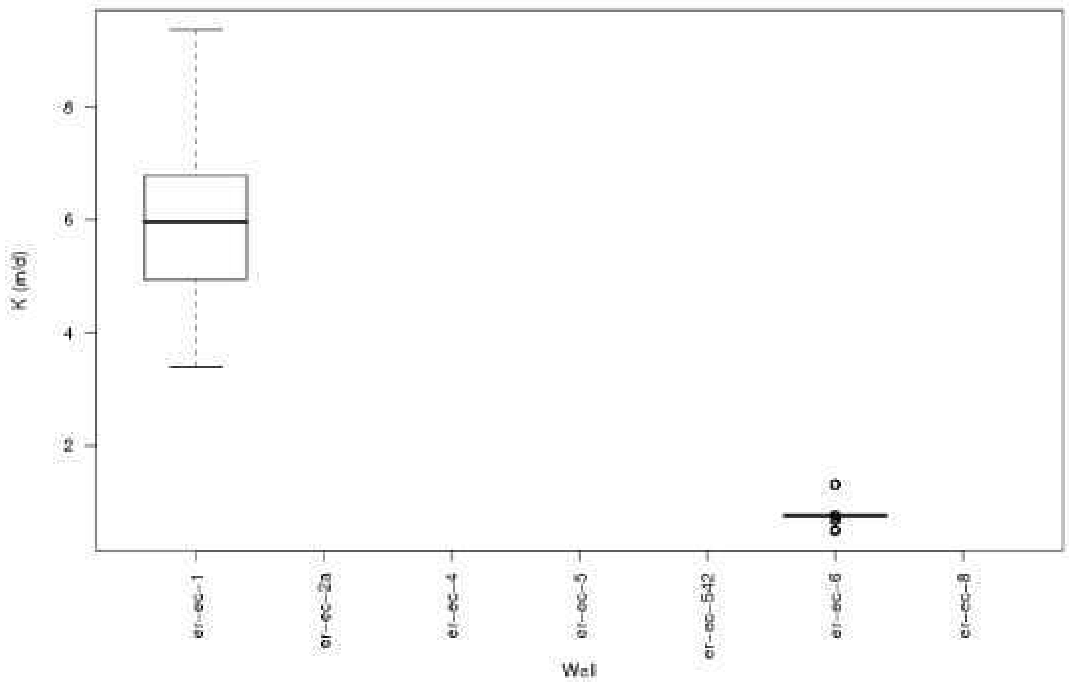


Figure 264. Heterogeneity of HSU: CHCU.

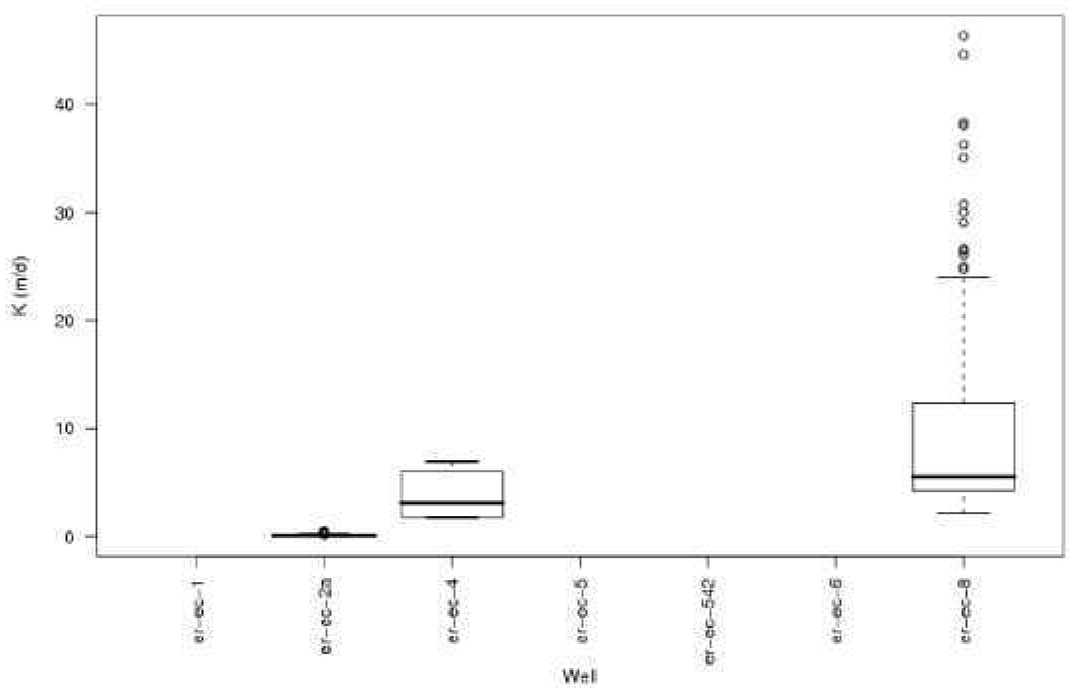


Figure 265. Heterogeneity of HSU: FCCM.

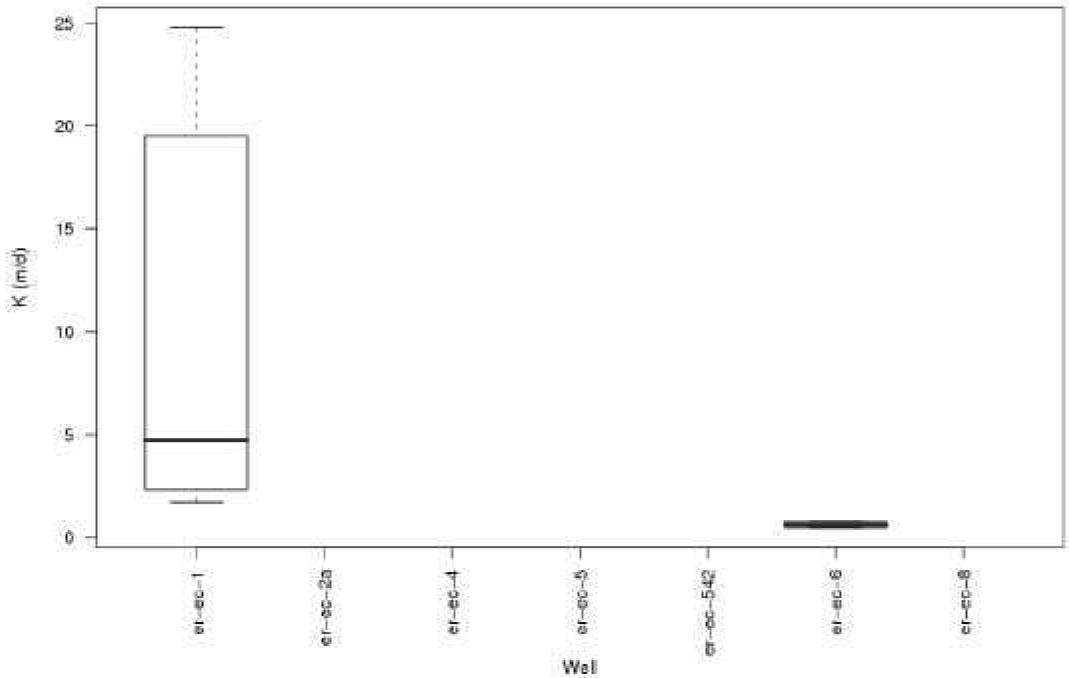


Figure 266. Heterogeneity of HSU: TCA.

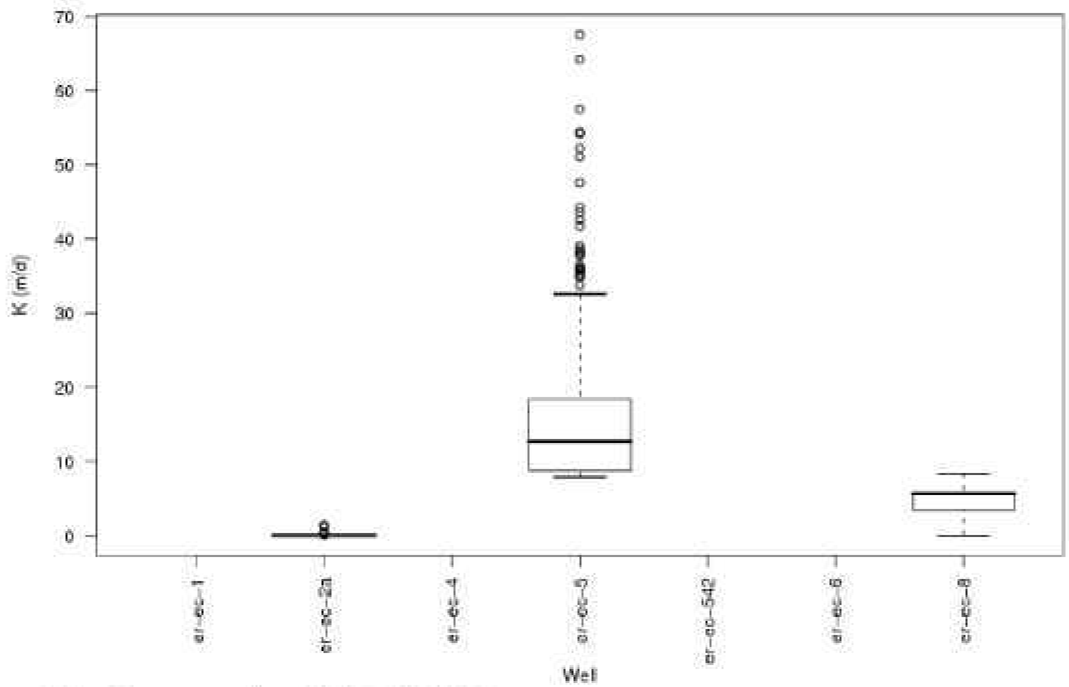


Figure 267. Heterogeneity of HSU: TMCM.

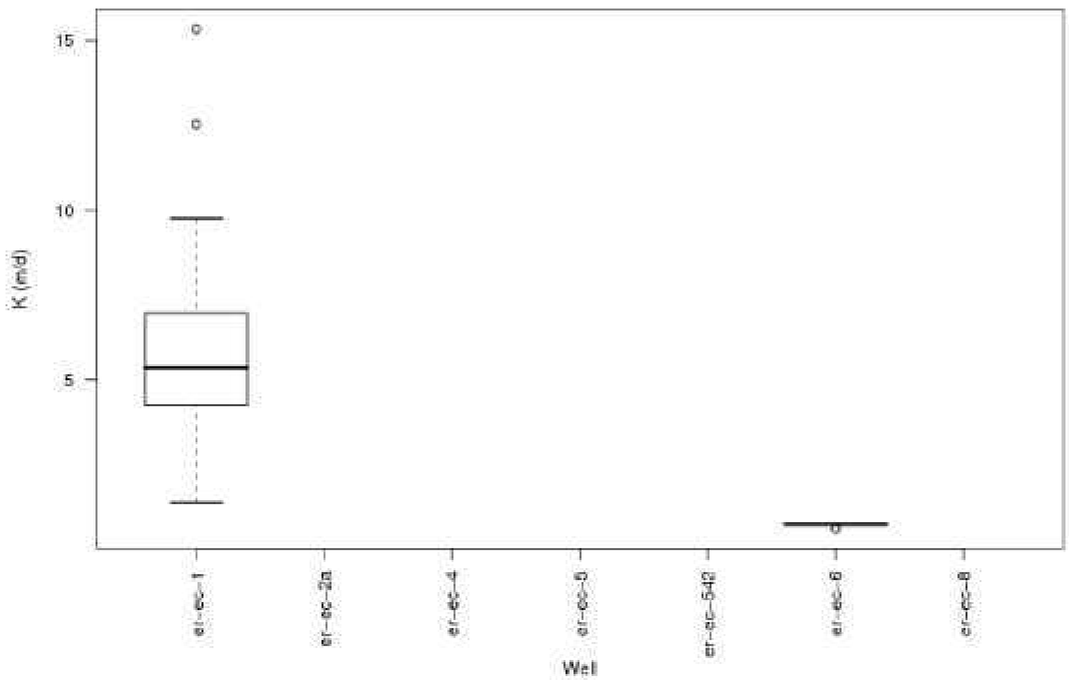


Figure 268. Heterogeneity of HSU: TSA.

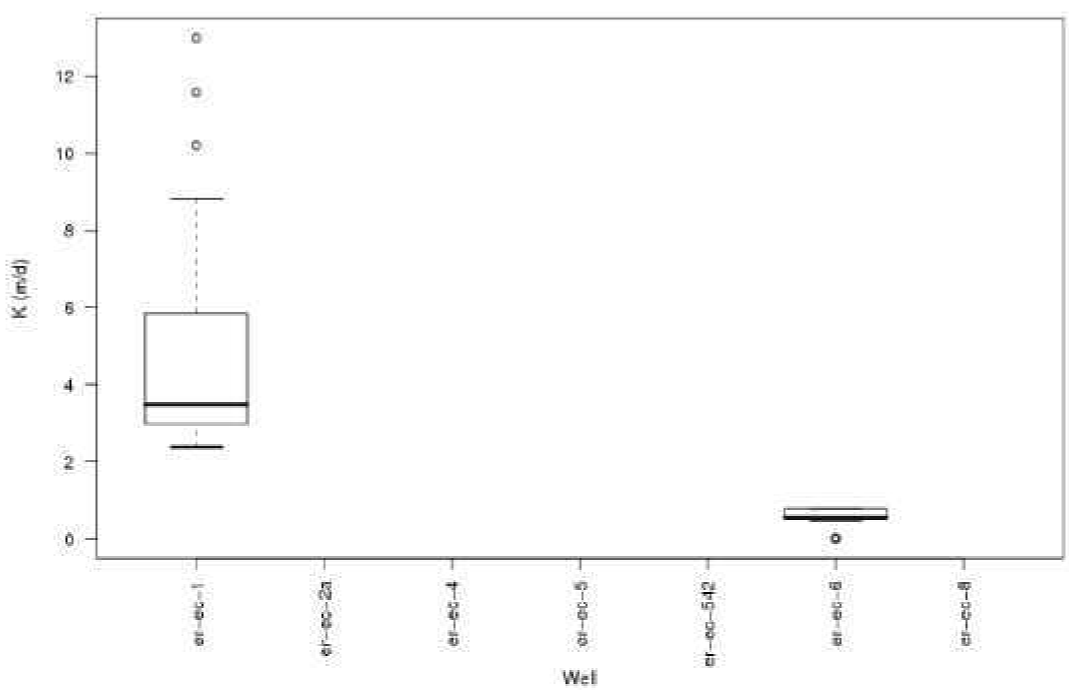


Figure 269. Heterogeneity of HSU: UPCU.

The results of the multiple comparison tests show that of the seven characteristics of HSU that occur in multiple wells, significant heterogeneity exists for all of them (BA, CHCU, FCCM, TCA, TMCM, TSA, and UPCU). The other five characteristics each occur in one well and could not be tested for heterogeneity.

Heterogeneity of HGUs

The following HGU characteristics occur in multiple wells: AA, LFA, TCU, and WTA.

Table 37. HGU characteristic two-well comparison by rock classification.

Classification	Wells Compared		p-value
AA	ER-EC-2a	ER-EC-4	0.000
LFA	ER-EC-1	ER-EC-4	no difference
LFA	ER-EC-1	ER-EC-6	0.000
LFA	ER-EC-4	ER-EC-6	0.000
TCU	ER-EC-1	ER-EC-2a	0.000
TCU	ER-EC-1	ER-EC-4	no difference
TCU	ER-EC-1	ER-5-4#2	0.003
TCU	ER-EC-1	ER-EC-6	0.000
TCU	ER-EC-1	ER-EC-8	no difference
TCU	ER-EC-2a	ER-EC-4	0.000
TCU	ER-EC-2a	ER-5-4#2	0.000
TCU	ER-EC-2a	ER-EC-6	0.000
TCU	ER-EC-2a	ER-EC-8	0.000
TCU	ER-EC-4	ER-5-4#2	0.001
TCU	ER-EC-4	ER-EC-6	0.000
TCU	ER-EC-4	ER-EC-8	no difference
TCU	ER-5-4#2	ER-EC-6	0.000
TCU	ER-5-4#2	ER-EC-8	0.001
TCU	ER-EC-6	ER-EC-8	0.000
WTA	ER-EC-1	ER-EC-2a	0.000
WTA	ER-EC-1	ER-EC-4	no difference
WTA	ER-EC-1	ER-EC-5	0.000
WTA	ER-EC-1	ER-EC-6	0.000
WTA	ER-EC-1	ER-EC-8	no difference
WTA	ER-EC-2a	ER-EC-4	0.000
WTA	ER-EC-2a	ER-EC-5	0.000
WTA	ER-EC-2a	ER-EC-6	0.000
WTA	ER-EC-2a	ER-EC-8	0.000
WTA	ER-EC-4	ER-EC-5	no difference
WTA	ER-EC-4	ER-EC-6	0.000
WTA	ER-EC-4	ER-EC-8	no difference
WTA	ER-EC-5	ER-EC-6	0.000
WTA	ER-EC-5	ER-EC-8	0.000
WTA	ER-EC-6	ER-EC-8	0.000

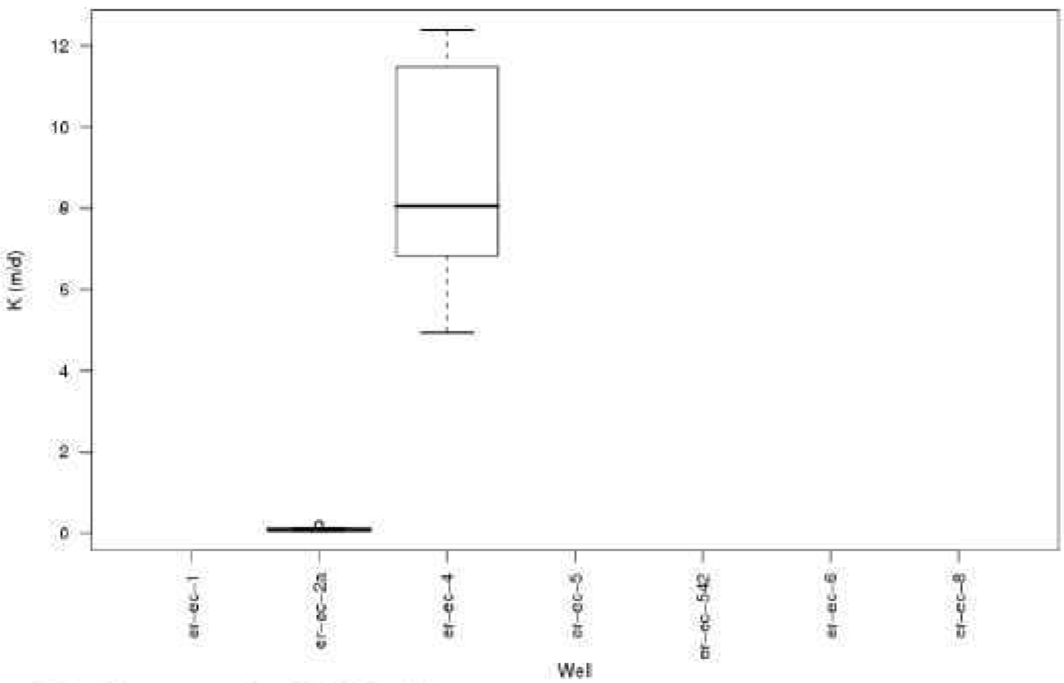


Figure 270. Heterogeneity of HGU: AA.

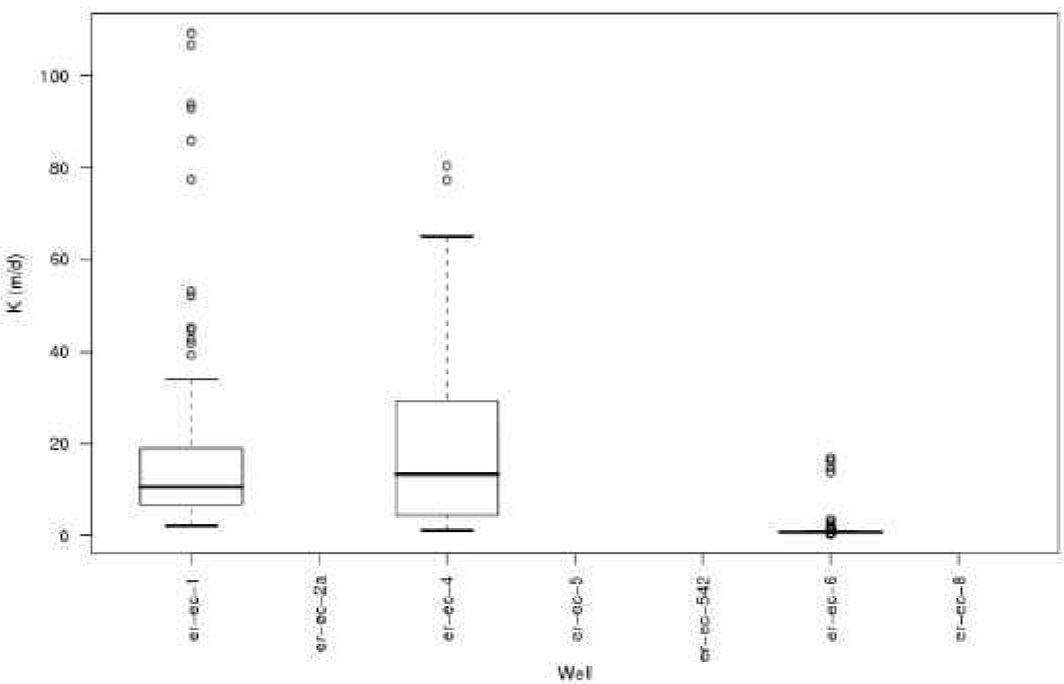


Figure 271. Heterogeneity of HGU: LFA.

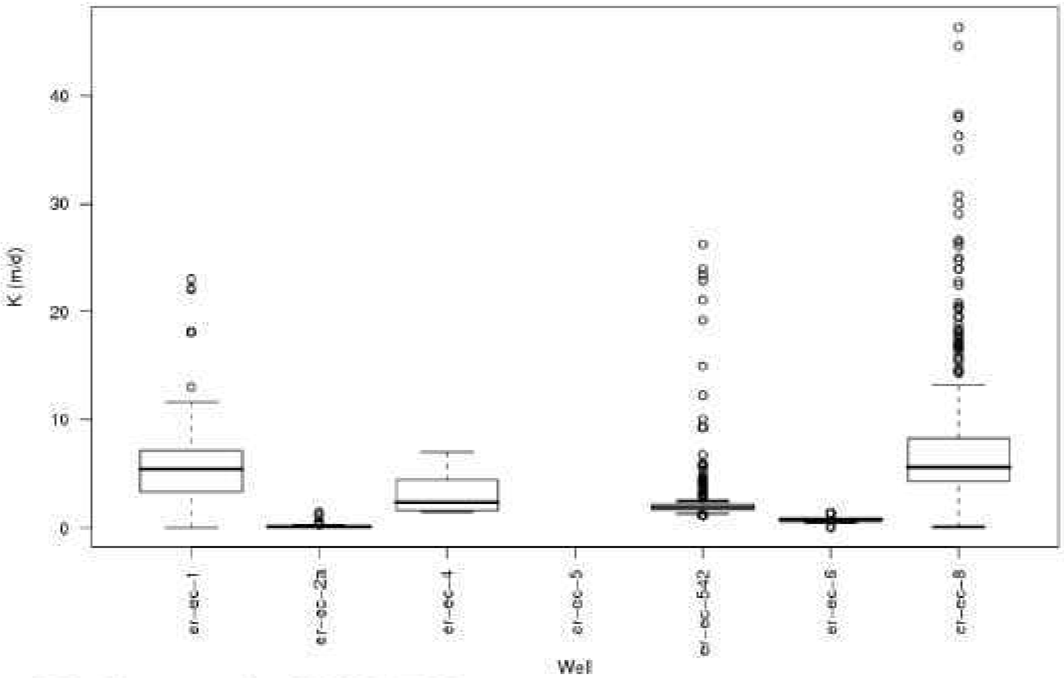


Figure 272. Heterogeneity of HGU: TCU.

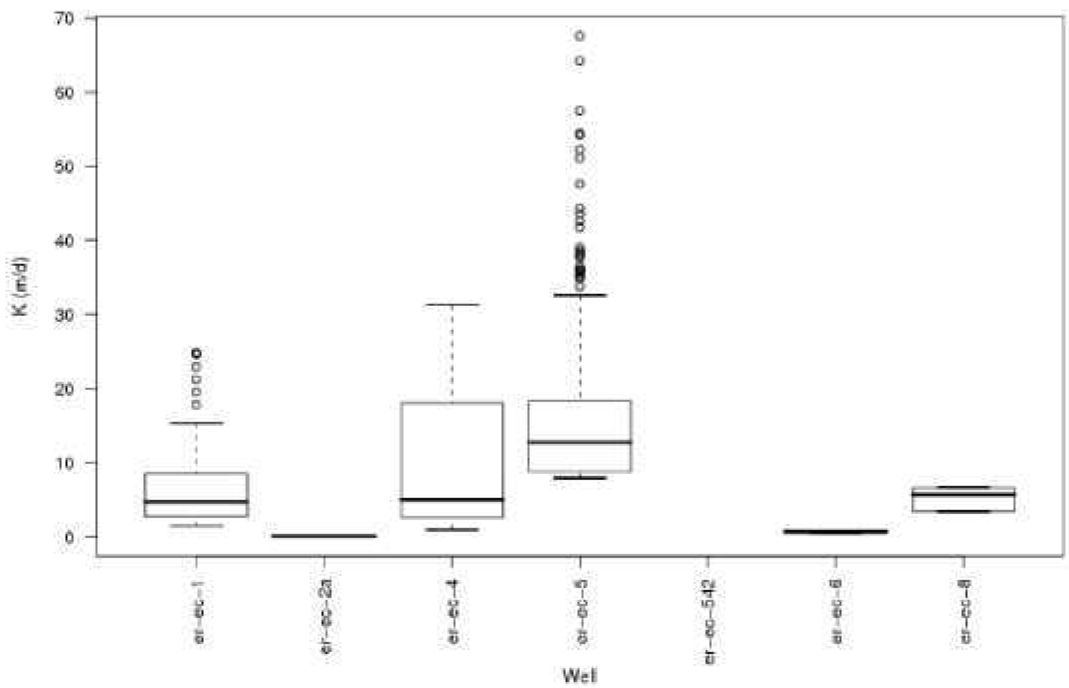


Figure 273. Heterogeneity of HGU: WTA.

The results of the multiple comparison tests show that of the four characteristics of HGU, significant heterogeneity exists for all of them (AA, LFA, TCU, and WTA).

Heterogeneity of LITHs

The following LITH characteristics occur in multiple wells: AA, LFA, TCU, WTA.

Table 38. LITH characteristic two-well comparison by rock classification.

Classification	Wells Compared		p-value
BED	ER-EC-1	ER-EC-2a	0.000
BED	ER-EC-1	ER-EC-4	no difference
BED	ER-EC-1	ER-EC-6	0.000
BED	ER-EC-2a	ER-EC-4	0.000
BED	ER-EC-2a	ER-EC-6	0.000
BED	ER-EC-4	ER-EC-6	0.000
LA	ER-EC-1	ER-EC-4	no difference
LA	ER-EC-1	ER-EC-6	0.000
LA	ER-EC-4	ER-EC-6	0.000
MWT	ER-EC-1	ER-EC-2a	0.000
MWT	ER-EC-1	ER-EC-4	no difference
MWT	ER-EC-1	ER-EC-5	0.000
MWT	ER-EC-1	ER-EC-6	0.000
MWT	ER-EC-2a	ER-EC-4	0.000
MWT	ER-EC-2a	ER-EC-5	0.000
MWT	ER-EC-2a	ER-EC-6	0.000
MWT	ER-EC-4	ER-EC-5	no difference
MWT	ER-EC-4	ER-EC-6	0.000
MWT	ER-EC-5	ER-EC-6	0.000
NWT	ER-EC-2a	ER-EC-4	0.000
NWT	ER-EC-2a	ER-5-4#2	0.000
NWT	ER-EC-2a	ER-EC-6	0.000
NWT	ER-EC-2a	ER-EC-8	0.000
NWT	ER-EC-4	ER-5-4#2	no difference
NWT	ER-EC-4	ER-EC-6	0.000
NWT	ER-EC-4	ER-EC-8	no difference
NWT	ER-5-4#2	ER-EC-6	0.000
NWT	ER-5-4#2	ER-EC-8	no difference
NWT	ER-EC-6	ER-EC-8	0.000
PWT	ER-EC-1	ER-EC-4	no difference
PWT	ER-EC-1	ER-EC-6	0.000
PWT	ER-EC-1	ER-EC-8	no difference
PWT	ER-EC-4	ER-EC-6	0.000
PWT	ER-EC-4	ER-EC-8	no difference
PWT	ER-EC-6	ER-EC-8	0.000
PWT-MWT	ER-EC-1	ER-EC-8	no difference
VT	ER-EC-1	ER-EC-4	no difference
VT	ER-EC-1	ER-EC-8	no difference
VT	ER-EC-4	ER-EC-8	no difference

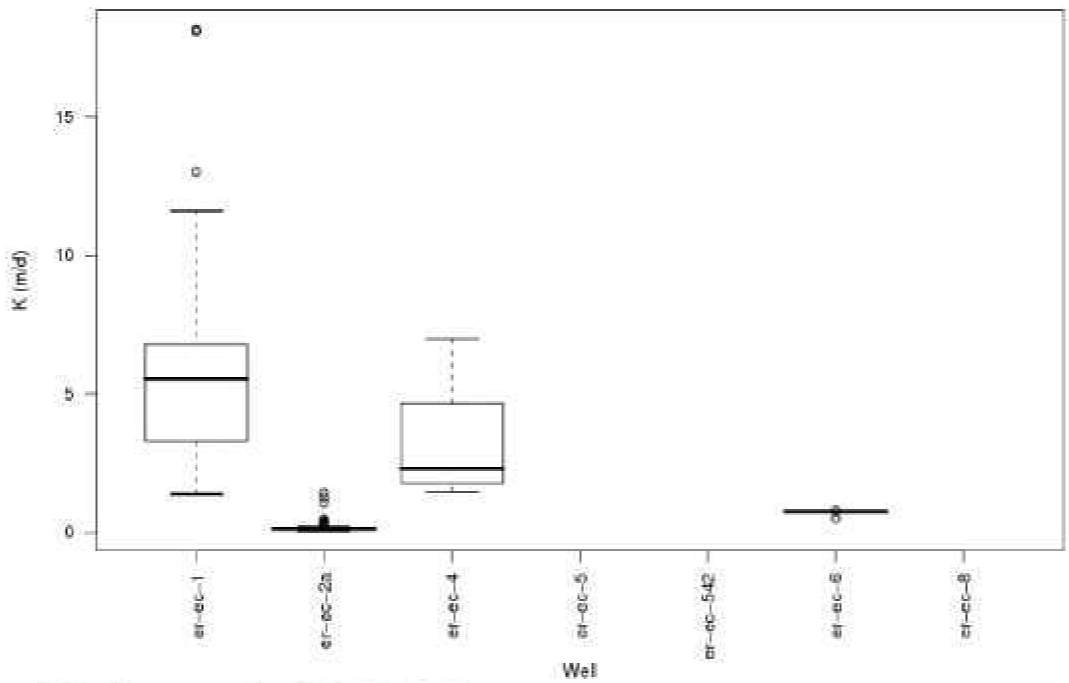


Figure 274. Heterogeneity of LITH: BED.

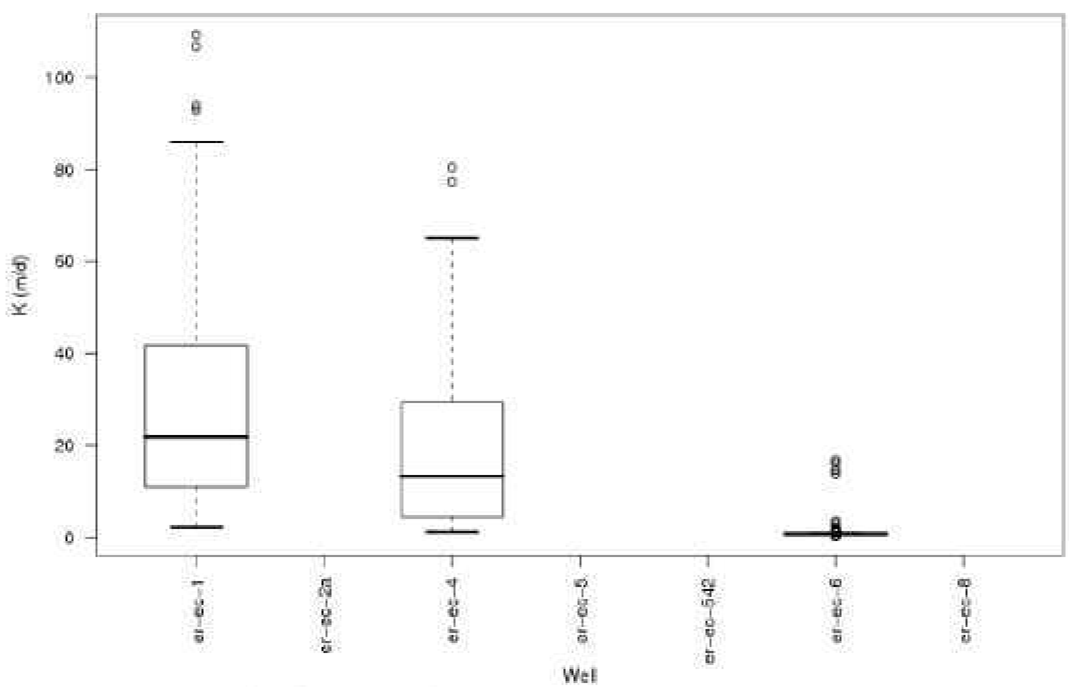


Figure 275. Heterogeneity of LITH: LA.

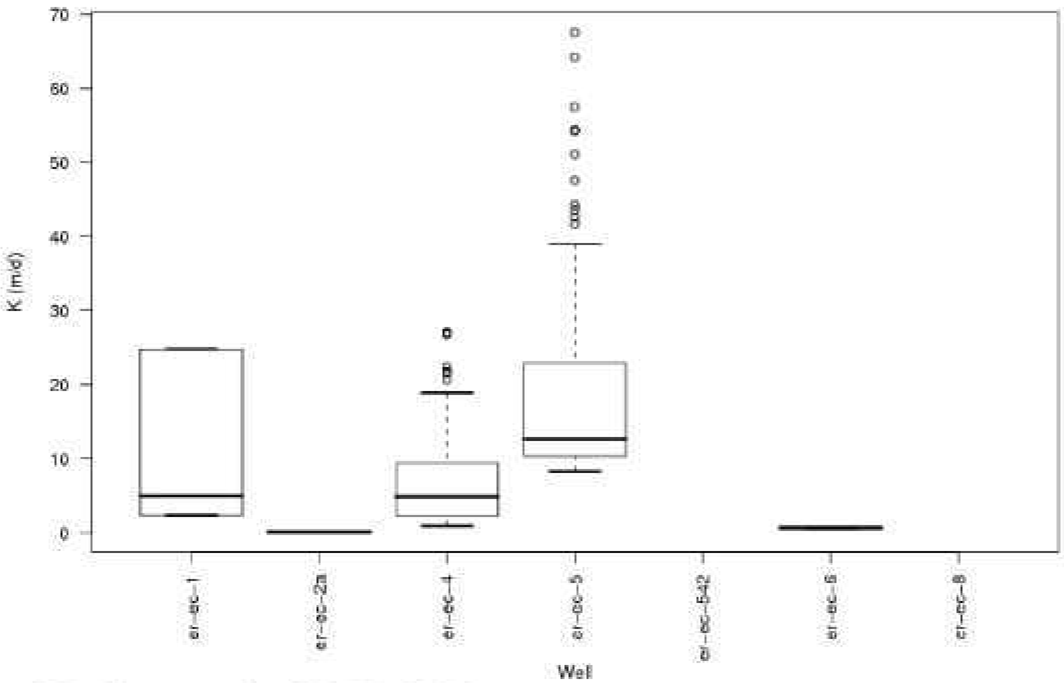


Figure 276. Heterogeneity of LITH: MWT.

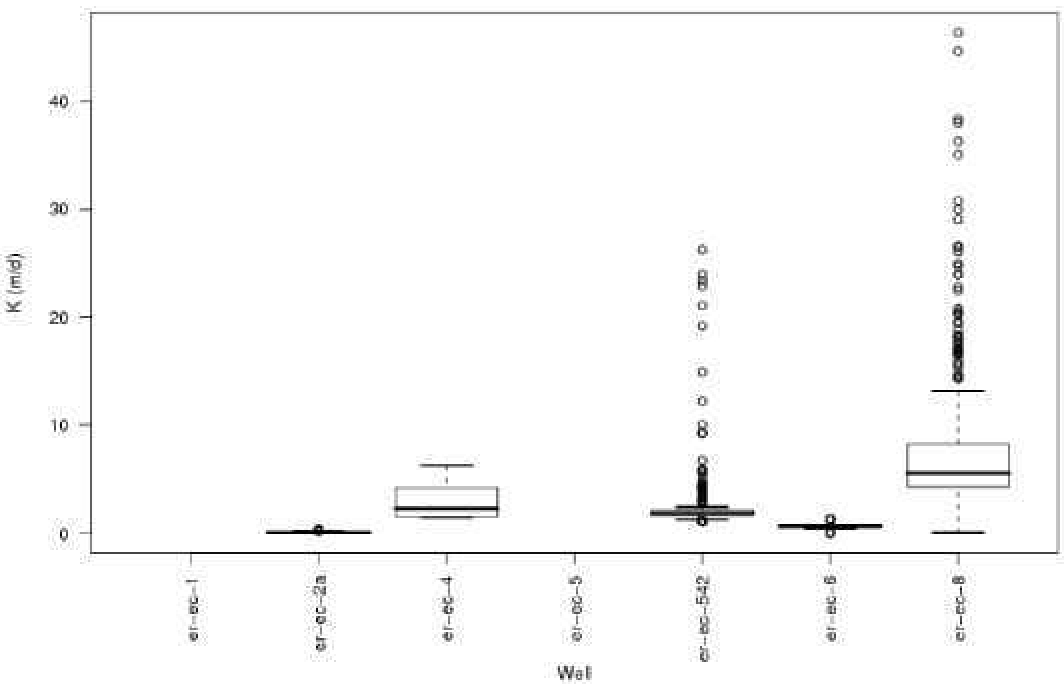


Figure 277. Heterogeneity of LITH: NWT.

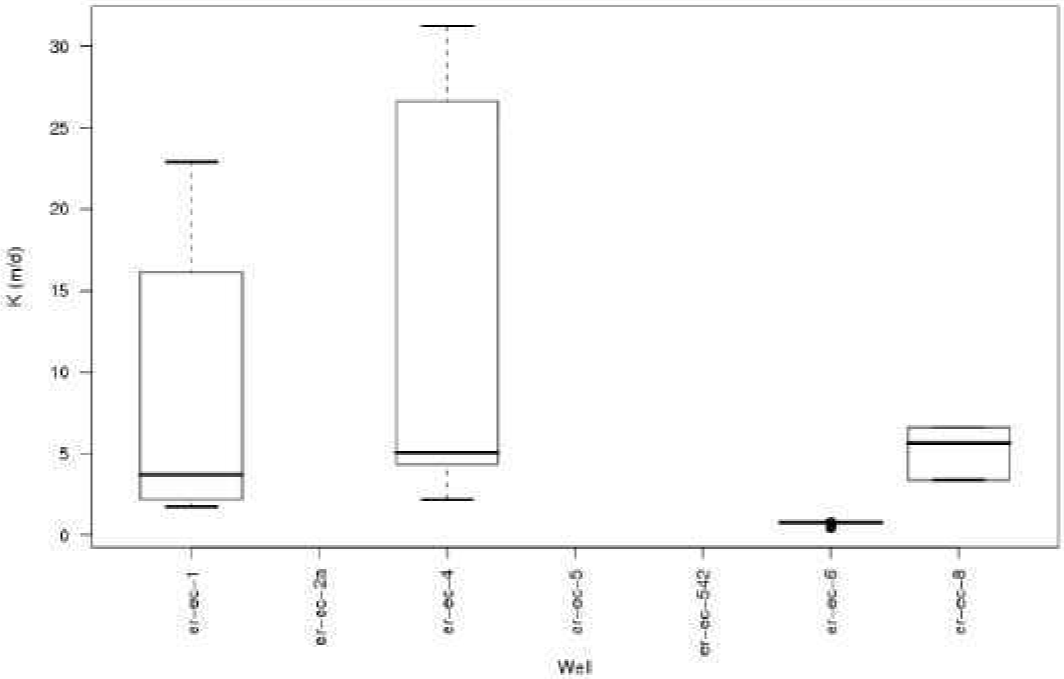


Figure 278. Heterogeneity of LITH: PWT.

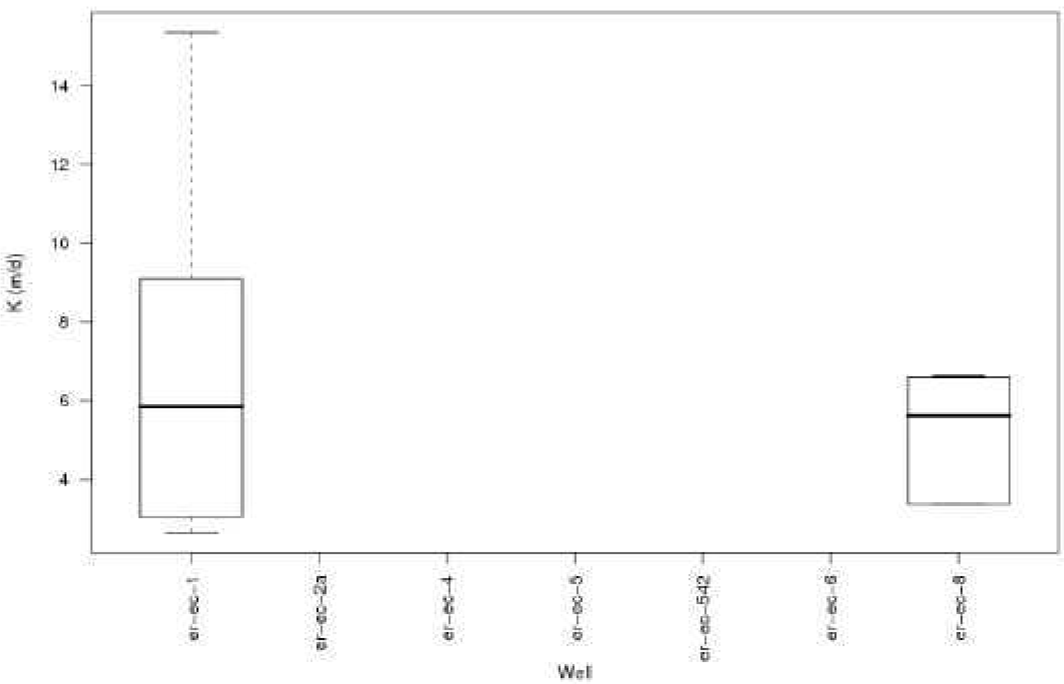


Figure 279. Heterogeneity of LITH: PWT-MWT.

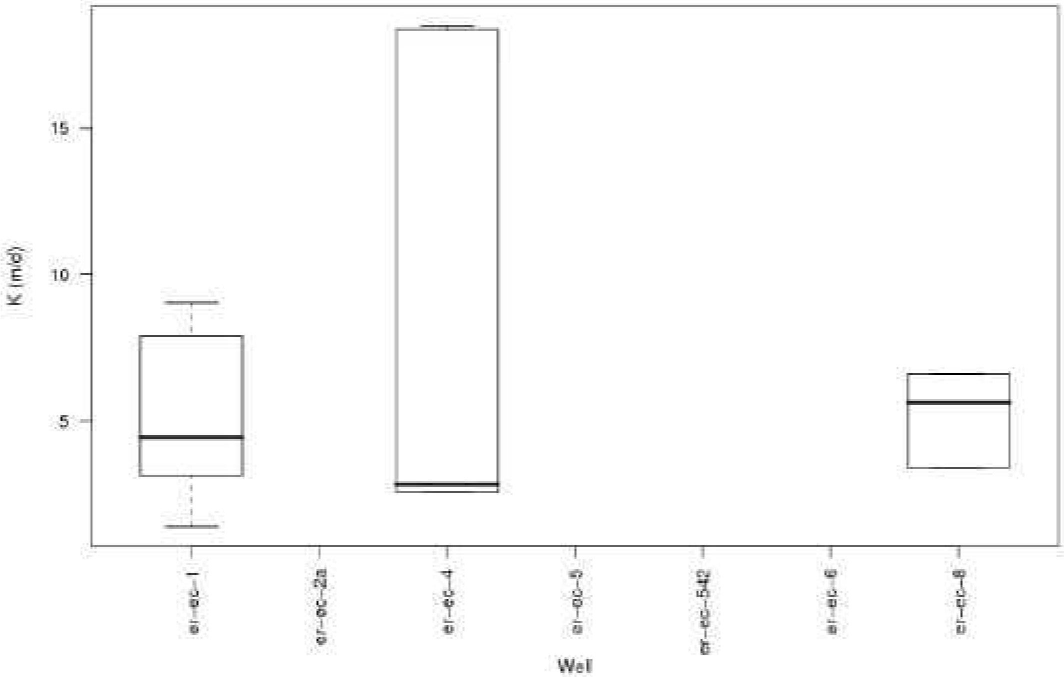


Figure 280. Heterogeneity of LITH: VT.

The results of the multiple comparison tests show that of the seven characteristics of LITH that occur in multiple wells, significant heterogeneity exists for five of them (BED, LA, MWT, NWT, and PWT), while two LITH types (PWT-MWT and VT) show no spatial heterogeneity. The other eight characteristics each only occur in one well and could not be tested for heterogeneity.

Heterogeneity of ALTERATIONs

The following ALTERATION characteristics occur in multiple wells: DV, GL, QF, and ZE.

Table 39. ALTERATION characteristic two-well comparison by rock classification.

Classification	Wells Compared		p-value
DV	ER-EC-1	ER-EC-4	no difference
DV	ER-EC-1	ER-EC-6	0.000
DV	ER-EC-1	ER-EC-8	no difference
DV	ER-EC-4	ER-EC-6	0.000
DV	ER-EC-4	ER-EC-8	no difference
DV	ER-EC-6	ER-EC-8	0.000
GL	ER-EC-1	ER-EC-4	no difference
GL	ER-EC-1	ER-EC-6	0.000
GL	ER-EC-4	ER-EC-6	0.000
QF	ER-EC-1	ER-EC-2a	0.000

Table 39. ALTERATION characteristic two-well comparison by rock classification (continued).

Classification	Wells Compared		p-value
QF	ER-EC-1	ER-EC-4	no difference
QF	ER-EC-1	ER-EC-5	0.000
QF	ER-EC-1	ER-EC-6	0.000
QF	ER-EC-1	ER-EC-8	no difference
QF	ER-EC-2a	ER-EC-4	0.000
QF	ER-EC-2a	ER-EC-5	0.000
QF	ER-EC-2a	ER-EC-6	0.000
QF	ER-EC-2a	ER-EC-8	0.000
QF	ER-EC-4	ER-EC-5	no difference
QF	ER-EC-4	ER-EC-6	0.000
QF	ER-EC-4	ER-EC-8	no difference
QF	ER-EC-5	ER-EC-6	0.000
QF	ER-EC-5	ER-EC-8	0.000
QF	ER-EC-6	ER-EC-8	0.000
QZ	ER-EC-1	ER-EC-8	no difference
ZE	ER-EC-1	ER-EC-2a	0.000
ZE	ER-EC-1	ER-EC-4	no difference
ZE	ER-EC-1	ER-5-4#2	no difference
ZE	ER-EC-2a	ER-EC-4	0.000
ZE	ER-EC-2a	ER-5-4#2	0.000
ZE	ER-EC-4	ER-5-4#2	0.001

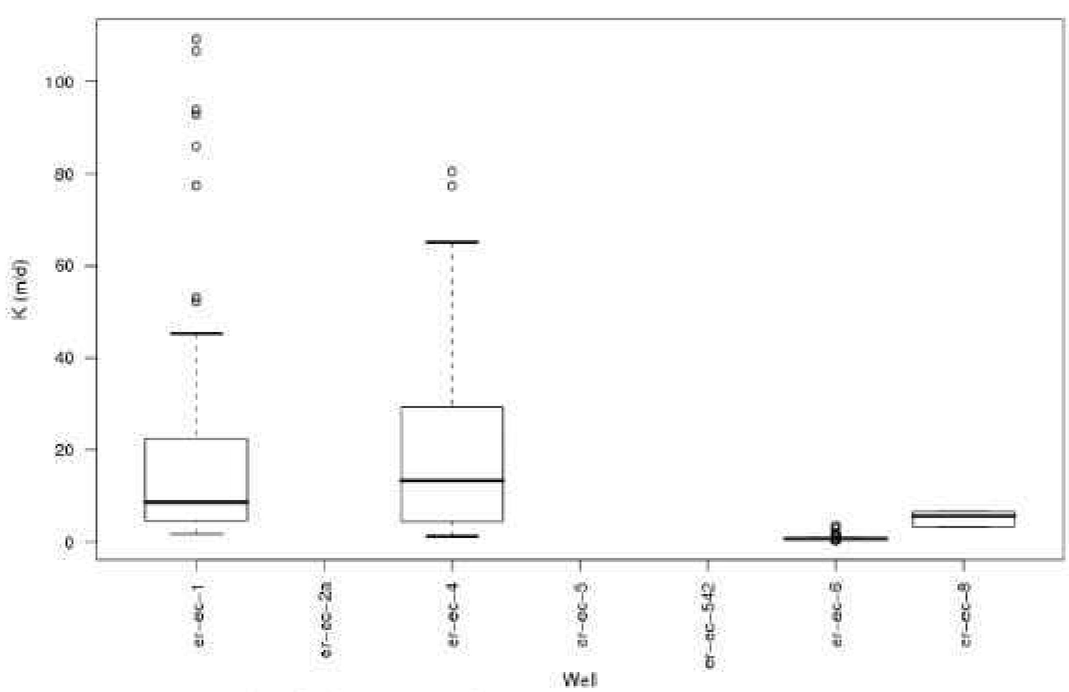


Figure 281. Heterogeneity of ALTERATION: DV.

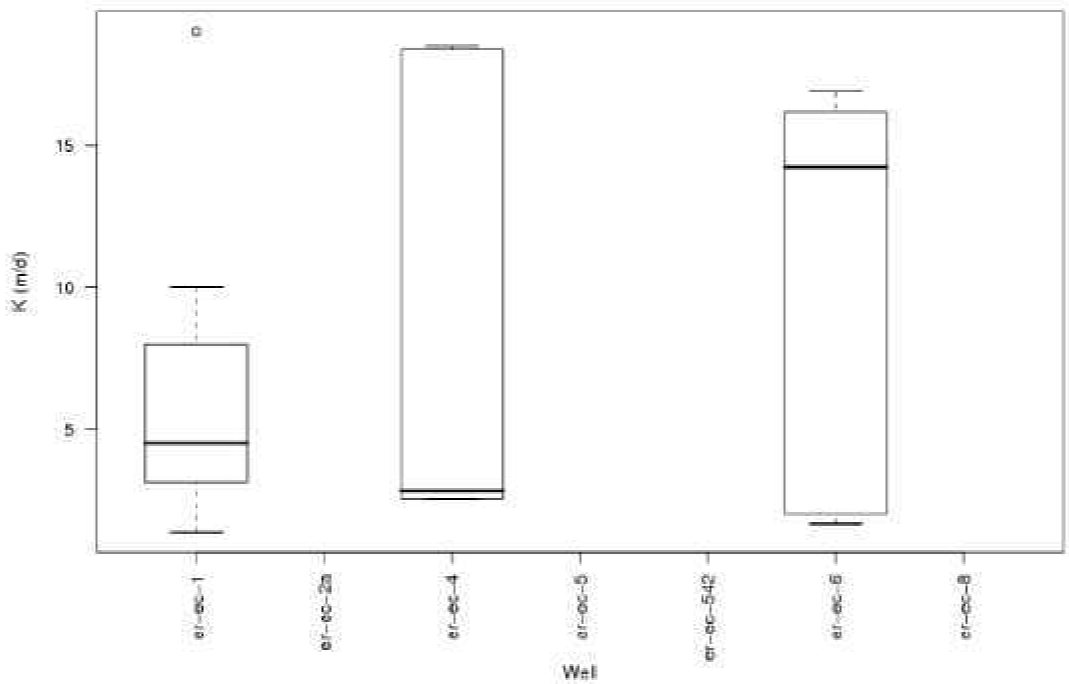


Figure 282. Heterogeneity of ALTERATION: GL.

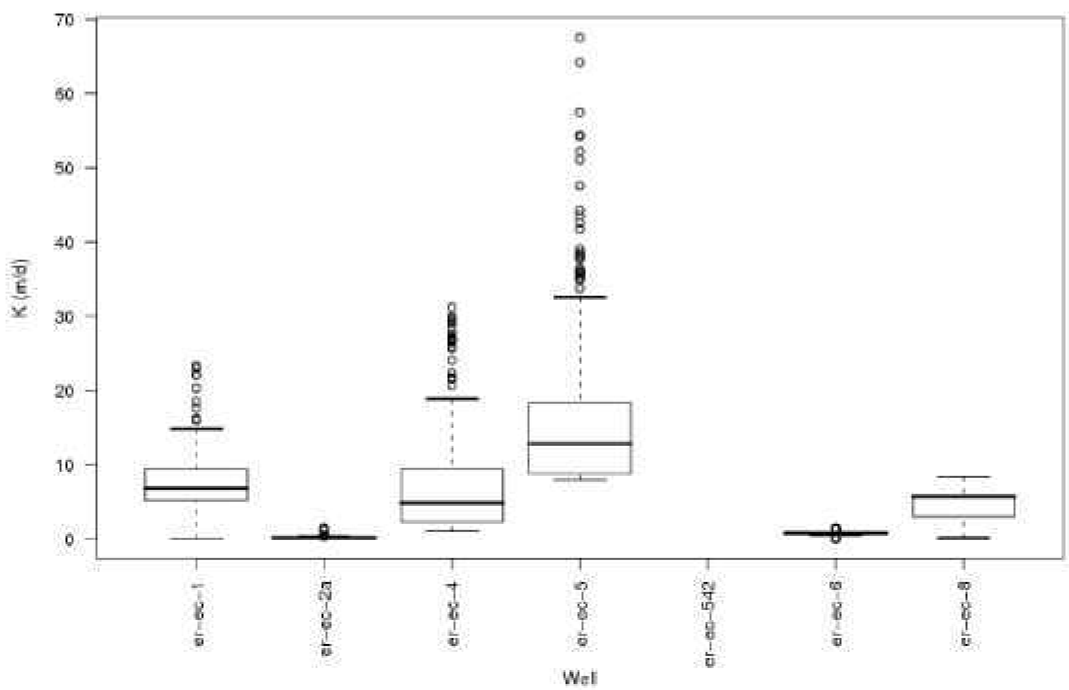


Figure 283. Heterogeneity of ALTERATION: QF.

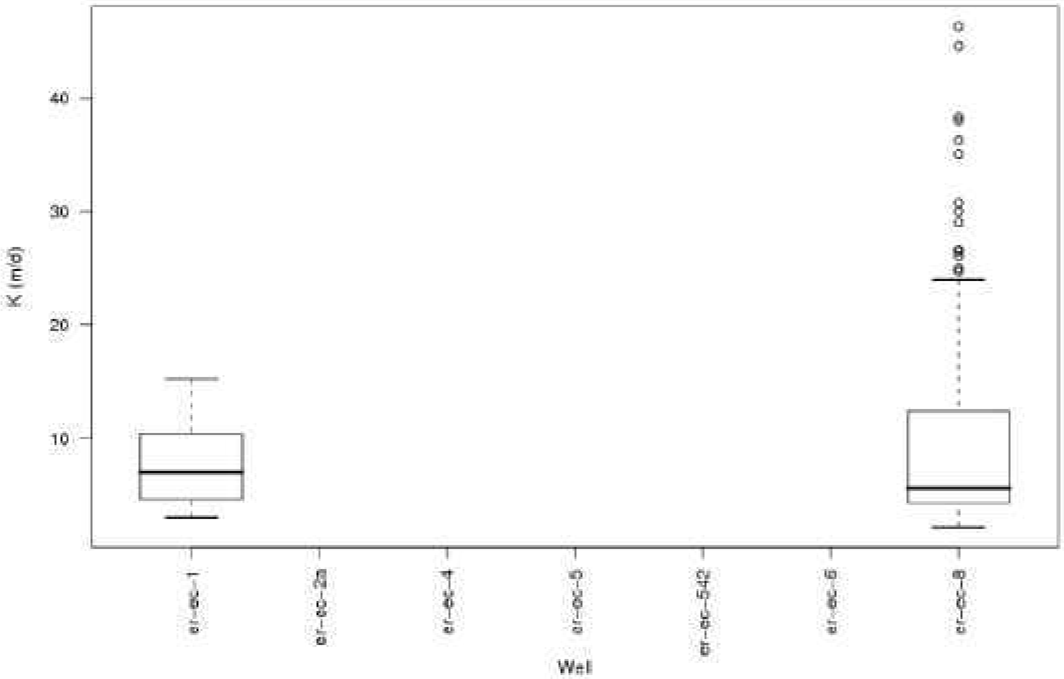


Figure 284. Heterogeneity of ALTERATION: QZ.

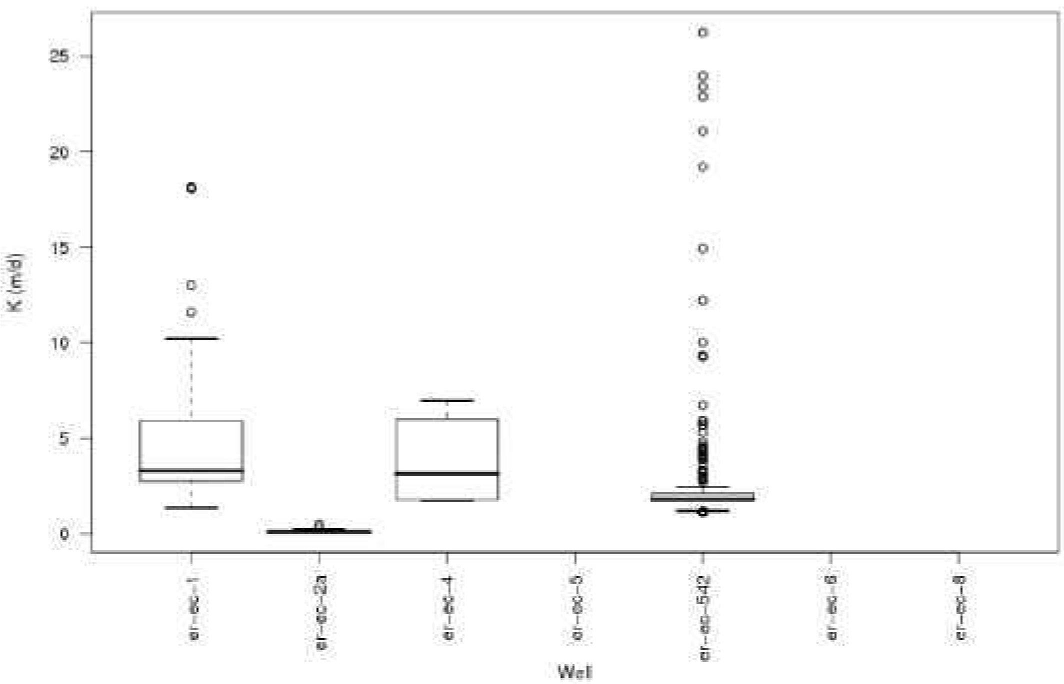


Figure 285. Heterogeneity of ALTERATION: ZE.

The results of the multiple comparison tests show that of the five characteristics of ALTERATION that occur in multiple wells, significant heterogeneity exists for four of them (DV, GL, QF, and ZE), while one ALTERATION type (QZ) shows no spatial heterogeneity. The other two characteristics each only occur in one well and could not be tested for heterogeneity.

Heterogeneity of STRATs

The following STRAT characteristics occur in multiple wells: Tfb, Tfbw, Thr, Tmap, Tmar, Tmaw, Tpb, Tpcm, Tptm.

Table 40. STRAT characteristic two-well comparison by rock classification.

Classification	Wells Compared		p-value
Tfb	ER-EC-2a	ER-EC-8	0.000
Tfbw	ER-EC-2a	ER-EC-4	0.000
Thr	ER-EC-1	ER-EC-6	0.000
Tmap	ER-EC-4	ER-EC-5	no difference
Tmap	ER-EC-4	ER-EC-8	no difference
Tmap	ER-EC-5	ER-EC-8	0.000
Tmar	ER-EC-2a	ER-EC-5	0.000
Tmaw	ER-EC-2a	ER-EC-8	0.000
Tpb	ER-EC-1	ER-EC-6	0.000
Tpcm	ER-EC-1	ER-EC-6	0.000
Tptm	ER-EC-1	ER-EC-6	0.000

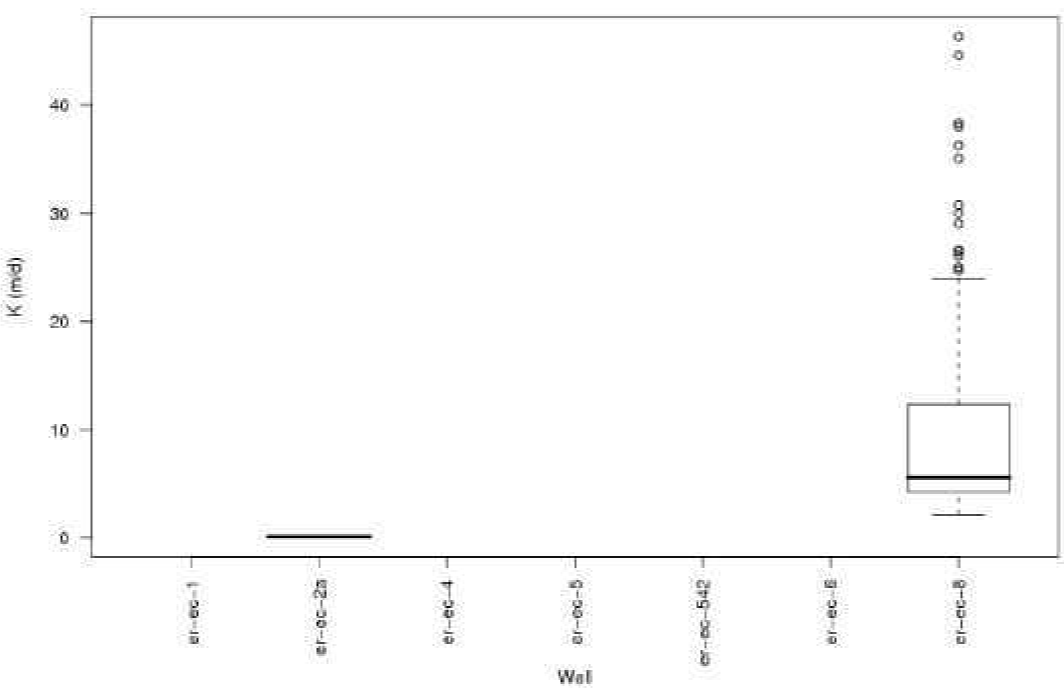


Figure 286. Heterogeneity of STRAT: Tfb.

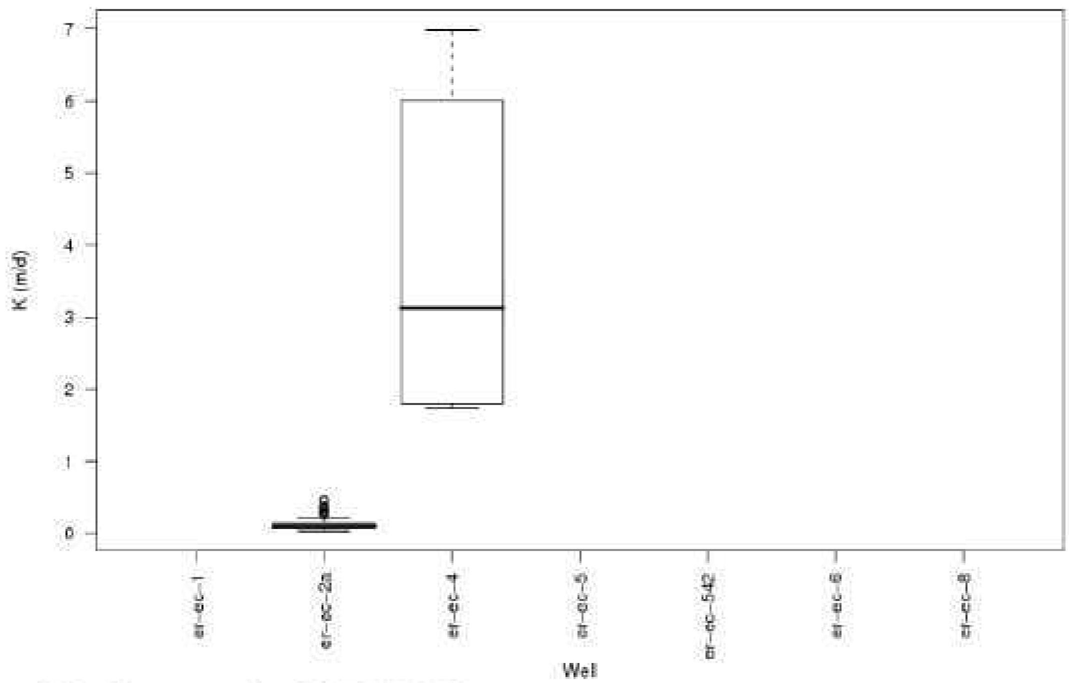


Figure 287. Heterogeneity of STRAT: Tfbw.

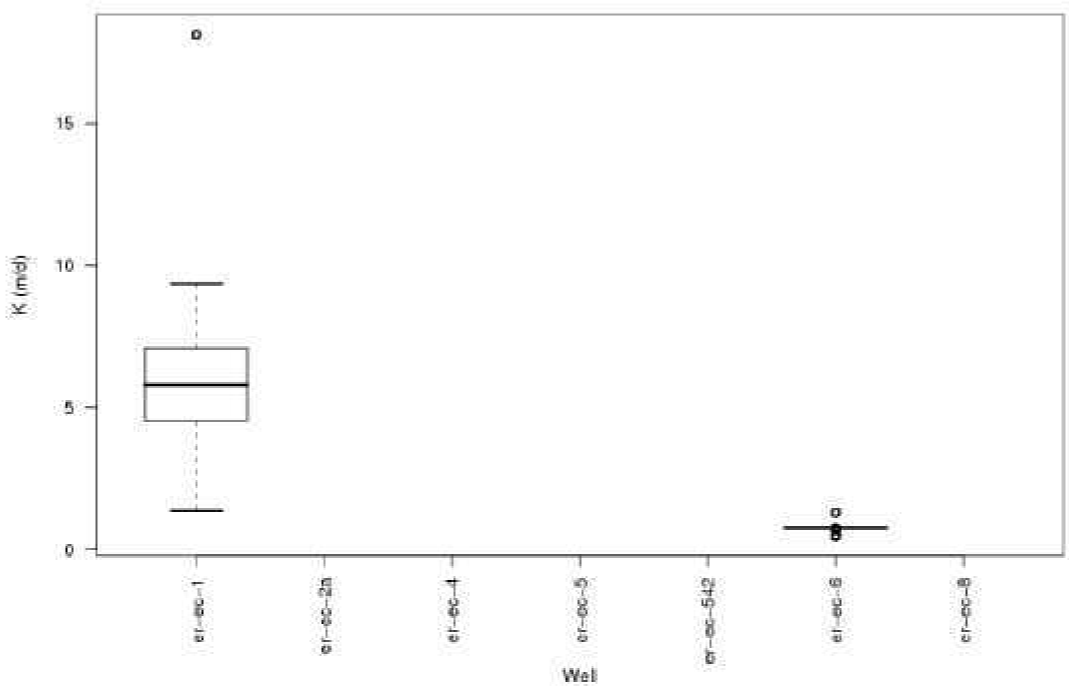


Figure 288. Heterogeneity of STRAT: Thr.

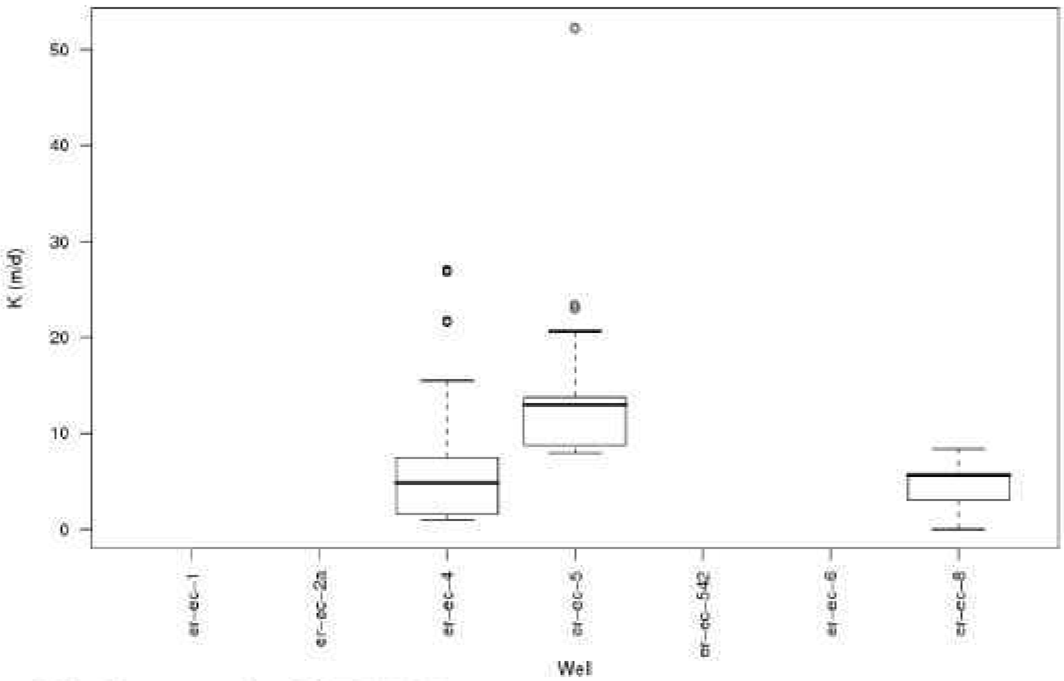


Figure 289. Heterogeneity of STRAT: Tmap.

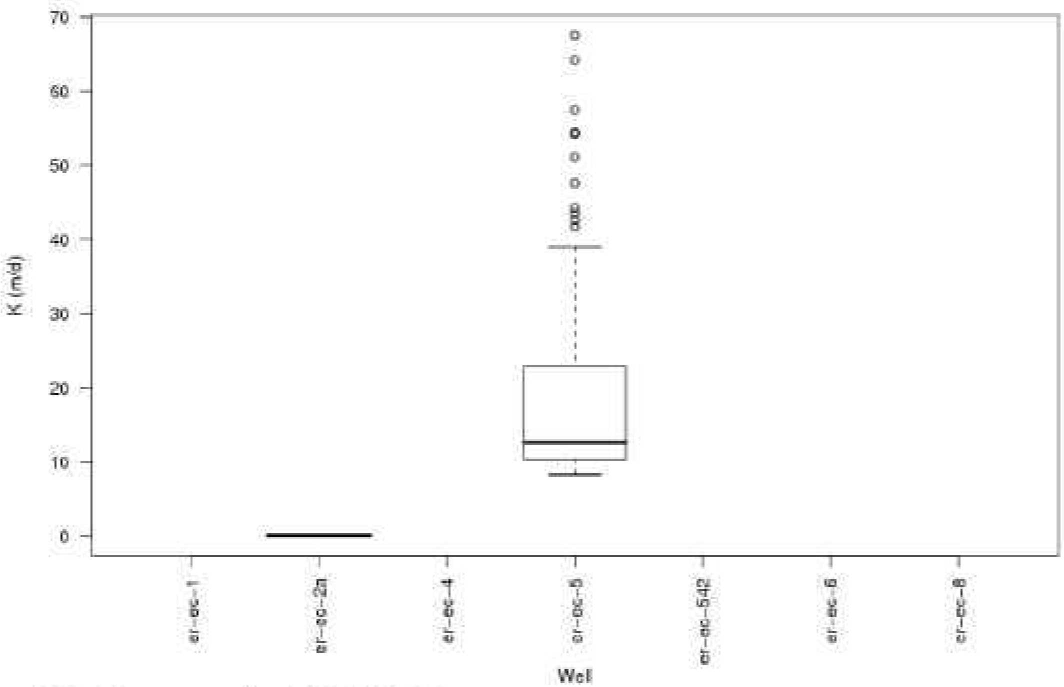


Figure 290. Heterogeneity of STRAT: Tmar.

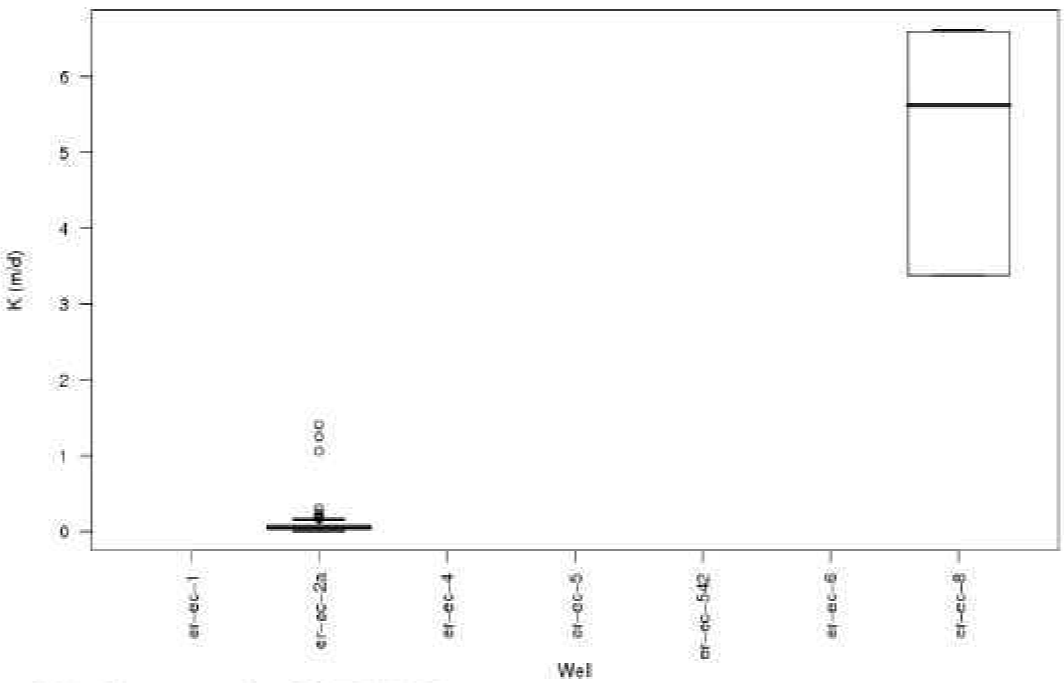


Figure 291. Heterogeneity of STRAT: Tmaw.

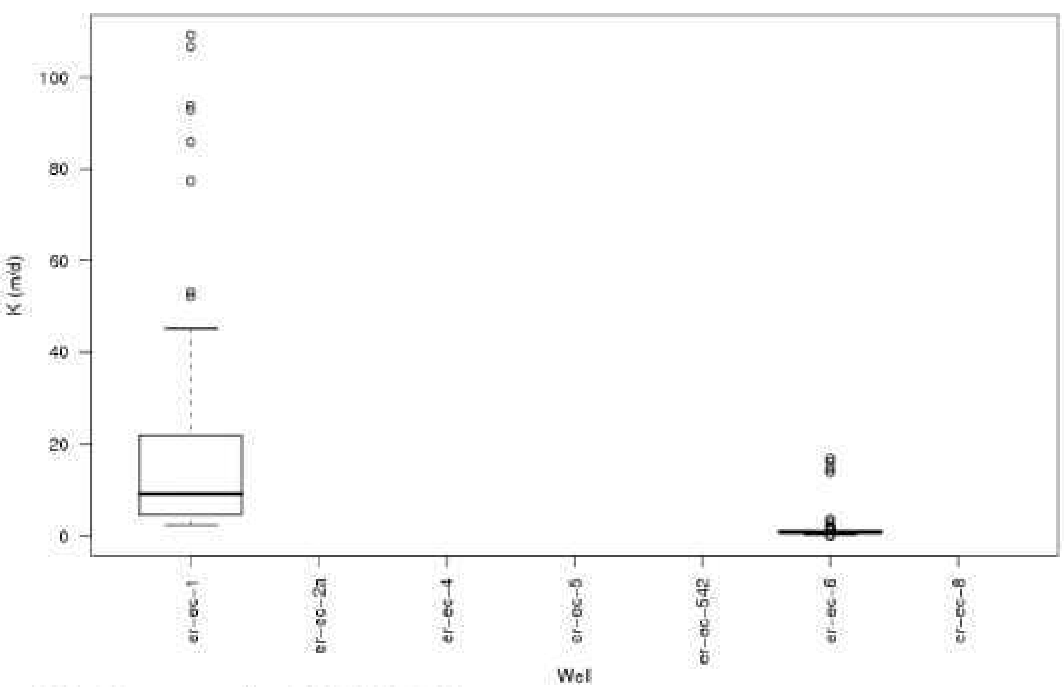


Figure 292. Heterogeneity of STRAT: Tpb.

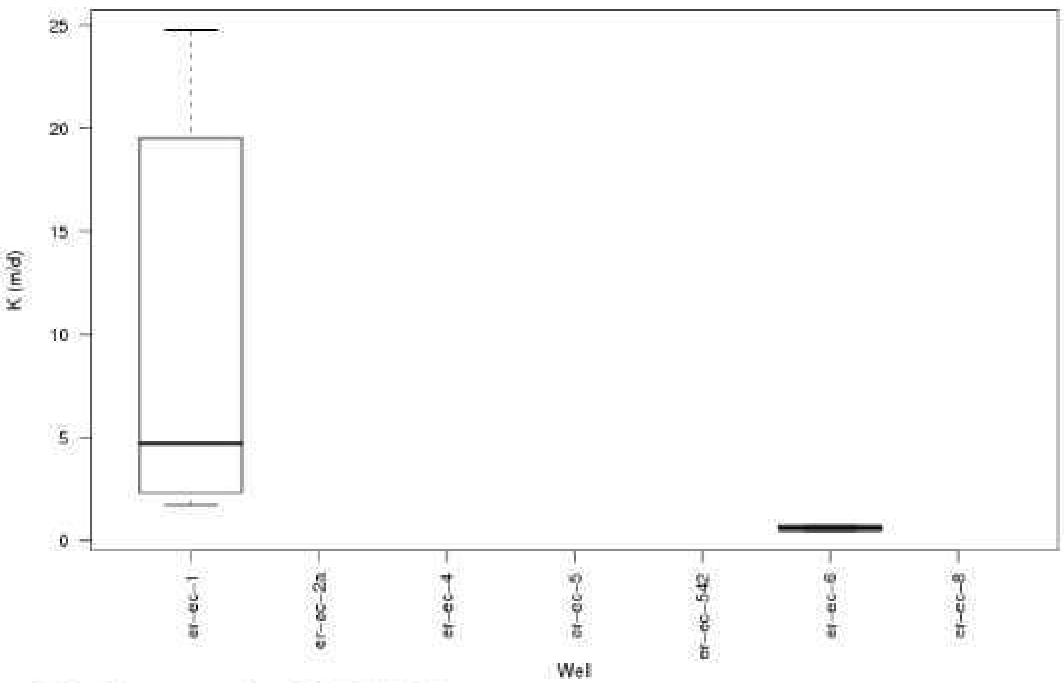


Figure 293. Heterogeneity of STRAT: Tpcm.

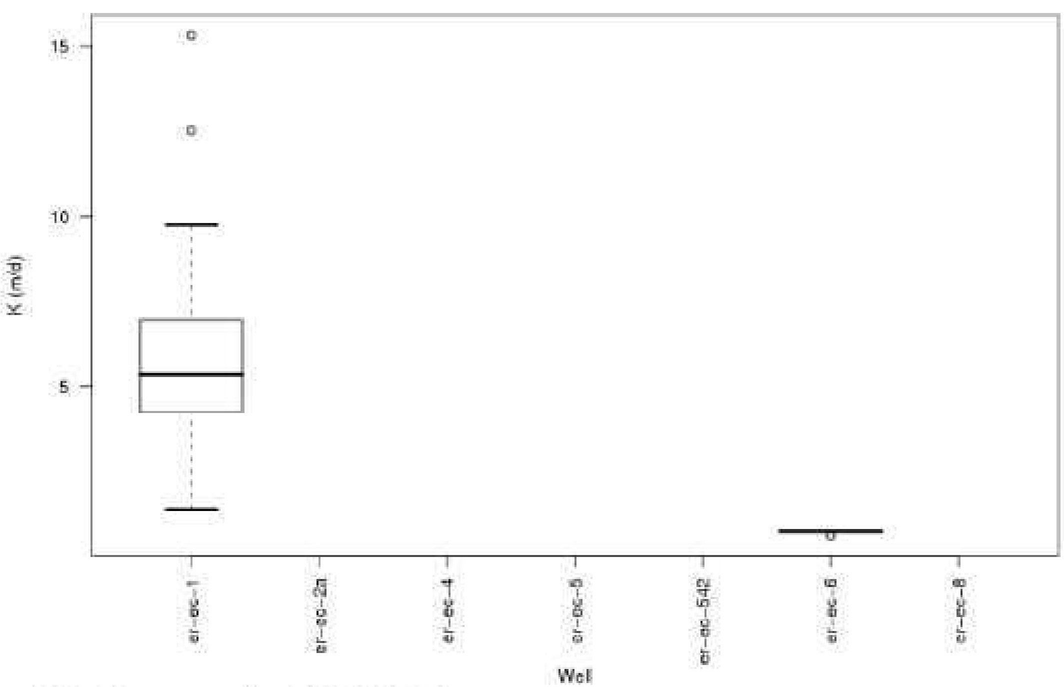


Figure 294. Heterogeneity of STRAT: Tptm.

The results of the multiple comparison tests show that of the nine characteristics of STRAT that occur in multiple wells, significant heterogeneity exists for all of them (Tfb, Tfbw, Thr, Tmap, Tmar, Tmaw, Tpb, Tpcm, and Tptm). The other six characteristics each only occur in one well and could not be tested for heterogeneity.

Conclusions

Many rock characteristics are only found in one well, and therefore cannot be analyzed for heterogeneity. Of the 32 classifications that occur in multiple wells, 29 exhibit some significant spatial heterogeneity. Furthermore, of the 126 possible combinations of tests, a significant difference was found in 90 of them (71 percent of the tests). Summarizing by rock classification:

HSU: 10 of 11 (91%) of the pairs showed a significant difference.

HGU: 22 of 34 (65%) of the pairs showed a significant difference.

LITH: 25 of 39 (64%) of the pairs showed a significant difference.

ALTERATION: 20 of 31 (64%) of the pairs showed a significant difference.

STRAT: 6 of 11 (54%) of the pairs showed a significant difference.

Conclusion: All rock classifications showed significant spatial heterogeneity.

HETEROGENEITY WITHIN ROCK CLASSIFICATIONS

In this section, the heterogeneity of each rock classification (HSU, HGU, etc.) is investigated. For example, comparisons are made between an HSU of BA and an HSU of TCA. Comparison of characteristics within each classification will yield insight into the suitability of using that classification to describe K. In other words, the greater the difference among the characteristics, the better that classification is at describing the data.

To test for differences between rock characteristics, multiple comparison tests using the nonparametric Wilcoxon method were performed. In this method, one performs a series of two-group score tests between each pair of groups. If the p-value for the test is less than the Bonferroni individual comparison level, the two groups can be declared to have different distribution functions at the chosen overall error rate. The Bonferroni comparison level is similar to the comparison level for a two sample test, but modified to account for multiple comparisons. For example, for the classification HGU, there are four (n) characteristics (AA, LFA, TCU, and WTA). This will yield six (n(n-1)/2) comparisons: [AA-LFA], [AA-TCU], [AA-WTA], [LFA-TCU], [LFA-WTA], and [TCU-WTA], which results in a Bonferroni comparison level of alpha/6.

The following are the results of the multiple comparison Wilcoxon test. The reader is reminded that boxplots can be misleading in this case since censored data cannot be plotted accurately and descriptively, but they still have value for visual comparisons.

Heterogeneity of HSUs

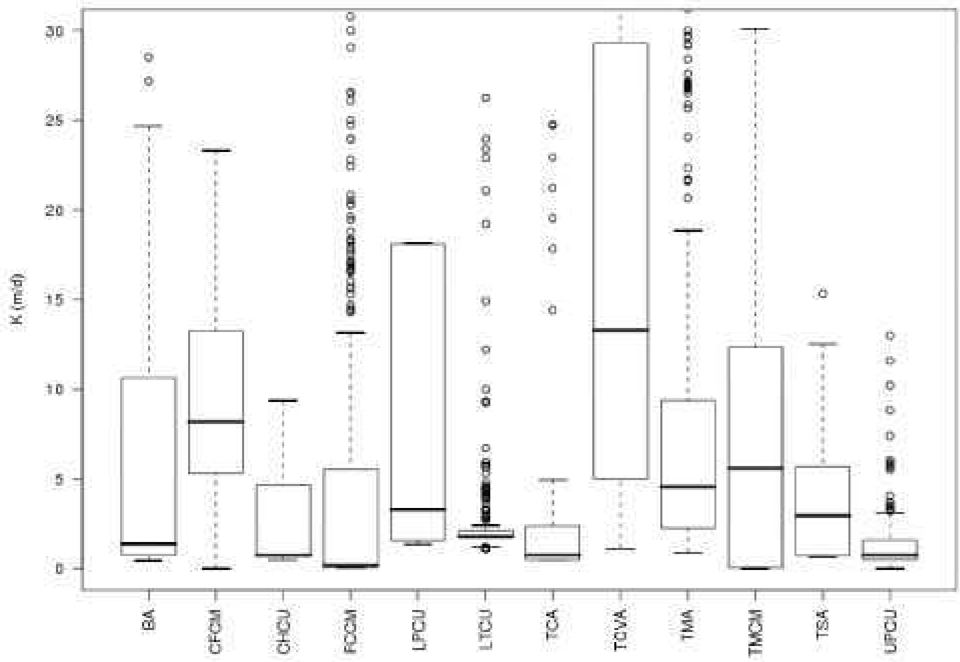


Figure 295. Heterogeneity of HSUs.
Results: 42 percent (28 of 66 comparisons) are different.

Heterogeneity of HGUs

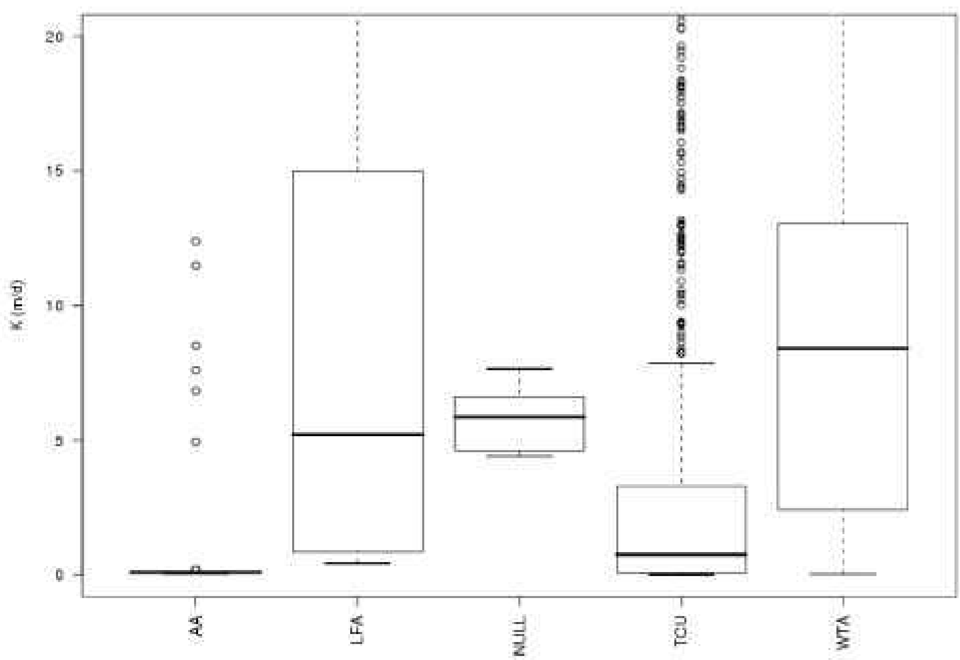


Figure 296. Heterogeneity of HGUs.
Results: 40 percent (4 of 10 comparisons) are different.

Heterogeneity of LITHs

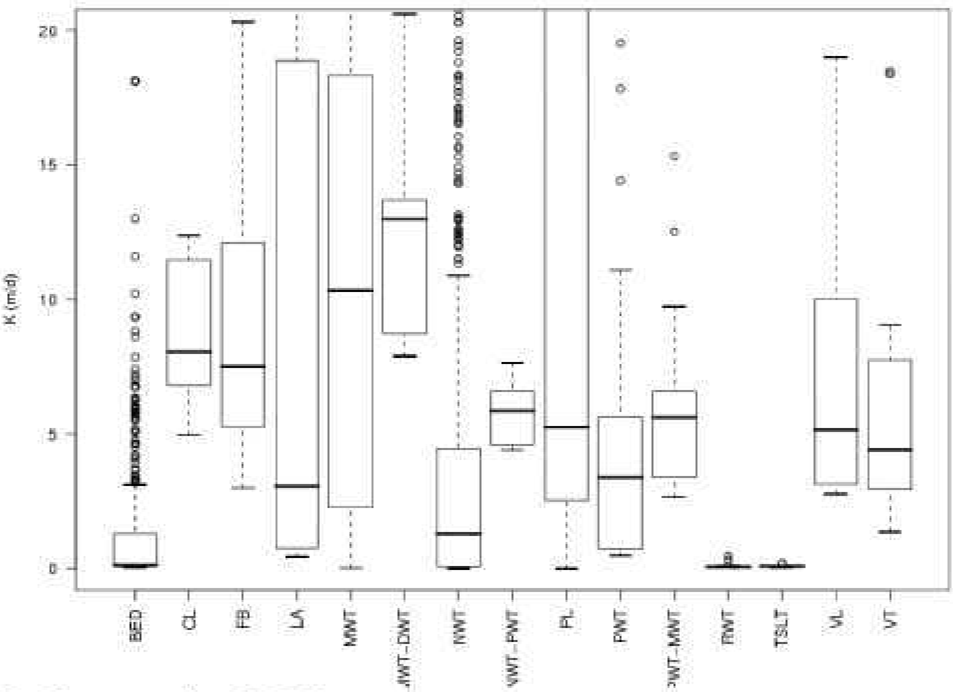


Figure 297. Heterogeneity of LITHs.
Results: 16 percent (17 of 105 comparisons) are different.

Heterogeneity of STRATs

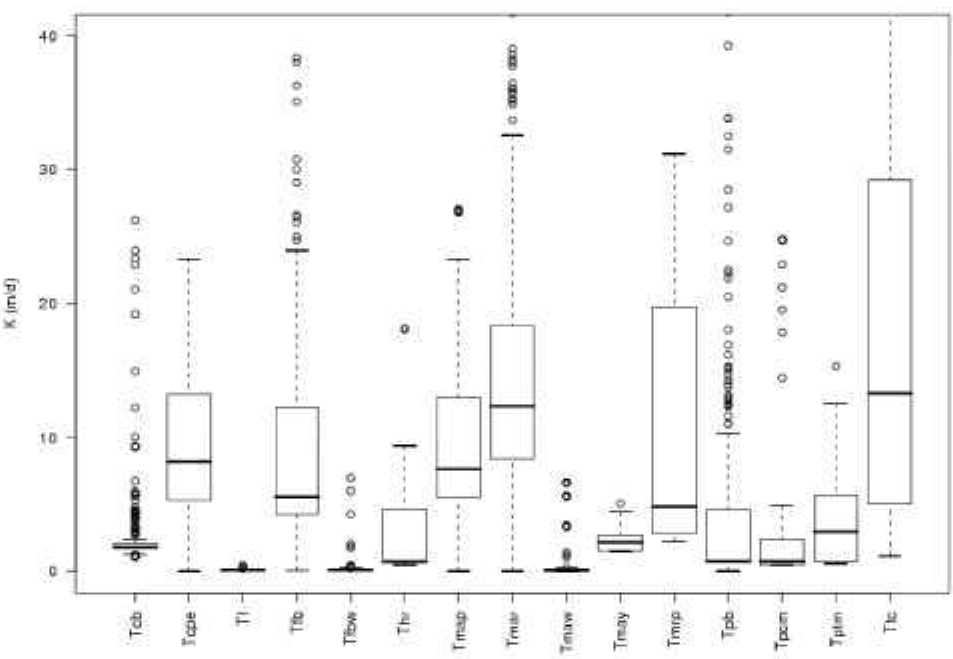


Figure 298. Heterogeneity of STRATs.
Results: 50 percent (53 of 105 comparisons) are different.

Heterogeneity of ALTERATIONSs

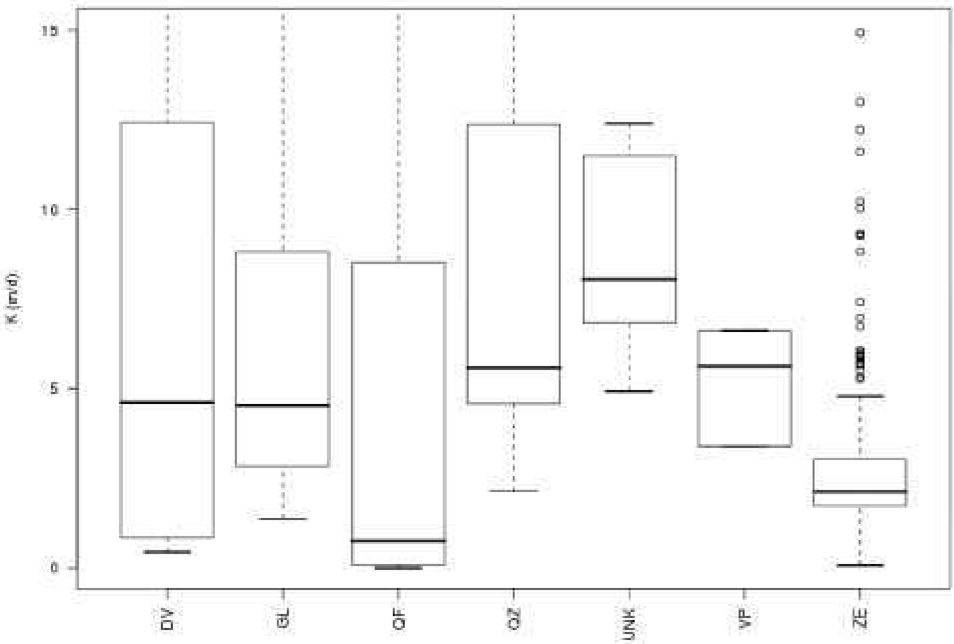


Figure 299. Heterogeneity of ALTERATIONs.
Results: 28 percent (6 of 21 comparisons) are different.

Summary

Using the fraction of possible comparisons that result in a significant difference, stratigraphic unit best describes differences in K, with 53 of 105 combinations yielding a significant difference. HSU is the next best, where 28 of 66 (42%) combinations have a significant difference in the distribution of K. Lithology is the worst descriptor of K, with 17 of 105 (16%) combinations with a difference in K.

COMPARE K WITH FRACTURES

Throughout this study, analyses were performed on data sets classified by their rock type. A casual investigation of the fracture data collected for each well (data found in U.S. Department of Energy (DOE), 2001) reveals a potential correlation between fracture location and conductivity. The figure below presents a plot of depth versus K with points identified by their proximity to a fracture.

The green points show those K values at a depth within 5 m of a fracture, which suggests that all Ks greater than 25 m/d are associated with a fracture. In other wells, this relationship is not as strong, but it does raise the question of how strongly correlated are K and fracture location? If there is a strong correlation, is the presence of a fracture, and not rock type, the only reason for high Ks? With regard to flow and transport, how significant are the fractures, and are they more significant than rock type?

Further investigation is required to answer the questions above, but a cursory analysis suggests the fractures may be very important in describing the permeability in all rock types.

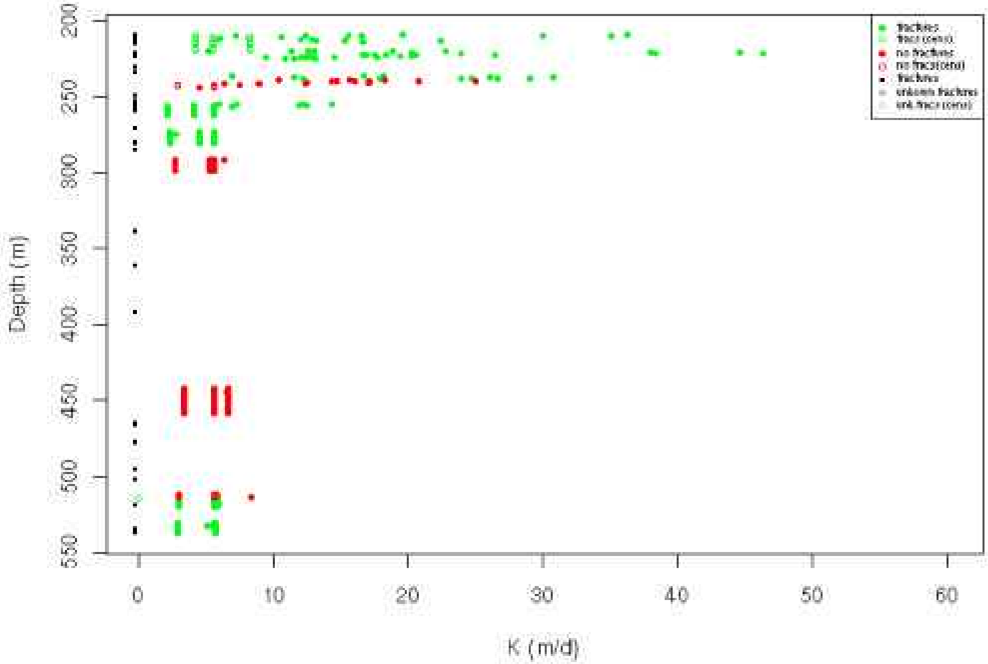


Figure 300. Correlation between fracture location and K: ER-EC-8.

STAGE 2 CONCLUSIONS

In this stage of the study, the permeability found in several wells was investigated using statistics for censored data. The purpose was to use the raw data from the flow logs, regardless of whether or not the data were below the minimum detection limit, and extract as much information as possible. The Exploratory Data Analysis (EDA) approach was used as described in Tukey (1977) and Helsel (2005). The following is a summary of the findings.

- The range of hydraulic conductivity is unknown, due to the presence of censored data. However, the smallest uncensored value is 0.001 m/d and the largest value is 109 m/d.
- Of the 88 possible values for rock classification, 21 show a statistically significant decrease in K with depth. However, of those 21, 16 occur within a small fraction of the total depth and extrapolation of this correlation to larger depths may not be appropriate.
- Of the 32 rock classifications that occur in multiple wells, 29 exhibit some spatial heterogeneity, which calls into question the usefulness of the classification. HSU showed the most heterogeneity among all classifications.
- For each rock classification (HSU, HGU, LITH, STRAT, and ALTERATION), there is significant overlap in K among the characteristics of the classification. However, stratigraphic unit showed the greatest differences among the characteristics, and may be the most appropriate way to describe conductivity. There was very little difference in the permeability described by lithology, making lithology a poor descriptor of conductivity.
- The presence of fractures may be correlated to high values of conductivity.

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APPENDIX. Hydraulic Conductivity at Depth (Dashes indicate hydraulic conductivity values are below detection within the interval).

ER-EC-1

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
701.77	25.01	Tpb	LA	DV	LFA	BA
703.51	97.76	Tpb	LA	DV	LFA	BA
705.09	33.42	Tpb	LA	DV	LFA	BA
706.62	43.74	Tpb	LA	DV	LFA	BA
708.29	46.51	Tpb	LA	DV	LFA	BA
723.29	10.03	Tpb	LA	DV	LFA	BA
725.03	15.19	Tpb	LA	DV	LFA	BA
726.61	-	-	-	-	-	-
728.14	12.84	Tpb	LA	DV	LFA	BA
729.81	13.75	Tpb	LA	DV	LFA	BA
744.81	21.76	Tpb	LA	DV	LFA	BA
746.52	90.86	Tpb	LA	DV	LFA	BA
748.07	12.25	Tpb	LA	DV	LFA	BA
749.59	8.87	Tpb	LA	DV	LFA	BA
751.27	35.57	Tpb	LA	DV	LFA	BA
766.33	7.32	Tpb	FB	QZ	LFA	BA
768.00	13.96	Tpb	FB	QZ	LFA	BA
769.53	-	-	-	-	-	-
770.99	-	-	-	-	-	-
772.61	-	-	-	-	-	-
787.66	-	-	-	-	-	-
789.37	5.75	Tpb	BED	ZE	TCU	UPCU
790.93	-	-	-	-	-	-
792.42	-	-	-	-	-	-
794.06	-	-	-	-	-	-
809.12	-	-	-	-	-	-
810.83	-	-	-	-	-	-
812.38	-	-	-	-	-	-
813.88	-	-	-	-	-	-
815.52	2.82	Tpb	BED	ZE	TCU	UPCU
830.58	-	-	-	-	-	-
832.32	-	-	-	-	-	-
833.90	-	-	-	-	-	-
835.43	-	-	-	-	-	-
837.10	2.31	Tpcm	PWT	DV	WTA	TCA
852.16	-	-	-	-	-	-
853.90	-	-	-	-	-	-
855.48	-	-	-	-	-	-
857.01	-	-	-	-	-	-
858.68	-	-	-	-	-	-
1,021.69	-	-	-	-	-	-
1,023.40	-	-	-	-	-	-
1,024.95	-	-	-	-	-	-
1,026.47	-	-	-	-	-	-
1,028.15	-	-	-	-	-	-
1,030.83	8.41	Tptm	PWT-MWT	DV	WTA	TSA
1,032.54	-	-	-	-	-	-
1,034.09	-	-	-	-	-	-
1,035.62	-	-	-	-	-	-
1,037.30	-	-	-	-	-	-
1,052.29	-	-	-	-	-	-
1,054.03	-	-	-	-	-	-
1,055.61	-	-	-	-	-	-
1,057.14	-	-	-	-	-	-
1,058.81	-	-	-	-	-	-
1,073.81	-	-	-	-	-	-
1,075.55	-	-	-	-	-	-
1,077.13	-	-	-	-	-	-
1,078.66	-	-	-	-	-	-
1,080.33	-	-	-	-	-	-

ER-EC-1 (continued)

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
1,095.39	-	-	-	-	-	-
1,097.13	-	-	-	-	-	-
1,098.71	-	-	-	-	-	-
1,100.24	-	-	-	-	-	-
1,101.91	-	-	-	-	-	-
1,116.85	-	-	-	-	-	-
1,118.56	-	-	-	-	-	-
1,120.11	-	-	-	-	-	-
1,121.63	-	-	-	-	-	-
1,123.31	-	-	-	-	-	-
1,138.31	-	-	-	-	-	-
1,140.04	-	-	-	-	-	-
1,141.63	-	-	-	-	-	-
1,143.15	-	-	-	-	-	-
1,144.83	-	-	-	-	-	-
1,357.27	-	-	-	-	-	-
1,358.98	-	-	-	-	-	-
1,360.54	-	-	-	-	-	-
1,362.06	-	-	-	-	-	-
1,363.74	-	-	-	-	-	-
1,378.73	-	-	-	-	-	-
1,380.47	-	-	-	-	-	-
1,382.05	-	-	-	-	-	-
1,383.58	-	-	-	-	-	-
1,385.26	-	-	-	-	-	-
1,400.19	-	-	-	-	-	-
1,401.87	-	-	-	-	-	-
1,403.39	11.65	Tcpe	FB	QF	LFA	CFCM
1,404.88	10.52	Tcpe	FB	QF	LFA	CFCM
1,406.53	-	-	-	-	-	-
1,421.53	-	-	-	-	-	-
1,423.26	-	-	-	-	-	-
1,424.85	-	-	-	-	-	-
1,426.37	-	-	-	-	-	-
1,428.05	-	-	-	-	-	-
1,430.73	-	-	-	-	-	-
1,432.44	-	-	-	-	-	-
1,433.99	-	-	-	-	-	-
1,435.49	-	-	-	-	-	-
1,437.13	-	-	-	-	-	-
1,439.81	-	-	-	-	-	-
1,441.37	-	-	-	-	-	-

Dashes indicate hydraulic conductivity values are below detection within the interval
Only the intervals within well screen are presented

ER-EC-2a

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
522.14	0.39	Tfbw	BED	QF	TCU	FCCM
523.68	0.19	Tfbw	BED	QF	TCU	FCCM
525.26	0.26	Tfbw	BED	QF	TCU	FCCM
526.85	-	-	-	-	-	-
528.43	0.15	Tfbw	BED	QF	TCU	FCCM
530.02	-	-	-	-	-	-
531.56	-	-	-	-	-	-
532.85	-	-	-	-	-	-
535.20	0.34	Tfbw	BED	QF	TCU	FCCM
536.72	0.16	Tfbw	BED	QF	TCU	FCCM
538.31	-	-	-	-	-	-
539.89	-	-	-	-	-	-
541.48	-	-	-	-	-	-
543.06	-	-	-	-	-	-
544.60	-	-	-	-	-	-
545.90	-	-	-	-	-	-
548.29	0.21	Tfbw	BED	QF	TCU	FCCM
549.83	0.15	Tfbw	BED	QF	TCU	FCCM
551.41	-	-	-	-	-	-
553.00	-	-	-	-	-	-
554.58	-	-	-	-	-	-
556.17	-	-	-	-	-	-
557.71	-	-	-	-	-	-
559.00	-	-	-	-	-	-
561.35	0.17	Tfbw	BED	QF	TCU	FCCM
562.87	0.14	Tfbw	BED	QF	TCU	FCCM
564.46	-	-	-	-	-	-
566.04	-	-	-	-	-	-
567.63	-	-	-	-	-	-
569.21	-	-	-	-	-	-
570.75	-	-	-	-	-	-
572.05	-	-	-	-	-	-
574.40	0.31	Tfbw	BED	QF	TCU	FCCM
575.92	0.15	Tfbw	BED	QF	TCU	FCCM
577.50	-	-	-	-	-	-
579.09	-	-	-	-	-	-
580.67	-	-	-	-	-	-
582.26	-	-	-	-	-	-
583.80	-	-	-	-	-	-
585.09	-	-	-	-	-	-
587.49	0.14	Tfbw	BED	QF	TCU	FCCM
589.03	0.13	Tfbw	BED	QF	TCU	FCCM
590.61	-	-	-	-	-	-
592.20	0.08	Tfbw	BED	QF	TCU	FCCM
593.78	-	-	-	-	-	-
595.37	-	-	-	-	-	-
596.91	-	-	-	-	-	-
598.20	-	-	-	-	-	-
600.55	0.19	Tfbw	BED	QF	TCU	FCCM
602.07	0.13	Tfbw	BED	QF	TCU	FCCM
603.66	-	-	-	-	-	-
605.24	-	-	-	-	-	-
606.83	-	-	-	-	-	-
608.41	-	-	-	-	-	-
609.95	-	-	-	-	-	-
611.25	-	-	-	-	-	-
613.59	0.19	Tfbw	BED	QF	TCU	FCCM
615.12	0.14	Tfbw	BED	QF	TCU	FCCM
616.70	-	-	-	-	-	-
618.29	0.10	Tfbw	BED	QF	TCU	FCCM
619.87	-	-	-	-	-	-
621.46	0.13	Tfbw	BED	QF	TCU	FCCM
623.00	-	-	-	-	-	-

ER-EC-2a (continued)

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
624.29	-	-	-	-	-	-
626.68	0.11	Tfbw	BED	QF	TCU	FCCM
628.22	0.13	Tfbw	BED	QF	TCU	FCCM
629.81	-	-	-	-	-	-
631.39	0.15	Tfbw	BED	QF	TCU	FCCM
632.98	-	-	-	-	-	-
634.56	-	-	-	-	-	-
636.10	0.16	Tfbw	BED	QF	TCU	FCCM
637.40	-	-	-	-	-	-
639.74	0.12	Tfbw	BED	QF	TCU	FCCM
641.27	0.09	Tfbw	BED	QF	TCU	FCCM
642.85	-	-	-	-	-	-
644.44	0.20	Tfbw	BED	QF	TCU	FCCM
646.02	0.10	Tfbw	BED	QF	TCU	FCCM
647.61	-	-	-	-	-	-
649.15	-	-	-	-	-	-
650.44	0.22	Tfbw	NWT	QF	TCU	FCCM
652.84	0.18	Tfbw	NWT	QF	TCU	FCCM
654.38	0.24	Tfbw	NWT	QF	TCU	FCCM
655.96	0.12	Tfbw	NWT	QF	TCU	FCCM
657.55	-	-	-	-	-	-
659.13	-	-	-	-	-	-
660.71	0.36	Tfbw	NWT	QF	TCU	FCCM
662.25	-	-	-	-	-	-
663.75	-	-	-	-	-	-
939.61	-	-	-	-	-	-
941.13	0.37	Tf	RWT	ZE	TCU	FCCM
942.72	-	-	-	-	-	-
944.30	-	-	-	-	-	-
945.89	-	-	-	-	-	-
947.47	-	-	-	-	-	-
949.01	-	-	-	-	-	-
950.31	-	-	-	-	-	-
952.70	-	-	-	-	-	-
954.24	0.14	Tf	TSLT	QF	AA	FCCM
955.82	-	-	-	-	-	-
957.41	-	-	-	-	-	-
958.99	0.07	Tf	TSLT	QF	AA	FCCM
960.58	0.10	Tf	TSLT	QF	AA	FCCM
962.12	0.14	Tmaw	BED	QF	TCU	TMCM
963.41	1.24	Tmaw	BED	QF	TCU	TMCM
965.76	0.15	Tmaw	BED	QF	TCU	TMCM
967.28	0.14	Tmaw	BED	QF	TCU	TMCM
968.87	-	-	-	-	-	-
970.45	-	-	-	-	-	-
972.04	-	-	-	-	-	-
973.62	-	-	-	-	-	-
975.16	-	-	-	-	-	-
976.46	-	-	-	-	-	-
978.85	-	-	-	-	-	-
980.39	0.10	Tmaw	RWT	QF	TCU	TMCM
981.97	-	-	-	-	-	-
983.56	-	-	-	-	-	-
985.14	-	-	-	-	-	-
986.73	-	-	-	-	-	-
988.27	-	-	-	-	-	-
989.56	-	-	-	-	-	-
991.91	-	-	-	-	-	-
993.43	-	-	-	-	-	-
995.02	-	-	-	-	-	-
996.60	-	-	-	-	-	-
998.19	-	-	-	-	-	-
999.77	0.30	Tmaw	NWT	QF	TCU	TMCM
1,001.31	-	-	-	-	-	-

ER-EC-2a (continued)

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
1,002.61	-	-	-	-	-	-
1,005.00	-	-	-	-	-	-
1,006.54	-	-	-	-	-	-
1,008.13	0.12	Tmaw	NWT	QF	TCU	TMCM
1,009.71	0.13	Tmaw	NWT	QF	TCU	TMCM
1,011.30	-	-	-	-	-	-
1,012.88	-	-	-	-	-	-
1,014.42	-	-	-	-	-	-
1,015.72	-	-	-	-	-	-
1,018.06	-	-	-	-	-	-
1,019.59	0.05	Tmaw	NWT	QF	TCU	TMCM
1,021.17	-	-	-	-	-	-
1,022.76	-	-	-	-	-	-
1,024.34	-	-	-	-	-	-
1,025.93	-	-	-	-	-	-
1,027.47	-	-	-	-	-	-
1,028.76	-	-	-	-	-	-
1,031.15	-	-	-	-	-	-
1,032.69	-	-	-	-	-	-
1,034.28	-	-	-	-	-	-
1,035.86	-	-	-	-	-	-
1,037.45	-	-	-	-	-	-
1,039.03	0.18	Tmaw	NWT	QF	TCU	TMCM
1,040.57	-	-	-	-	-	-
1,041.87	-	-	-	-	-	-
1,044.21	-	-	-	-	-	-
1,045.74	-	-	-	-	-	-
1,047.32	-	-	-	-	-	-
1,048.91	-	-	-	-	-	-
1,050.49	-	-	-	-	-	-
1,052.08	-	-	-	-	-	-
1,053.62	-	-	-	-	-	-
1,054.91	-	-	-	-	-	-
1,057.31	-	-	-	-	-	-
1,058.84	0.04	Tmaw	NWT	QF	TCU	TMCM
1,060.43	-	-	-	-	-	-
1,062.01	0.03	Tmaw	NWT	QF	TCU	TMCM
1,063.60	0.09	Tmaw	NWT	QF	TCU	TMCM
1,065.18	0.19	Tmaw	NWT	QF	TCU	TMCM
1,066.72	0.11	Tmaw	NWT	QF	TCU	TMCM
1,068.02	0.04	Tmaw	NWT	QF	TCU	TMCM
1,070.37	-	-	-	-	-	-
1,071.89	0.02	Tmaw	NWT	QF	TCU	TMCM
1,073.48	-	-	-	-	-	-
1,075.06	-	-	-	-	-	-
1,076.65	-	-	-	-	-	-
1,078.23	-	-	-	-	-	-
1,079.77	-	-	-	-	-	-
1,081.26	0.08	Tmaw	NWT	QF	TCU	TMCM
1,369.50	-	-	-	-	-	-
1,371.02	-	-	-	-	-	-
1,372.61	-	-	-	-	-	-
1,374.19	-	-	-	-	-	-
1,375.78	-	-	-	-	-	-
1,377.36	-	-	-	-	-	-
1,378.90	-	-	-	-	-	-
1,380.20	-	-	-	-	-	-
1,382.59	-	-	-	-	-	-
1,384.13	-	-	-	-	-	-
1,385.71	-	-	-	-	-	-
1,387.30	-	-	-	-	-	-
1,388.88	-	-	-	-	-	-
1,390.47	-	-	-	-	-	-
1,392.01	-	-	-	-	-	-

ER-EC-2a (continued)

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
1,393.30	-	-	-	-	-	-
1,395.65	-	-	-	-	-	-
1,397.17	-	-	-	-	-	-
1,398.76	-	-	-	-	-	-
1,400.34	-	-	-	-	-	-
1,401.93	-	-	-	-	-	-
1,403.51	-	-	-	-	-	-
1,405.05	-	-	-	-	-	-
1,406.35	-	-	-	-	-	-
1,408.69	-	-	-	-	-	-
1,410.22	-	-	-	-	-	-
1,411.80	-	-	-	-	-	-
1,413.39	-	-	-	-	-	-
1,414.97	-	-	-	-	-	-
1,416.56	-	-	-	-	-	-
1,418.10	-	-	-	-	-	-
1,419.39	-	-	-	-	-	-
1,421.79	-	-	-	-	-	-
1,423.32	-	-	-	-	-	-
1,424.91	-	-	-	-	-	-
1,426.49	-	-	-	-	-	-
1,428.08	-	-	-	-	-	-
1,429.66	-	-	-	-	-	-
1,431.20	-	-	-	-	-	-
1,432.50	-	-	-	-	-	-
1,434.85	-	-	-	-	-	-
1,436.37	-	-	-	-	-	-
1,437.95	-	-	-	-	-	-
1,439.54	-	-	-	-	-	-
1,441.12	-	-	-	-	-	-
1,442.71	-	-	-	-	-	-
1,444.25	-	-	-	-	-	-
1,445.54	-	-	-	-	-	-
1,447.89	-	-	-	-	-	-
1,449.42	-	-	-	-	-	-
1,451.00	-	-	-	-	-	-
1,452.59	-	-	-	-	-	-
1,454.17	-	-	-	-	-	-
1,455.76	-	-	-	-	-	-
1,457.29	-	-	-	-	-	-
1,458.59	-	-	-	-	-	-
1,460.94	-	-	-	-	-	-
1,462.46	-	-	-	-	-	-
1,464.05	-	-	-	-	-	-
1,465.63	-	-	-	-	-	-
1,467.22	-	-	-	-	-	-
1,468.80	-	-	-	-	-	-
1,470.34	0.07	Tmr	MWT	QF	WTA	TMCM
1,471.64	-	-	-	-	-	-
1,473.98	-	-	-	-	-	-
1,475.51	-	-	-	-	-	-
1,477.09	0.03	Tmr	MWT	QF	WTA	TMCM
1,478.68	-	-	-	-	-	-
1,480.26	-	-	-	-	-	-
1,481.85	-	-	-	-	-	-
1,483.39	0.02	Tmr	MWT	QF	WTA	TMCM
1,484.68	-	-	-	-	-	-
1,487.07	-	-	-	-	-	-
1,488.61	-	-	-	-	-	-
1,489.41	-	-	-	-	-	-

Dashes indicate hydraulic conductivity values are below detection within the interval
Only the intervals within well screen are presented

ER-EC-4

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
302.85	19.5	Tic	LA	DV	LFA	TCVA
304.56	25.0	Tic	LA	DV	LFA	TCVA
306.11	12.6	Tic	LA	DV	LFA	TCVA
307.63	-	-	-	-	-	-
309.31	-	-	-	-	-	-
311.99	54.8	Tic	LA	DV	LFA	TCVA
313.73	24.8	Tic	LA	DV	LFA	TCVA
315.32	38.1	Tic	LA	DV	LFA	TCVA
316.84	37.0	Tic	LA	DV	LFA	TCVA
318.52	37.8	Tic	LA	DV	LFA	TCVA
333.51	31.6	Tic	LA	DV	LFA	TCVA
335.25	74.0	Tic	LA	DV	LFA	TCVA
336.83	-	-	-	-	-	-
338.36	3.2	Tic	LA	DV	LFA	TCVA
340.03	2.5	Tic	LA	DV	LFA	TCVA
355.09	23.2	Tic	LA	DV	LFA	TCVA
356.83	42.6	Tic	LA	DV	LFA	TCVA
358.41	5.6	Tic	LA	DV	LFA	TCVA
359.94	-	-	-	-	-	-
361.61	-	-	-	-	-	-
364.30	8.5	Tic	CL	UNK	AA	TCVA
366.03	-	-	-	-	-	-
367.62	-	-	-	-	-	-
369.14	-	-	-	-	-	-
370.82	-	-	-	-	-	-
583.51	-	-	-	-	-	-
585.25	-	-	-	-	-	-
586.83	-	-	-	-	-	-
588.36	-	-	-	-	-	-
590.03	-	-	-	-	-	-
592.71	-	-	-	-	-	-
594.42	-	-	-	-	-	-
595.98	-	-	-	-	-	-
597.50	-	-	-	-	-	-
599.18	-	-	-	-	-	-
614.17	-	-	-	-	-	-
615.91	-	-	-	-	-	-
617.49	-	-	-	-	-	-
619.02	-	-	-	-	-	-
620.69	-	-	-	-	-	-
635.75	-	-	-	-	-	-
637.49	-	-	-	-	-	-
639.07	-	-	-	-	-	-
640.60	-	-	-	-	-	-
642.27	-	-	-	-	-	-
657.33	-	-	-	-	-	-
659.04	-	-	-	-	-	-
660.59	-	-	-	-	-	-
662.12	-	-	-	-	-	-
663.79	-	-	-	-	-	-
678.85	-	-	-	-	-	-
680.59	-	-	-	-	-	-
682.17	-	-	-	-	-	-
683.70	-	-	-	-	-	-
685.37	-	-	-	-	-	-
947.26	-	-	-	-	-	-
948.96	16.4	Tmrp	PWT	QF	WTA	TMA
950.52	-	-	-	-	-	-
952.04	-	-	-	-	-	-
953.72	-	-	-	-	-	-
956.40	-	-	-	-	-	-
958.11	-	-	-	-	-	-
959.66	-	-	-	-	-	-
961.19	-	-	-	-	-	-

ER-EC-4 (continued)

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
962 86	-	-	-	-	-	-
977 86	-	-	-	-	-	-
979 54	-	-	-	-	-	-
981 06	-	-	-	-	-	-
982 55	-	-	-	-	-	-
984 20	-	-	-	-	-	-
986 88	-	-	-	-	-	-
988 62	-	-	-	-	-	-
990 20	-	-	-	-	-	-
991 73	-	-	-	-	-	-
993 40	-	-	-	-	-	-
1,008 46	-	-	-	-	-	-
1,010 20	-	-	-	-	-	-
1,011 78	-	-	-	-	-	-
1,013 31	-	-	-	-	-	-
1,014 98	-	-	-	-	-	-
1,029 98	-	-	-	-	-	-
1,031 69	-	-	-	-	-	-
1,033 24	-	-	-	-	-	-
1,034 77	-	-	-	-	-	-
1,036 44	-	-	-	-	-	-

Dashes indicate hydraulic conductivity values are below detection within the interval
Only the intervals within well screen are presented

ER-EC-5

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
365.76	27.57	Tmar	MWT	QF	WTA	TMCM
366.37	17.89	Tmar	MWT	QF	WTA	TMCM
366.98	-	-	-	-	-	-
367.59	-	-	-	-	-	-
368.20	-	-	-	-	-	-
368.81	17.79	Tmar	MWT	QF	WTA	TMCM
369.42	15.55	Tmar	MWT	QF	WTA	TMCM
370.03	11.67	Tmar	MWT	QF	WTA	TMCM
370.64	-	-	-	-	-	-
371.25	-	-	-	-	-	-
371.86	-	-	-	-	-	-
372.47	-	-	-	-	-	-
373.08	-	-	-	-	-	-
375.15	12.91	Tmar	MWT	QF	WTA	TMCM
375.76	-	-	-	-	-	-
376.37	-	-	-	-	-	-
376.98	-	-	-	-	-	-
377.59	-	-	-	-	-	-
378.20	-	-	-	-	-	-
378.81	-	-	-	-	-	-
379.42	-	-	-	-	-	-
380.02	-	-	-	-	-	-
380.63	47.59	Tmar	MWT	QF	WTA	TMCM
381.24	-	-	-	-	-	-
381.85	-	-	-	-	-	-
382.46	-	-	-	-	-	-
396.67	46.42	Tmar	MWT	QF	WTA	TMCM
397.28	20.08	Tmar	MWT	QF	WTA	TMCM
397.89	-	-	-	-	-	-
398.50	14.52	Tmar	MWT	QF	WTA	TMCM
399.11	12.72	Tmar	MWT	QF	WTA	TMCM
399.71	-	-	-	-	-	-
400.32	-	-	-	-	-	-
400.93	-	-	-	-	-	-
401.54	-	-	-	-	-	-
402.15	-	-	-	-	-	-
402.76	-	-	-	-	-	-
403.37	-	-	-	-	-	-
403.86	-	-	-	-	-	-
418.19	12.47	Tmar	MWT	QF	WTA	TMCM
418.80	8.52	Tmar	MWT	QF	WTA	TMCM
419.40	-	-	-	-	-	-
420.01	-	-	-	-	-	-
420.62	-	-	-	-	-	-
421.23	-	-	-	-	-	-
421.84	-	-	-	-	-	-
422.45	-	-	-	-	-	-
423.06	-	-	-	-	-	-
423.67	-	-	-	-	-	-
424.28	-	-	-	-	-	-
424.89	-	-	-	-	-	-
425.38	-	-	-	-	-	-
577.84	-	-	-	-	-	-
578.45	8.80	Tmar	MWT	QF	WTA	TMCM
579.06	-	-	-	-	-	-
579.67	-	-	-	-	-	-
580.28	-	-	-	-	-	-
580.89	-	-	-	-	-	-
581.50	-	-	-	-	-	-
582.11	-	-	-	-	-	-
582.72	-	-	-	-	-	-
583.33	-	-	-	-	-	-
583.94	-	-	-	-	-	-

ER-EC-5 (continued)

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
584 55	-	-	-	-	-	-
585 09	12 06	Tmar	MWT	QF	WTA	TMCM
587 04	-	-	-	-	-	-
587 65	18 35	Tmar	MWT	QF	WTA	TMCM
588 26	27 97	Tmar	MWT	QF	WTA	TMCM
588 87	32 90	Tmar	MWT	QF	WTA	TMCM
589 48	27 62	Tmar	MWT	QF	WTA	TMCM
590 09	28 21	Tmar	MWT	QF	WTA	TMCM
590 70	37 80	Tmar	MWT	QF	WTA	TMCM
591 31	30 54	Tmar	MWT	QF	WTA	TMCM
591 92	14 46	Tmar	MWT	QF	WTA	TMCM
592 53	16 00	Tmar	MWT	QF	WTA	TMCM
593 14	-	-	-	-	-	-
593 75	21 57	Tmar	MWT	QF	WTA	TMCM
594 30	24 74	Tmar	MWT	QF	WTA	TMCM
608 56	35 60	Tmar	MWT	QF	WTA	TMCM
609 17	26 98	Tmar	MWT	QF	WTA	TMCM
609 78	31 64	Tmar	MWT	QF	WTA	TMCM
610 39	37 92	Tmar	MWT	QF	WTA	TMCM
611 00	44 99	Tmar	MWT	QF	WTA	TMCM
611 61	28 40	Tmar	MWT	QF	WTA	TMCM
612 22	11 44	Tmar	MWT	QF	WTA	TMCM
612 83	-	-	-	-	-	-
613 44	-	-	-	-	-	-
614 05	10 33	Tmar	MWT	QF	WTA	TMCM
614 66	20 27	Tmar	MWT	QF	WTA	TMCM
615 27	27 85	Tmar	MWT	QF	WTA	TMCM
615 82	48 34	Tmar	MWT	QF	WTA	TMCM
630 08	14 45	Tmar	MWT	QF	WTA	TMCM
630 69	15 38	Tmar	MWT	QF	WTA	TMCM
631 30	10 07	Tmar	MWT	QF	WTA	TMCM
631 91	-	-	-	-	-	-
632 52	12 37	Tmar	MWT	QF	WTA	TMCM
633 13	15 40	Tmar	MWT	QF	WTA	TMCM
633 74	9 09	Tmar	MWT	QF	WTA	TMCM
634 35	-	-	-	-	-	-
634 96	11 64	Tmar	MWT	QF	WTA	TMCM
635 57	9 00	Tmar	MWT	QF	WTA	TMCM
636 18	-	-	-	-	-	-
636 79	16 96	Tmar	MWT	QF	WTA	TMCM
637 34	26 14	Tmar	MWT	QF	WTA	TMCM
685 56	18 50	Tmap	MWT-DWT	QF	WTA	TMCM
686 17	15 91	Tmap	MWT-DWT	QF	WTA	TMCM
686 78	-	-	-	-	-	-
687 38	-	-	-	-	-	-
687 99	-	-	-	-	-	-
688 60	-	-	-	-	-	-
689 21	-	-	-	-	-	-
689 82	-	-	-	-	-	-
690 43	-	-	-	-	-	-
691 04	-	-	-	-	-	-
691 65	-	-	-	-	-	-
692 26	-	-	-	-	-	-
692 75	13 35	Tmap	MWT-DWT	QF	WTA	TMCM
707 08	-	-	-	-	-	-
707 68	-	-	-	-	-	-
708 29	-	-	-	-	-	-
708 90	-	-	-	-	-	-
709 51	-	-	-	-	-	-
710 12	-	-	-	-	-	-
710 73	-	-	-	-	-	-
711 34	-	-	-	-	-	-
711 95	-	-	-	-	-	-

ER-EC-5 (continued)

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
712.56	-	-	-	-	-	-
713.17	-	-	-	-	-	-
713.78	-	-	-	-	-	-
714.33	11.36	Tmap	MWT-DWT	QF	WTA	TMCM
728.59	-	-	-	-	-	-
729.20	13.75	Tmap	MWT-DWT	QF	WTA	TMCM
729.81	-	-	-	-	-	-
730.42	-	-	-	-	-	-
731.03	-	-	-	-	-	-
731.64	-	-	-	-	-	-
732.25	-	-	-	-	-	-
732.86	23.36	Tmap	MWT-DWT	QF	WTA	TMCM
733.47	-	-	-	-	-	-
734.08	-	-	-	-	-	-
734.69	31.00	Tmap	MWT-DWT	QF	WTA	TMCM
735.30	-	-	-	-	-	-
735.91	-	-	-	-	-	-

Dashes indicate hydraulic conductivity values are below detection within the interval
Only the intervals within well screen are presented

ER-5-4#2

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
1,974.83	-	-	-	-	-	-
1,975.50	-	-	-	-	-	-
1,976.11	-	-	-	-	-	-
1,976.72	-	-	-	-	-	-
1,977.33	-	-	-	-	-	-
1,977.94	4.36	Tcb	NWT	ZE	TCU	LTCU
1,978.55	21.06	Tcb	NWT	ZE	TCU	LTCU
1,979.16	24.53	Tcb	NWT	ZE	TCU	LTCU
1,979.77	12.16	Tcb	NWT	ZE	TCU	LTCU
1,980.38	4.50	Tcb	NWT	ZE	TCU	LTCU
1,980.99	1.89	Tcb	NWT	ZE	TCU	LTCU
1,981.60	-	-	-	-	-	-
1,982.21	-	-	-	-	-	-
1,982.82	-	-	-	-	-	-
1,983.43	-	-	-	-	-	-
1,984.03	-	-	-	-	-	-
1,984.64	-	-	-	-	-	-
1,985.25	-	-	-	-	-	-
1,986.02	-	-	-	-	-	-
1,988.12	-	-	-	-	-	-
1,988.91	-	-	-	-	-	-
1,989.52	-	-	-	-	-	-
1,990.13	-	-	-	-	-	-
1,990.74	3.26	Tcb	NWT	ZE	TCU	LTCU
1,991.35	3.21	Tcb	NWT	ZE	TCU	LTCU
1,991.96	-	-	-	-	-	-
1,992.57	6.73	Tcb	NWT	ZE	TCU	LTCU
1,993.18	-	-	-	-	-	-
1,993.79	-	-	-	-	-	-
1,994.40	-	-	-	-	-	-
1,995.01	-	-	-	-	-	-
1,995.62	-	-	-	-	-	-
1,996.23	2.41	Tcb	NWT	ZE	TCU	LTCU
1,996.84	-	-	-	-	-	-
1,997.45	3.89	Tcb	NWT	ZE	TCU	LTCU
1,998.06	-	-	-	-	-	-
1,998.67	10.02	Tcb	NWT	ZE	TCU	LTCU
1,999.21	8.09	Tcb	NWT	ZE	TCU	LTCU
2,001.01	-	-	-	-	-	-
2,001.71	-	-	-	-	-	-
2,002.32	-	-	-	-	-	-
2,002.93	5.94	Tcb	NWT	ZE	TCU	LTCU
2,003.54	3.63	Tcb	NWT	ZE	TCU	LTCU
2,004.15	3.46	Tcb	NWT	ZE	TCU	LTCU
2,004.76	2.05	Tcb	NWT	ZE	TCU	LTCU
2,005.37	2.60	Tcb	NWT	ZE	TCU	LTCU
2,005.98	-	-	-	-	-	-
2,006.59	-	-	-	-	-	-
2,007.20	-	-	-	-	-	-
2,007.81	-	-	-	-	-	-
2,008.42	-	-	-	-	-	-
2,009.03	4.24	Tcb	NWT	ZE	TCU	LTCU
2,009.64	2.80	Tcb	NWT	ZE	TCU	LTCU
2,010.25	3.42	Tcb	NWT	ZE	TCU	LTCU
2,010.86	2.24	Tcb	NWT	ZE	TCU	LTCU
2,011.47	-	-	-	-	-	-
2,012.08	-	-	-	-	-	-
2,014.36	-	-	-	-	-	-

ER-5-4#2 (continued)

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
2,015.12	-	-	-	-	-	-
2,015.73	4.51	Tcb	NWT	ZE	TCU	LTCU
2,016.34	-	-	-	-	-	-
2,016.95	2.03	Tcb	NWT	ZE	TCU	LTCU
2,017.56	2.34	Tcb	NWT	ZE	TCU	LTCU
2,018.17	3.24	Tcb	NWT	ZE	TCU	LTCU
2,018.78	-	-	-	-	-	-
2,019.39	1.21	Tcb	NWT	ZE	TCU	LTCU
2,020.00	5.32	Tcb	NWT	ZE	TCU	LTCU
2,020.61	4.58	Tcb	NWT	ZE	TCU	LTCU
2,021.22	1.80	Tcb	NWT	ZE	TCU	LTCU
2,021.83	2.12	Tcb	NWT	ZE	TCU	LTCU
2,022.44	1.52	Tcb	NWT	ZE	TCU	LTCU
2,023.05	-	-	-	-	-	-
2,023.66	5.90	Tcb	NWT	ZE	TCU	LTCU
2,024.27	-	-	-	-	-	-
2,024.88	-	-	-	-	-	-
2,025.46	-	-	-	-	-	-

Dashes indicate hydraulic conductivity values are below detection within the interval.
Only the intervals within well screen are presented.

ER-EC-6

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
497 37	15 33	Tpb	LA	GL	LFA	BA
497 98	15 44	Tpb	LA	GL	LFA	BA
498 59	1 85	Tpb	LA	GL	LFA	BA
499 20	-	-	-	-	-	-
499 81	-	-	-	-	-	-
500 42	-	-	-	-	-	-
501 03	-	-	-	-	-	-
501 64	-	-	-	-	-	-
502 25	-	-	-	-	-	-
502 86	-	-	-	-	-	-
503 47	-	-	-	-	-	-
504 08	0 82	Tpb	LA	DV	LFA	BA
504 63	3 28	Tpb	LA	DV	LFA	BA
518 95	1 79	Tpb	LA	DV	LFA	BA
519 56	1 47	Tpb	LA	DV	LFA	BA
520 17	-	-	-	-	-	-
520 78	-	-	-	-	-	-
521 39	-	-	-	-	-	-
522 00	-	-	-	-	-	-
522 61	-	-	-	-	-	-
523 22	-	-	-	-	-	-
523 83	-	-	-	-	-	-
524 44	-	-	-	-	-	-
525 05	-	-	-	-	-	-
525 66	-	-	-	-	-	-
526 15	-	-	-	-	-	-
540 47	-	-	-	-	-	-
541 08	-	-	-	-	-	-
541 69	-	-	-	-	-	-
542 30	-	-	-	-	-	-
542 91	-	-	-	-	-	-
543 52	-	-	-	-	-	-
544 13	-	-	-	-	-	-
544 74	-	-	-	-	-	-
545 35	-	-	-	-	-	-
545 96	-	-	-	-	-	-
546 57	-	-	-	-	-	-
547 18	-	-	-	-	-	-
547 66	-	-	-	-	-	-
561 99	-	-	-	-	-	-
562 60	-	-	-	-	-	-
563 21	-	-	-	-	-	-
563 82	-	-	-	-	-	-
564 43	-	-	-	-	-	-
565 04	-	-	-	-	-	-
565 65	-	-	-	-	-	-
566 26	-	-	-	-	-	-
566 87	-	-	-	-	-	-
567 48	-	-	-	-	-	-
568 09	-	-	-	-	-	-
568 70	-	-	-	-	-	-
569 18	0 70	Tpb	LA	DV	LFA	BA
669 95	-	-	-	-	-	-
670 56	-	-	-	-	-	-
671 17	-	-	-	-	-	-
671 78	-	-	-	-	-	-
672 39	-	-	-	-	-	-
673 00	-	-	-	-	-	-
673 61	-	-	-	-	-	-
674 22	-	-	-	-	-	-
674 83	-	-	-	-	-	-
675 44	-	-	-	-	-	-
676 05	-	-	-	-	-	-

ER-EC-6 (continued)

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
676.66	-	-	-	-	-	-
677.14	-	-	-	-	-	-
691.47	-	-	-	-	-	-
692.08	-	-	-	-	-	-
692.69	-	-	-	-	-	-
693.30	-	-	-	-	-	-
693.91	-	-	-	-	-	-
694.52	-	-	-	-	-	-
695.13	-	-	-	-	-	-
695.74	-	-	-	-	-	-
696.35	-	-	-	-	-	-
696.96	-	-	-	-	-	-
697.57	-	-	-	-	-	-
698.17	-	-	-	-	-	-
698.72	-	-	-	-	-	-
712.99	-	-	-	-	-	-
713.60	-	-	-	-	-	-
714.21	-	-	-	-	-	-
714.82	-	-	-	-	-	-
715.43	-	-	-	-	-	-
716.04	-	-	-	-	-	-
716.65	-	-	-	-	-	-
717.26	-	-	-	-	-	-
717.86	-	-	-	-	-	-
718.47	-	-	-	-	-	-
719.08	-	-	-	-	-	-
719.69	-	-	-	-	-	-
720.18	-	-	-	-	-	-
734.45	-	-	-	-	-	-
735.06	-	-	-	-	-	-
735.67	-	-	-	-	-	-
736.27	-	-	-	-	-	-
736.88	-	-	-	-	-	-
737.49	-	-	-	-	-	-
738.10	-	-	-	-	-	-
738.71	-	-	-	-	-	-
739.32	-	-	-	-	-	-
739.93	-	-	-	-	-	-
740.54	-	-	-	-	-	-
741.15	-	-	-	-	-	-
741.64	-	-	-	-	-	-
755.90	-	-	-	-	-	-
756.51	-	-	-	-	-	-
757.12	-	-	-	-	-	-
757.73	-	-	-	-	-	-
758.34	-	-	-	-	-	-
758.95	-	-	-	-	-	-
759.56	-	-	-	-	-	-
760.17	-	-	-	-	-	-
760.78	-	-	-	-	-	-
761.39	-	-	-	-	-	-
762.00	-	-	-	-	-	-
762.61	-	-	-	-	-	-
763.10	-	-	-	-	-	-
1,048.82	-	-	-	-	-	-
1,049.43	-	-	-	-	-	-
1,050.04	-	-	-	-	-	-
1,050.65	-	-	-	-	-	-
1,051.26	-	-	-	-	-	-
1,051.86	-	-	-	-	-	-
1,052.47	-	-	-	-	-	-
1,053.08	-	-	-	-	-	-
1,053.69	-	-	-	-	-	-

ER-EC-6 (continued)

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
1,054.30	-	-	-	-	-	-
1,054.91	-	-	-	-	-	-
1,055.52	-	-	-	-	-	-
1,056.01	-	-	-	-	-	-
1,057.96	-	-	-	-	-	-
1,058.57	-	-	-	-	-	-
1,059.18	-	-	-	-	-	-
1,059.79	-	-	-	-	-	-
1,060.40	-	-	-	-	-	-
1,061.01	-	-	-	-	-	-
1,061.62	-	-	-	-	-	-
1,062.23	-	-	-	-	-	-
1,062.84	-	-	-	-	-	-
1,063.45	-	-	-	-	-	-
1,064.06	-	-	-	-	-	-
1,064.67	-	-	-	-	-	-
1,065.15	-	-	-	-	-	-
1,067.17	-	-	-	-	-	-
1,067.78	-	-	-	-	-	-
1,068.38	-	-	-	-	-	-
1,068.99	-	-	-	-	-	-
1,069.60	-	-	-	-	-	-
1,070.21	-	-	-	-	-	-
1,070.82	-	-	-	-	-	-
1,071.43	-	-	-	-	-	-
1,072.04	-	-	-	-	-	-
1,072.65	-	-	-	-	-	-
1,073.26	-	-	-	-	-	-
1,073.87	-	-	-	-	-	-
1,074.42	-	-	-	-	-	-
1,088.75	-	-	-	-	-	-
1,089.36	-	-	-	-	-	-
1,089.96	-	-	-	-	-	-
1,090.57	-	-	-	-	-	-
1,091.18	-	-	-	-	-	-
1,091.79	-	-	-	-	-	-
1,092.40	-	-	-	-	-	-
1,093.01	-	-	-	-	-	-
1,093.62	-	-	-	-	-	-
1,094.23	-	-	-	-	-	-
1,094.84	-	-	-	-	-	-
1,095.45	-	-	-	-	-	-
1,096.00	-	-	-	-	-	-
1,110.26	-	-	-	-	-	-
1,110.87	-	-	-	-	-	-
1,111.48	-	-	-	-	-	-
1,112.09	-	-	-	-	-	-
1,112.70	-	-	-	-	-	-
1,113.31	-	-	-	-	-	-
1,113.92	-	-	-	-	-	-
1,114.53	-	-	-	-	-	-
1,115.14	-	-	-	-	-	-
1,115.75	-	-	-	-	-	-
1,116.36	-	-	-	-	-	-
1,116.97	-	-	-	-	-	-
1,117.52	-	-	-	-	-	-
1,131.78	-	-	-	-	-	-
1,132.39	-	-	-	-	-	-
1,133.00	-	-	-	-	-	-
1,133.61	-	-	-	-	-	-
1,134.22	-	-	-	-	-	-
1,134.83	-	-	-	-	-	-
1,135.44	-	-	-	-	-	-

ER-EC-6 (continued)

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
1,136.05	-	-	-	-	-	-
1,136.66	-	-	-	-	-	-
1,137.27	-	-	-	-	-	-
1,137.88	-	-	-	-	-	-
1,138.49	-	-	-	-	-	-
1,139.04	-	-	-	-	-	-
1,153.36	-	-	-	-	-	-
1,153.97	-	-	-	-	-	-
1,154.58	-	-	-	-	-	-
1,155.19	-	-	-	-	-	-
1,155.80	-	-	-	-	-	-
1,156.41	-	-	-	-	-	-
1,157.02	-	-	-	-	-	-
1,157.63	-	-	-	-	-	-
1,158.24	-	-	-	-	-	-
1,158.85	-	-	-	-	-	-
1,159.46	-	-	-	-	-	-
1,160.07	-	-	-	-	-	-
1,160.62	-	-	-	-	-	-

Dashes indicate hydraulic conductivity values are below detection within the interval
Only the intervals within well screen are presented

ER-EC-7

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
281.39	50.31	Tfbw	LA	QF	LFA	FCCM
282.00	-	-	-	-	-	-
282.61	-	-	-	-	-	-
283.22	-	-	-	-	-	-
283.83	-	-	-	-	-	-
284.44	6.13	Tfbw	LA	QF	LFA	FCCM
285.05	-	-	-	-	-	-
285.66	-	-	-	-	-	-
286.27	-	-	-	-	-	-
286.88	-	-	-	-	-	-
287.49	-	-	-	-	-	-
288.22	-	-	-	-	-	-
292.18	-	-	-	-	-	-
292.79	-	-	-	-	-	-
293.40	-	-	-	-	-	-
294.01	-	-	-	-	-	-
294.62	-	-	-	-	-	-
295.23	-	-	-	-	-	-
295.84	-	-	-	-	-	-
296.45	-	-	-	-	-	-
297.00	-	-	-	-	-	-
297.45	-	-	-	-	-	-
299.34	-	-	-	-	-	-
304.07	-	-	-	-	-	-
310.16	-	-	-	-	-	-
346.74	-	-	-	-	-	-
352.84	-	-	-	-	-	-
358.93	-	-	-	-	-	-
365.03	-	-	-	-	-	-
369.23	-	-	-	-	-	-
370.70	-	-	-	-	-	-
371.31	17.53	Tfb	LA	var	LFA	FCCM
371.92	14.26	Tfb	LA	var	LFA	FCCM
372.53	6.67	Tfb	LA	var	LFA	FCCM
373.14	-	-	-	-	-	-
373.75	-	-	-	-	-	-
374.36	-	-	-	-	-	-
374.96	-	-	-	-	-	-
378.50	-	-	-	-	-	-
379.08	-	-	-	-	-	-
379.78	-	-	-	-	-	-
380.39	13.37	Tfb	LA	var	LFA	FCCM
381.00	-	-	-	-	-	-
381.61	-	-	-	-	-	-
382.22	-	-	-	-	-	-
382.83	-	-	-	-	-	-
383.44	-	-	-	-	-	-
384.05	-	-	-	-	-	-
384.66	-	-	-	-	-	-

Dashes indicate hydraulic conductivity values are below detection within the interval
Only the intervals within well screen are presented

ER-EC-8

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
209.03	27.95	Tfb	NWT	QZ	TCU	FCCM
209.64	26.89	Tfb	NWT	QZ	TCU	FCCM
210.25	12.07	Tfb	NWT	QZ	TCU	FCCM
210.86	10.55	Tfb	NWT	QZ	TCU	FCCM
211.47	-	-	-	-	-	-
212.08	6.09	Tfb	NWT	QZ	TCU	FCCM
212.69	10.25	Tfb	NWT	QZ	TCU	FCCM
213.30	16.97	Tfb	NWT	QZ	TCU	FCCM
213.91	16.61	Tfb	NWT	QZ	TCU	FCCM
214.52	-	-	-	-	-	-
215.13	-	-	-	-	-	-
215.74	-	-	-	-	-	-
216.35	-	-	-	-	-	-
218.18	-	-	-	-	-	-
218.79	-	-	-	-	-	-
219.40	-	-	-	-	-	-
220.00	9.84	Tfb	NWT	QZ	TCU	FCCM
220.61	18.08	Tfb	NWT	QZ	TCU	FCCM
221.22	34.30	Tfb	NWT	QZ	TCU	FCCM
221.83	36.21	Tfb	NWT	QZ	TCU	FCCM
222.44	21.22	Tfb	NWT	QZ	TCU	FCCM
223.05	17.59	Tfb	NWT	QZ	TCU	FCCM
223.66	17.57	Tfb	NWT	QZ	TCU	FCCM
224.27	11.34	Tfb	NWT	QZ	TCU	FCCM
224.88	14.86	Tfb	NWT	QZ	TCU	FCCM
225.49	11.82	Tfb	NWT	QZ	TCU	FCCM
236.59	13.97	Tfb	NWT	QZ	TCU	FCCM
237.20	22.79	Tfb	NWT	QZ	TCU	FCCM
237.80	24.52	Tfb	NWT	QZ	TCU	FCCM
238.41	20.31	Tfb	NWT	QZ	TCU	FCCM
239.02	14.80	Tfb	NWT	QZ	TCU	FCCM
239.63	17.08	Tfb	NWT	QZ	TCU	FCCM
240.24	18.93	Tfb	NWT	QZ	TCU	FCCM
240.85	15.55	Tfb	NWT	QZ	TCU	FCCM
241.46	9.24	Tfb	NWT	QZ	TCU	FCCM
242.07	7.51	Tfb	NWT	QZ	TCU	FCCM
242.68	-	-	-	-	-	-
243.29	-	-	-	-	-	-
243.90	4.58	Tfb	NWT	QZ	TCU	FCCM
254.93	7.28	Tfb	NWT	QZ	TCU	FCCM
255.54	10.83	Tfb	NWT	QZ	TCU	FCCM
256.15	12.25	Tfb	NWT	QZ	TCU	FCCM
256.76	6.95	Tfb	NWT	QZ	TCU	FCCM
257.37	-	-	-	-	-	-
257.98	-	-	-	-	-	-
258.59	-	-	-	-	-	-
259.20	-	-	-	-	-	-
259.81	-	-	-	-	-	-
260.42	-	-	-	-	-	-
261.03	-	-	-	-	-	-
261.64	-	-	-	-	-	-
262.25	-	-	-	-	-	-
273.34	-	-	-	-	-	-
273.95	-	-	-	-	-	-
274.56	2.85	Tfb	NWT	QZ	TCU	FCCM
275.17	-	-	-	-	-	-
275.78	-	-	-	-	-	-
276.39	-	-	-	-	-	-
277.00	-	-	-	-	-	-
277.61	-	-	-	-	-	-
278.22	-	-	-	-	-	-
278.83	-	-	-	-	-	-
279.44	-	-	-	-	-	-

ER-EC-8 (continued)

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
280.05	-	-	-	-	-	-
280.66	-	-	-	-	-	-
291.63	-	-	-	-	-	-
292.24	6.36	Tfb	NWT	QZ	TCU	FCCM
292.85	-	-	-	-	-	-
293.46	-	-	-	-	-	-
294.07	-	-	-	-	-	-
294.68	-	-	-	-	-	-
295.29	-	-	-	-	-	-
295.90	-	-	-	-	-	-
296.51	-	-	-	-	-	-
297.12	-	-	-	-	-	-
297.73	-	-	-	-	-	-
298.34	-	-	-	-	-	-
298.95	-	-	-	-	-	-
441.90	-	-	-	-	-	-
442.51	-	-	-	-	-	-
443.12	-	-	-	-	-	-
443.73	-	-	-	-	-	-
444.34	-	-	-	-	-	-
444.95	-	-	-	-	-	-
445.56	-	-	-	-	-	-
446.17	-	-	-	-	-	-
446.78	-	-	-	-	-	-
447.39	-	-	-	-	-	-
448.00	-	-	-	-	-	-
448.60	-	-	-	-	-	-
449.21	-	-	-	-	-	-
451.04	-	-	-	-	-	-
451.65	-	-	-	-	-	-
452.26	-	-	-	-	-	-
452.87	-	-	-	-	-	-
453.48	-	-	-	-	-	-
454.09	-	-	-	-	-	-
454.70	-	-	-	-	-	-
455.31	-	-	-	-	-	-
455.92	-	-	-	-	-	-
456.53	-	-	-	-	-	-
457.14	-	-	-	-	-	-
457.75	-	-	-	-	-	-
458.36	-	-	-	-	-	-
512.00	-	-	-	-	-	-
512.61	-	-	-	-	-	-
513.22	5.68	Tmap	NWT	QF	TCU	TMCM
513.83	-	-	-	-	-	-
514.44	-	-	-	-	-	-
515.05	-	-	-	-	-	-
515.66	-	-	-	-	-	-
516.27	-	-	-	-	-	-
516.88	-	-	-	-	-	-
517.49	-	-	-	-	-	-
518.10	5.98	Tmap	NWT	QF	TCU	TMCM
518.71	-	-	-	-	-	-
519.32	-	-	-	-	-	-
530.29	-	-	-	-	-	-
530.90	-	-	-	-	-	-
531.51	-	-	-	-	-	-
532.12	-	-	-	-	-	-
532.73	5.16	Tmap	NWT	QF	TCU	TMCM
533.34	-	-	-	-	-	-
533.95	-	-	-	-	-	-
534.56	-	-	-	-	-	-
535.17	-	-	-	-	-	-

ER-EC-8 (continued)

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
535 78	-	-	-	-	-	-
536 39	-	-	-	-	-	-
537 00	-	-	-	-	-	-
537 61	-	-	-	-	-	-

Dashes indicate hydraulic conductivity values are below detection within the interval
Only the intervals within well screen are presented

ER-6-1

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
540.56	-	-	-	-	-	-
542.09	-	-	-	-	-	-
543.61	-	-	-	-	-	-
545.13	-	-	-	-	-	-
546.66	-	-	-	-	-	-
548.18	-	-	-	-	-	-
549.71	-	-	-	-	-	-
551.23	-	-	-	-	-	-
552.75	-	-	-	-	-	-
554.28	-	-	-	-	-	-
555.80	1.55	DSs	Dol	Unalt	CA	LCA
557.33	1.55	DSs	Dol	Unalt	CA	LCA
558.85	1.55	DSs	Dol	Unalt	CA	LCA
560.37	1.55	DSs	Dol	Unalt	CA	LCA
561.90	1.55	DSs	Dol	Unalt	CA	LCA
563.42	1.55	DSs	Dol	Unalt	CA	LCA
564.95	1.55	DSs	Dol	Unalt	CA	LCA
566.47	1.55	DSs	Dol	Unalt	CA	LCA
567.99	1.55	DSs	Dol	Unalt	CA	LCA
569.52	1.55	DSs	Dol	Unalt	CA	LCA
571.04	1.55	DSs	Dol	Unalt	CA	LCA
572.57	1.55	DSs	Dol	Unalt	CA	LCA
574.09	1.55	DSs	Dol	Unalt	CA	LCA
575.61	1.55	DSs	Dol	Unalt	CA	LCA
577.14	1.55	DSs	Dol	Unalt	CA	LCA
578.66	1.53	DSs	Dol	Unalt	CA	LCA
580.19	1.52	DSs	Dol	Unalt	CA	LCA
581.71	1.52	DSs	Dol	Unalt	CA	LCA
583.23	1.52	DSs	Dol	Unalt	CA	LCA
584.76	1.52	DSs	Dol	Unalt	CA	LCA
586.28	1.52	DSs	Dol	Unalt	CA	LCA
587.81	1.52	DSs	Dol	Unalt	CA	LCA
589.33	1.52	DSs	Dol	Unalt	CA	LCA
590.85	1.52	DSs	Dol	Unalt	CA	LCA
592.38	1.52	DSs	Dol	Unalt	CA	LCA
593.90	1.52	DSs	Dol	Unalt	CA	LCA
595.43	1.52	DSs	Dol	Unalt	CA	LCA
596.95	1.52	DSs	Dol	Unalt	CA	LCA
598.47	1.52	DSs	Dol	Unalt	CA	LCA
600.00	1.52	DSs	Dol	Unalt	CA	LCA
601.52	3.42	DSs	Dol	Unalt	CA	LCA
603.05	3.42	DSs	Dol	Unalt	CA	LCA
604.57	3.42	DSs	Dol	Unalt	CA	LCA
606.09	3.42	DSs	Dol	Unalt	CA	LCA
607.62	3.42	DSs	Dol	Unalt	CA	LCA
609.14	3.42	DSs	Dol	Unalt	CA	LCA
610.67	3.42	DSs	Dol	Unalt	CA	LCA
612.19	3.42	DSs	Dol	Unalt	CA	LCA
613.71	3.43	DSs	Dol	Unalt	CA	LCA
615.24	0.42	DSs	Dol	Unalt	CA	LCA
616.76	0.42	DSs	Dol	Unalt	CA	LCA
618.29	0.43	DSs	Dol	Unalt	CA	LCA
619.81	0.43	DSs	Dol	Unalt	CA	LCA
621.33	0.43	DSs	Dol	Unalt	CA	LCA
622.86	0.43	DSs	Dol	Unalt	CA	LCA
624.38	0.46	DSs	Dol	Unalt	CA	LCA
625.91	0.47	DSs	Dol	Unalt	CA	LCA
627.43	0.47	DSs	Dol	Unalt	CA	LCA
628.95	0.47	DSs	Dol	Unalt	CA	LCA
630.48	0.47	DSs	Dol	Unalt	CA	LCA
632.00	0.47	DSs	Dol	Unalt	CA	LCA
633.53	0.47	DSs	Dol	Unalt	CA	LCA

ER-6-1 (continued)

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
635.05	0.47	DSs	Dol	Unalt	CA	LCA
636.57	0.47	DSs	Dol	Unalt	CA	LCA
638.10	0.47	DSs	Dol	Unalt	CA	LCA
639.62	0.40	DSs	Dol	Unalt	CA	LCA
641.15	0.19	DSs	Dol	Unalt	CA	LCA
642.67	0.19	DSs	Dol	Unalt	CA	LCA
644.19	0.19	DSs	Dol	Unalt	CA	LCA
645.72	0.19	DSs	Dol	Unalt	CA	LCA
647.24	0.19	DSs	Dol	Unalt	CA	LCA
648.77	0.19	DSs	Dol	Unalt	CA	LCA
650.29	0.19	DSs	Dol	Unalt	CA	LCA
651.81	0.26	DSs	Dol	Unalt	CA	LCA
653.34	0.30	DSs	Dol	Unalt	CA	LCA
654.86	0.30	DSs	Dol	Unalt	CA	LCA
656.39	0.30	DSs	Dol	Unalt	CA	LCA
657.91	0.30	DSs	Dol	Unalt	CA	LCA
659.43	0.30	DSs	Dol	Unalt	CA	LCA
660.96	0.30	DSs	Dol	Unalt	CA	LCA
662.48	0.30	DSs	Dol	Unalt	CA	LCA
664.01	0.30	DSs	Dol	Unalt	CA	LCA
665.53	0.30	DSs	Dol	Unalt	CA	LCA
667.05	0.30	DSs	Dol	Unalt	CA	LCA
668.58	0.30	DSs	Dol	Unalt	CA	LCA
670.10	0.29	DSs	Dol	Unalt	CA	LCA
671.63	0.28	DSs	Dol	Unalt	CA	LCA
673.15	0.28	DSs	Dol	Unalt	CA	LCA
674.67	0.28	DSs	Dol	Unalt	CA	LCA
676.20	0.28	DSs	Dol	Unalt	CA	LCA
677.72	0.28	DSs	Dol	Unalt	CA	LCA
679.25	0.28	DSs	Dol	Unalt	CA	LCA
680.77	0.28	DSs	Dol	Unalt	CA	LCA
682.29	0.28	DSl	Dol	Unalt	CA	LCA
683.82	0.52	DSl	Dol	Unalt	CA	LCA
685.34	0.52	DSl	Dol	Unalt	CA	LCA
686.87	0.52	DSl	Dol	Unalt	CA	LCA
688.39	0.52	DSl	Dol	Unalt	CA	LCA
689.91	0.52	DSl	Dol	Unalt	CA	LCA
691.44	0.52	DSl	Dol	Unalt	CA	LCA
692.96	0.52	DSl	Dol	Unalt	CA	LCA
694.49	0.52	DSl	Dol	Unalt	CA	LCA
696.01	0.52	DSl	Dol	Unalt	CA	LCA
697.53	0.53	DSl	Dol	Unalt	CA	LCA
699.06	0.53	DSl	Dol	Unalt	CA	LCA
700.58	0.54	DSl	Dol	Unalt	CA	LCA
702.11	0.55	DSl	Dol	Unalt	CA	LCA
703.63	0.55	DSl	Dol	Unalt	CA	LCA
705.15	0.55	DSl	Dol	Unalt	CA	LCA
706.68	7.81	DSl	Dol	Unalt	CA	LCA
708.20	7.81	DSl	Dol	Unalt	CA	LCA
709.73	7.81	DSl	Dol	Unalt	CA	LCA
711.25	7.81	DSl	Dol	Unalt	CA	LCA
712.77	7.82	DSl	Dol	Unalt	CA	LCA
714.30	7.83	DSl	Dol	Unalt	CA	LCA
715.82	7.83	DSl	Dol	Unalt	CA	LCA
717.35	49.56	DSl	Dol	Unalt	CA	LCA
718.87	49.66	DSl	Dol	Unalt	CA	LCA
720.39	49.72	DSl	Dol	Unalt	CA	LCA
721.92	49.80	DSl	Dol	Unalt	CA	LCA
723.44	49.88	DSl	Dol	Unalt	CA	LCA
724.97	49.96	DSl	Dol	Unalt	CA	LCA
726.49	3.48	DSl	Dol	Unalt	CA	LCA
728.01	3.48	DSl	Dol	Unalt	CA	LCA
729.54	3.48	DSl	Dol	Unalt	CA	LCA

ER-6-1 (continued)

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
731.06	3.48	DSI	Dol	Unalt	CA	LCA
732.59	3.47	DSI	Dol	Unalt	CA	LCA
734.11	3.47	DSI	Dol	Unalt	CA	LCA
735.63	3.47	DSI	Dol	Unalt	CA	LCA
737.16	3.47	DSI	Dol	Unalt	CA	LCA
738.68	3.48	DSI	Dol	Unalt	CA	LCA
740.21	3.48	DSI	Dol	Unalt	CA	LCA
741.73	3.48	DSI	Dol	Unalt	CA	LCA
743.25	3.48	DSI	Dol	Unalt	CA	LCA
744.78	3.48	DSI	Dol	Unalt	CA	LCA
746.30	3.48	DSI	Dol	Unalt	CA	LCA
747.83	3.48	DSI	Dol	Unalt	CA	LCA
749.35	3.49	DSI	Dol	Unalt	CA	LCA
750.87	2.90	DSI	Dol	Unalt	CA	LCA
752.40	2.90	DSI	Dol	Unalt	CA	LCA
753.92	2.90	DSI	Dol	Unalt	CA	LCA
755.45	2.89	DSI	Dol	Unalt	CA	LCA
756.97	2.89	DSI	Dol	Unalt	CA	LCA
758.49	2.89	DSI	Dol	Unalt	CA	LCA
760.02	2.89	DSI	Dol	Unalt	CA	LCA
761.54	2.89	DSI	Dol	Unalt	CA	LCA
763.07	2.89	DSI	Dol	Unalt	CA	LCA
764.59	2.89	DSI	Dol	Unalt	CA	LCA
766.11	2.90	DSI	Dol	Unalt	CA	LCA
767.64	0.002	DSI	Dol	Unalt	CA	LCA
769.16	0.002	DSI	Dol	Unalt	CA	LCA
770.69	0.002	DSI	Dol	Unalt	CA	LCA
772.21	0.002	DSI	Dol	Unalt	CA	LCA
773.73	0.002	DSI	Dol	Unalt	CA	LCA
775.26	0.002	DSI	Dol	Unalt	CA	LCA
776.78	0.002	DSI	Dol	Unalt	CA	LCA
778.31	0.002	DSI	Dol	Unalt	CA	LCA
779.83	0.002	DSI	Dol	Unalt	CA	LCA
781.35	0.002	DSI	Dol	Unalt	CA	LCA
782.88	0.002	DSI	Dol	Unalt	CA	LCA
784.40	0.002	DSI	Dol	Unalt	CA	LCA
785.93	0.002	DSI	Dol	Unalt	CA	LCA
787.45	0.002	DSI	Dol	Unalt	CA	LCA
788.97	0.002	DSI	Dol	Unalt	CA	LCA
790.50	0.002	DSI	Dol	Unalt	CA	LCA
792.02	-	-	-	-	-	-
793.55	-	-	-	-	-	-
795.07	-	-	-	-	-	-
796.59	-	-	-	-	-	-
798.12	-	-	-	-	-	-
799.64	-	-	-	-	-	-
801.17	0.50	DSI	Dol	Unalt	CA	LCA
802.69	0.50	DSI	Dol	Unalt	CA	LCA
804.21	0.50	DSI	Dol	Unalt	CA	LCA
805.74	0.50	DSI	Dol	Unalt	CA	LCA
807.26	0.50	DSI	Dol	Unalt	CA	LCA
808.79	0.50	DSI	Dol	Unalt	CA	LCA
810.31	0.50	DSI	Dol	Unalt	CA	LCA
811.83	0.50	DSI	Dol	Unalt	CA	LCA
813.36	0.50	DSI	Dol	Unalt	CA	LCA
814.88	0.50	DSI	Dol	Unalt	CA	LCA
816.41	0.50	DSI	Dol	Unalt	CA	LCA
817.93	0.50	DSI	Dol	Unalt	CA	LCA
819.45	0.50	DSI	Dol	Unalt	CA	LCA
820.98	0.50	DSI	Dol	Unalt	CA	LCA
822.50	0.50	DSI	Dol	Unalt	CA	LCA
824.03	0.51	DSI	Dol	Unalt	CA	LCA
825.55	0.51	DSI	Dol	Unalt	CA	LCA

ER-6-1 (continued)

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
827.07	0.51	DSI	Dol	Unalt	CA	LCA
828.60	0.51	DSI	Dol	Unalt	CA	LCA
830.12	0.51	DSI	Dol	Unalt	CA	LCA
831.65	0.51	DSI	Dol	Unalt	CA	LCA
833.17	0.51	DSI	Dol	Unalt	CA	LCA
834.69	0.51	DSI	Dol	Unalt	CA	LCA
836.22	0.51	DSI	Dol	Unalt	CA	LCA
837.74	0.51	DSI	Dol	Unalt	CA	LCA
839.27	0.51	DSI	Dol	Unalt	CA	LCA
840.79	0.51	DSI	Dol	Unalt	CA	LCA
842.31	0.51	DSI	Dol	Unalt	CA	LCA
843.84	0.51	DSI	Dol	Unalt	CA	LCA
845.36	0.51	DSI	Dol	Unalt	CA	LCA
846.89	0.51	DSI	Dol	Unalt	CA	LCA
848.41	0.51	DSI	Dol	Unalt	CA	LCA
849.93	2.70	DSI	Dol	Unalt	CA	LCA
851.46	2.70	DSI	Dol	Unalt	CA	LCA
852.98	2.71	DSI	Dol	Unalt	CA	LCA
854.51	2.71	DSI	Dol	Unalt	CA	LCA
856.03	2.71	DSI	Dol	Unalt	CA	LCA
857.55	2.71	DSI	Dol	Unalt	CA	LCA
859.08	2.72	DSI	Dol	Unalt	CA	LCA
860.60	2.72	DSI	Dol	Unalt	CA	LCA
862.13	2.72	DSI	Dol	Unalt	CA	LCA
863.65	2.72	DSI	Dol	Unalt	CA	LCA
865.17	2.72	DSI	Dol	Unalt	CA	LCA
866.70	2.72	DSI	Dol	Unalt	CA	LCA
868.22	2.71	DSI	Dol	Unalt	CA	LCA
869.75	2.71	DSI	Dol	Unalt	CA	LCA
871.27	2.71	DSI	Dol	Unalt	CA	LCA
872.79	6.69	DSI	Dol	Unalt	CA	LCA
874.32	6.70	DSI	Dol	Unalt	CA	LCA
875.84	6.70	DSI	Dol	Unalt	CA	LCA
877.37	6.70	DSI	Dol	Unalt	CA	LCA
878.89	6.70	DSI	Dol	Unalt	CA	LCA
880.41	6.71	DSI	Dol	Unalt	CA	LCA
881.94	6.71	DSI	Dol	Unalt	CA	LCA
883.46	6.71	DSI	Dol	Unalt	CA	LCA
884.99	6.71	DSI	Dol	Unalt	CA	LCA
886.51	6.72	DSI	Dol	Unalt	CA	LCA
888.03	6.72	DSI	Dol	Unalt	CA	LCA
889.56	6.72	DSI	Dol	Unalt	CA	LCA
891.08	6.72	Oes	Dol	Unalt	CA	LCA
892.61	6.72	Oes	Dol	Unalt	CA	LCA
894.13	6.73	Oes	Dol	Unalt	CA	LCA
895.65	6.73	Oes	Dol	Unalt	CA	LCA
897.18	6.77	Oes	Dol	Unalt	CA	LCA
898.70	-	-	-	-	-	-
900.23	-	-	-	-	-	-
901.75	-	-	-	-	-	-
903.27	-	-	-	-	-	-
904.80	-	-	-	-	-	-
906.32	-	-	-	-	-	-
907.85	-	-	-	-	-	-
909.37	-	-	-	-	-	-
910.89	-	-	-	-	-	-
912.42	-	-	-	-	-	-

Dashes indicate hydraulic conductivity values are below detection within the interval
Only the intervals within well screen are presented

ER-6-1#2

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
568.73	-	-	-	-	-	-
570.25	-	-	-	-	-	-
571.77	-	-	-	-	-	-
573.30	-	-	-	-	-	-
574.82	-	-	-	-	-	-
576.35	-	-	-	-	-	-
577.87	-	-	-	-	-	-
579.39	-	-	-	-	-	-
580.92	-	-	-	-	-	-
582.44	-	-	-	-	-	-
583.97	-	-	-	-	-	-
585.49	-	-	-	-	-	-
587.01	-	-	-	-	-	-
588.54	-	-	-	-	-	-
590.06	-	-	-	-	-	-
591.59	-	-	-	-	-	-
593.11	-	-	-	-	-	-
594.63	-	-	-	-	-	-
596.16	-	-	-	-	-	-
597.68	-	-	-	-	-	-
599.21	-	-	-	-	-	-
600.73	-	-	-	-	-	-
602.25	0.64	DSI	Dol	Unalt	CA	LCA
603.78	0.64	DSI	Dol	Unalt	CA	LCA
605.30	0.64	DSI	Dol	Unalt	CA	LCA
606.83	0.64	DSI	Dol	Unalt	CA	LCA
608.35	0.64	DSI	Dol	Unalt	CA	LCA
609.87	0.64	DSI	Dol	Unalt	CA	LCA
611.40	0.64	DSI	Dol	Unalt	CA	LCA
612.92	0.64	DSI	Dol	Unalt	CA	LCA
614.45	0.64	DSI	Dol	Unalt	CA	LCA
615.97	0.64	DSI	Dol	Unalt	CA	LCA
617.49	0.64	DSI	Dol	Unalt	CA	LCA
619.02	0.64	DSI	Dol	Unalt	CA	LCA
620.54	0.64	DSI	Dol	Unalt	CA	LCA
622.07	0.64	DSI	Dol	Unalt	CA	LCA
623.59	0.64	DSI	Dol	Unalt	CA	LCA
625.11	0.64	DSI	Dol	Unalt	CA	LCA
626.64	2.33	DSI	Dol	Unalt	CA	LCA
628.16	2.33	DSI	Dol	Unalt	CA	LCA
629.69	2.33	DSI	Dol	Unalt	CA	LCA
631.21	2.33	DSI	Dol	Unalt	CA	LCA
632.73	2.33	DSI	Dol	Unalt	CA	LCA
634.26	2.33	DSI	Dol	Unalt	CA	LCA
635.78	2.33	DSI	Dol	Unalt	CA	LCA
637.31	-	-	-	-	-	-
638.83	-	-	-	-	-	-
640.35	-	-	-	-	-	-
641.88	-	-	-	-	-	-
643.40	-	-	-	-	-	-
644.93	-	-	-	-	-	-
646.45	-	-	-	-	-	-
647.97	-	-	-	-	-	-
649.50	-	-	-	-	-	-
651.02	-	-	-	-	-	-
652.55	9.06	DSI	Dol	Unalt	CA	LCA
654.07	9.06	DSI	Dol	Unalt	CA	LCA
655.59	9.06	DSI	Dol	Unalt	CA	LCA
657.12	-	-	-	-	-	-
658.64	-	-	-	-	-	-
660.17	-	-	-	-	-	-
661.69	-	-	-	-	-	-
663.21	13.05	DSI	Dol	Unalt	CA	LCA

ER-6-1#2 (continued)

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
664.74	13.05	DSI	Dol	Unalt	CA	LCA
666.26	13.05	DSI	Dol	Unalt	CA	LCA
667.79	13.05	DSI	Dol	Unalt	CA	LCA
669.31	13.05	DSI	Dol	Unalt	CA	LCA
670.83	13.05	DSI	Dol	Unalt	CA	LCA
672.36	13.05	DSI	Dol	Unalt	CA	LCA
673.88	13.05	DSI	Dol	Unalt	CA	LCA
675.41	13.05	DSI	Dol	Unalt	CA	LCA
676.93	13.05	DSI	Dol	Unalt	CA	LCA
678.45	13.05	DSI	Dol	Unalt	CA	LCA
679.98	13.05	DSI	Dol	Unalt	CA	LCA
681.50	13.05	DSI	Dol	Unalt	CA	LCA
683.03	13.05	DSI	Dol	Unalt	CA	LCA
684.55	13.05	DSI	Dol	Unalt	CA	LCA
686.07	-	-	-	-	-	-
687.60	-	-	-	-	-	-
689.12	-	-	-	-	-	-
690.65	-	-	-	-	-	-
692.17	-	-	-	-	-	-
693.69	-	-	-	-	-	-
695.22	-	-	-	-	-	-
696.74	-	-	-	-	-	-
698.27	-	-	-	-	-	-
699.79	-	-	-	-	-	-
701.31	-	-	-	-	-	-
702.84	-	-	-	-	-	-
704.36	-	-	-	-	-	-
705.89	-	-	-	-	-	-
707.41	-	-	-	-	-	-
708.93	-	-	-	-	-	-
710.46	-	-	-	-	-	-
711.98	-	-	-	-	-	-
713.51	-	-	-	-	-	-
715.03	-	-	-	-	-	-
716.55	-	-	-	-	-	-
718.08	2.54	DSI	Dol	Unalt	CA	LCA
719.60	2.54	DSI	Dol	Unalt	CA	LCA
721.13	2.54	DSI	Dol	Unalt	CA	LCA
722.65	2.54	DSI	Dol	Unalt	CA	LCA
724.17	2.54	DSI	Dol	Unalt	CA	LCA
725.70	2.54	DSI	Dol	Unalt	CA	LCA
727.22	2.54	DSI	Dol	Unalt	CA	LCA
728.75	2.54	DSI	Dol	Unalt	CA	LCA
730.27	2.54	DSI	Dol	Unalt	CA	LCA
731.79	2.54	DSI	Dol	Unalt	CA	LCA
733.32	2.54	DSI	Dol	Unalt	CA	LCA
734.84	2.54	DSI	Dol	Unalt	CA	LCA
736.37	2.54	DSI	Dol	Unalt	CA	LCA
737.89	2.54	DSI	Dol	Unalt	CA	LCA
739.41	2.54	DSI	Dol	Unalt	CA	LCA
740.94	-	-	-	-	-	-
742.46	-	-	-	-	-	-
743.99	-	-	-	-	-	-
745.51	-	-	-	-	-	-
747.03	-	-	-	-	-	-
748.56	-	-	-	-	-	-
750.08	-	-	-	-	-	-
751.61	-	-	-	-	-	-
753.13	-	-	-	-	-	-
754.65	-	-	-	-	-	-
756.18	-	-	-	-	-	-
757.70	2.56	DSI	Dol	Unalt	CA	LCA
759.23	2.56	DSI	Dol	Unalt	CA	LCA

Er-6-1#2 (continued)

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
760 75	2 56	DSI	Dol	Unalt	CA	LCA
762 27	2 56	DSI	Dol	Unalt	CA	LCA
763 80	2 56	DSI	Dol	Unalt	CA	LCA
765 32	2 56	DSI	Dol	Unalt	CA	LCA
766 85	2 56	DSI	Dol	Unalt	CA	LCA
768 37	2 56	DSI	Dol	Unalt	CA	LCA
769 89	2 56	DSI	Dol	Unalt	CA	LCA
771 42	2 56	DSI	Dol	Unalt	CA	LCA
772 94	2 56	DSI	Dol	Unalt	CA	LCA
774 47	2 56	DSI	Dol	Unalt	CA	LCA
775 99	2 56	DSI	Dol	Unalt	CA	LCA
777 51	2 56	DSI	Dol	Unalt	CA	LCA
779 04	2 56	DSI	Dol	Unalt	CA	LCA
780 56	2 56	DSI	Dol	Unalt	CA	LCA
782 09	2 56	DSI	Dol	Unalt	CA	LCA
783 61	0 35	DSI	Dol	Unalt	CA	LCA
785 13	0 35	DSI	Dol	Unalt	CA	LCA
786 66	0 35	DSI	Dol	Unalt	CA	LCA
788 18	0 35	DSI	Dol	Unalt	CA	LCA
789 71	0 35	DSI	Dol	Unalt	CA	LCA
791 23	0 35	DSI	Dol	Unalt	CA	LCA
792 75	0 35	DSI	Dol	Unalt	CA	LCA
794 28	0 35	DSI	Dol	Unalt	CA	LCA
795 80	0 35	DSI	Dol	Unalt	CA	LCA
797 33	0 35	DSI	Dol	Unalt	CA	LCA
798 85	0 35	DSI	Dol	Unalt	CA	LCA
800 37	0 35	DSI	Dol	Unalt	CA	LCA
801 90	0 35	DSI	Dol	Unalt	CA	LCA
803 42	0 35	DSI	Dol	Unalt	CA	LCA
804 95	0 35	DSI	Dol	Unalt	CA	LCA
806 47	0 35	DSI	Dol	Unalt	CA	LCA
807 99	0 35	DSI	Dol	Unalt	CA	LCA
809 52	0 35	DSI	Dol	Unalt	CA	LCA
811 04	0 35	DSI	Dol	Unalt	CA	LCA
812 57	0 35	DSI	Dol	Unalt	CA	LCA
814 09	0 35	DSI	Dol	Unalt	CA	LCA
815 61	0 35	DSI	Dol	Unalt	CA	LCA
817 14	0 35	DSI	Dol	Unalt	CA	LCA
818 66	0 35	DSI	Dol	Unalt	CA	LCA
820 19	0 35	DSI	Dol	Unalt	CA	LCA
821 71	0 35	DSI	Dol	Unalt	CA	LCA
823 23	0 35	DSI	Dol	Unalt	CA	LCA
824 76	0 35	DSI	Dol	Unalt	CA	LCA
826 28	0 35	DSI	Dol	Unalt	CA	LCA
827 81	0 35	DSI	Dol	Unalt	CA	LCA
829 33	0 35	DSI	Dol	Unalt	CA	LCA
830 85	0 35	DSI	Dol	Unalt	CA	LCA
832 38	0 35	DSI	Dol	Unalt	CA	LCA
833 90	0 35	DSI	Dol	Unalt	CA	LCA
835 43	0 35	DSI	Dol	Unalt	CA	LCA
836 95	0 35	DSI	Dol	Unalt	CA	LCA
838 47	0 35	DSI	Dol	Unalt	CA	LCA
840 00	0 35	DSI	Dol	Unalt	CA	LCA
841 52	0 35	DSI	Dol	Unalt	CA	LCA
843 05	0 35	DSI	Dol	Unalt	CA	LCA
844 57	0 35	DSI	Dol	Unalt	CA	LCA
846 09	0 35	DSI	Dol	Unalt	CA	LCA
847 62	0 35	DSI	Dol	Unalt	CA	LCA
849 14	0 35	DSI	Dol	Unalt	CA	LCA
850 67	0 35	DSI	Dol	Unalt	CA	LCA
852 19	0 35	DSI	Dol	Unalt	CA	LCA
853 71	0 35	DSI	Dol	Unalt	CA	LCA
855 24	0 35	DSI	Dol	Unalt	CA	LCA

ER-6-1#2 (continued)

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
856.76	0.35	DSI	Dol	Unalt	CA	LCA
858.29	0.35	DSI	Dol	Unalt	CA	LCA
859.81	0.35	DSI	Dol	Unalt	CA	LCA
861.33	0.35	DSI	Dol	Unalt	CA	LCA
862.86	0.35	DSI	Dol	Unalt	CA	LCA
864.38	0.35	DSI	Dol	Unalt	CA	LCA
865.91	8.15	DSI	Dol	Unalt	CA	LCA
867.43	8.15	DSI	Dol	Unalt	CA	LCA
868.95	8.15	DSI	Dol	Unalt	CA	LCA
870.48	8.15	DSI	Dol	Unalt	CA	LCA
872.00	8.15	DSI	Dol	Unalt	CA	LCA
873.53	8.15	DSI	Dol	Unalt	CA	LCA
875.05	8.15	DSI	Dol	Unalt	CA	LCA
876.57	6.68	DSI	Dol	Unalt	CA	LCA
878.10	6.68	DSI	Dol	Unalt	CA	LCA
879.62	6.68	DSI	Dol	Unalt	CA	LCA
881.15	6.68	DSI	Dol	Unalt	CA	LCA
882.67	6.68	DSI	Dol	Unalt	CA	LCA
884.19	6.68	DSI	Dol	Unalt	CA	LCA
885.72	6.68	DSI	Dol	Unalt	CA	LCA
887.24	6.68	DSI	Dol	Unalt	CA	LCA
888.77	6.68	DSI	Dol	Unalt	CA	LCA
890.29	6.68	DSI	Dol	Unalt	CA	LCA
891.81	6.68	DSI	Dol	Unalt	CA	LCA
893.34	6.68	Oes	Dol	Unalt	CA	LCA
894.86	6.68	Oes	Dol	Unalt	CA	LCA
896.39	6.68	Oes	Dol	Unalt	CA	LCA
897.91	6.68	Oes	Dol	Unalt	CA	LCA
899.43	6.68	Oes	Dol	Unalt	CA	LCA
900.96	6.68	Oes	Dol	Unalt	CA	LCA
902.48	6.68	Oes	Dol	Unalt	CA	LCA
904.01	6.68	Oes	Dol	Unalt	CA	LCA
905.53	6.68	Oes	Dol	Unalt	CA	LCA
907.05	-	-	-	-	-	-
908.58	-	-	-	-	-	-
910.10	-	-	-	-	-	-
911.63	-	-	-	-	-	-
913.15	-	-	-	-	-	-
914.67	-	-	-	-	-	-
916.20	-	-	-	-	-	-
917.72	-	-	-	-	-	-
919.25	-	-	-	-	-	-
920.65	-	-	-	-	-	-

Dashes indicate hydraulic conductivity values are below detection within the interval
Only the intervals within well screen are presented

ER-7-1

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
669.87	125.43	Pzu	Ls	Unalt	CA	LCA
671.34	191.98	Pzu	Ls	Unalt	CA	LCA
672.74	100.02	Pzu	Ls	Unalt	CA	LCA
674.14	63.01	Pzu	Ls	Unalt	CA	LCA
676.00	44.79	Pzu	Ls	Unalt	CA	LCA
678.26	41.16	Pzu	Ls	Unalt	CA	LCA
680.10	29.67	Pzu	Ls	Unalt	CA	LCA
681.56	29.10	Pzu	Ls	Unalt	CA	LCA
683.06	65.24	Pzu	Ls	Unalt	CA	LCA
684.55	20.65	Pzu	Ls	Unalt	CA	LCA
685.98	28.42	Pzu	Ls	Unalt	CA	LCA
687.42	8.91	Pzu	Ls	Unalt	CA	LCA
689.29	9.16	Pzu	Ls	Unalt	CA	LCA
691.55	17.61	Pzu	Ls	Unalt	CA	LCA
693.34	32.20	Pzu	Ls	Unalt	CA	LCA
694.75	28.49	Pzu	Ls	Unalt	CA	LCA
696.21	46.73	Pzu	Ls	Unalt	CA	LCA
697.67	12.90	Pzu	Ls	Unalt	CA	LCA
699.04	22.78	Pzu	Ls	Unalt	CA	LCA
700.42	15.83	Pzu	Ls	Unalt	CA	LCA
702.27	9.49	Pzu	Ls	Unalt	CA	LCA
704.53	5.33	Pzu	Ls	Unalt	CA	LCA
706.36	-	-	-	-	-	-
707.81	-	-	-	-	-	-
709.30	26.43	Pzu	Ls	Unalt	CA	LCA
710.79	7.89	Pzu	Ls	Unalt	CA	LCA
712.23	39.04	Pzu	Ls	Unalt	CA	LCA
713.66	21.23	Pzu	Ls	Unalt	CA	LCA
715.53	17.76	Pzu	Ls	Unalt	CA	LCA
717.79	15.11	Pzu	Ls	Unalt	CA	LCA
719.62	40.06	Pzu	Ls	Unalt	CA	LCA
721.07	30.58	Pzu	Ls	Unalt	CA	LCA
722.56	29.32	Pzu	Ls	Unalt	CA	LCA
724.05	17.57	Pzu	Ls	Unalt	CA	LCA
725.48	12.75	Pzu	Ls	Unalt	CA	LCA
726.92	3.15	Pzu	Ls	Unalt	CA	LCA
728.79	3.58	Pzu	Ls	Unalt	CA	LCA
731.05	-	-	-	-	-	-
732.88	-	-	-	-	-	-
734.32	5.06	Pzu	Ls	Unalt	CA	LCA
735.82	-	-	-	-	-	-
737.31	0.38	Pzu	Ls	Unalt	CA	LCA
738.74	-	-	-	-	-	-
738.80	124.43	Pzu	Ls	Unalt	CA	LCA
742.05	3.59	Pzu	Ls	Unalt	CA	LCA
744.31	-	-	-	-	-	-
746.14	-	-	-	-	-	-
747.58	-	-	-	-	-	-
749.08	-	-	-	-	-	-
750.57	-	-	-	-	-	-
751.99	9.29	Pzu	Ls	Unalt	CA	LCA
753.40	-	-	-	-	-	-
755.28	0.16	Pzu	Ls	Unalt	CA	LCA

Dashes indicate hydraulic conductivity values are below detection within the interval
Only the intervals within well screen are presented

ER-12-3

Center of Calculation Interval (m)	Volcanic Tuff Hydraulic Conductivity (m/d)	Assigned Stratigraphic Unit	Assigned Lithic Modifier	Assigned Lithic Alteration	Assigned Hydrogeologic Unit	Assigned Hydrostratigraphic Unit
1,099 75	-	-	-	-	-	-
1,106 09	-	-	-	-	-	-
1,112 55	-	-	-	-	-	-
1,118 95	-	-	-	-	-	-
1,125 35	1 79	Pzu	Dol	Unalt	CA	LCA
1,131 75	1 02	Pzu	Dol	Unalt	CA	LCA
1,138 15	0 80	Pzu	Dol	Unalt	CA	LCA
1,144 55	0 59	Pzu	Dol	Unalt	CA	LCA
1,150 96	0 53	Pzu	Dol	Unalt	CA	LCA
1,157 36	0 20	Pzu	Dol	Unalt	CA	LCA
1,250 62	-	-	-	-	-	-
1,256 96	-	-	-	-	-	-
1,263 43	-	-	-	-	-	-
1,269 83	-	-	-	-	-	-
1,276 23	-	-	-	-	-	-
1,282 63	-	-	-	-	-	-
1,289 03	-	-	-	-	-	-
1,295 43	-	-	-	-	-	-
1,301 83	-	-	-	-	-	-
1,308 23	-	-	-	-	-	-
1,314 57	-	-	-	-	-	-
1,321 03	0 02	Pzu	Ls	Unalt	CA	LCA
1,327 43	0 00	Pzu	Ls	Unalt	CA	LCA
1,333 84	-	-	-	-	-	-
1,340 24	-	-	-	-	-	-
1,346 64	0 00	Pzu	Ls	Unalt	CA	LCA
1,353 04	0 01	Pzu	Ls	Unalt	CA	LCA
1,359 44	-	-	-	-	-	-
1,365 84	-	-	-	-	-	-
1,372 18	-	-	-	-	-	-
1,378 64	-	-	-	-	-	-
1,385 04	-	-	-	-	-	-
1,391 44	-	-	-	-	-	-
1,397 84	-	-	-	-	-	-
1,404 24	0 02	Pzu	Ls	Unalt	CA	LCA
1,410 64	-	-	-	-	-	-
1,417 05	-	-	-	-	-	-
1,423 45	-	-	-	-	-	-
1,429 79	0 03	Pzu	Ls	Unalt	CA	LCA
1,436 25	-	-	-	-	-	-
1,442 65	0 07	Pzu	Ls	Unalt	CA	LCA
1,449 05	0 01	Pzu	Ls	Unalt	CA	LCA
1,455 45	-	-	-	-	-	-
1,461 85	-	-	-	-	-	-
1,468 25	-	-	-	-	-	-
1,473 71	-	-	-	-	-	-

Dashes indicate hydraulic conductivity values are below detection within the interval
Only the intervals within well screen are presented

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