

Appendix 18.F

Aquifer Testing Results from 1998 and 2007

**HYDRAULIC TESTING RESULTS FOR NAVAJO MINE EXTENSION PROJECT
AUGUST 2007**

Hydraulic testing of the Pictured Cliffs Sandstone (PCS) and the No. 8 coal seam was performed at BHP Navajo Coal Company's Navajo Mine Extension Project from August 14-18, 2007 on the following wells: Kpc2007-01, Kpc2007-02, Kpc2007-03, and Kf2007-01. The analyses of the test results were performed using codes in the Aqtesolv software package show good agreement with the previous findings.

Results:

Well Kpc2007-01 (Pictured Cliffs Sandstone)

A solution was obtained using the Theis Method, which assumes an extensive and homogeneous confined aquifer. The test was run with an average variable pumping rate of 0.95 gpm, results are attached. The solution indicates a transmissivity of 0.576 ft²/day and a hydraulic conductivity of 0.0074 ft/day (2.6×10^{-6} cm/sec)

Well Kpc2007-02 (Pictured Cliffs Sandstone)

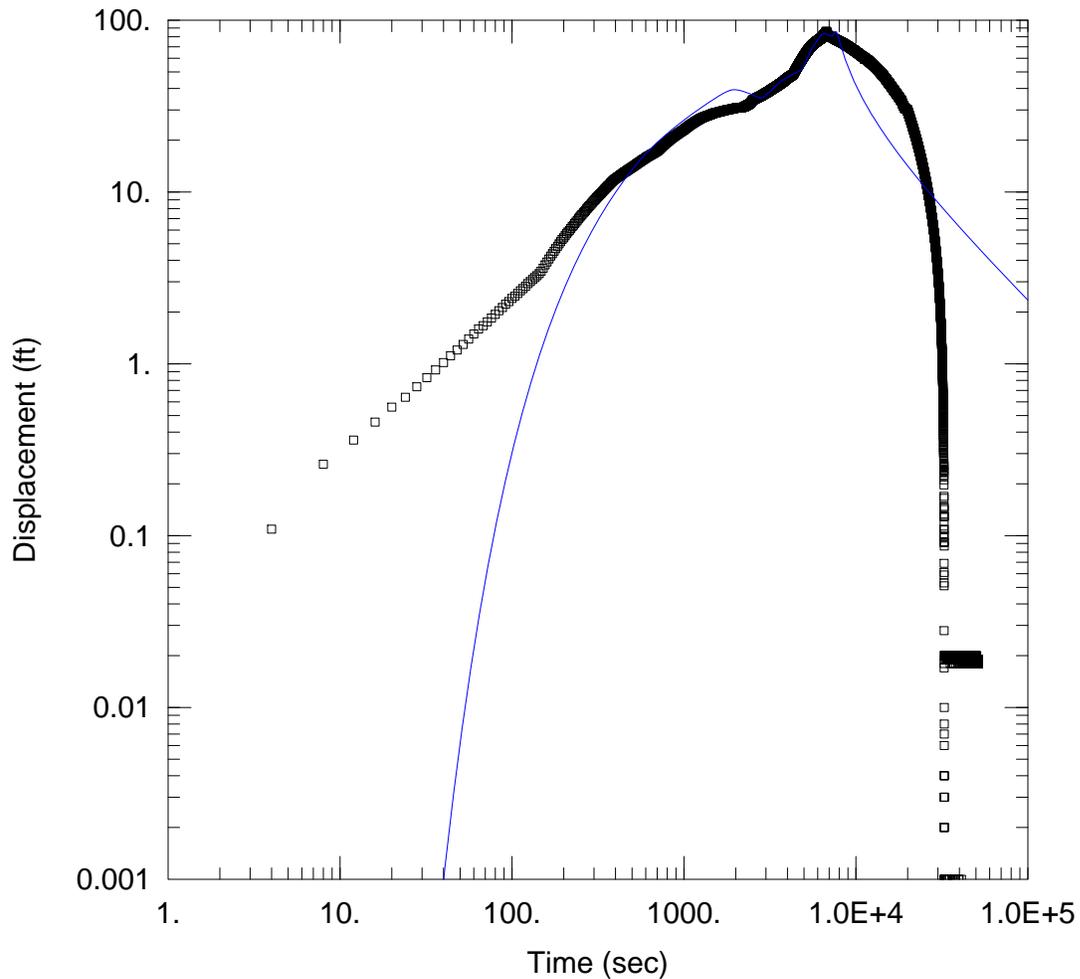
The drawdown rate in this well during pumping exactly matched casing volume dewatering, and recovery after pumping was very slow. Consequently, the results could not be interpreted as a pumping test. Instead, the recovery portion was analyzed using the Bouwer-Rice method for slug tests in confined aquifers. The results are attached. The very low hydraulic conductivity value of 0.0001 ft/day (3.51×10^{-8} cm/sec) was obtained from this test, indicating the formation is either exceptionally tight or the screen interval is compromised by cement. Wet cement was found at the bottom of this well and the pH of the entire water column was 11.8.

Well Kpc2007-03 (Pictured Cliffs Sandstone)

A slug test was performed at this well due to the low yield of the PCS combined with a water column of only 7 feet in the well based on an initial water level measurement of 129 ft. and a total well depth of 136 ft. A slug was made up with two-inch PVC, open at the top and packed with sand, and this was let below the water and later raised above it for falling and rising head tests. The Bouwer-Rice solution obtained the best fit to the data, and gave a hydraulic conductivity of 0.004 ft/day (1.4×10^{-6} cm/sec); the Hvorslev method gave 0.09 ft/day. The results are attached.

Well Kf2007-01 (No. 8A Seam)

This test showed delayed initial response, an abrupt "catch-up", and a faster than expected recovery. The later portion of the pumping test gave favorable fits to type curves for the Neuman-Witherspoon (leaky aquitard) and Papadopulos-Cooper (including well bore storage). The early pumping and recovery anomalies may be due to poor development and movement of coal fines during pumping, washout or fracturing of coals. The pumping rate was variable but averaged 1.5 gpm. Transmissivities determined for the variable rate interpretations of the Neuman-Witherspoon and Papadopulos-Cooper methods were 1.92 ft²/day and 1.398 ft²/day, respectively. A hydraulic conductivity value of 0.056 ft/day (2.0×10^{-5} cm/sec) was obtained from the Papadopulos-Cooper test results.



WELL TEST ANALYSIS

Data Set: S:\...\Theis_UpdatedFlowRates_Kpc2007-01.aqt

Date: 10/29/08

Time: 08:48:36

WELL DATA

Pumping Wells

Observation Wells

Well Name	X (ft)	Y (ft)
Kpc2007-01	0	0

Well Name	X (ft)	Y (ft)
□ Kpc2007-01	0	0

SOLUTION

Aquifer Model: Confined

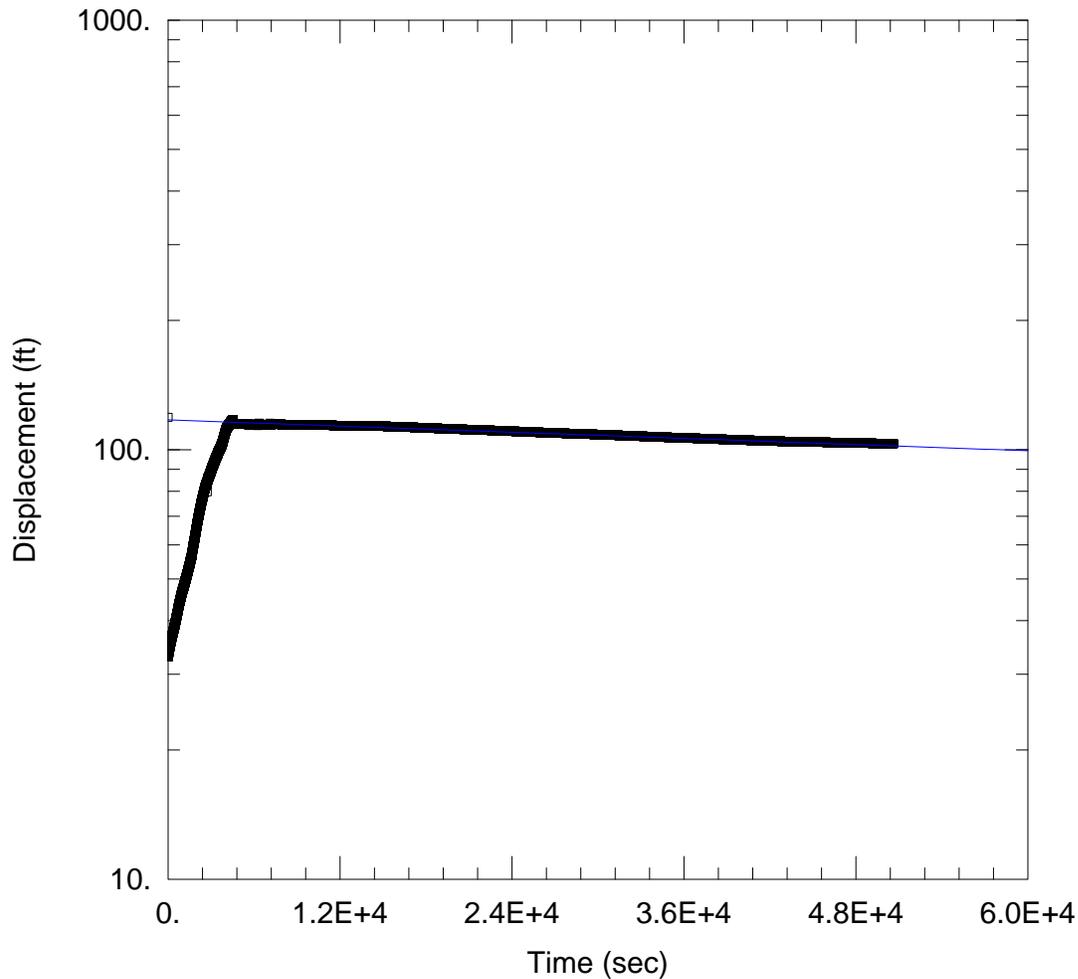
Solution Method: Theis

T = 0.5761 ft²/day

S = 0.0662

Kz/Kr = 1.

b = 70. ft



WELL TEST ANALYSIS

Data Set: S:\...\BouwerRice_Slug_Kpc2007-02_10-29-08.aqt
 Date: 10/29/08 Time: 08:52:45

PROJECT INFORMATION

Test Well: Kpc2007-02
 Test Date: 8/17/2007

AQUIFER DATA

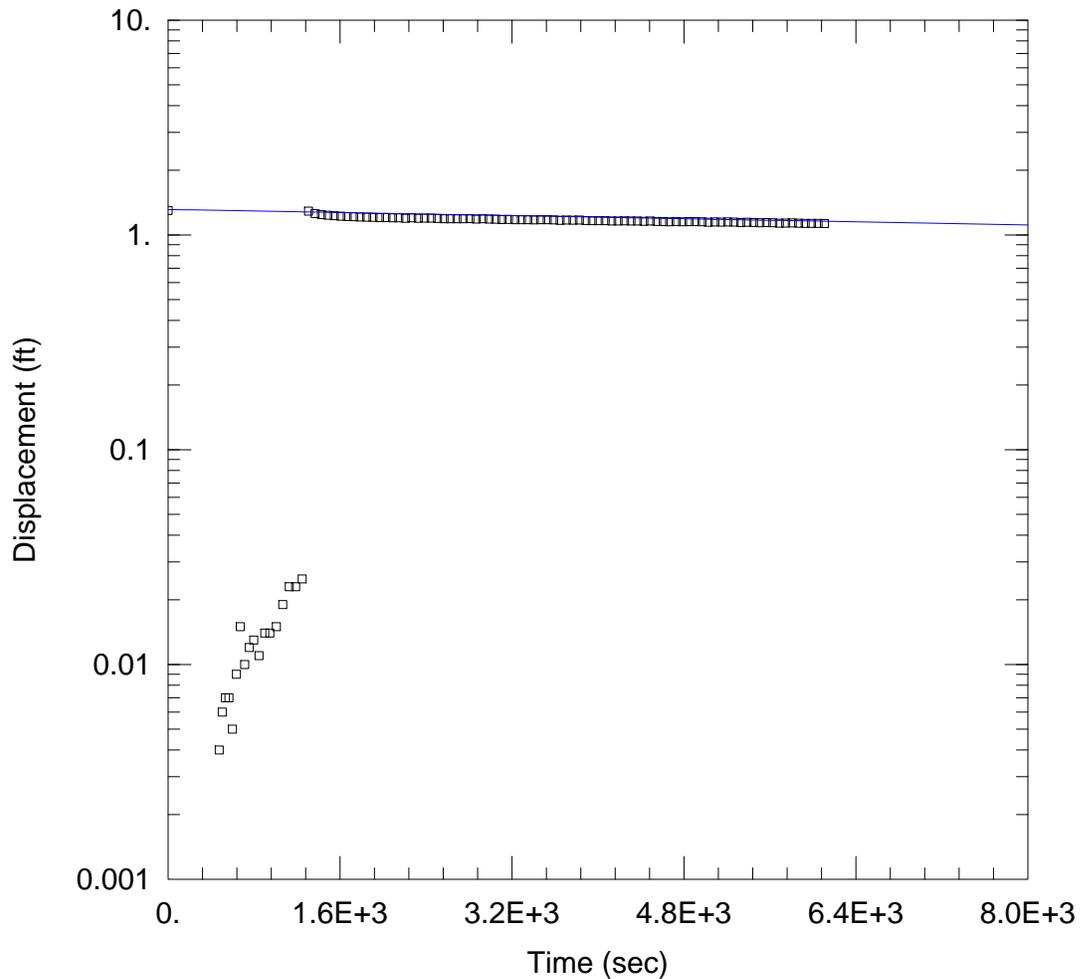
Saturated Thickness: 78. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (Kpc2007-02)

Initial Displacement: 119. ft Static Water Column Height: 152.2 ft
 Total Well Penetration Depth: 319. ft Screen Length: 70. ft
 Casing Radius: 0.1208 ft Well Radius: 0.3645 ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice
 K = 0.0001109 ft/day y0 = 117.3 ft



WELL TEST ANALYSIS

Data Set: S:\...\BouwerRice_Kpc2007-03.aqt

Date: 10/29/08

Time: 08:55:00

PROJECT INFORMATION

Test Well: Kpc2007-03

Test Date: 8/17/2007

AQUIFER DATA

Saturated Thickness: 10. ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (Kpc2007-03)

Initial Displacement: 1.3 ft

Static Water Column Height: 129.4 ft

Total Well Penetration Depth: 135. ft

Screen Length: 10. ft

Casing Radius: 0.12 ft

Well Radius: 0.364 ft

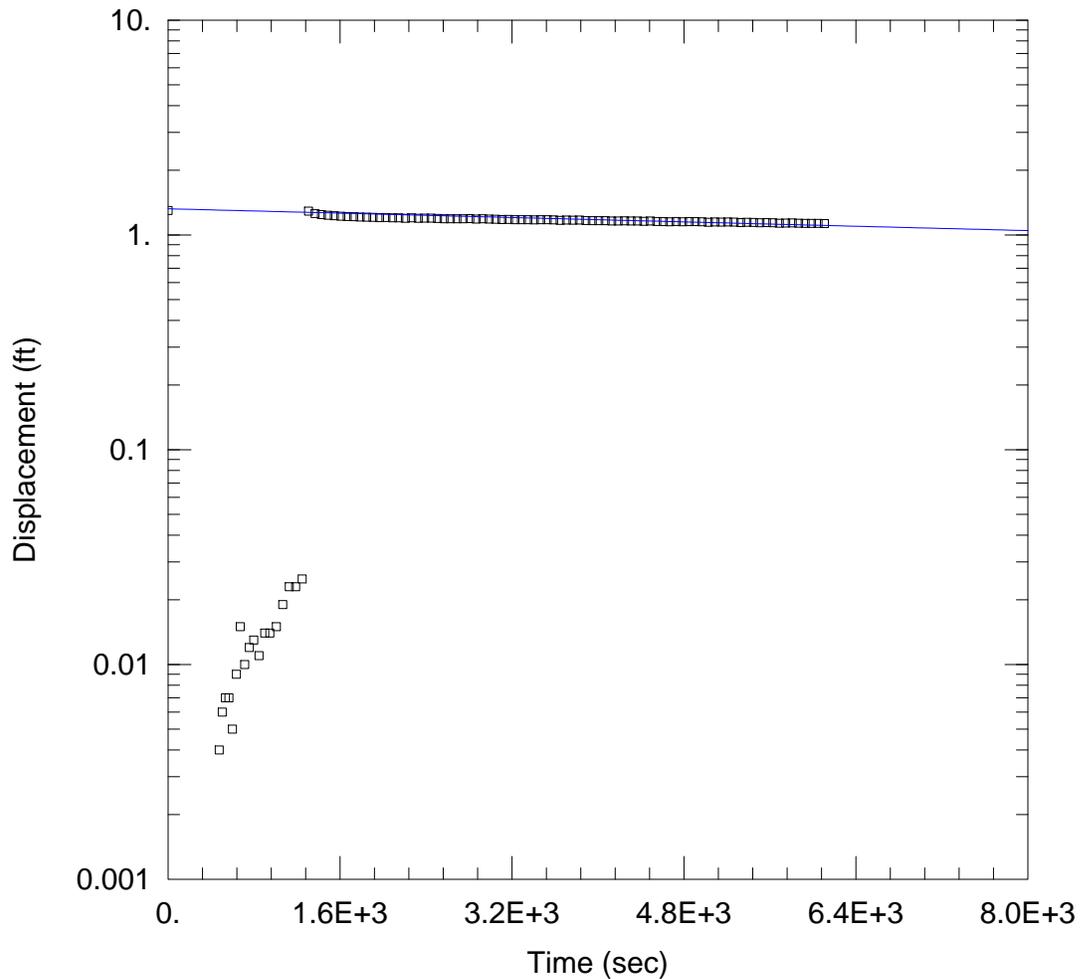
SOLUTION

Aquifer Model: Confined

Solution Method: Bouwer-Rice

K = 0.004462 ft/day

y0 = 1.314 ft



WELL TEST ANALYSIS

Data Set: S:\...\Hvorslev_Kpc2007-03.aqt
 Date: 10/29/08

Time: 08:55:41

PROJECT INFORMATION

Test Well: Kpc2007-03
 Test Date: 8/17/2007

AQUIFER DATA

Saturated Thickness: 10. ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (Kpc2007-03)

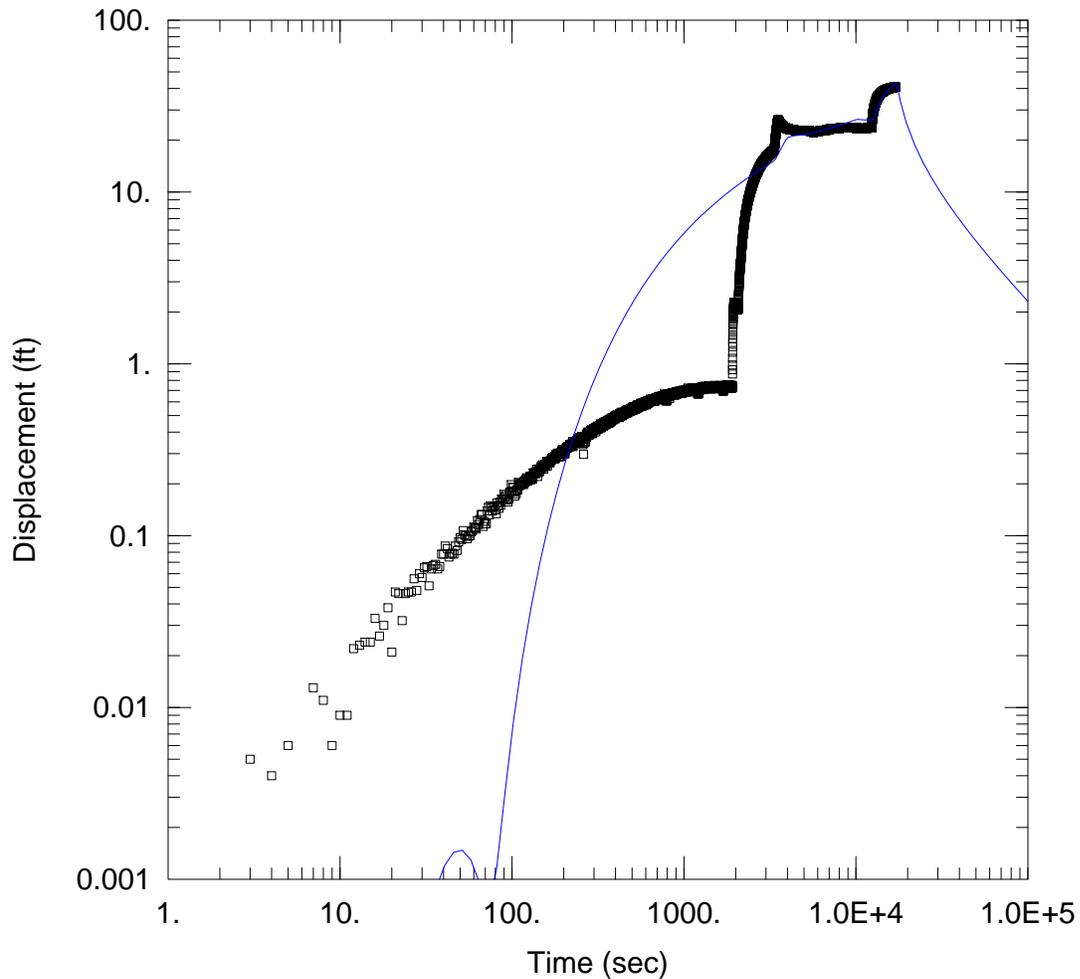
Initial Displacement: 1.3 ft
 Total Well Penetration Depth: 135. ft
 Casing Radius: 0.12 ft

Static Water Column Height: 129.4 ft
 Screen Length: 10. ft
 Well Radius: 0.364 ft

SOLUTION

Aquifer Model: Confined
 K = 0.008505 ft/day

Solution Method: Hvorslev
 y0 = 1.323 ft



WELL TEST ANALYSIS

Data Set: S:\...\NeumanWitherspoon_Kf2007-01.aqt

Date: 10/29/08

Time: 08:59:56

PROJECT INFORMATION

Test Well: Kf2007-01

Test Date: 8/17/2007

AQUIFER DATA

Saturated Thickness: 10. ft

Aquitard Thickness (b'): 1. ft

Anisotropy Ratio (Kz/Kr): 1.

Aquitard Thickness (b''): 1. ft

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
Kf2007-01	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
□ Kf2007-01	0	0

SOLUTION

Aquifer Model: Leaky

Solution Method: Neuman-Witherspoon

T = 1.92 ft²/day

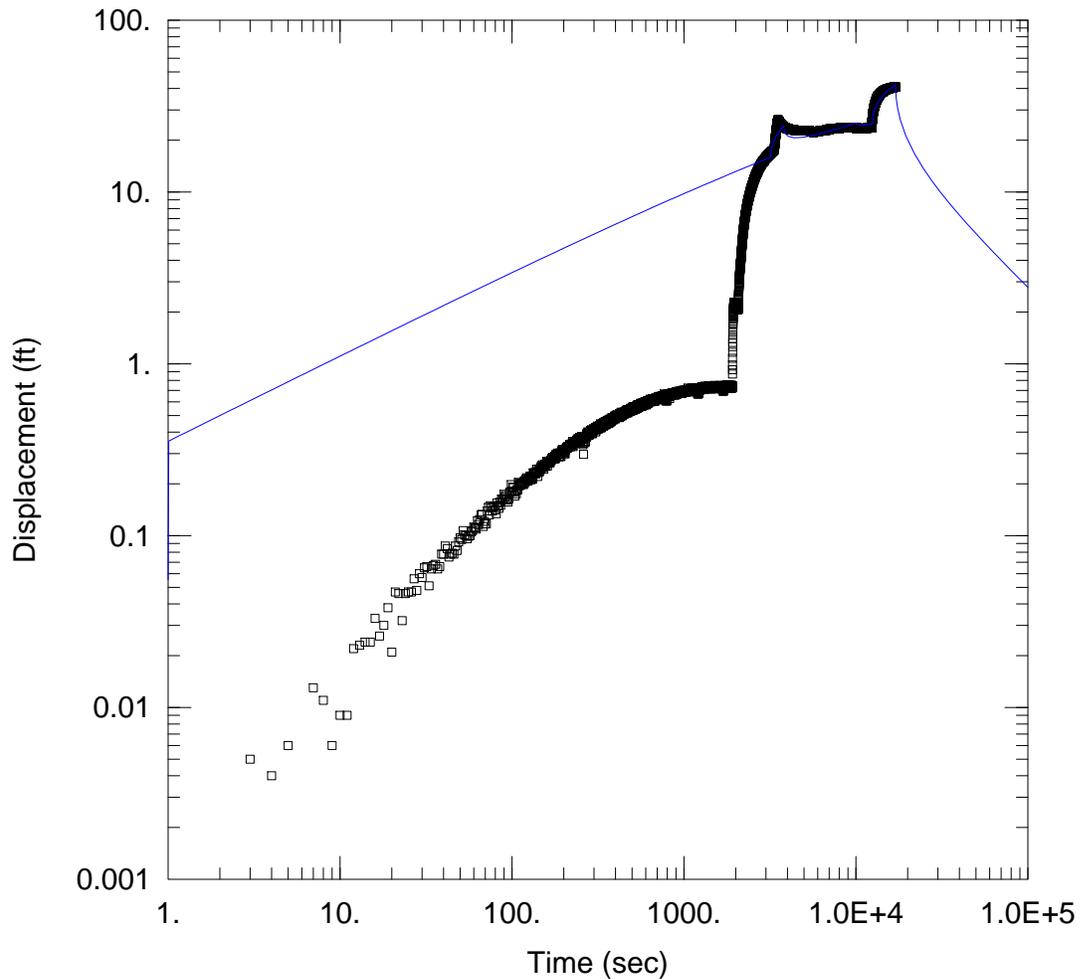
S = 0.3391

r/B = 1.0E-5

β = 1.0E-5

T2 = 1. ft²/day

S2 = 1.0E-10



WELL TEST ANALYSIS

Data Set: S:\...\PapadopoulosCooper_Kf2007-01.aqt

Date: 10/29/08

Time: 09:01:09

PROJECT INFORMATION

Test Well: Kf2007-01

Test Date: 8/17/2007

AQUIFER DATA

Saturated Thickness: 10. ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Observation Wells

Well Name	X (ft)	Y (ft)
Kf2007-01	0	0

Well Name	X (ft)	Y (ft)
□ Kf2007-01	0	0

SOLUTION

Aquifer Model: Confined

Solution Method: Papadopoulos-Cooper

T = 1.398 ft²/day

S = 1.

r(w) = 0.364 ft

r(c) = 0.12 ft

**PUMPING TEST RESULTS FOR PINABETE ALLUVIAL WELLS
MAY 16, 1998**

Pumping tests of wells PA-1 and PA-2 completed in Pinabete Alluvium were performed at BHP Navajo Coal Company's Area 4 South on May 16, 1998. The analyses of the test results were performed using codes in the Aqtesolv software package.

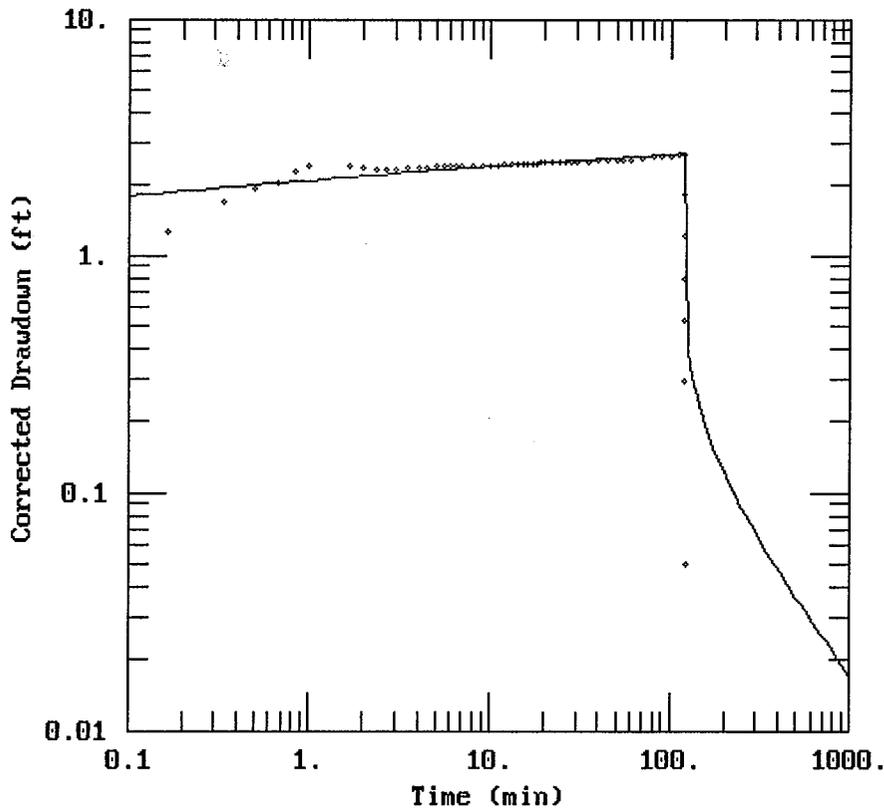
Results:

Well PA-1 (Pinabete Alluvium)

A solution was obtained using the Theis Method. The test was run with a constant pumping rate of 2.0 gpm, results are attached. The solution indicates a transmissivity of 230.7 ft²/day and a hydraulic conductivity of 51.3 ft/day (1.8×10^{-2} cm/sec). The results are attached.

Well PA-2 (Pinabete Alluvium)

A solution was obtained using the Theis Method. The test was run with a constant pumping rate of 0.75 gpm, results are attached. The solution indicates a transmissivity of 75.62 ft²/day and a hydraulic conductivity of 11.5 ft/day (4.1×10^{-3} cm/sec). The results are attached.



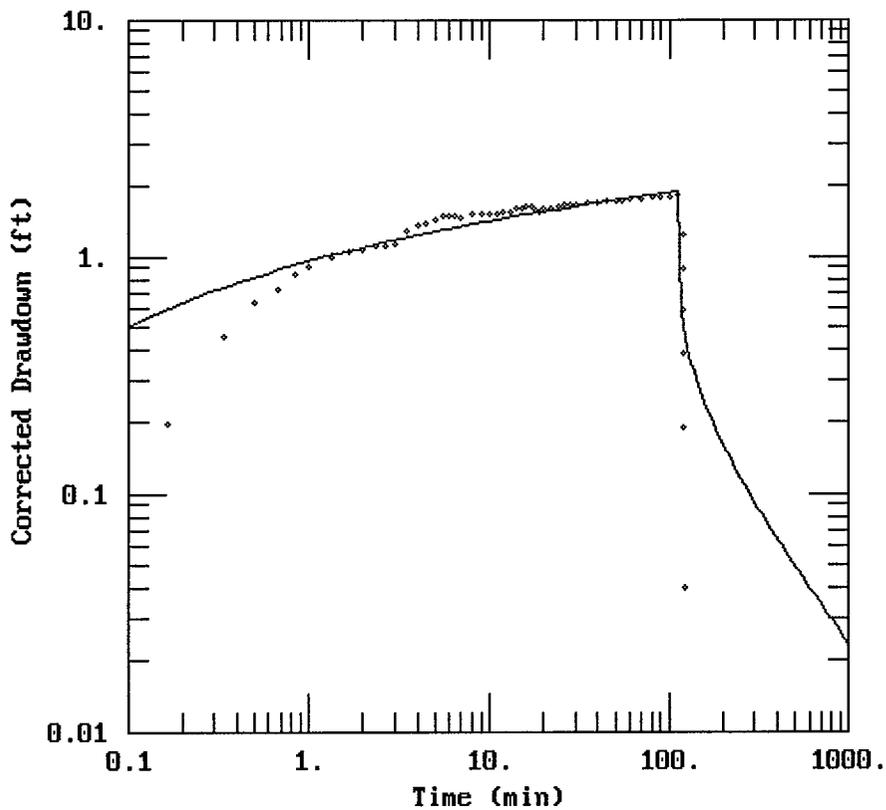
DATA SET:
 PA1P&REC.AQT
 08/25/98

AQUIFER MODEL:
 Unconfined
 SOLUTION METHOD:
 Theis

PROJECT DATA:
 test date: 5/16/98
 test well: PA-1
 obs. well: PA-1

TEST DATA:
 $Q = 0.2674 \text{ ft}^3/\text{min}$
 $r = 0. \text{ ft}$
 $r_c = 0.08333 \text{ ft}$
 $r_w = 0.08333 \text{ ft}$
 $b = 7. \text{ ft}$

PARAMETER ESTIMATES:
 $T = 230.7 \text{ ft}^2/\text{day}$
 $S = 7.791\text{E-}06$



DATA SET:
PA2P&REC.AQT
08/25/98

AQUIFER MODEL:
Unconfined
SOLUTION METHOD:
Theis

PROJECT DATA:
test date: 5/16/98
test well: PA-2
obs. well: PA-2

TEST DATA:
 $Q = 0.1003 \text{ ft}^3/\text{min}$
 $r = 0. \text{ ft}$
 $r_c = 0.08333 \text{ ft}$
 $r_w = 0.08333 \text{ ft}$
 $b = 7.5 \text{ ft}$

PARAMETER ESTIMATES:
 $T = 57.62 \text{ ft}^2/\text{day}$
 $S = 0.1073$