Exhibit 14A-1

Aquifer Test Data, Volume II, Appendix E
1996 Florence APP Application

APPENDIX E

CURRENT INVESTIGATION AQUIFER TEST ANALYSIS INFORMATION

Table E-1 Summary of Aquifer Test Field Program							
Pumping Well	**Observation Wells**	**Screened Interval (ft bgs)**	**Pump Rate (gpm)**	**Maximum Drawdown (ft)**	**Hydraulic Conductivity (ft/day)**	**Date Test Performed**	**Comments**
PW7-1		540 - 880	38	109.0	0.2	6/16/95 to 6/22/95	Irrigation wells BIA-10B & WW-3 pumped during test.
	OB7-1	540 - 880		67.9	0.1		
	O3-GL	325 - 365		8.7	N/A		
	Corehole OB-1	Not Screened		6.3[3]	N/A		
P5-O		414 - 770	66	51.8	N/A	10/18/95 to 10/24/95	Irrigation wells BIA-10B & BIA-9 pumped during test.
	O5.1-O	674 - 832		29.5	N/A		
	O5.2-O	712 - 771		31.7	N/A		
P8.1-O		400 - 580	12	212.7	N/A	9/7/95 to 9/13/95	Irrigation well BIA-9 is pumped during test.
	P8.2-O	396 - 576		4.5	N/A		
	P8-GU	128 - 248		0.49	N/A		
	08-O	401 - 579		72.6	N/A		
	08-GU	133 - 251		0	N/A		
P8-GU		128 - 248	85	6.9	61.3	9/18/95 to 9/22/95	Irrigation wells BIA-10B & BIA-9 pumped during test.
	P8.1-O	400 - 580		9.2	N/A		
	P8.2-O	396 - 576		9.5	N/A		
	O8-O	401 - 579		8.9	N/A		
	O8-GU	133 - 251		6.9	N/A		
P12-O		440 - 940	64	35.5	0.4	6/1/95 to 6/8/95	Irrigation well WW-3 is pumped during test.
	O12-O	434 - 939		42.8	0.6		
	O12-GL	125 - 165		N/A[4]	N/A		
P13.1-O		772 - 1,449	46	93.1	N/A	10/9/95 to 10/16/95	No irrigation wells pumped during test.
	P13.2-O	781 - 1,379		19.2	N/A		
	P13-GL	690 - 760		0	N/A		
	O13-O	770 - 1,393		4.4	N/A		
P15-O		580 - 1,300	59	40.9	N/A	9/29/95 to 10/5/95	Irrigation wells BIA-10B & BIA-9 pumped during test.
	O15-O	632 - 1,296		22.4	N/A		
	O15-GL	421 - 481		1.3	N/A		

Table E-1 Summary of Aquifer Test Field Program							
Pumping Well	**Observation Wells**	**Screened Interval (ft bgs)**	**Pump Rate (gpm)**	**Maximum Drawdown (ft)**	**Hydraulic Conductivity (ft/day)**	**Date Test Performed**	**Comments**
P19.1-O		402 - 600	24	155.2	0.3	7/3/95 to 7/6/95	Irrigation wells BIA-10B & WW-3 pumped during test.
	P19.2-O	404 - 602		25.7	0.2		
	019-O	410 - 608		16.9	0.2		
	019-GL	375 - 435		2.4	N/A		
	Corehole 138	Not Screened		0	N/A		
P28.1-O		395 - 495	30	7.9	7.7	8/15/95 to 8/21/95	Low pump rate test. No irrigation wells pumped during test.
	P28.2-O	398 - 497		5.4	N/A		
	P28-GL	279 - 309		1.03	N/A		
	028.1-O	394 - 494		4.7	N/A		
	028.2-S	454 - 494		3.2	N/A		
	028-GL	277 - 307		1.7	N/A		
P28.1-O		395 - 495	85	50.4	3.6	9/7/95 to 9/13/95	High pump rate test conducted. Irrigation well BIA-9 pumped during test.
	P28.2-O	398 - 497		28.3	2.7		
	P28-GL	279 - 309		7.1	N/A		
	028.1-O	394 - 494		22.8	N/A		
	028.2-S	454 - 494		14.2	N/A		
	028-GL	277 - 307		10.1	N/A		
P28-GL		279 - 309	75	115.2	8.3	9/18/95 to 9/28/95	Irrigation wells BIA-10B & BIA-9 pumped during test.
	P28.1-O	395 - 495		11.7	N/A		
	P28.2-O	398 - 497		11.6	N/A		
	O28.1-O	394 - 494		11.9	N/A		
	O28.2-S	454 - 494		12.2	N/A		
	O28-GL	277 - 307		18.8	25.5		
P28.2-O		398 - 497	80	33.8	3.1	10/2/95 to 10/5/95	Irrigation wells BIA-10B & BIA-9 pumped until 10/5/95.
	P28.1-O	395 - 495		2.3	N/A		
	P28-GL	279 - 309		8.7	N/A		
	O28.1-O	394 - 494		18.5	3.0		
	O28.2-S	454 - 494		15.4	N/A		
	O28-GL	277 - 307		11.9	N/A		

Table E-1 Summary of Aquifer Test Field Program

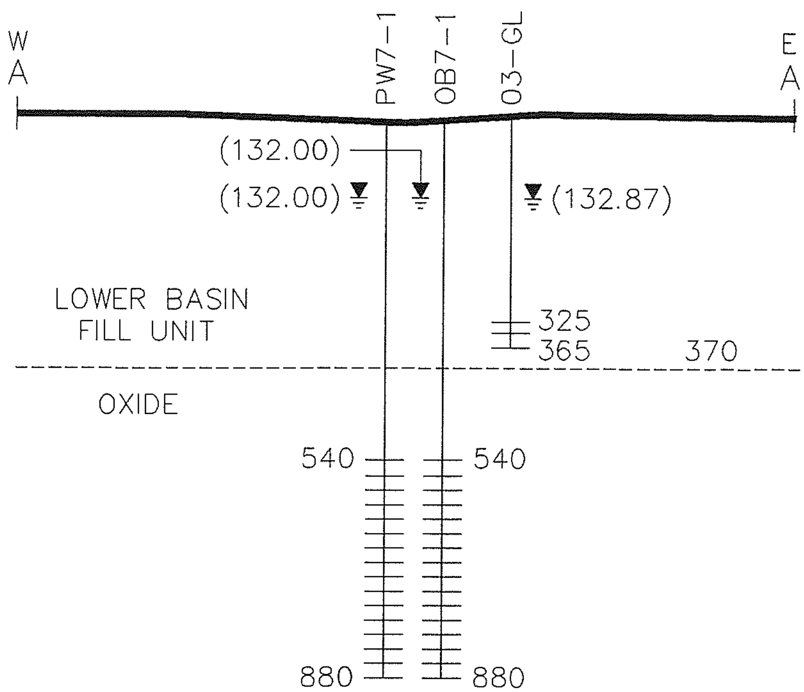
Pumping Well	Observation Wells	Screened Interval (ft bgs)	Pump Rate (gpm)	Maximum Drawdown (ft)	Hydraulic Conductivity (ft/day)	Date Test Performed	Comments
P39-O		471 - 826	55	108	0.3	5/19/95 to	No irrigation wells pumped during test.
	O39-O	474 - 890		23	0.3	5/21/95	
P49-O		808 - 1,222	40	298	N/A	10/11/95 to	No irrigation wells pumped during test.
	O49-O	812 - 1,227		091	N/A	10/16/95	
	O49-GL	661 - 721		0.47	N/A		
M2-GU		198 - 237	10	0.38	N/A	7/25/95 to	Short duration test(1). Irrigation wells BIA-10B & England No. 3 pumped during test.
	M3-GL	298 - 338		0	N/A	7/26/95	
	M4-O	405 - 465		0	N/A		
	M5-S	516 - 576		0	N/A		
M3-GL		298 - 338	10	5.6	15.9	7/26/95 to	Short duration test(1). Irrigation well England No. 3 pumped during test.
	M2-GU	198 - 237		0	N/A	7/27/95	
	M4-O	405 - 465		0.58	N/A		
	M5-S	516 - 576		0	N/A		
M4-O		405 - 465	15	190.4	0.6	7/28/95 to	Short duration test(1). Irrigation well England No. 3 pumped during test.
	M2-GU	198 - 237		0.445	N/A	7/30/95	
	M3-GL	298 - 338		1.09	14.8		
	M5-S	516 - 576		0	N/A		
M10-GU		218 - 258	15	0.508	N/A	7/25/95 to	Short duration test(1). Irrigation wells BIA-10B & England No.3 pumped during test.
	M11-GL	290 - 330		0.222	N/A	7/29/95	
	M12-O	420 - 480		0.318	N/A		
	M13-S	851 - 911		0	N/A		
M11-GL		290 - 330	15	16.7	N/A	7/29/95 to	Short duration test(1). Irrigation well England No. 3 pumped during test.
	M10-GU	218 - 258		4.5	N/A	7/31/95	
	M12-O	420 - 480		4.6	N/A		
	M13-S	851 - 911		0	N/A		

Table E-1 Summary of Aquifer Test Field Program

Pumping Well	Observation Wells	Screened Interval (ft bgs)	Pump Rate (gpm)	Maximum Drawdown (ft)	Hydraulic Conductivity (ft/day)	Date Test Performed	Comments
M12-O		420 - 480	14	19.5	N/A	7/31/95 to 8/2/95	Short duration test[1]. Irrigation wells BIA-10B & England No. 3 pumped during test.
	M10-GU	218 - 258		1.36	N/A		
	M11-GL	290 - 330		3.08	N/A		
	M13-S	851 - 911		0	N/A		
M18-GU		178 - 218	10	7.7	19.6	8/8/95 to 8/9/95	Short duration test[1].
	M1-GL	315 - 355		0	N/A		
M1-GL		315 - 355	10	5.4	17.3	8/11/95 to 8/12/95	Short duration test[1].
	M18-GU	178 - 218		0.157	N/A		
M15-GU		554 - 594	10	47.5	2.6	8/8/95 to 8/9/95	Short duration test[1].
	M14-GL	778 - 838		0	N/A		
M14-GL		778 - 838	10	30.1	1.7	8/11/95 to 8/12/95	Short duration test[1].
	M15-GU	554 - 594		1.56	N/A		
WW-3[2]		240 - 930	2000	N/A	N/A	8/23/95 to 8/29/95	Large scale aquifer test. No other irrigation well pumped during test.
	OB7-1	540 - 880		13.3	N/A		
	O3-GL	325 - 365		12.5	N/A		
	O12-O	434 - 939		23.2	N/A		
	O12-GL	125 - 165		29.9	N/A		
	P15-O	580 - 1,300		32.7	N/A		
	O15-O	632 - 1,296		26.7	N/A		
	O15-GL	421 - 481		7.4	N/A		
	O19-O	410 - 608		5.19	N/A		
	O19-GL	375 - 435		5.3	N/A		
	P28.1-O	395 - 495		2.1	N/A		
	P28.2-O	398 - 497		2.05	N/A		
	O28.1-O	394 - 494		2.06	N/A		
	028-GL	277 - 307		1.9	N/A		
	M14-GL	778 - 838		10.7	N/A		
	M15-GL	554 - 594		9.9	N/A		
	AIRSHAFT	Not Screened		5.0	N/A		

Table E-1 Summary of Aquifer Test Field Program							
Pumping Well	**Observation Wells**	**Screened Interval (ft bgs)**	**Pump Rate (gpm)**	**Maximum Drawdown (ft)**	**Hydraulic Conductivity (ft/day)**	**Date Test Performed**	**Comments**
BIA-9[2]		80 - 494	2350	N/A	N/A	8/29/95 to 9/6/95	Large scale aquifer test. BIA-10B pumped during test.
	OB7-1	540 - 880		21.5	N/A		
	O3-GL	325 - 365		26.2	N/A		
	O12-O	434 - 939		10.3	N/A		
	O12-GL	125 - 165		10.2	N/A		
	P15-O	580 - 1,300		10.3	N/A		
	O15-O	632 - 1,296		5.3	N/A		
	O15-GL	421 - 481		4.7	N/A		
	O19-O	410 - 608		4.3	N/A		
	O19-GL	375 - 435		3.9	N/A		
	P28.1-O	395 - 495		4.1	N/A		
	P28.2-O	398 - 497		4.1	N/A		
	O28.1-O	394 - 494		4.3	N/A		
	028-GL	277 - 307		4.4	N/A		
	M14-GL	778 - 838		6.3	N/A		
	M15-GL	554 - 594		3.9	N/A		
	AIRSHAFT	Not Screened		11.6	N/A		

[1] Short duration tests performed at the monitoring well clusters. Each test was performed by pumping each well in the cluster for approximately 24 hours (Except sulfide wells).
[2] Regional tests performed using existing high discharge irrigation wells.
[3] Drawdown due to irrigation well not test pumping well.
[4] No information available, transducer malfunctioned.
ft bgs - feet below ground surface
ft/day - feet per day
gpm - gallons per minute
See section 2.3.5 (II) for discussion of aquifer tests.
Additional Aquifer test data is presented in Appendix E (II).



EXPLANATION

POTENTIOMETRIC SURFACE (151.00)

(SHOWN IN FEET BELOW GROUND SURFACE)

WELL PREFIXES

PUMPED WELL	P
MONITOR WELL	M
OBSERVATION WELL	O

WELL SUFFIXES
(AQUIFER COMPONENT SCREEN)

BASIN FILL	GU
BASIN FILL	GL
OXIDE BEDROCK	O
SULFIDE BEDROCK	S

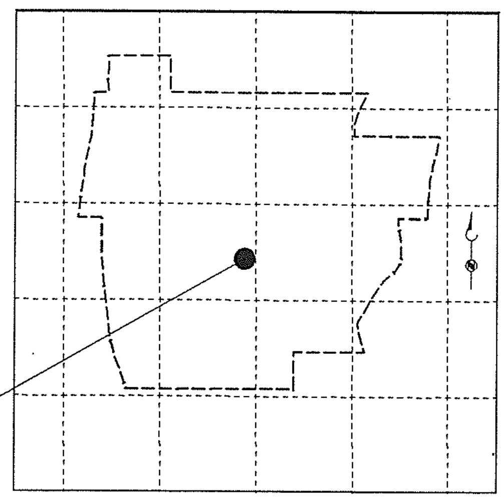
FEET BELOW GROUND SURFACE

880

SCREENED INTERVAL

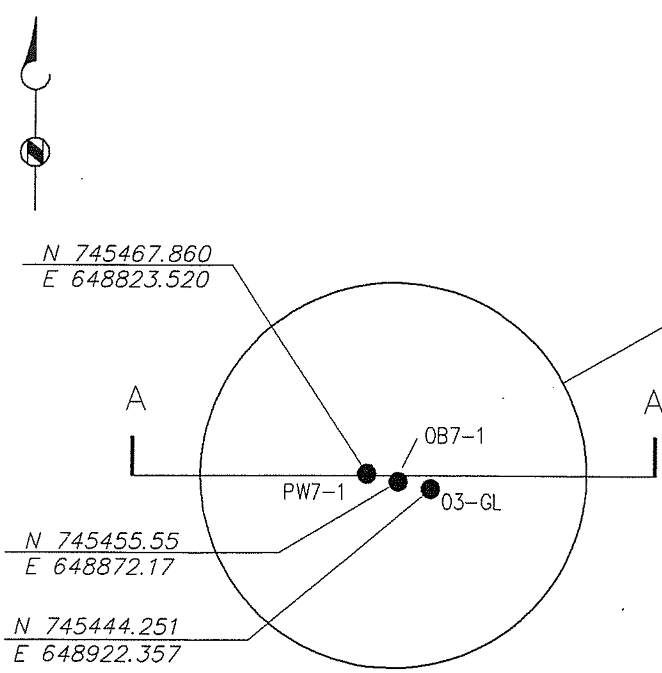
SIMPLIFIED EAST-WEST CROSS SECTION

Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 150'



WELL LOCATION MAP

Approximate Scale: 1"= 2000'



WELL PLAN VIEW

Approximate Scale: 1"= 300'

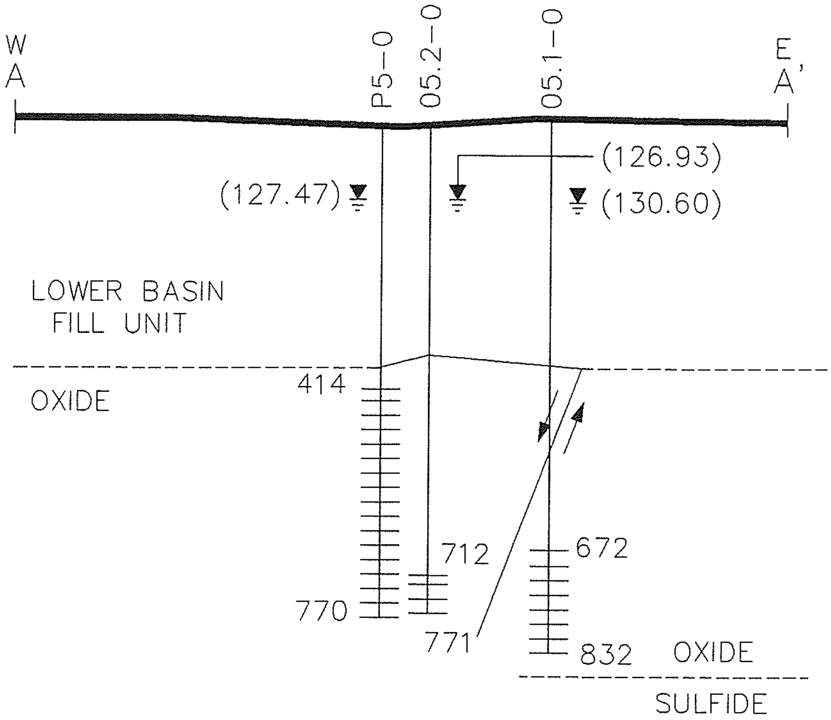
BROWN AND CALDWELL

E-1_2 12-01-95 DanH

Figure E-1 (II)
LOCATION SUMMARY
AQUIFER TEST CLUSTER NO. 3

MAGMA

MAGMA COPPER COMPANY
Florence, Arizona



SIMPLIFIED EAST-WEST CROSS SECTION

Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 150'

EXPLANATION

POTENTIOMETRIC SURFACE (151.00)

(SHOWN IN FEET BELOW GROUND SURFACE)

WELL PREFIXES

PUMPED WELL	P
MONITOR WELL	M
OBSERVATION WELL	O

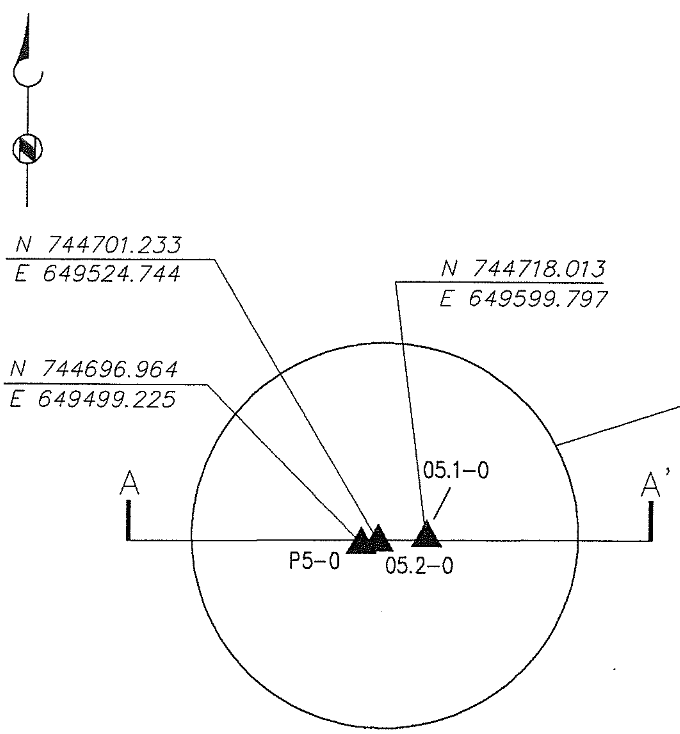
WELL SUFFIXES
(AQUIFER COMPONENT SCREEN)

BASIN FILL	GU
BASIN FILL	GL
OXIDE BEDROCK	O
SULFIDE BEDROCK	S

FEET BELOW GROUND SURFACE

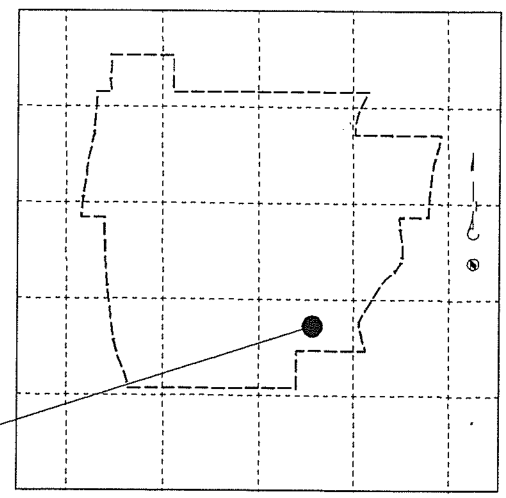
832

SCREENED INTERVAL



WELL PLAN VIEW

Approximate Scale: 1"= 300'



WELL LOCATION MAP

Approximate Scale: 1"= 2000'

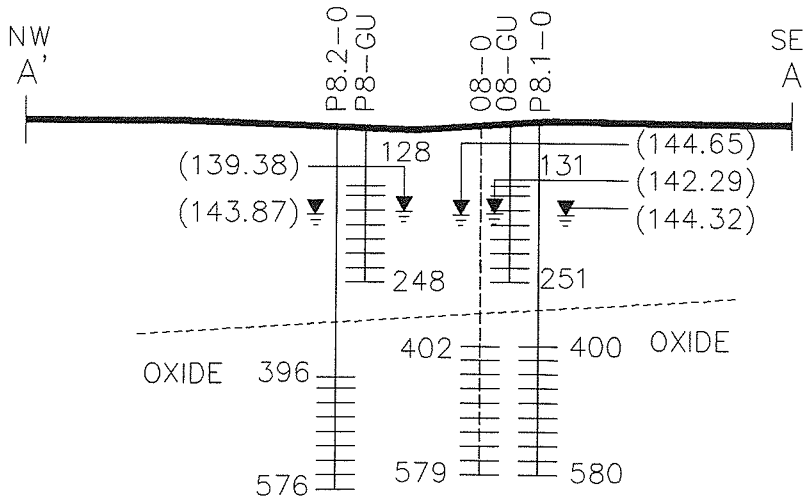
Figure E-2 (II)
LOCATION SUMMARY AQUIFER TEST CLUSTER 5

MAGMA

MAGMA COPPER COMPANY
Florence, Arizona

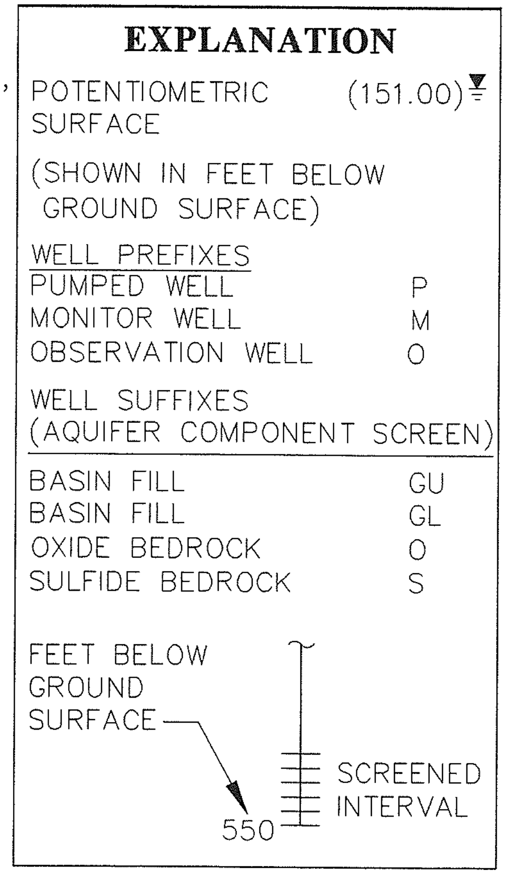
BROWN AND CALDWELL

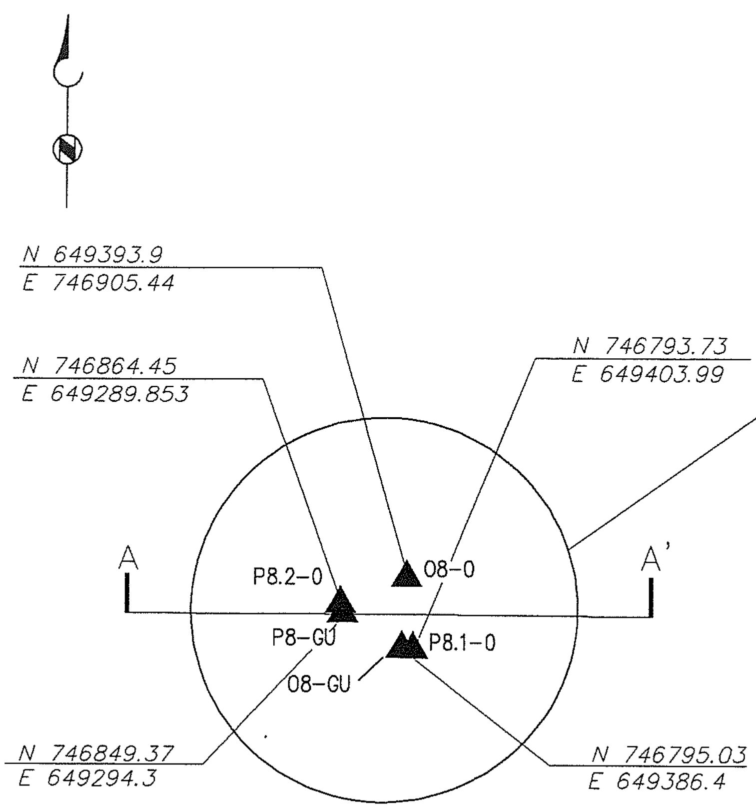
E-2_2 12-01-95 DanH



SIMPLIFIED EAST-WEST CROSS SECTION

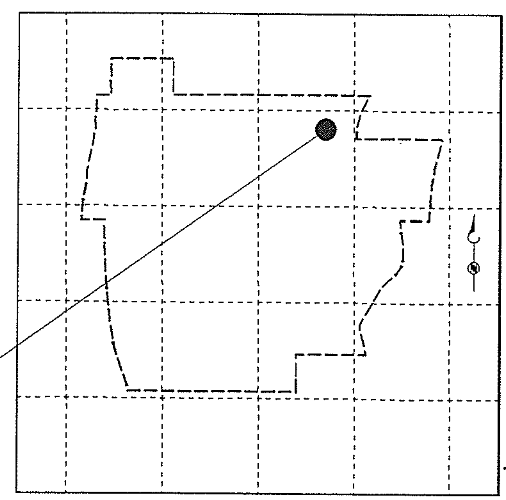
Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 150'





WELL PLAN VIEW

Approximate Scale: 1"= 300'



WELL LOCATION MAP

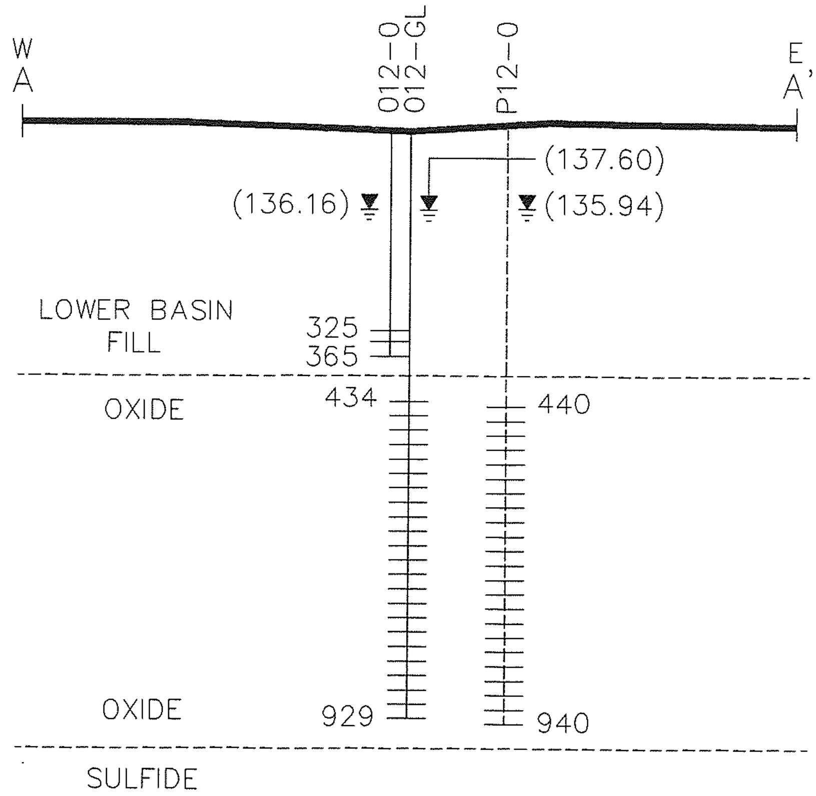
Approximate Scale: 1"= 2000'

Figure E-3 (II)
LOCATION SUMMARY
AQUIFER TEST
CLUSTER 8

BROWN AND CALDWELL

MAGMA
MAGMA COPPER COMPANY
Florence, Arizona

E-3_2 12-01-95 DanH



SIMPLIFIED EAST-WEST CROSS SECTION

Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 150'

EXPLANATION

POTENTIOMETRIC SURFACE (151.00)

(SHOWN IN FEET BELOW GROUND SURFACE)

WELL PREFIXES

PUMPED WELL	P
MONITOR WELL	M
OBSERVATION WELL	O

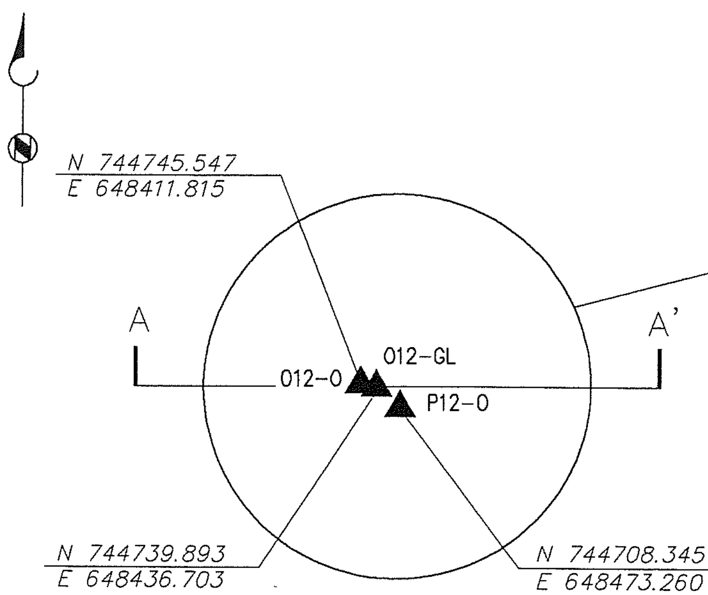
WELL SUFFIXES (AQUIFER COMPONENT SCREEN)

BASIN FILL	GU
BASIN FILL	GL
OXIDE BEDROCK	O
SULFIDE BEDROCK	S

FEET BELOW GROUND SURFACE

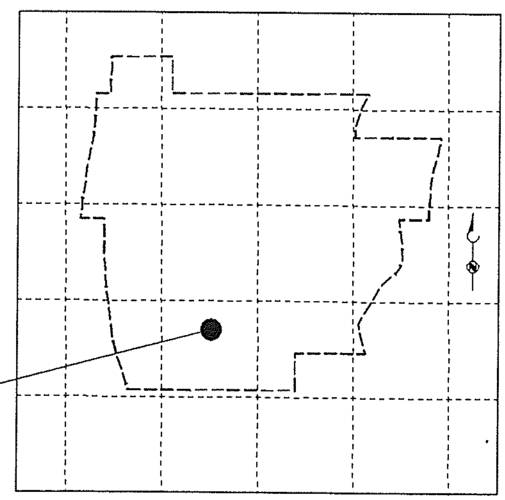
940

SCREENED INTERVAL



WELL PLAN VIEW

Approximate Scale: 1"= 300'



WELL LOCATION MAP

Approximate Scale: 1"= 2000'

Figure E-4 (II)

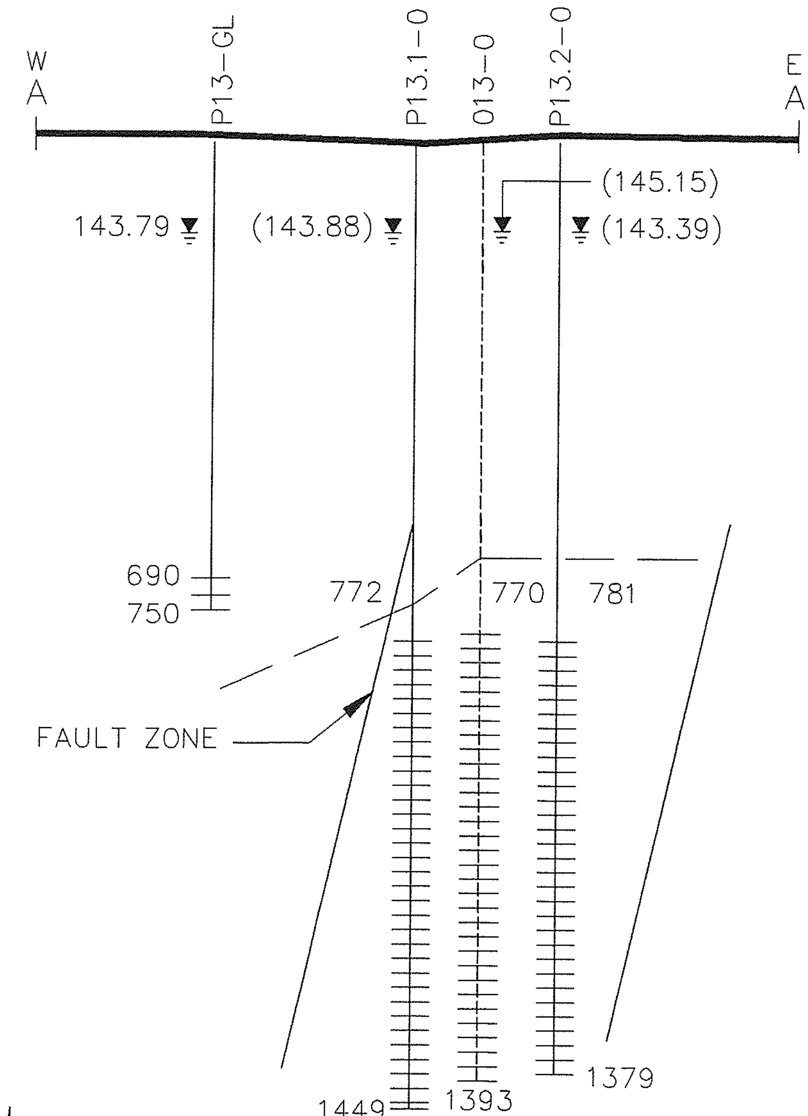
LOCATION SUMMARY AQUIFER TEST CLUSTER 12

MAGMA

MAGMA COPPER COMPANY
Florence, Arizona

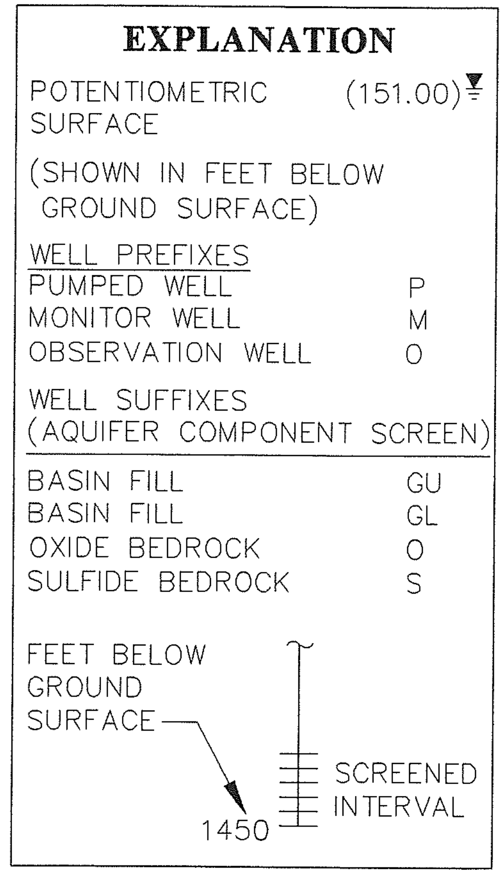
BROWN AND CALDWELL

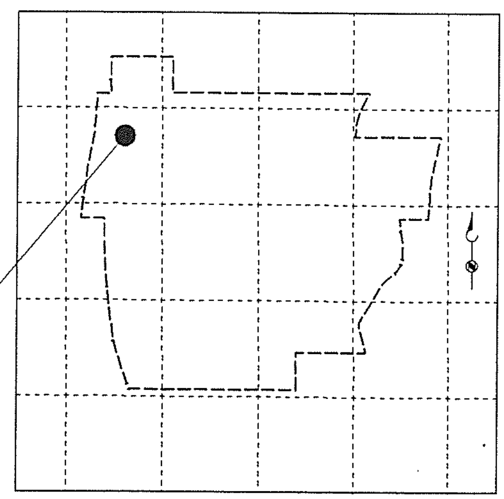
E-4_2 12-01-95 DanH



SIMPLIFIED EAST-WEST CROSS SECTION

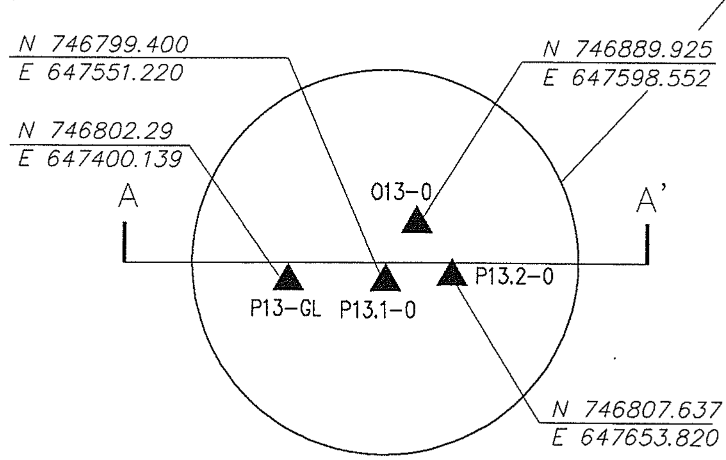
Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 600'





WELL LOCATION MAP

Approximate Scale: 1"= 2000'



WELL PLAN VIEW

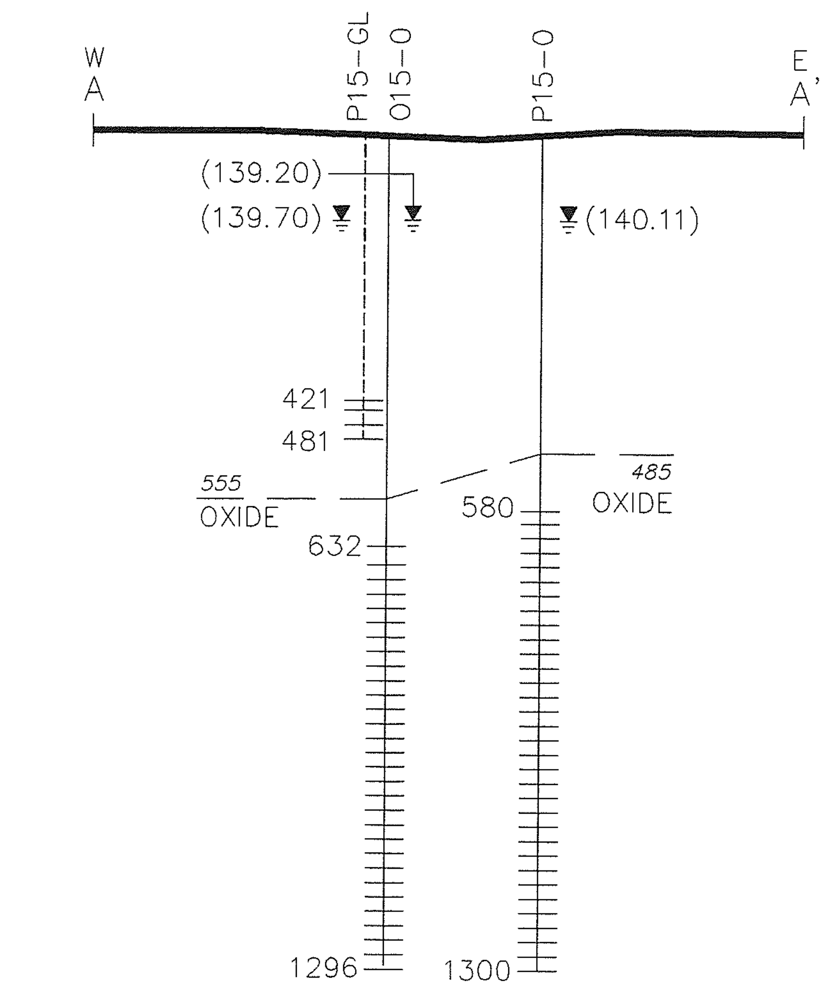
Approximate Scale: 1"= 300'

Figure E-5 (II)
LOCATION SUMMARY AQUIFER TEST CLUSTER 13

MAGMA COPPER COMPANY
Florence, Arizona

BROWN AND CALDWELL

E-5_2 12-01-95 DanH



SIMPLIFIED EAST-WEST CROSS SECTION

Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 150'

EXPLANATION

POTENTIOMETRIC SURFACE (151.00)

(SHOWN IN FEET BELOW GROUND SURFACE)

WELL PREFIXES

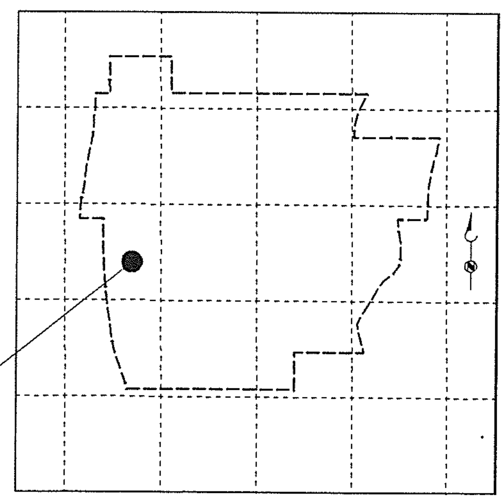
PUMPED WELL	P
MONITOR WELL	M
OBSERVATION WELL	O

WELL SUFFIXES
(AQUIFER COMPONENT SCREEN)

BASIN FILL	GU
BASIN FILL	GL
OXIDE BEDROCK	O
SULFIDE BEDROCK	S

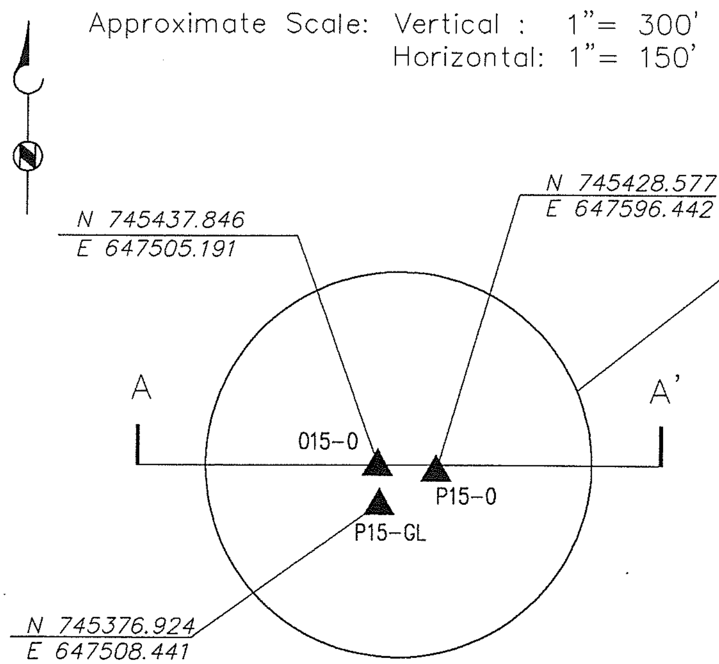
FEET BELOW GROUND SURFACE 610

SCREENED INTERVAL



WELL LOCATION MAP

Approximate Scale: 1"= 2000'



WELL PLAN VIEW

Approximate Scale: 1"= 300'

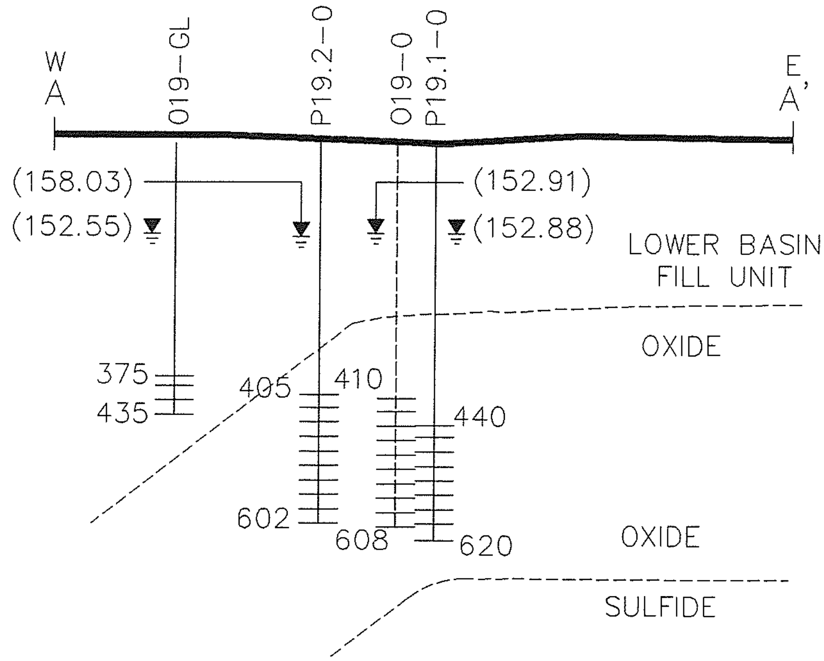
E-6_2 12-01-95 DanH

BROWN AND CALDWELL

Figure E-6 (II)
LOCATION SUMMARY AQUIFER TEST CLUSTER 15

MAGMA

MAGMA COPPER COMPANY
Florence, Arizona



SIMPLIFIED EAST-WEST CROSS SECTION

Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 150'

EXPLANATION

POTENTIOMETRIC SURFACE (151.00)

(SHOWN IN FEET BELOW GROUND SURFACE)

WELL PREFIXES

PUMPED WELL	P
MONITOR WELL	M
OBSERVATION WELL	O

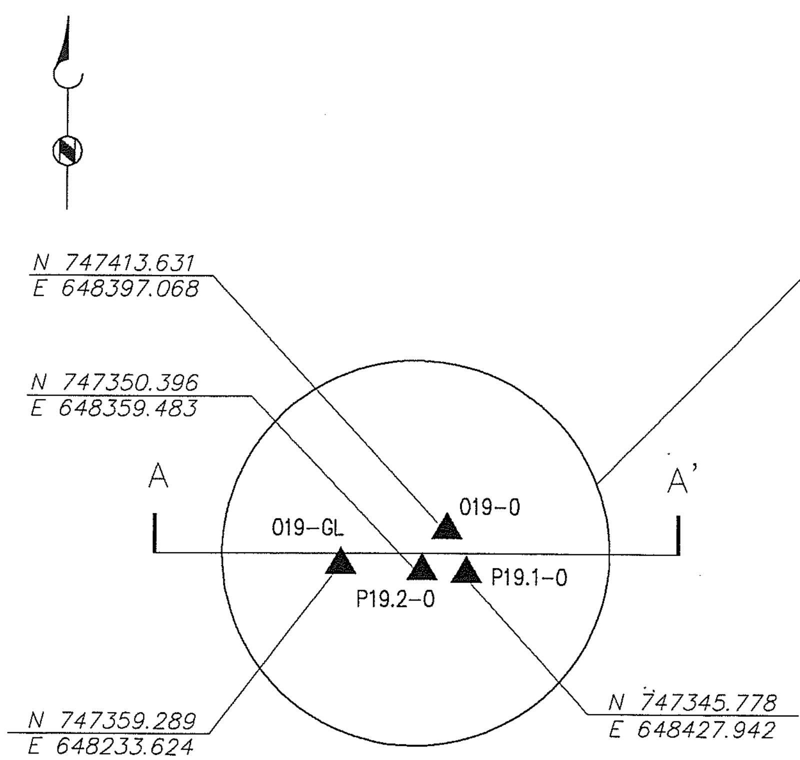
WELL SUFFIXES
(AQUIFER COMPONENT SCREEN)

BASIN FILL	GU
BASIN FILL	GL
OXIDE BEDROCK	O
SULFIDE BEDROCK	S

FEET BELOW GROUND SURFACE

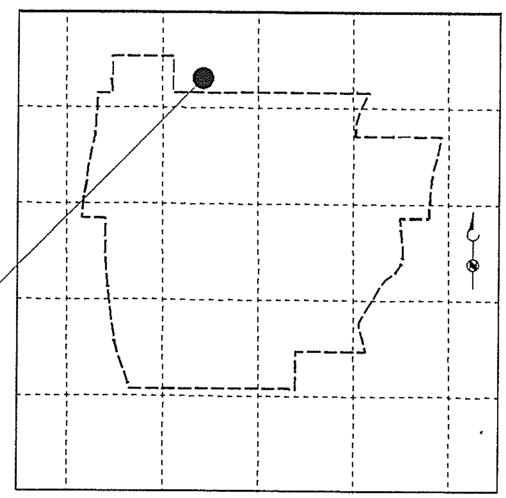
610

SCREENED INTERVAL



WELL PLAN VIEW

Approximate Scale: 1"= 300'



WELL LOCATION MAP

Approximate Scale: 1"= 2000'

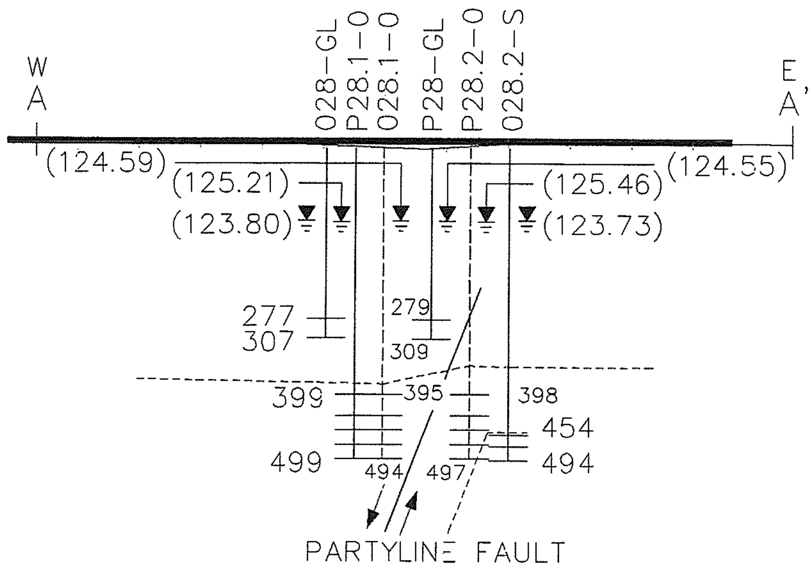
Figure E-7 (II)
LOCATION SUMMARY
AQUIFER TEST
CLUSTER 19

BROWN AND CALDWELL

MAGMA

MAGMA COPPER COMPANY
Florence, Arizona

E-7_2 12-01-95 DanH



NOTE:
WELLS 028.1-0 AND P28.2-0 ARE SCREENED ACROSS FAULT ZONE.

SIMPLIFIED EAST-WEST CROSS SECTION

Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 150'

EXPLANATION

POTENTIOMETRIC SURFACE (151.00)

(SHOWN IN FEET BELOW GROUND SURFACE)

WELL PREFIXES

PUMPED WELL	P
MONITOR WELL	M
OBSERVATION WELL	O

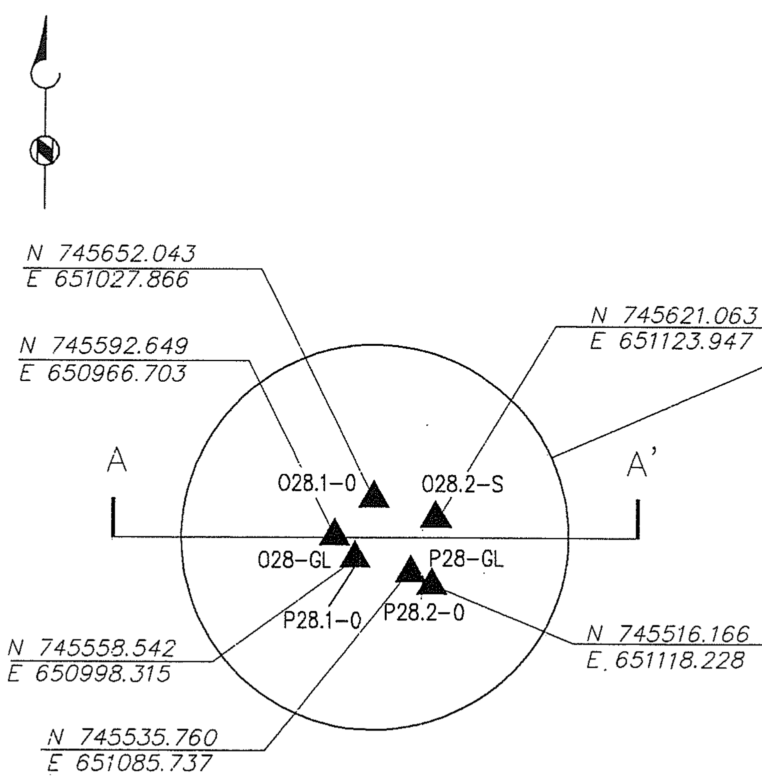
WELL SUFFIXES
(AQUIFER COMPONENT SCREEN)

BASIN FILL	GU
BASIN FILL	GL
OXIDE BEDROCK	O
SULFIDE BEDROCK	S

FEET BELOW GROUND SURFACE

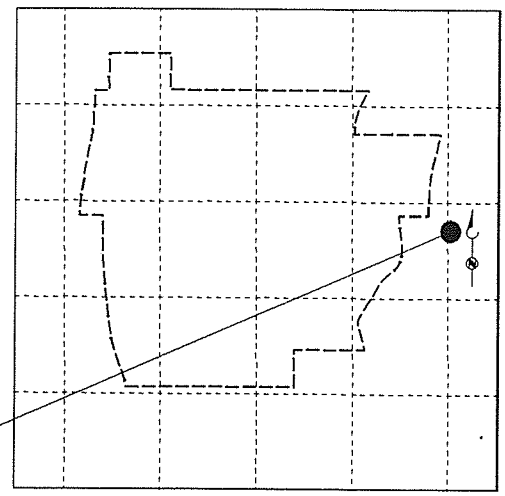
494

SCREENED INTERVAL



WELL PLAN VIEW

Approximate Scale: 1"= 300'



WELL LOCATION MAP

Approximate Scale: 1"= 2000'

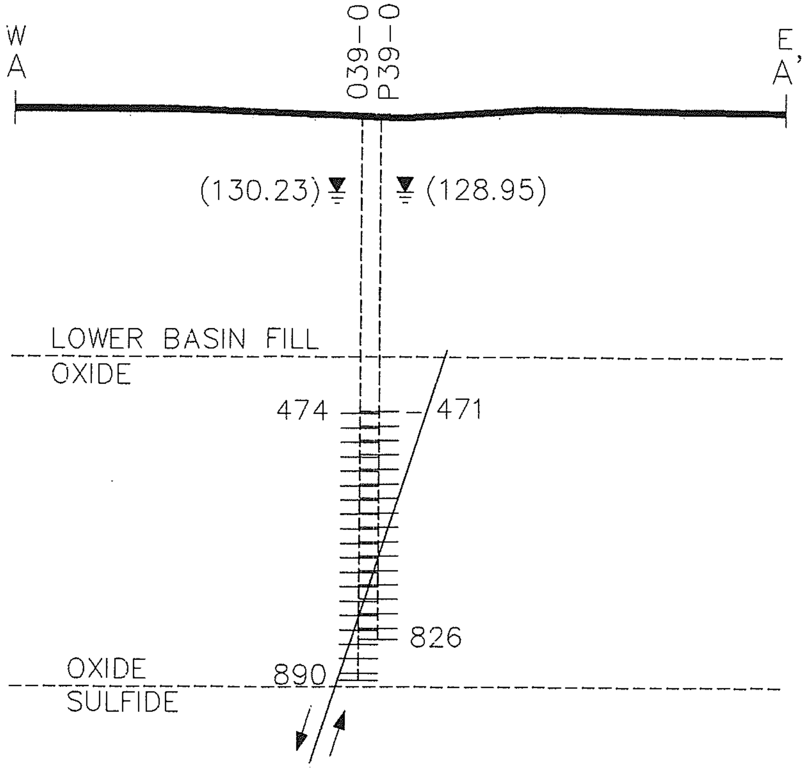
Figure E-8 (II)
LOCATION SUMMARY AQUIFER TEST CLUSTER 28

BROWN AND CALDWELL

MAGMA

MAGMA COPPER COMPANY
Florence, Arizona

E-8_2 12-01-95 DanH



EXPLANATION

POTENTIOMETRIC SURFACE (151.00)

(SHOWN IN FEET BELOW GROUND SURFACE)

WELL PREFIXES

PUMPED WELL	P
MONITOR WELL	M
OBSERVATION WELL	O

WELL SUFFIXES (AQUIFER COMPONENT SCREEN)

BASIN FILL	GU
BASIN FILL	GL
OXIDE BEDROCK	O
SULFIDE BEDROCK	S

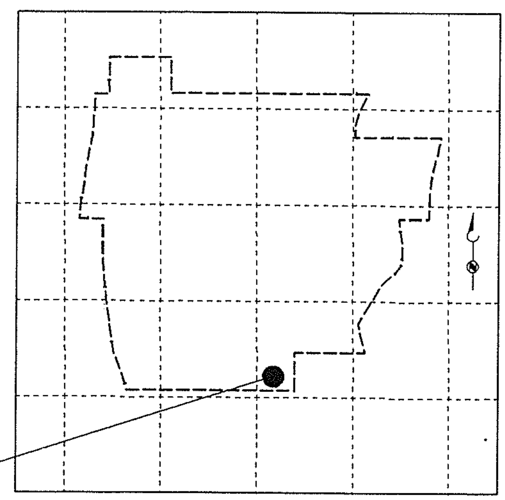
FEET BELOW GROUND SURFACE

610

SCREENED INTERVAL

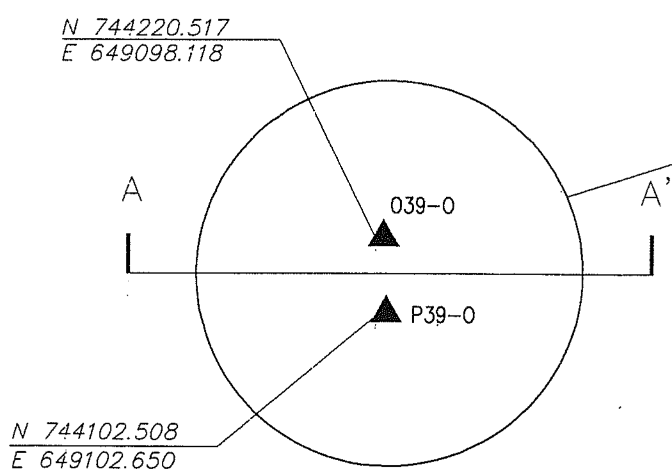
SIMPLIFIED EAST-WEST CROSS SECTION

Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 150'



WELL LOCATION MAP

Approximate Scale: 1"= 2000'



WELL PLAN VIEW

Approximate Scale: 1"= 300'

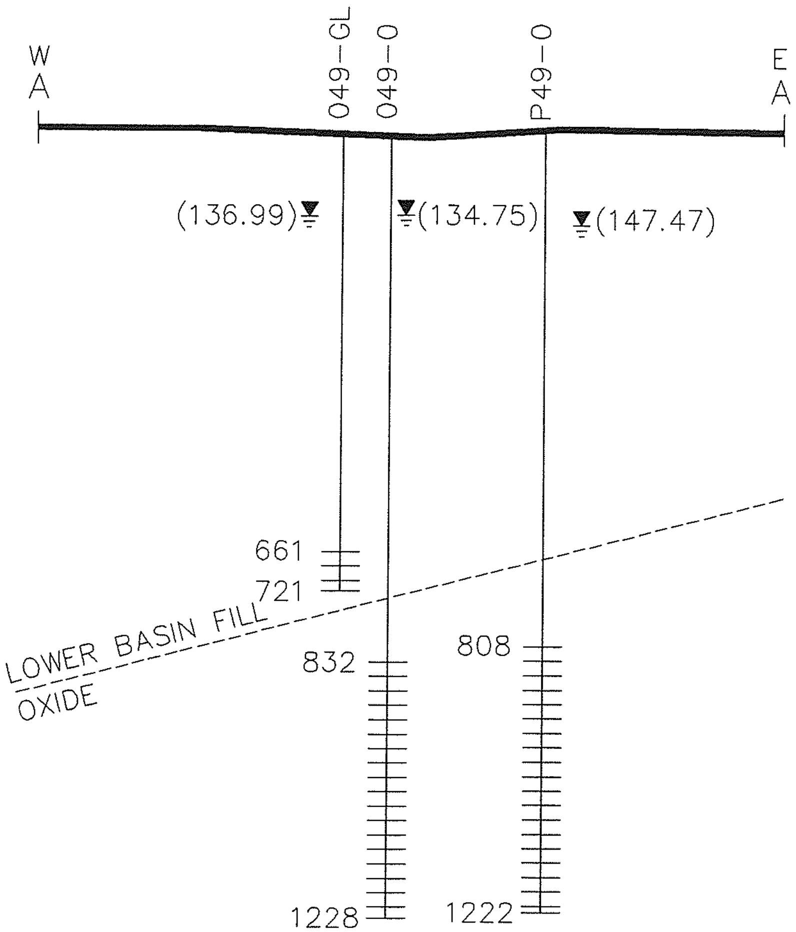
Figure E-9 (II)
LOCATION SUMMARY AQUIFER TEST CLUSTER 39

BROWN AND CALDWELL

MAGMA

MAGMA COPPER COMPANY
Florence, Arizona

E-9_2 12-01-95 DanH



EXPLANATION

POTENTIOMETRIC SURFACE (151.00)

(SHOWN IN FEET BELOW GROUND SURFACE)

WELL PREFIXES

PUMPED WELL	P
MONITOR WELL	M
OBSERVATION WELL	O

WELL SUFFIXES
(AQUIFER COMPONENT SCREEN)

BASIN FILL	GU
BASIN FILL	GL
OXIDE BEDROCK	O
SULFIDE BEDROCK	S

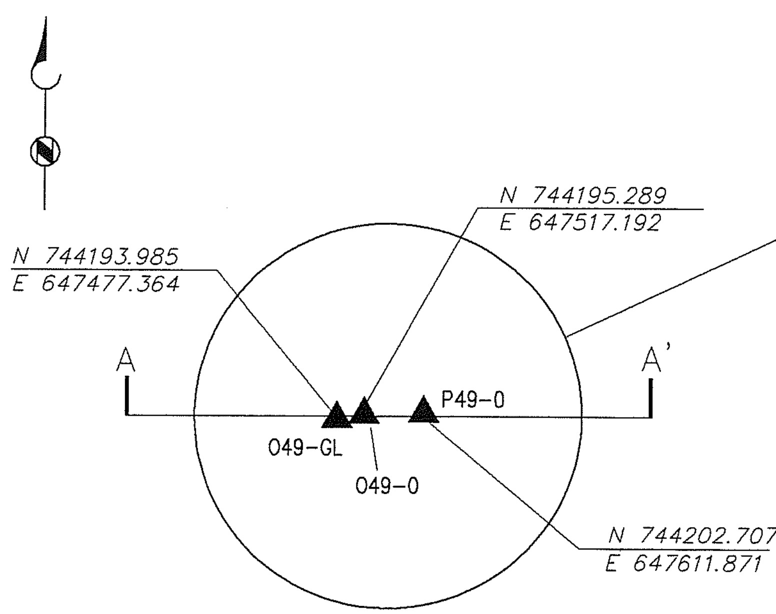
FEET BELOW GROUND SURFACE

890

SCREENED INTERVAL

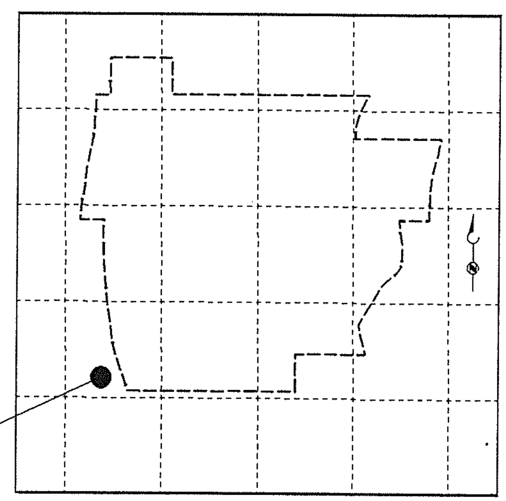
SIMPLIFIED EAST-WEST CROSS SECTION

Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 150'



WELL PLAN VIEW

Approximate Scale: 1"= 300'



WELL LOCATION MAP

Approximate Scale: 1"= 2000'

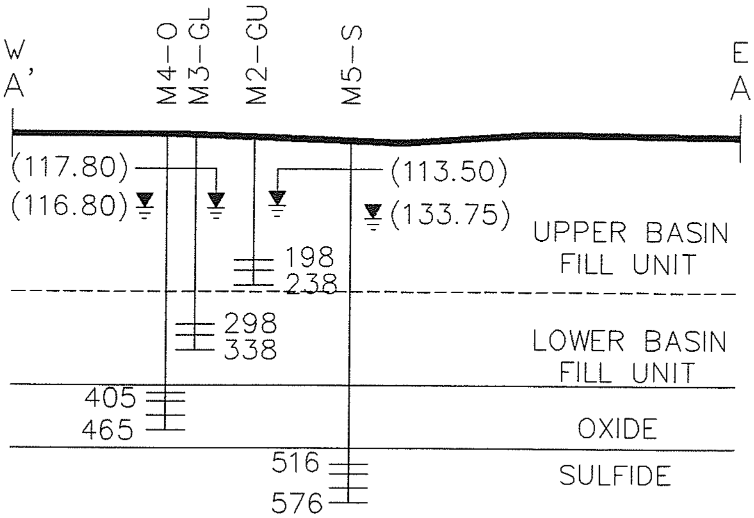
Figure E-10 (II)
LOCATION SUMMARY AQUIFER TEST CLUSTER 49

E-10_2 12-01-95 DanH

BROWN AND CALDWELL

MAGMA

MAGMA COPPER COMPANY
Florence, Arizona



SIMPLIFIED EAST-WEST CROSS SECTION

Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 150'

EXPLANATION

POTENTIOMETRIC SURFACE (151.00)

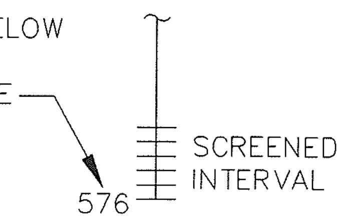
(SHOWN IN FEET BELOW GROUND SURFACE)

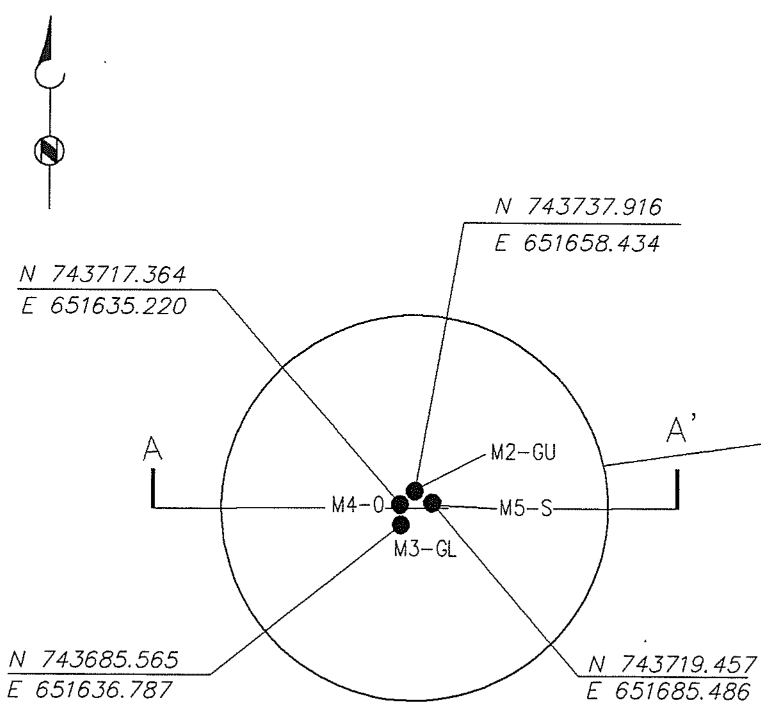
WELL PREFIXES

PUMPED WELL	P
MONITOR WELL	M
OBSERVATION WELL	O

WELL SUFFIXES (AQUIFER COMPONENT SCREEN)

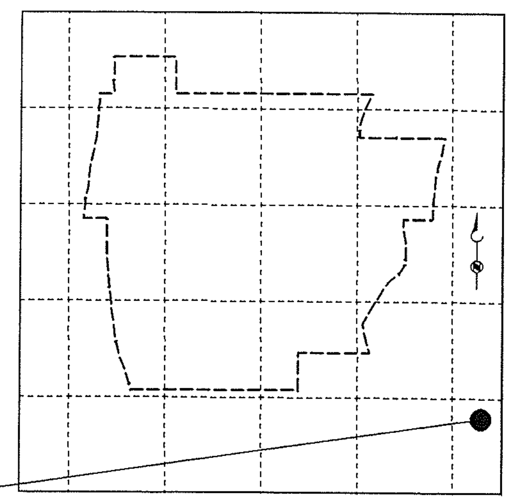
BASIN FILL	GU
BASIN FILL	GL
OXIDE BEDROCK	O
SULFIDE BEDROCK	S





WELL PLAN VIEW

Approximate Scale: 1"= 300'



WELL LOCATION MAP

Approximate Scale: 1"= 2000'

Figure E-11 (II)

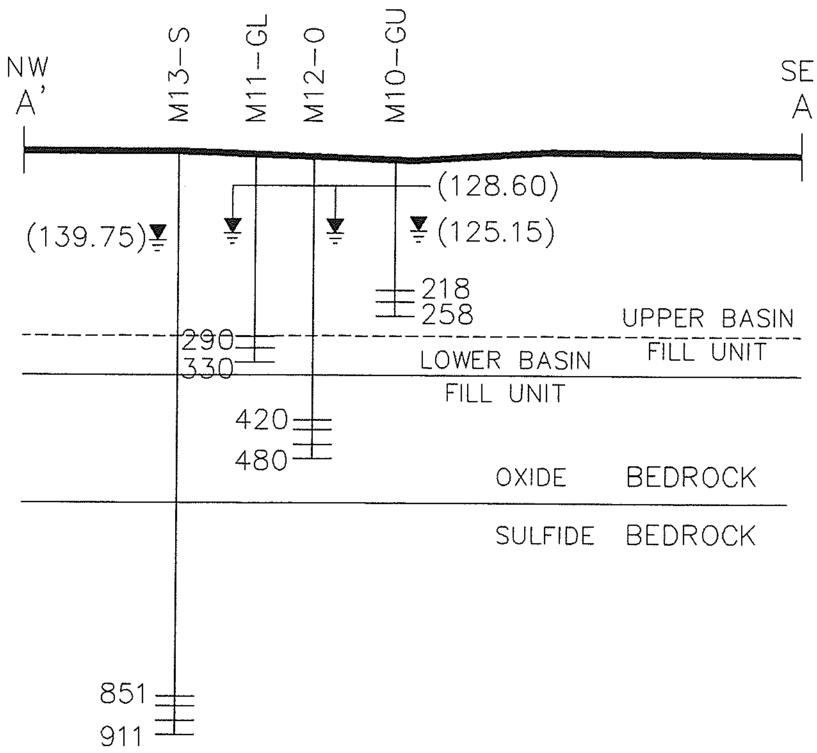
LOCATION SUMMARY SOUTHEAST MONITORING WELL CLUSTER

MAGMA

MAGMA COPPER COMPANY
Florence, Arizona

BROWN AND CALDWELL

E-11_2 12-01-95 DanH



SIMPLIFIED NORTHWEST-SOUTHEAST CROSS SECTION

Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 150'

EXPLANATION

POTENTIOMETRIC SURFACE (151.00)

(SHOWN IN FEET BELOW GROUND SURFACE)

WELL PREFIXES

PUMPED WELL	P
MONITOR WELL	M
OBSERVATION WELL	O

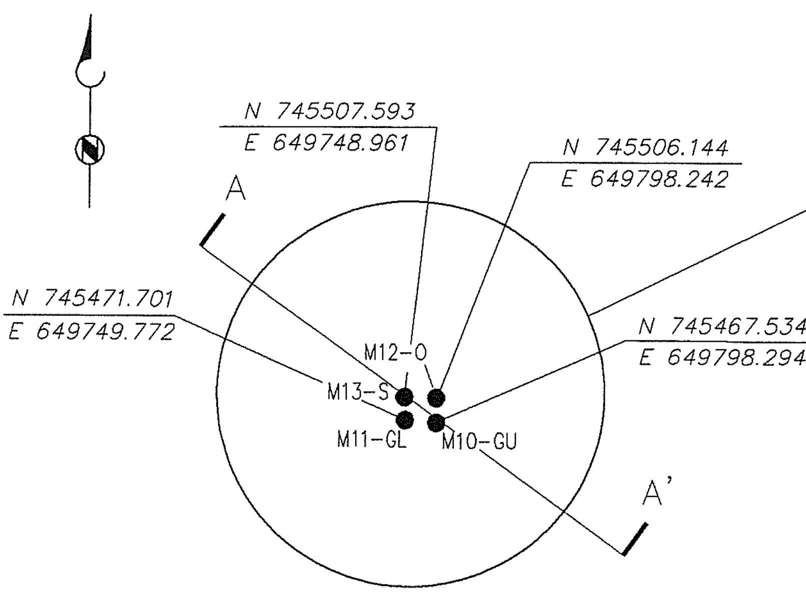
WELL SUFFIXES (AQUIFER COMPONENT SCREEN)

BASIN FILL	GU
BASIN FILL	GL
OXIDE BEDROCK	O
SULFIDE BEDROCK	S

FEET BELOW GROUND SURFACE

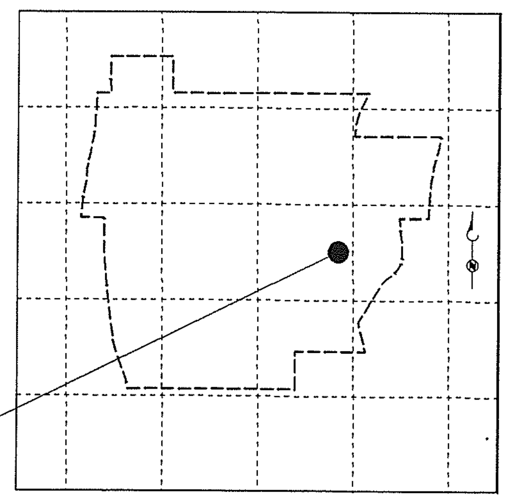
480

SCREENED INTERVAL



WELL PLAN VIEW

Approximate Scale: 1"= 300'



WELL LOCATION MAP

Approximate Scale: 1"= 2000'

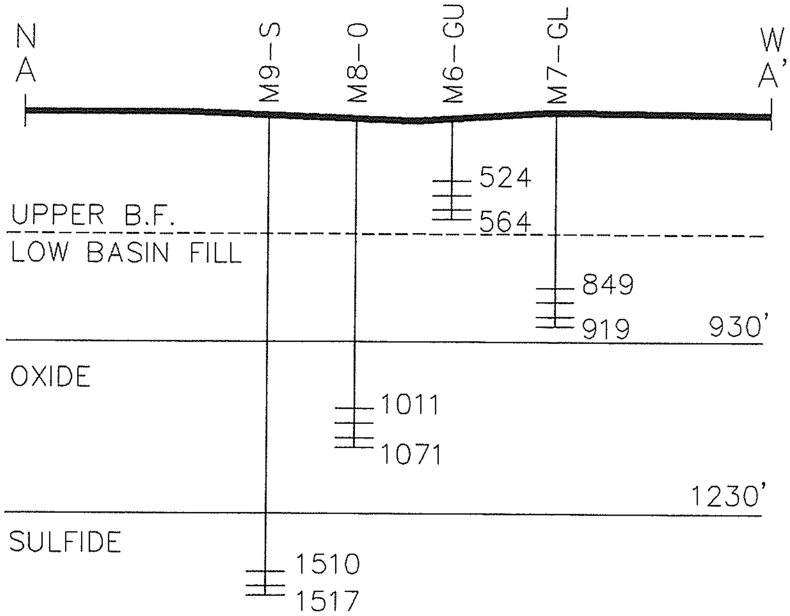
Figure E-12 (II) LOCATION SUMMARY MIDDLE MONITORING WELL CLUSTER

BROWN AND CALDWELL

MAGMA

MAGMA COPPER COMPANY
Florence, Arizona

E-12_2 12-01-95 DonH



SIMPLIFIED NORTH-WEST CROSS SECTION

Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 150'

EXPLANATION

POTENTIOMETRIC SURFACE (151.00)

(SHOWN IN FEET BELOW GROUND SURFACE)

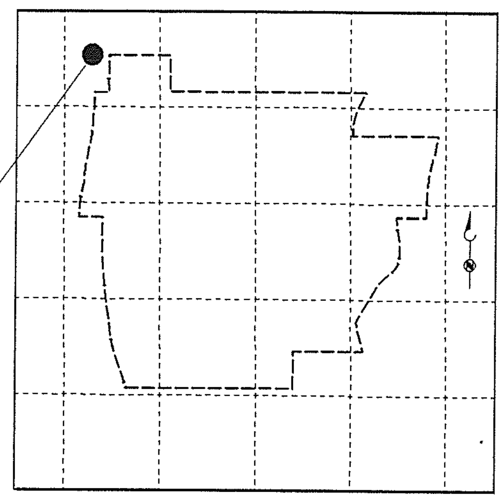
WELL PREFIXES

PUMPED WELL	P
MONITOR WELL	M
OBSERVATION WELL	O

WELL SUFFIXES
(AQUIFER COMPONENT SCREEN)

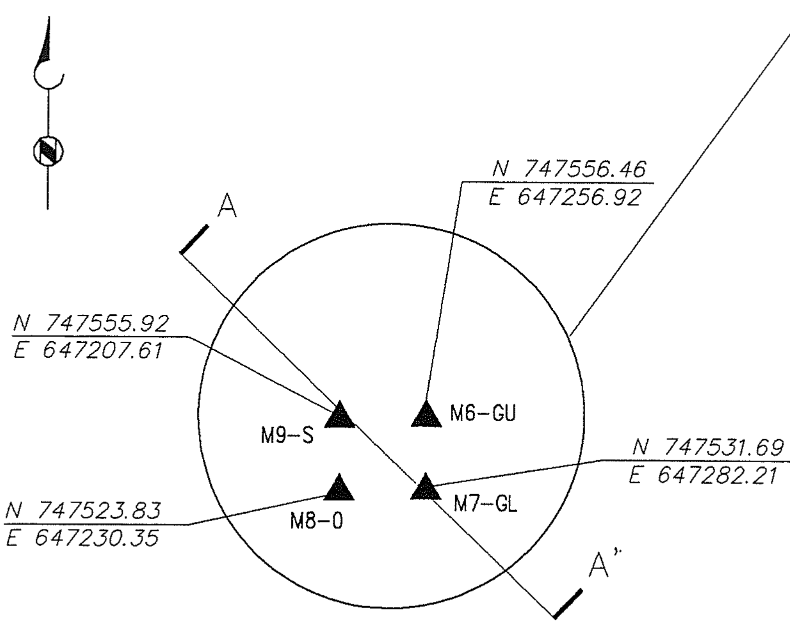
BASIN FILL	GU
BASIN FILL	GL
OXIDE BEDROCK	O
SULFIDE BEDROCK	S

FEET BELOW GROUND SURFACE
890
SCREENED INTERVAL



WELL LOCATION MAP

Approximate Scale: 1"= 2000'



WELL PLAN VIEW

Approximate Scale: 1"= 300'

BROWN AND CALDWELL

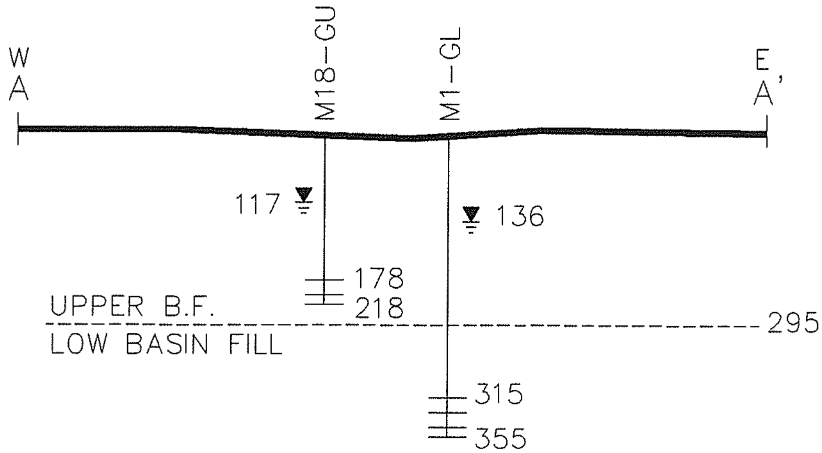
E-13_2 12-01-95 DanH

Figure E-13 (II)

LOCATION SUMMARY NORTHWEST MONITORING WELL CLUSTER

MAGMA

MAGMA COPPER COMPANY
Florence, Arizona



SIMPLIFIED EAST-WEST CROSS SECTION

Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 150'

EXPLANATION

POTENTIOMETRIC SURFACE (151.00)
(SHOWN IN FEET BELOW GROUND SURFACE)

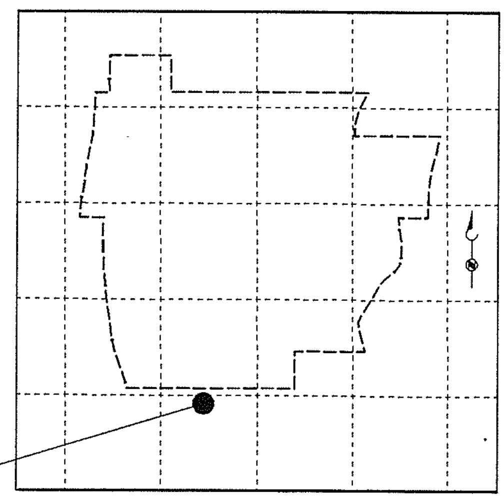
WELL PREFIXES

PUMPED WELL	P
MONITOR WELL	M
OBSERVATION WELL	O

WELL SUFFIXES
(AQUIFER COMPONENT SCREEN)

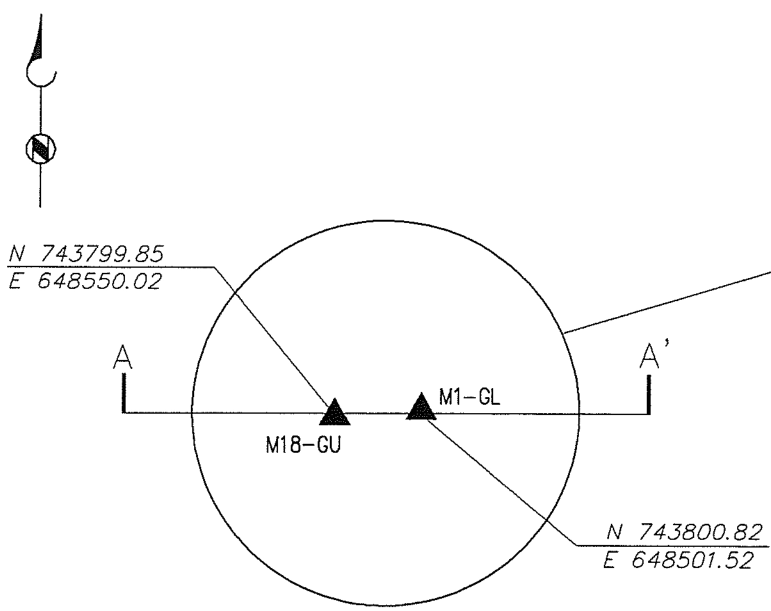
BASIN FILL	GU
BASIN FILL	GL
OXIDE BEDROCK	O
SULFIDE BEDROCK	S

FEET BELOW GROUND SURFACE
890
SCREENED INTERVAL



WELL LOCATION MAP

Approximate Scale: 1"= 2000'



WELL PLAN VIEW

Approximate Scale: 1"= 300'

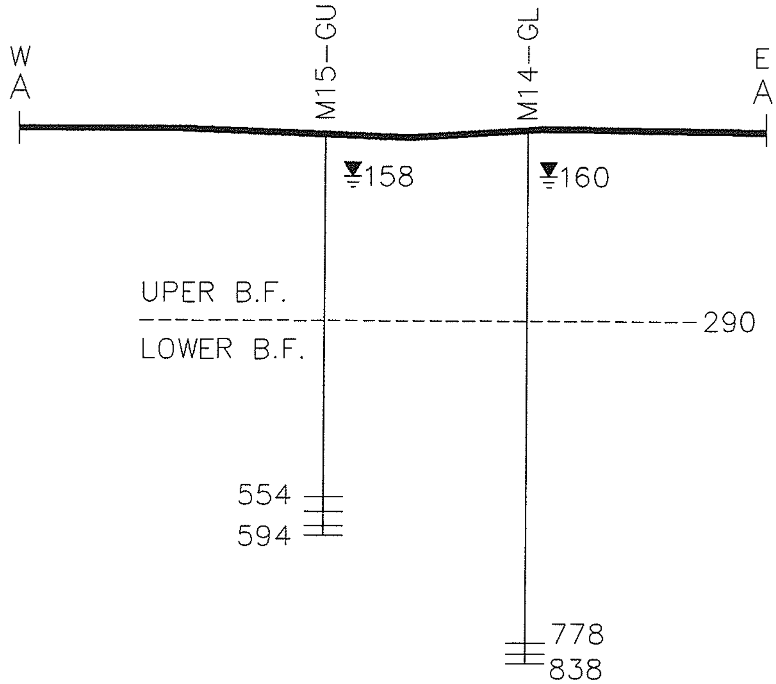
Figure E-14 (II)

LOCATION SUMMARY MONITORING WELL CLUSTER 1 & 18

E-14_2 12-01-95 DanH

BROWN AND CALDWELL

MAGMA
MAGMA COPPER COMPANY
Florence, Arizona



SIMPLIFIED EAST-WEST CROSS SECTION

Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 150'

EXPLANATION

POTENTIOMETRIC SURFACE (151.00)

(SHOWN IN FEET BELOW GROUND SURFACE)

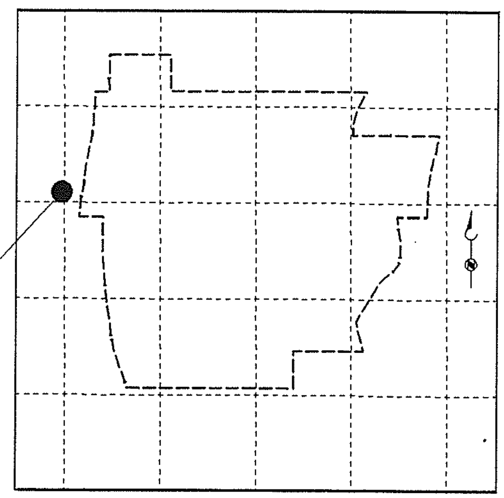
WELL PREFIXES	
PUMPED WELL	P
MONITOR WELL	M
OBSERVATION WELL	O

WELL SUFFIXES (AQUIFER COMPONENT SCREEN)	
BASIN FILL	GU
BASIN FILL	GL
OXIDE BEDROCK	O
SULFIDE BEDROCK	S

FEET BELOW GROUND SURFACE

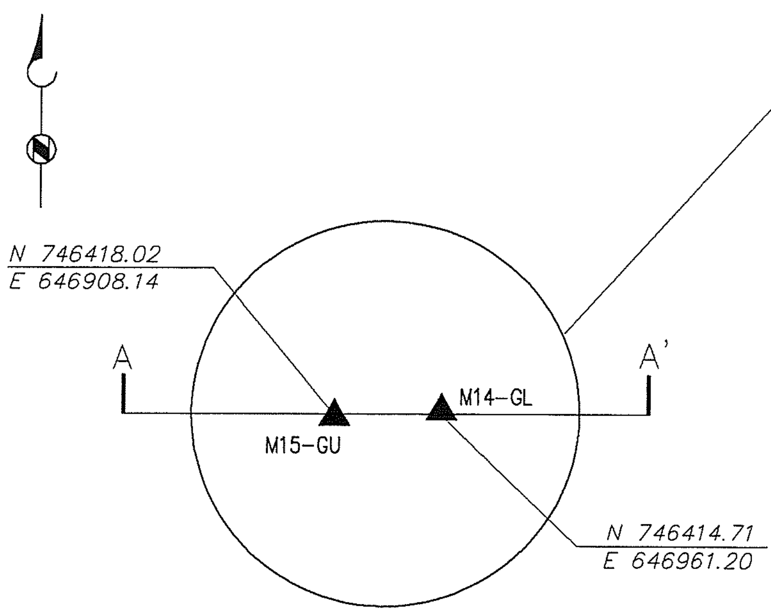
890

SCREENED INTERVAL



WELL LOCATION MAP

Approximate Scale: 1"= 2000'



WELL PLAN VIEW

Approximate Scale: 1"= 300'

Figure E-15 (II)

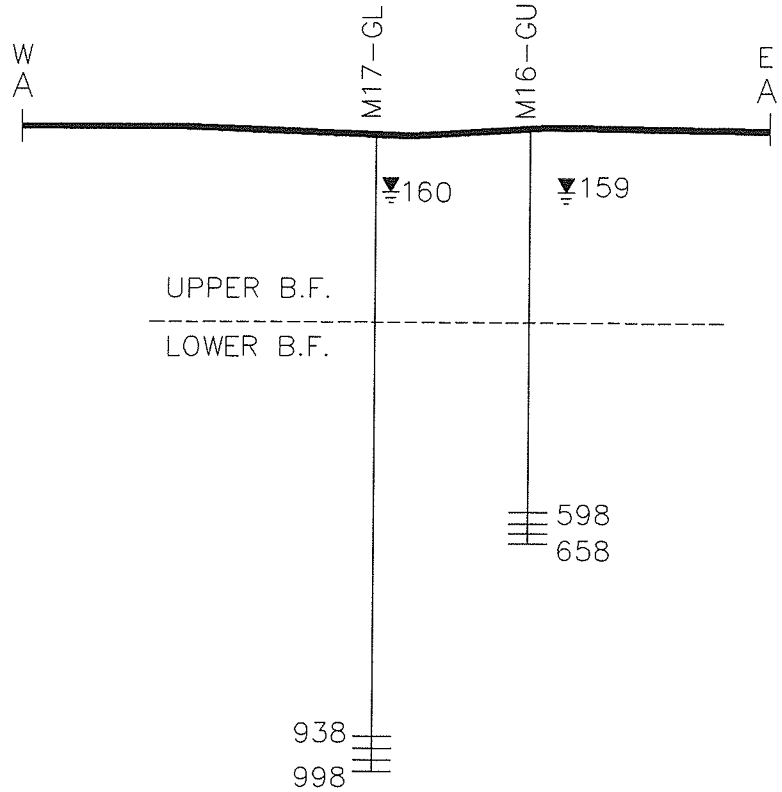
LOCATION SUMMARY MONITORING WELL CLUSTER 14 & 15

BROWN AND CALDWELL

MAGMA

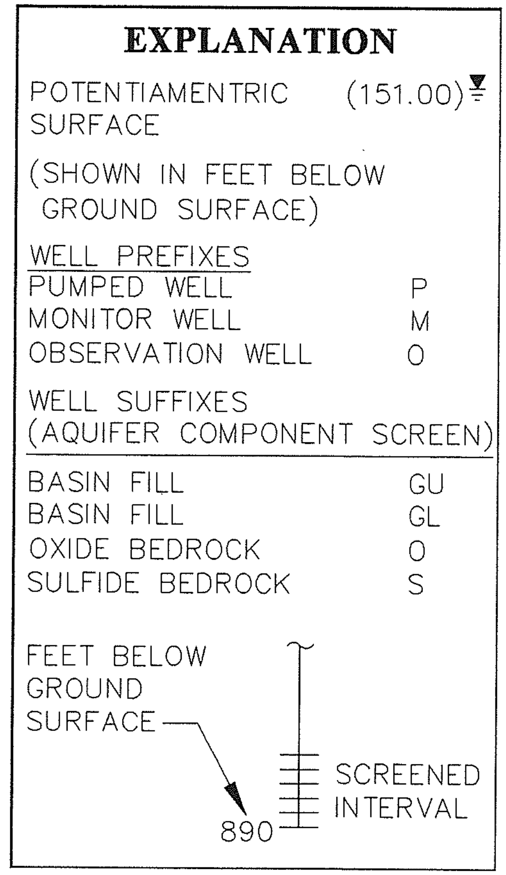
MAGMA COPPER COMPANY
Florence, Arizona

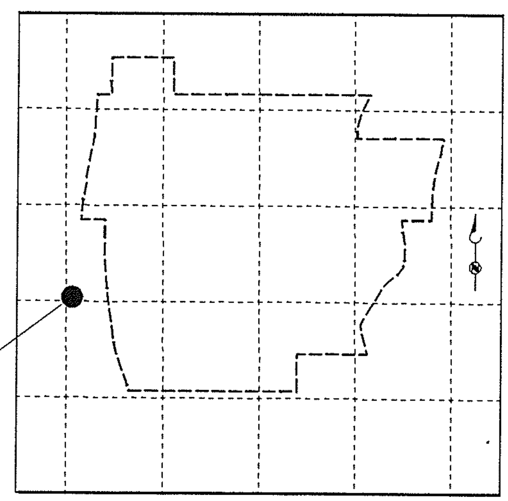
E-15_2 12-01-95 DonH



SIMPLIFIED EAST-WEST CROSS SECTION

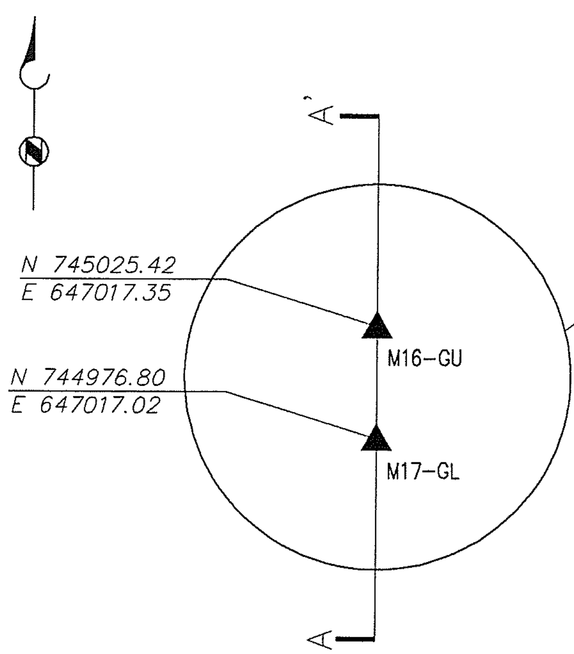
Approximate Scale: Vertical : 1"= 300'
Horizontal: 1"= 150'





WELL LOCATION MAP

Approximate Scale: 1"= 2000'



WELL PLAN VIEW

Approximate Scale: 1"= 300'

Figure E-16 (II)
LOCATION SUMMARY AQUIFER TEST CLUSTER 16/17

E-16_2 12-01-95 DanH

BROWN AND CALDWELL

MAGMA
MAGMA COPPER COMPANY
Florence, Arizona

Golder Associates Inc.

4730 N. Oracle Road
Suite 210
Tucson, AZ USA 85705
Telephone (520) 888-8818
Facsimile (520) 888-8817

Data Report for Initial Interpretation of the Hydraulic Tests at the Florence Mine Site

for

Magma Copper Company Aquifer Protection Permit Florence In Situ Leaching Project

Prepared for:

Magma Copper Company
Resource and Development Group
7400 N. Oracle Road, Suite 162
Tucson, Arizona 85704

Prepared by:

Golder Associates Inc.
4700 N. Oracle Road, Suite 210
Tucson, Arizona 85704

Distribution:
2 Copies - John Kline, Magma Copper Company
2 Copies - Dan Ramey, Magma Copper Company
2 Copies - Steve Mellon, Brown and Caldwell
2 Copies - Golder Associates

12/1/95

November 1995

Golder Associates

TABLE OF CONTENTS

Registered Professional Engineer (Civil)
CERTIFICATE NO.
25292
GREGORY R.
CARLSON
Date Signed
ARIZONA U.S.A.

LIST OF TABLES AND FIGURES

FIGURE **PAGE**

FIGURE		PAGE

1.0 INTRODUCTION

This report presents the results of the interpretation of hydraulic tests in the area of Magma Copper Company's (Magma) proposed in-situ mining project near Florence, Arizona. The purpose of this report is to provide a technical basis for hydraulic parameter estimation for site characterization in support of state and federal environmental review and permitting requirements.

This report has been prepared as a technical appendix to the Aquifer Protection Permit (APP) Application document prepared by Brown and Caldwell (1995). As such, only hydrogeologic information pertinent to test data interpretation is discussed in this report. The interested reader is directed to the above reference for additional detail.

The analyses presented in this report are based on standard methods developed in the oil and gas industry. These methods are applied to data collected and provided by Brown and Caldwell. Interpretation of the field data is performed with the FLOWDIM™ software of Golder Associates.

This report is divided into three major sections. Chapter 2 presents the mathematical foundation for the well test analysis. A brief discussion of each test and application of this theory to the aquifer test at the Florence Site is presented in Chapter 3. Tables and graphical representation of these analyses are provided in Appendixes A through C. The field data used in these analyses are included in electronic format in the attached diskette.

1.1 Background

Magma has undertaken field studies to characterize the hydrogeologic conditions near its proposed in-situ mining site in the Poston Butte porphyry copper deposit. The proposed mine site is located in the Basin and Range Physiographic Province of southern Arizona, in the Eloy Sub-basin of the Pinal Active Management Area (AMA), and is about 1 mile southwest of Poston Butte and 2 miles northwest of the Town of Florence, Arizona.

The rock units in the study area range in age from Precambrian to Quaternary. The floodplain alluvium is Quaternary in age and consists mainly of unconsolidated silt, sand, gravel and boulders. The Cenozoic basin fill deposits have been divided into three major units; the Upper (UBFU), Middle (MBFU) and the Lower (LBFU) Basin Fill Units. The UBFU is composed of unconsolidated to weakly cemented, interbedded clay, silt, sand gravel and boulders. The thickness of the UBFU ranges from 200 to about 500 feet in the vicinity of the mine site. The MBFU is a discontinuous layer composed by silt and clay that varies in thickness from zero to about 80 feet. Weakly to moderately cemented sand, silt and clay constitute the lower unit (LBFU). The thickness of this latter unit varies from less than 50 feet on the east to about 800 feet to the west of the mine site. The bedrock complex consists of quartz monzonite and granodiorite porphyry, and diabase, basalt and other volcanic rocks.

Magma has retained Brown and Caldwell of Phoenix, Arizona to prepare the APP application for the Florence in-situ project. As part of this APP-site characterization effort, Brown and Caldwell has installed forty six (46) monitoring wells and seventeen (17) test wells around the site. Eight (8) of these wells are completed within the UBF Unit, seventeen (17) within the LBF Unit and thirty eight (38) within the bedrock complex. To date, Brown and Caldwell has conducted twenty five (25) aquifer tests which include monitoring wells as well as test boreholes. Magma requested that Golder Associates assist Brown and Caldwell with the design and interpretation of the hydraulic tests required as part of the APP process. Nineteen (19) aquifer test locations were selected for interpretation. These locations cover the range of typical hydrogeologic conditions observed at the site. The following sections present an overview of the theory and methods of interpretation, and the analytical results for a portion of these aquifer tests.

2.0 THEORY AND METHODS OF INTERPRETATION

Well testing provides a means of acquiring knowledge of the properties of hydrogeological formations. In the process of a well test, a known signal (usually a change in flow rate) is applied to the formation and the resulting output signal or response is measured (usually in terms of a change in pressure). Well test interpretation is therefore an inverse problem in that the formation parameters are inferred by comparing a simulated model response to the measured response. The formation parameters are derived by adjusting the flow model parameters to obtain a simulation response that matches the measured data. Clearly, there can be significant ambiguity and non-uniqueness involved in this process, as more than one flow model with different physical assumptions and attributes may match the data. In most situations this can be minimized by careful validation of the selected model using other data.

The overall methodology for the detailed well test analysis of the Florence Project data was as follows:

- the data set was divided into its major components, such as the drawdown period and the shut-in or recovery period;
- appropriate parts were then analyzed separately, with different methods of analysis for flow periods and shut-in periods;
- the analyses of the different periods were checked for consistency.

2.1 Analysis of Recovery Period

The analysis of recovery (shut-in) periods is usually based on the assumption that the shut-in period corresponds to an event of zero flow rate following a fixed period of known finite, constant flow rate. If the flow rate prior to the shut-in period is variable, then this flow history can be included in the analysis by using the superposition of a number of different but constant flow rates of different durations.

The next step in an hydraulic test analysis involves the selection of an appropriate flow model. these models are generally divided into three basic components.

- inner boundary conditions (i.e., wellbore storage and skin effects, and fracture flow effects);
- formation flow component (i.e., homogeneous formation, dual porosity, and composite model);.
- outer boundary conditions (i.e., infinite extent condition, no flow or constant pressure conditions).

In practice, recognition of a suitable model is performed using diagnostic plots. The data are plotted in different coordinate systems (such as, log-log plots, semi-log Horner plots, etc.) to help the analyst identify the appropriate model from the shape of the data. One key diagnostic plot is the derivative plot where the derivative of the pressure with respect to the natural logarithm of elapsed time is plotted against the log of time. The pressure derivative is extremely sensitive to the shape of the pressure data and as such constitutes the most useful tool for diagnostic purposes. For example, a horizontal line on a derivative plot (presented in a log-log scale) indicates infinite-acting radial flow behavior.

Data from shut-in periods are examined in both log-log and semi-log diagnostic plots. This approach allows the analyst to review the characteristics of the shut-in period. For example, when the effects of the pre-test injection/extraction flows during drilling are significant, the shut-in pressure data reach a peak before starting to decline at late time. This form of data is referred to as a 'rollover' and can be easily diagnosed on the log-log and semi-log plots. The log-log and the semi-log diagnostic plots are also used to fit selected portions of the shut-in data with appropriate straight lines and obtain initial estimates of formation parameters.

After the flow model has been selected, the quality of the fit of the data with the model response (called 'type curves') is adjusted by using automated regression methods. During this stage of the analysis, the entire data from the selected shut-in period is considered. However, during the final regression stages, emphasis is always placed on the fit of the type curves to specific portions of the data. Judgment of the relative goodness of fit to specific portions of the shut-in data comprises one of the most important aspects of the automated data fitting procedure. Once a suitable and consistent fit of the data is obtained to the type curves, the fit is reviewed for final refinement. The entire measured data set from the shut-in period generated using the best flow model parameters derived from the shut-in analysis is displayed in a cartesian plot.

After the flow model has been selected and a consistent set of analysis results obtained, a sensitivity analysis could be conducted. This exercise is designed to quantify the likely uncertainty in the estimated hydraulic conductivity. When carried out, it helps to determine the range of the parameter within which a reasonably good fit is retained between the model response and the data. The ranges of this parameter therefore reflect uncertainty in the analysis.

2.2 Analysis of Drawdown Period

If a sufficient hydraulic head change is achieved during the drawdown period, the available data were analyzed as a constant discharge test. Otherwise, the data were not use in the interpretation.

In an analysis of the main flow period, the source signal is assumed to be in the form of an instantaneous pressure change from undisturbed in-situ conditions. The data for this flow period is the measured hydraulic head decrease during the test resulting from fluid extraction from the formation. The analysis used a simple set of type curves which correspond to a single interpretation model :

- inner boundary condition: wellbore storage and skin;
- formation: homogeneous; and
- outer boundary condition: infinite lateral extent.

Only one of two parameter sets can be determined from this analysis: hydraulic conductivity and wellbore skin (the static water level being an input parameter for this analysis) or hydraulic conductivity and storativity. The best fit of the data to the type curves therefore corresponds to finding the optimum set of the two output parameters.

The following section (Section 2.3) describes the general theory underlying hydraulic test analysis. Section 2.4 presents the governing equations and related assumptions. The parameters for various flow models are discussed in Section 2.5. Section 2.6 outlines general methods that are applied to the analysis of hydraulic tests. The reader interested in the specific methodology of detailed test interpretation is therefore directed to Section 2.6.

2.3 Theoretical Background

The purpose of this discussion is to provide a summary of the mathematical and physical background of the aspects of well test analysis that are relevant to the Florence Site. The presentation is divided into three parts:

Part one defines the basic rock and fluid parameters used in the analysis of transient well tests (Section 2.3.1). The second part presents the 'diffusion equation' that governs the flow in porous media, identifies its underlying assumptions, and describes some special solutions (Section 2.4). Data analyses of Florence hydraulic tests are based on various solutions of the diffusion equation. Finally, the third part describes the interpretation models that have been applied to analyze the Florence hydraulic test data (Section 2.6).

Aspects of theoretical well testing have been documented in numerous papers and textbooks, both in the petroleum engineering and the groundwater literature. The interested reader is directed to the following summarizing references: Kruseman and de Ridder (1991) and Dawson and Istok (1991) for theoretical aspects of pump test analyses written mainly for the 'hydrogeology audience' and Earlougher (1977), Streltsova (1988), Horne (1990) and Sabet (1991) targeted mainly at the 'petroleum formation evaluation audience.'

2.3.1 Rock and Fluid Properties

2.3.1.1 Porosity and Compressibility

Fluid properties such as water compressibility, density, viscosity, and in some cases the thermal expansion coefficient, have to be estimated prior to analysis of the test data. Formation compressibility and porosity must be known (or a reasonable value assumed) in order to analyze transient tests and to obtain estimates for the skin coefficient.

Rock porosity, ϕ, is defined as the ratio of the void volume to the total bulk volume. For analysis of fluid movement the effective porosity of the rock is used. It represents the interconnected volume of pores available for fluid transport. For the Florence hydraulic tests, it was assumed that the average porosity of the Oxide and unconsolidated alluvial sediments is 0.05 and 0.10 respectively. Fractured reservoir rocks can be represented as comprising of two overlapping continua with different porosities. One is the intergranular matrix porosity and the other is the porosity created by the void spaces of fractures. These two types of porosity are called primary and secondary porosity respectively. The total porosity (or total effective porosity) of the double-porosity system is the sum of the primary and secondary porosities. Laboratory measurements on various types of fractured rock have shown that the fracture porosity is usually significantly less than the matrix porosity (von Golf-Racht, 1982)

The isothermal compressibility of water (and rock) is generally defined as:

$$c = \frac{1}{V}\frac{dV}{dP}\Big|_T \qquad 2.1$$

where the derivative is taken under the condition of constant temperature. In Eq. 2.1, V is the total volume of a given mass of material, and dV is the instantaneous change in volume induced by an instantaneous change in pressure dP.

The total compressibility of the rock-fluid system with 100% water saturation is made up of two components;

$$c_T = c_W + c_R \qquad 2.2$$

where:

c_T	=	total compressibility	Pa^{-1}
c_W	=	compressibility of water	Pa^{-1}
c_R	=	compressibility of rock	Pa^{-1}

Total compressibility was assumed equal to 5.4×10^{-4} Pa^{-1} for the analyses of the aquifer tests at the Florence site. Water compressibility data are readily available as a function of salinity, temperature and pressure. The correct estimation of the rock compressibility, however, is difficult. Data in the literature cited in Belanger et al. (1989) give a possible range of the fractured rock compressibility as 2.0×10^{-9} kPa^{-1} to 2.0×10^{-5} kPa^{-1}.

Specific storage, S_S, of a saturated confined aquifer is defined as the volume of water that a unit volume of aquifer releases from storage under a unit decline in hydraulic head. This parameter depends directly on the ϕc_T product (Earlougher, 1977):

$$S_S = \phi c_T (\rho g) \qquad m^{-1} \tag{2.3}$$

where:

ρ	=	density of water	kg/m^3
g	=	acceleration of gravity	ms^{-2}.

2.3.1.2 Wellbore Storage

Another form of compressibility, of the fluid inside the borehole, is wellbore storage. During a hydraulic test, wellbore storage causes the downhole flow rate to change more slowly than the surface flow rate. The borehole storage is equal to the change in the volume of fluid in the wellbore, per unit change in the downhole pressure. The wellbore storage coefficient is defined by

$$C = \frac{\Delta V}{\Delta P} \qquad m^3 Pa^{-1} \tag{2.4}$$

noting that ΔV refers to the change in volume of fluid inside the wellbore, and ΔP refers to the change in the downhole (borehole) pressure.

In a wellbore with a changing fluid level (for example during a constant rate pumping period) the wellbore storage coefficient is given by:

$$C = \frac{\pi r_t^2}{\rho g} \qquad 2.5$$

where:

πr_t^2 = volume of tubing per unit length

ρg = change in pressure per unit length

When the fluid level is fixed (for example during a shut-in period) the wellbore storage coefficient is given by

$$C = \pi r_W^2 h c_{WW} = V_W c_{WW} \qquad 2.6$$

where V_W is the test section volume (h is the test section length and r_W the wellbore radius) and c_{WW} is the compressibility of the water in the wellbore. The wellbore storage coefficient varies by orders of magnitude depending on the mode of storage within a test. For example, assuming $\rho g = 10$ kPa/m, $h = 50$ m, $r_W = 0.079$ m, $r_t = 0.035$ m and $c_{WW} = 4 \times 10^{-7}$ kPa^{-1}, values of C from equations 2.5 and 2.6 are calculated to be 3.8×10^{-4} m^3/kPa and 3.9×10^{-7} m^3/kPa, respectively.

2.3.1.3 Permeability and Hydraulic Conductivity

The estimation of hydraulic conductivity was the primary objective of the aquifer testing at the Florence site. This parameter is related to both the fluid and fluid transmitting characteristics of the formation. This relationship can be illustrated through the well-known Darcy equation:

$$q = -K\frac{dH}{dL} \qquad 2.7$$

where:

q	=	Darcy flux	ms^{-1},
K	=	hydraulic conductivity	ms^{-1},
dH/dL	=	hydraulic gradient	*unitless*,
H	=	hydraulic head	*m*,
L	=	length or distance	*m*.

The Darcy flux assumes that flow occurs over the entire flow area. In other words, it is a macroscopic velocity. Darcy's law holds only for laminar flow.

The same equation can be expressed in terms of intrinsic permeability (k) which represents the conductance that the rock offers to fluid flow:

$$q = -\frac{k}{\mu}\frac{dP}{dL} \qquad 2.8$$

where:

P	=	pressure	*Pa*,
μ	=	dynamic viscosity	*Pa-s*,
k	=	intrinsic permeability	m^2.

Intrinsic permeability is defined for a single fluid flowing through the rock and represents a transmissive property of only the rock system. Equating Eq. 2.8 with Eq. 2.7 and including the head-pressure correlation, results in an equation relating hydraulic conductivity and intrinsic permeability:

$$K = \frac{k}{\mu}\rho g \qquad 2.9$$

2.3.1.4 Hydraulic Head

The hydraulic head is expressed in terms of the pressure (P) and an elevation (Z) relative to a known datum. It can be thought of as a column of fluid of length H with a specific density ρ, assuming an atmospheric pressure of P_{atm}, and acceleration of gravity g,

$$H = \frac{P - P_{atm}}{\rho g} - Z \qquad 2.10$$

2.4 Assumptions and Governing Equation

The general well test analysis approach is based on solutions to the diffusion equation (also known, in the petroleum literature, as the diffusivity equation) for various sets of initial and boundary conditions. There are two common ways of presenting these solutions:

a) Hydraulic head, hydraulic conductivity and storage, or
b) Pressure, permeability, porosity, compressibility and fluid viscosity.

When expressed in terms of pressure, the diffusion equation is (see, for example, Lee, 1982):

$$\frac{\partial^2 P}{\partial r^2} + \frac{1}{r}\frac{\partial P}{\partial r} = \frac{\phi \mu c_t}{k}\frac{\partial P}{\partial t} \qquad 2.11$$

where:

r	=	radial distance	*m*,
t	=	time	*s*.

This equation is a linear parabolic partial differential equation, that is derived using the following assumptions (Horne, 1990):

a) Darcy's Law applies;
b) Porosity, permeability, viscosity and rock compressibility are constant;
c) Fluid compressibility is small and constant;
d) Pressure gradients in the formation are small;
e) Flow is single phase;
f) Gravity and thermal effects are negligible;
g) Permeability is isotropic; and
h) Only horizontal radial flow is considered.

The solutions of the diffusion equation are usually given in terms of dimensionless parameters. The dimensionless variables lead to both a simplification and generalization of the mathematics (Dake, 1978). Moreover, with dimensionless variables, the solutions are invariant in form, irrespective of the units system used. The dimensionless pressure, P_D, is a solution to Eq. 2.11 for specific initial and boundary conditions. In the case of the constant surface flow rate (q), the pressure at any point in the formation penetrated by the well is described by the generalized solution below (Earlougher, 1977):

$$P_i - P(r,t) = \frac{qB\mu}{2\pi kh}[P_D(t_D,r_D,C_D,\omega,\lambda,...) + s] \qquad 2.12$$

where B is the formation volume factor, equal to a volume of fluid at well pressure and temperature normalized to standard surface conditions (B is considered to be unity during the analyses of the Florence data). The variables t_D and r_D are the dimensionless time and radius, respectively; C_D is the dimensionless wellbore storage. The other parameters are defined in the Nomenclature section (Section 6.0).

The physical pressure drop is equal to a dimensionless pressure drop times a scaling factor. The scaling factor depends only on flow rate and reservoir properties. The concept applies in general, even for complex situations. It is this generality that makes the dimensionless solution approach useful. P_D is a function of time, location, system geometry and other variables (Earlougher, 1977).

The dimensionless time, t_D, in Eq. 2.12 is defined by:

$$t_D = \frac{kt}{\phi\mu c_t r_W^2} \qquad 2.13$$

where r_W is the radius of the well. The definitions for the dimensionless radius and the dimensionless wellbore storage are:

$$r_D = \frac{r}{r_W} \qquad 2.14$$

and,

$$C_D = \frac{C}{2\pi\phi c_t r_W^2 h} \qquad 2.15$$

Equations 2.13 through 2.15 are expressed in a consistent set of units. In the simple case of steady state radial flow, P_D is equal to ln (r_e/r_W), where r_e is the radius of the circular constant pressure boundary, and Eq. 2.12 becomes the well known steady-state radial form of Darcy's Equation (Earlougher, 1977), or the Thiem Equation (see Section 2.1.1 of Kruseman and de Ridder, 1991). For transient flow, P_D is always a function of dimensionless time (Eq. 2.13), dimensionless radius (Eq. 2.14), and other parameters related to the flow geometry (Earlougher, 1977). Dimensionless pressure can be applied easily, and results in simple general equations that apply to any sort of reservoir properties. It is easily adapted to mathematical manipulation and superposition so that more complex systems can be considered.

In order to account for tests that do not have a constant flow rate (the assumption used to derive Eq. 2.12), the superposition technique is applied. This approach makes it possible to describe a variable rate event (including a shut-in, which is an event with a zero surface flow rate) using a number of constant rate events. The variable rate superposition has been described in detail in well testing literature (Earlougher, 1977; Lee, 1982; Horne, 1990).

The principle of superposition holds for systems that can be described mathematically as 'linear systems' (Horne, 1990). Since most well test solutions are derived from linear diffusive flow equations with linear boundary conditions, the principle of superposition is applicable for most of the standard response functions. The superposition theorem simply states that the sum of individual solutions of a linear flow equation is also a solution of that equation (Drake, 1978). For a variable rate event, the principle of superposition in time can be used to describe the flow response, using a series of constant rate solutions. If a variable rate event is separated (discretized) into 'n' constant rate flow periods, a solution for the n^{th} flow period can be found by solving the diffusivity equation for each flow rate individually and superposing the solutions according to the following equation (Gringarten, 1979; Bourdet et al., 1989):

$$P_D = \sum_{i=1}^{n-1} \frac{q_i - q_{i-1}}{q_{n-1} - q_n} [P_D(\sum_{j=1}^{n-1} \Delta t_{jD}) - P_D(\sum_{j=1}^{n-1} \Delta t_{jD} + \Delta t_D)] + P_D(\Delta t_D) \qquad 2.16$$

where each of the 'n' flow periods has a flow rate of q_i ($q_i \geq 0$) and a duration of Δt_i with Δt being the elapsed time in the 'nth' flow sequence. The subscript 'D' for the time refers to dimensionless time, which is proportional to real time and is given by Eq 2.13.

2.5 Interpretation Models

Type curve matching for pumping test data was first introduced by Theis (1935) for interpreting crosshole responses in homogeneous aquifers. Since then, type curve matching has become one of the most common tools in the interpretation of well test data, both in petroleum and groundwater areas. A type curve is a graphical representation of the theoretical response during a test of an interpretation model that represents the well and the formation being tested. A type curve is therefore specific to the type of test for a given flow system. The type curve analysis of well test data essentially consists of selecting a type curve that can adequately describe the actual response of the wellbore and the formation during the test.

Type curves, therefore, include the entire dynamic behavior of an interpretation model during a test; in other words, type curves include all the individual 'flow regimes' of an interpretation model. 'Flow regimes' are but characteristic features for the various components of an interpretation model. The individual components of an interpretation model dominate the well test response at different times. These responses are broadly divided into three groups: early time, middle time, and late time (Earlougher, 1977).

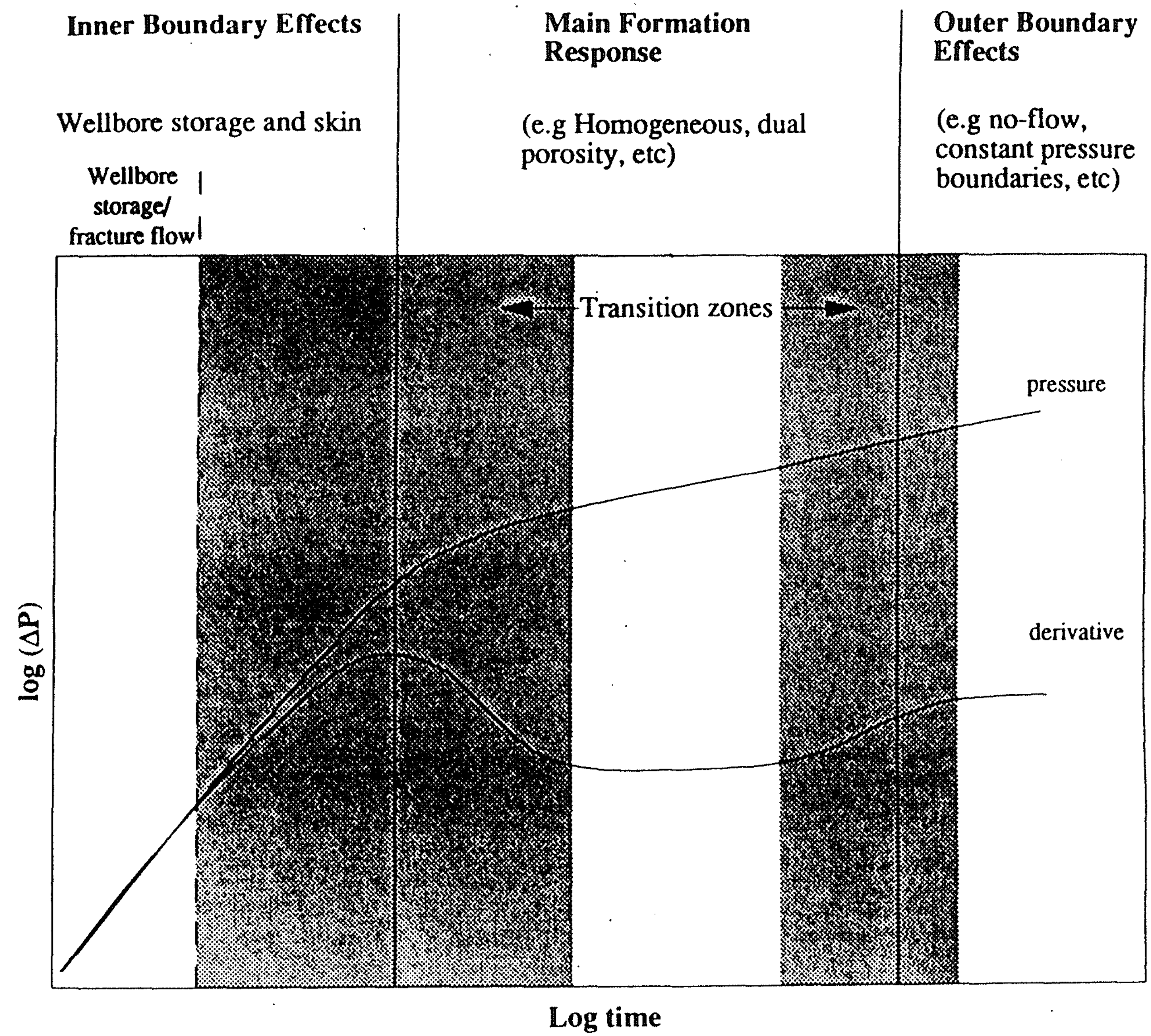
As a given test starts, the pressure transients generated by the test move away from the generator (ie. the source/sink well) and into the formation. At early time, the pressure signals are dominated by features in the flow system close to the source - such as wellbore storage and skin, presence of fractures intersecting the source, etc. As the test progresses, the pressure transients move farther away from the source and the test section pressure response reflects the transmission of pressure through each of the significant features in the flow system in succession. The development of the individual flow regimes in the pressure responses does not occur in discreet steps but are separated by 'transition periods' in which the influences of parameters characterizing the two regimes are combined. After the early time effects are over, the pressure response is indicative of larger scale conditions in the formation. During this phase of the pressure response, features such as double porosity, homogeneous behavior, etc. dominate the pressure response. As the test duration increases, the pressure response reflects the formation conditions farther away from the borehole and features such as boundary effects may affect the pressure response. Until the boundary effects are 'seen' by the pressure signals, the formation effectively responds as if it were of 'infinite lateral extent'.

Type curves combine all the flow regimes, including the transition periods, for specific interpretation models. Well test interpretation models are used to define the complete theoretical flow system and the characteristics of the interpretation models are divided into these distinct periods:

1. Inner Boundary (wellbore storage, fracture flow etc.);
2. Formation Flow Behavior (homogeneity, dual porosity etc.); and
3. Outer Boundary (infinite acting, constant pressure etc.).

These periods are illustrated in Figure 1 for pressure and pressure derivative curves. The first period represents the inner boundary condition of the interpretation model and governs the early time response of the model. The formation flow behavior is the flow regime when the pressure response at the pumping well is dominated by formation flow parameters. The outer boundary condition, as the name implies, characterizes the late-time effects.

In an idealized data set the pressure or pressure derivative will have a recognizable shape which can be related to what is happening in the formation. When analyzing well test data it is now common practice to plot the pressure derivative (derivative of pressure change with respect to the natural



CLIENT/PROJECT						TITLE
Magma Florence			Golder Associates Tucson, Arizona			FIGURE 1
DRAWN AMG	CHECKED AGG	REVIEWED AGG	DATE NOV 1995	SCALE NO SCALE	JOB NO. 953-2908	Hydraulic Test Interpretation - Flow Periods

logarithm of time) in addition to the pressure because it is easier to recognize the characteristic shapes of the test periods on the pressure derivative (Bourdet et al, 1983; Bourdet et al. 1989). Examination of pressure derivative plots allows the analyst to determine the extent of each of the three periods and, from diagnostic curve shapes, identify different types of formation response and boundary effects. The following interpretation models are available in Golder's FLOWDIM™ code:

Inner Boundary Conditions:

a) Wellbore storage and skin;

b) Infinite conductivity or uniform flux fracture; and

b) Finite conductivity fracture.

Formation Flow Behavior:

a) Homogeneous -standard 'porous medium' flow;

b) Dual porosity -fractures in a less permeable matrix; and

c) Fractional Dimension -fracture controlled flow with "imperfect" connections.

Outer Boundary Conditions:

I) Single boundary -constant pressure or no flow.

The following sections discuss only the interpretation models and parameters, which are applied to the analyses of the Florence data. The models are:

- Inner Boundary -Wellbore storage and Skin, and Fractures;
- Formation Flow -Homogeneous and Dual Porosity; and
- Outer Boundary -Infinite Acting.

Different sets of constitutive parameters are used to represent each of the components of the well test interpretation models. The parameters are:

C:	wellbore storage;
h:	total thickness of the formation (equals the test section length, for a 'fully penetrating well' assumption);
k:	formation permeability;
k_f:	fracture permeability in a double porosity system;
k_{fw}:	permeability of finite conductivity fracture;
s:	skin factor;
w:	fracture width;
x_f:	fracture half length;
ω:	interporosity storativity ratio; and
λ:	interporosity flow coefficient.

These components of the interpretation models are described in the following sections.

2.5.1 Inner Boundary

2.5.1.1 Wellbore Storage and Skin

The wellbore storage effect prevents the downhole flow rate from instantaneously following the surface flow rate in the case of constant rate tests. This affects the early-time transient pressure response to a considerable extent. The wellbore storage effect can mask the formation response in tests of very low permeability formations. Wellbore storage is characterized by a wellbore storage constant, C, which is the change in wellbore fluid volume with pressure. For a well filled with a single phase fluid occupying a fixed volume V_W, this constant is given by Eq. 2.6. For a well with a changing liquid level (open tubing flow) the wellbore storage constant is given by Eq. 2.5.

To account for the wellbore storage effect in the solutions of Eq. 2.11, a dimensionless wellbore storage constant C_D was introduced (Eq. 2.15) and P_D becomes a function of t_D, C_D and s, together with other system parameters.

It is important to note that the compressibility on Eq. 2.6 is that of the fluid in the wellbore. In fractured formations, the actual wellbore storage values can exceed those computed with Eq. 2.6 because part of the storage is due to the volume of fractures in communication with the wellbore. The difference can be a factor of 10 to 100 depending on borehole conditions (Ostrowski and Kloska, 1989). Other effects, such as tool compliance or tool induced injections, can also increase the apparent wellbore storage and cause the wellbore storage constant to be higher than calculated.

Another important dimensionless variable is the skin factor (s) which quantifies the near-borehole flow conditions. Skin factors estimated from transient testing include all features that affect the efficiency of fluid flow into the wellbore. The skin factor represents a steady sate dimensionless pressure drop at the well face in addition to the normal transient pressure drop in the formation. The additional pressure drop is assumed to occur in an infinitesimally thin "skin zone" (van Everdingen, 1953). The additional pressure drop can be the result of local permeability alteration (for example, caused by plugging of flow paths by fines in the drilling fluid, etc.). This pressure drop could also be caused by deviation from purely 2-D radial flow near the well (for example, caused by a fracture near the well giving rise to more linear than cylindrical symmetry flow at early time); this is also called 'pseudo-skin' (Earlougher, 1977). The skin factor is related to this additional pressure drop by the following equation (Earlougher, 1977):

$$s = \frac{2\pi k h}{q B \mu} \Delta P_s \qquad 2.17$$

where Δp_s, is the additional pressure drop in the skin zone. A more physically realistic concept of skin is obtained by assuming that the skin effect is due to an altered zone of radius r_S with a skin zone hydraulic conductivity (K_S); for such a case the skin effect can be calculated from the following equation (Earlougher, 1977):

$$s = [\frac{K}{K_s} - 1] \ln[\frac{r_s}{r_W}] \quad (unitless) \qquad 2.18$$

It can be seen from this equation that when the skin zone hydraulic conductivity (K_S) is higher than the formation hydraulic conductivity (K) the skin effect is negative. There is clearly a practical limit to how large the magnitude of skin can become; for the Florence tests, skin coefficients typically vary between -7.5 and 12.0.

Pseudo-skins result from situations such as partial penetration of the water bearing formations, turbulent flow, multiphase effects, and fractures intersecting the wellbore. The important difference between mechanical skins and pseudo-skins is that the pseudo-skins penetrate the formation, creating transient pressure drops that become stable only some time after the beginning of flow in the well (Dowell Schlumberger, 1985). The total skin effect is the combination of the mechanical and all pseudo-skins.

2.5.1.2 Fracture Flow

When the borehole penetrates a single fracture, the early time pressure response is determined by wellbore storage and the flow behavior within the fracture. Two different kinds of fractures are considered, an infinite conductivity fracture and a finite conductivity fracture. In both these models, the flow is assumed to take place from the formation to the fracture and from the fracture into the wellbore. For the infinite conductivity fracture, a negligible pressure drop is assumed to occur within the fracture itself. For this model, the flow goes through two flow regimes:

a) Linear flow towards the fracture from the formation, and then
b) A global radial flow in the formation.

These two successive flow regimes are also shown by a 'uniform flux' fracture (Earlougher, 1977;

Horne, 1990). A uniform flux fracture is a fully penetrating vertical fracture with a uniform flow into the fracture along its length. Both the infinite conductivity and the uniform flux fracture models are based on the following assumption:

a) There is no wellbore storage;
b) The fracture is vertical and fully penetrating;
c) Pressure within the fracture and the borehole is the same at all points;
d) The fracture is characterized by a half-length (x_f); and
e) The fracture is in a homogeneous aquifer.

Analysis using these models yields an estimate of:

x_f = Fracture half-length

In a finite conductivity fracture model, pressure drop is allowed to take place within the fracture. For a finite conductivity fracture, the flow goes through three regimes:

a) Linear flow within the fracture;
b) Linear flow toward the fracture and within the fracture (bilinear flow); and
c) Global radial flow.

In this case, the flow is determined by the fracture half length as in the case of the infinite conductivity fracture and also by the product of fracture permeability and fracture width. Fracture permeability is not a parameter for the case of an infinite conductivity fracture model, since it is considered to be infinitely large. Analysis with the finite conductivity vertical fracture yields estimates for:

x_f = Fracture half-length

k_{fw} = Fracture permeability

None of the Florence tests analyzed so far have shown a response that could be associated to either of these models. In other words, all of the tests analyzed to date have hydraulic responses typical of porous media flow.

2.5.2 Formation Flow Behavior

Many theoretical models have been developed to describe the flow of fluids through different types of formations in the subsurface. Flow models have been developed to account for a multitude of heterogeneous formation behaviors. These models have increased in complexity in line with the increased computational and graphical display powers of desktop computers. To discuss all the models and combinations of models currently available is beyond the scope of this report. Therefore, only the models that are or might be potentially useful for the analyses of the Florence data are discussed here, namely; homogeneous and dual porosity flow models.

2.5.2.1 Homogeneous

The homogeneous model is the simplest formation flow model. It describes flow through the pore spaces of a homogeneous isotropic formation. Analysis with this model in FLOWDIM™ yields estimates of:

k = permeability; and
s = skin.

This flow model is typically combined with the wellbore storage and skin (Inner boundary) and infinite acting (Outer boundary) models to produce the theoretical model of the simplest formation response.

2.5.2.2 Dual Porosity

A different method of analysis is applied to fractured formations in which flow occurs through both the matrix and through a network of fractures. To analyze tests conducted in these formations, a dual porosity flow model was developed by Warren and Root (1963). They showed that a model which included two fracture related parameters, in addition to permeability and skin, could be used to describe the pressure-time behavior of a fractured formation. These additional parameters represent the storativity ratio of the fractures and the matrix, and the ratio of the matrix permeability to the fracture permeability. It should be noted that the dual porosity model may also be used to represent flow in a fracture system, where relatively low conductivity and less well connected 'background fractures' can be equated with the 'matrix' and more dominant transmissive features with the 'fractures.'

The dual porosity models available in the well testing literature are characterized by the way flow in the more permeable flow conduits (i.e., the fractures) interacts with that in the less permeable flow medium (i.e. the matrix). There are two types of dual porosity models available within FLOWDIM™ depending on the different types of interporosity flow:

a) Restricted Interporosity Flow: In this model there is a skin between the more permeable medium (the fissures) and the less permeable medium (the matrix blocks) which restricts flow; and

b) Unrestricted Interporosity Flow: In this model there is no impediment to flow between the two media and the less permeable medium is assumed to be shaped either like slabs or spheres.

Analysis using the dual porosity model in FLOWDIM™ yields estimates of:

k_f	=	permeability of the more permeable medium;
s	=	skin factor of the well;
s_f	=	skin factor between fissures and the matrix;
ω	=	interporosity storativity ratio; and
λ	=	interporosity flow coefficient.

The definitions of permeability and skin are similar to those in Section 2.3.1.3 and 2.5.1.1. The modifications necessary to fit them into the dual porosity model are noted below. The first of the parameters specific to the dual porosity model, interporosity storativity ratio 'ω', is defined by:

$$\omega = \frac{(\phi c_t)_f}{(\phi c_t)_f + (\phi c_t)_m} \qquad 2.19$$

This relationship characterizes the relative storage capacity of the two media, fracture and matrix (characterized by subscripts 'f' and 'm' respectively). The interporosity flow coefficient 'λ', characterizes the ability of the matrix to flow into the fractures and is defined by:

$$\lambda = \alpha \frac{k_m}{k_f} r_w^2 \qquad 2.20$$

where α is a geometrical factor which depends on the shape of the matrix block. For spherical matrix blocks of radius r_m,

$$\alpha = \frac{15}{r_m^2} \qquad 2.21$$

and for horizontal slab matrix blocks of thickness h_m.

$$\alpha = \frac{12}{h_m^2} \qquad 2.22$$

The theory of the Warren and Root model (Warren and Root, 1963) is extensively discussed in the well test literature (Earlougher, 1977; Streltsova, 1988; Horne, 1990; Sabet, 1991). Therefore, only practical aspects and the physical meaning of the dual-porosity flow parameters are discussed below.

The interporosity storativity ratio, ω, represents the ratio between storage capacity of the fracture network and the total storage capacity of the formation. A value of ω close to zero corresponds to a formation with a very small fracture storage capacity; $\omega = 1$ represents a reservoir with a single dominant flow medium. Small values of ω (<0.1) typically reflect the small storage capacity of fractures relative to the much larger storage capacity of the rock matrix.

The interporosity flow coefficient, λ, represents the dimensionless interporosity flow capacity which depends, primarily, on the ratio of the matrix permeability to the fracture permeability, k_m/k_f. For a given block shape factor α, small λ values correspond to a large contrast between fracture and matrix block permeability. A permeability ratio equal to 1 represents a single porosity (homogeneous) reservoir.

Alternatively, if k_m/k_f is known (e.g. k_m from laboratory tests and k_f from hydraulic testing), it is possible to estimate the characteristics of the fractures. High α values mean large contact surface and consequently smaller matrix blocks (high fracture density). A low value of α corresponds to a smaller contact surface, large matrix blocks and consequently low fracture density.

To date, none of the Florence hydraulic test responses have shown a dual-porosity behavior.

2.5.3 Outer Boundary

2.5.3.1 Infinite Lateral Extent

The model that simulates an infinite acting formation response requires no additional parameters. In this model there is no outer boundary response different from the formation flow response.

2.6 Well Test Analysis

Pressure transient testing has been a subject of extensive work both in the field of groundwater hydrogeology and in the oil industry for the past forty years. Over this period better measuring devices have become available, providing more reliable field data and this, together with the advent of powerful desktop computers, has given rise to the development of more sophisticated interpretation techniques.

In general, transient well tests can be separated into three basic types based on the nature of the source signal:

a) constant rate;
b) constant pressure; and
c) slug and pulse tests.

For constant rate and constant pressure tests, the surface rate and the surface pressure, respectively, are kept constant during the testing period. A slug test is initiated by an instantaneous pressure change (withdraw or injection) and then the groundwater is allowed to flow to the open borehole and to return to initial conditions. A pulse test is very similar to a slug test, the only difference is that the interval is shut-in so that the fluid volume is kept constant. The hydraulic tests conducted at the Florence site are constant rate type tests.

Depending on the type of test, different analysis methods have been developed and documented in numerous papers and manuals. The interested reader is directed to the following summarizing references: Earlougher (1977), Gringarten (1979), Lee (1982), and Bourdet et al. (1983 and 1989) for the analysis of constant rate tests, including multi-rate and shut-in tests; Grisak et al. (1985) for the analysis of wellbore storage dominated pulse and slug, where practical and theoretical aspects of testing in low permeability formations are also discussed; and Pickens et al. (1987) present some interesting practical considerations on interpretation of hydraulic tests in low permeability formations. For detailed descriptions of the various well test analysis methods currently in use, the interested reader is referred to the following additional references: Streltsova (1988), Sabet (1991) and Dawson and Istok (1991).

The purpose of this section is to present some aspects of the test analysis methods that are found to be important for interpretation of the Florence test data. The only tests that will be described in detail are the constant rate tests since these are the type of tests used at the Florence site.

The principles governing the test analysis can be considered as a special pattern recognition problem (Gringarten, 1986). In a well test, a known signal (e.g. pumping rate) is applied to an unknown system and the response of that system (e.g. the change in water pressure) is measured during the test. This type of problem is known as the 'inverse problem.' Its solution involves finding a well defined theoretical system, whose response to the same input signal is as close as possible to that of the actual flow system. Normally this solution is not unique, but with reasonable assumptions and information from other sources like geophysical and geological data, in most cases it is possible to give at least a confined range of solutions.

2.6.1 Constant Rate Tests

The analysis methods for a constant rate test can be divided into two general classes:

a) Straight line analysis methods; and

b) Type curve matching.

After plotting the data in specific coordinate systems, straight lines can be fitted to specific segments of the data set and reservoir parameters determined from the slope and intercept of these lines. This approach requires the data to be divided into discrete sections representing the near wellbore, formation, and outer boundary responses. Each section is then analyzed separately.

The type curve matching approach considers the data as a continuous record. In this approach the data is matched to type curves that represent pressure response models for different combinations of formation and boundary conditions. The type curves are represented in terms of the dimensionless parameters which were introduced in Section 2.4. The formation parameters are calculated from the match points between the measured data and the type curves. These two methods are discussed in more detail in the sections that follow.

2.6.2 Straight Line Analysis Methods

A commonly used method of obtaining reservoir parameters is by straight line analysis. In this approach, pressure data is plotted on specialized plots, e.g. versus log(t), and straight lines fitted to specific portions of the data are used to derive formation parameters. The theory behind straight line methods, especially semilog Horner and MDH has been extensively described in the literature (Earlougher, 1977). Therefore only the application of this method will be discussed here.

Straight lines fitted to the early time portion of the data can be used to obtain estimates of the wellbore storage (pressure versus time or log pressure versus log time) or near well fracture flow parameters (pressure vs. $t^{1/2}$ or $t^{1/4}$). Straight line fits to semilog plots (pressure versus log time), or log (Horner time) can be used to obtain estimates of wellbore storage, skin, permeability and initial pressure; Horner time is defined later in this section. Straight lines fitted to multiple periods of pseudo radial flow can also be used to identify a dual porosity response and estimate the appropriate flow parameters (λ and ω, see nomenclature).

Straight line analysis methods can also be applied to data presented on log-log plots. A horizontal line fitted to a pseudo radial flow portion of the pressure derivative will provide an estimate of the formation permeability, similar to the Horner approach. Distances to outer boundaries and the existence of multiple boundaries can also be estimated by fitting lines to the log-log plot.

The necessary condition for application of the straight line approach to determine initial hydraulic head and hydraulic conductivity is that the aquifer must be 'infinite acting.' This means that the pressure response must extend beyond the influence of wellbore storage and skin effects and into a period of pseudo-radial flow. In the case of heterogeneous behavior, the total system response must be obtained for the method to be applied. When these conditions are met, the basic reservoir parameters (e.g. hydraulic conductivity) can be derived. The straight line method was in many cases not applicable to the Florence test data, even for the estimation of basic formation parameters, because many of the hydraulic tests are strongly affected by pumping in nearby irrigation wells, rendering the pseudo-radial flow period difficult to identify.

Nonetheless, the basic ideas of the straight line analysis are presented here for the benefit of the reader. A special application of this method is the case of the analysis of a shut-in period after a constant rate flow period. According to the superposition principle, the solution for this case is (Horne, 1990):

$$P_D = P_D[t_{pD} + \Delta t_D] - P_D[\Delta t_D] \qquad 2.23$$

where t_{pD} is the dimensionless flow period duration and Δt_D is the dimensionless elapsed time from the start of the shut-in. The dimensionless pressure (P_D) and the dimensionless time are defined in Section 2.5.2. For infinite acting radial flow during both the flow period and the shut-in, Eq. 2.23

leads to the following solution for the source well in a homogeneous reservoir:

$$P(\Delta t) = P_i - \frac{qB\mu}{4\pi kh} \ln \frac{t_p + \Delta t}{\Delta t} \qquad 2.24$$

Therefore when the pressure is plotted against the natural logarithm of $(t_p + \Delta t)/\Delta t$, where t_p is the flow period duration and Δt is the shut-in time, the data will show a straight line with a slope of

$$m = \frac{qB\mu}{4\pi kh} \qquad 2.25$$

during a period of infinite acting radial flow. The pressure axis intercept represents the initial formation pressure (P_i) or equivalently the static water level. Such a plot is known as a Horner plot and $(t_p + \Delta t)/\Delta t$ is referred to as Horner time which is a dimensionless quantity. For a multiple rate transient test this method can be generalized by plotting (Gringarten et al., 1980):

$$P(\Delta t)\ vs.\ \frac{1}{|q_{n-1} - q_n|}\left[\sum_{i=1}^{n-1} (q_i - q_{i-1}) \log\left[\sum_{j=1}^{n-1} \Delta t_j + \Delta t\right] - (q_{n-1} - q_n)\log \Delta t\right] \qquad 2.26$$

where Δt_j is the duration of each constant rate event. In Eq, 2.26 the time/rate function is referred to as the superposition function, and the plot is known as a generalized Horner plot.

2.6.3 Type Curve Matching and Automatic Regression

A transient well test generally comprises an input impulse (e.g. a change in flow rate) which is imposed on the test interval, and the recorded response (e.g. a change in pressure). The nature and shape of the response is governed by test geometry parameters (interval volume, flow rate, etc.), fluid parameters (viscosity, compressibility, etc), and formation flow parameters (permeability, porosity, etc.). Some of these are known directly or can be measured either in-situ during the test or in laboratory tests. However, some of the parameters which control the formation response cannot be measured directly and must be inferred from the test response. An analytical mathematical model of the dependence of the formation response on the formation flow parameters can be developed and solved. Then by matching the measured test response to the model response it can be inferred that the model parameters have the same values as the actual reservoir parameters. This process is known as 'Type Curve Matching.'

2.6.4 Theory of Type Curve Matching

We will consider the single constant rate case to present the basic theory of type curve matching. For a constant rate case, the dimensionless pressure is defined as (Horne, 1990):

$$P_D = \frac{2\pi kh}{qB\mu}(P_i - P) = A\,\Delta P \qquad 2.27$$

where A is a function of k, h, q, B, and μ.

Re-arranging Eq.'s 2.13 and 2.27, we get:

$$\frac{t_D}{C_D} = B\left(\frac{\Delta t}{C}\right) \qquad 2.28$$

where B is a function of k, h, and μ. Or in logarithmic terms:

$$Log P_D = Log \Delta P + Log A \tag{2.29}$$

$$Log(\frac{t_D}{C_D}) = Log \Delta t + Log(\frac{B}{C}) \tag{2.30}$$

The combination of the dimensionless time and wellbore storage is a way to reduce the number of independent variables and make the type curves easier to distinguish from each other. Since, by definition, the dimensionless pressure and time/storage are linear functions of actual pressure and time, the log of actual pressure change will differ from the log of the dimensionless pressure drop by a constant amount. The same is also true for the log of actual time. Thus when the appropriate interpretation model has been selected, the actual pressure vs. (time) curve and the theoretical curve P_D vs. (T_D/C_D) have identical shapes, but are shifted with respect to one and other when plotted on the same log-log scale.

The objective of this type curve analysis is to evaluate the amount of shift between the two sets of curves. When the actual data is matched to the theoretical curve on the log-log axes, a match point is selected and the reservoir parameters obtained by rearranging and substituting P_D and ΔP, and (T_D/c_D) and Δt into the above equations as follows:

$$[\frac{P_D}{\Delta P}]\, matchpoint = A \Rightarrow permeability \tag{2.31}$$

$$[\frac{t_D/C_D}{\Delta t}]\, matchpoint = (B/C) + permeability \Rightarrow wellbore\ storage \tag{2.32}$$

Originally P_D was plotted versus t_D on a series of distinct curves for welbore storage/skin and infinite acting radial flow (Agarwal et al., 1970). Manipulation of the dimensionless pressure equation, created a combined storage and skin variable, C_De^{2s} that could be used to generate a series of type curves (Gringarten, 1979) for different C_De^{2s} values. The skin factor is obtained by substitution of the calculated dimensionless storage into the C_De^{2s} value obtained from the type curve that gives the best match, and the corresponding C_De^{2s} appropriate to that curve. Other type curves have been developed for fractured reservoirs (see, for example, Bourdet and Gringarten, 1980) and for formations with composite behavior.

For further details of the theoretical aspects of type curve matching, the interested reader is referred to Gringarten (1987), Chapter 4 of Sabet (1991), and Section 3.3 of Earlougher (1977).

2.6.5 Dimensionless Type Curves

The solutions to the analytical models can be expressed as a series of dimensionless variables (Section 2.5.1). These dimensionless variables are important because they simplify the formation response models by representing the transient test parameters in terms of model parameters which remain fixed during the test, thus reducing the total number of unknowns which need to be considered. They also have the additional advantage of providing model solutions that are independent of units. The definition of these dimensionless variables assumes that the test parameters (flow rate, interval volume), the fluid parameters (viscosity, compressibility), and the reservoir parameters (permeability, compressibility, porosity, and reservoir thickness) all remain constant throughout the test.

Theoretical models of reservoir behavior can be presented as a family of dimensionless type curves, expressed in terms of dimensionless pressure (P_D), that are a function of t_D and other dimensionless variables. Each curve in the family is characterized by dimensionless variables that depend on the particular model. These parameters are defined as the product of a measured parameter (e.g. pressure or time change) and parameters characterizing the reservoir (porosity, permeability, etc.).

The type curves used for the analysis of a pumped withdrawal test in a formation are called drawdown type curves and are defined as:

$$P_D = P_D[(\Delta t)_D] \qquad 2.33$$

The actual data for type curve analysis are defined as:

$$\Delta P = P_i - P(\Delta t) \qquad 2.34$$

The change in pressure (ΔP) is plotted against the change in time (Δt) where Δt is the elapsed time since the start of the pumping sequence, and ΔP is the corresponding pressure reading.

Interpretation models can be obtained by a combination of the appropriate component (inner boundary, formation behavior, and outer boundary) models which have been developed. Their dimensionless solutions are superposed (in space and time) to obtain the type curves required for analysis. Type curves have been published for most of the common reservoir configurations (e.g. homogeneous, dual porosity, etc).

The drawdown type curves are not strictly valid for analyzing flow periods (drawdowns or build-ups) after the first drawdown. For each drawdown type curve there exists a 'family' of build-up type curves that depend on the production period, t_p. The corresponding theoretical build-up type curve is obtained from the appropriate drawdown curve by superposition as follows (Gringarten et al., 1980):

$$(P_D)_{BU} = P_D(T_{pD}) - P_D(t_{pD} + \Delta t_D) + P_D(\Delta t_D) \qquad 2.35$$

The build-up type curves must be calculated for each test, because they depend upon the test conditions. For a multi rate (MR) flow test the type curve can be expressed by Eq. 2.16 in Section 2.5.

2.6.6 Derivative Type Curves

A relatively recent innovation (Bourdet et al., 1983), made much easier with the introduction of computer aided techniques, is to plot the derivative of P_D with respect to ln (t_D/C_D) on the same axes as the P_D vs. T_D/C_D. The derivative is useful as a diagnostic plot when trying to determine the different flow regimes that may occur during the test. The advantage of the derivative plot is that it is able to display in a single graph many separate characteristics that would otherwise require different plots.

During pure wellbore storage (Earlougher, 1977) showed that:

$$P_D = \frac{t_D}{C} \qquad 2.36$$

then taking the derivative

$$\frac{dP_D}{d\left(\frac{t_D}{C_D}\right)} = P_D' = 1 \qquad 2.37$$

During infinite acting radial flow (which does not show a characteristic response on a log-log scale) in a homogeneous formation (Bourdet et al., 1983):

$$P_D = 0.5[\ln(\frac{t_D}{C_D}) + 0.80907 + \ln(C_D e^2 s)] \quad 2.38$$

then taking the derivative

$$\frac{dP_D}{d(\frac{t_D}{C_D})} = P_D^{\prime} = 0.5/(\frac{t_D}{C_D}) \quad 2.39$$

Therefore, both at early and late times, all P_D' behaviors are identical and independent of the C_De^{2s} values. At early time, all the curves merge into a straight line corresponding to $P_D' = 1$. At late time the curves merge into a single straight line of slope = -1, corresponding to $P_D' = 0.5/(t_D/C_D)$. Between these two asymptotes, each of the C_De^{2s} curves exhibit a specific shape. It is more useful however, to plot the type curves as $P_D' (t_D/C_D)$ versus (t_D/C_D). This is a better choice of axes because the pressure and time axes are now consistent with the dimensioless pressure axes described earlier.

At early time, the type curves follow a unit slope log-log straight line. When infinite acting radial flow is reached, the derivative curves become horizontal at $P_D' (t_D/C_D) = 0.5$. Between these two asymptotes, the type curves and derivatives are distinctly different for the combined 'family' of C_de^{2s} curves. This makes it easier to correctly identify the correct C_de^{2s} curve corresponding to the data. The derivative shape also provides an improved diagnostic tool for other formation models such as dual porosity, composite, fracture flow, and outer boundary responses.

Modern well test analysis has been greatly enhanced by the introduction of the pressure derivative type curves. The advent of computer aided interpretation has made calculation of the derivative of real data relatively straightforward. The advantage of the derivative plot is that it is able to display in a single graph many separate characteristics of the flow system that would otherwise require different plots (Horne, 1990). The power of the pressure derivative arises from the fact that it magnifies the differences in shapes between the various flow regimes that can be present during a given flow period, thereby enhancing the diagnostic capabilities of the analyst by a significant amount (Gringarten, 1986).

The interpretation method implemented in FLOWDIM, a Golder Associates proprietary software, takes full advantage of the derivative approach as discussed above. Test interpretation of the aquifer tests in the Florence study area were conducted using this software. The following section presents a brief discussion of the interpretation of each test.

3.0 TEST INTERPRETATION RESULTS

This section provides a brief description of the conditions during each aquifer test, general comments on the quality of the data, and results from the analytical interpretation. One critical piece of information during any hydraulic test program is the location of nearby active wells and their pumping rates and duration of pumping periods. In the case of the Florence aquifer tests, a precise discharge rate history for nearby agricultural wells is, in general, not available. Complete interpretation of the affected aquifer tests is not possible without this information, and the resulting estimated hydraulic conductivity may be inaccurate.

In some cases, boundary effects and abrupt changes in the pumped well discharge rate complicated the interpretation of the drawdown and recovery data, not to mention the effect of nearby agricultural wells. To the extent permitted by the data, an attempt was made to discern amongst effects produced by geological controls and those produced by the cycling of nearby agricultural wells. Information about the hydraulic tests conducted to date is summarized in Table 1 (See Appendix A). Also shown in this table are the name designations of the wells participating in a given test, starting and ending date of the test, and available information regarding geologic formation, screen location, drawdown and discharge data.

Table 2 (See Appendix A) presents a summary of the hydraulic conductivity estimates resulting from our interpretation. Also included in this table is the name of the formation penetrated by the particular well(s), and comments and qualifiers on the conductivity estimates. The available data are classified into three different categories; fair, acceptable and good. A fair data set is one that is interpretable but the estimated hydraulic conductivity should be used with caution. An acceptable data set represents a test with some uncertainty and usually results in an underestimate of the formation hydraulic parameters. A good data set results in a hydraulic conductivity that is deemed as a close representation of the formation conductivity.

The following table is considered useful for the understanding of subsequent section ans is therefore included in the text. The table provides an abbreviated summary of the estimate hydraulic

Well Identification	Active/Observation	K (feet/day)
Basin Fill Deposits		
M1-GL	Active	17.3
M3-GL	Active	15.9
M14-GL	Active	1.7
M14-GL3d	Active	0.1
M15-GU	Active	2.6
M18-GL	Active	19.6
P28-GL	Active	8.3
O28-GL	Observation (P28-GL)	23.2
M3-GL	Observation (M4-O)	14.8
P8-GU	Active	61.3
Oxide		
M4-O	Active	0.6
PW2-1	Active	1.4
PW4-1	Active	3.8
PW7-1	Active	0.2
OB7-1	Observation (PW7-1)	0.1
P12-O	Active	0.4
O12-O	Observation (P12-O)	0.6
P19.1-O	Active	0.3
P19-O	Observation (P19.1-O)	0.2
P19.2-O	Observation (P19.1-O)	0.2
P19.1-O3d	Active	1.00E-02
P19-O3d	Observation (P19.1-O)	2.39E-04
P19.2-O3d	Observation (P19.1-O)	1.99E-04
P39-O	Active	0.3
O39-O	Observation (P39-O)	0.3
P28.1-O	Active	7.7
P28.1-O (2)	Active	3.6
P28.2 -O	Observation (P28.1-O)	2.7
P28.2-O	Active	3.1
O28.1-O	Observation (P28.2-O)	3.0
P13.1-O	Active	0.3
P49-O3d	Active/Recovery Data	7.75E-03
P15-O	Active	0.5

conductivity presented in Table 2 in Appendix A. This abbreviated table divides wells into those testing the Basin Fill Units, and those testing the mineralized bedrock.

As seen from this table, the hydraulic conductivity for the Basin Fill Units vary from 1.7 to 61.3 feet per day (ft/day), whereas that for the quartz monzonite and the granodiorite porphyry vary from 0.1 to 7.7 ft/day (with exception of the 3-D analyses). The maximum conductivity value for the Basin Fill units was derived from a test in the Upper Unit. The smaller variation in the hydraulic conductivity suggest a greater degree of heterogeneity than that of the mineralized bedrock.

Appendix A contains a summary sheet for each test interpretation, including a calculation of hydraulic conductivity in feet per minute (ft/min), feet/day (ft/day), meter per second (m/sec), and centimeter per second (cm/sec), as well as the estimated value of the skin factor. Appendix B presents the log-log plots of the type curve selected for the analysis, and observed drawdown versus time. Appendix C includes report forms from the FLOWDIM interpretation for each test. This form contains the well name, type of test, and date of the test. Well geometry information, such as well radius, interval length, formation tested, total depth, as well as discharge rate and test duration are also included in this form. In addition, this form presents also the model assumptions and numerical values for hydraulic parameters.

The following paragraphs offer a cursory description of test conditions and hydraulic conductivity estimates for each test. The first few tests are discussed in detail to provide the reader with a basis for understanding the remaining tests presented in Appendix A through C. Detailed discussion for unique and interesting tests is given as warranted by test response.

Aquifer Test on M1-GL

This constant rate test involved a single well with a discharge of 10 gallons per minute (gpm). Well M1-GL is a monitoring borehole completed within the lower basin fill unit (LBFU). Nearby agricultural wells BIA-9 and BIA-10B were reported to be active during the test. The test response shows a slight "recovery" of the hydraulic head during the test. This effect is responsible for the decrease in drawdown (circles) in the late time data presented in Figure 1B in Appendix B. Final recovery of the hydraulic head resulted in a water elevation higher than the elevation reported at the beginning of the test; indicating that the observed hydraulic head response is a superposition of more than one stress on the aquifer (namely; the transient effects from wells BIA-9 and BIA-10B).

The log-log plot presented in Figure 1B shows both the drawdown data and its derivative with respect to the natural log of time (triangles) versus time, and the dimensionless type curve that was selected for interpretation of this test. In this particular case the selected type curve corresponds to a two-dimensional (notice the asymptotic approach to $p_D' = 0.5$), homogeneous flow model, with a C_De^{2s} parameter equal to 2×10^{8}. This value, in turn, results in a skin coefficient of 3.3 (see summary interpretation in Figure 1A in Appendix A) indicating some possible formation clogging near the well face. Figure 1B shows the transient effects produced by nearby pumping, and that the match between the data and the type curve is poor. The pressure derivative of the data shows a large amount of random variation in late time, making it difficult to better assess the hydraulic parameters. The hydraulic conductivity estimate is 17.3 ft/day. It is our opinion that this conductivity value most likely overestimates the actual conductivity of the formation in that the observed drawdown appears to be affected by a recovery trend that limits its final magnitude. The effect of nearby pumping (recovery) may be responsible for the extremely small estimate of the storage coefficient (8.4×10^{-9}).

Aquifer Test on M3-GL

Aquifer test on monitoring well M3-GL (Figure 14B) involved wells M2-GU, M4-O and M5-S as observation points. Average discharge from M3-GL during this test was reported at 10 gpm. Well M3-GL is completed in the Lower Basin Fill Unit, while M2-GU and M4-O are completed in the Upper Basin Fill Unit (UBFU) and the oxide unit, respectively. Irrigation Well ENGLAND #3 was on during the test but no information regarding its pumping rate is available. Observation wells M2-GU and M5-S showed recovery 100 minutes into the test. The hydraulic response for wells M2-GU and M4-O is minimal and quite erratic. This small response between M2-GU and M3-GL may indicate a limited hydraulic connection between the lower and Upper Basin Fill Unit in this area of the site. After shut in of well M3-GL, observation wells M2-GU and M4-O showed a slight recovery and then began to drop off again which may be the result of cycling of agricultural pumping. The hydraulic response of well M5-S appears completely independent of pumping on well M3-GL. Due to the above conditions, the hydraulic responses from the observation wells were considered not suitable for interpretation.

Data interpretation for this test was accomplished by means of a 2-D, homogeneous model (as indicated by the approach of the derivative of $p_D = 0.5$) with a C_De^{2s} parameter equal to 1 x 10 6 (Figure 14B). The skin parameter was estimated to be 1.16 (Figure 14A); indicating slight formation clogging near the well face. The overall fit of the drawdown data and the selected type curve is relatively good up to about 10 hours into the test. However, the pressure derivative data deviates sharply from the type curve just after about 0.1 hour into the test. The estimated hydraulic conductivity for the Lower Basin Fill Unit is 15.9 ft/day with a storage coefficient of 3×10^{-7}. The deviation of the data from the derivative and this small storage coefficient may be an effect produced by pumping from ENGLAND #3 well.

Aquifer Test on M14-GL

Well M14-GL was tested under a constant discharge of about 10 gpm. This well is completed within the Lower Basin Fill Unit (LBFU). Well M15-GU, in the Upper Basin Fill Unit, serves as an observation well. Irrigation Wells BIA-9 and BIA-10B were on during the test but no information is available regarding their pumping rate history. Additionally, M1-GL was pumping during testing. Very little drawdown was seen in the observation well (M15-GU). However, a sharp increase in hydraulic head was observed at about 1,000 minutes after pumping in M14-GL ceased. Recovery in the pumping well went beyond initial reported static water level. It is suspected that one or both of the pumping agricultural wells may be responsible for these effects. Field data from the observation well was not considered suitable for interpretation.

Two interpretation models were applied to the drawdown data from well M14-GL. First, a 2-D, homogeneous model (Figure 3A) was used to match the field data. It was seen (Figure 3B) that only the early data (t < 50 min) closely approximated both the pressure and pressure derivative of the 2-D type curve. At later times, the derivative of the field data deviated sharply from the type curve. As discussed in Section 2.6, this type of deviation is characteristic of a 3-D flow regime. Analyses of these data using a 3-D model (Figures 4A and 4B) shows that the overall fit to both pressure and pressure derivative improved significantly. Given the relatively short length of the screened interval as compared to the thickness of the Lower Basin Fill Unit in that location, it is not surprising that the test response suggests 3-D flow (typical of a partially penetrating well). Hydraulic conductivity estimates from these two different models are reported in Table 2 as well as in Figures 3C and 4C. The resulting conductivity estimates are 1.7 and 0.1 ft/day for the 2-D and 3-D models respectively. Although the 3-D type-curve better represents this field data, it is recommended, for the sake of conservatism, that numerical simulation of flow and transport be conducted with the larger hydraulic conductivity estimate. As will be discussed later for some of the other tests, 3-D conductivity estimates are typically smaller than corresponding 2-D estimates.

Aquifer Test on M15-GU

This constant rate test involved a single pumping well (M15-GU) discharging at 10 gpm from the upper consolidated unit (UBFU) and one observation well (M14-GL) which was completed in the Lower Basin Fill Unit (LBFU). Irrigation Wells BIA-9 and BIA-10B were on during the test but no information is available regarding their pumping rate history. The pumping well recovery rose above the static water level. It may be that one or both of the irrigation wells were shut off during testing, causing these effects. Due to the above effects the data form the observation well were not considered suitable for interpretation. Only the data for M15-GU was analyzed.

The selected type curve for the pumping well data (M15-GU) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 10 (see Figure 5C). This value, in turn, results in a skin coefficient of 6.6 indicating (Figure 5A), perhaps, some formation clogging near the well face. As shown in the log-log plot (Figure 5B), the match between the data and the type curve is good. The hydraulic conductivity estimate is 2.6 ft/day. The estimate for the storage coefficient is 1.1×10^{-11} which is clearly too small and another indication of the difficulty involved in modeling marginal data.

Aquifer Test on M18-GU

This constant rate test involved a single pumping well (M18-GU) with a discharge of 10 gpm from the Upper Basin Fill Unit (UBFU). This was a short duration test with no observation wells. The data set is fair for interpretation.

The selected type curve for the pumping well data (M18-GU) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 1.0×10^{15}. This value, in turn, results in a skin coefficient of 11.4 (Figure 6A) indicating significant formation clogging near the well face. As shown in the log-log plot (Figure 6B), the match between the data and the type curve is good. The hydraulic conductivity estimate is 19.6 ft/day. The estimate for the storage coefficient is 8.7×10^{-16} which is clearly much too small and another indication of only a fair data set.

Aquifer Test on P39-O

This constant rate test involved a single pumping well (P39-O) with a discharge of 55 gpm pumping from the oxide zone. It had a single observation well (O39-O) which was also completed in the oxide zone. The data appears to be good and suitable for analysis.

The selected type curve for the pumping well data (P39-O) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 100. This value, in turn, results in a skin coefficient of -1.8 (Figure 7A). As shown in the log-log plot (Figure 7B), the match between the data and the type curve is good. The hydraulic conductivity estimate is 0.3 ft/day and the estimate for the storage coefficient is 9.6 x 10^{-4}.

The selected type curve for the observation well data (O39-O) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 2.0. As shown in this log-log plot (Figure 8B), the match between the data and the type curve is good. The hydraulic conductivity estimate is 0.3 ft/day and the estimate for the storage coefficient is 4.3 x 10^{-4} (Figure 8C).

Aquifer Test on PW7-1

This constant rate test involved a single pumping well (PW7-1) with a discharge of 38 gpm from the oxide zone. Observation wells OB7-1 and OB-1 are also completed in the oxide zone. Observation well O3-GL straddles the interface between the basin fill deposits and the oxide. Irrigation wells BIA-10B and WW-3 were on during testing and appear to have had some effect on the data as shown by early recovery in these wells. However, data sets from PW7-1 and OB7-1 appear acceptable and suitable for analysis.

The selected type curve for the pumping well data (PW7-1) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 100. This value, in turn, results in a skin coefficient of -2.1 (Figure 17A) which indicates enhanced hydraulic conductivity near the well. As shown in the log-log plot (Figure 17B), and in spite of the transient effects produced by nearby pumping, the match between the data and the type curve is good. The hydraulic conductivity estimate is 0.2 ft/day and the estimate for the storage coefficient is 1.8 x 10^{-3} (Figure 17C).

The selected type curve for the observation well data (OB7-1) corresponds to a 2-D, homogeneous flow model. As shown in this log-log plot (Figure 9B), and due to the transient effects produced by nearby pumping, the match between the data and the type curve is fair. The hydraulic conductivity estimate is 0.1 ft/day and the estimate for the storage coefficient is 1.3×10^{-4} (Figure 9C).

Aquifer Test on P12-O

This constant rate test involved a single pumping well (P12-O) with a discharge of 64 gpm from the oxide zone. Observation well O12-O was also completed in the oxide zone whereas observation well O12-GL was completed within the LBFU. The data appear to show multiple pumping well effects. Drawdown increased at approximately 500 minutes into the test, recovery was observed at 3,000 minutes, additional drawdown was seen at 7,000 minutes, and more recovery was observed at approximately 9,000 minutes. Large drawdown variations were also recorded the observation wells. Due to the above effects, this test is considered marginal for interpretation, and only the first 3,000 minutes of data from wells P12-O and O12-O were used.

The selected type curve for the pumping well data (P12-O) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 3.0. This value, in turn, results in a skin coefficient of -4.3 which indicates enhanced hydraulic conductivity near the well. This enhanced conductivity could be natural, as resulting from nearby fractures, or it could be due to the drilling and well development process. As shown in the log-log plot (Figure 19B), the match between the data and the type curve is fair. The hydraulic conductivity estimate is 0.4 ft/day and the estimate for the storage coefficient is 4.2×10^{-1}.

The selected type curve for observation well data (O12-O) corresponds to a 2-D, homogeneous flow model. As shown in this log-log plot (Figure 10B), the match between the data and the type curve is fair. The hydraulic conductivity estimate is 0.6 ft/day and the estimate for the storage coefficient is 2.2×10^{-3}.

Aquifer Test on P28-GL

This constant rate test involved a single pumping well (P28-GL) with a discharge of 75 gpm from the Lower Basin Fill Unit (LBFU). Observation well O28-GL was completed in the Lower Basin Fill Unit (LBFU) and observation wells P28.1-O, P28.2-O and O28.1-O were completed in the oxide zone. Observation well O28.2-S was completed in the sulfide zone. Irrigation Wells BIA-9 and BIA-10B were on during the test but no information is available regarding their pumping rate history. Additionally ENGLAND #3 and WW-3 were on briefly for sampling toward the beginning of the test, and P8-GU was also pumping during this test. The test results appear good and suitable for analysis, however, only data from P28-O and O29-GL were interpreted.

The selected type curve for the pumping well data (P28-GL) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 1.0×10^{6} . This value, in turn, results in a skin coefficient of 1.3 which may indicate some formation damage near the well face. As shown in the log-log plot (Figure 29B), and in spite of the transient effects produced by nearby pumping, the match between the data and the type curve is good. The hydraulic conductivity estimate is 8.3 ft/day and the estimate for the storage coefficient is 3.4×10^{-7}.

The selected type curve for the observation well data (O28-GL) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 2.0. As shown in this log-log plot (Figure 11B), and in spite of the transient effects produced by nearby pumping, the match between the data and the type curve is fair. The hydraulic conductivity estimate is 23.2 ft/day. The estimate for the storage coefficient is 2.7×10^{-5}.

Aquifer Test on P28.2-O

This constant rate test involved a single pumping well (P28.2-O) with a discharge of 77 gpm pumping from the oxide zone. Observation wells P28-GL and O28-GL were completed in the Lower

Basin Fill Unit (LBFU), observation well O28.1-O and P28.1-O were completed in the oxide zone. and observation well O28.2-S was completed in the sulfide zone. Irrigation Wells BIA-9 and BIA10-B were on during the test but no information is available regarding their pumping rate history. These wells did affect the data in all observation wells as evidenced by decrease in the drawdown at later time in all observation wells. Also, the recovery in the pumping well went beyond static water level, indicating that the observations in the pumping well are not ideal for interpretation. However, overall, the test is judged to be acceptable for interpretation.

The selected type curve for the pumping well data (P28.2-O) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 10. This value, in turn, results in a skin coefficient of -6.5 which indicates enhanced hydraulic conductivity near the well. This enhanced conductivity could result from nearby fractures, or it could be due to the drilling and well development process. As shown in the log-log plot (Figure 33B), and due to the transient effects produced by nearby pumping, the match between the data and the type curve is only fair. The hydraulic conductivity estimate is 3.1 ft/day. The estimate for the storage coefficient turns out to be 3.8 which is clearly unreasonable (S is a dimensionless quantity smaller than one). This unreasonable storage coefficient estimate results, most likely, from a data set affected by pumping from wells BIA-9 and BIA 10-B. The resulting storativity estimates are, therefore, not reliable.

The selected type curve for the observation well data (O28.1-O) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 2.0. As shown in this log-log plot (Figure 12B), and in spite of the transient effects produced by nearby pumping, the match between the data and the type curve is acceptable. The hydraulic conductivity estimate is 3.0 ft/day. The estimate for the storage coefficient is 1.1×10^{-3} (a much better result than was obtained from the pumping well).

Aquifer Test on PW2-1

This constant rate test involved a single pumping well (PW2-1) and one observation well OB2-1, both on the oxide unit. Only the drawdown data for PW2-1 was analyzed; however, the observation well data appear suitable for analysis.

The selected type curve for the pumping well data (PW2-1) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 2.0×10^8. The estimated skin coefficient is 4.3 indicating, perhaps, some formation clogging near the well face. As shown in the log-log plot (Figure 13B), the match between the data and the type curve is good. The hydraulic conductivity estimate is 1.4 ft/day. Interestingly, the estimated storage coefficient (3.2×10^{-9}) seems too small compared to that computed for other tests on the oxide unit.

Aquifer Test on PW4-1 (Test 1)

This constant rate test involved a single pumping well (PW4-1) and one observation well OB4-1. Only the drawdown data for PW4-1 was analyzed; however, the observation data appear to be good and suitable for analysis.

The selected type curve for the pumping well data (PW4-1) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 2.0×10^8 which results in a skin coefficient of 4.6 indicating (Figure 15A), perhaps, some formation clogging near the well face. As shown in the log-log plot (Figure 15B), the match between the data and the type curve is good. The hydraulic conductivity estimate is 3.8 ft/day, however the estimate for the storage coefficient seems to small (2.5×10^{-9}).

Aquifer Test on M4-O

The aquifer test on monitoring well M4-O involved wells M2-GU, M3-GL and M5-S as observation points. Average discharge from M4-O during this test was reported at 15 gpm. Irrigation Well

ENGLAND #3 was on during the test but no information is available regarding its pumping rate history. Little or no drawdown was seen in any of the observation wells. However, at about 550 minutes into the test, the hydraulic head in all the wells shows a sharp decrease. After turning the pump off in well M4-O, the observation wells in the unconsolidated unit showed some partial recovery and then, at about 1,900 minutes, show a sharp drawdown. The hydraulic connection between the oxide unit and the overlain unconsolidated units seems limited at this location. Observation well M5-S (completed in the sulfide unit) did not show any drawdown, but instead recovered throughout the test indicating a very limited connection to the oxide unit. Due to these conditions, the test response from the observation wells M2-GU and M5-S was not considered suitable for interpretation.

FLOWDIM interpretation for the pumping well results in a fair match (Figure 16B) between the homogeneous 2-D model ($C_De^{2s} = 2 \times 10^8$) and the field data. The hydraulic conductivity estimate is 0.6 ft/day, with a skin factor of 3.8. The hydraulic conductivity is, however, deemed an underestimation of the actual formation conductivity due to the effect of pumping well ENGLAND #3.

Interpretation of observation well M3-GL used a 2-D model and resulted in a permeability estimate of 14.8 ft/day, and storativity of 8.8×10^{-2}. The match to the selected type curve is presented in Figure 2B.

Aquifer Test on P8-GU

This aquifer test involved a single pumping well (P8-GU) with a discharge of 85 gpm from the Upper Basin Fill Unit (UBFU). Four observations wells (P8.1-O, P8.2-O, O8-O, and O8-GL) were monitored. Irrigation wells BIA-9 and BIA-10B were on during the test but no information is available regarding their pumping rate history. Additionally, irrigation well WW-3 was turned on briefly for sampling toward the beginning of testing, and P28-GL was also pumped during testing. These wells did affect the measurements in the observation wells as evidenced by their lack of recovery when the pumping in P8-GU was stopped at about 3200 minutes into the test. Also, the recovery in the pumping well did not reach static water level, indicating that the observations in the pumping well are only fair for interpretation.

Field data interpretation was attempted with a type curve for the drawdown data (P8-GU) corresponding to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 1.0×10^6. This value, in turn, results in a skin coefficient of 0.9 indicating, perhaps, only minor formation clogging near the well face. As shown in the log-log plot (Figure 18B), the match between the data and the type curve is fair. The hydraulic conductivity estimate is 61.3 ft/day and the estimate for the storage coefficient is 3.2×10^{-6}.

Aquifer Test on P13.1-O

This constant rate test involved a single pumping well (P13.1-O) with a discharge of 46 gpm. All irrigation wells are reported to be off during the test. Observation well P13-GL data shows some irregularity, but the pumping well and observation well P13.2-O appear suitable for analysis. Observation well O13-O showed no response during this test.

The selected type curve corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 1×10^6. This value, in turn, results in a skin coefficient of -3.4 which indicates enhanced hydraulic conductivity near the well. This enhanced conductivity could be the result of natural fractures or it might be due to the drilling and well development process. As shown in the log-log plot (Figure 20B), there is a good match between the data and the type curve so results of this test are judged to be good. The hydraulic conductivity estimate is 0.3 ft/day which is a typical value for the oxide zone and the storage coefficient estimate is 4.7×10^{-7}.

The hydraulic response for observation well P13.2-O shows a strong 3-D component (Figure 21B). Analyses of these data result in a hydraulic conductivity of 1.3×10^{-4} ft/day and a storativity of 7.0

$x10^{-7}$.

Aquifer Test on P15-O

This constant rate test involved a single pumping well (P15-O) with a discharge of 60 gpm. However, irrigation Wells BIA-9 and BIA-10B were on during the test but no information is available regarding their pumping rates. These wells did affect observation wells (P15-GL and O15-O) as evidenced by the sudden change in drawdown near the end of the test. The sudden change in drawdown is superimposed upon the drawdown due to P15-O and is difficult to separate. These irregularities indicate that the observation wells are not suitable for interpretation. The pumping well is suitable, however.

The selected type curve corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 1 x 10^2. This value, in turn, results in a skin coefficient of -5.0 which indicates enhanced hydraulic conductivity near the well. As shown in the log-log plot (Figure 22B), there is a fair match between the data and the type curve so results of this test are judged to be acceptable when considering the complications introduced by additional pumping wells (BIA-9 and BIA-10B). The hydraulic conductivity estimate is 0.5 ft/day which is a typical value for the oxide zone and the storage coefficient estimate is 1.3 x 10^{-2}.

Aquifer Test on P19.1-O

This constant rate test involved a single pumping well (P19.1-O) with a discharge of 24 gpm pumping from the oxide zone. Observation wells P19-O and P19.2-O were also completed in the oxide zone. Two additional observations wells were also monitored during this test (O19-GL and well 138). The data from these two wells were strongly affected by pumping in irrigation wells BIA-10B and WW-3. However, the data sets for the oxide wells appear acceptable for analysis.

The selected type curve for the pumping well data (P19.1-O) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 2.0×10^8 . This value, in turn, results in a skin coefficient of 5.1 indicating some formation damage or clogging near the well face. As shown in the log-log plot (Figure 25B), the match between the data and the type curve is acceptable. The hydraulic conductivity estimate is 0.3 ft/day and the estimate for the storage coefficient is 6.2×10^{-10}.

The selected type curve for observation well data (P19-O) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 3.0. As shown in this log-log plot (Figure 23B), the match between the data and the type curve is good. The hydraulic conductivity estimate is 0.2 ft/day and the estimate for the storage coefficient is 7.7×10^{-4}.

The selected type curve for observation well data (P19.2-O) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 2.0. As shown in this log-log plot (Figure 27B), the match between the data and the type curve is fair. The hydraulic conductivity estimate is 0.2 ft/day and the estimate for the storage coefficient is 1.5×10^{-4}.

The above analyses show that the data deviates strongly from the 2-D flow model. Therefore, these data were reinterpreted using a 3-D model. For this interpretation, the selected type curve for the pumping well data.(P19.1-O) corresponds a C_De^{2s} parameter equal to 10. As shown in the log-log plot (Figure 26B), the match between the data and the type curve is slightly better than that obtained with the 2-D model. The estimated skin coefficient is -3.3 which indicates enhanced hydraulic conductivity near the well as opposed to the formation clogging indicated by the 2-D interpretation. The hydraulic conductivity estimate is 0.01 ft/day and the estimate for the storage coefficient is 5.6 $\times 10^{-3}$.

The selected 3-D type curve for observation well data (P19-O) corresponds a C_De^{2s} parameter equal to 3.0. As shown in this log-log plot (Figure 24B), the match between the data and the type curve is only slightly better than that obtained with the 2-D model. The hydraulic conductivity estimate is 2.4×10^{-4} ft/day and the estimate for the storage coefficient is 1.4×10^{-6}.

The selected 3-D type curve for observation well data (P19.2-O) corresponds a C_De^{2s} parameter equal to 3.0. As shown in this log-log plot (Figure 28B), the match between the data and the type curve is acceptable. The hydraulic conductivity estimate is 2.0 x 10^{-4} ft/day and the estimate for the storage coefficient is 3.4 x 10^{-7}.

Aquifer Test on P28.1-O (Test #1)

This constant rate test involved a single pumping well (P28.1-O) with a discharge of 28 gpm from the oxide zone. Observation wells P28-GL and O28-GL were completed in the Lower Basin Fill Unit (LBFU) and observation wells P28.2-O and O28.1-O were completed in the oxide zone. Irrigation Well England #3 was on during the test but no information is available regarding its pumping rate history. Also, the recovery in the pumping well went beyond static water level. Test interpretation included only the data set from the pumping well.

The selected type curve for the pumping well data (P28.1-O) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 10. This value, in turn, results in a skin coefficient of -6.7 which indicates enhanced hydraulic conductivity near the well. This enhanced conductivity could be natural, as resulting from nearby fractures, or it could be due to the drilling and well development process. As shown in the log-log plot (Figure 30B), and due to the transient effects produced by nearby pumping, the match between the data and the type curve is only fair. The hydraulic conductivity estimate is 7.7 ft/day. The estimate for the storage coefficient is 5.2 which is clearly unreasonable (S is a dimensionless quantity smaller than one). This impossible storage coefficient estimate results from a data set affected by pumping from irrigation well England #3. This data set is hard to match with a type curve.

Aquifer Test on P28.1-O (Test #2)

This constant rate test involved a single pumping well (P28.1-O) with a discharge of 86 gpm from the oxide zone. Observation wells P28-GL and O28-GL were completed in the Lower Basin Fill Unit (LBFU) and observation wells P28.2-O and O28.1-O were completed in the oxide zone. Irrigation Well BIA-9 was on during testing, as was well P8.1-O. However, the data appear well-behaved and suitable for analysis.

The selected type curve for the pumping well data (P28.1-O) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 10. This value, in turn, results in a skin coefficient of -4.2 which indicates enhanced hydraulic conductivity near the well. This enhanced conductivity could be natural, as resulting from nearby fractures, or it could be due to the drilling and well development process. As shown in the log-log plot (Figure 31B), and in spite of the transient effects produced by nearby pumping, the match between the data and the type curve is good. The hydraulic conductivity estimate is 3.6 ft/day and the estimate for the storage coefficient is 3.4×10^{-2}.

The selected type curve for the observation well data (P28.2-O) corresponds to a 2-D, homogeneous flow model, with a C_De^{2s} parameter equal to 2.0. As shown in this log-log plot (Figure 32B), and in spite of the transient effects produced by nearby pumping, the match between the data and the type curve is good. The hydraulic conductivity estimate is 2.7 ft/day. The estimate for the storage coefficient is 2.9×10^{-4}.

Aquifer Test on P49-O

The aquifer test conducted on well P49-O consisted of a constant discharge of about 40 gpm. Two observation wells were monitored during this test; well O49-O, completed in the oxide unit, and well O49-GL completed in the Lower Basin Fill Unit. More than 180 ft of drawdown in the pumping well rendered the pressure transducer dry. Pressure response on the observation wells was relatively clean, with well O49-O showing a drawdown of about 95 ft, and a drawdown in the basin fill well of about 0.5 ft. No other wells were reported in operation during this test, so the quality of the data is good. As mentioned before, only partial data was collected during drawdown in the pumping well, so the hydraulic conductivity for this test was estimated from the shut in data.

The log-log plot (Figure 34B) for this test shows that a 3-D model represents the observed data quite well. A type-curve parameter C_De^{2s} of 0.3 produces and estimated hydraulic conductivity value of 7.8×10^{-3} ft/day and a skin coefficient of -7.7. The estimated storage coefficient is however surprisingly high (0.8). The reason for this extreme value is not apparent at this time.

4.0 DISCUSSION

The hydraulic conductivity estimates from aquifer tests in the basin fill are quite variable, ranging from 0.1 to 61.3 ft/day and, as expected, they are about an order of magnitude larger than the hydraulic conductivity estimates for the oxide zone. The majority of hydraulic conductivity estimates in the Basin Fill and oxide zone are reasonable. A large variation in storativity is observed and some of these estimates are unrealistically small. The smallest values are usually derived from interpretation of pumping well data. As commonly found in most filed tests, and also indicated by the Florence data, test analyses in observation wells tend to give more reasonable storativity estimates than analyses of pumping well data.

Analyses of many of the tests described above show the effects from multiple pumping wells with unknown pumping rate history. It is our opinion that further analyses of these tests would be better accomplished by inverse techniques that use available drawdown data to simultaneously estimate the unknown flow rate history in the agricultural wells and the aquifer parameters. Golder Associates has initiated work to accomplish these analyses. The actual effect of additional pumping from wells in the vicinity of a test on the magnitude of the estimated hydraulic parameters is not well understood. It would depend on whether a particular well is pumping or shut in after some period of pumping. When a nearby well is pumping, the estimates would more likely underestimate the actual aquifer parameters. The true effect needs, however, to be evaluated through analytical studies that simulate typical conditions observed in the field.

Several of the hydraulic responses for the tests analyzed in this report seem to be better interpreted by assuming a 3-D flow geometry. However, the estimated hydraulic conductivity and storativity obtained through the 3-D analysis are two or three orders of magnitude smaller than those obtained from the traditional 2-D radial flow model. The reason for the smaller hydraulic parameters is clear when one considers the area available for flow under each of these models. Under the 2-D radial flow model this area increases as a linear function of the distance from the pumping well, whereas for the 3-D model, it increases with the square of this distance.

In terms of predicting the producing capacity of a well, the distinction between alternative flow geometries is not crucial. However, for evaluation of transport of solutes through the aquifer this distinction becomes extremely relevant. It is important to notice, however, that for the simulation of solute transport in the context of the APP process, use of the 2-D hydraulic parameters results in conservative estimates of solute migration. By using a "reduced" area for solute transport (interaction) one would necessarily overestimate the potential migration of solutes. It is recommended that numerical simulations of flow and transport be carried out with the 2-D hydraulic parameter estimates.

Of paramount importance for the in-situ operation and for environmental protection, is the distinction between porous media flow and that resulting from discrete features. So far, the available field data indicate that flow at the Florence Site can safely be simulated with a porous media approach such as that built within numerical flow models like MODFLOW.

Golder Associates will continue interpreting the available hydraulic test data to support potential needs for the APP process and future mining needs. The next phase of aquifer test interpretation will concentrate on data from observation wells using inverse procedures as briefly described above. The three-dimensional model does not seem to fit the data sets any better than the two-dimensional model. Again, for the sake of conservatism, and due to the large uncertainty in the interpretation of these tests, it is recommended that the values obtained from the 2-D model be used for subsequent numerical simulations.

5.0 REFERENCES

Belanger, D.W.. Freeze. G.A.. Lolcama. J.L., and Pickens. J.F., 1989. *Interpretation of Hydraulic Testing in Crystalline Rock at the Leuggern Borehole*, NAGRA Technischer Bericht 87-19.

Bourdet. D., Whittle, T.M., Douglas, A.A., and Pirard. Y.M., 1983, *A New Set of Type Curves Simplifies Well Test Analysis*, World Oil, May 1983, pp.95-1-6.

Bourdet, D., Ayoub, J.A., and Pirard. Y.M., 1989, *Use of Pressure Derivative in Well-Test Interpretation, SPE Formation Evaluation*, June 1989, pp. 293-302.

Dake, L.P., 1978, *Fundamentals of Reservoir Engineering*, Chapter 7, Elsevier, Amsterdam, 1978.

Dawson, K.J. and Istok, J.D., 1991, *Aquifer Testing: Design and Analysis of Pumping and Slug Tests*, Lewis Publishers, Michigan, 1991.

Dowell Schlumberger, 1985, *Well Test Manual*, Internal Edition, 1985.

Earlougher, R.C. Jr., 1977, *Advances in Well Test Analysis*, Monograph 5 of the Henry L. Doherty Series, Society of Petroleum Engineers of AIME, New York, Second Edition, 1977.

Gringarten, A.C., 1979, *A Comparison Between Different Skin and Wellbore Storage Type Curves for Early-Time Transient Analysis*, SPE Paper No. 8205, 1979.

Gringarten, A.C., Bourdet, D., Fjare, D.S., and Viturat, D., 1980, *Horner Type-Curve Analysis*, SPE Paper NO. 8291, Sept. 1980.

Gringarten. A.C., 1986, *Computer-Aided Well Test Analysis*, SPE Paper No. 14099, March 1986.

Gringarten. A.C., 1987, *Type Curve Analysis: What it Can and Cannot Do*, Journal of Petroleum Technology, January 1987. pp. 11-13.

Grisak, G.E.. Pickens, J.F., Balanger, D.W., and Avis, J.D.. 1985. *Hydrogeologic Testing of Crystalline Rocks During the Nagra Deep Drilling Program*. Nagra Technischer Bericht 85-08.

Horne. R.N., 1990. *Modern Well Test Analysis: A Computer Aided Approach*, Petroway. Palo Alto. California. 1990.

Kruseman, G.P. and de Ridder, N.A., 1991, *Analysis and Evaluation of Pumping Test Data*, Second Edition (Reprinted), International Institute for Land Reclamation and Improvement (ILRI) Publication 47, Wageningen, The Netherlands, 1991.

Lee, J., 1982, *Well Testing*, First Printing, Society of Petroleum Engineers of AIME, New York, 1982.

Ostrowski, L.P. and Kloska, M.B., 1989, *Final Interpretation of Hydraulic Testing at the Siblingen Borehole*, Nagra/CISRA Technical Report 89-10, Baden, Switzerland, Sept., 1989.

Pickens, J.F., Grisak, G.E., Avis, J.D., Belanger, D.W., and Thury, M., 1987, *Analysis and Interpretation of Borehole Hydraulic Tests in Deep Boreholes: Principles, Model Development and Applications*, Water Resources Research, Vol. 23, No. 7, 1987, pp. 1341-1375.

Sabet, M.A., 1991, *Well Test Analysis*, Gulf Publishing Company, Houston, Texas, 1991.

Streltsova, T.D., 1988, *Well Testing in Heterogeneous Formations*, Exxon Monograph, John-Wiley & Sons, New York, 1988.

Theis, C.V., 1935, *The Relation Between the Lowering of the Piezometric Surface and the Rate and Duration of Discharge of a Well Using Groundwater Storage*, Transactions of the American Geophysical Union, Vol. 16, 1935, pp. 519-524.

van Everdingen, A.F., 1953, *The Skin Effect and its Influence on the Productive Capacity of a Well*, Transactions of AIME, Vol. 198, 1953, pp. 171-176.

van Golf-Racht, T.D., 1982, *Fundamentals of Fractured Reservoir Engineering*, Developments in Petroleum Science 12, Elsevier Publishing Company, Amsterdam, The Netherlands, 1982.

Warren, J.E. and Root, P.J., 1963, *The Behaviour of Naturally Fractured Reservoirs*, Society of Petroleum Engineers Journal, Sept. 1963, pp. 245-255.

6.0 NOMENCLATURE

Symbol		**Unit**
B	formation volume factors	-
c_r	rock compressibility	Pa^{-1}
c_t	total compressibility	Pa^{-1}
c_w	water compressibility	Pa^{-1}
c_{ww}	water compressibility in wellbore	Pa^{-1}
C	wellbore storage coefficient	m^3/Pa
C_D	dimensionless wellbore storage coefficient	-
d_i	distance to boundary "I"	m
g	acceleration due to gravity	ms^{-2}
h	test section length	m
h_m	thickness of matrix blocks	m
H	head	m
k	intrinsic permeability (1 milli Darcy = 10^{-15} m^2)	m^2
k_f	fracture permeability (in a double porosity system)	m^2
k_{fD}	dimensionless fracture permeability	-
k_{fw}	fracture permeability	m^2
k_m	matrix permeability	m^2
$(kh/\mu)_{1/2}$	mobility ratio	-
K	hydraulic conductivity	ms^{-1}
K_s	hydraulic conductivity of the skin zone	ms^{-1}
l	linear distance	m
m	meters	m
P	pressure	Pa
P_{atm}	atmospheric pressure	Pa
P_D	dimensionless pressure	-
q	flow rate	m^3/day
q_i	the i^{th} constant rate flow period	m^3/s
r	radial distance	m
r_D	dimensionless radius	-
r_e	radius of circular constant pressure boundary	m
r_1	radius of the composite discontinuity	m
r_w	wellbore radius	m
r_{we}	effective well radius	m
s	skin factor of the well	-
s_f	skin factor between the fractures and the matrix	-
S	formation storage (storativity)	-
S_S	specific storage	m^{-1}

NOMENCLATURE - *continued*

Symbol		Unit
t	time	s
t_m	thickness of the matrix blocks	m
t_p	flow period duration	s
t_{pD}	dimensionless flow period duration	-
t_D	dimensionless time	-
V	volume of fluid	m^3
V_w	test section volume	m^3
x_f	fracture half-length	m
Z	elevation	m
α	dual porosity block geometry scale factor	-
ϕ	porosity	fraction
ϕ_f	fracture porosity	fraction
ϕ_m	matrix porosity	fraction
$(\phi c_t h)_{1/2}$	storativity ratio	-
λ	interporosity flow coefficient	-
μ	dynamic viscosity	Pa-s
ω	interporosity storativity ratio	-
ρ	density	Kg m^{-3}
Δt	time change	s
Δt_I	duration of the i^{th} constant rate event	s

Tables

Table 1 Summary of Available Hydraulic Test Data

Active Well	Observation Wells	Start Date	End Date	Well Location	Screen Location	Drawdown Data	Rate Data	Summary Sheet
M1-GL		11-Aug	13-Aug	X	X	X	X	X
	none							
M2-GU		25-Jul	26-Jul	X	X	X	X	X
	M3-GL			X	X	X		X
	M4-O			X	X	X		X
	M5-S			X	?	X		X
M3-GL		26-Jul	27-Jul	X	X	X	X	X
	M2-GU			X	X	X		X
	M4-O			X	X	X		X
	M5-S			X	X	X		X
M4-O		28-Jul	29-Jul	X	X	X	X	X
	M2-GU			X	X	X		X
	M3-GL			X	X	X		X
	M5-S			X	?	X		X
M10-GU		25-Jul	26-Jul	X	X	X	X	X
	M11-GL			X	X	X		X
	M12-O			X	X	X		X
	M13-S			X	X	X		X
M11-GL		29-Jul	30-Jul	X	X	X	X	X
	M10-GU			X	X	X		X
	M12-O			X	X	X		X
	M13-S			X	X	X		X
M12-O		31-Jul	1-Aug	X	X	X	X	X
	M10-GU			X	X	X		X
	M11-GL			X	X	X		X
	M13-S			X	?	X		X
M14-GL		11-Aug	13-Aug	X	X	X	X	X
	M15-GU			X	X	X		X
M15-GU		8-Aug	11-Aug	X	X	X	X	X
	M14-GL			X	X	X		X
M18-GU		8-Aug	11-Aug	X	X	X	X	X
	none							
PW2-1		8-Mar	?	X	X	X	X	N/A
	OB2-1			X	X			
PW3-1		24-Mar	1-Apr	X	X	X	?	N/A
	OB3-1			X	X	X		
PW4-1	(Test 1)	19-May	?	X	X	X	X	N/A
	OB4-1			X	X	X		
PW4-1	(Test 2)	23-May	31-May	X	X	X	X	N/A
	OB4-1			X	X			
P5-O		18-Oct	24 0ct	X	X	X	X	X
	O5.1-O			X	X	X		X
	O5.2-O			X	X	X		X
P5-O-MOD		18-Oct	24 0ct	X	X	X	X	X
	O5.1-O			X	X	X		X
	O5.2-O			X	X	X		X

Table 1 Summary of Available Hydraulic Test Data

Active Well	Observation Wells	Start Date	End Date	Well Location	Screen Location	Drawdown Data	Rate Data	Summary Sheet
PW7-1		16-Jun	21-Jun	X	X	X	X	N/A
	OB7-1			X	X	X		
	O3-GL			X	X	X		
	OB-1			X	X	X		
P8.2-O		?	?	X	X	?	X	?
	P8-GL			X	X	?		
	P8.1-O			X	X	?		
	O8-O			X	X	?		
	O8-GL			X	X	?		
P8.1-O		8-Sep-95	11-Sep	X	X	X	X	X
	P8-GU			X	X	X		X
	P8.2-O			X	X	X		X
	O8-O			X	X	X		X
	O8-GU			X	X	X		X
P8-GU		18-Sep	22-Sep	X	X	X	X	X
	P8.1-O			X	X	X		X
	P8.2-O			X	X	X		X
	O8-O			X	X	X		X
	O8-GU			X	X	X		X
P12-O		1-Jun	7-Jun	X	X	X	X	X
	O12-O			X	X	X		X
	O12-GL			X	X	X		X
P13.1-O		9-Oct	16-Oct	X	X	X	X	X
	P13-GL			X	X	X		X
	P13.2-O			X	X	X		X
	O13-O			X	X	X		X
P15-O		29-Sep	5-Oct	X	X	X	X	X
	P15-GL			X	X	X		X
	O15-O			X	X	X		X
	WW3			?	?	?		X
	BIA-9			?	?	?		X
P19.1-O		3-Jul	6-Jul	X	X	X	X	N/A
	P19-O			X	X	X		
	P19.2-O			X	X	X		
	O19-GL			X	X	X		
	138			X	X	X		
P28-GL		20-Sep	25-Sep	X	X	X	X	X
	P28.1-O			X	X	No Data		
	P28.2-O			X	X	X		X
	O28-GL			X	X	X		X
	O28.1-O			X	X	X		X
	O28.2-S			X	X	X		X
P28.1-O		15-Aug	18-Aug	X	X	X	X	X
(Test 1)	P28.2-O			X	X	X		X
	P28-GL			X	X	X		X
	O28-GL			X	X	X		X
	O28.1-O			X	X	X		X
	O28.2-S			X	X	No Data		

Table 1 Summary of Available Hydraulic Test Data

Active Well	Observation Wells	Start Date	End Date	Well Location	Screen Location	Drawdown Data	Rate Data	Summary Sheet
P28.1-O		8-Sep	11-Sep	X	X	X	X	X
(Test 2)	P28.2-O			X	X	X		X
	P28-GL			X	X	X		X
	O28-GL			X	X	X		X
	O28.1-O			X	X	X		X
	O28.2-S			X	X	No Data		
P28.2-O		2-Oct	5-Oct	X	X	X	X	X
	P28-GL			X	X	X		X
	P28.1-O			X	X	X		X
	O28.1-O			X	X	X		X
	O28-GL			X	X	X		X
	O28.2-O			X	X	X		X
P39-O		19-May	20-May	X	X	X	X	X
	O39-O			X	X	X		X
P49-O		11-Oct	16-Oct	X	X	X	X	X
	O49-O			X	X	X		X
	O49-GL			X	X	X		X

Table 2. Hydraulic Conductivity Estimates

Well	Active/Observation	K (feet/day)	Screened Formation	Comments
M1-GL	Active	17.3	LBFU	(1), (2); Acceptable
M3-GL	Active	15.9	LBFU	(1), (3); Acceptable
M14-GL	Active	1.7	LBFU	(1), (2); Acceptable
M14-GL3d	Active	0.1	LBFU	(1), (2); Acceptable
M15-GU	Active	2.6	LBFU	(1), (2), (3); Acceptable
M18-GL	Active	19.6	LBFU	(1); Fair
P28-GL	Active	8.3	LBFU	(1), (3); Acceptable
O28-GL	Observation (P28-GL)	23.2	LBFU	(1), (3); Acceptable
M3-GL	Observation (M4-O)	14.8	LBFU	(1), (3); Acceptable
P8-GU	Active	61.3	UBFU	(1), (2), (3); Fair
M4-O	Active	0.6	Oxide	(1), (3); Acceptable
PW2-1	Active	1.4	Oxide	Good
PW4-1	Active	3.8	Oxide	Good
PW7-1	Active	0.2	Oxide	(1), (3); Acceptable
OB7-1	Observation (PW7-1)	0.1	Oxide	(1), (3); Acceptable
P12-O	Active	0.4	Oxide	(1), (2), (3); Fair
O12-O	Observation (P12-O)	0.6	Oxide	(1), (2), (3); Fair
P19.1-O	Active	0.3	Oxide	(1), (2), (3); Acceptable
P19-O	Observation (P19.1-O)	0.2	Oxide	(1), (2), (3); Acceptable
P19.2-O	Observation (P19.1-O)	0.2	Oxide	(1), (2), (3); Fair
P19.1-O3d	Active	1.00E-02	Oxide	(1), (2), (3); Acceptable
P19-O3d	Observation (P19.1-O)	2.39E-04	Oxide	(1), (2), (3); Acceptable
P19.2-O3d	Observation (P19.1-O)	1.99E-04	Oxide	(1), (2), (3); Acceptable
P39-O	Active	0.3	Oxide	Good
O39-O	Observation (P39-O)	0.3	Oxide	Good
P28.1-O	Active	7.7	Oxide	(1), (3); Fair
P28.1-O (2)	Active	3.6	Oxide	(1); Good
P28.2 -O	Observation (P28.1-O)	2.7	Oxide	(1); Good
P28.2-O	Active	3.1	Oxide	(1), (3); Fair
O28.1-O	Observation (P28.2-O)	3.0	Oxide	(1), (3); Acceptable
P13.1-O	Active	0.3	Oxide	Good
				Obs. Well shows 3-D behavior
P49-O3d	Active/Recovery Data	7.75E-03	Oxide	Good, Clear 3-D behavior
P15-O	Active	0.5	Oxide	(1),(3); Acceptable

(1) Other wells were pumping during this test at an unknown rate
(2) Data indicates recovery over the initial "static" water table
(3) Observation wells show effects of recovery or drawdown produced by other wells

Qualifiers	Description
Good	The reported K value is a good indication of the formation hydraulic conductivity
Acceptable	The reported K value is most likely an under-estimation of the formation conductivity
Fair	The reported K value has a large uncertainty due to conditions during test

Figures

APPENDIX A

FlowDim Analysis File : **m1-gld.dat**

	Parameter		Units
r_w	Well radius	**0.064**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**10.00**	%
C	Wellbore storage	**4.35E-06**	m^3/Pa
h	Length of aquifer tested	**12.19**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s} \, 2 \pi \phi c_t h r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	2.0000E+08
P (kPa)	7.5335E-01
T (hr)	3.9350E+02

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
7.43E-04	**1.20E-02**	**17.29**	**6.10E-05**	**6.10E-03**	**3.32**

FlowDim Analysis File : m3gloddb.fd1

	Parameter		Units
r_w	Well radius	0.064	m
μ	Groundwater viscosity	1.000E-03	Pa s
ρ	Groundwater density	1.000E+03	kg/m^3
c_t	Total compressibility	5.400E-10	1/Pa
ϕ	Porosity of formation	5.00	%
C	Wellbore storage	N/A	m^3/Pa
h	Length of aquifer tested	18.29	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\, 2\, \pi\, \phi\, c_t\, h\, r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	N/A
P (kPa)	6.4470E-01
T (hr)	4.1462E-01

Results

$T(m^2/sec)$	K (feet/min)	K(feet/dat)	K (m/s)	K (cm/s)	Skin
9.53E-04	1.03E-02	14.77	5.21E-05	5.21E-03	#########

FlowDim Analysis File : **m14-gld.dat**

	Parameter		Units
r_w	Well radius	**0.064**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**10.00**	%
C	Wellbore storage	**2.35E-06**	m^3/Pa
h	Length of aquifer tested	**18.29**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s} \, 2 \pi \phi c_t h r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	1.0000E+06
P (kPa)	1.1410E-01
T (hr)	1.1015E+02

Results

T(m^2/sec)	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
1.12E-04	**1.21E-03**	**1.74**	**6.15E-06**	**6.15E-04**	**1.18**

FlowDim Analysis File : m14gld3d.dat

	Parameter		Units
r_w	Well radius	0.064	m
μ	Groundwater viscosity	1.00E-03	Pa s
ρ	Groundwater density	1.00E+03	kg/m^3
c_t	Total compressibility	5.40E-10	1/Pa
ϕ	Porosity of formation	10.00	%
C	Wellbore storage	2.22E-06	m^3/Pa
h	Length of aquifer tested	18.29	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln(C_D e^{2s}\, 2\pi\, \phi\, c_t\, h\, r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	1.0000E+01
P (kPa)	1.0766E-02
T (hr)	1.1022E+01

Results

$T (m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
5.31E-06	5.71E-05	0.08	2.90E-07	2.90E-05	-4.54

FlowDim Analysis File : **m15-gud.dat**

	Parameter		Units
r_w	Well radius	**0.064**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**10.00**	%
C	Wellbore storage	**2.78E-07**	m^3/Pa
h	Length of aquifer tested	**12.19**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\ 2\ \pi\ \phi\ c_t\ h\ r_w^{\ 2} / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	1.0000E+10
P (kPa)	1.1287E-01
T (hr)	9.2222E+02

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
1.11E-04	**1.80E-03**	**2.59**	**9.14E-06**	**9.14E-04**	**6.65**

FlowDim Analysis File : **m18-gud.dat**

	Parameter		Units
r_w	Well radius	0.064	m
μ	Groundwater viscosity	1.00E-03	Pa s
ρ	Groundwater density	1.00E+03	kg/m^3
c_t	Total compressibility	5.40E-10	1/Pa
ϕ	Porosity of formation	10.00	%
C	Wellbore storage	2.25E-06	m^3/Pa
h	Length of aquifer tested	12.19	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\, 2 \pi \phi c_t h r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	1.0000E+15
P (kPa)	8.5570E-01
T (hr)	8.6654E+02

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
8.44E-04	**1.36E-02**	**19.64**	**6.93E-05**	**6.93E-03**	**11.36**

FlowDim Analysis File : mf39pwpd.dat

	Parameter		Units
r_w	Well radius	0.130	m
μ	Groundwater viscosity	1.00E-03	Pa s
ρ	Groundwater density	1.00E+03	kg/m^3
c_t	Total compressibility	5.40E-10	1/Pa
ϕ	Porosity of formation	5.00	%
C	Wellbore storage	1.04E-06	m^3/Pa
h	Length of aquifer tested	108.20	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s} \, 2 \pi \phi c_t h r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	1.0000E+02
P (kPa)	2.0728E-02
T (hr)	2.4897E+02

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
1.12E-04	2.04E-04	0.29	1.04E-06	1.04E-04	-1.76

FlowDim Analysis File : mf39owpd.dat

	Parameter		Units
r_w	Well radius	**0.127**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**50.00**	%
C	Wellbore storage	**NA**	m^3/Pa
h	Length of aquifer tested	**126.80**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\ 2 \pi \phi c_t h r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	2.0000E+00
P (kPa)	2.6738E-02
T (hr)	9.3173E-01

Results

T(m^2/sec)	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
1.44E-04	**2.24E-04**	**0.32**	**1.14E-06**	**1.14E-04**	########

FlowDim Analysis File : ob7-1dda.fd1

	Parameter		Units
r_w	Well radius	**0.076**	m
μ	Groundwater viscosity	**1.000E-03**	Pa s
ρ	Groundwater density	**1.000E+03**	kg/m^3
c_t	Total compressibility	**5.400E-10**	1/Pa
ϕ	Porosity of formation	**5.00**	%
C	Wellbore storage	**N/A**	m^3/Pa
h	Length of aquifer tested	**103.63**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\ 2\ \pi\ \phi\ c_t\ h\ r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	N/A
P (kPa)	1.2560E-02
T (hr)	5.7458E+00

Results

$T(m^2/sec)$	K (feet/min)	K(feet/dat)	K (m/s)	K (cm/s)	Skin
4.95E-05	**9.40E-05**	**0.14**	**4.78E-07**	**4.78E-05**	#########

FlowDim Analysis File : 012-oddc.fd1

	Parameter		Units
r_w	Well radius	**0.051**	m
μ	Groundwater viscosity	**1.000E-03**	Pa s
ρ	Groundwater density	**1.000E+03**	kg/m^3
c_t	Total compressibility	**5.400E-10**	1/Pa
ϕ	Porosity of formation	**5.00**	%
C	Wellbore storage	**N/A**	m^3/Pa
h	Length of aquifer tested	**152.40**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\, 2\, \pi\, \phi\, c_t\, h\, r_w^{\,2} / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	N/A
P (kPa)	5.0164E-02
T (hr)	1.0792E+00

Results

$T(m^2/sec)$	K (feet/min)	K(feet/dat)	K (m/s)	K (cm/s)	Skin
3.21E-04	**4.15E-04**	**0.60**	**2.11E-06**	**2.11E-04**	########

FlowDim Analysis File : **o28-gld.dat**

	Parameter		Units
r_w	Well radius	**0.051**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**10.00**	%
C	Wellbore storage	**NA**	m^3/Pa
h	Length of aquifer tested	**9.14**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s} \, 2 \, \pi \, \phi \, c_t \, h \, r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	2.0000E+00
P (kPa)	1.0130E-01
T (hr)	6.1809E+01

Results

$T (m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
7.49E-04	1.61E-02	23.22	8.19E-05	8.19E-03	########

FlowDim Analysis File : **o281-od.dat**

	Parameter		Units
r_w	Well radius	**0.051**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**5.00**	%
C	Wellbore storage	**NA**	m^3/Pa
h	Length of aquifer tested	**30.48**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\, 2 \pi \phi c_t h r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	2.0000E+00
P_{DM}	4.2352E-02
T_{DM}	4.3542E-01

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
3.17E-04	**2.05E-03**	**2.95**	**1.04E-05**	**1.04E-03**	#########

FlowDim Analysis File : pw2-1d.dat

	Parameter		Units
r_w	Well radius	**0.076**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**5.00**	%
C	Wellbore storage	**2.36E-06**	m^3/Pa
h	Length of aquifer tested	**67.06**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln\left(C_D e^{2s}\, 2\, \pi\, \phi\, c_t\, h\, r_w^{\,2} / C \right)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	2.0000E+08
P (kPa)	6.5031E-02
T (hr)	3.1235E+02

Results

T(m^2/sec)	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
3.20E-04	**9.41E-04**	**1.35**	**4.78E-06**	**4.78E-04**	**4.31**

FlowDim Analysis File : pm3-glda.fd1

	Parameter		Units
r_w	Well radius	0.064	m
μ	Groundwater viscosity	1.00E-03	Pa s
ρ	Groundwater density	1.00E+03	kg/m^3
c_t	Total compressibility	5.40E-10	1/Pa
ϕ	Porosity of formation	10.00	%
C	Wellbore storage	8.16E-07	m^3/Pa
h	Length of aquifer tested	12.19	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s} \, 2 \pi \phi c_t h r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	1.0000E+06
P (kPa)	6.9300E-01
T (hr)	1.9300E+03

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
6.83E-04	1.10E-02	15.88	5.60E-05	5.60E-03	1.51

FlowDim Analysis File : pw4-1.dat

	Parameter		Units
r_w	Well radius	0.076	m
μ	Groundwater viscosity	1.00E-03	Pa s
ρ	Groundwater density	1.00E+03	kg/m^3
c_t	Total compressibility	5.40E-10	1/Pa
ϕ	Porosity of formation	5.00	%
C	Wellbore storage	1.87E-06	m^3/Pa
h	Length of aquifer tested	103.63	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\, 2\, \pi\, \phi\, c_t\, h\, r_w^{\,2} / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	2.0000E+08
P (kPa)	1.9640E-01
T (hr)	1.6933E+03

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
1.37E-03	2.61E-03	3.76	1.33E-05	1.33E-03	4.65

FlowDim Analysis File : pm4-od.fd1

	Parameter		Units
r_w	Well radius	**0.06**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**5.00**	%
C	Wellbore storage	**1.38E-06**	m^3/Pa
h	Length of aquifer tested	**18.29**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln(C_D e^{2s}\, 2\pi\, \phi\, c_t\, h\, r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	2.0000E+08
P (kPa)	2.4300E-02
T (hr)	6.0000E+01

Results

$T (m^2/sec)$	K (feet/min)	K (feet/day)	K (m/s)	K (cm/s)	Skin
3.59E-05	**3.86E-04**	**0.56**	**1.96E-06**	**1.96E-04**	**3.75**

FlowDim Analysis File : PW7-1dda.fd1

	Parameter		Units
r_w	Well radius	**0.076**	m
μ	Groundwater viscosity	**1.000E-03**	Pa s
ρ	Groundwater density	**1.000E+03**	kg/m^3
c_t	Total compressibility	**5.400E-10**	1/Pa
ϕ	Porosity of formation	**5.00**	%
C	Wellbore storage	**6.871E-07**	m^3/Pa
h	Length of aquifer tested	**103.63**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln(C_D e^{2s}\, 2\,\pi\,\phi\, c_t\, h\, r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	1.0000E+02
P (kPa)	2.1298E-02
T (hr)	2.8162E+02

Results

T(m^2/sec)	K (feet/min)	K (feet/day)	K (m/s)	K (cm/s)	Skin
8.40E-05	**1.59E-04**	**0.23**	**8.10E-07**	**8.10E-05**	**-2.10**

FlowDim Analysis File : **p8-gud.dat**

	Parameter		Units
r_w	Well radius	**0.076**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**10.00**	%
C	Wellbore storage	**1.19E-05**	m^3/Pa
h	Length of aquifer tested	**36.58**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\, 2\, \pi\, \phi\, c_t\, h\, r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	1.0000E+06
P (kPa)	9.0703E-01
T (hr)	1.5374E+03

Results

$T (m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
7.91E-03	**4.26E-02**	**61.31**	**2.16E-04**	**2.16E-02**	**0.90**

FlowDim Analysis File : **P12-oddc.fd1**

	Parameter		Units
r_w	Well radius	**0.076**	m
μ	Groundwater viscosity	**1.000E-03**	Pa s
ρ	Groundwater density	**1.000E+03**	kg/m^3
c_t	Total compressibility	**5.400E-10**	1/Pa
ϕ	Porosity of formation	**10.00**	%
C	Wellbore storage	**4.640E-06**	m^3/Pa
h	Length of aquifer tested	**152.40**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln\left(C_D e^{2s}\, 2\,\pi\,\phi\, c_t\, h\, r_w^{\,2} / C\right)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	3.0000E+00
P (kPa)	3.1823E-02
T (hr)	1.0126E+02

Results

$T(m^2/sec)$	K (feet/min)	K (feet/day)	K (m/s)	K (cm/s)	Skin
2.04E-04	**2.63E-04**	**0.38**	**1.34E-06**	**1.34E-04**	**-4.27**

FlowDim Analysis File : **P131od.dat**

	Parameter		Units
r_w	Well radius	**0.076**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**0.05**	%
C	Wellbore storage	**1.75E-03**	m^3/Pa
h	Length of aquifer tested	**206.35**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\, 2\,\pi\, \phi\, c_t\, h\, r_w^{\,2} / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	1.0000E+06
P (kPa)	4.2200E-02
T (hr)	2.5150E+02

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
1.91E-04	**1.82E-04**	**0.26**	**9.26E-07**	**9.26E-05**	**-3.38**

FlowDim Analysis File : **P132od3d.dat**

	Parameter		Units
r_w	Well radius	**0.076**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**0.05**	%
C	Wellbore storage	**N/A**	m^3/Pa
h	Length of aquifer tested	**182.27**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s} \, 2 \, \pi \, \phi \, c_t \, h \, r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	N/A
P (kPa)	3.6000E-05
T (hr)	4.2500E-01

Results

$T (m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
8.18E-08	**8.84E-08**	**1.27E-04**	**4.49E-10**	**4.49E-08**	########

FlowDim Analysis File : **P150d.dat**

	Parameter		Units
r_w	Well radius	**0.076**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**0.05**	%
C	Wellbore storage	**4.94E-06**	m^3/Pa
h	Length of aquifer tested	**219.46**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\, 2\,\pi\,\phi\, c_t\, h\, r_w^{\,2} / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	1.0000E+02
P (kPa)	6.6100E-02
T (hr)	1.7940E+02

Results

$T (m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
3.84E-04	**3.44E-04**	**0.50**	**1.75E-06**	**1.75E-04**	**-5.02**

FlowDim Analysis File : **p19-od.dat**

	Parameter		Units
r_w	Well radius	**0.076**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**5.00**	%
C	Wellbore storage	**NA**	m^3/Pa
h	Length of aquifer tested	**60.35**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\ 2\ \pi\ \phi\ c_t\ h\ r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	3.0000E+00
P (kPa)	1.8917E-02
T (hr)	3.7000E-01

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
4.10E-05	**1.34E-04**	**0.19**	**6.80E-07**	**6.80E-05**	########

FlowDim Analysis File : p19-od3d.dat

	Parameter		Units
r_w	Well radius	0.076	m
μ	Groundwater viscosity	1.00E-03	Pa s
ρ	Groundwater density	1.00E+03	kg/m^3
c_t	Total compressibility	5.40E-10	1/Pa
ϕ	Porosity of formation	5.00	%
C	Wellbore storage	NA	m^3/Pa
h	Length of aquifer tested	60.35	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\, 2\, \pi\, \phi\, c_t\, h\, r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	3.0000E+00
P (kPa)	4.6825E-05
T (hr)	2.4582E-01

Results

$T (m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
5.08E-08	1.66E-07	0.00	8.41E-10	8.41E-08	########

FlowDim Analysis File : p191-od.dat

	Parameter		Units
r_w	Well radius	**0.076**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**5.00**	%
C	Wellbore storage	**4.58E-07**	m^3/Pa
h	Length of aquifer tested	**60.35**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\, 2\, \pi\, \phi\, c_t\, h\, r_w^{\,2} / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	2.0000E+08
P (kPa)	2.9442E-02
T (hr)	3.2135E+02

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
6.39E-05	**2.08E-04**	**0.30**	**1.06E-06**	**1.06E-04**	**5.08**

FlowDim Analysis File : p191od3d.dat

	Parameter		Units
r_w	Well radius	0.076	m
μ	Groundwater viscosity	1.00E-03	Pa s
ρ	Groundwater density	1.00E+03	kg/m^3
c_t	Total compressibility	5.40E-10	1/Pa
ϕ	Porosity of formation	5.00	%
C	Wellbore storage	4.19E-07	m^3/Pa
h	Length of aquifer tested	60.35	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\ 2\ \pi\ \phi\ c_t\ h\ r_w^{\ 2} / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	1.0000E+01
P (kPa)	2.1754E-03
T (hr)	2.5952E+01

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
2.36E-06	7.70E-06	0.01	3.91E-08	3.91E-06	-3.28

FlowDim Analysis File : **p192-od.dat**

	Parameter		Units
r_w	Well radius	0.051	m
μ	Groundwater viscosity	1.00E-03	Pa s
ρ	Groundwater density	1.00E+03	kg/m^3
c_t	Total compressibility	5.40E-10	1/Pa
ϕ	Porosity of formation	5.00	%
C	Wellbore storage	NA	m^3/Pa
h	Length of aquifer tested	60.35	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s} \, 2 \pi \phi \, c_t \, h \, r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	2.0000E+00
P (kPa)	1.4484E-02
T (hr)	1.7103E+00

Results

$T (m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
3.14E-05	1.02E-04	0.15	5.20E-07	5.20E-05	#########

FlowDim Analysis File : p192od3d.dat

	Parameter		Units
r_w	Well radius	**0.051**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**5.00**	%
C	Wellbore storage	**NA**	m^3/Pa
h	Length of aquifer tested	**60.35**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\ 2\ \pi\ \phi\ c_t\ h\ r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	3.0000E+00
P (kPa)	3.8942E-05
T (hr)	1.0011E+00

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
4.22E-08	**1.38E-07**	**0.00**	**7.00E-10**	**7.00E-08**	########

FlowDim Analysis File : **p28-gld.dat**

	Parameter		Units
r_w	Well radius	**0.064**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**10.00**	%
C	Wellbore storage	**8.71E-07**	m^3/Pa
h	Length of aquifer tested	**9.14**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s} \, 2\, \pi\, \phi\, c_t\, h\, r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	1.0000E+06
P (kPa)	3.6017E-02
T (hr)	7.0454E+02

Results

$T (m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
2.66E-04	**5.73E-03**	**8.26**	**2.91E-05**	**2.91E-03**	**1.33**

FlowDim Analysis File : p281-oad.dat

	Parameter		Units
r_w	Well radius	0.067	m
μ	Groundwater viscosity	1.00E-03	Pa s
ρ	Groundwater density	1.00E+03	kg/m^3
c_t	Total compressibility	5.40E-10	1/Pa
ϕ	Porosity of formation	5.00	%
C	Wellbore storage	1.50E-04	m^3/Pa
h	Length of aquifer tested	30.48	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln \left(C_D e^{2s} \, 2 \pi \phi c_t h r_w^2 / C \right)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	1.0000E+01
P (kPa)	2.8879E-01
T (hr)	1.2647E+01

Results

$T (m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
8.25E-04	5.33E-03	7.68	2.71E-05	2.71E-03	-6.69

FlowDim Analysis File : p281-obd.dat

	Parameter		Units
r_w	Well radius	**0.076**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**5.00**	%
C	Wellbore storage	**1.28E-06**	m^3/Pa
h	Length of aquifer tested	**30.48**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\, 2\, \pi\, \phi\, c_t\, h\, r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	1.0000E+01
P (kPa)	4.6017E-02
T (hr)	6.9315E+02

Results

T(m^2/sec)	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
3.86E-04	**2.49E-03**	**3.59**	**1.26E-05**	**1.26E-03**	**-4.18**

FlowDim Analysis File : p282-obd.dat

	Parameter		Units
r_w	Well radius	**0.051**	m
μ	Groundwater viscosity	**1.00E-03**	Pa s
ρ	Groundwater density	**1.00E+03**	kg/m^3
c_t	Total compressibility	**5.40E-10**	1/Pa
ϕ	Porosity of formation	**5.00**	%
C	Wellbore storage	**NA**	m^3/Pa
h	Length of aquifer tested	**30.18**	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln(C_De^{2s}\, 2\pi\, \phi\, c_t\, h\, r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

C_De^{2s}	2.0000E+00
P (kPa)	3.3963E-02
T (hr)	3.9303E+00

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
2.84E-04	**1.86E-03**	**2.67**	**9.43E-06**	**9.43E-04**	########

FlowDim Analysis File : p282-od.dat

	Parameter		Units
r_w	Well radius	0.076	m
μ	Groundwater viscosity	1.00E-03	Pa s
ρ	Groundwater density	1.00E+03	kg/m^3
c_t	Total compressibility	5.40E-10	1/Pa
ϕ	Porosity of formation	5.00	%
C	Wellbore storage	1.41E-04	m^3/Pa
h	Length of aquifer tested	30.18	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\, 2\, \pi\, \phi\, c_t\, h\, r_w^2 / C)}{2}$$

Match Point Parameters From Analysis

$C_D e^{2s}$	1.0000E+01
P (kPa)	4.4105E-02
T (hr)	5.4115E+00

Results

$T(m^2/sec)$	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
3.30E-04	2.15E-03	3.10	1.09E-05	1.09E-03	-6.53

FlowDim Analysis File : P49Od.dat

	Parameter		Units
r_w	Well radius	0.076	m
μ	Groundwater viscosity	1.00E-03	Pa s
ρ	Groundwater density	1.00E+03	kg/m^3
c_t	Total compressibility	5.40E-10	1/Pa
ϕ	Porosity of formation	0.05	%
C	Wellbore storage	1.78E-06	m^3/Pa
h	Length of aquifer tested	126.19	m

Skin Factor Calculation

Assuming formation storativity, the skin factor (s) can be calculated from the following equation.

$$s = \frac{\ln (C_D e^{2s}\, 2\, \pi\, \phi\, c_t\, h\, r_w^2 / C)}{2}$$

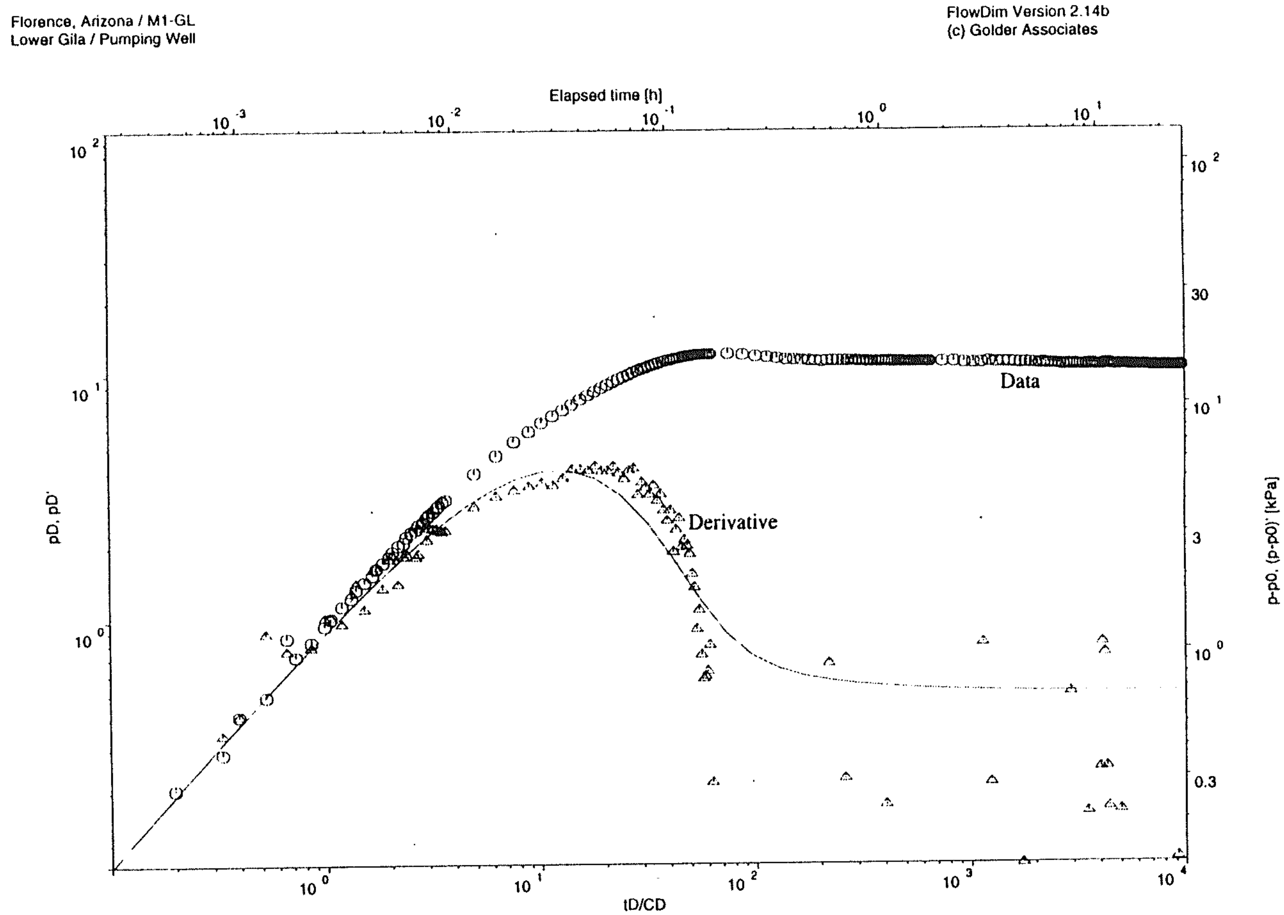
Match Point Parameters From Analysis

$C_D e^{2s}$	3.0000E-01
P (kPa)	1.7500E-03
T (hr)	8.9400E+00

Results

T(m^2/sec)	K (feet/min)	K (ft/day)	K (m/s)	K (cm/s)	Skin
3.45E-06	5.38E-06	7.75E-03	2.73E-08	2.73E-06	-7.69

APPENDIX B



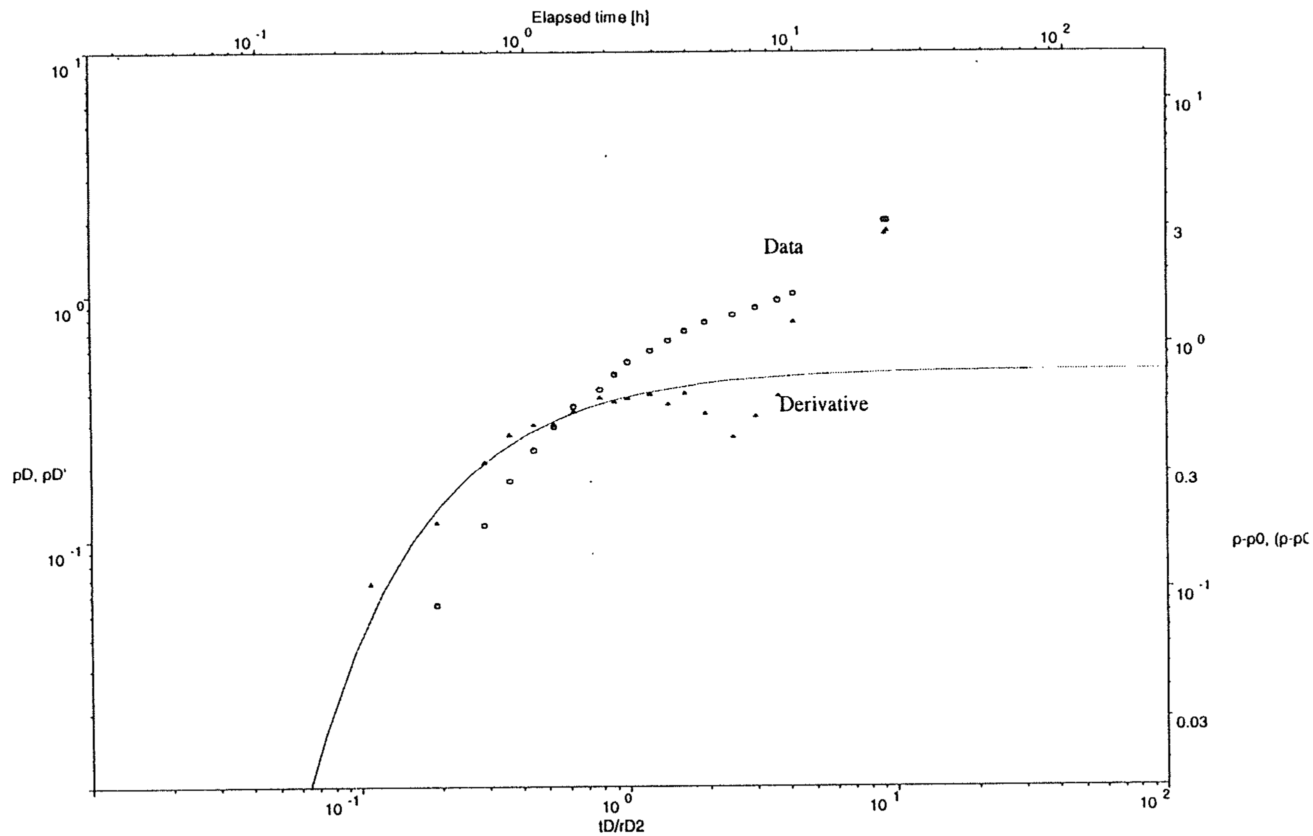
FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

C=	4.35E-06	m3/Pa
T=	7.43E-04	m2/s
S=	8.43E-09	-
s=	0.00E+00	-
n=	2.00E+00	-

Figure 1B

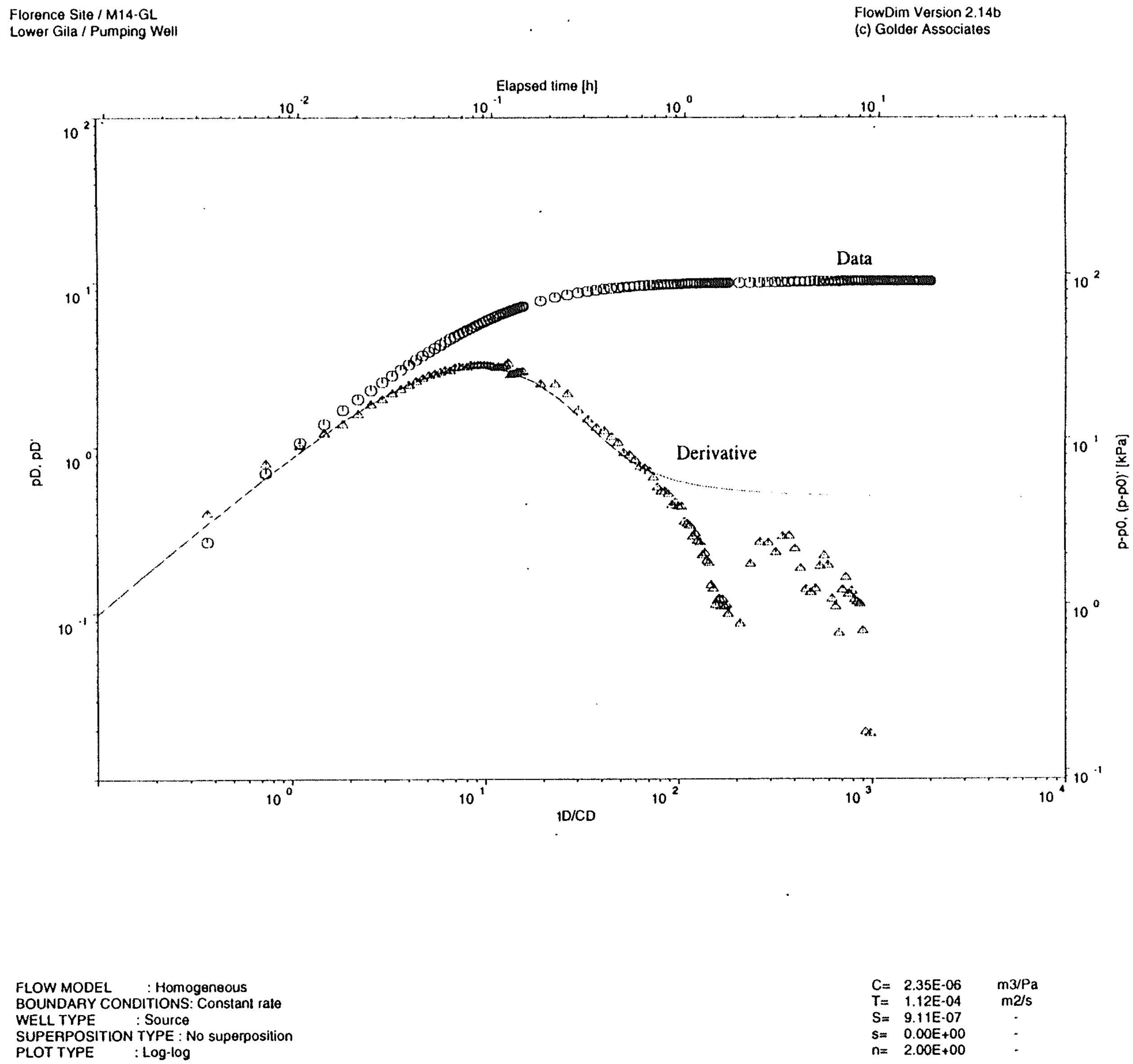
Florence, Arizona / M3-GL
Lower Gila / Obs Well

FlowDim Version
(c) Golder Associates



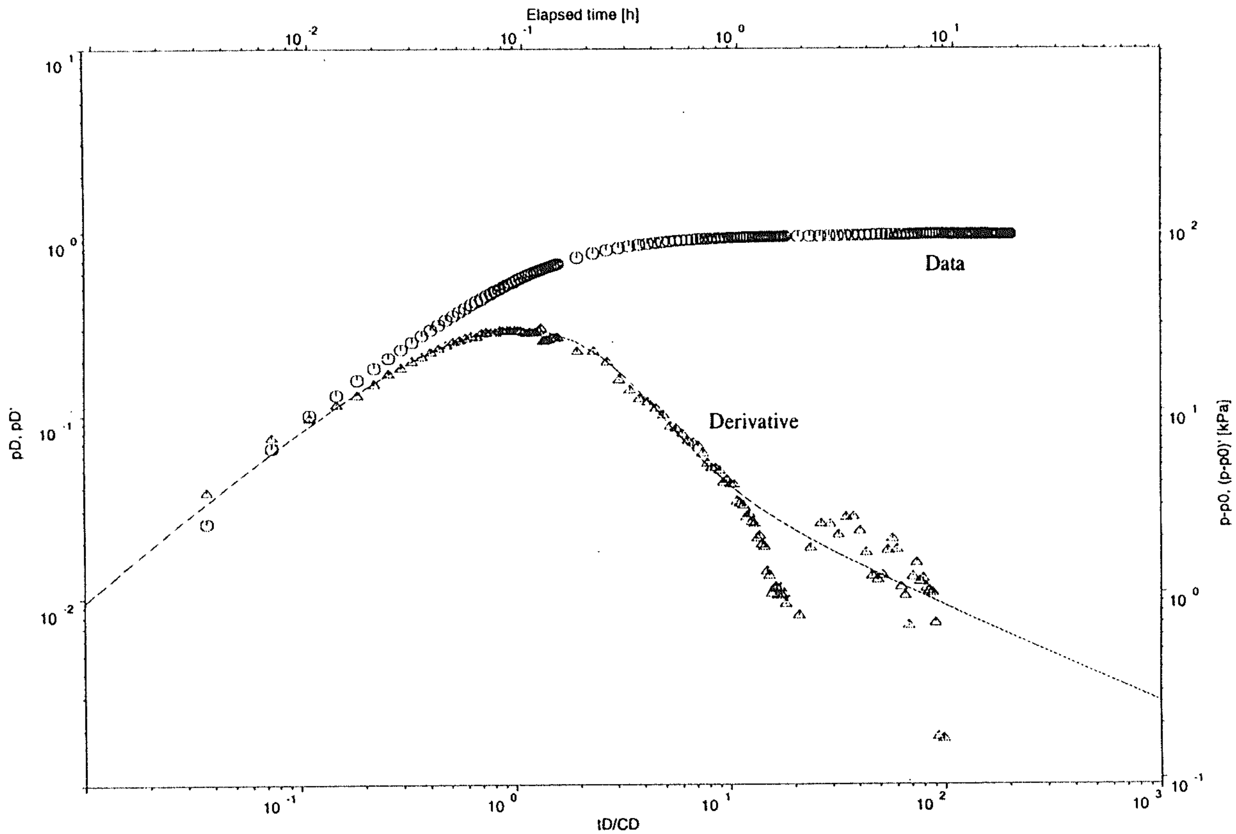
FLOW MODEL :
BOUNDARY CONDITIONS: Constant rate
WELL TYPE :
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-

T=	9.53E-04	m2/s
S=	8.78E-02	-
rD=	1.53E+02	-
n=	2.00E+00	-


Florence Site / M14-GL
Lower Gila / Pumping Well
FlowDim Version 2.14b
(c) Golder Associates
Elapsed time [h]
Data
Derivative
pD, pD'
p-p0, (p-p0)' [kPa]
tD/CD
FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log
C= 2.35E-06 m3/Pa
T= 1.12E-04 m2/s
S= 9.11E-07 -
s= 0.00E+00 -
n= 2.00E+00 -

Florence Site / M14-GL
Lower Gila / Pumping Well

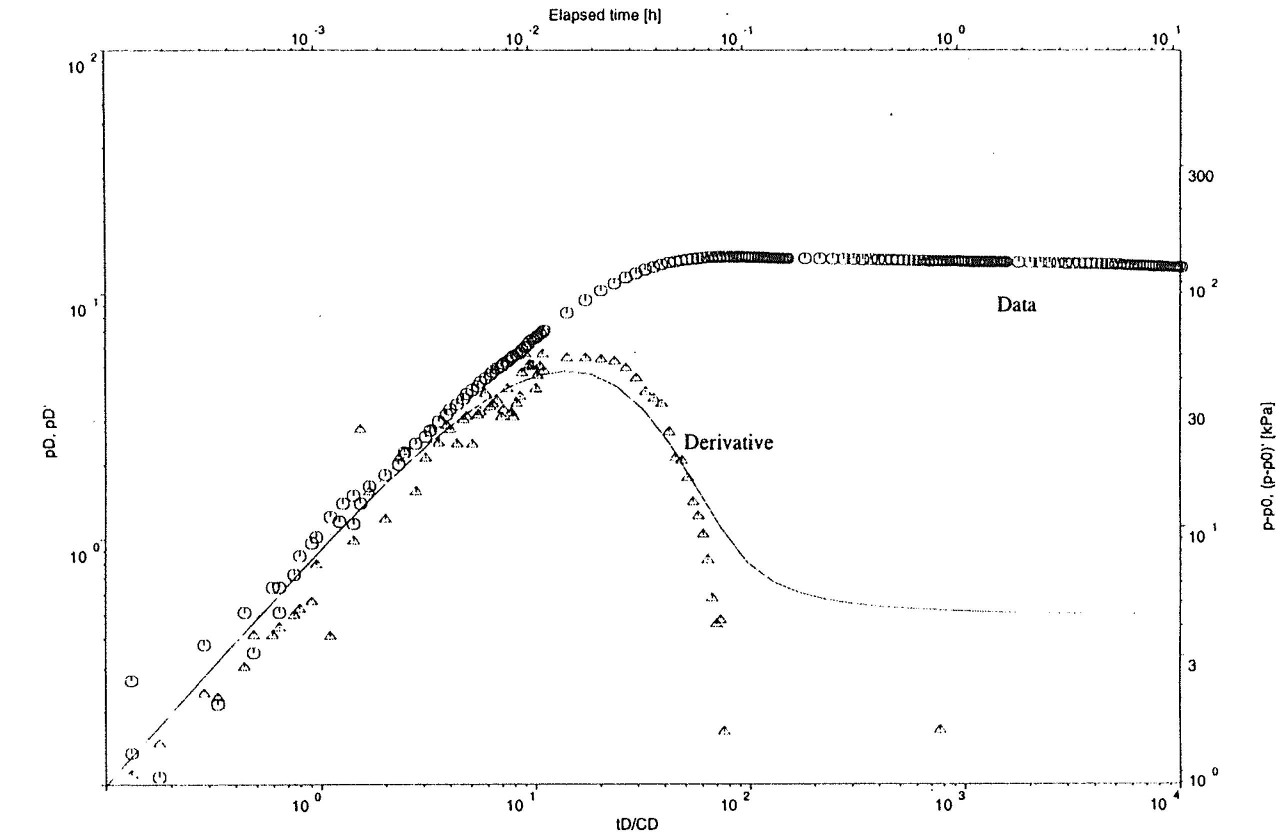
FlowDim Version 2.14b
(c) Golder Associates



FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

C=	2.22E-06	m3/Pa
T=	5.31E-06	m2/s
S=	4.30E-02	-
s=	0.00E+00	-
n=	3.00E+00	-

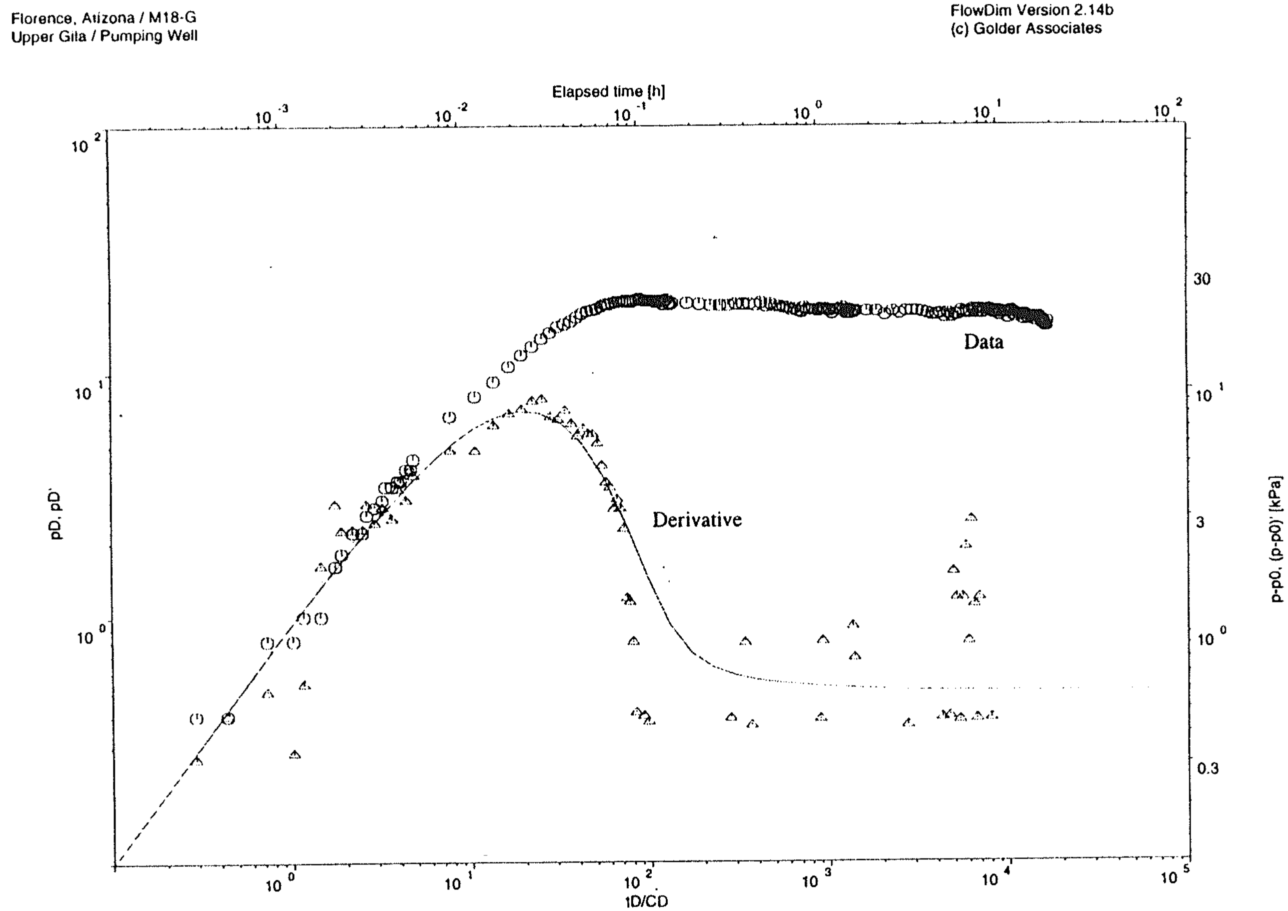
Figure 4B



FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

C=	2.78E-07	m3/Pa
T=	1.11E-04	m2/s
S=	1.08E-11	-
s=	0.00E+00	-
n=	2.00E+00	-

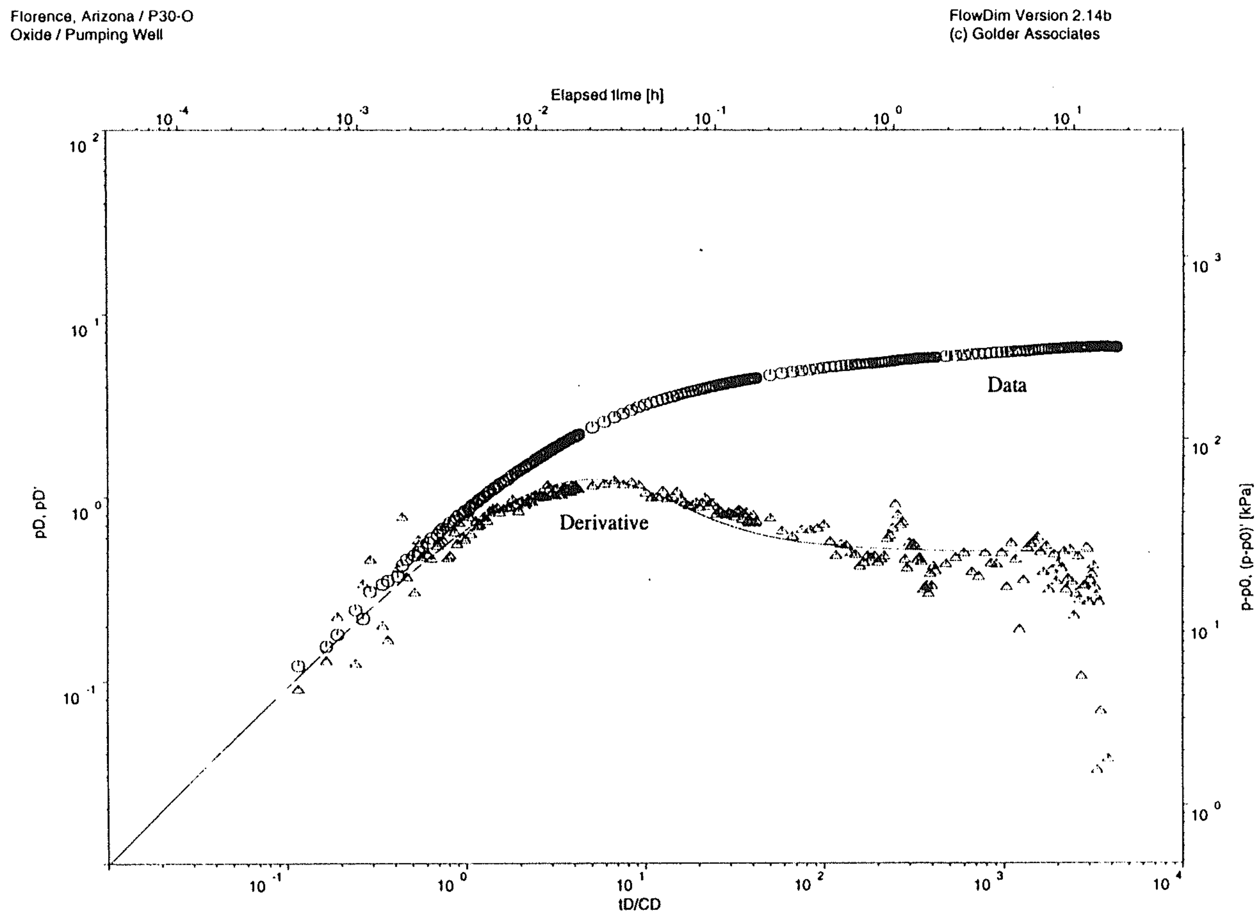
Figure 5B



FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

C=	2.25E-06	m3/Pa
T=	8.44E-04	m2/s
S=	8.70E-16	-
s=	0.00E+00	-
n=	2.00E+00	-

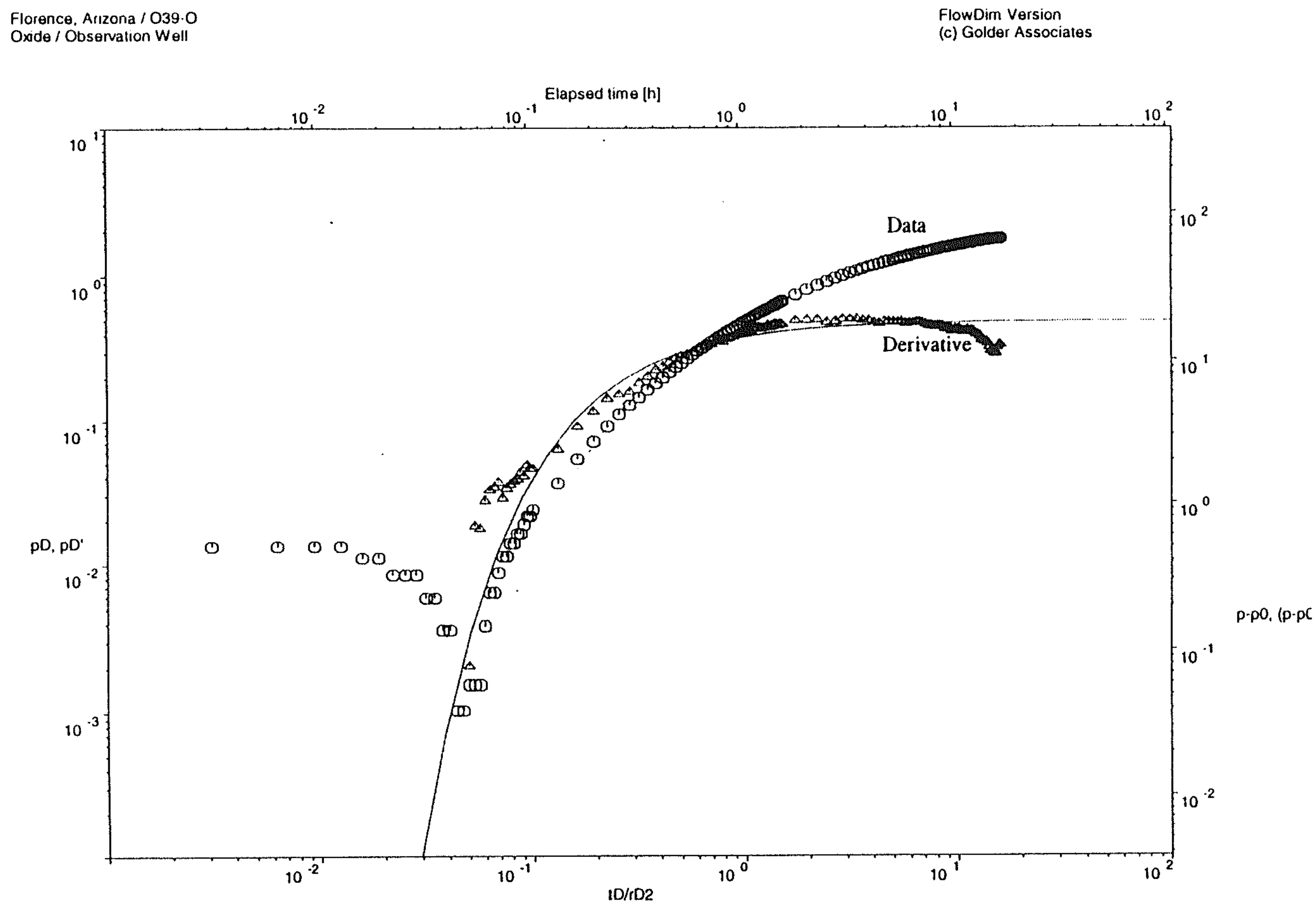
Figure 6B



FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

C=	1.04E-06	m3/Pa
T=	1.12E-04	m2/s
S=	9.60E-04	-
s=	0.00E+00	-
n=	2.00E+00	-

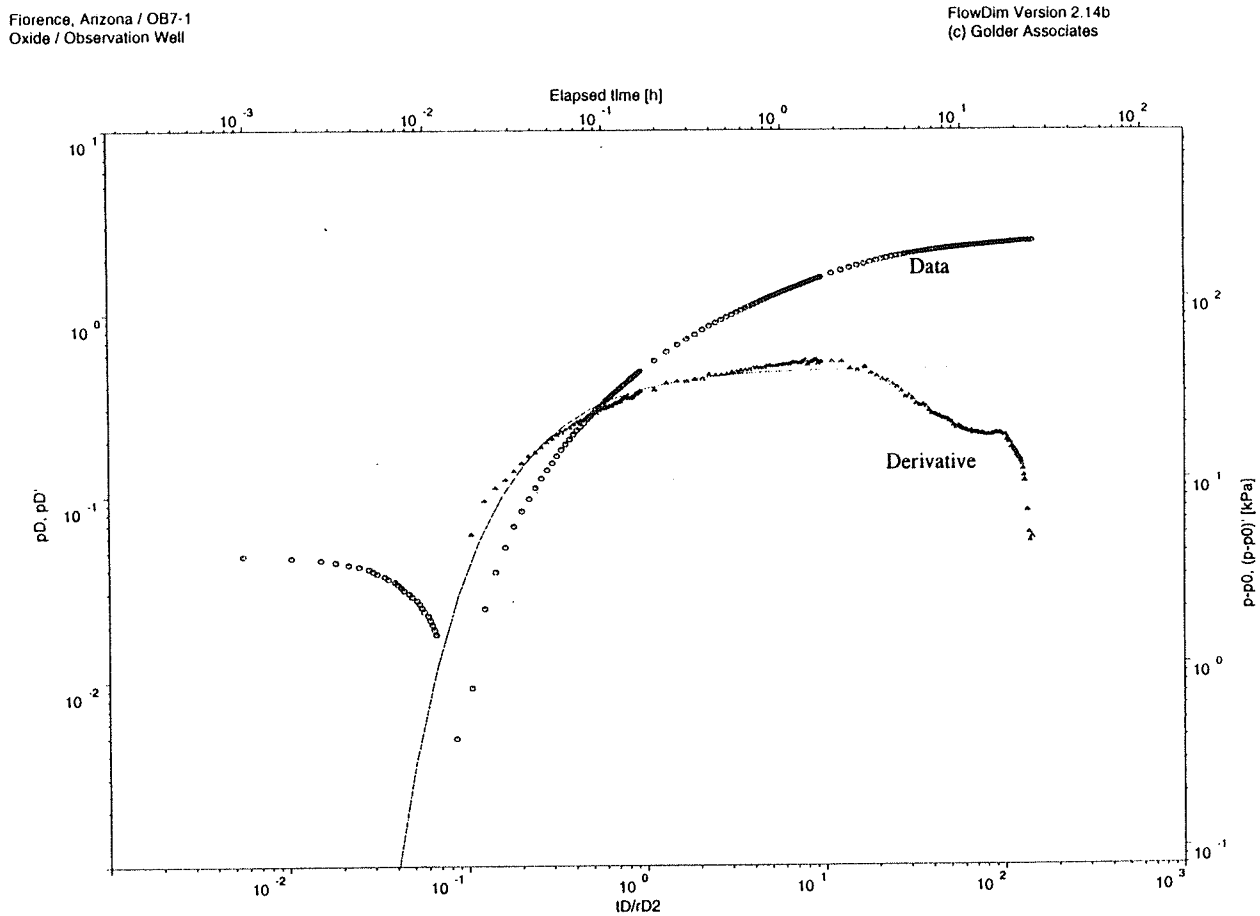
Figure 7B



FLOW MODEL :
BOUNDARY CONDITIONS: Constant rate
WELL TYPE :
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-

T=	1.45E-04	m2/s
S=	4.32E-04	-
rD=	2.83E+02	-
n=	2.00E+00	-

Figure 8B



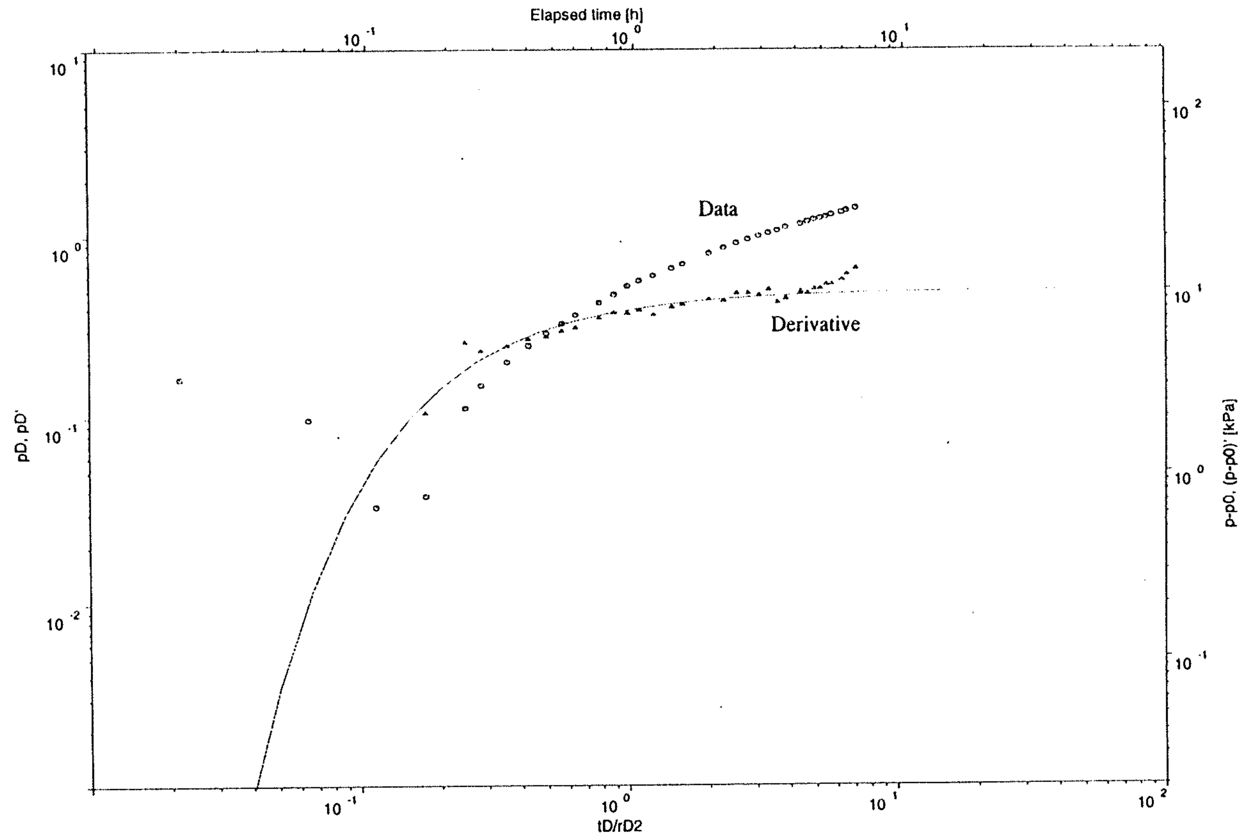
FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Observation
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

T= 4.95E-05 m2/s
S= 1.33E-04 -
rD= 2.01E+02 -
n= 2.00E+00 -

Figure 9B

Florence, Arizona / O12-O
Oxide / Observation Well

FlowDim Version 2.14b
(c) Golder Associates



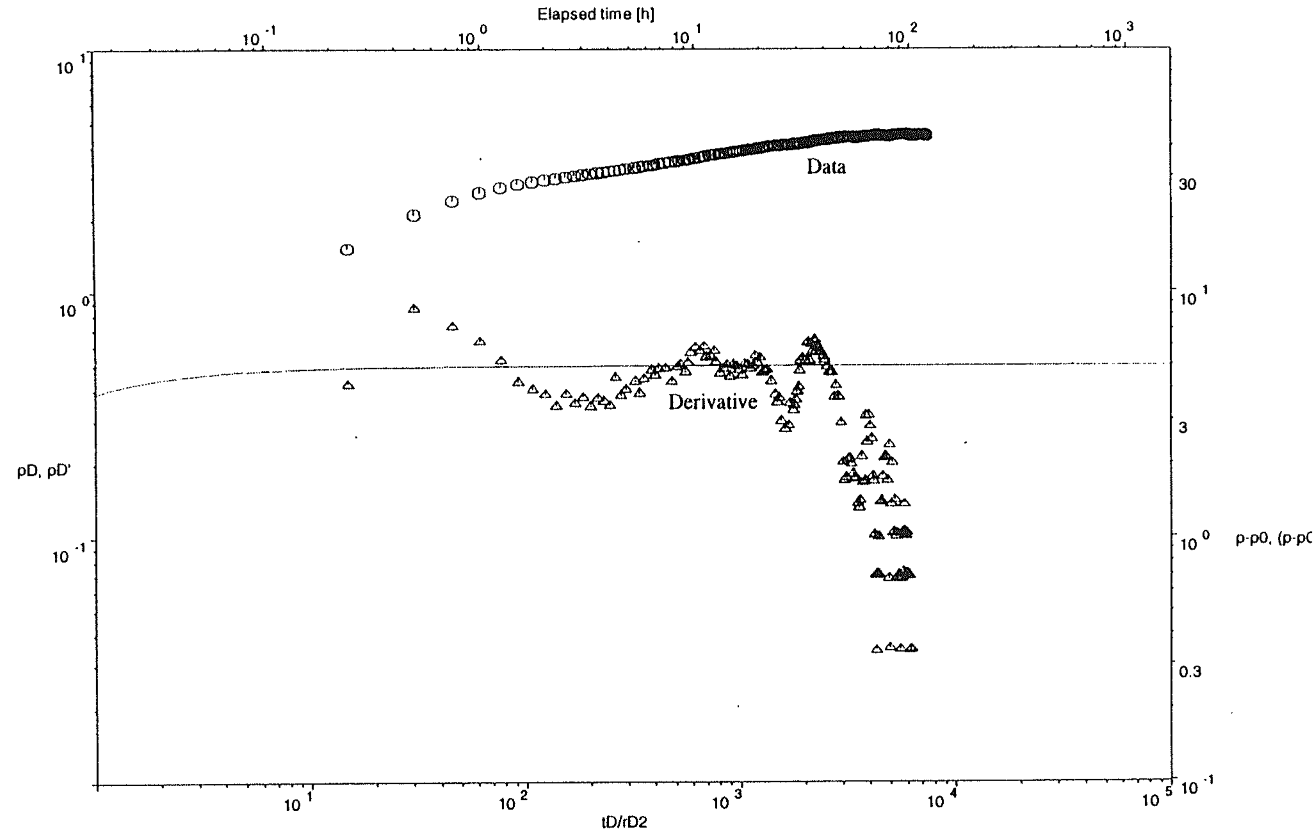
FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Observation
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

T=	3.21E-04	m2/s
S=	2.24E-03	-
rD=	2.87E+02	-
n=	2.00E+00	-

Figure 10B

Florence, Arizona / O28-G
Lower Gila / Obs. Well

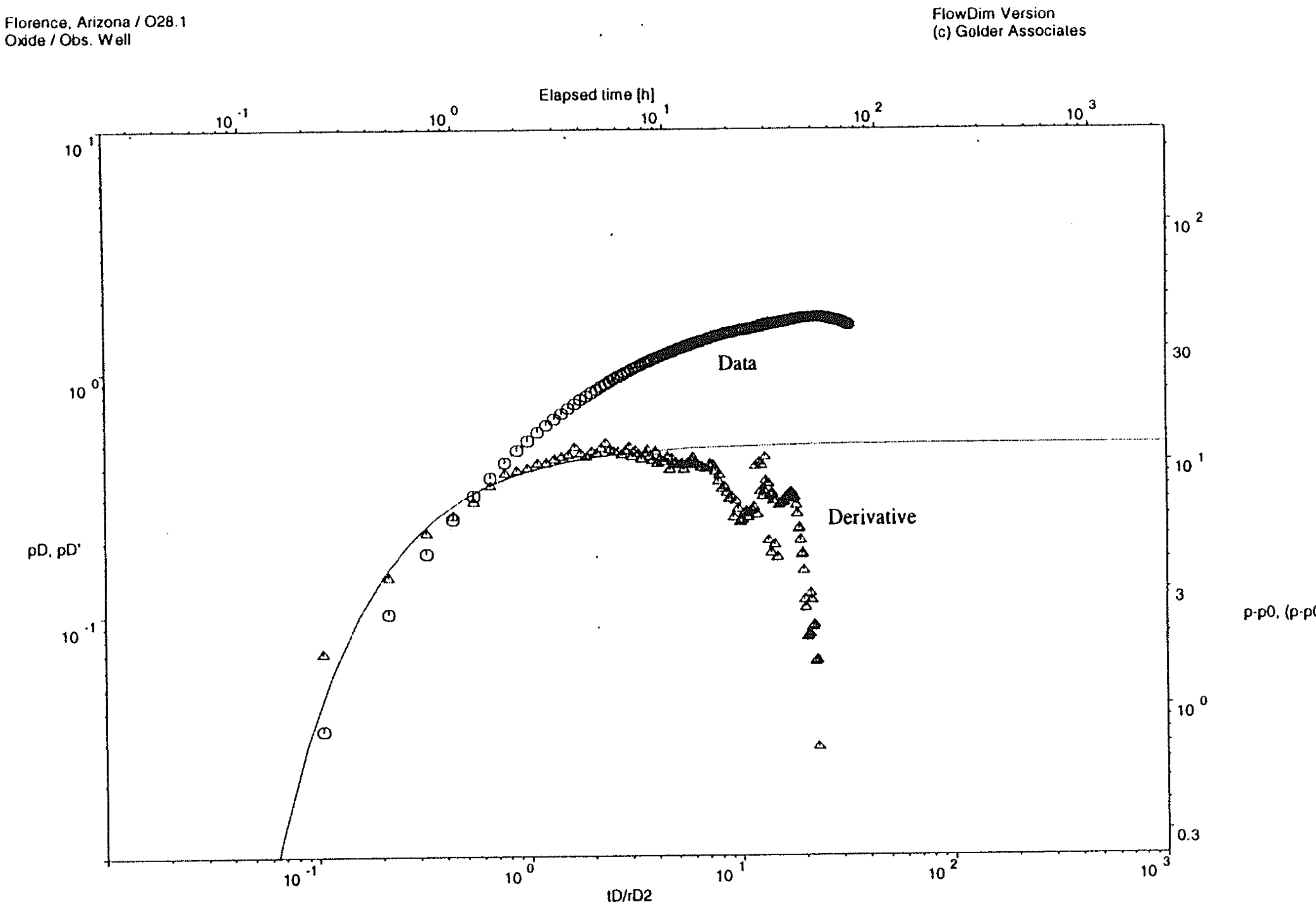
FlowDim Version
(c) Golder Associates



FLOW MODEL :
BOUNDARY CONDITIONS: Constant rate
WELL TYPE :
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-

T=	7.49E-04	m2/s
S=	2.70E-05	-
rD=	7.92E+02	-
n=	2.00E+00	-

Figure 11B



FLOW MODEL :
BOUNDARY CONDITIONS: Constant rate
WELL TYPE :
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-

T=	3.17E-04	m2/s
S=	1.06E-03	-
rD=	9.79E+02	-
n=	2.00E+00	-

Figure 12B

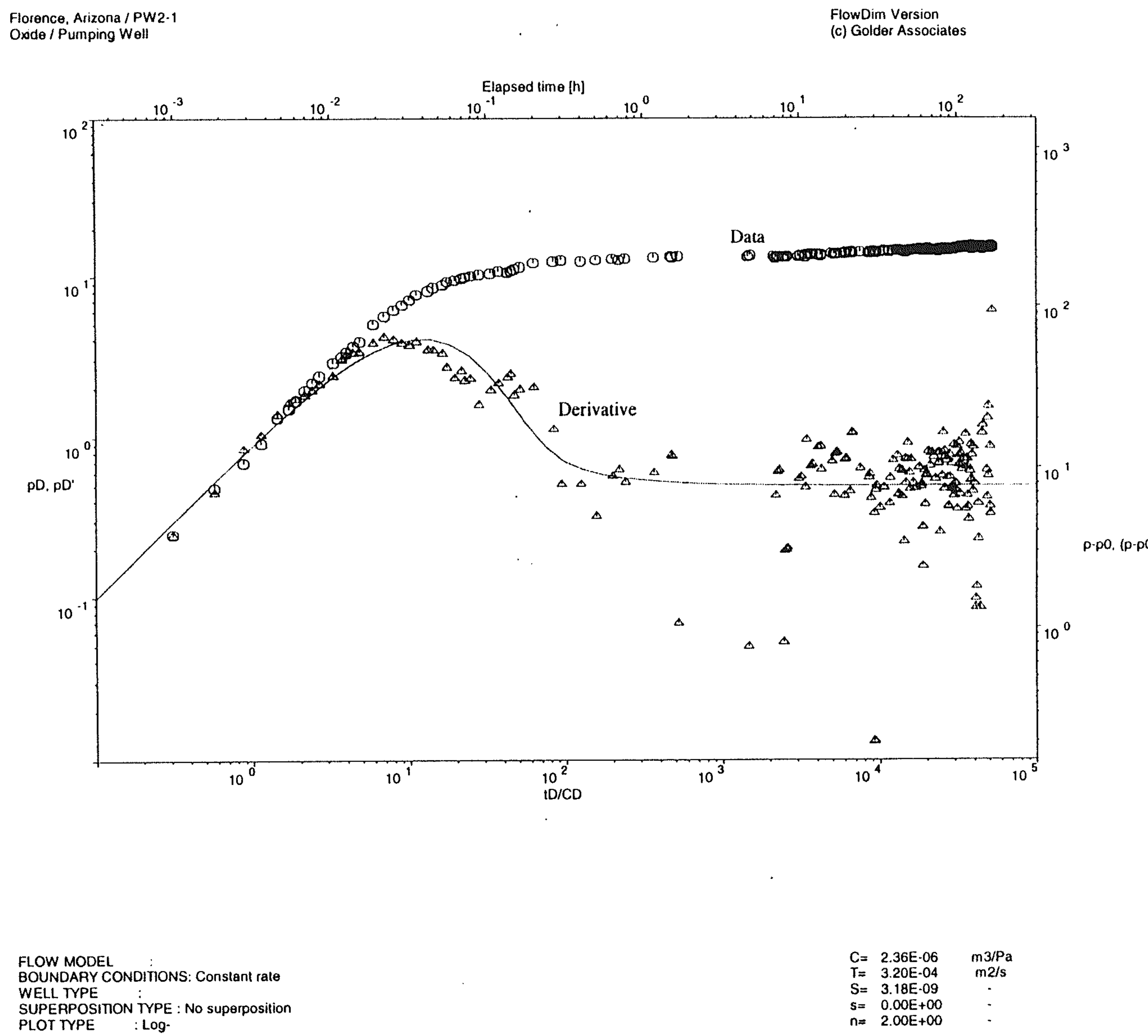
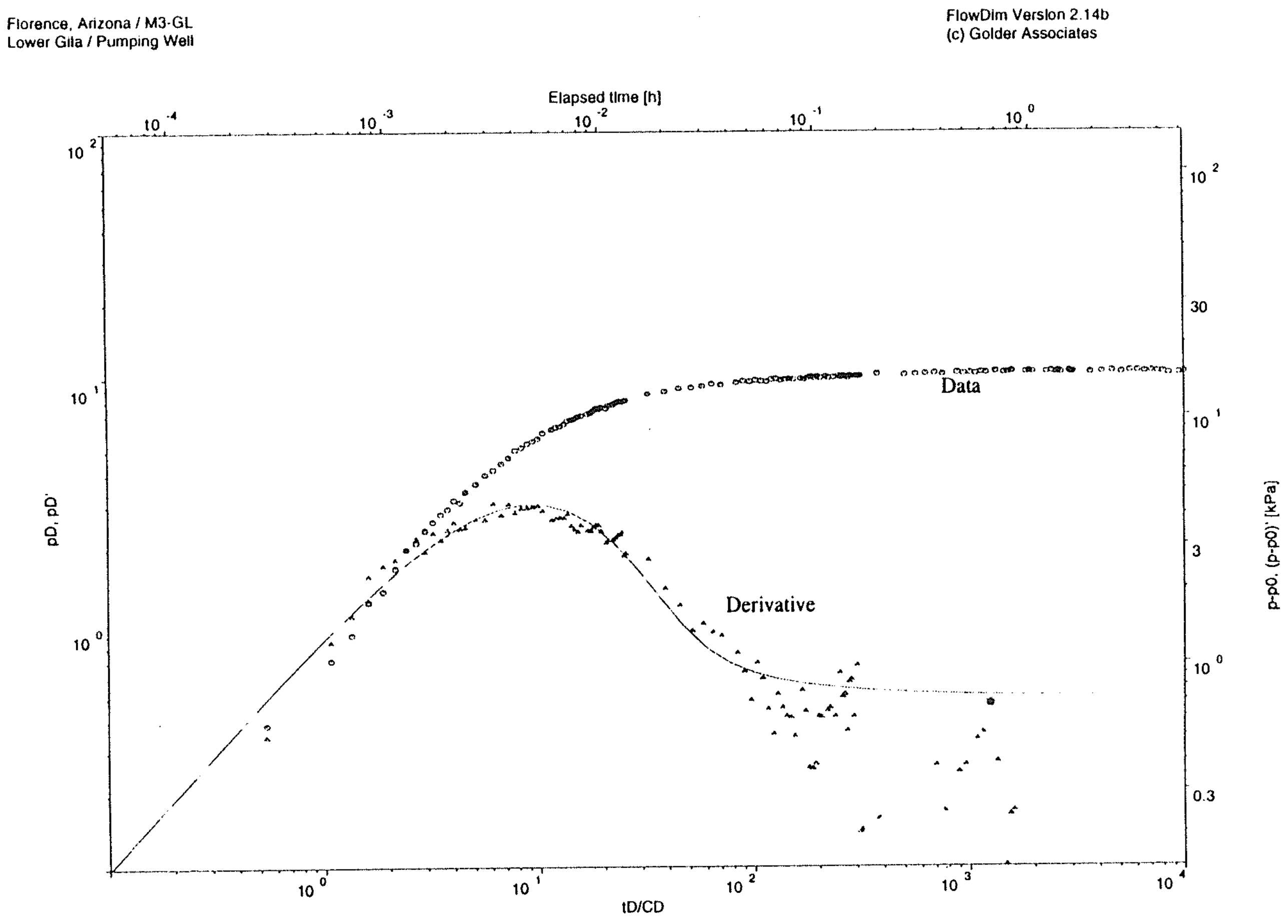

Florence, Arizona / PW2-1
Oxide / Pumping Well
FlowDim Version
(c) Golder Associates
Elapsed time [h]
Data
Derivative
pD, pD'
p-p0, (p-p0
tD/CD
FLOW MODEL :
BOUNDARY CONDITIONS: Constant rate
WELL TYPE :
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-
C= 2.36E-06 m3/Pa
T= 3.20E-04 m2/s
S= 3.18E-09 -
s= 0.00E+00 -
n= 2.00E+00 -

Figure 13B



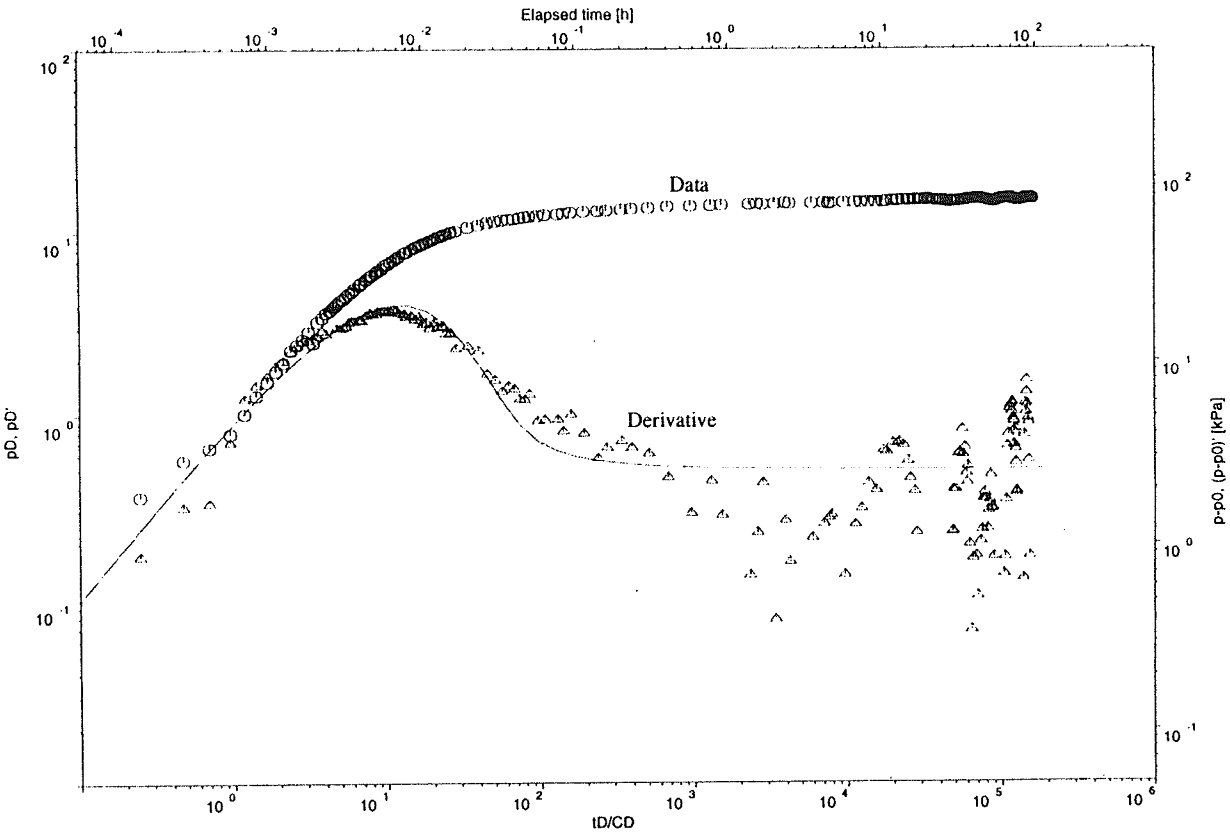
FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

C=	8.16E-07	m3/Pa
T=	6.83E-04	m2/s
S=	3.16E-07	-
s=	0.00E+00	-
n=	2.00E+00	-

Figure 14B

Florence, Arizona / PW4-1
Oxide / Pumping Well

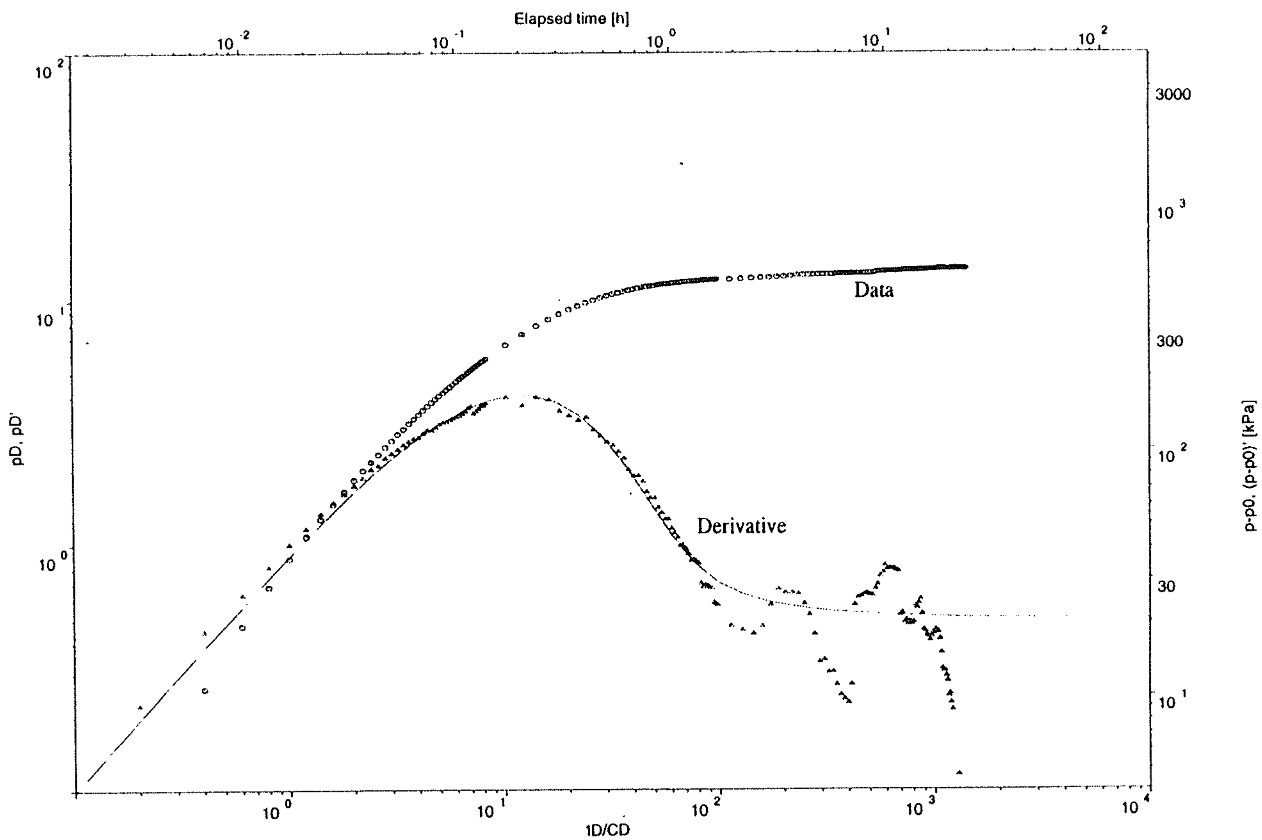
FlowDim Version 2.14b
(c) Golder Associates



FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

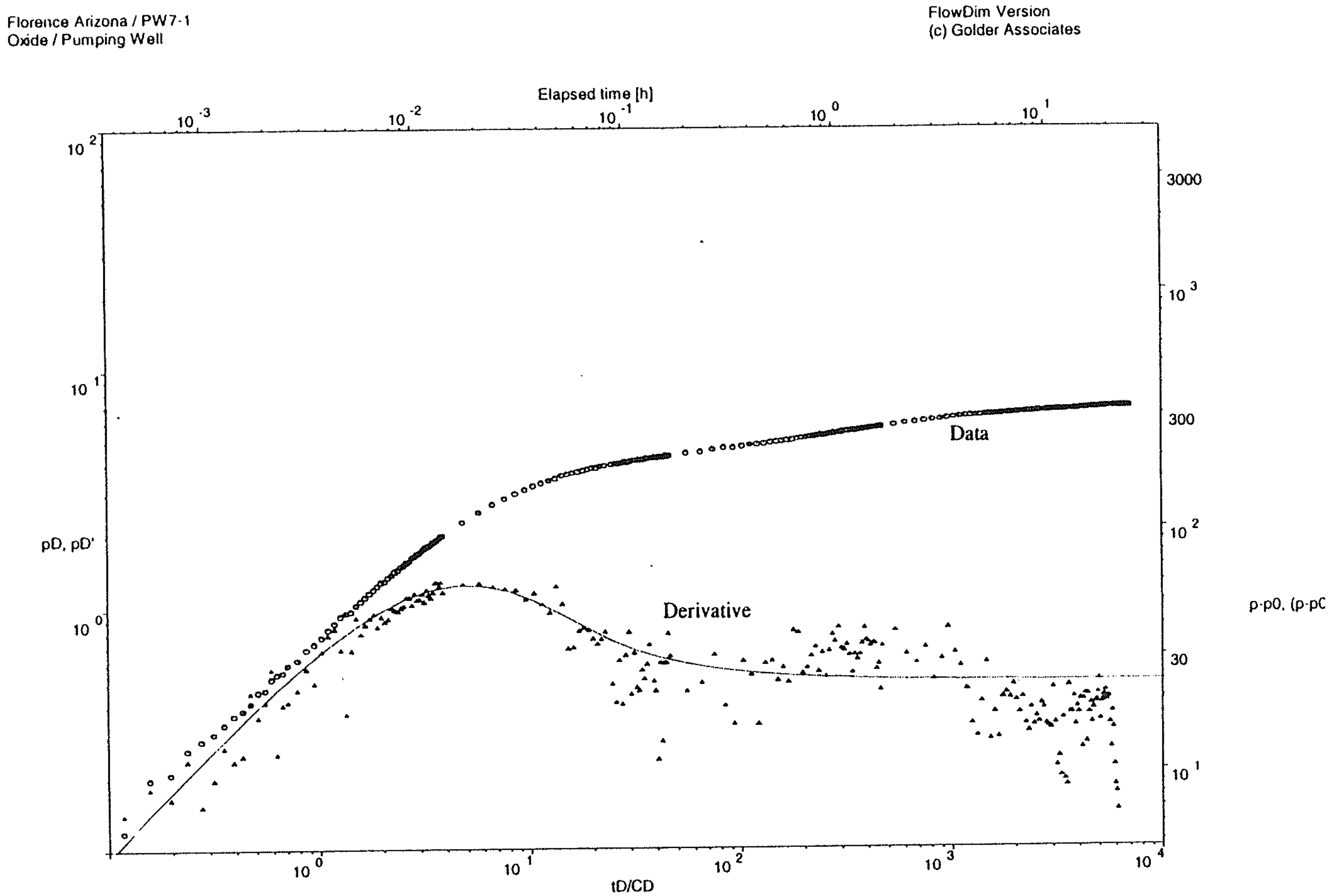
C=	1.87E-06	m3/Pa
T=	1.37E-03	m2/s
S=	2.52E-09	-
s=	0.00E+00	-
n=	2.00E+00	-

Figure 15B



FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

C=	1.38E-06	m3/Pa
T=	3.59E-05	m2/s
S=	2.68E-09	-
s=	0.00E+00	-
n=	2.00E+00	-



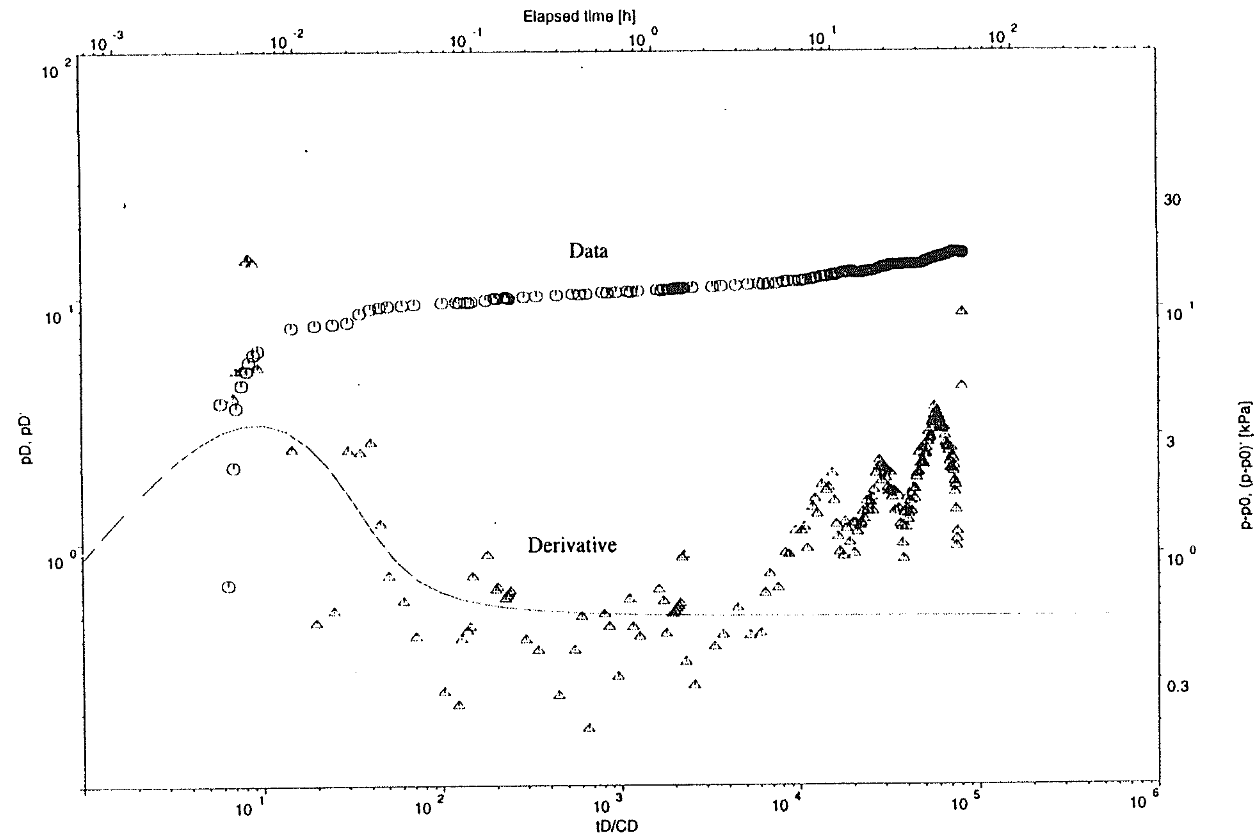
FLOW MODEL :
BOUNDARY CONDITIONS: Constant rate
WELL TYPE :
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-

C=	6.87E-07	m3/Pa
T=	8.40E-05	m2/s
S=	1.85E-03	-
s=	0.00E+00	-
n=	2.00E+00	-

Figure 17B

Florence, Arizona / P8-GU
Upper Gila / Pumping Well

FlowDim Version 2.14b
(c) Golder Associates



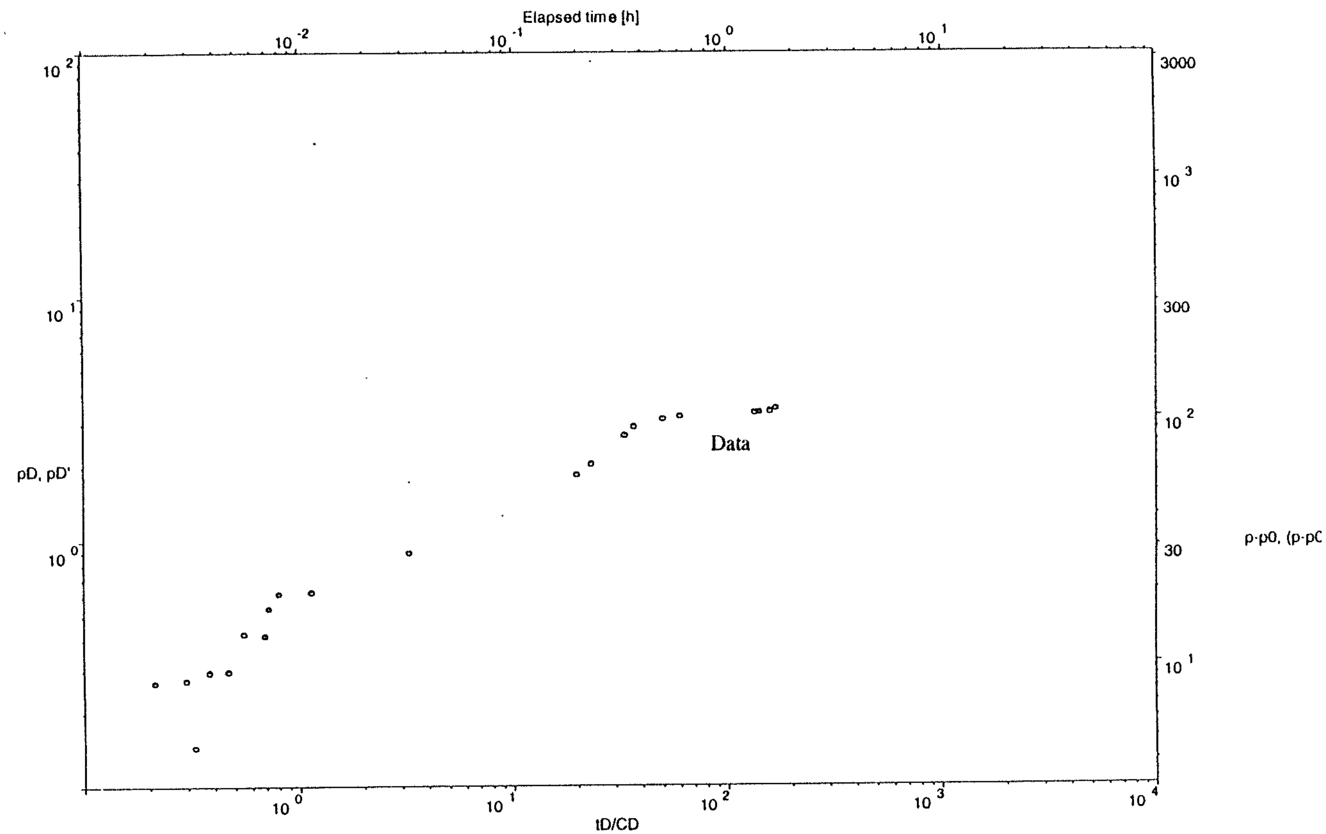
FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

C=	1.19E-05	m3/Pa
T=	7.91E-03	m2/s
S=	3.19E-06	-
s=	0.00E+00	-
n=	2.00E+00	-

Figure 18B

Florence Arizona / P12-O
Oxide / Pumping Well

FlowDim Version
(c) Golder Associates



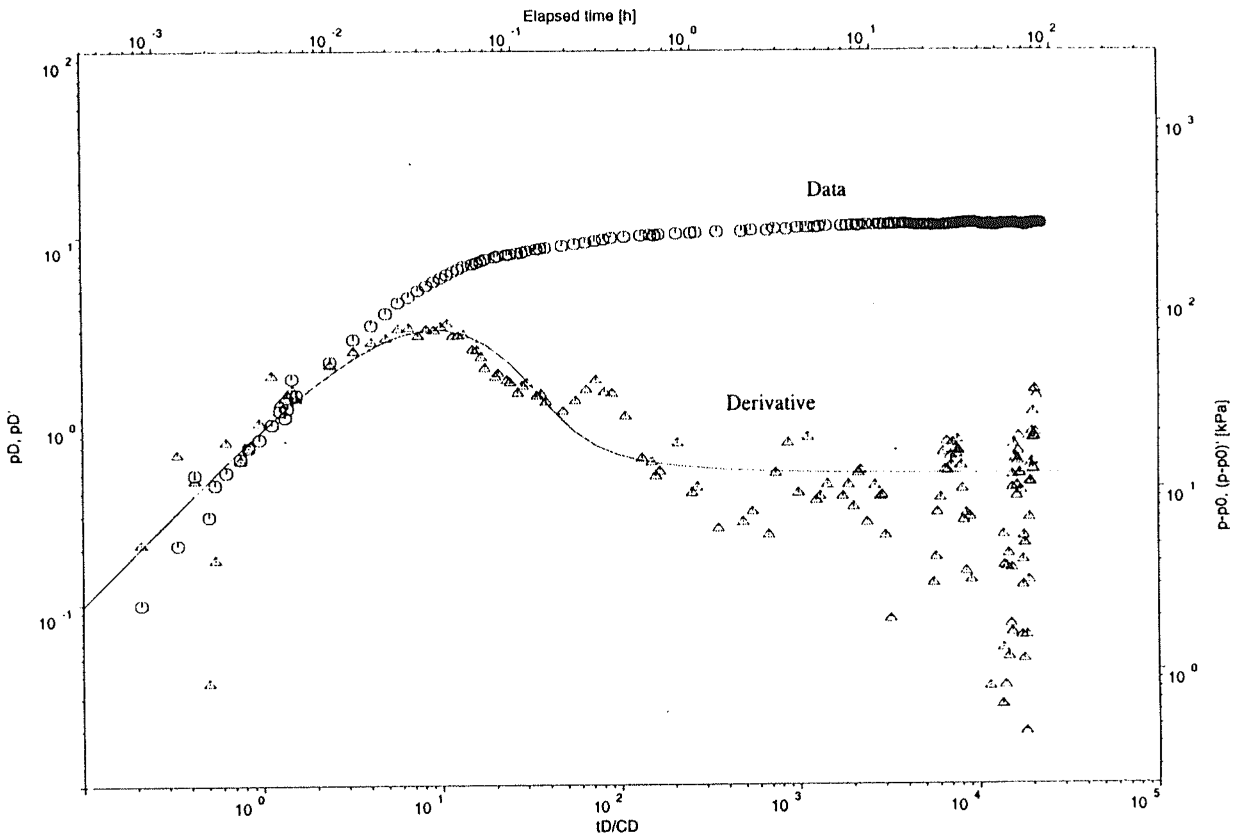
FLOW MODEL :
BOUNDARY CONDITIONS: Constant rate
WELL TYPE :
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-

C=	4.64E-06	m3/Pa
T=	2.04E-04	m2/s
S=	4.16E-01	-
s=	0.00E+00	-
n=	2.00E+00	-

Figure 19B

Florence, Arizona / P13.1
Oxide / Pumping Well

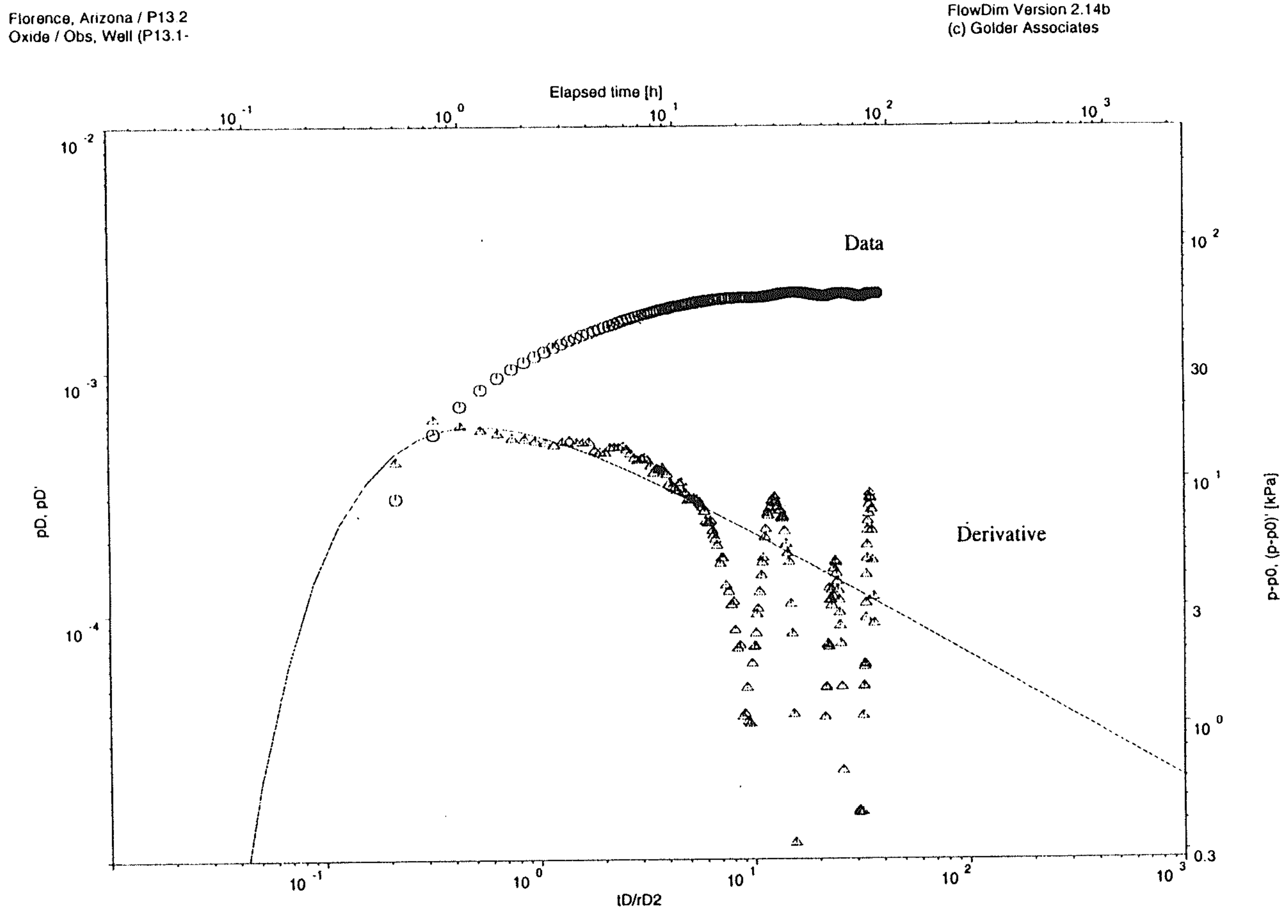
FlowDim Version 2.14b
(c) Golder Associates



FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

C=	1.75E-06	m3/Pa
T=	1.91E-04	m2/s
S=	4.72E-07	-
s=	0.00E+00	-
n=	2.00E+00	-

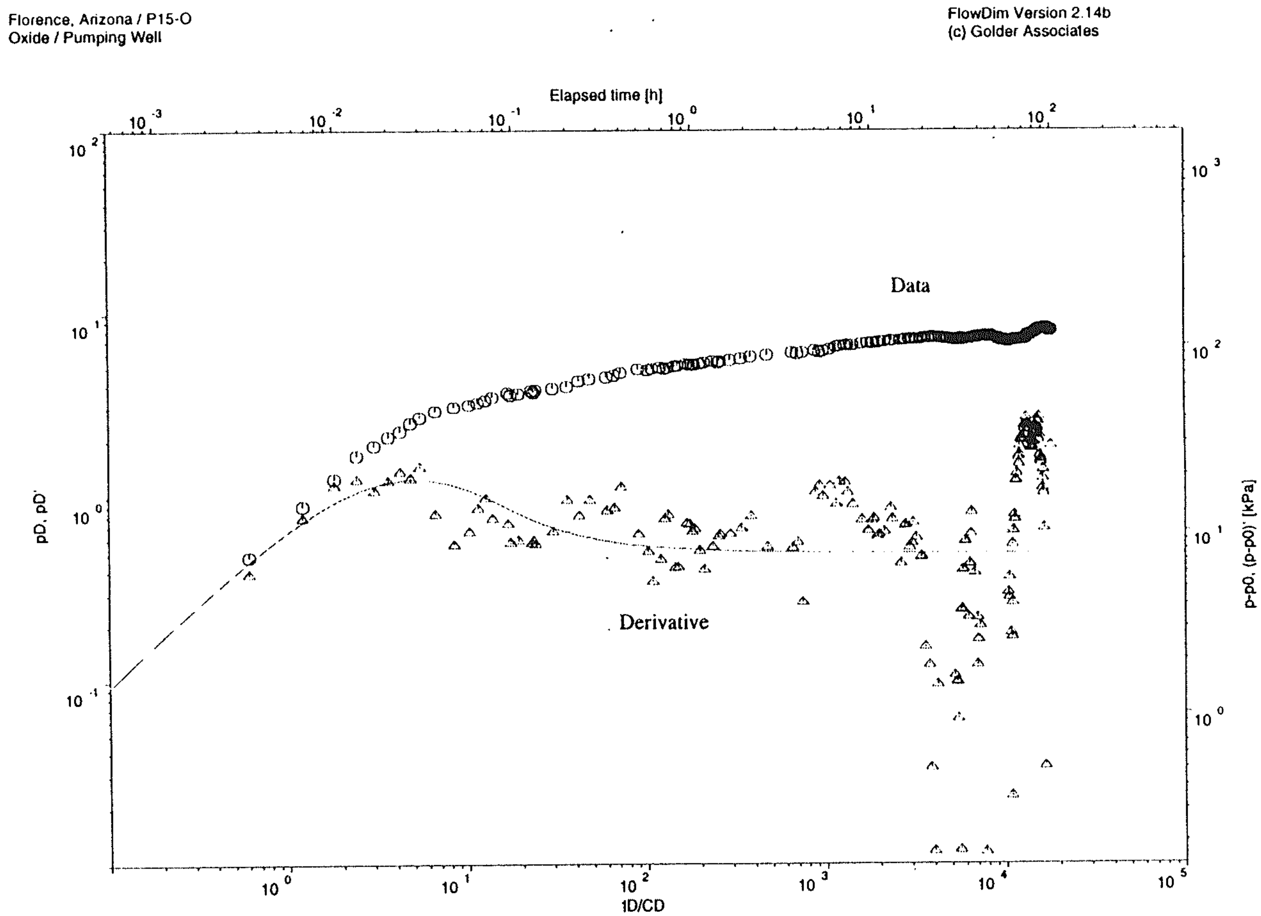
Figure 20B



FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Observation
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

T=	8.18E-08	m2/s
S=	7.04E-07	-
rD=	4.12E+02	-
n=	3.00E+00	-

Figure 21B



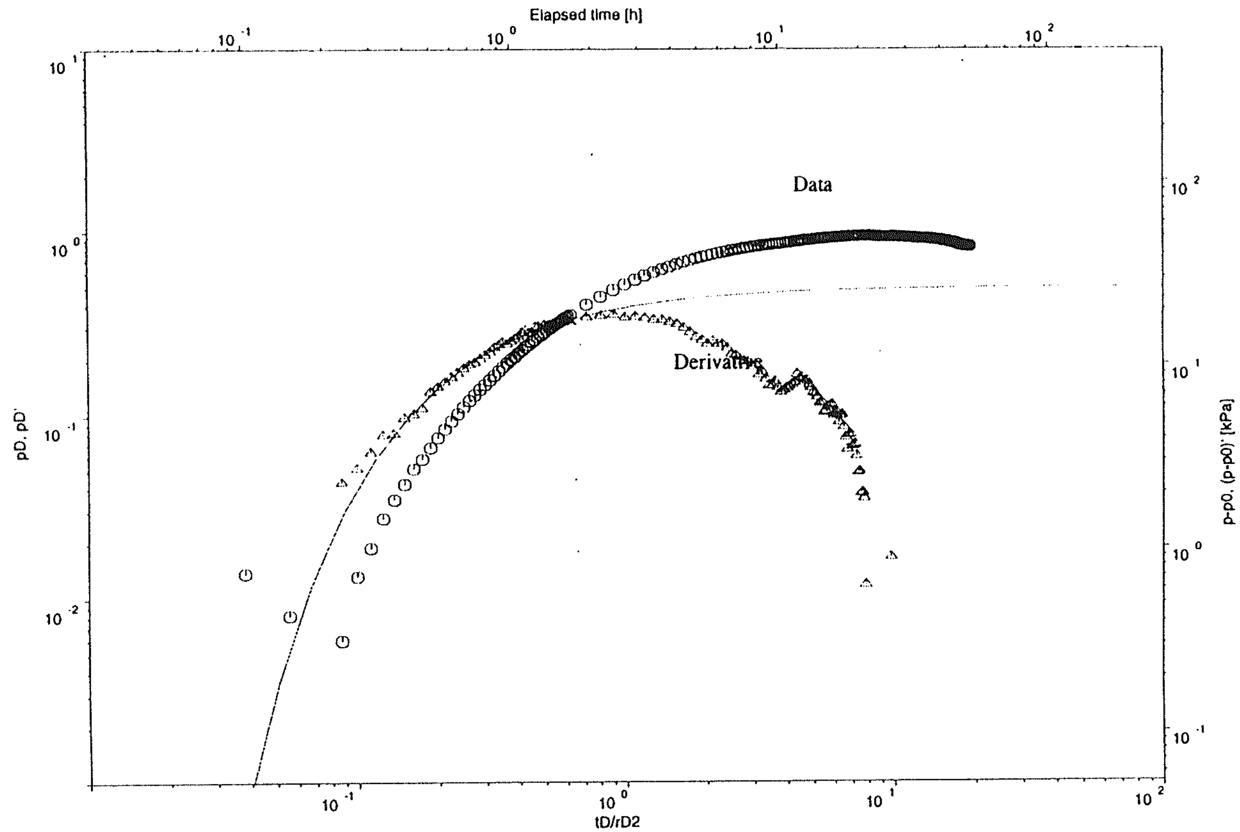
FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

C=	4.94E-06	m3/Pa
T=	3.84E-04	m2/s
S=	1.33E-02	-
s=	0.00E+00	-
n=	2.00E+00	-

Figure 22B

Florence, Arizona / P19-O
Oxide / Observ. Well

FlowDim Version 2.14b
(c) Golder Associates



FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Observation
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

T=	4.10E-05	m2/s
S=	7.66E-04	-
rD=	2.98E+02	-
n=	2.00E+00	-

Figure 23B

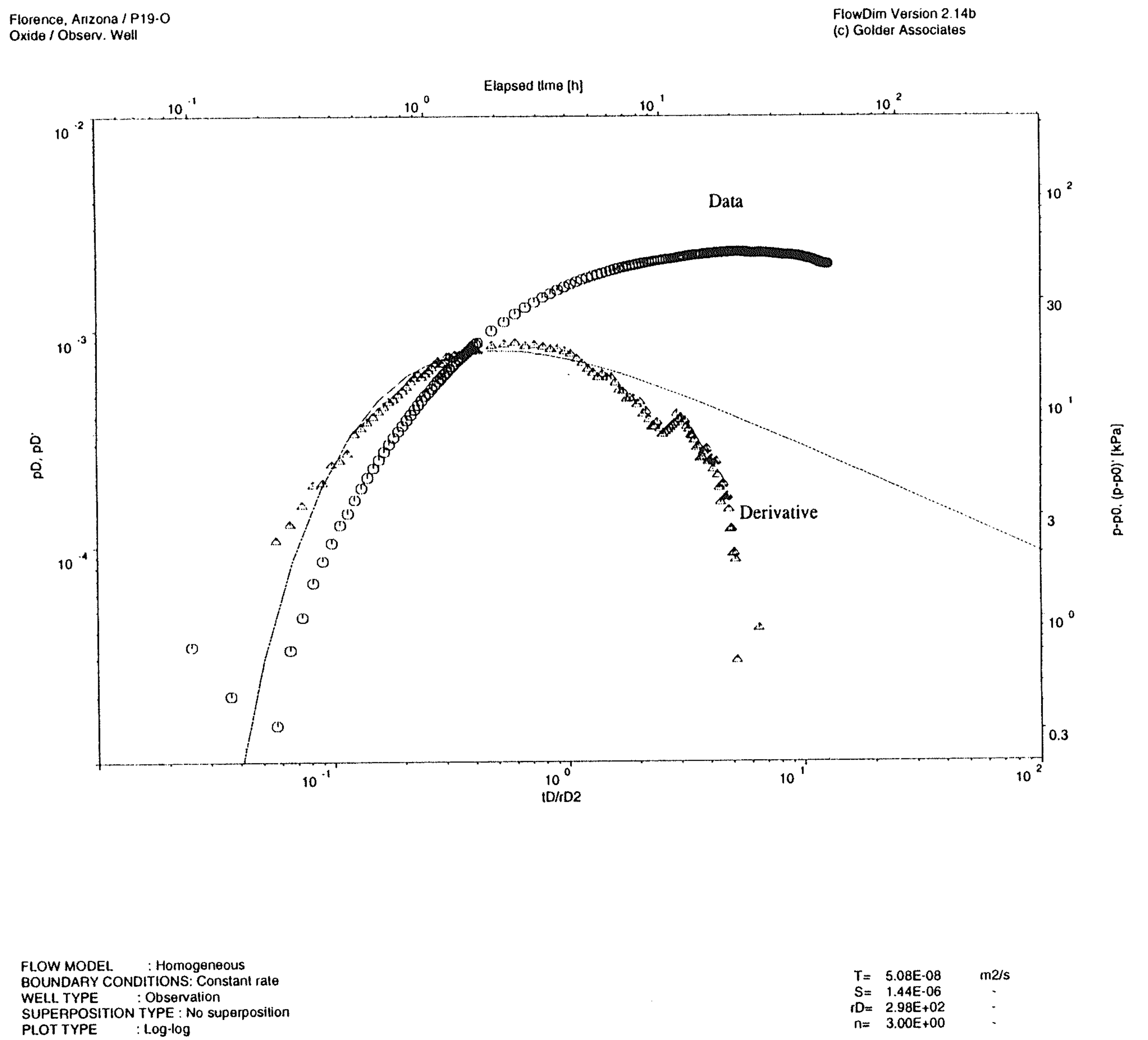
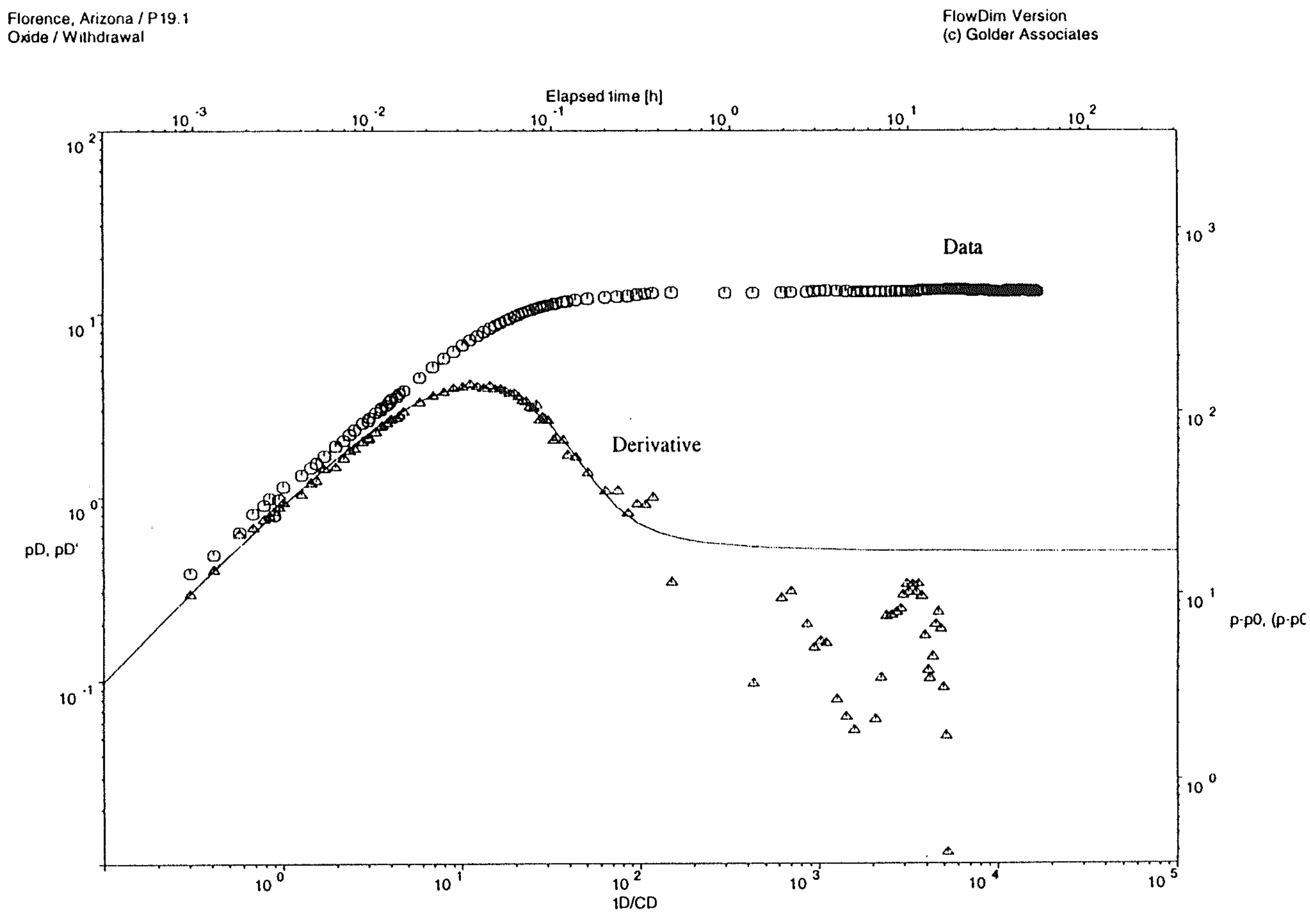

Florence, Arizona / P19-O
Oxide / Observ. Well
FlowDim Version 2.14b
(c) Golder Associates
Elapsed time [h]
Data
Derivative
pD, pD'
p-p0, (p-p0)' [kPa]
tD/rD2
FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Observation
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log
T= 5.08E-08 m2/s
S= 1.44E-06 -
rD= 2.98E+02 -
n= 3.00E+00 -

Figure 24B



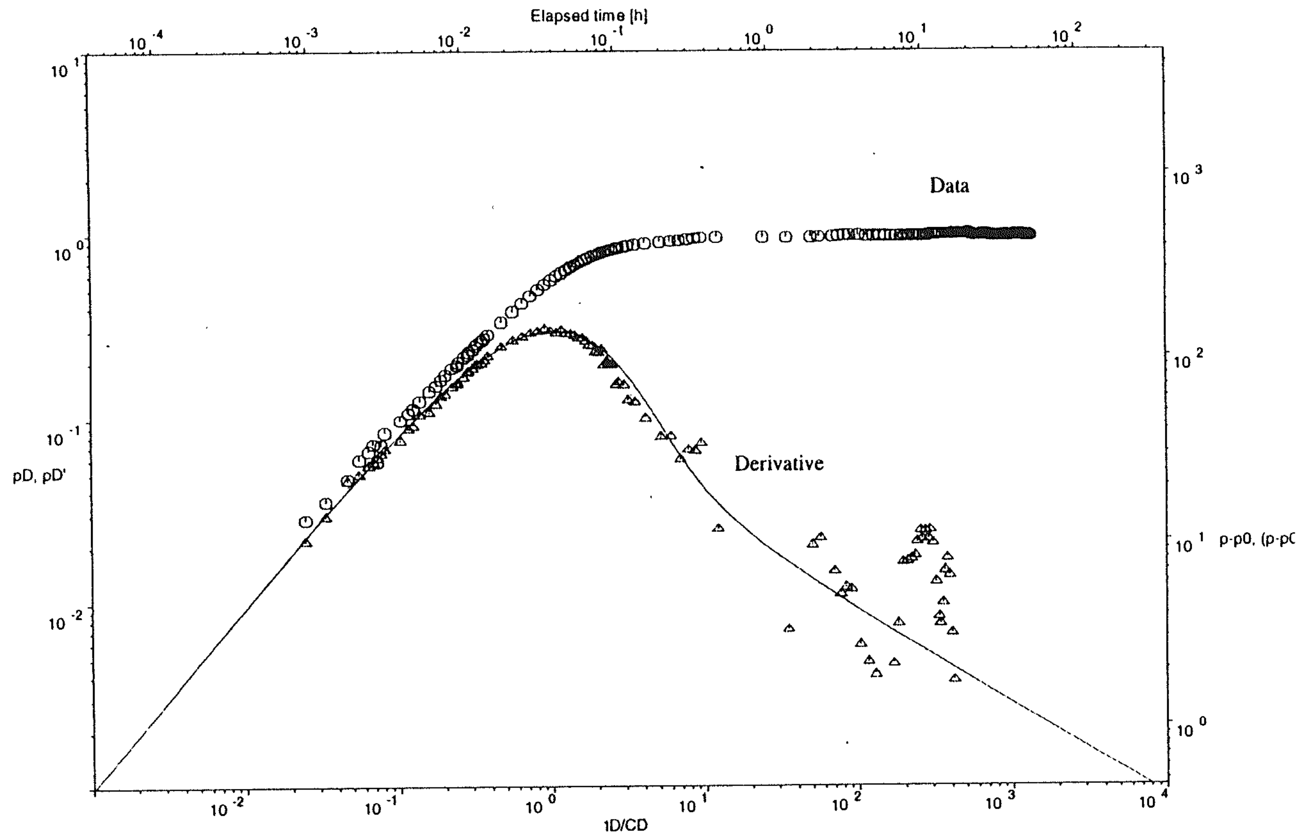
FLOW MODEL :
BOUNDARY CONDITIONS: Constant rate
WELL TYPE :
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-

C=	4.58E-07	m3/Pa
T=	6.39E-05	m2/s
S=	6.16E-10	-
s=	0.00E+00	-
n=	2.00E+00	-

Figure 25B **Golder Associates**

Florence, Arizona / P19.1
Oxide / Withdrawal

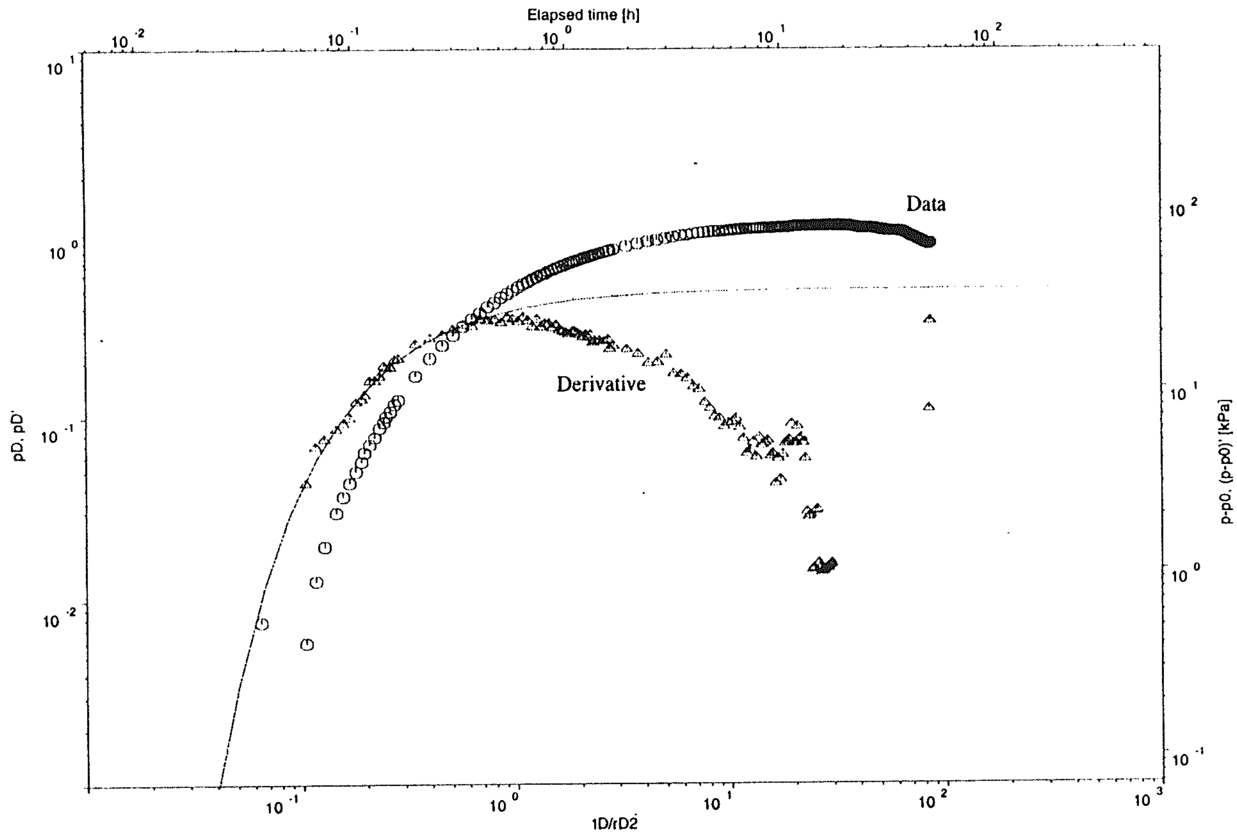
FlowDim Version
(c) Golder Associates



FLOW MODEL :
BOUNDARY CONDITIONS: Constant rate
WELL TYPE :
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-

C=	4.19E-07	m3/Pa
T=	2.36E-06	m2/s
S=	5.64E-03	-
s=	0.00E+00	-
n=	3.00E+00	-

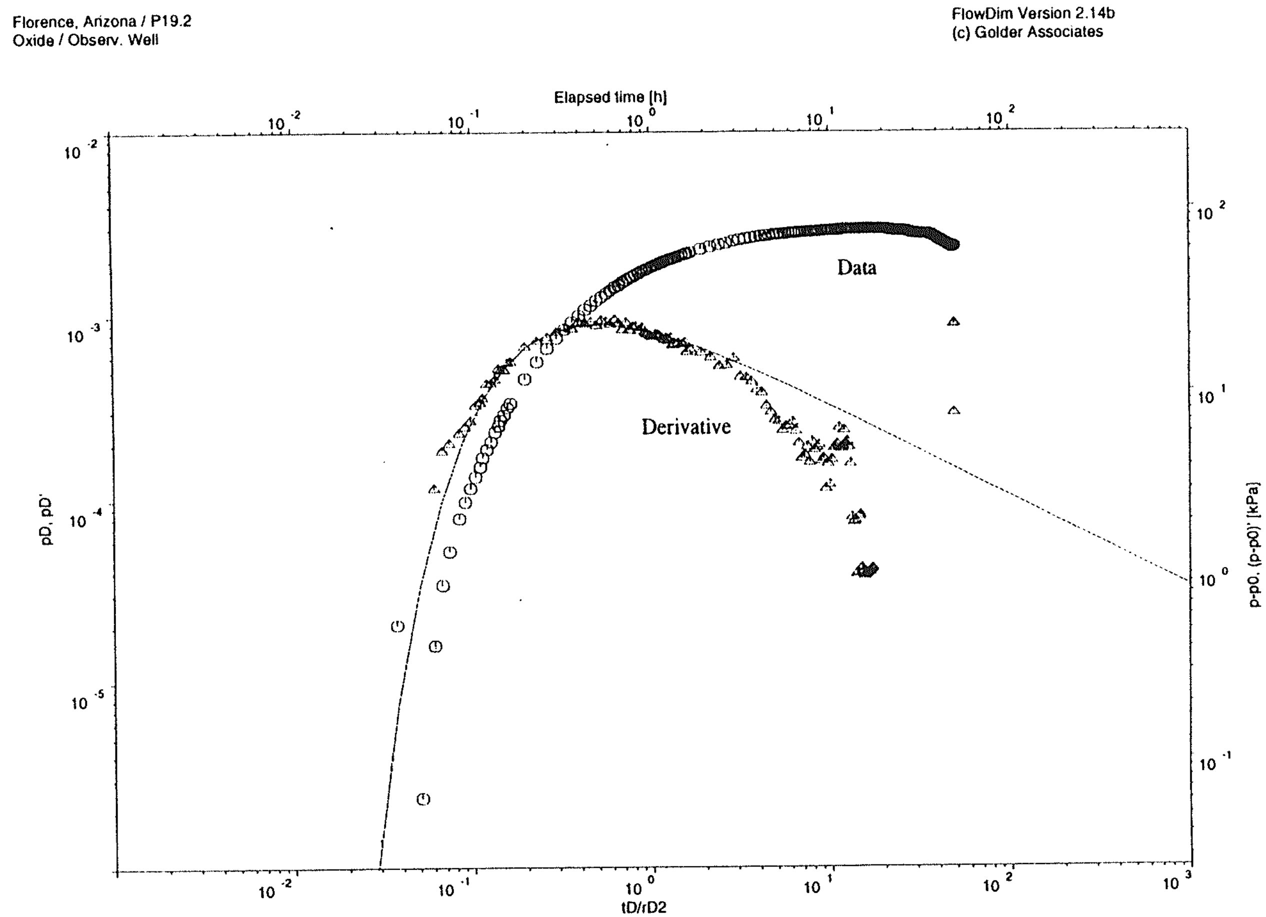
Figure 26B



FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Observation
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

T=	3.14E-05	m2/s
S=	1.47E-04	-
rD=	2.68E+02	-
n=	2.00E+00	-

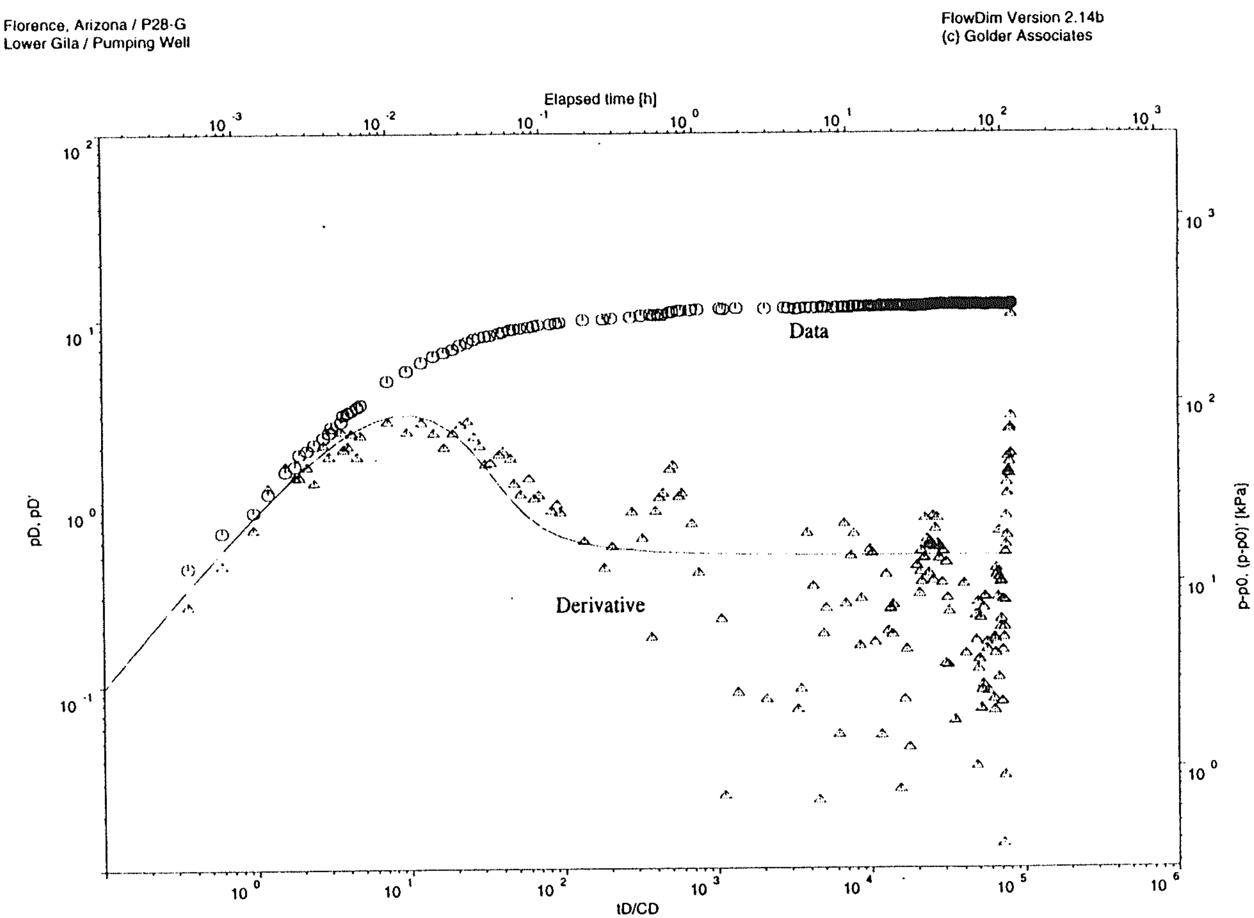
Figure 27B



FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Observation
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

T=	4.22E-08	m2/s
S=	3.38E-07	-
rD=	2.68E+02	-
n=	3.00E+00	-

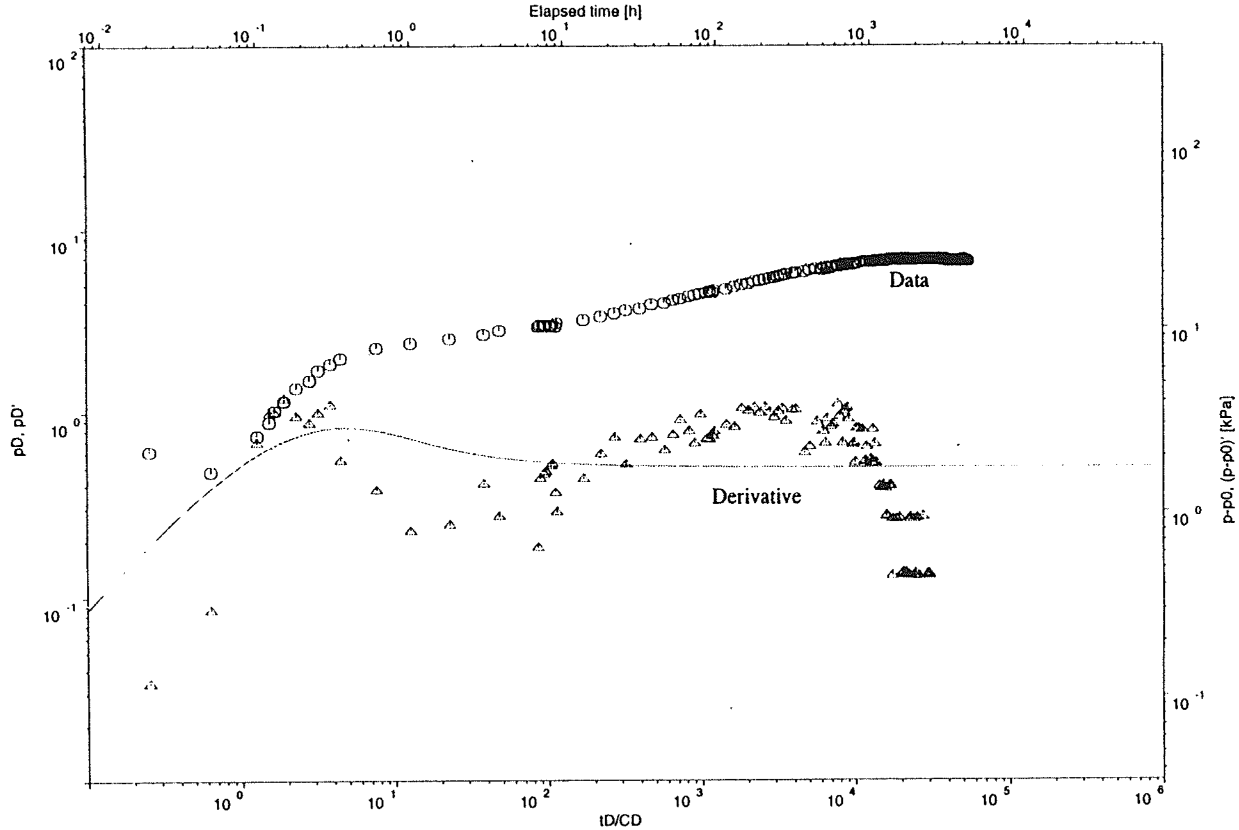
Figure 28B



FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

C=	8.71E-07	m3/Pa
T=	2.66E-04	m2/s
S=	3.37E-07	-
s=	0.00E+00	-
n=	2.00E+00	-

Figure 29B



FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

C=	1.50E-04	m3/Pa
T=	8.25E-04	m2/s
S=	5.20E+00	-
s=	0.00E+00	-
n=	2.00E+00	-

Figure 30B **Golder Associates**

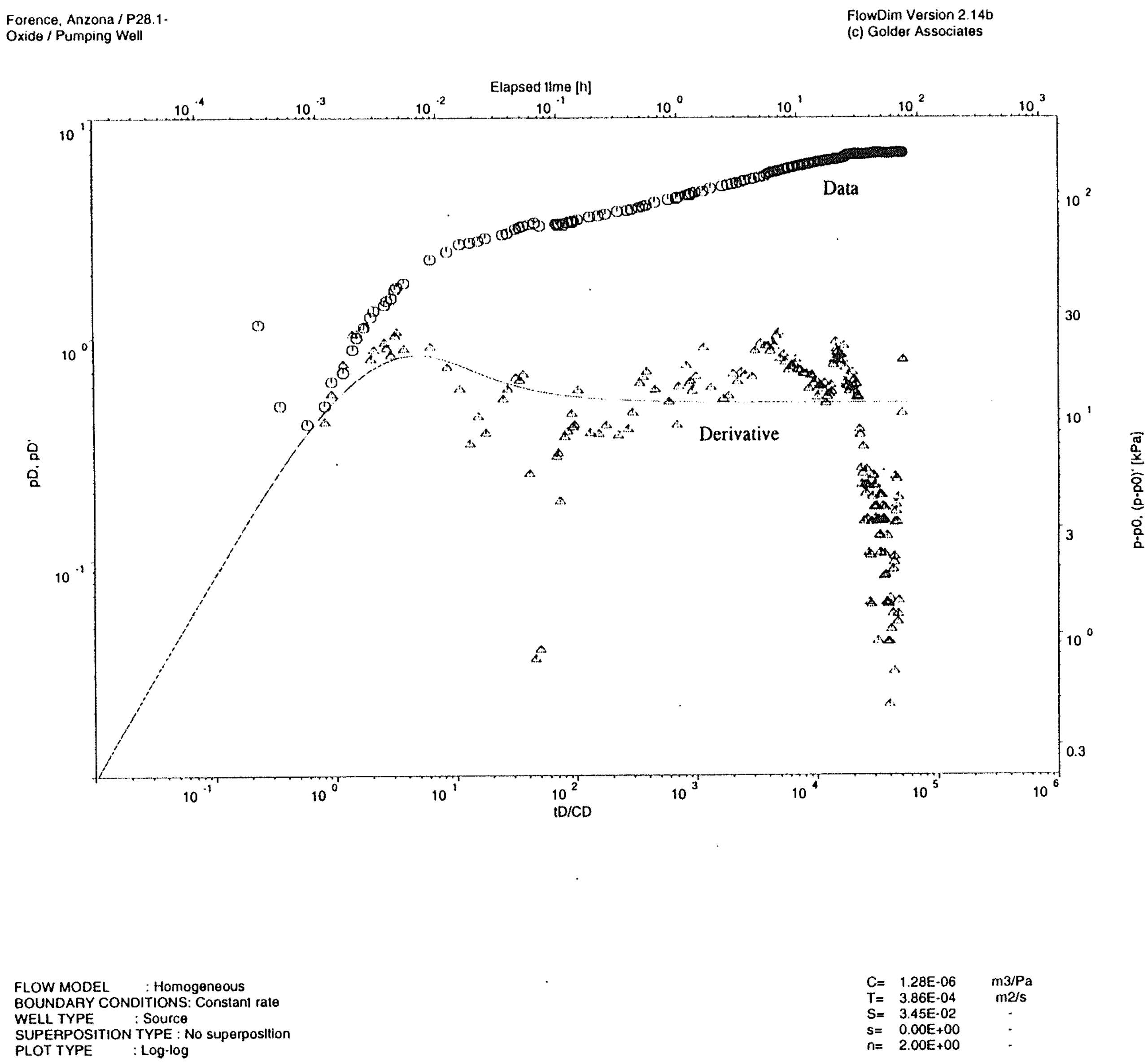
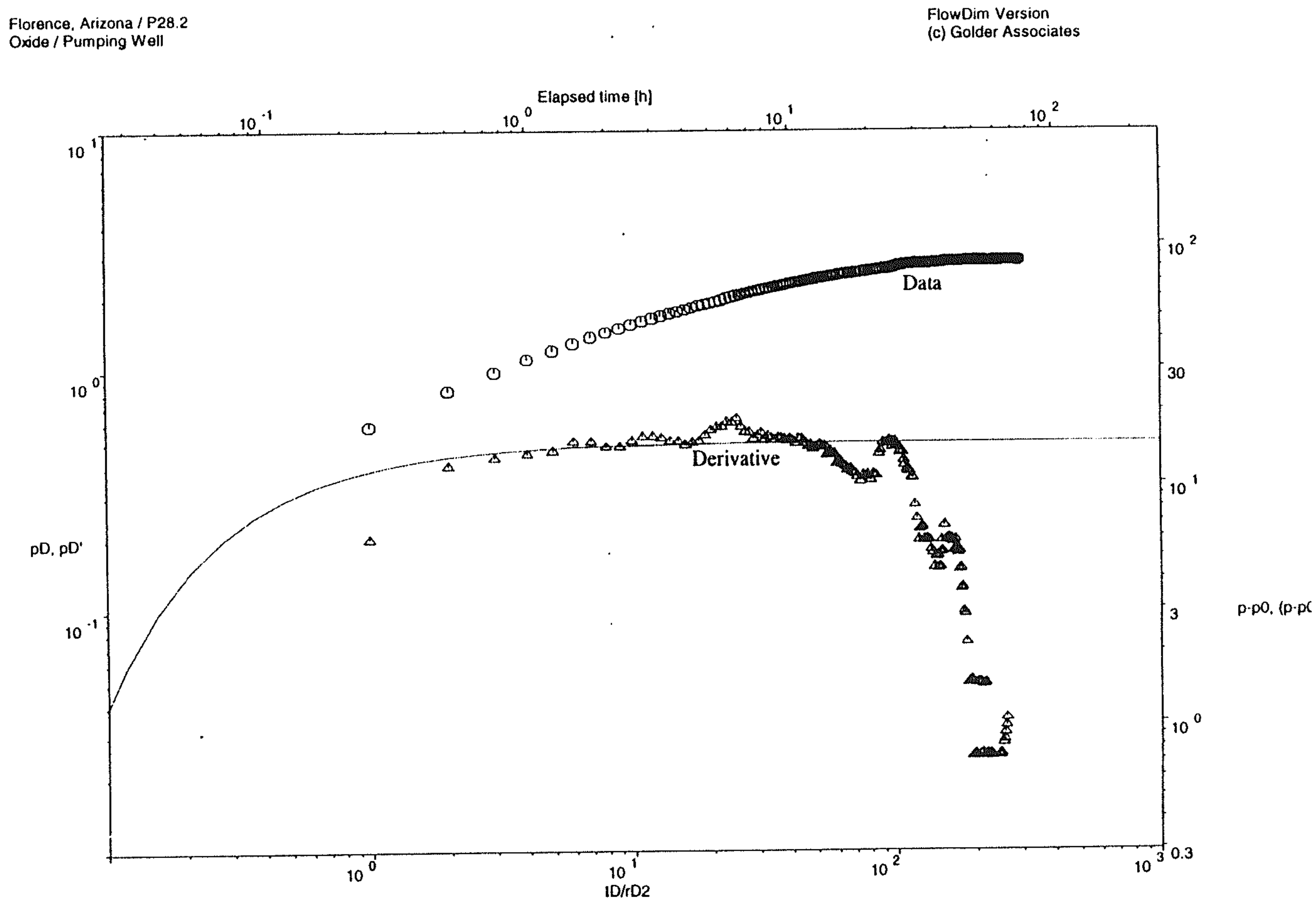


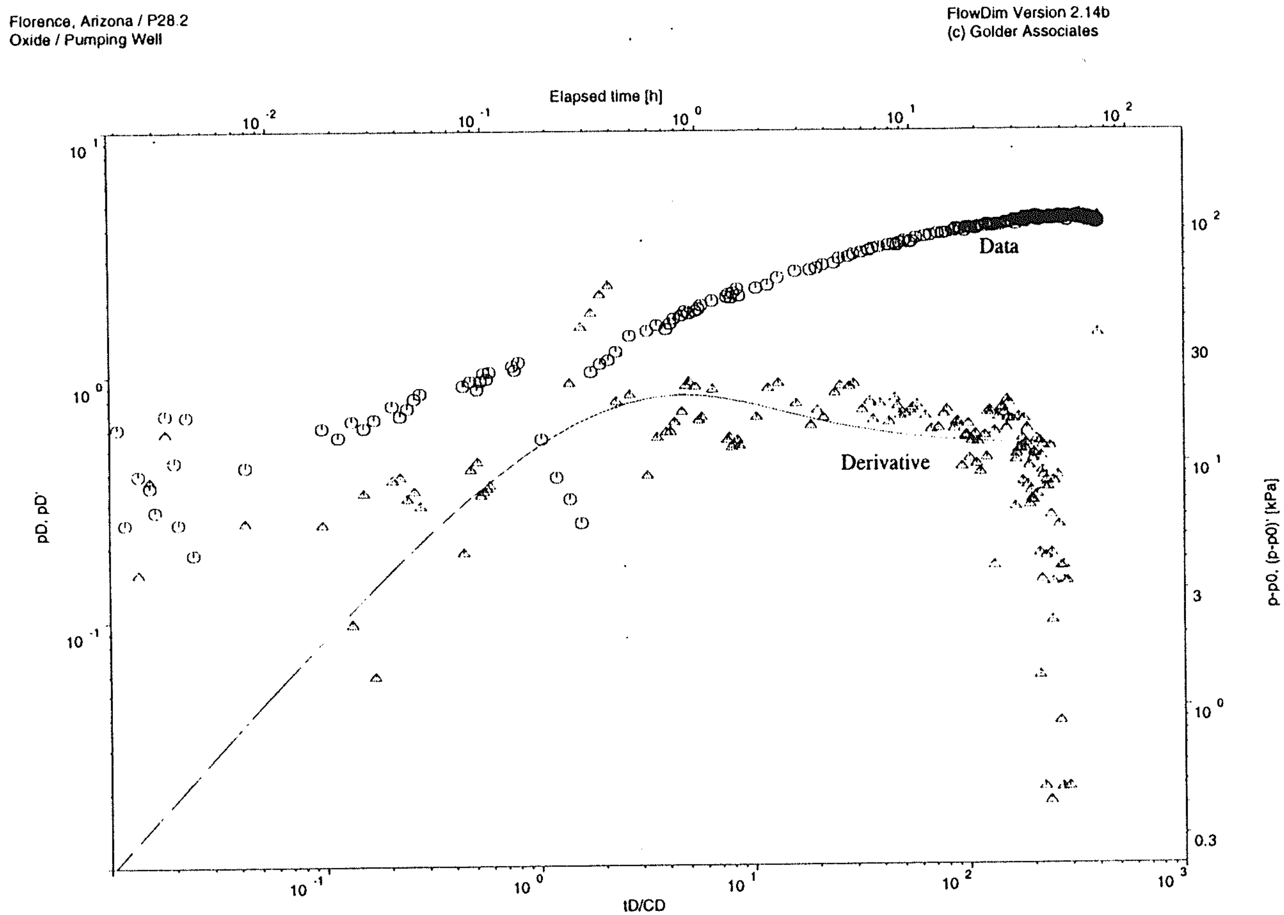
Figure 31B **Golder Associates**



FLOW MODEL :
BOUNDARY CONDITIONS: Constant rate
WELL TYPE :
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-

T=	2.84E-04	m2/s
S=	2.91E-04	-
rD=	5.89E+02	-
n=	2.00E+00	-

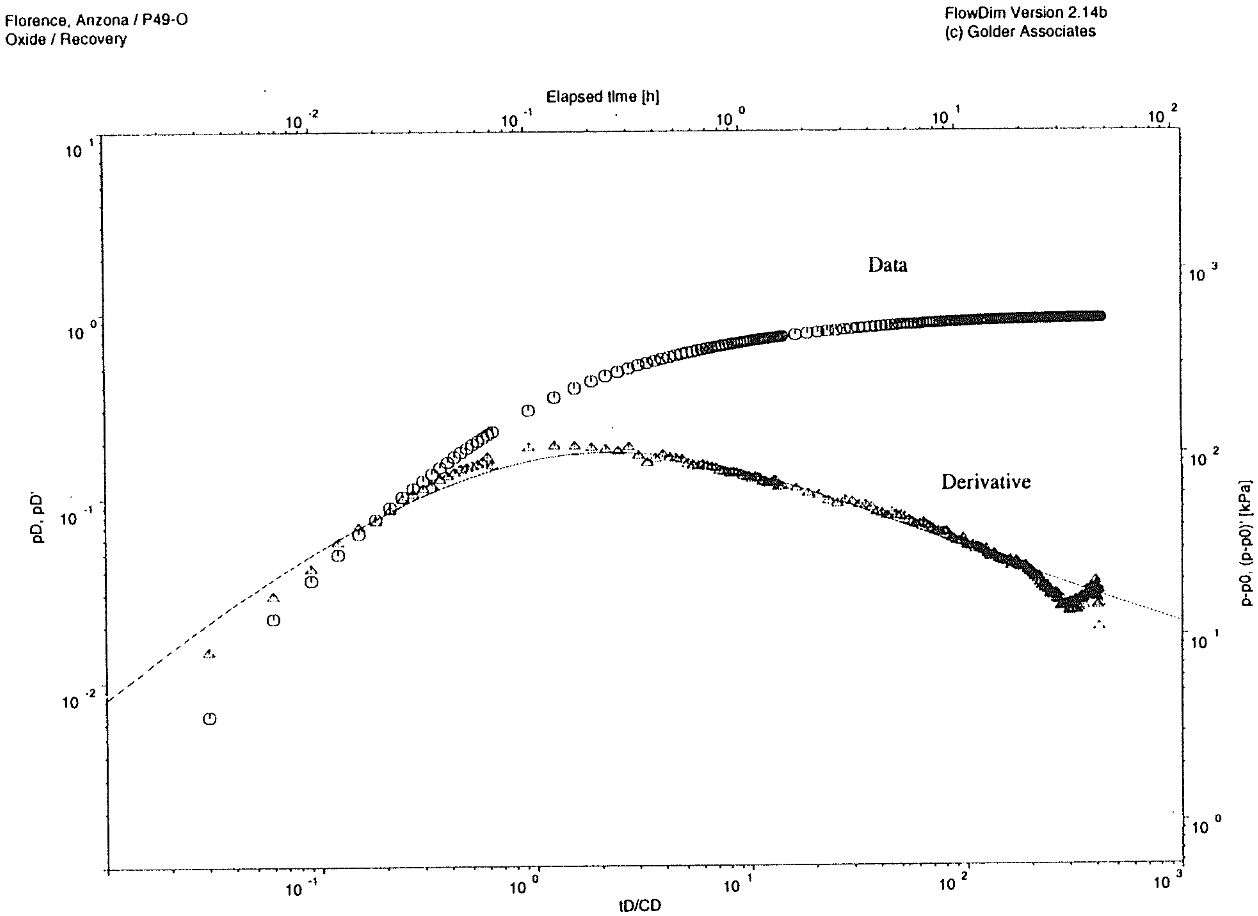
Figure 32B



FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : No superposition
PLOT TYPE : Log-log

C=	1.41E-04	m3/Pa
T=	3.30E-04	m2/s
S=	3.78E+00	-
s=	0.00E+00	-
n=	2.00E+00	-

Figure 33B



FLOW MODEL : Homogeneous
BOUNDARY CONDITIONS: Constant rate
WELL TYPE : Source
SUPERPOSITION TYPE : Build-up TC
PLOT TYPE : Log-log

C=	1.78E-06	m3/Pa
T=	3.45E-06	m2/s
S=	7.99E-01	-
s=	0.00E+00	-
n=	3.00E+00	-

Figure 34B

APPENDIX C

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	M1-GL
Interval name	Lower Gila
Event name	Pumping Well
Test date	11 - 13 Aug. 1995
Input file name	m1-gld.rec

Well parameters

Well depth	[m brp]	1.2802E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	6.3500E-02
Interval length	[m]	1.2190E+01

Testparameter

Flow rate	[1/min]	3.7900E+01
Test duration	[h]	2.4458E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	1.0000E-01

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	7.5775E-11
Transmissivity	[m2/s]	7.4335E-04
Storage	[m/Pa]	8.5961E-13
Storativity	[-]	8.4327E-09
Wellbore storage	[m3/Pa]	4.3535E-06
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	3.9350E+02
Pressure match	[1/kPa]	7.5335E-01

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 29.10.1995

Identification

Site name	Florence, Arizona
Well name	M3-GL
Interval name	Lower Gila
Event name	Observation Well (M4-O)
Test date	28 - 29 July, 1995
Input file name	m3gloddb.fd1

Well parameters

Well depth	[m bgl]	1.5545E+02
Wellbore radius	[m]	6.3500E-02
Interval length	[m]	1.8290E+01
Distance to active well	[m]	9.7100E+00
Active wellbore radius	[m]	6.3500E+02

Testparameter

Flow rate	[l/min]	5.6780E+01
Test duration	[h]	2.2171E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Observation
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	9.7150E-11
Transmissivity	[m2/s]	9.5304E-04
Storage	[m/Pa]	8.9465E-06
Storativity	[-]	8.7765E-02
Inner shell flow dimension	[-]	2.0000E+00
Dimensionles obs. point distance	[-]	1.5291E+02
Time match	[1/h]	4.1462E-01
Pressure match	[1/kPa]	6.4470E-01

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence Site
Well name	M14-GL
Interval name	Lower Gila
Event name	Pumping Well
Test date	11 - 12 Aug. 1995
Input file name	m14-gld.rec

Well parameters

Well depth	[m brp]	2.8956E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	6.3500E-02
Interval length	[m]	1.8290E+01

Testparameter

Flow rate	[l/min]	3.7850E+01
Test duration	[h]	1.8180E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	1.0000E-01

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	1.1462E-11
Transmissivity	[m2/s]	1.1244E-04
Storage	[m/Pa]	9.2897E-11
Storativity	[-]	9.1132E-07
Wellbore storage	[m3/Pa]	2.3524E-06
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	1.1015E+02
Pressure match	[1/kPa]	1.1410E-01

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence Site
Well name	M14-GL
Interval name	Lower Gila
Event name	Pumping Well
Test date	11 - 12 Aug. 1995
Input file name	m14gld3d.rec

Well parameters

Well depth	[m brp]	2.8956E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	6.3500E-02
Interval length	[m]	1.8290E+01

Testparameter

Flow rate	[l/min]	3.7850E+01
Test duration	[h]	1.8180E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	1.0000E-01

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	5.4085E-13
Transmissivity	[m2/s]	5.3057E-06
Storage	[m/Pa]	4.3810E-06
Storativity	[-]	4.2977E-02
Wellbore storage	[m3/Pa]	2.2182E-06
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	3.0000E+00
Time match	[1/h]	1.1022E+01
Pressure match	[1/kPa]	1.0766E-02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	M15-GU
Interval name	Upper Gila
Event name	Pumping Well
Test date	8 - 9 Aug. 1995
Input file name	m15-gud.rec

Well parameters

Well depth	[m brp]	1.9202E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	6.3500E-02
Interval length	[m]	1.2190E+01

Testparameter

Flow rate	[l/min]	3.7900E+01
Test duration	[h]	1.6695E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	1.0000E-01

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	1.1353E-11
Transmissivity	[m2/s]	1.1137E-04
Storage	[m/Pa]	1.0991E-15
Storativity	[-]	1.0782E-11
Wellbore storage	[m3/Pa]	2.7832E-07
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	9.2222E+02
Pressure match	[1/kPa]	1.1287E-01

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	M18-GU
Interval name	Upper Gila
Event name	Pumping Well
Test date	8 - 11 Aug. 1995
Input file name	m18-gud.rec

Well parameters

Well depth	[m brp]	7.3150E+01
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	6.3500E-02
Interval length	[m]	1.2190E+01

Testparameter

Flow rate	[l/min]	3.7900E+01
Test duration	[h]	1.9194E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	1.0000E-01

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	8.6070E-11
Transmissivity	[m2/s]	8.4434E-04
Storage	[m/Pa]	8.8678E-20
Storativity	[-]	8.6993E-16
Wellbore storage	[m3/Pa]	2.2455E-06
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	8.6654E+02
Pressure match	[1/kPa]	8.5570E-01

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 15.11.1995

Identification

Site name	Florence, Arizona
Well name	P39-O
Interval name	Oxide
Event name	Pumping Well
Test date	19 - 20 May, 1995
Input file name	mf39pwpd.rec

Well parameters

Well depth	[m brp]	2.7890E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	1.3000E-01
Interval length	[m]	1.0820E+02

Testparameter

Flow rate	[l/min]	2.0800E+02
Test duration	[h]	1.6917E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	1.1442E-11
Transmissivity	[m2/s]	1.1225E-04
Storage	[m/Pa]	9.7900E-08
Storativity	[-]	9.6040E-04
Wellbore storage	[m3/Pa]	1.0390E-06
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	2.4897E+02
Pressure match	[1/kPa]	2.0728E-02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 15.11.1995

Identification

Site name	Florence, Arizona
Well name	O39-O
Interval name	Oxide
Event name	Observ. Well (P39-O)
Test date	19 - 20 May, 1995
Input file name	mf39owpd.rec

Well parameters

Well depth	[m brp]	2.7920E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	1.2700E-01
Interval length	[m]	1.2680E+02
Distance to active well	[m]	3.6000E+01

Testparameter

Flow rate	[l/min]	2.0800E+02
Test duration	[h]	1.6857E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-01

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Observation
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	1.4760E-11
Transmissivity	[m2/s]	1.4479E-04
Storage	[m/Pa]	4.4004E-08
Storativity	[-]	4.3168E-04
Inner shell flow dimension	[-]	2.0000E+00
Dimensionles obs. point distance	[-]	2.8346E+02
Time match	[1/h]	9.3173E-01
Pressure match	[1/kPa]	2.6738E-02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 27.10.1995

Identification

Site name	Florence, Arizona
Well name	OB7-1
Interval name	Oxide
Event name	Observation Well
Test date	16 - 21 June, 1995
Input file name	ob7-1dda.fd1

Well Parameters

Well depth	[m bgl]	2.7432E+02
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	1.0363E+02
Distance to active well	[m]	1.5300E+01

Test Parameters

Flow rate	[l/min]	1.5142E+02
Test duration	[h]	2.4666E+01

Fluid and Formation Parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Observation
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	5.0475E-12
Transmissivity	[m2/s]	4.9516E-05
Storage	[m/Pa]	1.3510E-08
Storativity	[-]	1.3253E-04
Inner shell flow dimension	[-]	2.0000E+00
Dimensionles obs. point distance	[-]	2.0079E+02
Time match	[1/h]	5.7458E+00
Pressure match	[1/kPa]	1.2560E-02
Type Curve Match	[-]	

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 27.10.1995

Identification

Site name	Florence, Arizona
Well name	O12-O
Interval name	Oxide
Event name	Observation Well
Test date	1 - 7 June, 1995
Input file name	o12-oddc.fd1

Well Parameters

Well depth	[m bgl]	2.9570E+02
Wellbore radius	[m]	5.0800E-02
Interval length	[m]	1.5240E+02
Distance to active well	[m]	2.1900E+01
Radius of active well	[m]	7.6200E-02

Test Parameters

Flow rate	[1/min]	2.4610E+02
Test duration	[h]	6.6313E+00

Fluid and Formation Parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Observation
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	3.2764E-11
Transmissivity	[m2/s]	3.2141E-04
Storage	[m/Pa]	2.2788E-07
Storativity	[-]	2.2355E-03
Inner shell flow dimension	[-]	2.0000E+00
Dimensionles obs. point distance	[-]	2.8740E+02
Time match	[1/h]	1.0792E+00
Pressure match	[1/kPa]	5.0164E-02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	O28-GL
Interval name	Lower Gila
Event name	Obs. Well (P28-GL)
Test date	20 - 25 Sep. 1995
Input file name	o28-gld.rec

Well parameters

Well depth	[m brp]	9.7540E+01
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	5.0800E-02
Interval length	[m]	9.1400E+00
Distance to active well	[m]	4.0220E+01

Testparameter

Flow rate	[l/min]	2.8391E+02
Test duration	[h]	1.1873E+02

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	1.0000E-01

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Observation
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	7.6324E-11
Transmissivity	[m2/s]	7.4874E-04
Storage	[m/Pa]	2.7481E-09
Storativity	[-]	2.6959E-05
Inner shell flow dimension	[-]	2.0000E+00
Dimensionles obs. point distance	[-]	7.9173E+02
Time match	[1/h]	6.1809E+01
Pressure match	[1/kPa]	1.0130E-01

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	O28.1-O
Interval name	Oxide
Event name	Obs. Well (P28.2-O)
Test date	2 - 5 Oct. 1995
Input file name	o281-od.rec

Well parameters

Well depth	[m brp]	1.6154E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	5.0800E-02
Interval length	[m]	3.0480E+01
Distance to active well	[m]	4.9730E+01

Testparameter

Flow rate	[l/min]	2.8770E+02
Test duration	[h]	7.3888E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Observation
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	3.2337E-11
Transmissivity	[m2/s]	3.1723E-04
Storage	[m/Pa]	1.0811E-07
Storativity	[-]	1.0605E-03
Inner shell flow dimension	[-]	2.0000E+00
Dimensionles obs. point distance	[-]	9.7894E+02
Time match	[1/h]	4.3542E-01
Pressure match	[1/kPa]	4.2352E-02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	PW2-1
Interval name	Oxide
Event name	Pumping Well
Test date	8 Mar. 1995
Input file name	pw2-1d.rec

Well parameters

Well depth	[m brp]	1.9507E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	6.7060E+01

Testparameter

Flow rate	[l/min]	1.8927E+02
Test duration	[h]	1.6767E+02

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	3.2665E-11
Transmissivity	[m2/s]	3.2045E-04
Storage	[m/Pa]	3.2419E-13
Storativity	[-]	3.1803E-09
Wellbore storage	[m3/Pa]	2.3643E-06
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	3.1235E+02
Pressure match	[1/kPa]	6.5031E-02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 27.10.1995

Identification

Site name	Florence, Arizona
Well name	M3-GL
Interval name	Lower Gila
Event name	Pumping Well
Test date	26 - 27 July, 1995
Input file name	pm3-glda.fdl

Well parameters

Well depth	[m bgl]	1.1278E+02
Wellbore radius	[m]	6.3500E-02
Interval length	[m]	1.2190E+01

Test parameters

Flow rate	[l/min]	3.7850E+01
Test duration	[h]	2.6919E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	6.9585E-11
Transmissivity	[m2/s]	6.8263E-04
Storage	[m/Pa]	3.2211E-11
Storativity	[-]	3.1599E-07
Wellbore storage	[m3/Pa]	8.1567E-07
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	1.9287E+03
Pressure match	[1/kPa]	6.9273E-01
Type Curve Match	[-]	1.0000E+06

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	PW4-1
Interval name	Oxide
Event name	Pumping Well
Test date	19 May, 1995
Input file name	pw4-1.rec

Well parameters

Well depth	[m brp]	2.4384E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	1.0363E+02

Testparameter

Flow rate	[l/min]	2.6876E+02
Test duration	[h]	9.5190E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	1.4008E-10
Transmissivity	[m2/s]	1.3742E-03
Storage	[m/Pa]	2.5645E-13
Storativity	[-]	2.5158E-09
Wellbore storage	[m3/Pa]	1.8703E-06
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	1.6933E+03
Pressure match	[1/kPa]	1.9640E-01

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 27.10.1995

Identification

Site name	Florence, Arizona
Well name	M4-O
Interval name	Oxide
Event name	Pumping Well
Test date	28 - 29 July, 1995
Input file name	pm4-od.fd1

Well parameters

Well depth	[m bgl]	1.5240E+02
Wellbore radius	[m]	6.3500E-02
Interval length	[m]	1.8290E+01

Test parameters

Flow rate	[l/min]	5.6780E+01
Test duration	[h]	2.3641E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	3.6643E-12
Transmissivity	[m2/s]	3.5947E-05
Storage	[m/Pa]	2.7270E-13
Storativity	[-]	2.6752E-09
Wellbore storage	[m3/Pa]	1.3811E-06
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	5.9983E+01
Pressure match	[1/kPa]	2.4317E-02
Type Curve Match	[-]	2.0000E+08

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 26.10.1995

Identification

Site name	Florence, Arizona
Well name	PW7-1
Interval name	Oxide
Event name	Pumping Test
Test date	16 - 21 June 1995
Input file name	pw7-1dda.fd1

Well parameters

Well depth	[m bgl]	2.7432E+02
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	1.0363E+02

Test parameter

Flow rate	[l/min]	1.5142E+02
Test duration	[h]	2.4919E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	8.5587E-12
Transmissivity	[m2/s]	8.3960E-05
Storage	[m/Pa]	1.8842E-07
Storativity	[-]	1.8484E-03
Wellbore storage	[m3/Pa]	6.8707E-07
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	2.8162E+02
Pressure match	[1/kPa]	2.1298E-02
Type Curve Match	[-]	1.0000E+02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	P8-GU
Interval name	Upper Gila
Event name	Pumping Well
Test date	18 - 22 Sep. 1995
Input file name	p8-gud.rec

Well parameters

Well depth	[m brp]	8.2300E+01
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	3.6580E+01

Testparameter

Flow rate	[l/min]	3.3501E+02
Test duration	[h]	5.3012E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	1.0000E-01

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	8.0643E-10
Transmissivity	[m2/s]	7.9111E-03
Storage	[m/Pa]	3.2522E-10
Storativity	[-]	3.1904E-06
Wellbore storage	[m3/Pa]	1.1859E-05
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	1.5374E+03
Pressure match	[1/kPa]	9.0703E-01

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 26.10.1995

Identification

Site name	Florence Arizona
Well name	P12-O
Interval name	Oxide
Event name	Pumping Test
Test date	1 - 7 June, 1995
Input file name	p12-oddc.fdt

Well parameters

Well depth	[m bgl]	1.0000E+02
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	1.5240E+02

Test parameters

Flow rate	[l/min]	2.4610E+02
Test duration	[h]	1.6624E+00

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	1.0000E-01

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	2.0785E-11
Transmissivity	[m2/s]	2.0390E-04
Storage	[m/Pa]	4.2419E-05
Storativity	[-]	4.1613E-01
Wellbore storage	[m3/Pa]	4.6404E-06
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	1.0126E+02
Pressure match	[1/kPa]	3.1823E-02
Type Curve parameter	[-]	3.0000E+00

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 23.11.1995

Identification

Site name	Florence, Arizona
Well name	P13.1-O
Interval name	Oxide
Event name	Pumping Well
Test date	9 - 16 Oct. 1995
Input file name	p131od.rec

Well parameters

Well depth	[m brp]	4.4958E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	2.0635E+02

Testparameter

Flow rate	[l/min]	1.7413E+02
Test duration	[h]	8.8082E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	1.9503E-11
Transmissivity	[m2/s]	1.9133E-04
Storage	[m/Pa]	4.8082E-11
Storativity	[-]	4.7168E-07
Wellbore storage	[m3/Pa]	1.7533E-06
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	2.5149E+02
Pressure match	[1/kPa]	4.2203E-02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 24.11.1995

Identification

Site name	Florence, Arizona
Well name	P13.2-O
Interval name	Oxide
Event name	Obs, Well (P13.1-O)
Test date	9 - 16 Oct. 1995
Input file name	p132od3d.rec

Well parameters

Well depth	[m brp]	4.2672E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	1.8227E+02
Distance to active well	[m]	3.1370E+01

Testparameter

Flow rate	[l/min]	1.7413E+02
Test duration	[h]	8.8176E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Observation
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	8.3410E-15
Transmissivity	[m2/s]	8.1825E-08
Storage	[m/Pa]	7.1721E-11
Storativity	[-]	7.0358E-07
Inner shell flow dimension	[-]	3.0000E+00
Dimensionles obs. point distance	[-]	4.1168E+02
Time match	[1/h]	4.2545E-01
Pressure match	[1/kPa]	3.6089E-05

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 25.11.1995

Identification

Site name	Florence, Arizona
Well name	P15-O
Interval name	Oxide
Event name	Pumping Well
Test date	29 Sep-5 Oct. 1995
Input file name	p15od.rec

Well parameters

Well depth	[m brp]	4.2062E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	2.1946E+02

Testparameter

Flow rate	[l/min]	2.2330E+02
Test duration	[h]	1.0083E+02

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	3.9175E-11
Transmissivity	[m2/s]	3.8431E-04
Storage	[m/Pa]	1.3542E-06
Storativity	[-]	1.3285E-02
Wellbore storage	[m3/Pa]	4.9380E-06
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	1.7936E+02
Pressure match	[1/kPa]	6.6105E-02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	P19-O
Interval name	Oxide
Event name	Observ. Well
Test date	3 - 6 Jul. 1995
Input file name	p19-0d.rec

Well parameters

Well depth	[m brp]	2.0726E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	6.0350E+01
Distance to active well	[m]	2.2720E+01

Testparameter

Flow rate	[l/min]	8.3280E+01
Test duration	[h]	5.1266E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Observation
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	4.1810E-12
Transmissivity	[m2/s]	4.1016E-05
Storage	[m/Pa]	7.8809E-08
Storativity	[-]	7.7311E-04
Inner shell flow dimension	[-]	2.0000E+00
Dimensionles obs. point distance	[-]	2.9816E+02
Time match	[1/h]	3.7000E-01
Pressure match	[1/kPa]	1.8917E-02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	P19-O
Interval name	Oxide
Event name	Observ. Well
Test date	3 - 6 Jul. 1995
Input file name	p19-od3d.rec

Well parameters

Well depth	[m brp]	2.0726E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	6.0350E+01
Distance to active well	[m]	2.2720E+01

Testparameter

Flow rate	[l/min]	8.3280E+01
Test duration	[h]	5.1266E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Observation
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	5.1759E-15
Transmissivity	[m2/s]	5.0775E-08
Storage	[m/Pa]	1.4684E-10
Storativity	[-]	1.4405E-06
Inner shell flow dimension	[-]	3.0000E+00
Dimensionles obs. point distance	[-]	2.9816E+02
Time match	[1/h]	2.4582E-01
Pressure match	[1/kPa]	4.6825E-05

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	P19.1-O
Interval name	Oxide
Event name	Withdrawal
Test date	3 - 6 Jul. 1995
Input file name	p191-od.rec

Well parameters

Well depth	[m brp]	2.0726E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	6.0350E+01

Testparameter

Flow rate	[l/min]	8.3300E+01
Test duration	[h]	5.1267E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	6.5087E-12
Transmissivity	[m2/s]	6.3851E-05
Storage	[m/Pa]	6.2788E-14
Storativity	[-]	6.1595E-10
Wellbore storage	[m3/Pa]	4.5791E-07
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	3.2135E+02
Pressure match	[1/kPa]	2.9442E-02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	P19.1-O
Interval name	Oxide
Event name	Withdrawal
Test date	3 - 6 Jul. 1995
Input file name	p191od3d.rec

Well parameters

Well depth	[m brp]	2.0726E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	6.0350E+01

Testparameter

Flow rate	[l/min]	8.3300E+01
Test duration	[h]	5.1267E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	2.4052E-13
Transmissivity	[m2/s]	2.3595E-06
Storage	[m/Pa]	5.7460E-07
Storativity	[-]	5.6368E-03
Wellbore storage	[m3/Pa]	4.1894E-07
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	3.0000E+00
Time match	[1/h]	2.5952E+01
Pressure match	[1/kPa]	2.1754E-03

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	P19.2-O
Interval name	Oxide
Event name	Observ. Well
Test date	3 - 6 Jul. 1995
Input file name	p192-od.rec

Well parameters

Well depth	[m brp]	1.9111E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	5.0800E-02
Interval length	[m]	6.0350E+01
Distance to active well	[m]	2.1200E+01

Testparameter

Flow rate	[l/min]	8.3280E+01
Test duration	[h]	4.9513E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Observation
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	3.2012E-12
Transmissivity	[m2/s]	3.1404E-05
Storage	[m/Pa]	1.4992E-08
Storativity	[-]	1.4707E-04
Inner shell flow dimension	[-]	2.0000E+00
Dimensionles obs. point distance	[-]	2.6835E+02
Time match	[1/h]	1.7103E+00
Pressure match	[1/kPa]	1.4484E-02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	P19.2-O
Interval name	Oxide
Event name	Observ. Well
Test date	3 - 6 Jul. 1995
Input file name	p192od3d.rec

Well parameters

Well depth	[m brp]	1.9111E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	5.0800E-02
Interval length	[m]	6.0350E+01
Distance to active well	[m]	2.1200E+01

Testparameter

Flow rate	[l/min]	8.3280E+01
Test duration	[h]	4.9513E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Observation
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	4.3045E-15
Transmissivity	[m2/s]	4.2228E-08
Storage	[m/Pa]	3.4441E-11
Storativity	[-]	3.3786E-07
Inner shell flow dimension	[-]	3.0000E+00
Dimensionles obs. point distance	[-]	2.6835E+02
Time match	[1/h]	1.0011E+00
Pressure match	[1/kPa]	3.8942E-05

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	P28-GL
Interval name	Lower Gila
Event name	Pumping Well
Test date	20 - 25, Sep. 1995
Input file name	p28-gld.rec

Well parameters

Well depth	[m brp]	9.7540E+01
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	6.3500E-02
Interval length	[m]	9.1400E+00

Testparameter

Flow rate	[l/min]	2.8390E+02
Test duration	[h]	1.1539E+02

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	1.0000E-01

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	2.7137E-11
Transmissivity	[m2/s]	2.6622E-04
Storage	[m/Pa]	3.4388E-11
Storativity	[-]	3.3735E-07
Wellbore storage	[m3/Pa]	8.7080E-07
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	7.0454E+02
Pressure match	[1/kPa]	3.6017E-02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	P28.1-O
Interval name	Oxide
Event name	Pumping Well
Test date	15 - 18 Aug, 1995
Input file name	p281-oad.rec

Well parameters

Well depth	[m brp]	1.5850E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	6.7200E-02
Interval length	[m]	3.0480E+01

Testparameter

Flow rate	[l/min]	1.0978E+02
Test duration	[h]	4.2844E+03

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	8.4137E-11
Transmissivity	[m2/s]	8.2539E-04
Storage	[m/Pa]	5.3035E-04
Storativity	[-]	5.2027E+00
Wellbore storage	[m3/Pa]	1.5040E-04
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	1.2647E+01
Pressure match	[1/kPa]	2.8879E-01

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 15.11.1995

Identification

Site name	Forence, Arizona
Well name	P28.1-O
Interval name	Oxide
Event name	Pumping Well
Test date	8 - 11 Sep, 1995
Input file name	p281-obd.rec

Well parameters

Well depth	[m brp]	1.5850E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	3.0480E+01

Testparameter

Flow rate	[l/min]	3.2180E+02
Test duration	[h]	7.4053E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	3.9300E-11
Transmissivity	[m2/s]	3.8554E-04
Storage	[m/Pa]	3.5153E-06
Storativity	[-]	3.4485E-02
Wellbore storage	[m3/Pa]	1.2818E-06
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	6.9315E+02
Pressure match	[1/kPa]	4.6017E-02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 15.11.1995

Identification

Site name	Florence, Arizona
Well name	P28.2-O
Interval name	Oxide
Event name	Obs. Well (P28.1-O)
Test date	8 - 11 Sep, 1995
Input file name	p282-obd.rec

Well parameters

Well depth	[m brp]	1.6150E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	5.0800E-02
Interval length	[m]	3.0180E+01
Distance to active well	[m]	2.9910E+01

Testparameter

Flow rate	[l/min]	3.2170E+02
Test duration	[h]	7.3898E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Observation
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	2.8996E-11
Transmissivity	[m2/s]	2.8446E-04
Storage	[m/Pa]	2.9688E-08
Storativity	[-]	2.9124E-04
Inner shell flow dimension	[-]	2.0000E+00
Dimensionles obs. point distance	[-]	5.8878E+02
Time match	[1/h]	3.9303E+00
Pressure match	[1/kPa]	3.3963E-02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 16.11.1995

Identification

Site name	Florence, Arizona
Well name	P28.2-O
Interval name	Oxide
Event name	Pumping Well
Test date	2 - 5 Oct. 1995
Input file name	p282-od.rec

Well parameters

Well depth	[m brp]	1.5820E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	3.0180E+01

Testparameter

Flow rate	[l/min]	2.8769E+02
Test duration	[h]	7.4052E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-02

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Drawdown

Results of analysis

Transmissibility	[m3]	3.3674E-11
Transmissivity	[m2/s]	3.3035E-04
Storage	[m/Pa]	3.8581E-04
Storativity	[-]	3.7848E+00
Wellbore storage	[m3/Pa]	1.4068E-04
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	2.0000E+00
Time match	[1/h]	5.4115E+00
Pressure match	[1/kPa]	4.4105E-02

Comments

FlowDim V2.14b

TEST ANALYSIS REPORT 25.11.1995

Identification

Site name	Florence, Arizona
Well name	P49-O
Interval name	Oxide
Event name	Recovery
Test date	11 - 16 Oct. 1995
Input file name	p490r.rec

Well parameters

Well depth	[m brp]	3.9258E+02
Reference point elevation	[m asl]	0.0000E+00
Wellbore radius	[m]	7.6200E-02
Interval length	[m]	1.2619E+02

Testparameter

Production/Injection time	[h]	4.5700E+01
Flow rate	[l/min]	1.5142E+02
Test duration	[h]	4.7164E+01

Fluid and formation parameters

Viscosity	[Pa s]	1.0000E-03
Total compressibility	[1/Pa]	5.4000E-10
Porosity	[-]	5.0000E-03

Model assumptions

Flow model	Homogeneous
Boundary conditions	Constant rate
Well type	Source
Superposition type	Buildup

Results of analysis

Transmissibility	[m3]	3.5205E-13
Transmissivity	[m2/s]	3.4536E-06
Storage	[m/Pa]	8.1397E-05
Storativity	[-]	7.9851E-01
Wellbore storage	[m3/Pa]	1.7804E-06
Skin (assumed)	[-]	0.0000E+00
Inner shell flow dimension	[-]	3.0000E+00
Time match	[1/h]	8.9386E+00
Pressure match	[1/kPa]	1.7517E-03

Comments

FlowDim V2.14b

MEMORANDUM

TO: Mr. Steven A. Mellon
Brown and Caldwell
3636 N. Central Ave., Suite 300
Phoenix, Arizona 85012

FROM: Amado Guzman
Tucson Office

Our Reference: 953-2908

DATE: December 1, 1995

RE: Florence Electronic Data

Dear Steve:

Please find enclosed the reduced data files for the hydraulic tests included in our interpretation report. I have prepared a list of these files and their relationship to the figures presented in Appendix B. Please let me know if you need any additional information.

Cheers!

Enc. (12) Diskettes

cc. Mr. John Kline
Magma Copper Co.
Resource Development Technology Group
7400 N. Oracle Rd. Suite 162
Tucson, Arizona 85704
WITH ENCLOSURES (1) Diskette

GOLDER ASSOCIATES INC. - TUCSON OFFICE
4730 N. Oracle Rd., Suite 210, Tucson Arizona, USA 85705
Phone (520) 888-8818, Facsimile (520) 888-8817

Reduced data files and corresponding figures within Appendix B. Files contain two columns; time (hours) versus head (KPa).

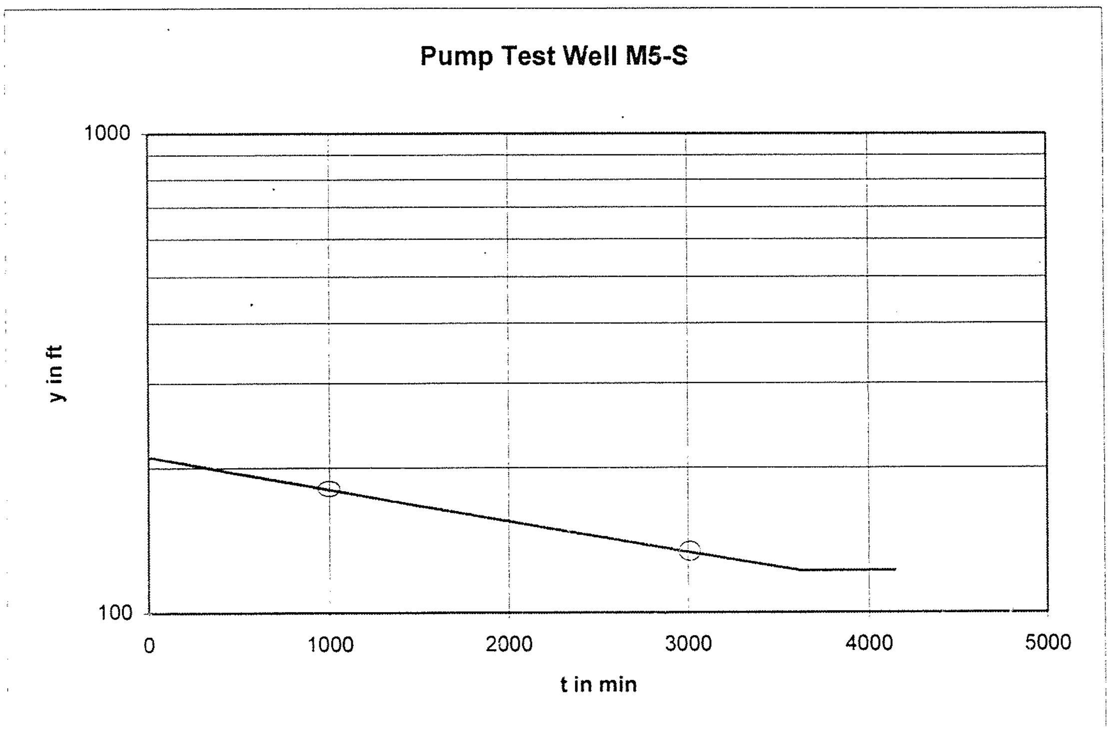
Figure	Well ID	Name of Data File			
1B,	M1-GL	M1-GLD DAT	7,342	11-16-95	3:41a
2B,	M3-GL	M3GLPD DAT	6,354	08-29-95	9:31p
3B,	M14-GL	M14-GLD DAT	5,302	11-16-95	3:43a
4B,	M14-GL (3-D)	Same as previous			
5B,	M15-GU	M15-GUD DAT	7,138	11-16-95	3:42a
6B,	M18-GL	M18-GUD DAT	6,186	11-16-95	3:40a
7B,	P39-O	MF39PWPD DAT	7,920	11-15-95	12:01p
8B,	O39-O	MF39OWPD DAT	4,758	11-15-95	12:02p
9B,	OB7-1	OB7-1OD DAT	8,328	12-01-95	2:25p
10B,	O12-O	O12-ODDC FD1	22,449	10-27-95	11:44a
11B,	O28-GL	O28-GLD DAT	6,458	11-16-95	2:29a
12B,	O28.1-O	O281-OD DAT	6,220	11-16-95	1:24a
13B,	PW2-1	PW2-1D DAT	8,498	11-16-95	4:54p
14B,	M3-GL	M3GLODDB FDT	746	10-29-95	3:18p
15B,	PW4-1	PW4-1 DAT	7,478	11-16-95	4:29p
16B,	M4-O	M4OPD DAT	5,469	08-29-95	9:57p
17B,	PW7-1	PW7-1OD DAT	8,158	12-01-95	2:27p
18B,	P8-GU	P8-GUD DAT	6,696	11-16-95	2:26a
19B,	P12-O	P12-ODDB FDT	2,684	10-22-95	7:22p
20B,	P13.1-O	P131OD DAT	7,988	11-23-95	12:41p
21B,	P13.2-O (3-D)	P132OD DAT	8,294	11-23-95	12:44p
22B,	P15-O	P15OD DAT	8,260	11-25-95	12:06p
23B,	P19-O	P19-OD DAT	8,396	11-16-95	11:30a
24B,	P19-O (3-D)	Same as previous			
25B,	P19.1-O	P191-OD DAT	6,390	11-16-95	11:29a
26B,	P19.1-O (3-D)	Same as Previous			
27B,	P19.2-O	P192-OD DAT	8,838	11-16-95	11:32a
28B,	P19.2-O (3-D)	Same as Previous			
29B,	P28-GL	P28-GLD DAT	8,770	11-16-95	2:27a
30B,	P28.1-O	P281-OAD DAT	7,444	11-15-95	1:33p
31B,	P28.1-O (Test #2)	P281-OBD DAT	7,852	11-15-95	2:06p
32B,	P28.2-O (Test #2)	P282-OBD DAT	6,662	11-15-95	2:06p
33B,	P28.2-O	P282-OD DAT	8,090	11-16-95	1:22a
34B,	P49-O (3-D)	P49OR DAT	8,498	11-24-95	7:21p

M5-S Pump Out Slug Test
Brown and Caldwell

Project: 1899 for Magma Copper Company, Florence, AZ
Test Date: July 25-28, 1995

Depth of well, Dw=	380	ft
Depth to water Dd=	122.13	ft
D=Dw-Dd	257.87	ft
b=D	257.87	ft
d=	60	ft
y=	211	ft
rc=	0.2	ft
rw=	0.35	ft
d/rw=	171.4286	
b/rw=	736.7714	
from Fig 16.6		
C=	11.6	
ln(Re/rw)	4.268473	
K=	3.1E-04	ft/day

t=tx-to=	2005
ln(ho/ht)=	0.300301
slope=	0.00015



Reference: Bouwer, H., The Bouwer and Rice Slug Test - An Update. Ground Water Vol. 27, No. 3, 1989

M13-S Pump Out Slug Test
Brown and Caldwell

Project: 1899 for Magma Copper Company, Florence, AZ
Test Date: July 28 - Aug 1, 1995

Depth of well, Dw=	345	ft
Depth to water Dd=	150.79	ft
D=Dw-Dd	194.21	ft
b=D	194.21	ft
d=	60	ft
y=	349	ft
rc=	0.2	ft
rw=	0.35	ft

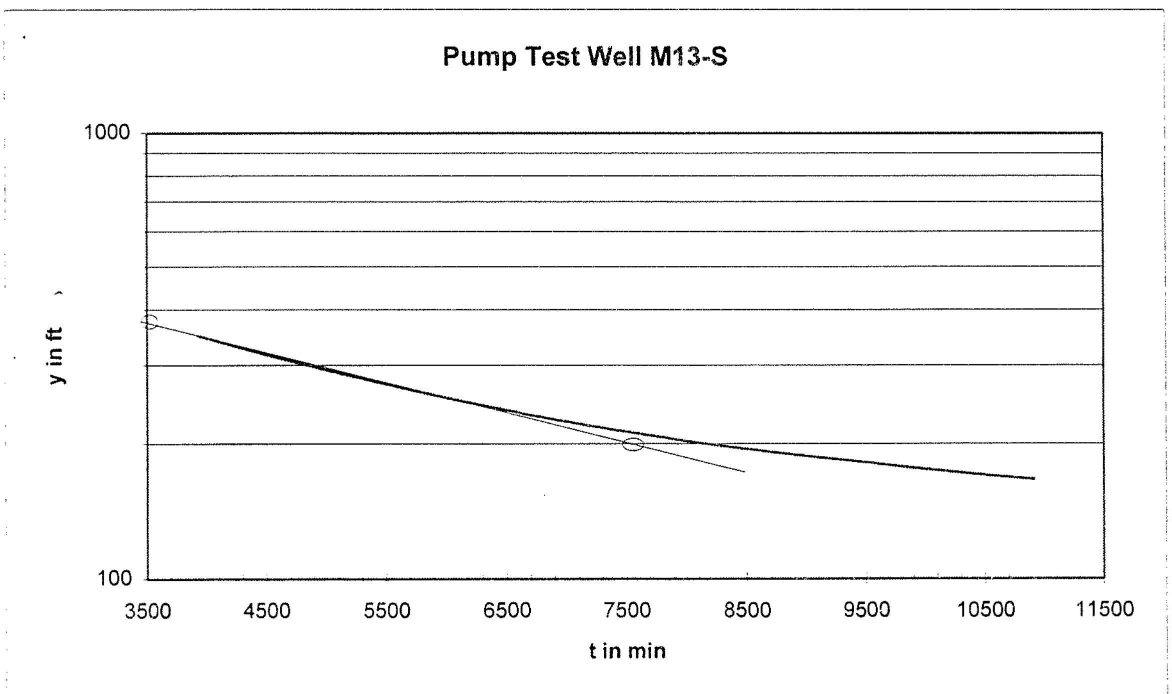
t=tx-to=	4050
ln(ho/ht)=	0.641854
slope=	0.000158

d/rw= 171.4286
b/rw= 554.8857

from Fig 16.6
C= 11.6

ln(Re/rw) 4.136481

K= 3.1E-04 ft/day



Reference: Bouwer, H., The Bouwer and Rice Slug Test - An Update. Ground Water
Vol. 27, No. 3, 1989