

**HYDROLOGIC ASSOCIATES U.S.A., INC.
ENVIRONMENTAL CONSULTANTS**

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January 17, 1994

Mr. Gene McLoughlin, P.E.
MDWASA
P.O. Box 330316
Miami, Florida 33233-0316

Dear Mr. McLoughlin,

The purpose of this letter report is to describe the procedures used and the results obtained from quantitative hydraulic analysis of a potential monitoring zone within the Floridan Aquifer system penetrated by Injection well I-14. The straddle packer test and subsequent hydraulic analysis were conducted in the zone of the aquifer between 1510 and 1540 feet below land surface (BLS).

METHOD

A straddle packer was used to isolate the test zone for drawdown and recovery tests. Stress was imposed on the hydraulic system with a centrifugal pump. Water level changes were measured in the drill stem with a pressure transducer and recorded on a Hermit 1000-C data logger. Prior to testing, the wells were developed by pumping the formation fluid until the specific conductance stabilized. Specific conductance readings taken during the test are included in Appendix I. The well was then allowed to recover from development before performing the test.

BACKGROUND

A 12 1/4 inch pilot hole was drilled below casing to a depth of 1900 feet below land surface. A suite of geophysical logs were run and, together with the borehole cutting samples, the test zone was selected by the WASA project hydrogeologist. The zone was selected between 1510-1540 feet below land surface. The zone was isolated with an inflatable straddle packer with 30 feet 10 feet of perforated pipe, open to the formation, between the two packer elements.

The packer assembly was lowered on the drill stem into the original pilot hole to the tested interval of 1510-1540 feet B.L.S. The packer elements were then inflated. A centrifugal pump was installed to develop the formation fluids between the packer elements. After more than thirteen hours of pumping, a constant specific conductance of 14,200 umhos was reached. The well was allowed to recover to its initial antecedent conditions and then pumped for 1 hour while drawdown data was recorded. Recovery data were recorded until formation water level had again reached antecedent conditions. Background, drawdown and recovery water level data is graphed on Figure 1. The test was run at a pumping rate of 143 gpm, and is analyzed as follows. Raw data are presented in Appendix II.

During early background data collection a valve on the centrifugal pump was left open, when this was discovered the valve was closed and the background level stabilized at approximately 15.4 feet. The initial readings from the drawdown data are missing due to the opening of this same valve prior to data collection.

AQUIFER TEST I-14 ZONE 1510-1540

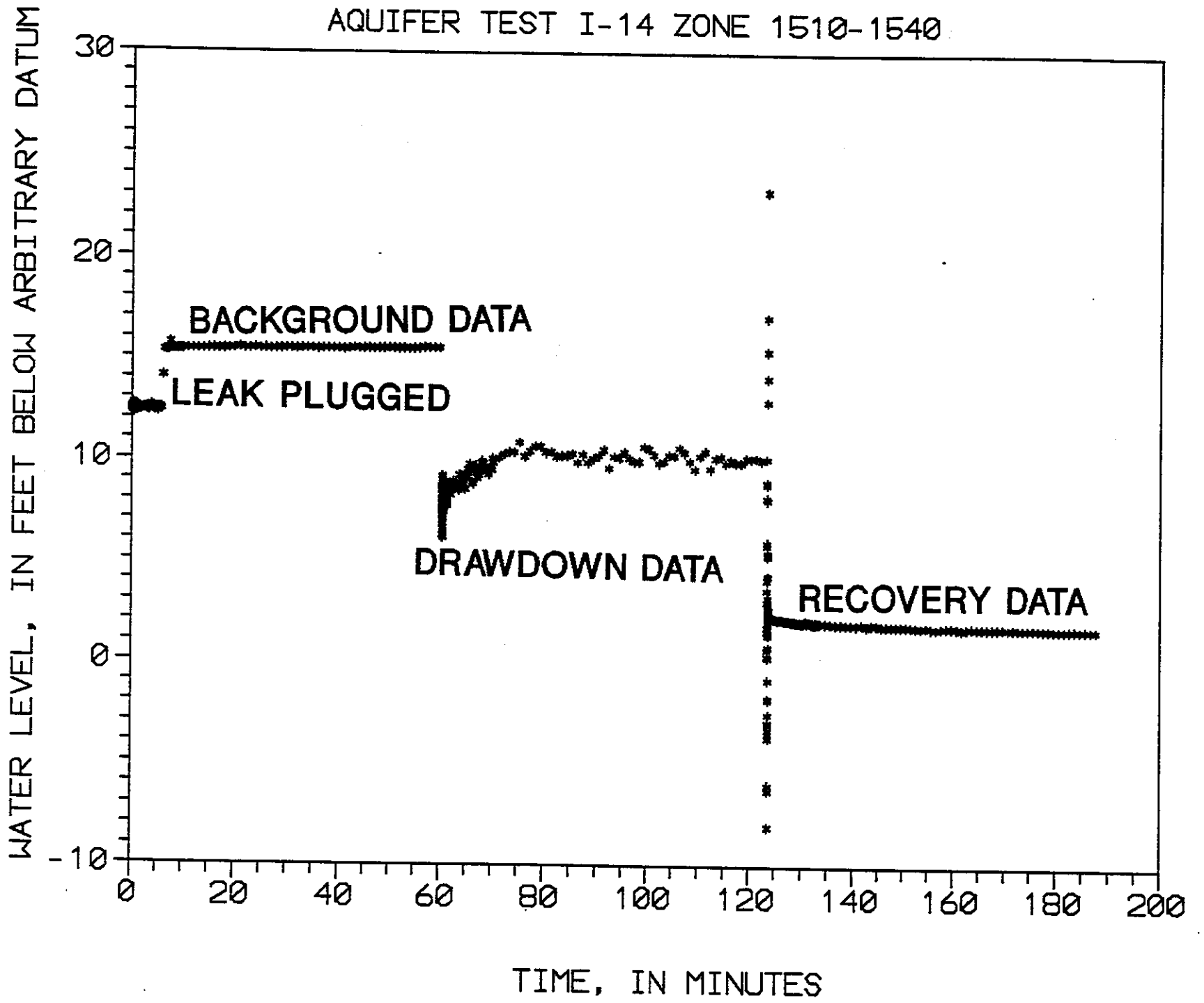


Figure 1... Background, drawdown and recovery data from I-14, zone 1510 to 1540

DATA ANALYSIS

Two methods of data analysis was used to calculate the transmissivity for the packer setting between 1510 and 1540 feet below land surface.

1. Cooper-Jacob Analysis

The Cooper-Jacob method (figure 2) (Todd, 1980 p. 129) was used to compute a transmissivity value. The equation is as follows:

$$T = \frac{(2.3) (Q)}{(4) (\pi) (\Delta s_t)}$$

where

Q = discharge in cubic feet per day

s_t = drawdown over one log cycle of time

The data were plotted on semi-log paper (s verses log t) and a straight line is fitted to the data.

Using the observed drawdown over a single log cycle, (s), the transmissivity can be determined from the equation given by Todd (1980, p. 130) as:

$$T = \frac{2.3 (27527.5) \text{ ft}^3/\text{day}}{(4) (3.1416) (1.85 \text{ ft})}$$

$$T = 2723.2 \text{ ft}^2/\text{D}$$

Using a unit thickness of 30 ft., the horizontal hydraulic conductivity is:

$$K = 90.8 \text{ ft}^2/\text{D}$$

$$K = 3.2 \times 10^{-2} \text{ cm/sec.}$$

COOPER-JACOB DRAWDOWN ANALYSIS I-14 ZONE 1510-1540

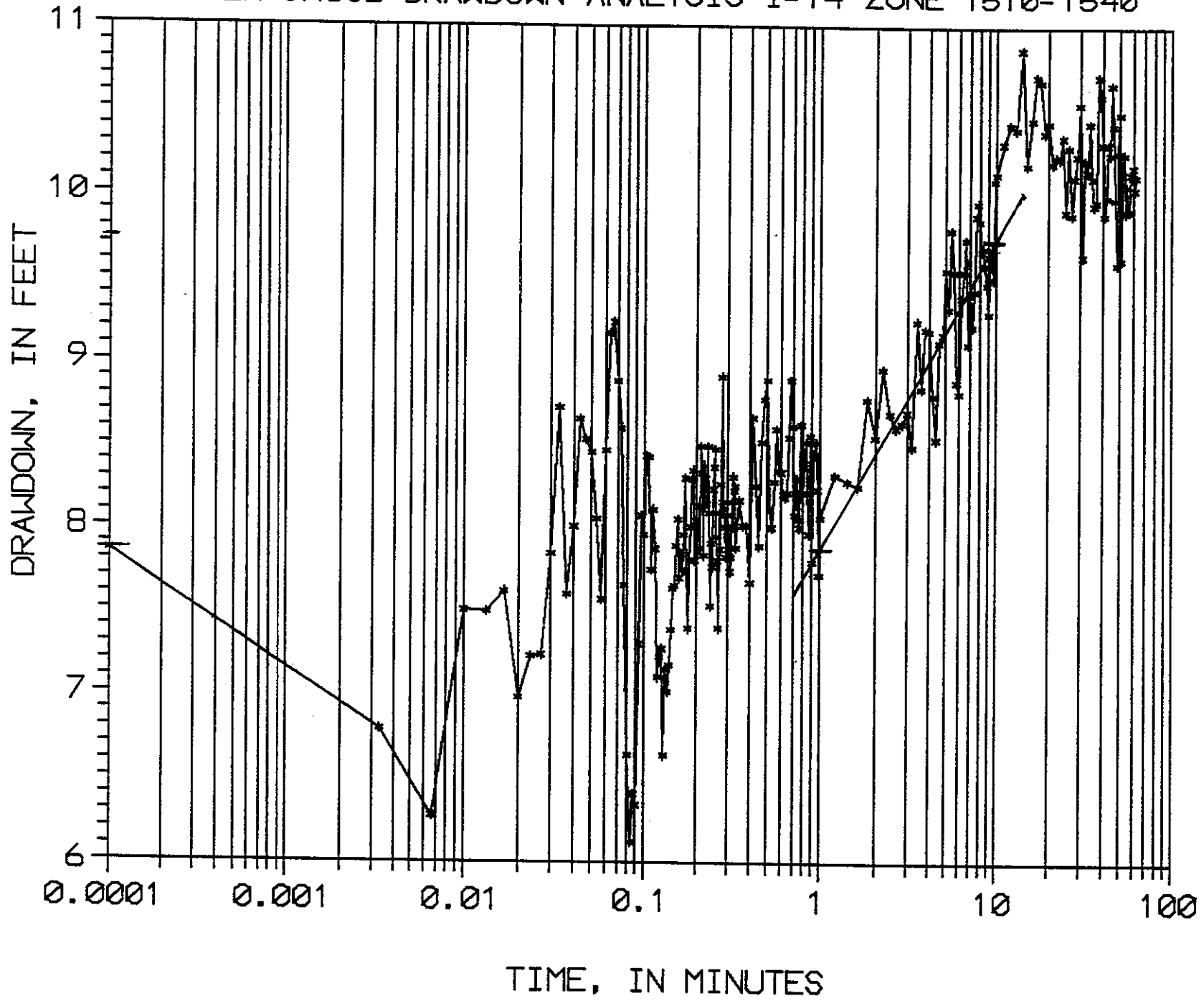


Figure 2.-- Cooper-Jacob Drawdown Analysis I-14, zone 1510 to 1540

2. Theis Analysis

The time-drawdown data for the packer test was analyzed using the Theis nonequilibrium equation given by (Todd, 1980, Pg. 123) as:

$$s = \frac{(Q) (W(u))}{(4) (\pi) (T)}$$

Where s is the drawdown, Q is the pumping rate and T is the transmissivity.

$W(u)$ is the well function and (u is the exponential integral function) where

$$u = \frac{(r^2) \cdot (S)}{(4) (\pi) (T) (t)}$$

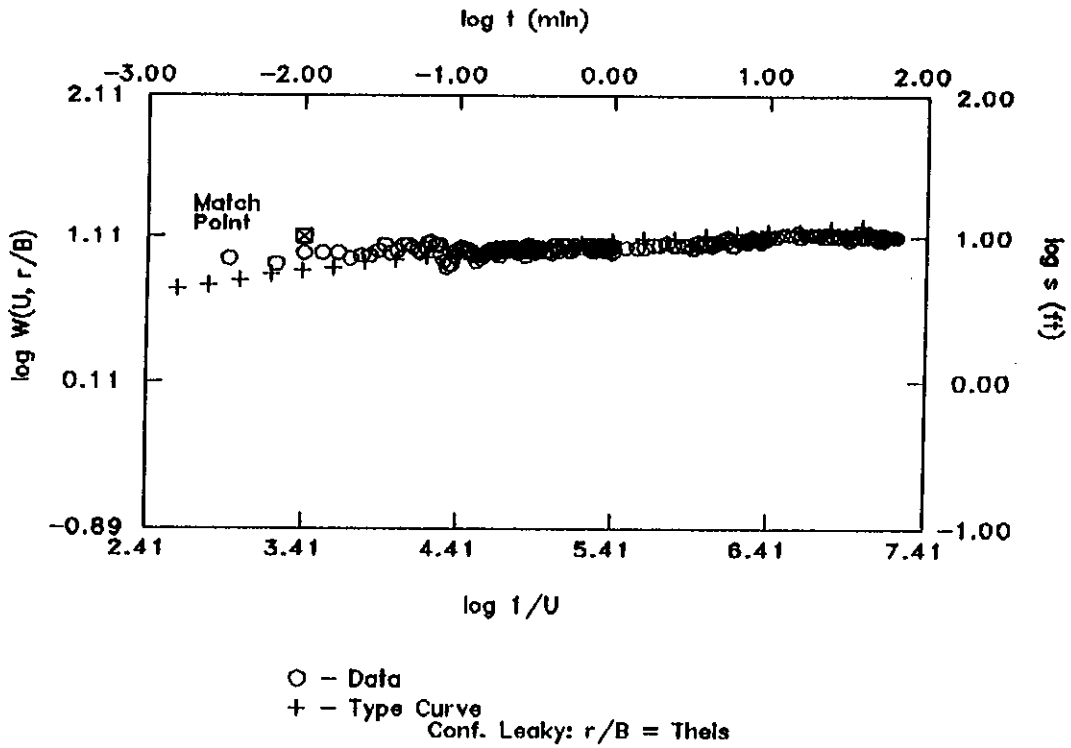
Where r is the distance to the observation well (r = well radius for a single well test).

S = Storage coefficient
 t = Time since the start of pumping

Transmissivity and storage coefficient values were determined from the drawdown data by type - curve matching techniques as described in Todd (Pgs. 125-128) by using the computer package GWAP (Graphical Well Analysis Package). Figures 3 shows the type curve superimposed on the drawdown data plot and the resulting computed values for transmissivity, hydraulic conductivity and storativity (Storage coefficient divided by unit thickness). Although somewhat of a match occurs, the flatness of the curve is not the most accurate data to match. Values for horizontal hydraulic conductivity expressed in standard units are:

$K = 94.0 \text{ ft/D}$
 $K = 3.3 \times 10^{-2} \text{ cm/sec}$

I-14 ZONE 1510-1540



MATCH POINT		SOLUTION	
t	= 1.000E-0002	Transmissivity (T)	= 2.111E+0004 gpd/ft
s	= 1.000E+0001	Hydraulic Conductivity (K)	= 7.035E+0002 gpd/sq ft
$1/U$	= 2.570E+0003	Storativity (S)	= 1.220E-0004
$W(U, r/B)$	= 1.288E+0001		
WELL INFORMATION			
WELL IDENTIFICATION	:	I-14	
DATE OF AQUIFER TEST	:	1/04/94	
AQUIFER THICKNESS (b)	:	3.000E+0001 ft	
DISCHARGE RATE (Q)	:	1.430E+0002 gpm	
PUMPING WELL RADIUS (r)	:	5.000E-0001 ft	
DISTANCE OF OBSERVATION WELL FROM PUMPING WELL (d)	:	5.000E-0001 ft	

Figure 3.--Theis Leaky Curve Analysis I-14, zone 1510 to 1540

If you have any questions or comments please feel free to contact me or Leo Swayze.

Sincerely,

Edmand B. Workman, P.G.

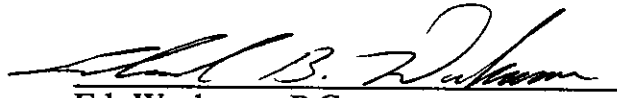
EBW/na

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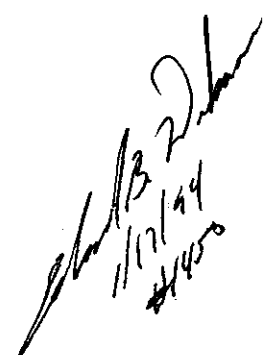
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CERTIFICATION

I hereby certify that I have examined this document, and attest that it has been prepared with good geological practices.



Ed. Workman, P.G.
Hydrogeologist



Date: 11/17/94

Registration # 1450

State: Florida

Appendix I
Specific Conductance Test Data

<u>TEMP °C</u>	<u>CONDUCTIVITY umhos</u>	<u>TIME</u>
24	15,200	7:30pm
23.9	15,000	7:45
23.9	15,000	8:00
24	14,800	8:15
24	14,800	8:30
23.9	14,200	8:45
23.9	14,500	9:00
23.9	14,500	9:15
23.9	14,200	9:30
23.9	14,500	9:45
23.9	14,500	10:00
23.5	14,200	10:15
23.5	14,500	10:30
23.9	14,200	10:45
23.9	13,800	11:00
23.9	14,000	11:15
24	14,000	11:30
24	14,000	11:45
24	14,000	12:00am
24	14,200	12:15
23.5	14,200	12:30
23.5	15,500	12:45
23.9	15,200	1:00
23.5	15,000	1:15
23.5	15,000	1:30
23.9	15,000	1:45
23	14,800	2:00
23	15,000	2:15
23.2	14,900	2:30
23	14,900	2:45
23	14,500	3:00
23	14,500	3:15
23	14,200	3:30
23	14,200	3:45
23	14,500	4:00

<u>TEMP °C</u>	<u>CONDUCTIVITY umhos</u>	<u>TIME</u>
22.9	14,500	4:15
23	14,200	4:30
23	14,500	4:45
23	14,500	5:00
23	14,000	5:15
23	14,000	5:30
23	14,500	5:45
23	14,200	6:00
23	14,200	6:15
23	14,500	6:30
23	14,200	6:45
23	14,200	7:00
23	14,000	7:15
23	14,200	7:30
23	14,200	7:45
23	14,200	8:00
23	14,200	8:15
23	14,200	8:30

Appendix II
Raw Aquifer Test Data

I-14
ZONE 1510-1540
DRAWDOWN DATA

TIME	WATER LEVEL
0.0000	7.853
0.0033	6.785
0.0066	6.270
0.0100	7.500
0.0133	7.491
0.0166	7.615
0.0200	6.976
0.0233	7.224
0.0266	7.233
0.0300	7.843
0.0333	8.720
0.0366	7.596
0.0400	8.006
0.0433	8.653
0.0466	8.530
0.0500	8.453
0.0533	8.053
0.0566	7.567
0.0600	8.463
0.0633	9.168
0.0666	9.235
0.0700	8.882
0.0733	8.596
0.0766	7.653
0.0800	6.633
0.0833	6.118
0.0866	6.404
0.0900	6.337
0.0933	7.300
0.0966	8.072
0.1000	7.958
0.1033	8.434
0.1066	8.425
0.1100	7.748
0.1133	8.110
0.1166	7.872
0.1200	7.100
0.1233	7.224
0.1266	7.271

0.1300	6.633
0.1333	7.147
0.1366	7.014
0.1400	7.176
0.1433	7.386
0.1466	7.634
0.1500	7.653
0.1533	7.891
0.1566	8.053
0.1600	7.700
0.1633	7.843
0.1666	7.748
0.1700	7.958
0.1733	8.301
0.1766	7.729
0.1800	7.395
0.1833	7.805
0.1866	8.006
0.1900	8.291
0.1933	8.349
0.1966	7.805
0.2000	8.044
0.2033	7.853
0.2066	8.129
0.2100	7.882
0.2133	8.492
0.2166	8.329
0.2200	7.834
0.2233	8.377
0.2266	8.301
0.2300	8.148
0.2333	8.492
0.2366	8.091
0.2400	7.529
0.2433	7.910
0.2466	7.767
0.2500	8.234
0.2533	8.367
0.2566	8.473
0.2600	7.948
0.2633	7.805
0.2666	7.395
0.2700	8.091
0.2733	7.872
0.2766	8.263
0.2800	8.911

0.2833	8.158
0.2866	8.120
0.2900	8.006
0.2933	7.824
0.2966	8.082
0.3000	7.958
0.3033	8.015
0.3066	7.862
0.3100	7.738
0.3133	7.824
0.3166	8.158
0.3200	8.006
0.3233	8.310
0.3266	8.225
0.3300	8.253
0.3333	7.882
0.3500	8.167
0.3666	8.015
0.3833	8.015
0.4000	7.672
0.4166	8.663
0.4333	8.253
0.4500	7.891
0.4666	8.520
0.4833	8.777
0.5000	8.892
0.5166	8.120
0.5333	8.006
0.5500	8.282
0.5666	8.596
0.5833	8.349
0.6000	8.339
0.6166	8.206
0.6333	8.187
0.6500	8.215
0.6666	8.549
0.6833	8.892
0.7000	8.615
0.7166	8.082
0.7333	8.301
0.7500	8.053
0.7666	8.006
0.7833	8.625
0.8000	8.215
0.8166	8.396
0.8333	8.520

0.8500	8.215
0.8666	7.967
0.8833	8.558
0.9000	7.796
0.9166	8.453
0.9333	8.444
0.9500	8.520
0.9666	8.234
0.9833	7.720
1.0000	8.063
1.2000	8.320
1.4000	8.282
1.6000	8.253
1.8000	8.777
2.0000	8.549
2.2000	8.959
2.4000	8.692
2.6000	8.606
2.8000	8.635
3.0000	8.701
3.2000	8.492
3.4000	9.244
3.6000	8.844
3.8000	9.197
4.0000	9.187
4.2000	8.796
4.4000	8.539
4.6000	9.121
4.8000	9.168
5.0000	9.549
5.2000	9.321
5.4000	9.787
5.6000	9.540
5.8000	8.882
6.0000	8.815
6.2000	9.387
6.4000	9.540
6.6000	9.730
6.8000	9.111
7.0000	9.406
7.2000	9.216
7.4000	9.426
7.6000	9.873
7.8000	9.950
8.0000	9.845
8.2000	9.664

8.4000	9.683
8.6000	9.578
8.8000	9.464
9.0000	9.292
9.2000	9.635
9.4000	9.683
9.6000	9.502
9.8000	10.083
10.0000	9.864
11.0000	10.121
12.0000	10.302
13.0000	10.416
14.0000	10.388
15.0000	10.864
16.0000	10.178
17.0000	10.445
18.0000	10.702
19.0000	10.673
20.0000	10.369
21.0000	10.426
22.0000	10.188
23.0000	10.226
24.0000	10.216
25.0000	10.340
26.0000	9.902
27.0000	10.283
28.0000	9.883
29.0000	10.102
30.0000	10.235
31.0000	10.540
32.0000	9.635
33.0000	10.207
34.0000	10.140
35.0000	10.426
36.0000	10.102
37.0000	9.940
38.0000	9.959
39.0000	10.702
40.0000	10.588
41.0000	10.302
42.0000	9.883
43.0000	9.988
44.0000	10.302
45.0000	10.245
46.0000	10.654
47.0000	10.416

48.0000	9.978
49.0000	9.587
50.0000	10.255
51.0000	10.483
52.0000	9.616
53.0000	10.130
54.0000	10.245
55.0000	9.902
56.0000	10.054
57.0000	9.912
58.0000	9.912
59.0000	10.130
60.0000	10.111
61.0000	10.169
62.0000	10.035
63.0000	10.111

I-14
ZONE 1510-1540
RECOVERY DATA

TIME	WATER LEVEL
0.0000	0.649
0.0033	0.305
0.0066	1.537
0.0100	5.946
0.0133	8.167
0.0166	8.844
0.0200	8.940
0.0233	5.803
0.0266	3.561
0.0300	2.988
0.0333	4.086
0.0366	1.737
0.0400	-8.061
0.0433	-33.051
0.0466	1.642
0.0500	15.424
0.0533	12.911
0.0566	23.254
0.0600	2.215
0.0633	-6.022
0.0666	17.088
0.0700	14.092
0.0733	4.239
0.0766	1.499
0.0800	-6.309
0.0833	5.431
0.0866	5.278
0.0900	1.394
0.0933	-3.316
0.0966	-1.767
0.1000	-3.048
0.1033	0.248
0.1066	-0.859
0.1100	-2.953
0.1133	-3.727
0.1166	-3.488
0.1200	-2.570
0.1233	-1.825
0.1266	1.346

0.1300	2.119
0.1333	3.198
0.1366	4.286
0.1400	5.364
0.1433	2.959
0.1466	2.855
0.1500	1.938
0.1533	1.480
0.1566	0.773
0.1600	2.234
0.1633	2.148
0.1666	2.482
0.1700	2.959
0.1733	3.150
0.1766	2.473
0.1800	2.368
0.1833	2.454
0.1866	1.995
0.1900	2.148
0.1933	2.253
0.1966	2.454
0.2000	2.177
0.2033	2.616
0.2066	2.387
0.2100	2.482
0.2133	2.349
0.2166	2.473
0.2200	2.110
0.2233	2.396
0.2266	2.339
0.2300	2.368
0.2333	2.368
0.2366	2.434
0.2400	2.377
0.2433	2.358
0.2466	2.387
0.2500	2.301
0.2533	2.358
0.2566	2.349
0.2600	2.349
0.2633	2.301
0.2666	2.358
0.2700	2.339
0.2733	2.339
0.2766	2.320
0.2800	2.358

0.2833	2.320
0.2866	2.368
0.2900	2.320
0.2933	2.368
0.2966	2.320
0.3000	2.339
0.3033	2.329
0.3066	2.339
0.3100	2.339
0.3133	2.320
0.3166	2.320
0.3200	2.291
0.3233	2.368
0.3266	2.301
0.3300	2.329
0.3333	2.291
0.3500	2.301
0.3666	2.301
0.3833	2.329
0.4000	2.301
0.4166	2.311
0.4333	2.282
0.4500	2.301
0.4666	2.301
0.4833	2.263
0.5000	2.282
0.5166	2.272
0.5333	2.282
0.5500	2.272
0.5666	2.263
0.5833	2.234
0.6000	2.253
0.6166	2.244
0.6333	2.272
0.6500	2.253
0.6666	2.234
0.6833	2.244
0.7000	2.224
0.7166	2.224
0.7333	2.224
0.7500	2.234
0.7666	2.215
0.7833	2.224
0.8000	2.234
0.8166	2.205
0.8333	2.205

0.8500	2.205
0.8666	2.205
0.8833	2.205
0.9000	2.205
0.9166	2.205
0.9333	2.196
0.9500	2.205
0.9666	2.186
0.9833	2.196
1.0000	2.186
1.2000	2.167
1.4000	2.158
1.6000	2.177
1.8000	2.139
2.0000	2.110
2.2000	2.110
2.4000	2.158
2.6000	2.148
2.8000	2.119
3.0000	2.100
3.2000	2.091
3.4000	2.072
3.6000	2.100
3.8000	2.053
4.0000	2.081
4.2000	2.062
4.4000	2.053
4.6000	2.034
4.8000	2.043
5.0000	2.034
5.2000	2.034
5.4000	2.005
5.6000	2.024
5.8000	2.005
6.0000	2.005
6.2000	2.024
6.4000	1.995
6.6000	1.967
6.8000	1.986
7.0000	2.062
7.2000	2.072
7.4000	2.034
7.6000	1.995
7.8000	2.062
8.0000	2.024
8.2000	1.967

8.4000	1.957
8.6000	1.986
8.8000	1.909
9.0000	1.909
9.2000	1.986
9.4000	1.957
9.6000	1.948
9.8000	1.957
10.0000	1.967
11.0000	1.948
12.0000	1.929
13.0000	1.900
14.0000	1.909
15.0000	1.890
16.0000	1.890
17.0000	1.871
18.0000	1.919
19.0000	1.823
20.0000	1.909
21.0000	1.890
22.0000	1.805
23.0000	1.814
24.0000	1.823
25.0000	1.814
26.0000	1.814
27.0000	1.814
28.0000	1.785
29.0000	1.776
30.0000	1.747
31.0000	1.785
32.0000	1.737
33.0000	1.709
34.0000	1.747
35.0000	1.776
36.0000	1.776
37.0000	1.737
38.0000	1.671
39.0000	1.737
40.0000	1.766
41.0000	1.728
42.0000	1.728
43.0000	1.718
44.0000	1.728
45.0000	1.718
46.0000	1.747
47.0000	1.699

48.0000	1.728
49.0000	1.699
50.0000	1.709
51.0000	1.709
52.0000	1.699
53.0000	1.699
54.0000	1.680
55.0000	1.690
56.0000	1.661
57.0000	1.661
58.0000	1.661
59.0000	1.671
60.0000	1.671
61.0000	1.652
62.0000	1.671
63.0000	1.661
64.0000	1.652

I-14
ZONE 1510-1540
BACKGROUND DATA

TIME	WATERLEVEL
0.0000	12.420
0.0033	12.337
0.0066	12.399
0.0100	12.403
0.0133	12.436
0.0166	12.457
0.0200	12.387
0.0233	12.333
0.0266	12.469
0.0300	12.432
0.0333	12.428
0.0366	12.420
0.0400	12.254
0.0433	12.341
0.0466	12.544
0.0500	12.250
0.0533	12.453
0.0566	12.486
0.0600	12.473
0.0633	12.341
0.0666	12.341
0.0700	12.560
0.0733	12.444
0.0766	12.391
0.0800	12.399
0.0833	12.544
0.0866	12.374
0.0900	12.523
0.0933	12.411
0.0966	12.258
0.1000	12.461
0.1033	12.461
0.1066	12.362
0.1100	12.444
0.1133	12.457
0.1166	12.333
0.1200	12.498
0.1233	12.564
0.1266	12.428
0.1300	12.333
0.1333	12.432
0.1366	12.453
0.1400	12.387
0.1433	12.432
0.1466	12.453
0.1500	12.304

0.1533	12.391
0.1566	12.490
0.1600	12.316
0.1633	12.515
0.1666	12.428
0.1700	12.366
0.1733	12.436
0.1766	12.449
0.1800	12.320
0.1833	12.453
0.1866	12.465
0.1900	12.374
0.1933	12.411
0.1966	12.320
0.2000	12.366
0.2033	12.556
0.2066	12.399
0.2100	12.362
0.2133	12.291
0.2166	12.527
0.2200	12.424
0.2233	12.424
0.2266	12.366
0.2300	12.366
0.2333	12.535
0.2366	12.411
0.2400	12.490
0.2433	12.267
0.2466	12.453
0.2500	12.482
0.2533	12.341
0.2566	12.672
0.2600	12.535
0.2633	12.349
0.2666	12.424
0.2700	12.477
0.2733	12.490
0.2766	12.511
0.2800	12.329
0.2833	12.325
0.2866	12.345
0.2900	12.519
0.2933	12.341
0.2966	12.585
0.3000	12.345
0.3033	12.399
0.3066	12.407
0.3100	12.296
0.3133	12.498
0.3166	12.234
0.3200	12.308
0.3233	12.469
0.3266	12.428
0.3300	12.473

0.3333	12.420
0.3500	12.465
0.3666	12.449
0.3833	12.461
0.4000	12.515
0.4166	12.172
0.4333	12.362
0.4500	12.440
0.4666	12.477
0.4833	12.353
0.5000	12.411
0.5166	12.246
0.5333	12.436
0.5500	12.382
0.5666	12.387
0.5833	12.502
0.6000	12.420
0.6166	12.498
0.6333	12.449
0.6500	12.395
0.6666	12.577
0.6833	12.411
0.7000	12.329
0.7166	12.316
0.7333	12.370
0.7500	12.515
0.7666	12.378
0.7833	12.349
0.8000	12.457
0.8166	12.399
0.8333	12.428
0.8500	12.316
0.8666	12.399
0.8833	12.308
0.9000	12.362
0.9166	12.461
0.9333	12.325
0.9500	12.391
0.9666	12.349
0.9833	12.531
1.0000	12.523
1.2000	12.449
1.4000	12.415
1.6000	12.362
1.8000	12.362
2.0000	12.411
2.2000	12.411
2.4000	12.382
2.6000	12.440
2.8000	12.465
3.0000	12.349
3.2000	12.420
3.4000	12.300
3.6000	12.345

3.8000	12.577
4.0000	12.424
4.2000	12.387
4.4000	12.407
4.6000	12.320
4.8000	12.473
5.0000	12.395
5.2000	12.254
5.4000	12.473
5.6000	12.420
5.8000	12.482
6.0000	12.382
6.2000	14.049
6.4000	15.320
6.6000	15.315
6.8000	15.328
7.0000	15.336
7.2000	15.340
7.4000	15.344
7.6000	15.701
7.8000	15.357
8.0000	15.357
8.2000	15.365
8.4000	15.361
8.6000	15.365
8.8000	15.365
9.0000	15.369
9.2000	15.382
9.4000	15.374
9.6000	15.411
9.8000	15.378
10.0000	15.390
11.0000	15.411
12.0000	15.407
13.0000	15.407
14.0000	15.415
15.0000	15.419
16.0000	15.427
17.0000	15.436
18.0000	15.436
19.0000	15.444
20.0000	15.448
21.0000	15.523
22.0000	15.452
23.0000	15.460
24.0000	15.494
25.0000	15.452
26.0000	15.465
27.0000	15.456
28.0000	15.469
29.0000	15.473
30.0000	15.489
31.0000	15.502
32.0000	15.477

33.0000	15.494
34.0000	15.502
35.0000	15.489
36.0000	15.481
37.0000	15.502
38.0000	15.485
39.0000	15.494
40.0000	15.502
41.0000	15.481
42.0000	15.502
43.0000	15.531
44.0000	15.502
45.0000	15.527
46.0000	15.510
47.0000	15.498
48.0000	15.518
49.0000	15.518
50.0000	15.547
51.0000	15.518
52.0000	15.518
53.0000	15.523
54.0000	15.502
55.0000	15.514
56.0000	15.527
57.0000	15.576
58.0000	15.547
59.0000	15.535
60.0000	15.531