APPENDIX: Groundwater Study

Hydraulic Conductivity Pump-Test Data

Table 1.

Well Id	Date of Test	Length of Test (min)	Avg Pmp Rate (gpm)	Static Water Level (ft bgs)	Total Depth (ft bgs)	Sat Thick (ft)	Drawdown (ft)	Q/s (gpm/ft)
A-2	10/16/2003	81	2	24.24	42.3	18.1	8.36	0.24
B-2	10/16/2003	122	3.8	13.06	70.1	57	9.72	0.39
C-2	10/17/2003	51	5.7	20.44	46	25.6	NM	NM
D-2	10/17/2003	32	5.7	9.82	36	36.2	0.09	63.33
E-2	10/17/2003	108	1.2	29.52	65	35.5	12.24	0.10
F-2	10/17/2003	68	0.94	26.3	51	24.7	16.6	0.06

Table 2.

Well Id	Analytical Method: Theis		Cooper Jacobs		Newman			
	Transmissivity (ft2/min)	Hyd Conductivity (ft/min)	Transmissivity (ft2/min)	Hyd Conductivity (ft/min)	Transmissivity (ft2/min)	Hyd Conductivity (ft/min)	Average Trans (ft2/min)	Avg Hyd Cond. (ft/min)
A-2	1.30E-02	7.24E-04	1.64E-02	9.10E-04	NA	NA	1.47E-02	8.17E-04
B-2*	3.75E-02	6.60E-04	2.91E-02	5.11E-04	1.49E-02	2.62E-04	7.89E-02	1.39E-03
			2.34E-01	4.11E-03	NA	NA	-	-
C-2**	-	-	-	-	-	-	-	-
D-2	2.90E+00	1.11E-01	3.21E+00	1.22E-01	NA	NA	3.06E+00	1.17E-01
E-2	6.63E-03	1.87E-04	7.38E-03	2.08E-04	NA	NA	7.01E-03	1.98E-04
F-2	3.97E-03	1.60E-04	3.23E-03	1.31E-04	NA	NA	3.60E-03	1.46E-04

*Cooper Jacobs method was applied to two distinct parts of the drawdown curve, the smaller value representing early time, the larger value representing late time in the test.

** No measurable response observed at C-2 during the pumping test of that well

Assume that well C-2 has a least as high a hydraulic conductivity value as D-2

NA-Not analyzed using the listed method.

Table 3.

	Calculations for various units					
	Average Trans (ft2/min)	Avg Hyd Cond. (ft/min)	Average Trans (ft2/day)	Avg Hyd Cond. (ft/day)	Average Trans (cm2/sec)	Avg Hyd Cond. (cm/sec)
A-2	1.47E-02	8.17E-04	2.12E+01	1.18E+00	7.47E-03	4.15E-04
B-2*	7.89E-02	1.39E-03	1.14E+02	2.00E+00	4.01E-02	7.04E-04
C-2**	> 3.06E-00	>1.17E-01	>4.40e+03	>1.68E+02	>1.55E+00	>5.92E-02
D-2	3.06E+00	1.17E-01	4.40E+03	1.68E+02	1.55E+00	5.92E-02
E-2	7.01E-03	1.98E-04	1.01E+01	2.84E-01	3.56E-03	1.00E-04
F-2	3.60E-03	1.46E-04	5.18E+00	2.10E-01	1.83E-03	7.39E-05

Technical Memorandum (Diamond Lake Project)

Introduction

Aquifer tests were performed on six monitor wells located around the periphery of Diamond Lake, Oregon. The tests were conducted to assess hydrologic characteristics of the shallow water table aquifer located in the vicinity of the lake. The aquifer tests consisted of short-term, low flow rate pumping of the following wells; A-2, B-2, C-2, D-2, E-2 and F-2. The aquifer tests are conducted as single well tests with no additional observation wells.

Methodology

The methodology for conducting the aquifer test was as follows. The well cover and cap from the well were removed. Each of the boreholes was completed with 2' PVC casing. A Solinst water level meter was used to determine the depth to water below ground surface and the total depth of the well. Dedicated bailers that were in the well were pulled out. A Grundfos Rediflo 2 submersible pump was lowered in the borehole to approximately one foot from the bottom of the well. The end of discharge hose for the pump was placed at a distance of at least 50 feet from the well. A 4-gallon bucket and a stopwatch were positioned near the discharge hose to measure the pumping rate. Electrical power was supplied to the pump by a Honda EU 1000i generator. A downhole transducer was used to measure changes in head (water levels) during the aquifer test. The transducer was setup to the appropriate operating conditions and initialized using a portable laptop computer. The transducer was lowered into the hole, usually to a depth of one foot above the top of the pump. In some of the tests a second transducer was also placed in the well, approximately five feet above the first transducer. The water level in the well was rechecked to confirm that the water level had stabilized following removal of the bailer and placement of the pump and transducer(s). Once the water level was stabilized, the pump was turned on at a rate of approximately 4 gallons per minute (gpm). Water level readings were periodically taken to determine if the initial pumping rate resulted in acceptable drawdown in the well to continue the test. In two of the aquifer tests, the initial rate resulted in rapid dewatering of the well. For those tests (A-2 and E-2) the test was terminated and the water level was allowed to recover back to the initial static water level. Then the test was rerun using a lower pumping rate. For well F-2, the initial pumping rate was set at approximately 1 gpm. For the tests on wells C-2 and D-2, the 4 gpm initial rate did not result in measurable drawdown so the rate was increased to the maximum capacity of the pump/generator, which was 6 gpm. Following completion of the test, the transducer was removed from the well and the data was downloaded onto the portable laptop computer. The data were then reduced and entered into pumping test analysis software (Aquifer Test by Waterloo Hydrologic Inc.) Recovery data was not used in the data analysis because the pump assembly was not equipped with a backflow preventor, resulting in rapid discharge to the well of water that was still in the discharge pipe when the pump was shut off.

Test Results

The duration, pumping rate, static water level, total depth, saturated thickness and total drawdown for each of the pumping tests are summarized in Table 1.

Analysis of the data included the use of the Theis and the Cooper-Jacobs methods for each well except for the test on C-2, which had no measurable drawdown. Because each of the test were

conducted in an unconfined water table aquifer, the drawdown data were all adjusted using the Jacob correction for unconfined conditions prior to using the Aquifer Test program. The Neuman method for unconfined aquifers was also applied to the B-2 Test. An estimate of aquifer transmissivity was derived from these analytical methods. A value for hydraulic conductivity was calculated by dividing the transmissivity by the saturated thickness of the aquifer. The results of the analysis are provided in Table 2.

Table 3 provides a summary of the average transmissivity and hydraulic conductivity values derived from the analysis in different units of measure for ease of use and evaluation.

Based on the analyses, wells C-2 and D-2 appear to be located in a zone of relatively high transmissivity, compared to the other tested wells. Drawdown in these wells ranged from non measureable to less than 1 tenth of one foot at a pumping rate just under 6 gpm. Hydraulic conductivity for these wells is calculated as greater than 150 ft/d. Wellls A-2 and B-2 are completed in an area of intermediate transmissivity, with hydraulic conductivity values estimated at 1 to 2 ft/d. Wells E-2 and F-2 are completed in a portion of the aquifer with low transmissivity and hydraulic conductivity values are on the order of 0.2 to 0.3 ft/d

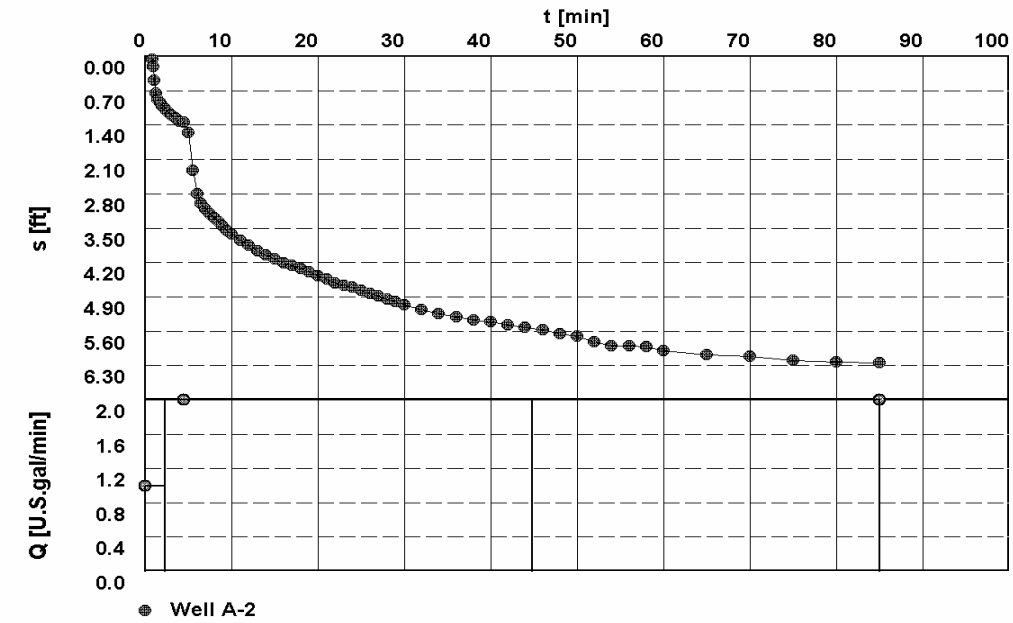
Summary

Short-term low flow rate pumping tests were conducted on six monitoring wells located along the edges of Diamond Lake. The pumping tests, although limited in duration, provide at least a relative estimate of aquifer properties of the water table aquifer in the immediate vicinity of the lake. The results of the testing and analysis can be used to develop a conceptual model of the groundwater flow budget.

Pumping Test Analysis-Diamond Lake Project
Pumping Test – Well A-2
Discharge Rate – 1.97 gallons per minute

Evaluated by E. Lawrence
Date of Test - 10/16/03

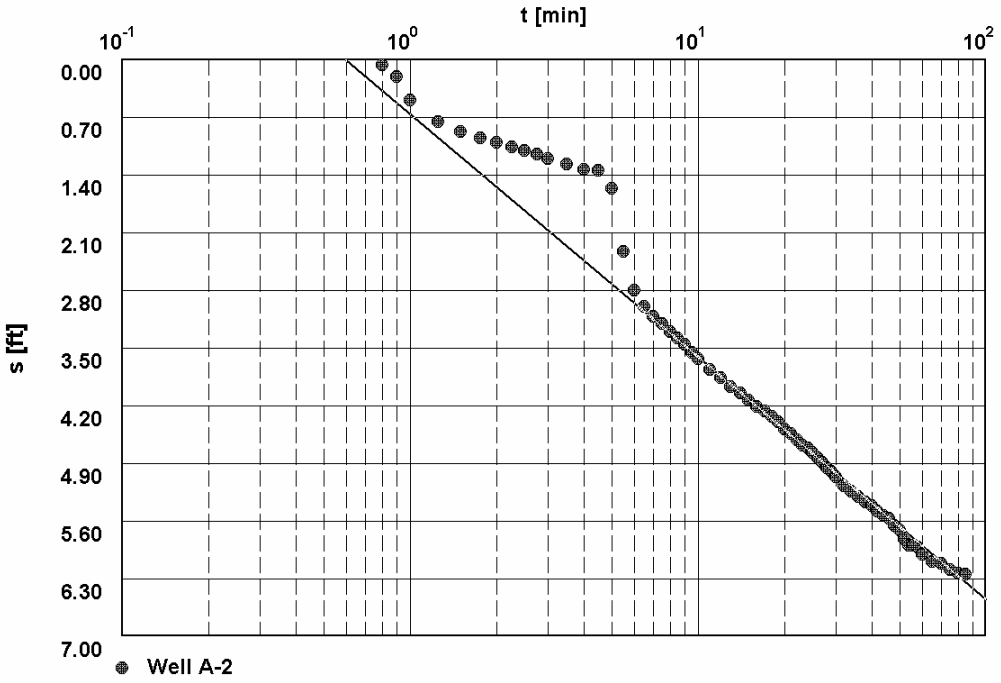
A-2 Pumping Test - Time Drawdown Plot with Discharge



A-2 Pumping Test Data

Time (min)	Drawdown (ft)	Time (min)	Drawdown (ft)
0.8	0.07	21	4.54
0.9	0.21	22	4.62
1	0.49	23	4.68
1.25	0.75	24	4.71
1.5	0.88	25	4.77
1.75	0.95	26	4.83
2	1.01	27	4.89
2.25	1.06	28	4.95
2.5	1.11	29	5
2.75	1.15	30	5.06
3	1.2	32	5.17
3.5	1.27	34	5.24
4	1.33	36	5.31
4.5	1.35	38	5.37
5	1.56	40	5.41
5.5	2.33	42	5.48
6	2.8	44	5.53
6.5	3	46	5.57
7	3.12	48	5.65
7.5	3.21	50	5.71
8	3.3	52	5.82
8.5	3.38	54	5.9
9	3.46	56	5.9
9.5	3.55	58	5.92
10	3.63	60	6
11	3.76	65	6.09
12	3.86	70	6.11
13	3.97	75	6.19
14	4.05	80	6.23
15	4.13	85	6.25
16	4.21		
17	4.27		
18	4.33		
19	4.4		
20	4.48		

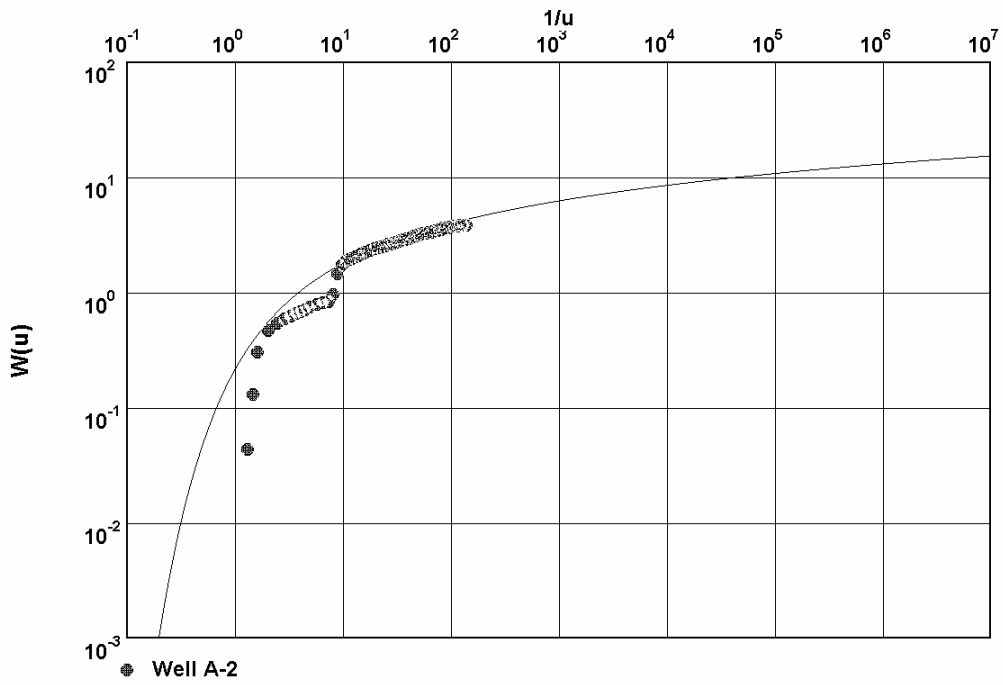
A-2 Pumping Test Analysis - Cooper-Jacobs Method



Results of A-2 Pumping Test Analysis

Transmissivity (ft^2/min)-1.64x10^{-2} Hydraulic conductivity (ft/min) – 9.1 x 10^{-4}
Saturated Thickness (ft) – 18.02

A-2 Pumping Test Analysis-Theis Method



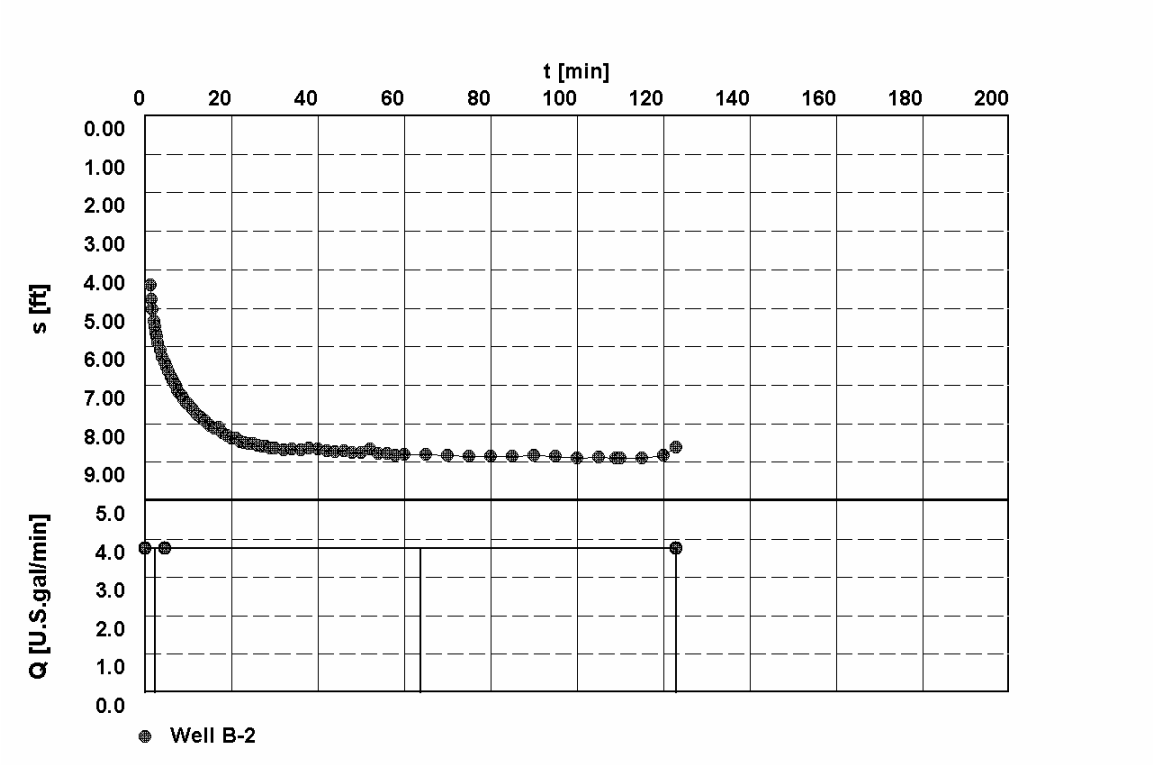
Results of A-2 Pumping Test Analysis

Transmissivity (ft^2/min)-1.3x10^{-2} Hydraulic conductivity (ft/min) – 7.24 x 10^{-4}
Saturated Thickness (ft) – 18.02

Pumping Test Analysis-Diamond Lake Project
Pumping Test – Well B-2
Discharge Rate – 3.75 gallons per minute

Evaluated by E. Lawrence
Date of Test - 10/16/03

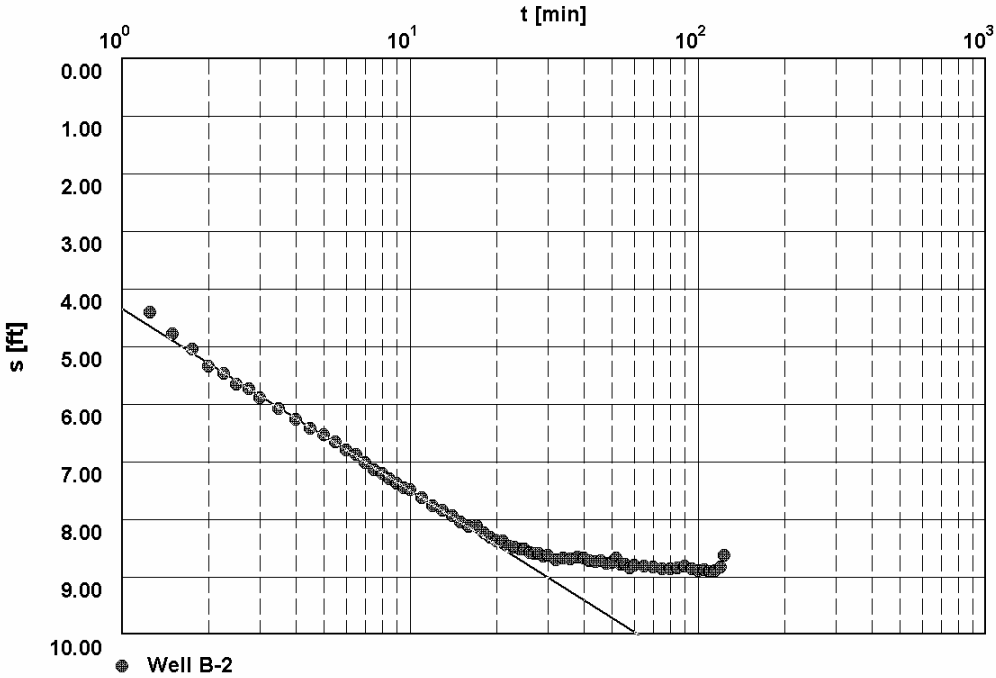
B-2 Pumping Test - Time Drawdown Plot with Discharge



B-2 Pumping Test Data

Time (min)	Drawdown (ft)	Time (min)	Drawdown (ft)
1.25	4.41	26	8.58
1.5	4.78	27	8.6
1.75	5.04	28	8.59
2	5.34	29	8.64
2.25	5.47	30	8.63
2.5	5.65	32	8.7
2.75	5.73	34	8.67
3	5.89	36	8.69
3.5	6.08	38	8.65
4	6.27	40	8.67
4.5	6.42	42	8.72
5	6.53	44	8.74
5.5	6.66	46	8.72
6	6.8	48	8.76
6.5	6.88	50	8.75
7	7.01	52	8.67
7.5	7.14	54	8.78
8	7.21	56	8.78
8.5	7.29	58	8.84
9	7.38	60	8.8
9.5	7.46	65	8.81
10	7.49	70	8.83
11	7.63	75	8.86
12	7.77	80	8.86
13	7.85	85	8.85
14	7.93	90	8.82
15	8.05	95	8.86
16	8.13	100	8.89
17	8.11	105	8.88
18	8.24	109	8.9
19	8.31	110	8.91
20	8.38	115	8.89
21	8.38	120	8.83
22	8.47	123	8.62
23	8.49		
24	8.52		
25	8.52		

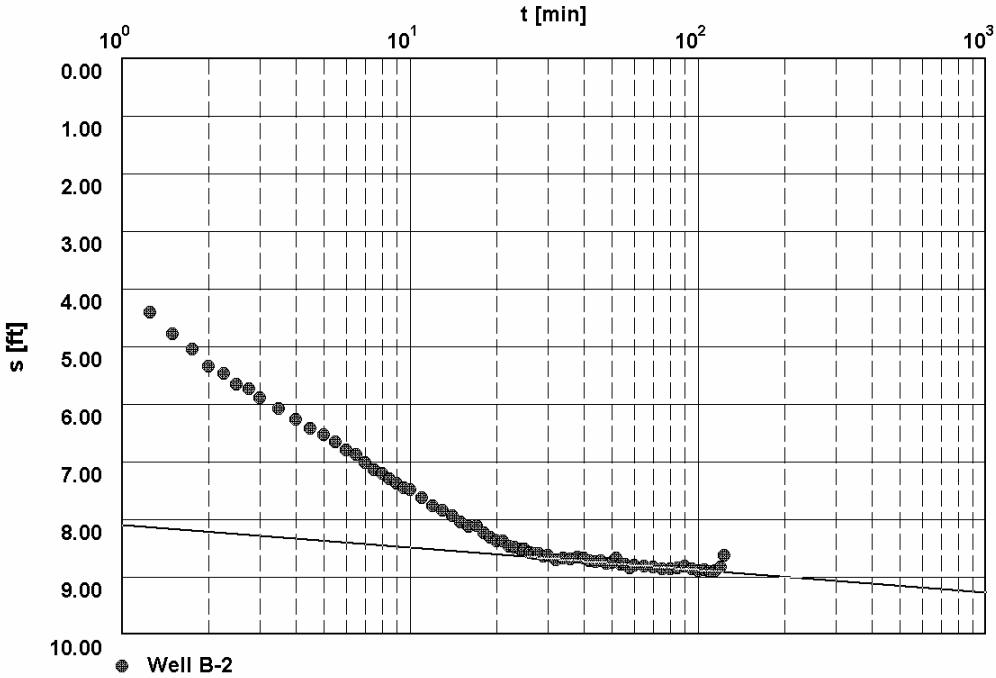
B-2 Pumping Test Analysis - Cooper-Jacobs Method



Results of B-2 Pumping Test Analysis

Transmissivity (ft^2/min)-2.91×10^{-2} Hydraulic conductivity (ft/min) – 5.11×10^{-4}
Saturated Thickness (ft) – 56.94

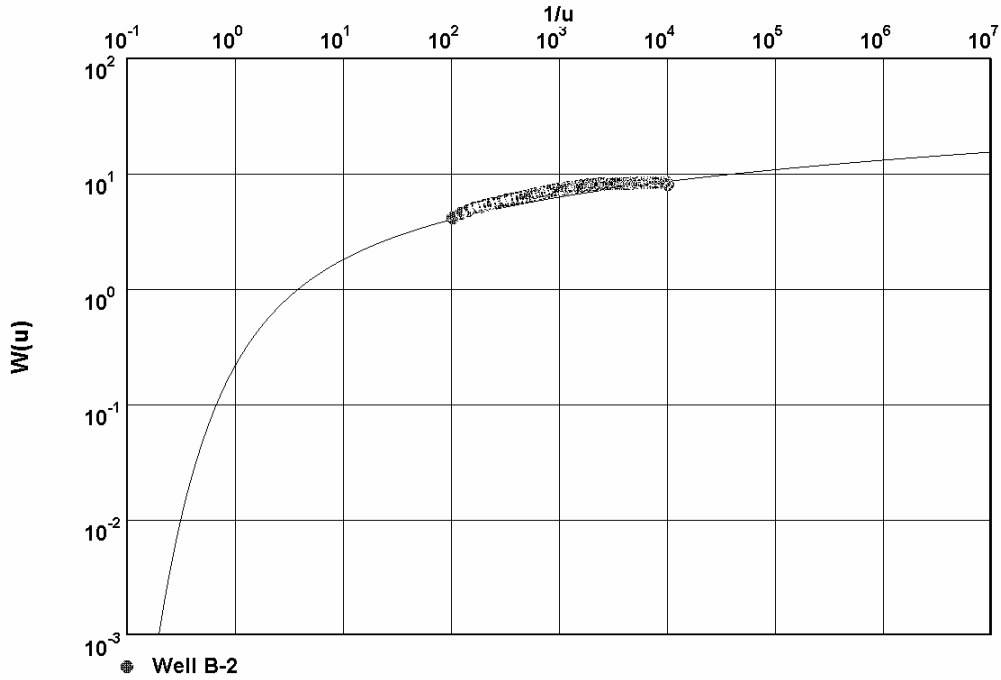
B-2 Pumping Test Analysis - Cooper-Jacobs Method –2nd Analysis



Results of B-2 Pumping Test Analysis

Transmissivity (ft^2/min)-2.34×10^{-1} Hydraulic conductivity (ft/min) – 4.11×10^{-3}
Saturated Thickness (ft) – 56.94

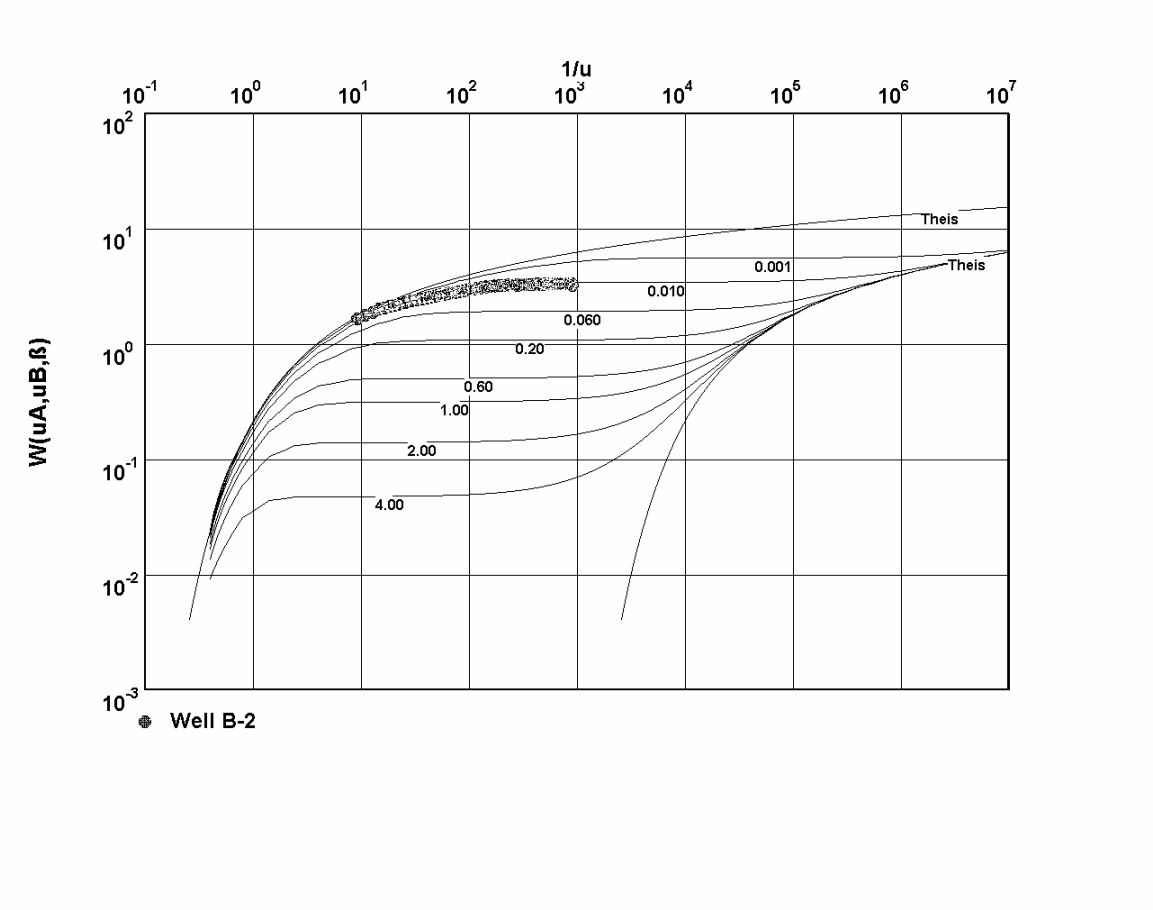
B-2 Pumping Test Analysis-Theis Method



Results of B-2 Pumping Test Analysis

Transmissivity (ft^2/min)-3.75x10^{-2} Hydraulic conductivity (ft/min) – 6.60 x 10^{-4}
Saturated Thickness (ft) – 56.94

B-2 Pumping Test Analysis-Neuman Method



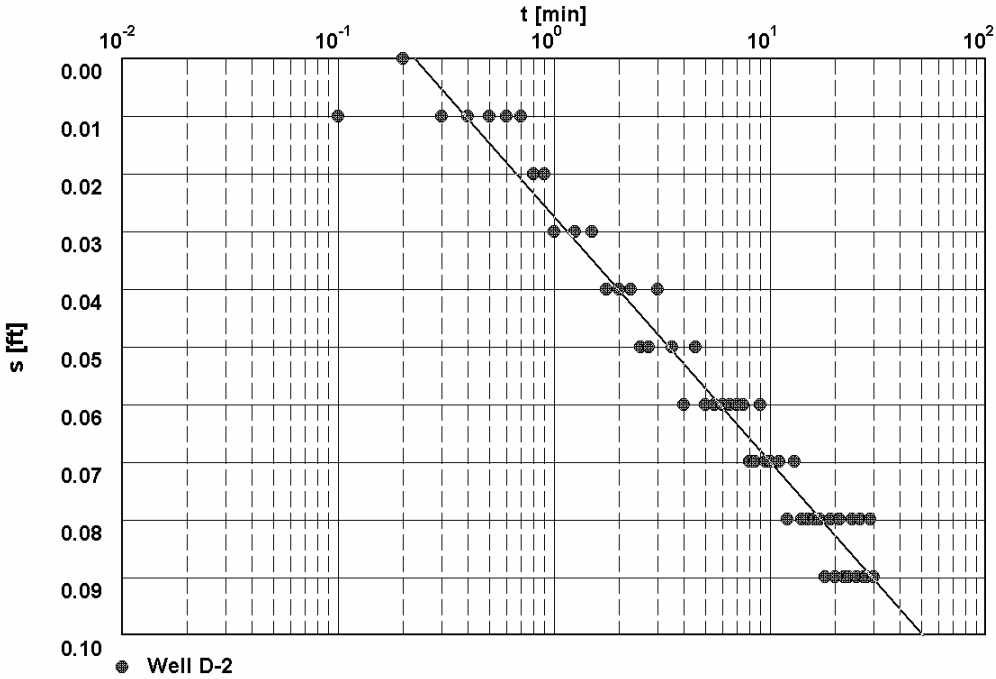
Results of B-2 Pumping Test Analysis

Transmissivity (ft^2/min)-1.49x10^{-2} Hydraulic conductivity (ft/min) – 2.62 x 10^{-4}
Saturated Thickness (ft) – 56.94

Pumping Test Analysis-Diamond Lake Project
Pumping Test – Well D-2
Discharge Rate – 5.58 gallons per minute

Evaluated by E. Lawrence
Date of Test - 10/17/03

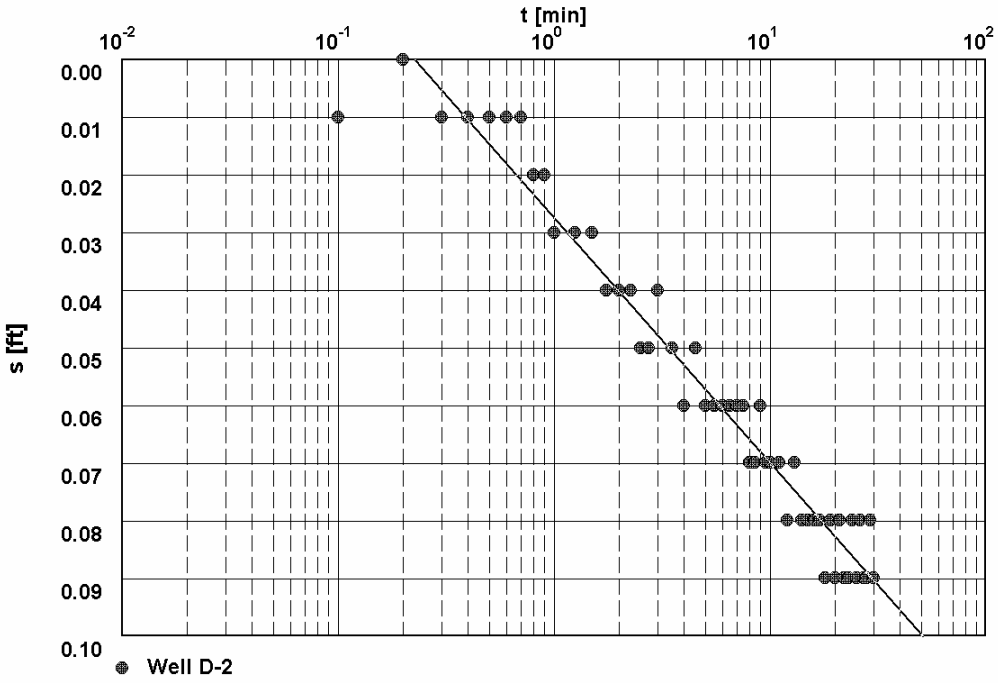
D-2 Pumping Test - Time Drawdown Plot with Discharge



D-2 Pumping Test Data

Time (min)	Drawdown (ft)	Time (min)	Drawdown (ft)
0.1	0.01	11	0.07
0.2	0	12	0.08
0.3	0.01	13	0.07
0.4	0.01	14	0.08
0.5	0.01	15	0.08
0.6	0.01	16	0.08
0.7	0.01	17	0.08
0.8	0.02	18	0.09
0.9	0.02	19	0.08
1	0.03	20	0.09
1.25	0.03	21	0.08
1.5	0.03	22	0.09
1.75	0.04	23	0.09
2	0.04	24	0.08
2.25	0.04	25	0.09
2.5	0.05	26	0.08
2.75	0.05	27	0.09
3	0.04	28	0.09
3.5	0.05	29	0.08
4	0.06	30	0.09
4.5	0.05		
5	0.06		
5.5	0.06		
6	0.06		
6.5	0.06		
7	0.06		
7.5	0.06		
8	0.07		
8.5	0.07		
9	0.06		
9.5	0.07		
10	0.07		

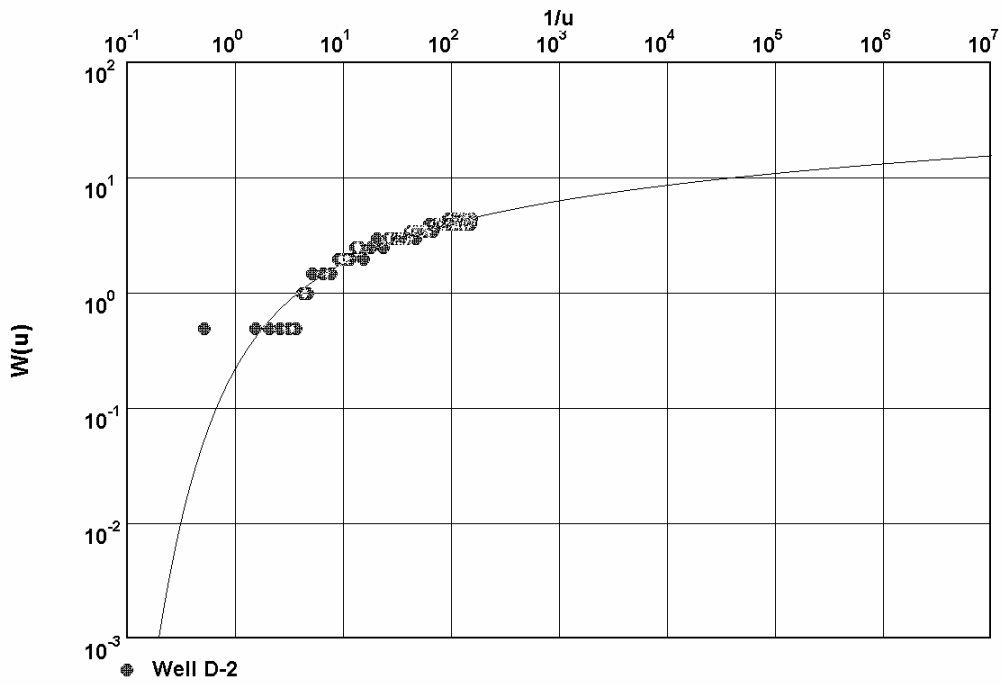
D-2 Pumping Test Analysis - Cooper-Jacobs Method



Results of D-2 Pumping Test Analysis

Transmissivity (ft^2/min)- 3.21 Hydraulic conductivity (ft/min) – 1.22×10^{-1}
Saturated Thickness (ft) – 26.18

D-2 Pumping Test Analysis-Theis Method



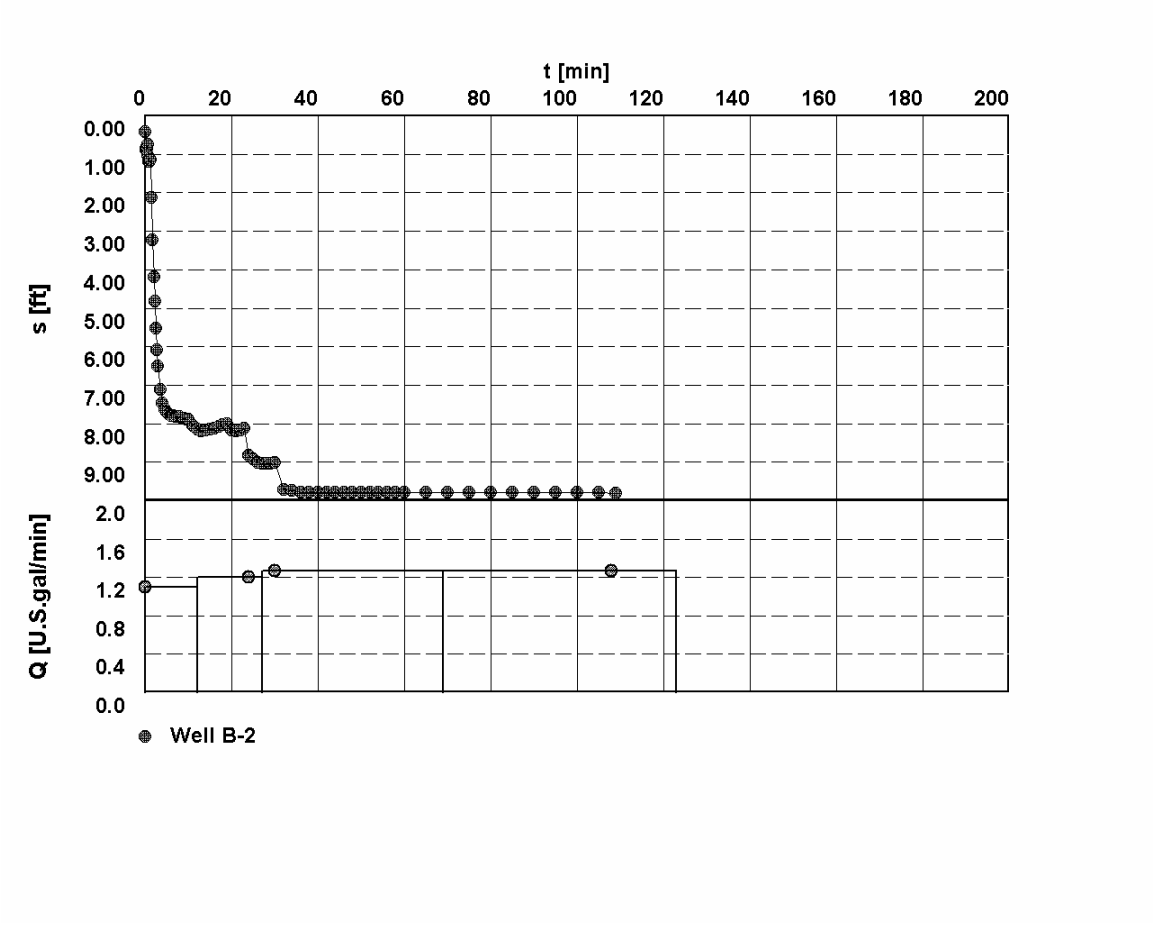
Results of D-2 Pumping Test Analysis

Transmissivity (ft^2/min)- 2.90 Hydraulic conductivity (ft/min) – 1.11×10^{-1}
Saturated Thickness (ft) – 26.18

Pumping Test Analysis-Diamond Lake Project
Pumping Test – Well E-2
Discharge Rate – 1.24 gallons per minute

Evaluated by E. Lawrence
Date of Test - 10/17/03

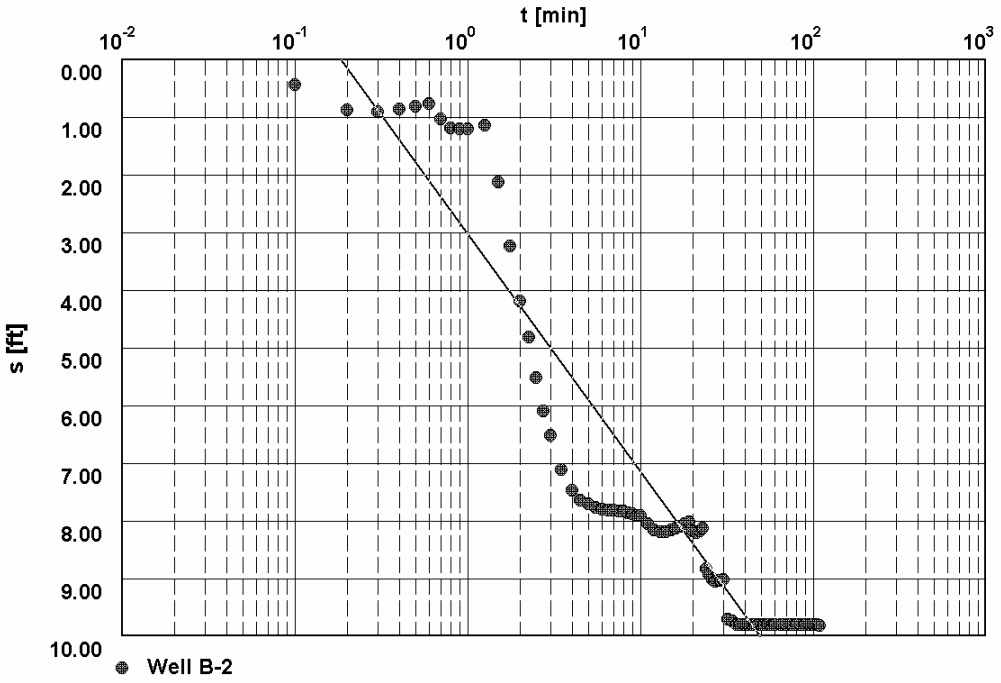
E-2 Pumping Test - Time Drawdown Plot with Discharge



E-2 Pumping Test Data

Time (min)	Drawdown (ft)	Time (min)	Drawdown (ft)
0.1	0.43	21	8.2
0.2	0.87	22	8.17
0.3	0.9	23	8.13
0.4	0.86	24	8.83
0.5	0.82	25	8.92
0.6	0.76	26	9.02
0.7	1.03	27	9.04
0.8	1.18	28	9.03
0.9	1.2	29	9.03
1	1.2	30	9.01
1.25	1.14	32	9.71
1.5	2.13	34	9.74
1.75	3.24	36	9.8
2	4.19	38	9.79
2.25	4.82	40	9.8
2.5	5.52	42	9.79
2.75	6.09	44	9.79
3	6.52	46	9.79
3.5	7.11	48	9.79
4	7.47	50	9.79
4.5	7.64	52	9.79
5	7.71	54	9.79
5.5	7.76	56	9.79
6	7.8	58	9.79
6.5	7.81	60	9.79
7	7.82	65	9.8
7.5	7.83	70	9.8
8	7.83	75	9.8
8.5	7.86	80	9.8
9	7.88	85	9.8
9.5	7.9	90	9.8
10	7.9	95	9.8
11	8.05	100	9.8
12	8.15	105	9.8
13	8.19	109	9.81
14	8.18		
15	8.16		
16	8.12		
17	8.09		
18	8.04		
19	8.02		
20	8.17		

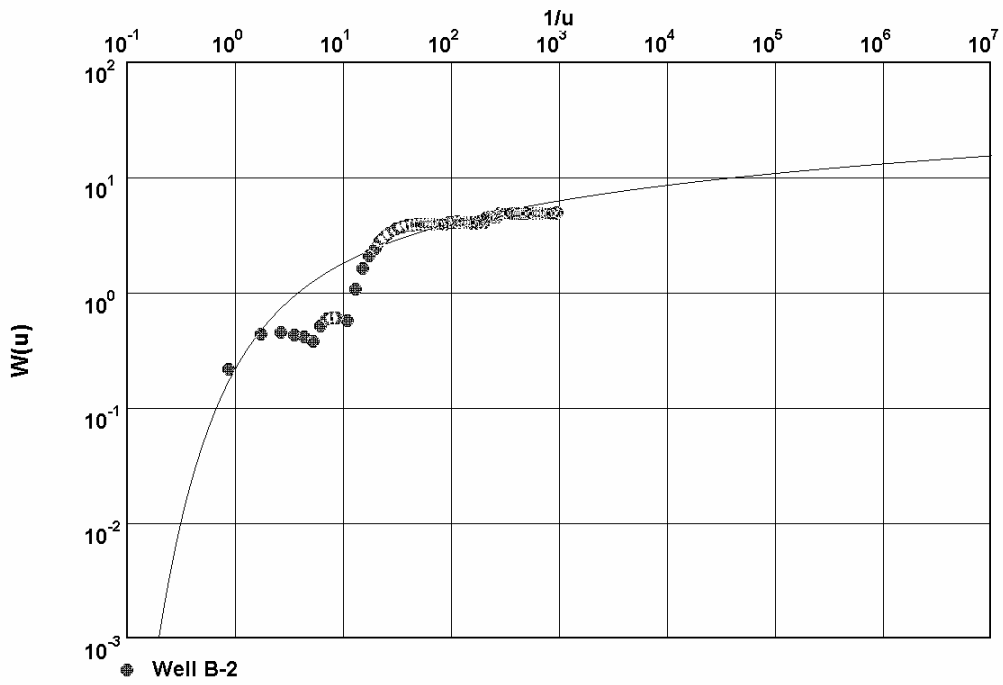
E-2 Pumping Test Analysis - Cooper-Jacobs Method



Results of E-2 Pumping Test Analysis

Transmissivity (ft^2/min)- 7.38 x 10^{-3} Hydraulic conductivity (ft/min) – 2.08 x 10^{-4}
Saturated Thickness (ft) – 35.44

E-2 Pumping Test Analysis-Theis Method



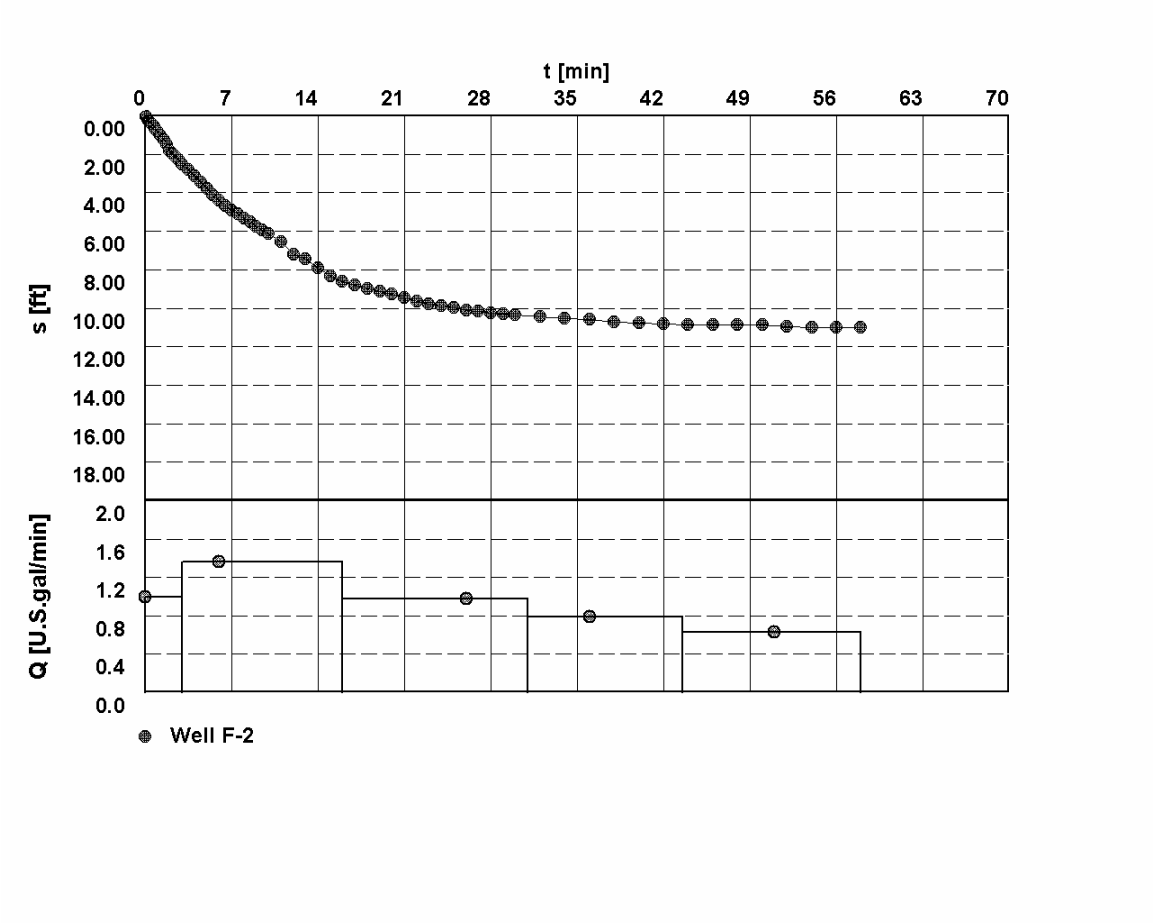
Results of E-2 Pumping Test Analysis

Transmissivity (ft^2/min)- 6.63 x 10^{-3} Hydraulic conductivity (ft/min) – 1.87 x 10^{-4}
Saturated Thickness (ft) – 35.44

Pumping Test Analysis-Diamond Lake Project
Pumping Test – Well F-2
Discharge Rate – 0.94 gallons per minute

Evaluated by E. Lawrence
Date of Test - 10/17/03

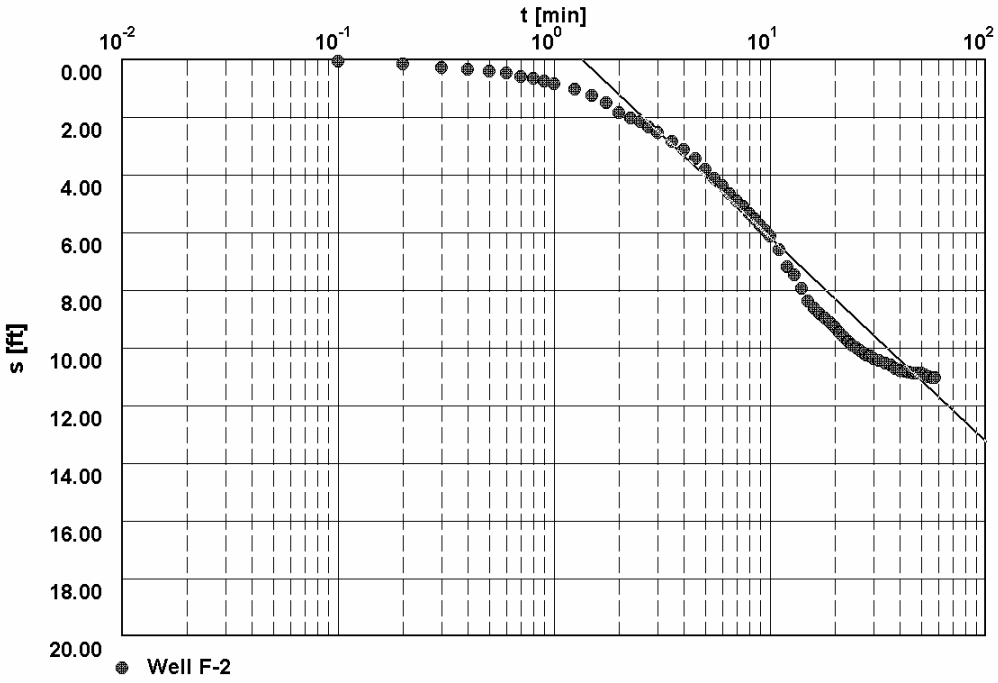
F-2 Pumping Test - Time Drawdown Plot with Discharge



F-2 Pumping Test Data

Time (min)	Drawdown (ft)	Time (min)	Drawdown (ft)
0.1	0.06	11	6.58
0.2	0.17	12	7.19
0.3	0.27	13	7.46
0.4	0.33	14	7.93
0.5	0.42	15	8.36
0.6	0.47	16	8.61
0.7	0.58	17	8.8
0.8	0.67	18	8.98
0.9	0.75	19	9.14
1	0.83	20	9.29
1.25	1.03	21	9.48
1.5	1.26	22	9.64
1.75	1.49	23	9.77
2	1.85	24	9.9
2.25	2.03	25	10
2.5	2.16	26	10.1
2.75	2.34	27	10.18
3	2.54	28	10.24
3.5	2.83	29	10.29
4	3.13	30	10.36
4.5	3.45	32	10.45
5	3.81	34	10.53
5.5	4.11	36	10.59
6	4.39	38	10.71
6.5	4.67	40	10.78
7	4.91	42	10.82
7.5	5.1	44	10.85
8	5.33	46	10.86
8.5	5.54	48	10.86
9	5.75	50	10.87
9.5	5.94	52	10.94
10	6.13	54	11
		56	11.03
		58	11.03

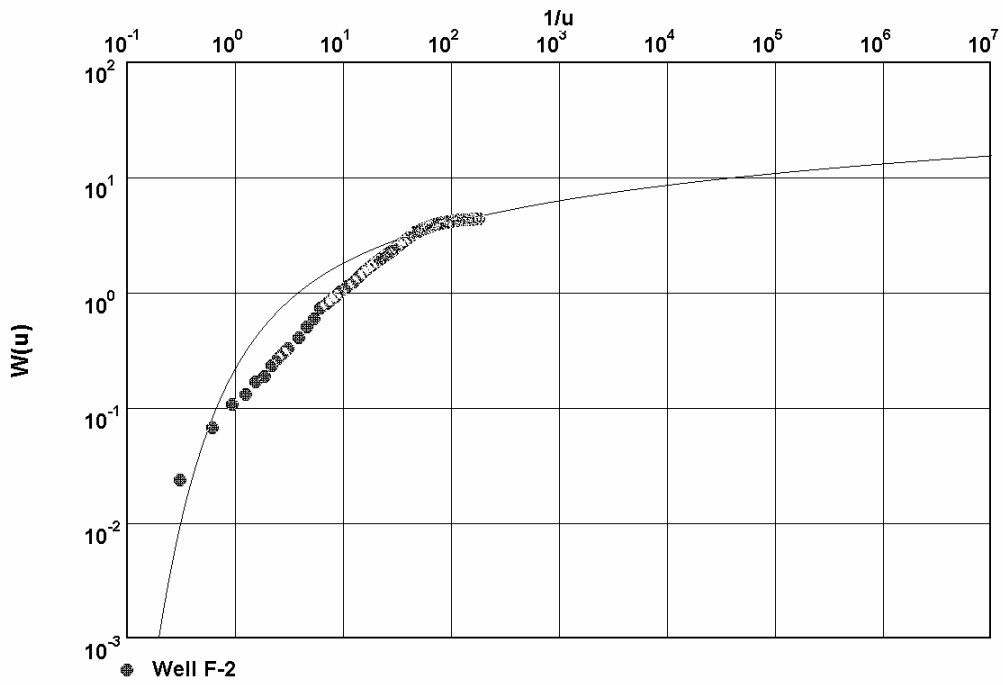
F-2 Pumping Test Analysis - Cooper-Jacobs Method



Results of F-2 Pumping Test Analysis

Transmissivity (ft^2/min)- 3.23 x 10^{-3} Hydraulic conductivity (ft/min) – 1.31 x 10^{-4}
Saturated Thickness (ft) – 24.70

F-2 Pumping Test Analysis-Theis Method



Results of F-2 Pumping Test Analysis

Transmissivity (ft^2/min)- 3.97 x 10^{-3} Hydraulic conductivity (ft/min) – 1.60 x 10^{-4}
Saturated Thickness (ft) – 24.70