LIONS PARK WELL - WTN 83010, 82E 013 341 #32
CPR WELL - WTN 83011, 82E 013 341 #31
RENOVATED 16" BLACK SAGE WELL - WTN 49481, 82E 013132 #11

BUCHANAN RD WELL - WTN 21873
82E 023123 #15

ROCKCLIFFE WELL (WELL NO. 4)
- WTN 82376, 82E 013 332 #2

TOWN OF OLIVER

Reference Materials for Groundwater Wells

(1) Buchannan Road Well
(2) Tuc-el-Nuit Wells
(3) Lions Park and CPR Wells
(4) Fairview Well
(5) Rockcliffe Well
(6) System 2 – Black Sage Wells - RENOVATED 16" WELL - WTN 49481
(7) Oliver Area Groundwater Study –
Water Management Branch 1985

prepared by

TRUE
CONSULTING GROUP

***TRUE* Consulting Group**
May 2002

BRITISH COLUMBIA

Well Tag Number 000000021873

Owner: S.O.L.I.D.

Address:

Area: TUG-UL-NUIT LAKE

WELL LOCATION:
SIMILKAMEEN Land District
District Lot 2450S Plan 2280 Lot 718
Township Section Range
Indian Reserve Meridian Block
Quarter
Island
BCGS Number (NAD 27) 082E023123 Well 15

Well Use Unknown Well Use
Construction Method Drilled
Diameter 8.0 inches
Well Depth 114.0 feet
Elevation 0
Bedrock Depth UNK feet
Screen from 57 to 72 feet
Slot Size 1 0 Slot Size 2 0
Slot Size 3 0 Slot Size 4 0

Construction Date 19681009

Driller OSYOOS TILE WORKS
License Number

PRODUCTION DATA AT TIME OF DRILLING:
Well Yield 402 USGM
Artesian Flow 0
Static Level 7 feet

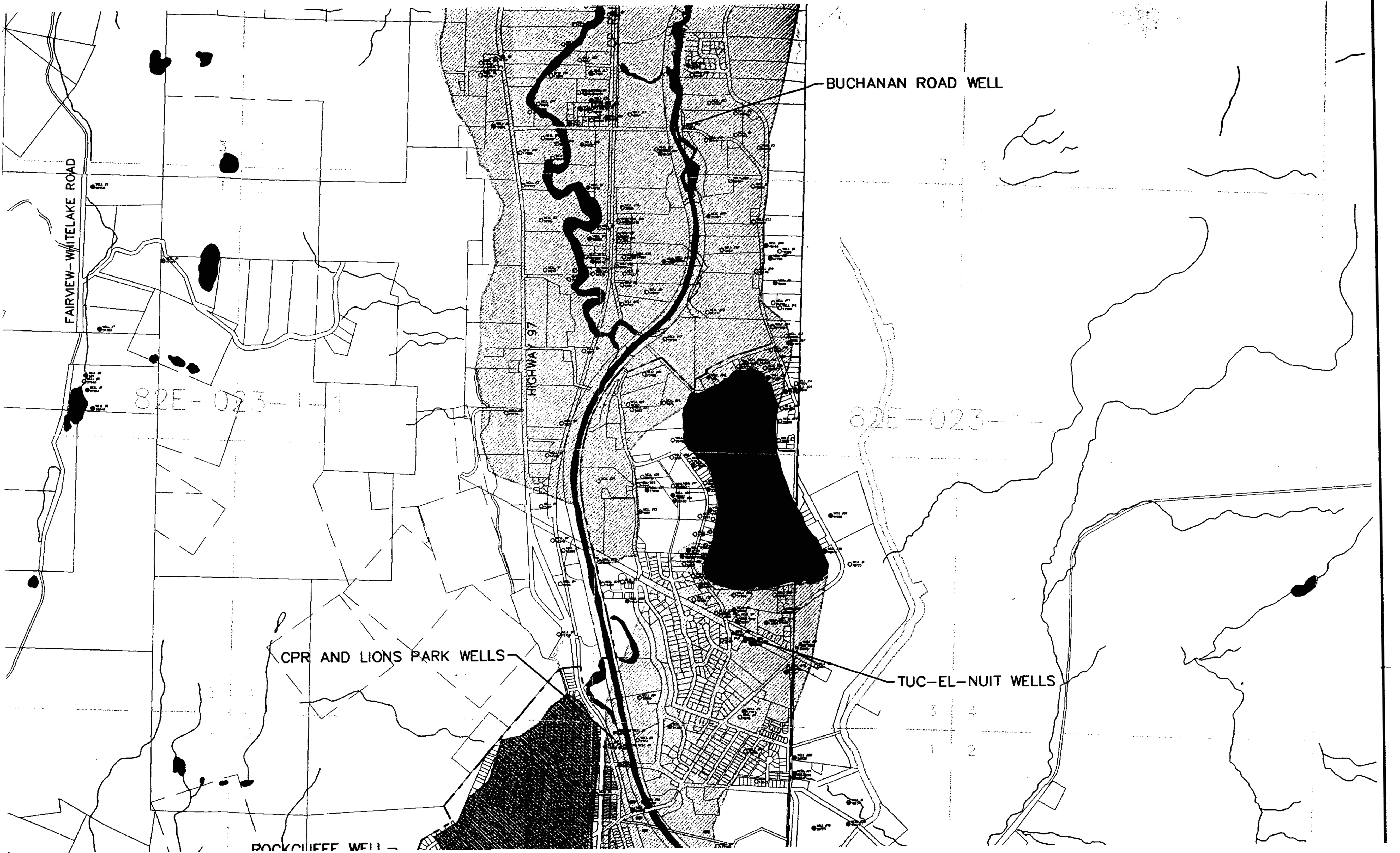
Water Utility
Lithology Info Flag Y
Pump Test Info Flag
File Info Flag
Sieve Info Flag
Screen Info Flag
Water Chemistry Info Flag
Field Chemistry Info Flag
Site Info (SEAM)
Other Info Flag

GENERAL REMARKS:
ANOTHER CARD ATTACHED

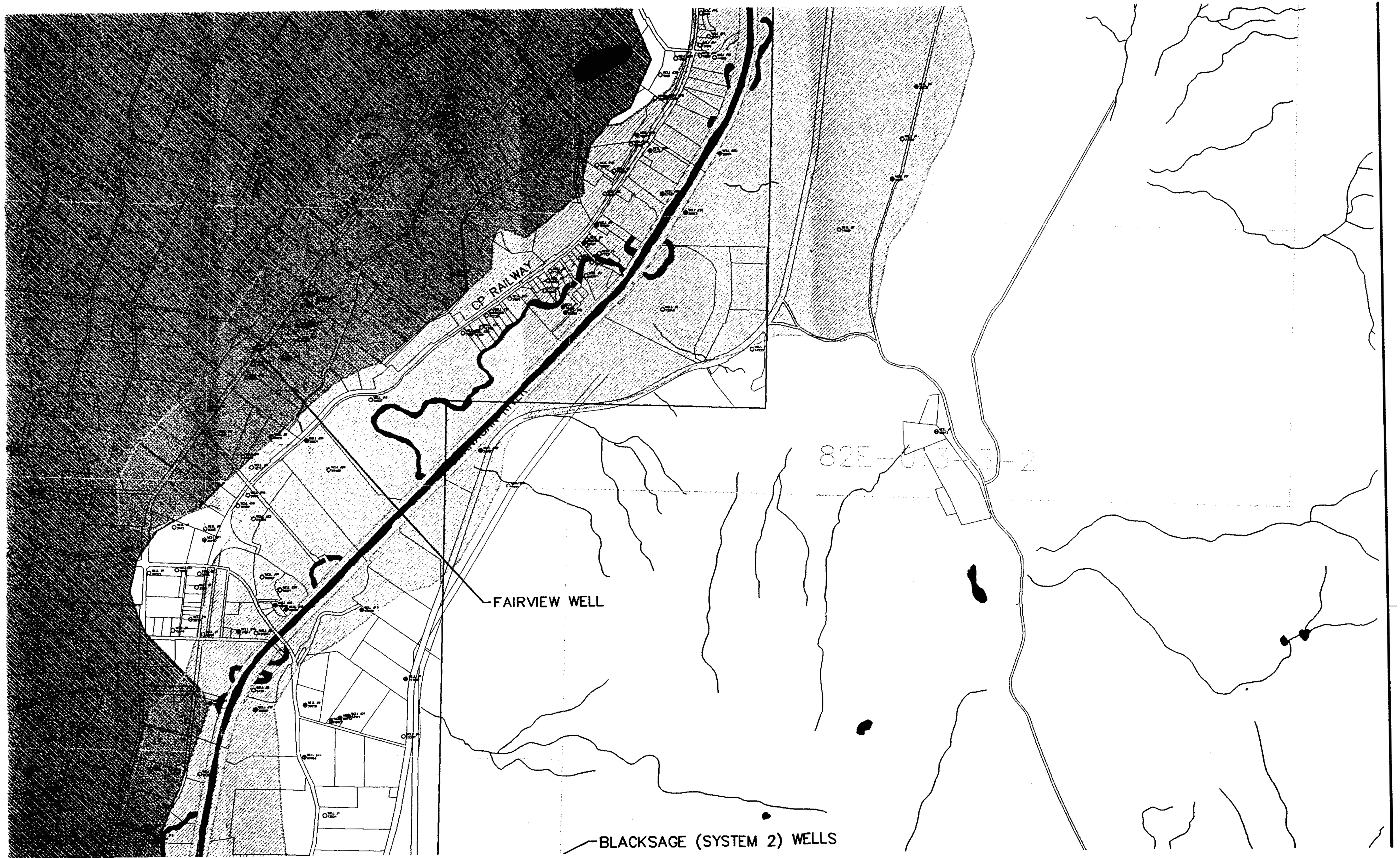
From	0	To	5	Ft.	compact clayish sand
From	5	To	24	Ft.	sharp gravel and sand (static 6'10" at
From	0	To	0	Ft.	24 ft.)
From	24	To	32	Ft.	sand and gravel, some silt (tight)
From	32	To	46	Ft.	sand and gravel, some silt (loose) (sta-
From	0	To	0	Ft.	tic 5'2" at 46 ft.)
From	46	To	74	Ft.	gravel and sand (loose and permeable)
From	74	To	95	Ft.	brown sandy silt
From	0	To	0	Ft.	
From	0	To	0	Ft.	Note: any gravel in the samples from
From	0	To	0	Ft.	80' to 100' is presumably caved down
From	0	To	0	Ft.	from the 74 ft. level.
From	0	To	0	Ft.	Caving stopped at 95 ft.
From	95	To	110	Ft.	blue silt
From	114	To	0	Ft.	? gravel
From	0	To	0	Ft.	
From	0	To	0	Ft.	Note: drilled open hole for 20 ft. to
From	0	To	0	Ft.	114 ft. Caving at 114 ft. S.W.L. (well
From	0	To	0	Ft.	depth 95 ft.) 6'3"

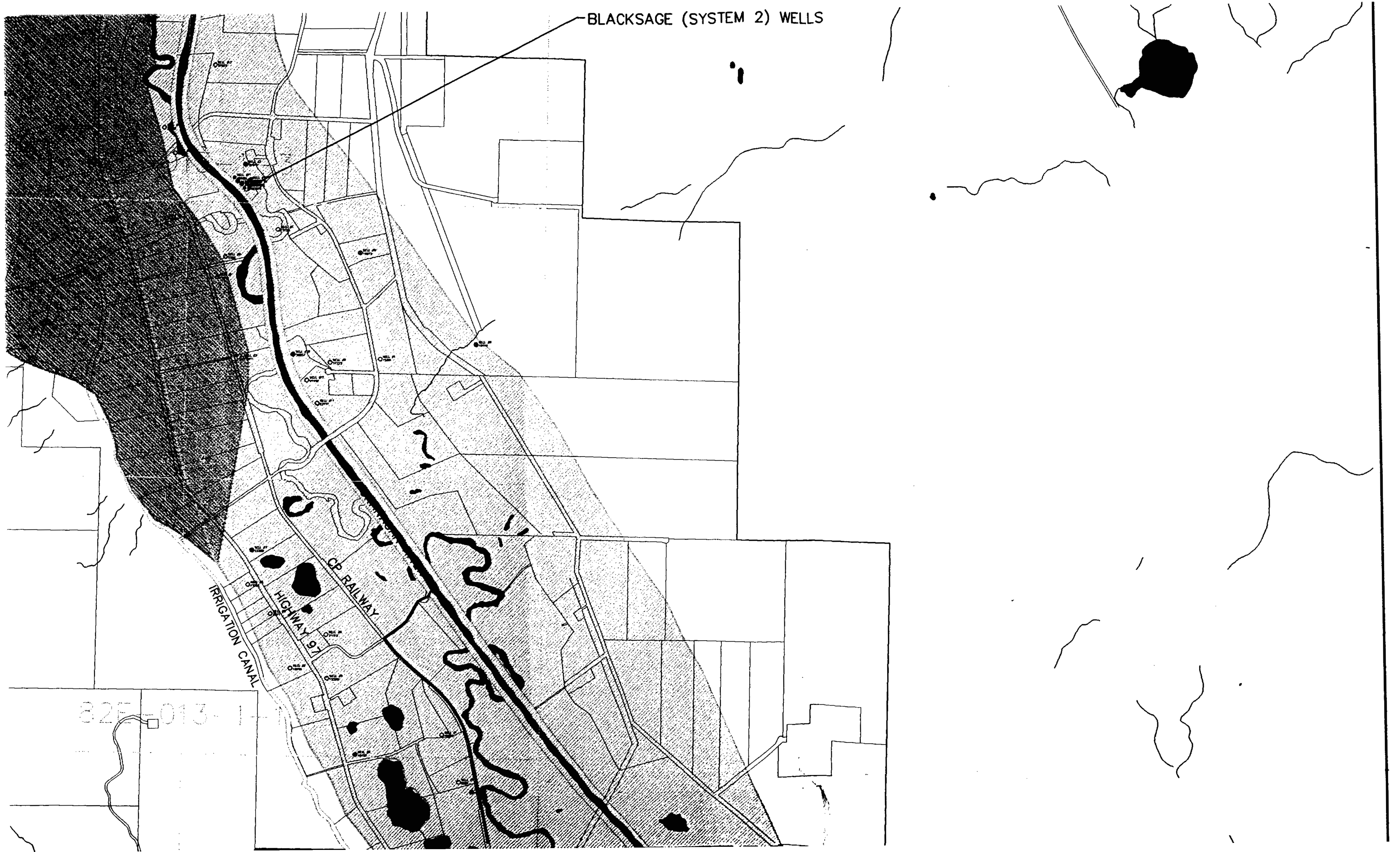
19 rows selected.

Date entered to WELL


BUCHANAN ROAD WELL
FAIRVIEW-WHITELAKE ROAD
HIGHWAY 97
82E-023-1-1
82E-023-
CPR AND LIONS PARK WELLS
TUC-EL-NUIT WELLS
ROCKCLIFFE WELL


N


CP RAILWAY
FAIRVIEW WELL
BLACKSAGE (SYSTEM 2) WELLS


BLACKSAGE (SYSTEM 2) WELLS
CP RAILWAY
HIGHWAY 97
IRRIGATION CANAL
82E-013-1-1

9				
8				
7				
6				
5				
4				
3				

SCALE	1:20,000
DESIGN BY	TRU
DRAWN BY	VW/DL
DATE	MAY 2002
CHK. BY:	
DATE	

TOWN OF OLIVER

OVERALL PLAN ILLUSTRATING

-EXISTING WELLS
-AQUIFERS

Kala Groundwater Consulting Ltd.
Vernon - Kamloops
Water Supply and Environmental Assessments

January 5, 2000

Town of Oliver
34765 – 91st Street
Box 638
Oliver, B.C.
V0H 1T0

Attention: Bruce Hamilton

Dear Sirs:

Re: Aquifer Evaluation
Tuc El Nuit Pump Station

1.0 Introduction

The present groundwater study has been undertaken at the request of the Town of Oliver to assess aquifer performance in the vicinity of the Tuc El Nuit Pump Station and to determine the possibility of increasing production from the existing well field. More specifically, the program was carried out with two basic objectives in view, namely: (a) to determine the feasibility of increasing the capacity of Well No. 2 from 700 USgpm to 1200 USgpm, and (b) allowing for drawdown interference while pumping Well No. 2 at 1200 USgpm, determine the feasibility of continuing production from Wells 1 and 3 at the original rated capacities of 200 and 500 USgpm respectively.

The program has involved a 24-hour pumping test with Well No. 2, noting drawdown interference in Wells 1 and 3. The following report outlines the results of the program and provides recommendations for a safe sustained yield from each of the three existing water wells, along with recommended pump settings. A brief background on the existing wells is provided in the section which follows, and detailed data obtained during the pumping test program is attached to the Appendices of this report.

#3 - 3107A - 31st Avenue, Vernon, B.C. V1T 2G9 . Tel: (250) 545-1720 Fax: (250) 545-1720 E-mail: Kalapal@mindlink.net
#207 - 220 4th Avenue, Kamloops, B.C. V2C 3N6 . Tel: (250) 372-9194 Fax: (250) 372-9398 E-mail: Kalapac@kamloops.net

2.0 Background

The Tuc El Nuit Pump Station is comprised of three wells which range between 45 and 47 feet (13.7 and 14.3 metres) in depth. Based on a previous study conducted by the B.C. Ministry of Environment, Groundwater Section, the existing wells are completed in an unconfined aquifer which is probably in direct hydraulic communication with Tuc El Nuit Lake. The aquifer is considered to be an abandoned channel of the Okanagan River, or its post glacial counterpart. Wells 1 and 2 were constructed in 1971 on a consulting basis by the Groundwater Section of the Inventory and Engineering Branch, B.C. Ministry of Environment. Well No. 2 was completed in 1982 under the supervision of Kala Groundwater Consulting Ltd. A brief summary of well construction and well performance is provided in Table 1 following.

Table 1 – Summary of Existing Wells – Tuc El Nuit Pump Station				
Well Designation	***Well Depth***	***Well Diameter***	***Screened Interval***	***Specific Capacity In USgpm per foot of drawdown***
Well 1	46 feet	8-inch	36.0 to 46.0 ft.	110 USgpm, pumping at 250 USgpm
Well 2	47 feet	12-inch	34.0 to 47.0 ft.	405 USgpm, pumping at 700 USgpm
Well 3	45 feet	10-inch	32.6 to 45.0 ft.	206 USgpm, pumping at 627 USgpm

3.0 Description of Present Program

The present program has involved a 24-hour constant rate pumping test with Well No. 2, noting water level drawdown in the pumping well and drawdown interference in the two adjoining wells (Wells 1 and 3). During the initial 50 minutes of the pumping interval, a step-drawdown test was conducted, pumping the well at progressively higher rates for 10 minute intervals. It was planned to increase the pumping rate to 1200 USgpm for the final step, starting at 51 minutes into the test, but 1125 USgpm was the maximum the existing pump equipment could produce. The 1125 USgpm pumping rate was maintained from 51 minutes until the end of the test. The initial pumping rates used during the step-drawdown test were 707, 797, 904, 999, and 1100 USgpm. Following termination of the pumping interval, recovery was measured in all of the wells for a 24-hour period.

During the pumping interval, water was discharged to waste into Tuc El Nuit Lake through 8-inch lay-flat pipe. The pumping rate was monitored using a conventional orifice discharge and piezometer tube. Water levels in the existing wells were measured with electric well sounders.

4.0 Program Findings

Results of the pumping test have been tabulated and plotted on semi-log and log-log plots of drawdown versus time (See Appendices). A summary of results obtained from the initial step-drawdown test is shown in Table 2 following.

Table 2 – Summary of Step-Drawdown Test Results				
Step Number	*Pumping Rate*	*Drawdown in Meters*	*Drawdown in Feet*	*Specific Capacity USgpm per foot of drawdown*
1	707 USgpm	0.67	2.20	321
2	797 USgpm	0.75	2.46	324
3	904 USgpm	0.89	2.92	310
4	999 USgpm	1.00	3.28	305
5	1100 USgpm	1.10	3.61	305

As the pumping rate is increased beyond 800 USgpm, there is a decrease in specific capacity. This decrease however is relatively small and the specific capacity remains fairly constant at the higher pumping rates. Of more significance possibly is the fact that Well No. 2 shows a decline in well performance since it was originally completed. The specific capacity has decreased from 405 USgpm per foot of drawdown to 321 USgpm, determined at a pumping rate of 700 USgpm. This reduction in specific capacity may be the result of partial encrustation of the well screen assembly and surrounding aquifer material. The reduction in well performance does not however effect our final conclusions with respect to well yield (see Sections 5.0 and 6.0).

With respect to the constant rate test, a summary of results is shown in Table 3.

Table 3 – Summary of Results for Constant Rate Pumping Test – Well No. 2	
Item Description	*Comments*
Pumping Rate	1125 USgpm
Total Drawdown at end of test	1.29 metres (4.23 feet)
Percent of total available drawdown utilized at end of test	18.5 %
Drawdown per log cycle	0.08 metres (0.26 feet)
Total drawdown interference in Well No. 1	0.29 metres (0.95 feet)
Total drawdown interference in Well No. 3	0.25 metres (0.82 feet)
Percentage recovery after 60 minutes	93 %
Percentage recovery after 24 hours	99.2 %

Based on the test results and applying data from the two observation wells (Well's 1 and 3), a determination for the coefficients of transmissivity and storativity is 8.7 m^2/min (1.0 x 10^6 USgpd/ft) and 1.0 x 10^{-1} respectively. These parameters match closely to those determined by ***Kala*** during the 1982 project, which was conducted in connection with the completion and testing of Well No. 3.

As a final note to conclude this section, an inspection of the drawdown curves for each of the three wells indicates that the aquifer is approaching steady-state conditions where the pumping rate is balanced by rate of recharge to the aquifer and no further drawdown is observed. It did however require over 24 hours for Well No. 2 to fully recover and therefore for purposes of long-term yield projections, ***Kala*** is assuming that drawdown will continue to occur in the aquifer with extended pumping.

5.0 Discussion of Program Findings

As noted in the previous section, the total available drawdown utilized in Well No. 2 while pumping at 1125 USgpm for a 24-hour period was 1.29 metres, which is 18.5 percent. A projection of the total available drawdown which would be utilized in Well No. 2, pumping at 1200 USgpm for a 20-year continuous period, is 1.68 metres or 24 percent of the total available. This is well within the 70 percent margin that hydrogeologists use in safe yield projections and consequently it is ***Kala***'s opinion that Well No. 2 can be pumped at 1200 USgpm on a sustained basis with no problems with respect to drawdown in the aquifer. The next question relates to the well field performance and drawdown interference effects with two and possibly all three wells pumping simultaneously. Our drawdown projections are shown in Table 4 which follows.

Table 4 – Drawdown Projections – Tuc El Nuit Pumping Station

Description	***Well No. 2***	***Well No. 3***	***Well No. 1***
Well No. 2 pumping	1.68 metres	0.91 metres	0.95 metres
Well's 2 and 3 pumping	1.94	1.90 metres	1.25 metres
Well's 2, 3 and 1 pumping	2.34	2.25 metres	1.90 metres
Percentage of total available drawdown	34 %	35 %	17 %
Pumping Rate	1200 USgpm	500 USgpm	200 USgpm
Depth to water from base of pump head	5.74 metres	5.76 metres	5.13 metres

Notes: - Shaded cell denotes well pumping
- The drawdown interference projections are based on 20 years of continuous pumping

Based on the above evaluation, all three wells can be pumped simultaneously at a combined rate of 1900 USgpm, with a maximum of 35 percent available drawdown utilized within each of the wells. Because this is an unconfined aquifer, up to 60 percent would be considered allowable.

It is important to note that Well No. 2 is designed to pump 700 USgpm at the recommended entrance velocity of 0.1 feet per second. In recent years however, Johnson's Well Screens have altered their opinion and now feel that if the water is not of an encrustive nature, the 0.1 feet per second entrance velocity can be exceeded. ***Kala*** recommends a program of routine water level monitoring to ensure that problems are not occurring.

6.0 Conclusion and Recommendations

Based on the results of the present program, the key objectives regarding well yield upgrading at the Tuc El Nuit Pump Station have been achieved, namely:

a) The capacity of Well No. 2 can be increased from 700 to 1200 USgpm, and
b) All three wells can be pumped simultaneously at a combined rate of 1900 USgpm.

A summary of the pertinent details is shown in Table 4 below.

Table 4 – Drawdown Projections – Tuc El Nuit Pumping Station

Description	***Well No. 2***	***Well No. 3***	***Well No. 1***
Well No. 2 pumping	1.68 metres	0.91 metres	0.95 metres
Well's 2 and 3 pumping	1.94 metres	1.90 metres	1.25 metres
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Percentage of total available drawdown	34 %	35 %	17 %
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Depth to water from base of pump head	5.74 metres	5.76 metres	5.13 metres

Notes: - Shaded cell denotes well pumping
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Based on the above evaluation, all three wells can be pumped simultaneously at a combined rate of 1900 USgpm, with a maximum of 35 percent available drawdown utilized within each of the wells. Because this is an unconfined aquifer, up to 60 percent would be considered allowable.

It is important to note that Well No. 2 is designed to pump 700 USgpm at the recommended entrance velocity of 0.1 feet per second. In recent years however, Johnson's Well Screens have altered their opinion and now feel that if the water is not of an encrustive nature, the 0.1 feet per second entrance velocity can be exceeded. ***Kala*** recommends a program of routine water level monitoring to ensure that problems are not occurring.

With respect to pump settings, ***Kala*** recommends a pump setting of at least 2.0 metres below the projected pumping levels shown in Table 4.

We trust this meets your present requirements and if there are any questions, please do not hesitate to contact the undersigned.

Yours truly,
Kala Groundwater Consulting Ltd.

L.C. Topp, P. Geo.
Hydrogeologist

LCT/it
Encl:

c.c. Terry Underwood, P. Eng.

Appendix A

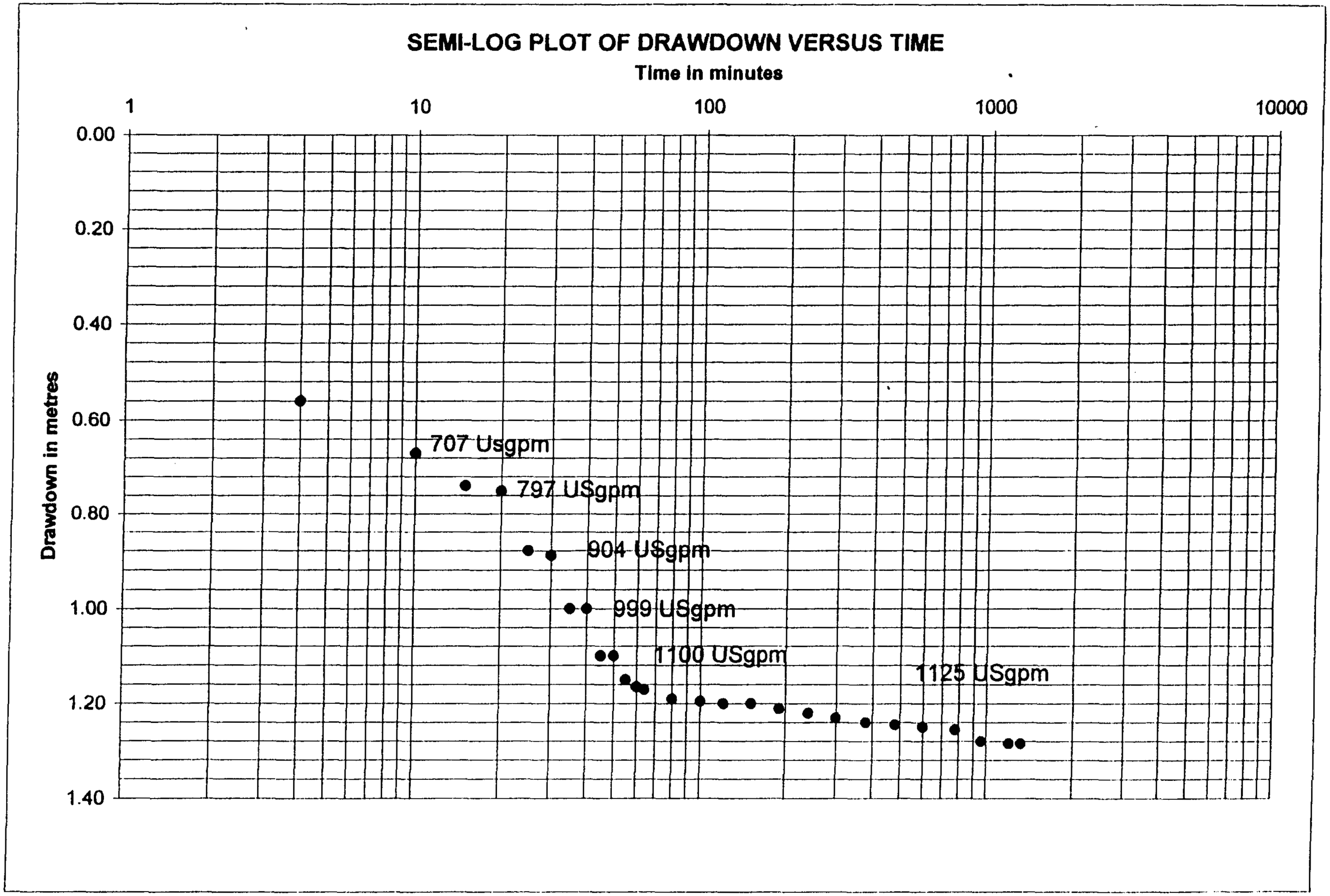
Pumping Test Data - Well No. 2

PUMPTEST (Drawdown) **Tuc El Nuit Pump Station**
Well No.2 - Pumping

Date test started: Dec. 13/99
Time test started: 1:00 PM
Ave. pumping rate: 1125 USgpm
Pre-test water level: 3.40 metres

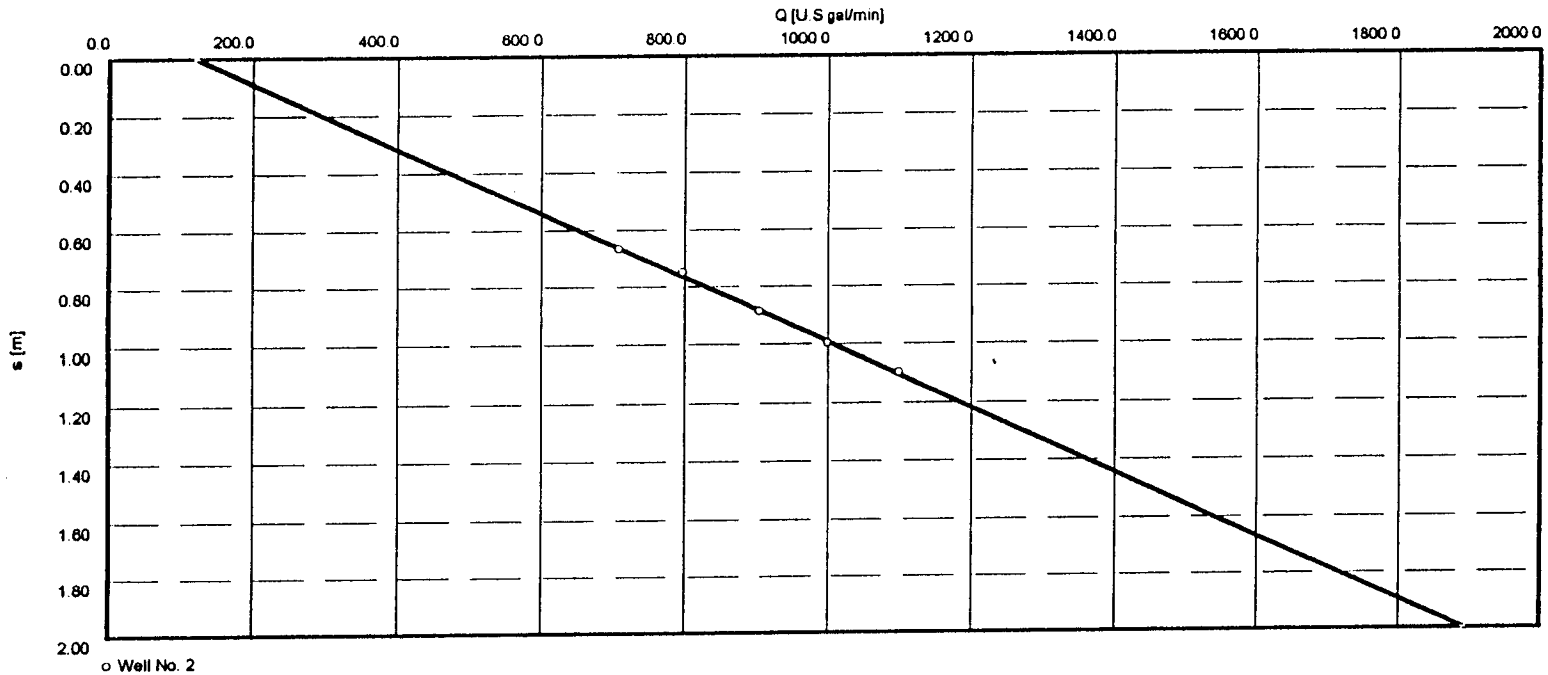
Reference Point: Top of well probe access
Height of ref. point: ground level
Depth of well: 14.3 metres
Screen Interval: 10.4 to 14.3 metres

Time (t) since pumping started in minutes	Depth to water in metres	Drawdown in metres	Comments
0	3.40	0.00	
4	3.96	0.56	Adjusting pumping rate up to 707 USgpm
10	4.07	0.67	Pumping rate: 707 USgpm
15	4.14	0.74	Increase rate to 797 USgpm
20	4.15	0.75	
25	4.28	0.88	Increase rate to 904 USgpm
30	4.29	0.89	
35	4.40	1.00	Increase rate to 999 USgpm
40	4.40	1.00	
45	4.50	1.10	Increase rate to 1100
50	4.50	1.10	
55	4.55	1.15	Increase rate to 1125 USgpm
60	4.57	1.17	
64	4.57	1.17	Pumping rate: 1125 USgpm
80	4.59	1.19	
100	4.60	1.20	
120	4.60	1.20	
150	4.60	1.20	
190	4.61	1.21	
240	4.62	1.22	
300	4.63	1.23	
380	4.64	1.24	
480	4.65	1.25	
600	4.65	1.25	
780	4.66	1.26	
960	4.68	1.28	
1200	4.69	1.29	
1440	4.69	1.29	Pumping rate: 1125 USgpm


SEMI-LOG PLOT OF DRAWDOWN VERSUS TIME
Time in minutes
1
10
100
1000
10000
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Drawdown in metres
707 Usgpm
797 USgpm
904 USgpm
999 USgpm
1100 USgpm
1125 USgpm

Waterloo Hydrogeologic 180 Columbia St. W. Waterloo,Ontario,Canada ph.(519)746-1798	Pumping test analysis Well performance test Determination of specific capacity	Date: 04.01.2000	Step Drawdown, Page 1
		Project: Tuc El Nuit	
		Evaluated by: LCT	

Pumping Test No. Test No. 1	Test conducted on: Dec. 13/99
Well No. 2	



specific capacity C [m³/min]. 3.36×10^{0}

Waterloo Hydrogeologic
180 Columbia St. W.
Waterloo,Ontario,Canada
ph.(519)746-1798

Pumping test analysis
Well performance test
Determination of specific capacity

Date: 04.01.2000 | Step Drawdown, Page 2

Project: Tuc El Nuit

Evaluated by: LCT

Pumping Test No. Test No. 1

Test conducted on: Dec. 13/99

Well No. 2

Well No. 2

	Discharge [U.S.gal/min]	Water level below datum [m]	Drawdown [m]
1	707.00	4.070	0.670
2	797.00	4.150	0.750
3	904.00	4.290	0.890
4	999.00	4.400	1.000
5	1100.00	4.500	1.100

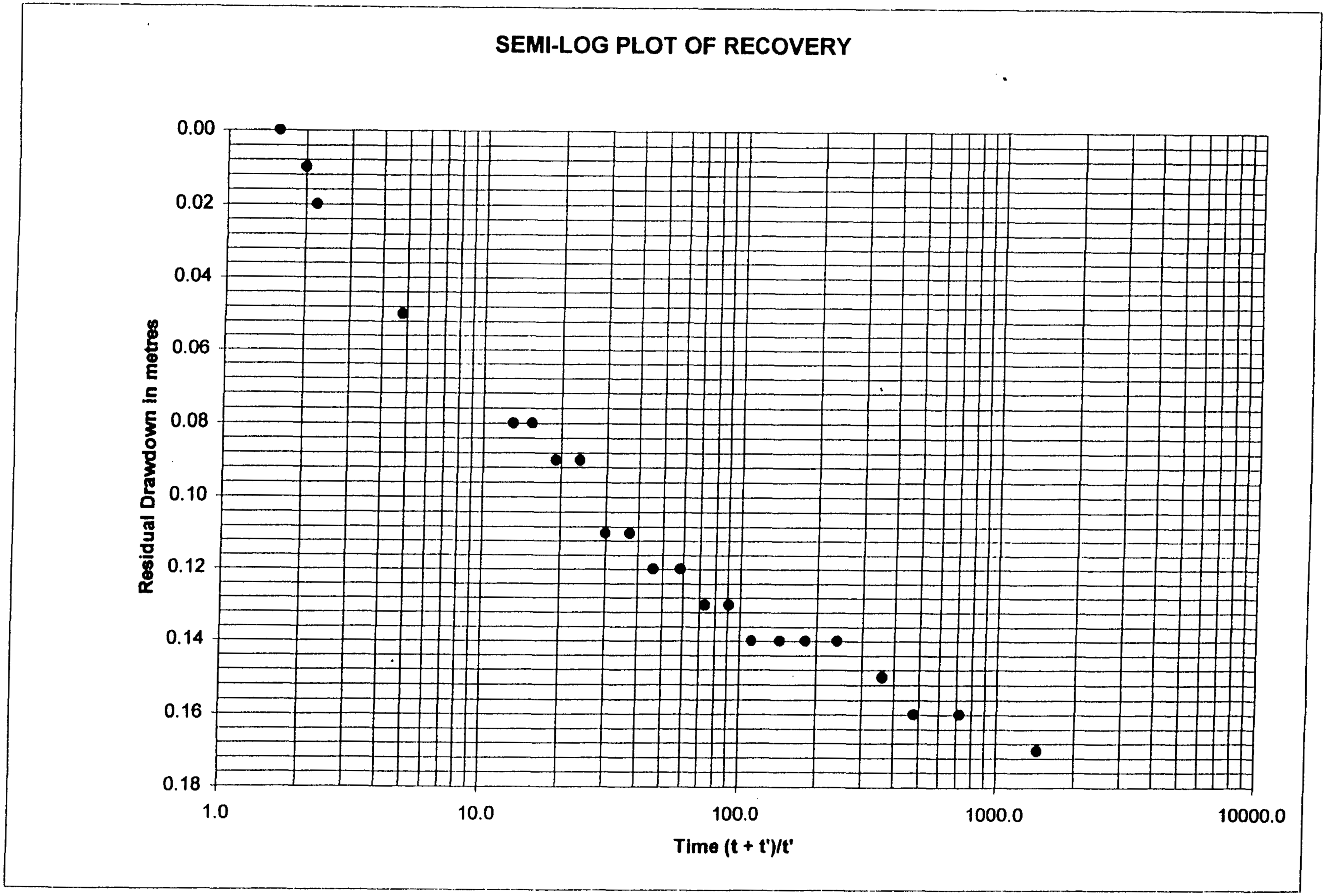
PUMPTEST (RECOVERY)

Tuc El Nuit Pumping Station
Well No. 2

Date test started: Dec. 14/99
Time test started: 1:00 PM
Ave. pumping rate: 1125 USgpm
Pre-test water level: 3.40 metres

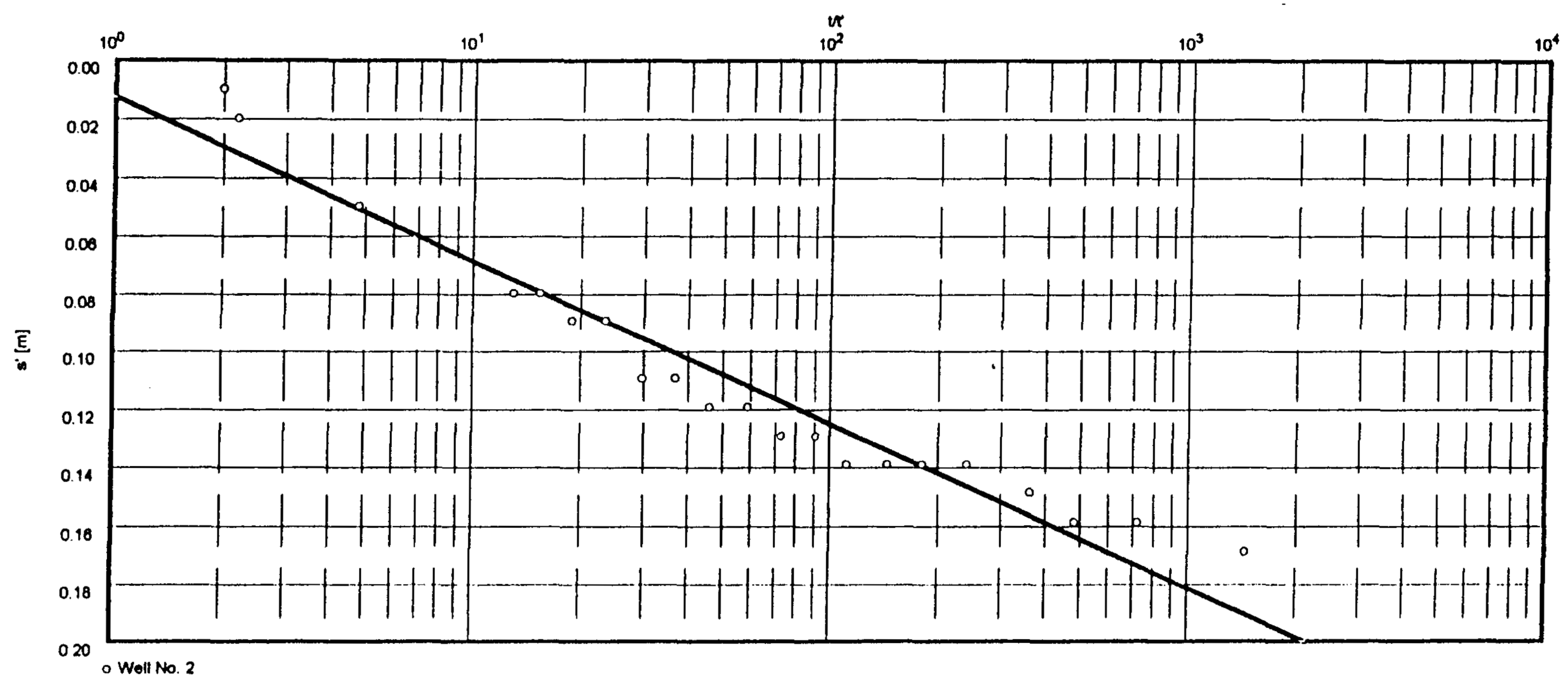
Reference point: Top of well probe access
Height of reference: ground level
Depth of well: 14.3 metres
Top of screen: 10.4 metres

Time t' since pumping stopped in minutes	(t + t')/t'	Depth to water in metres	Residual Drawdown in metres	Comments
0	1440.0	4.69	1.29	
1	1441.0	3.57	0.17	
2	721.0	3.56	0.16	
3	481.0	3.56	0.16	
4	361.0	3.55	0.15	
6	241.0	3.54	0.14	
8	181.0	3.54	0.14	
10	145.0	3.54	0.14	
13	111.8	3.54	0.14	
16	91.0	3.53	0.13	
20	73.0	3.53	0.13	
25	58.6	3.52	0.12	
32	46.0	3.52	0.12	
40	37.0	3.51	0.11	
50	29.8	3.51	0.11	
64	23.5	3.49	0.09	
80	19.0	3.49	0.09	
100	15.4	3.48	0.08	
120	13.0	3.48	0.08	
380	4.8	3.45	0.05	
1200	2.2	3.42	0.02	
1440	2.0	3.41	0.01	
2520	1.6	3.40	0.00	


SEMI-LOG PLOT OF RECOVERY
Residual Drawdown in metres
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
1.0
10.0
100.0
1000.0
10000.0
Time (t + t')/t'

Waterloo Hydrogeologic 180 Columbia St. W. Waterloo,Ontario,Canada ph (519)746-1798	Pumping test analysis Recovery method after THEIS & JACOB Unconfined aquifer	Date: 24.12.1999	Recovery, Page 1
		Project: Tucelnuit	
		Evaluated by: LCT	

Pumping Test No. No. 1	Test conducted on: Dec. 14/00
Well No. 2	
Discharge 1125.00 U.S.gal/min	
	Pumping test duration: 1440.00 min



Transmissivity [m²/min]: 1.38×10^1

Hydraulic conductivity [m/min]: 1.27×10^0

Aquifer thickness [m]: 10.900

Waterloo Hydrogeologic 180 Columbia St. W. Waterloo,Ontario,Canada ph.(519)746-1798	Pumping test analysis Recovery method after THEIS & JACOB Unconfined aquifer	Date: 24.12.1999	Recovery, Page 2
		Project: Tucelnuit	
		Evaluated by: LCT	

Pumping Test No. No. 1	Test conducted on: Dec. 14/00
Well No. 2	Well No. 2
Discharge 1125.00 U.S.gal/min	Distance from the pumping well 0.120 m
Static water level: 3.400 m below datum	Pumping test duration: 1440.00 min

	Time from end of pumping [min]	Water level [m]	Residual drawdown [m]	Corrected drawdown [m]
1	1.00	3.570	0.170	0.169
2	2.00	3.560	0.160	0.159
3	3.00	3.560	0.160	0.159
4	4.00	3.550	0.150	0.149
5	6.00	3.540	0.140	0.139
6	8.00	3.540	0.140	0.139
7	10.00	3.540	0.140	0[illegible]
8	13.00	3.540	0.140	0.1[illegible]
9	16.00	3.530	0.130	0.129
10	20.00	3.530	0.130	0.129
11	25.00	3.520	0.120	0.119
12	32.00	3.520	0.120	0.119
13	40.00	3.510	0.110	0.109
14	50.00	3.510	0.110	0.109
15	64.00	3.490	0.090	0.090
16	80.00	3.490	0.090	0.090
17	100.00	3.480	0.080	0.080
18	120.00	3.480	0.080	0.080
19	380.00	3.450	0.050	0.050
20	1200.00	3.420	0.020	0.020
21	1440.00	3.410	0.010	0.010

Appendix B

Pumping Test Data - Well No. 3

PUMPTEST (Drawdown)

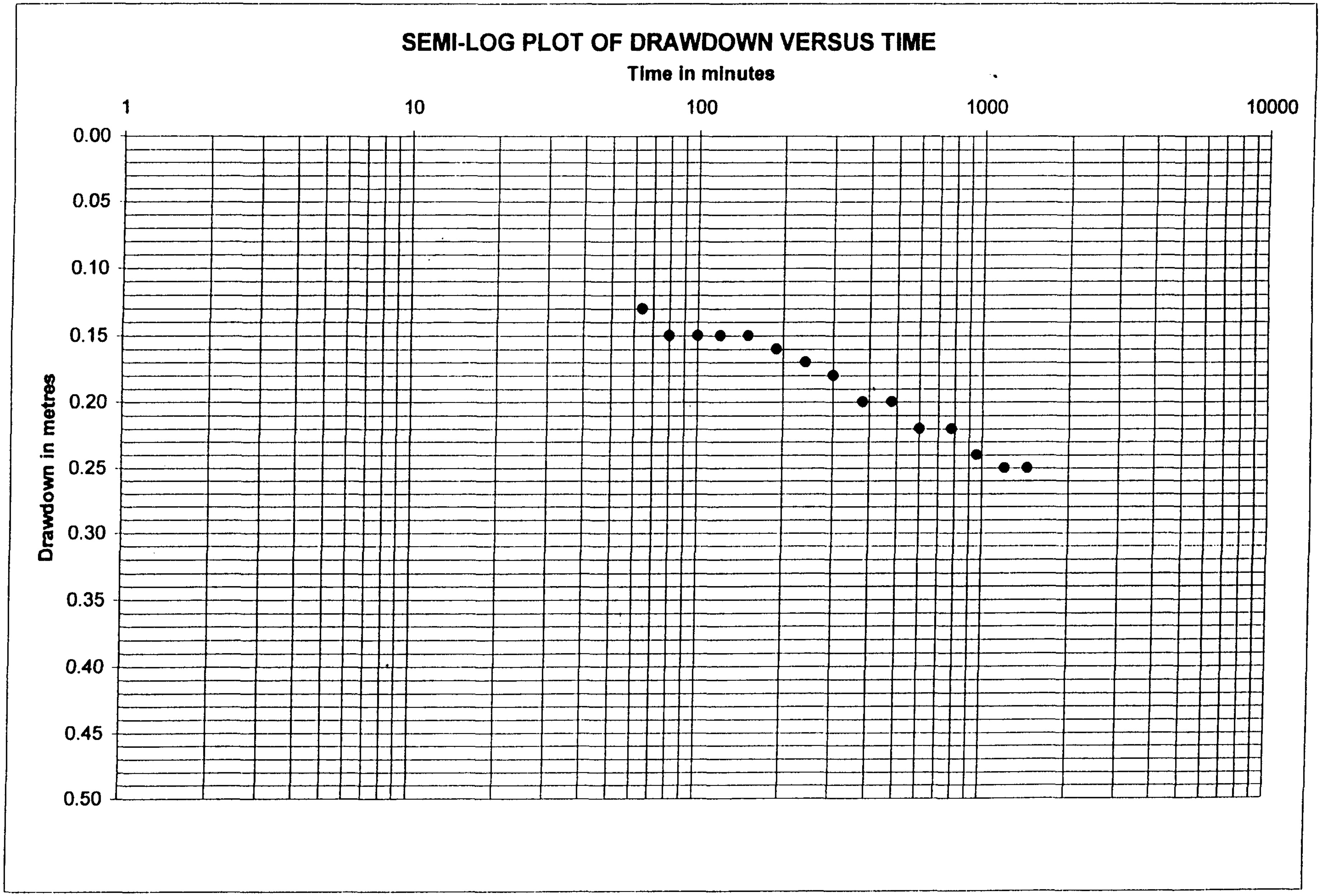
Tuc El Nuit Pump Station
Well No.3 - Observation (r = 21 m.)

Date test started: Dec. 13/99
Time test started: 1:00 PM
Ave. pumping rate: 1125 USgpm
Pre-test water level: 3.51 metres

Reference Point: Top of well probe access
Height of ref. point: 0.15 m.
Depth of well: 13.7 metres
Screen Interval: 9.9 to 13.7 metres

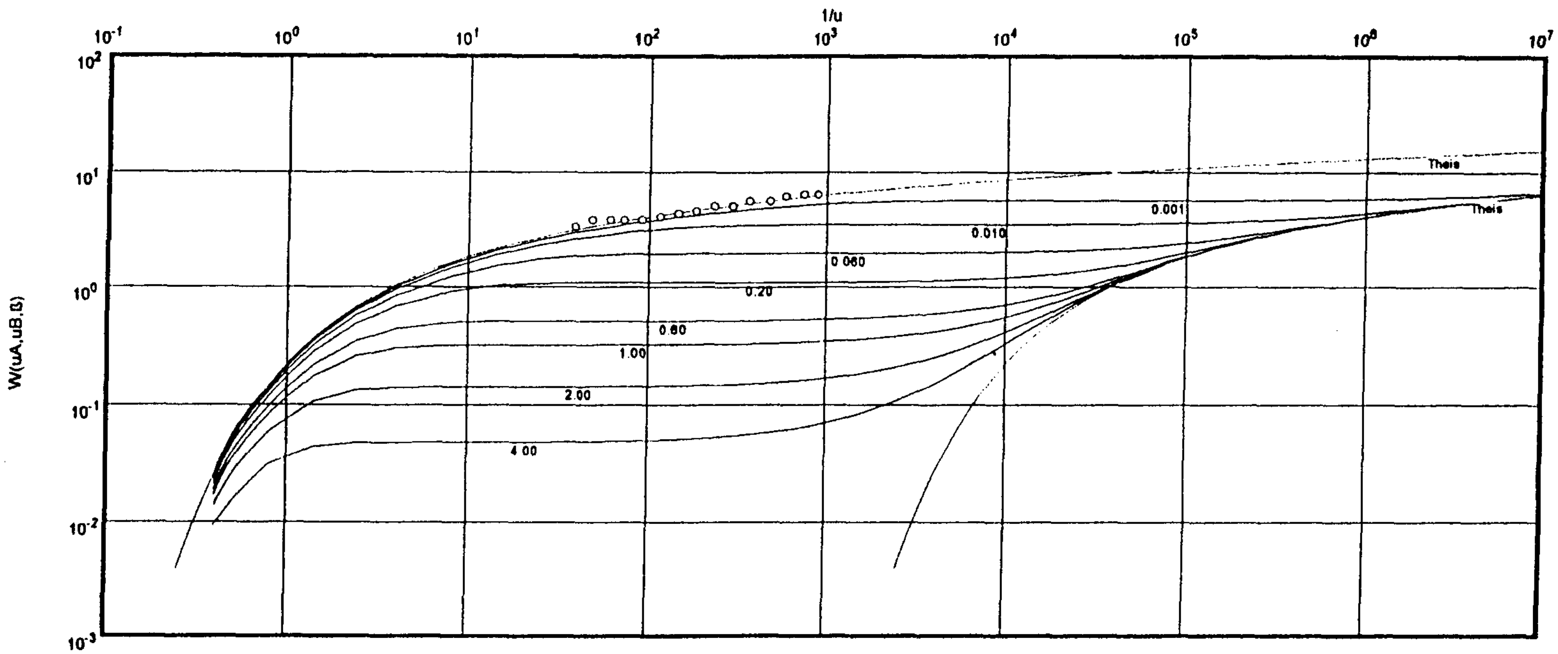
Time (t) since pumping started in minutes	Depth to water in metres	Drawdown in metres	Comments
0	3.51	0.00	
64	3.64	0.13	Pumping rate: 1125 USgpm
80	3.66	0.15	
100	3.66	0.15	
120	3.66	0.15	
150	3.66	0.15	
190	3.67	0.16	
240	3.68	0.17	
300	3.69	0.18	
380	3.71	0.20	
480	3.71	0.20	
600	3.73	0.22	
780	3.73	0.22	
960	3.75	0.24	
1200	3.76	0.25	
1440	3.76	0.25	Pumping rate: 1125 USgpm

Tuc El Nuit | Well No. 3 | Observation



Waterloo Hydrogeologic 180 Columbia St. W. Waterloo,Ontario,Canada ph.(519)746-1798	Pumping test analysis NEUMAN's method Unconfined aquifer with *delayed watertable response*	*Date: 21.12.1999*	Observation, Page 2
		Project: TucElNuit	
		Evaluated by: LCT	

Pumping Test No. No. 1	Test conducted on: Dec. 13/99
Well No. 3	
Discharge 1125.00 U.S.gal/min	



o Well No. 3

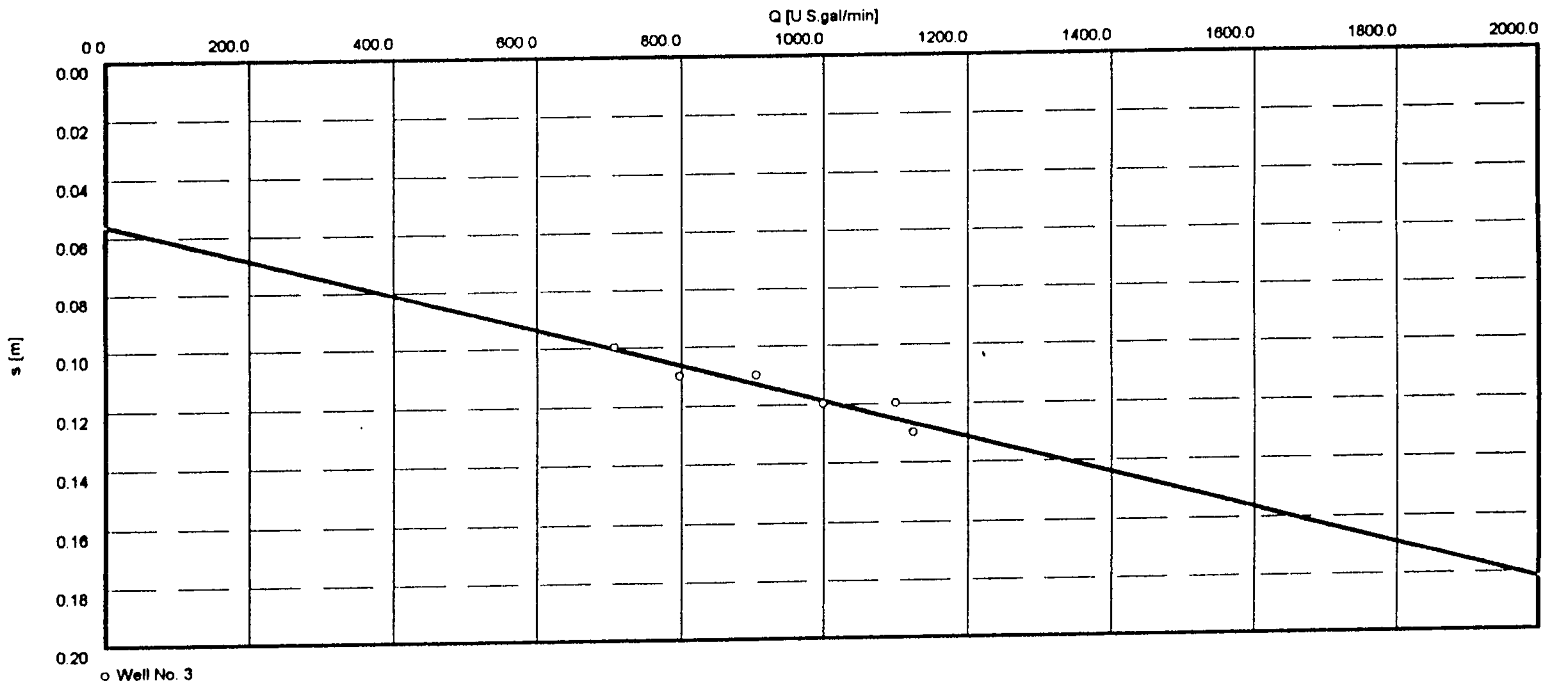
Transmissivity [m²/min]: 8.43 x 10^{0}

Storativity: 1.25 x 10^{-1}

Specific yield: 1.25 x 10^{3}

Waterloo Hydrogeologic 180 Columbia St. W. Waterloo,Ontario,Canada ph (519)746-1798	Pumping test analysis Well performance test Determination of specific capacity	Date: 24.12.1999	Step-drawdown, Page 1
		Project: TucElNuit	
		Evaluated by: LCT	

Pumping Test No. No. 1	Test conducted on: Dec. 13/99
Well No. 3	



specific capacity C [m³/min]: 6.02×10^{1}

Waterloo Hydrogeologic 180 Columbia St. W. Waterloo,Ontario,Canada ph (519)746-1798	Pumping test analysis Well performance test Determination of specific capacity	Date: 24.12.1999	Step-drawdown, Page 2
		Project: TucElNult	
		Evaluated by: LCT	

Pumping Test No. No. 1	Test conducted on: Dec. 13/99
Well No. 3	Well No. 3

	Discharge [U.S.gal/min]	Water level below datum [m]	Drawdown [m]
1	707.00	3.610	0.100
2	797.00	3.620	0.110
3	904.00	3.620	0.110
4	999.00	3.630	0.120
5	1100.00	3.630	0.120
6	1125.00	3.640	0.130

Appendix C

Pumping Test Data - Well No. 1

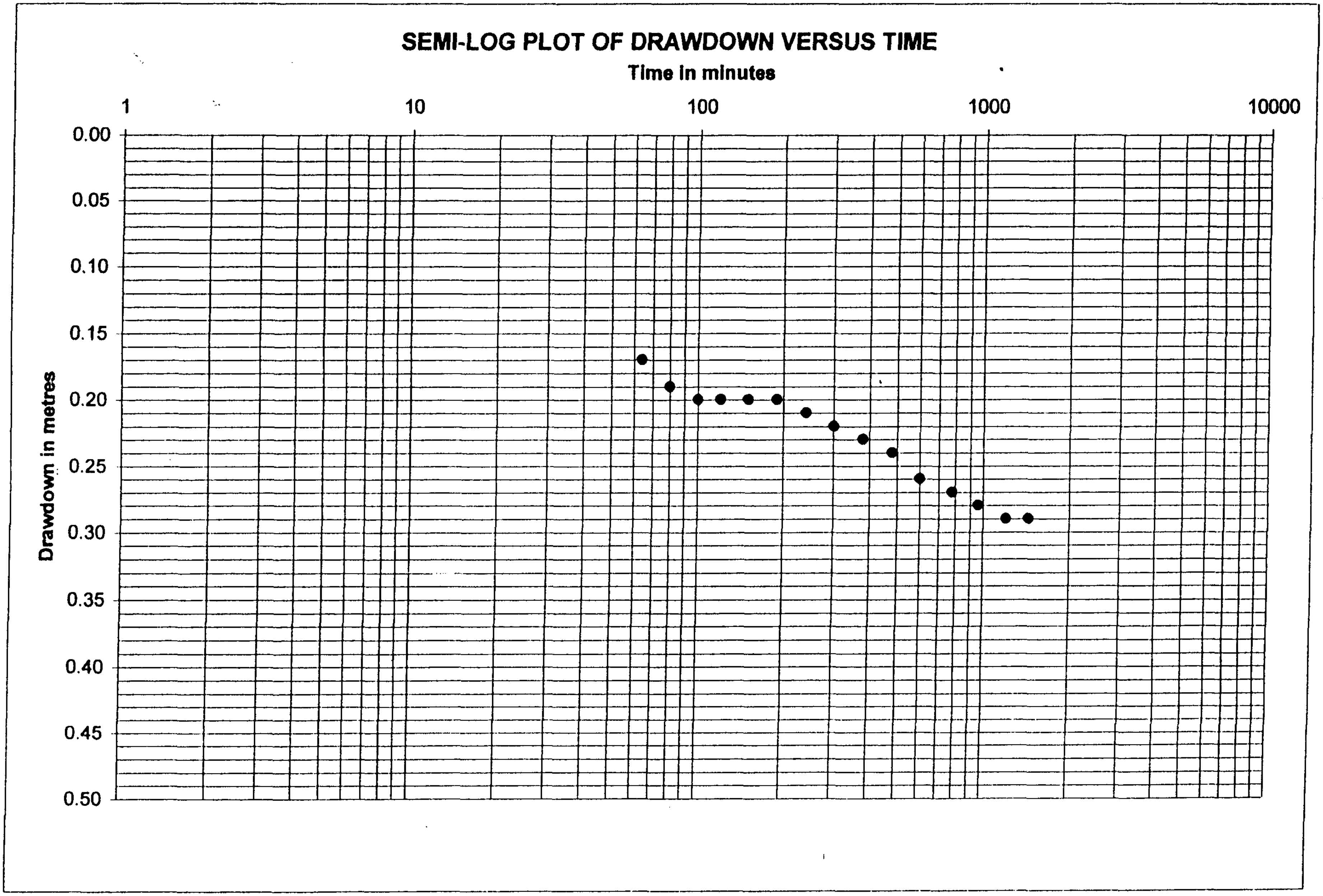
PUMPTEST (Drawdown)

Tuc El Nuit Pump Station
Well No.1 - Observation (r = 14.3 m.)

Date test started: Dec. 13/99
Time test started: 1:00 PM
Ave. pumping rate: 1125 USgpm
Pre-test water level: 3.23 metres

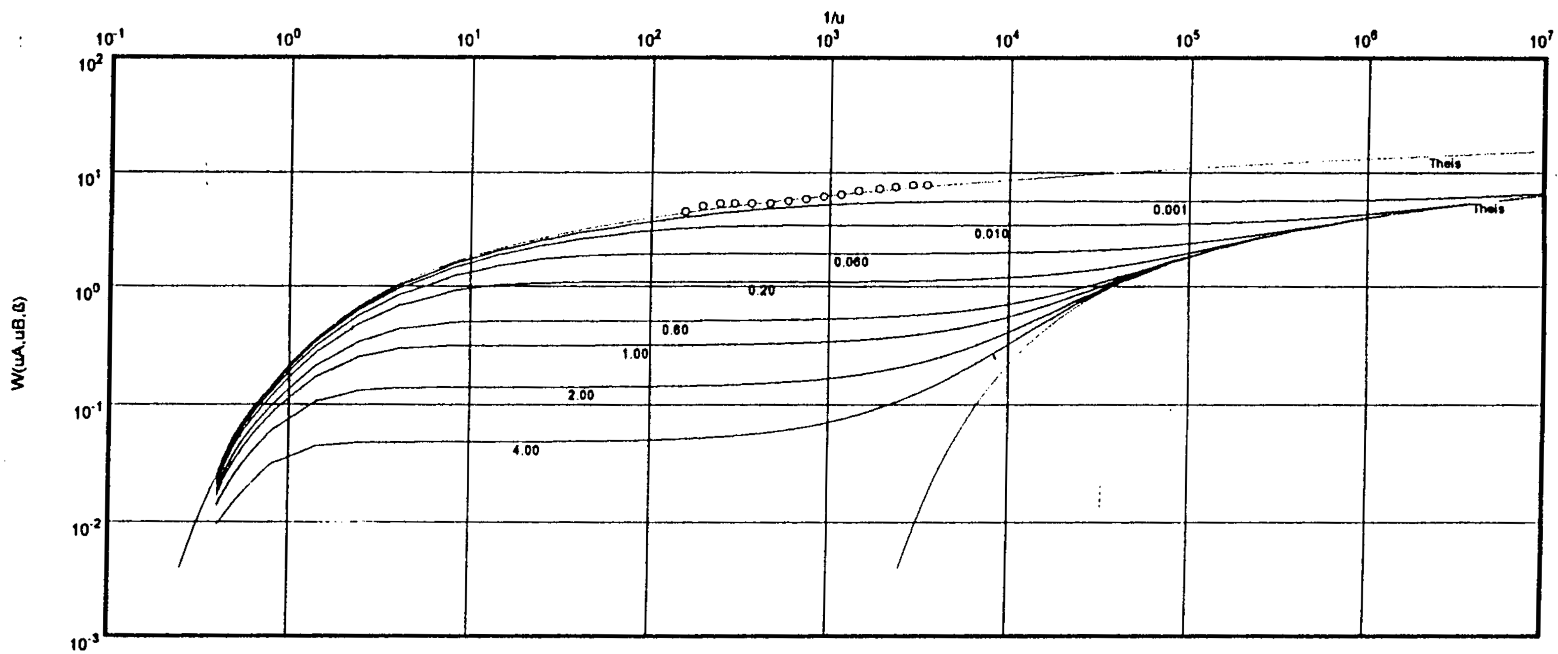
Reference Point: Top of well probe access
Height of ref. point: ground level
Depth of well: 14.0 metres
Screen Interval: ———

Time (t) since pumping started in minutes	Depth to water in metres	Drawdown in metres	Comments
0	3.23	0.00	
64	3.40	0.17	Pumping rate: 1125 USgpm
80	3.42	0.19	
100	3.43	0.20	
120	3.43	0.20	
150	3.43	0.20	
190	3.43	0.20	
240	3.44	0.21	
300	3.45	0.22	
380	3.46	0.23	
480	3.47	0.24	
600	3.49	0.26	
780	3.50	0.27	
960	3.51	0.28	
1200	3.52	0.29	
1440	3.52	0.29	Pumping rate: 1125 USgpm


SEMI-LOG PLOT OF DRAWDOWN VERSUS TIME
Time in minutes
1
10
100
1000
10000
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
Drawdown in metres

Waterloo Hydrogeologic 180 Columbia St. W. Waterloo,Ontario,Canada ph.(519)746-1798	Pumping test analysis NEUMAN's method Unconfined aquifer with delayed watertable response	Date: 21.12.1999 Project: TucElNult Evaluated by: L.C.T.	Observation Well, Page 1

Pumping Test No. One	Test conducted on: Dec. 13/99
No. 1	
Discharge 1125.00 U.S.gal/min	



o Well No. 1

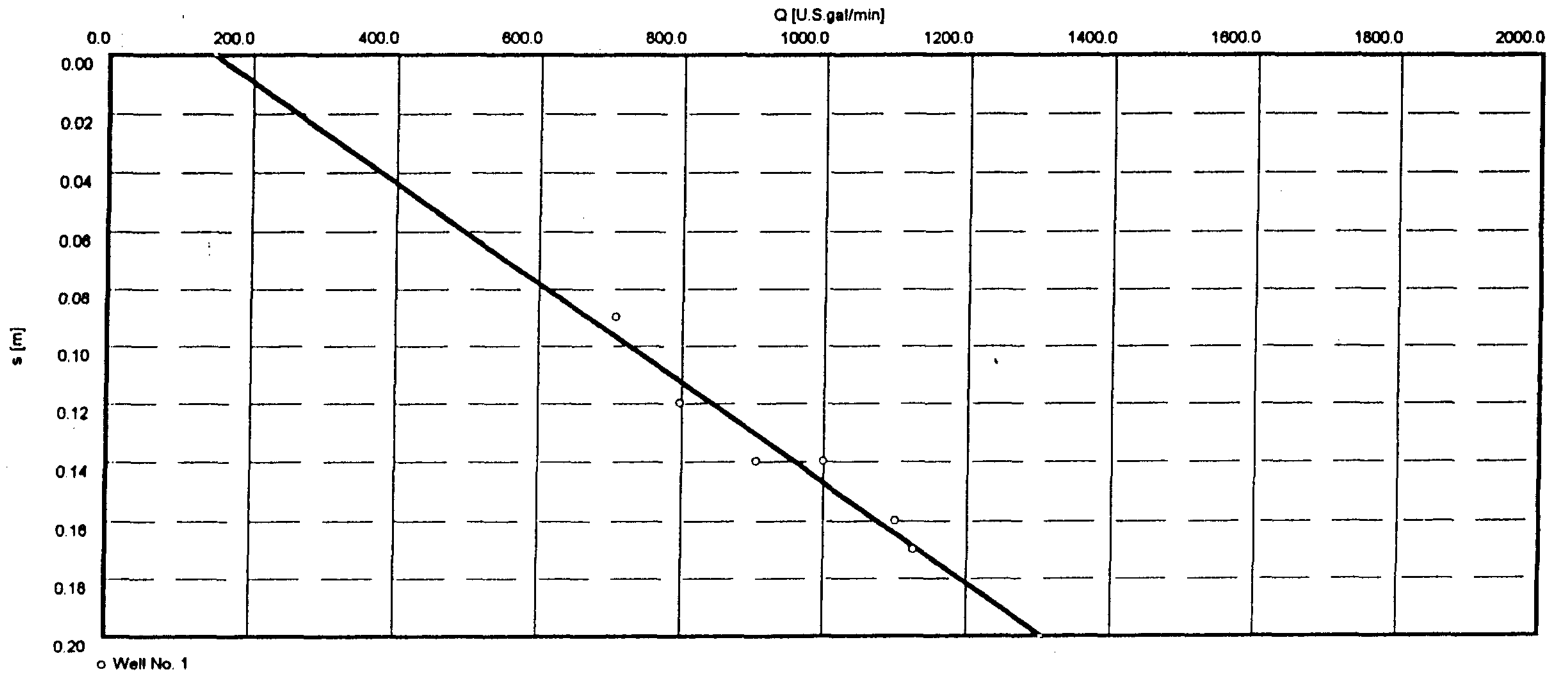
Transmissivity [m²/min]: 8.91 x 10^{0}

Storativity: 7.19 x 10^{-2}

Specific yield: 7.19 x 10^{2}

Waterloo Hydrogeologic 180 Columbia St. W. Waterloo,Ontario,Canada ph (519)746-1798	Pumping test analysis Well performance test Determination of specific capacity	Date: 24.12.1999	Step-drawdown, Page 1
		Project: TucElNuit	
		Evaluated by: LCT	

Pumping Test No. No. 1	*Test conducted on: Dec. 13/99*
Well No. 1	



specific capacity C [m³/min]: 2.19 x 10[1]

Waterloo Hydrogeologic 180 Columbia St. W. Waterloo,Ontario,Canada ph (519)746-1798	Pumping test analysis Well performance test Determination of specific capacity	Date: 24.12.1999	Step-drawdown, Page 2
		Project: TucElNult	
		Evaluated by: LCT	

Pumping Test No. No. 1	Test conducted on: Dec. 13/99
Well No. 1	Well No. 1

	Discharge [U.S.gal/min]	Water level below datum [m]	Drawdown [m]
1	707.00	3.320	0.090
2	797.00	3.350	0.120
3	904.00	3.370	0.140
4	999.00	3.370	0.140
5	1100.00	3.390	0.160
6	1125.00	3.400	0.170

S.O.L.I.D.

System No. 3 Extension

Groundwater Development Program

(Water Well No. 3)

370th

Tuc El-nuit well.

wells #1 + #2 - existing wells

present program - well #3

Prepared For

Southern Okanagan Lands Irrigation District

By

KALA GROUNDWATER CONSULTING LTD.

November 1982

SECTION 1

INTRODUCTION

The present program was undertaken to develop and evaluate an additional supply of groundwater for the Southern Okanagan Lands Irrigation District (S.O.L.I.D.) No. 3 System at Oliver. The existing well field, which comprises two water wells, has a combined rated capacity of approximately 950 U.S. gallons per minute. The work was carried out at the request of S.O.L.I.D. under the direction of Mr. S. Mold, Consulting Engineering for the project.

The program involved the test drilling and completion of a ten-inch water well, followed by an aquifer testing phase. All of the drilling and pump testing operations were conducted by Quality Water Wells Ltd. of Okanagan Falls. The new well is located adjacent to the existing well field on the west Kootenay Power and Light right-of-way, south of Tugulnuit Lake (see Figure 1).

The following report outlines the nature of the drilling program and provides a discussion of the results. Detailed pump test data and sieve analysis are included in the Appendix. In order to conform to the drilling contractors measurements and also water level records which have been maintained on the existing wells, the Imperial system of measurement has been used throughout this report.

The writer wishes to acknowledge S.O.L.I.D. personnel for their assistance during various phases of the program.

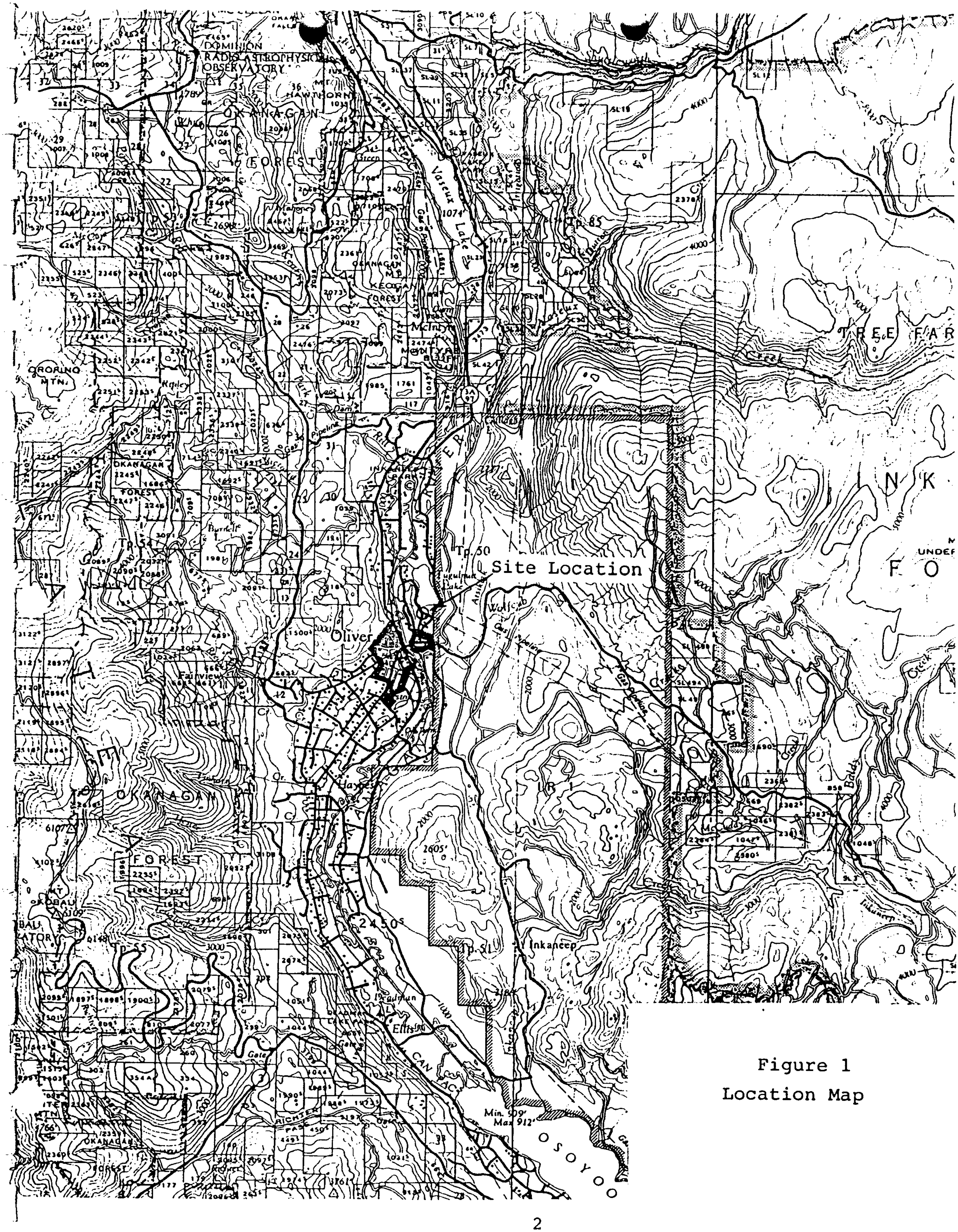


Figure 1
Location Map

SECTION 2

BACKGROUND

The two existing wells which have been utilized as a source of water supply for System No. 3, were constructed in 1971. This work was carried out on a consulting basis by the Groundwater Section of the Inventory and Engineering Branch, Ministry of Environment.

The first well drilled is an eight-inch test-production well constructed to a depth of 46 feet. This well is completed with #60 slot (60 thousands of an inch openings) screen, and has a specific capacity of 110 U.S. gallons per minute per foot of drawdown, pumping at a rate of 250 U.S. gallons per minute.

The second well is 47 feet deep, and is constructed with 12-inch steel casing. It is completed with #80 slot well screen, and has a specific capacity of 405 U.S. gallons per minute per foot of drawdown at 700 U.S. gallons per minute.

Based on the results of their investigation, the Groundwater Section have indicated that these wells are completed in an unconfined aquifer which is probably in direct hydraulic communication with Tugulnuit Lake. The aquifer is considered to be an abandoned channel of Okanagan River or its post glacial counterpart. Results of pump testing with the wells provided a transmissivity determination of approximately one million U.S. gallons per day/ft. (1×10^6 U.S. gpd/ft.).

SECTION 3

PRESENT PROGRAM

3.1 Test Drilling and Well Construction

The present program of designing and constructing a new well for the System No. 3 extension, was initiated with the drilling of a ten-inch hole by the Cable Tool method. As drilling progressed, ten-inch, welded joint casing was driven into place. Once the water-bearing zone was encountered, samples of the formation material were obtained at two-foot intervals. The samples were later forwarded to Interior Testing Services Ltd. of Kelowna for sieve analysis (see Appendix B).

Test drilling was terminated at 56 feet where a hard cemented lens of gravelly material was encountered. It was also decided at this stage, that materials penetrated above 56 feet, especially from approximately 30 to 45 feet, would produce sufficient quantities of water to meet contract specifications. A copy of the driller's litholog is included in this section of the report.

Based on the results of the sieve analysis, twelve feet of telescoping water well screen was selected for the well. The screen assembly included seven feet of #200 slot (200 thousands of an inch aperture) screen, and five feet of #60 slot. After setting the screens in the depth interval 33 to 45 feet, the casing was pulled back exposing the screens. A completion diagram is shown in Figure 3.

Finally, the well was developed by surging, and then pumping the fines to waste. The development phase required approximately 30 hours until all of the fines were removed.

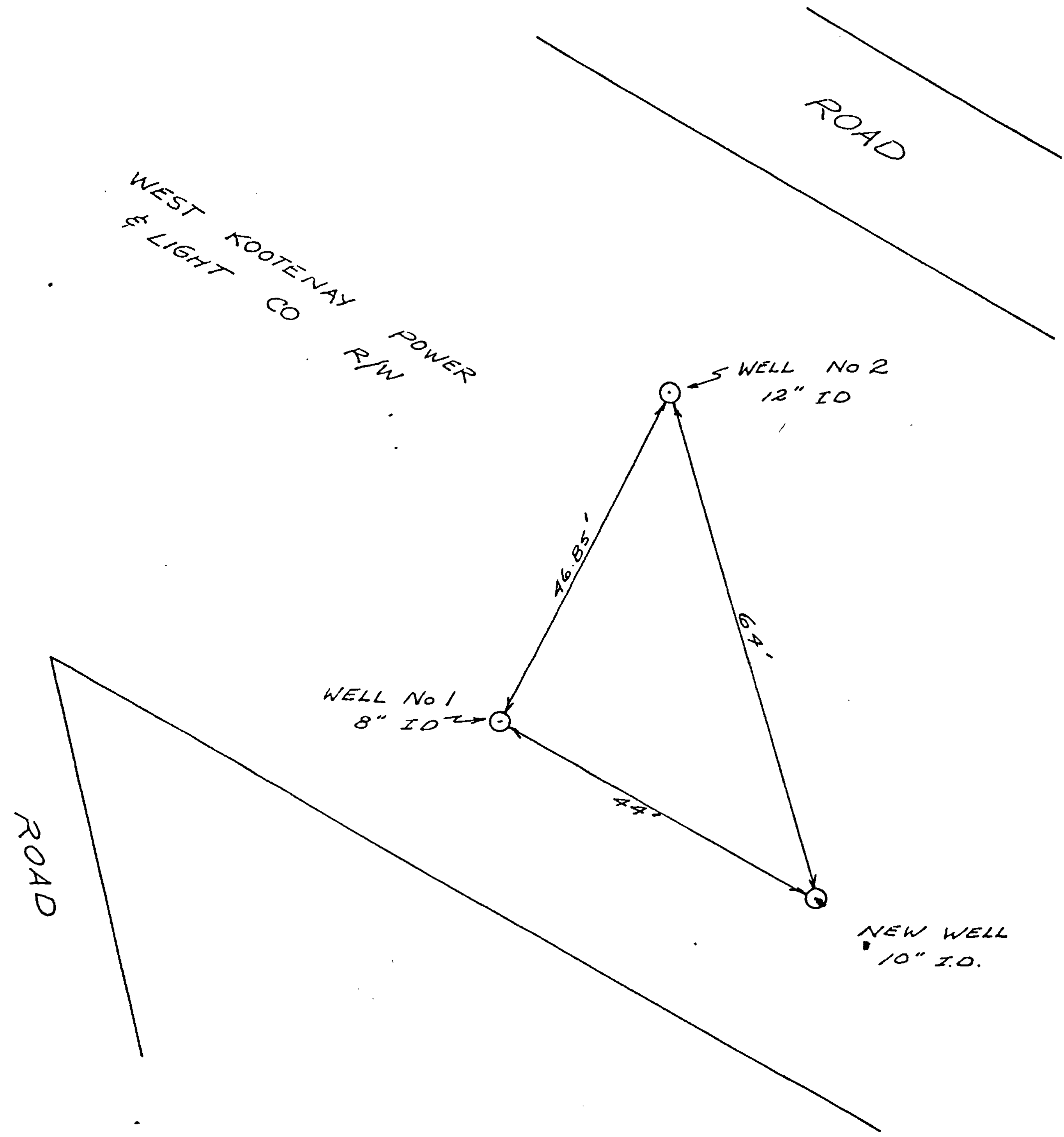


Figure 2

Sketch of Well Locations

S.O.L.I.D.

System No. 3 Extension

Groundwater Development Program

Well Completion Diagram

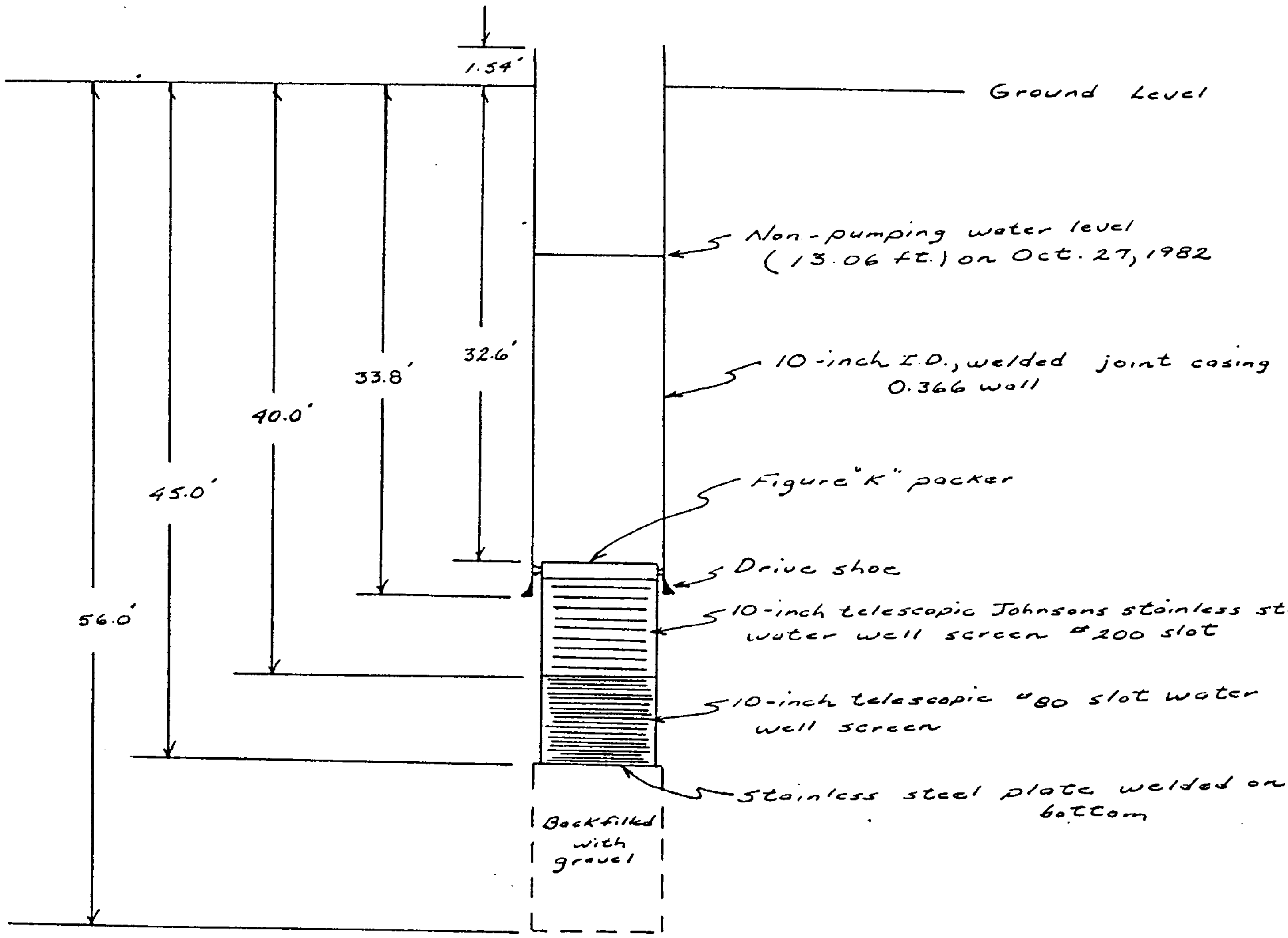


Figure 3

S.O.L.I.D.

System No. 3 Extension

Groundwater Development Program

DRILLERS LITHOLOG

Depth Interval (in feet)	Lithologic Description
0-2	Sandy top soil
2-8	Brown sand and coarse gravel
8-14	Gravel, pea to pebble size with coarse brown sand
14-16	Coarse clean sand with medium to small pebbles
16-18	Clean brown sand,finer than above with medium small cobbles
18-20	Brown sand, coarse with large cobbles and some fines
20-22	Clean brown sand with medium to large cobbles
22-24	Brown sand, becoming coarser, with small pebbles
24-28	Clean brown sand with small pebbles
28-34	Coarse clean sand with pebbles, polished
34-36	Medium to small gravel, polished,little sand fines 10-15%
36-38	Medium to small polished gravel, pea to pebble with little fines
38-40	Clean polished gravel, some fines
40-44	Coarser polished gravel and clean sand
44-46	Coarse brown sand, very clean with small pebbles
46-48	Coarse sand, very clean, some pebbles, little fines
48-50	Clean sand, coarse, some pebbles (20-30 slot)
50-56	Coarse clean sand with pebbles
56	Cemented lens

SECTION 4

DISCUSSION OF AQUIFER TEST RESULTS

4.1 Step-Drawdown Test

Data obtained during the aquifer tests have been plotted on semi-log and log-log graphs (see Appendix A), which in turn have been used to determine the various aquifer parameters discussed in the following section.

As previously mentioned, three steps of 408, 627 and 831 U.S. gallons per minute were run for 60 minute intervals during the step-drawdown test. Drawdown in the pumping well at the end of each 60 minute period was 1.51, 3.05 and 4.74 feet respectively. Specific capacities at these rates are 270, 206 and 175 USgpm per foot of drawdown, representing a decrease of approximately 37% over the range of pumping rates. The most significant drop in specific capacity occurs somewhere between the 400 and 600 USgpm pumping range. At this stage formation and well losses become increasingly more noticeable. This decrease in specific capacity is not considered serious, and will be discussed further under the constant rate test results.

4.2 Constant Rate Test

During the constant rate test, drawdown measured in the pumping well was 3.08 feet after one minute, and 3.48 feet after 22 hours. The drawdown interference in Observation Well No. 1 (8-inch well) was 0.56 feet, and 0.37 feet in Observation Well No. 2, after 22 hours of pumping.

Based on drawdown observations in the pumping well, steady-state conditions had apparently been reached after 22 hours and the test was terminated. However, examination of the drawdown versus time graphs suggest that further drawdown would have occurred with extended pumping. What we may have experienced, is an apparent leveling of water level drawdown as water is released from storage by gravity drainage, which is typical for water table aquifers.

An average value of transmissivity and storativity for the aquifer has been determined by analyzing the test data by either the Modified Jacob or the Theis curve fitting technique. Table 4.1 summarizes the aforementioned results and the method of analysis used.

Based on this data an average value of transmissivity for the aquifer is 1.2×10^6 USgpd/ft., and an average storage coefficient is 1×10^{-2}. It is interesting to note that the highest transmitting capacity of the aquifer appears to be in the vicinity of Water Well No. 2. This may explain in part why Well No. 2 has the highest specific capacity of the three wells. The material encountered near Well No. 2 was a fairly well sorted fine to medium gravel. Whereas the extremely coarse material in the vicinity of the new well may in effect decrease the storativity and transmitting capacity of the aquifer.

Table 4.1 - Summary of Results from Aquifer Test No. 2

Well Designation	Status	Transmissivity (USgpd/ft.)	Storativity	Method of Analysis
New Well (Well No. 3)	Pumped Well	8.2×10^5 (pumping)	-	Modified Jacob
		1.2×10^6 (recovery)	-	Modified Jacob
Well No. 1 (8-inch)	Observation (r=44 feet)	1.1×10^6	-	Modified Jacob
		7.6×10^5	0.9×10^{-2}	Theis-curve fitting
Well No. 3 (12-inch)	Observation (r=64 feet)	1.5×10^6	-	Modified Jacob
		1.7×10^6	1.8×10^{-2}	Theis-curve fitting

4.3 Well Field Capacity

Based on the aquifer parameters determined during the present program, it is estimated that the aquifer will produce in the order of 2500 USgpm from a properly designed well or combination of wells. As a result, pumping all three wells at their design capacity, which is approximately 1500 USgpm, should not produce serious water level drawdown or "mining" within the aquifer.

An estimate of drawdown interference between the three wells, with various combinations of pumping and recovery is outlined in Table 4.2.

Table 4.2

* Projection of Drawdown Interference Between Wells

New Well	Well No. 1 (8-inch)	Well No. 2 (12-inch)
13.12	10.08	10.67
16.60	10.65	11.04
17.50	11.55	13.30
17.85	13.70	13.70

* Note: - the various figures in the table represent depth to water from measuring points referred to in report

- when underlined the well is pumping, otherwise it is in the recovery stage

Examination of the above data, indicates that when all three wells are pumping, the maximum drawdown in the aquifer is approximately 4.7 feet, about 28% of the available drawdown.

SECTION 5

SUMMARY AND CONCLUSIONS

A ten-inch well with a design capacity of 650 U.S. gallons per minute (USgpm), has been successfully completed for the S.O.L.I.D., System No. 3 Extension. Based on the present program of test drilling, well completion and aquifer testing, the following conclusions have been derived with respect to the new well and aquifer in the immediate vicinity:

1) The well has a specific capacity of 206 USgpm per foot of drawdown, pumping at a rate of 627 USgpm.

2) It is completed in an unconfined aquifer, which is comprised for the most part, of relatively clean (free of fines), coarse, granular material.

3) The aquifer test results provide an average transmissivity determination of 1.2×10^{6} USgpd/ft, and a average storage coefficient of 1×10^{-2} for the aquifer.

4) Projected drawdown interference calculations, indicate that with all three wells pumping at their design capacities, the maximum drawdown in the aquifer will be approximately 4.7 feet, about 28% of the available drawdown.

5) An inspection of water level records for the existing wells provides a fairly good indication that steady-state conditions (balance between groundwater diversion and recharge) occur within the aquifer with extended pumping.

APPENDIX A

Aquifer Test Data

S.O.L.I.D.

System No 3 Extension

Groundwater Development Program

AQUIFER TEST NO. 1

Step-Drawdown

Date of test: October 27, 1982

Pre-test water level: 13.06 feet

Time test started: 11:00 A.M.

Average pumping rate 408,627.831 USgpm

Reference point: Top of casing 1.54 feet above ground level

PUMPING INTERVAL Time (t) Since Pumping Started in minutes	Depth to Water in Feet	Drawdown (s) in Feet	Comments
Step No. 1			
1	16.18	3.12	Pumping rate 744 USgpm
2	16.14	3.08	
3	15.29	2.23	Adjusting pumping rate
4	14.93	1.87	↓
6	14.78	1.72	
8	14.14	1.08	
10	14.12	1.07	408 USgpm
13	14.21	1.15	
16	14.08	1.02	
20	14.63	1.57	
25	14.53	1.48	
32	14.52	1.46	
40	14.47	1.41	
50	14.50	1.44	
60	14.57	1.51	
Step No. 2			
1	15.13	2.07	Pumping rate 627 USgpm
2	15.52	2.07	
3	16.34	3.281	
4	16.24	3.18	
6	16.24	3.18	
8	16.08	3.02	
10	16.14	3.08	

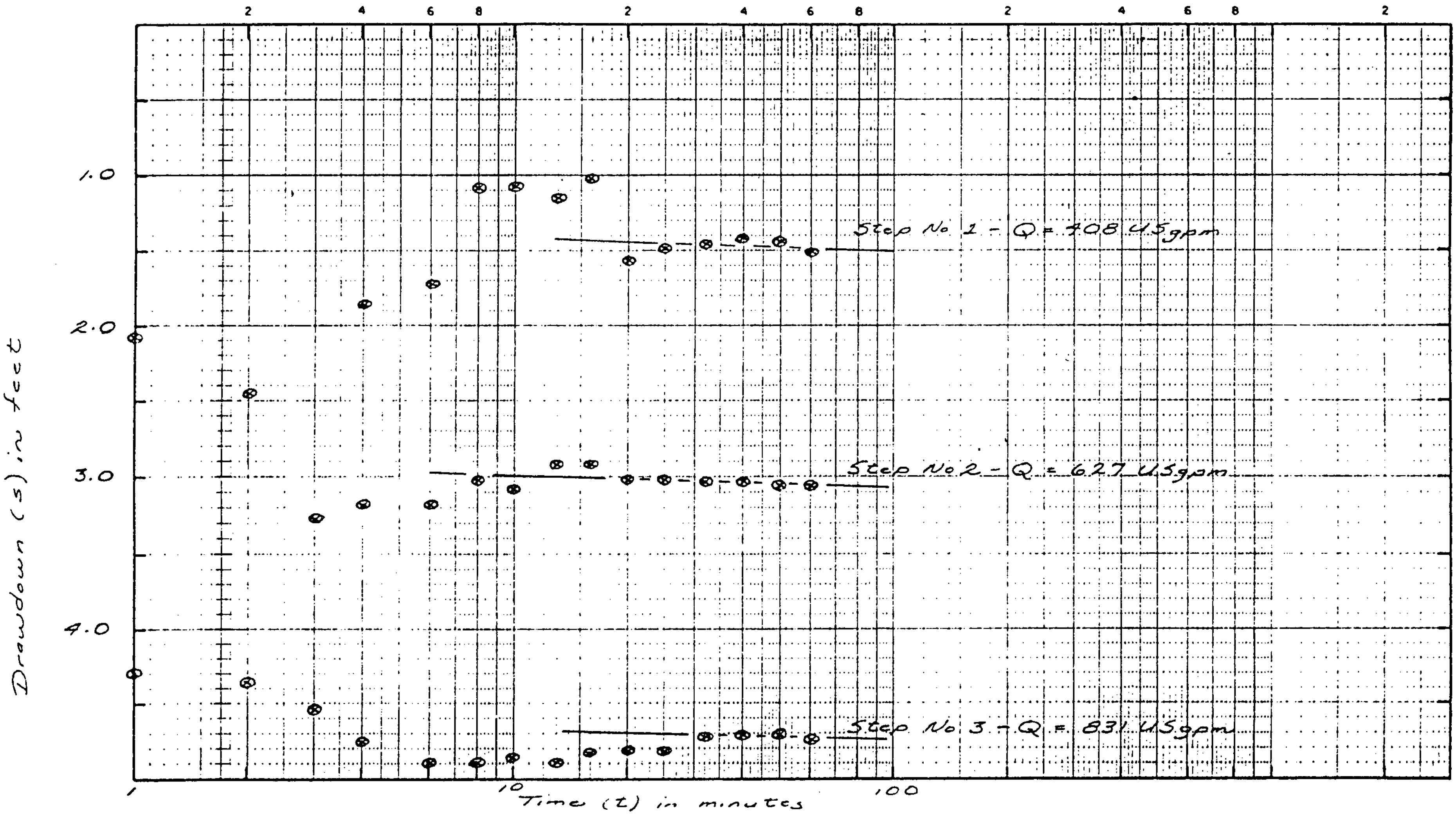
Aquifer Test No. 1 (Continued)

Time (t) Since Pumping Started in Minutes	Depth to Water in Feet	Drawdown (s) in Feet	Comments
13	15.98	2.92	
16	15.98	2.92	627 USgpm
20	16.08	3.02	
25	16.08	3.02	
32	16.09	3.03	
40	16.09	3.03	
50	16.11	3.05	
60	16.11	3.05	
Step No. 3			
1	17.36	4.30	Pumping rate 831 USgpm
2	17.42	4.36	
3	17.59	4.53	
4	17.82	4.76	
6	17.95	4.89	
8	17.95	4.89	
10	17.91	4.86	
13	17.95	4.89	
16	17.88	4.82	
20	17.88	4.82	
25	17.88	4.82	
32	17.78	4.72	
40	17.77	4.71	
50	17.77	4.74	Drawdown in Observation Well 1 0.52 feet

System No. 3 Extension

Aquifer Test No 1

Step-Drawdown



Well No. (Status) : New Well (Pumping)

Date : October 27, 1982

Aquifer Test : No. 1 - Step-Drawdown

Discharge (Q) : 408, 627 & 831 USgpm

Pre-test Water Level : 13.06 feet

Reference Point : Top of casing 1.54 ft above surface.

Remarks :

RALA GROUNDWATER CONSULTING LTD.

S.O.L.I.D.
System No. 3 Extension
Groundwater Development Program
AQUIFER TEST NO. 2 (Constant-rate)
Pumping Well (New Well)

Date test started: Oct. 27, 1982
Pre-test water level: 13.12 feet
Pumping interval: 1320 minutes
Recovery interval: 240 minutes

Completion details: see Figure 3
Time test started: 3:30 P.M.
Average pumping rate: 627 USgpm
Reference point: Top of casing 1.54 feet above ground

PUMPING INTERVAL

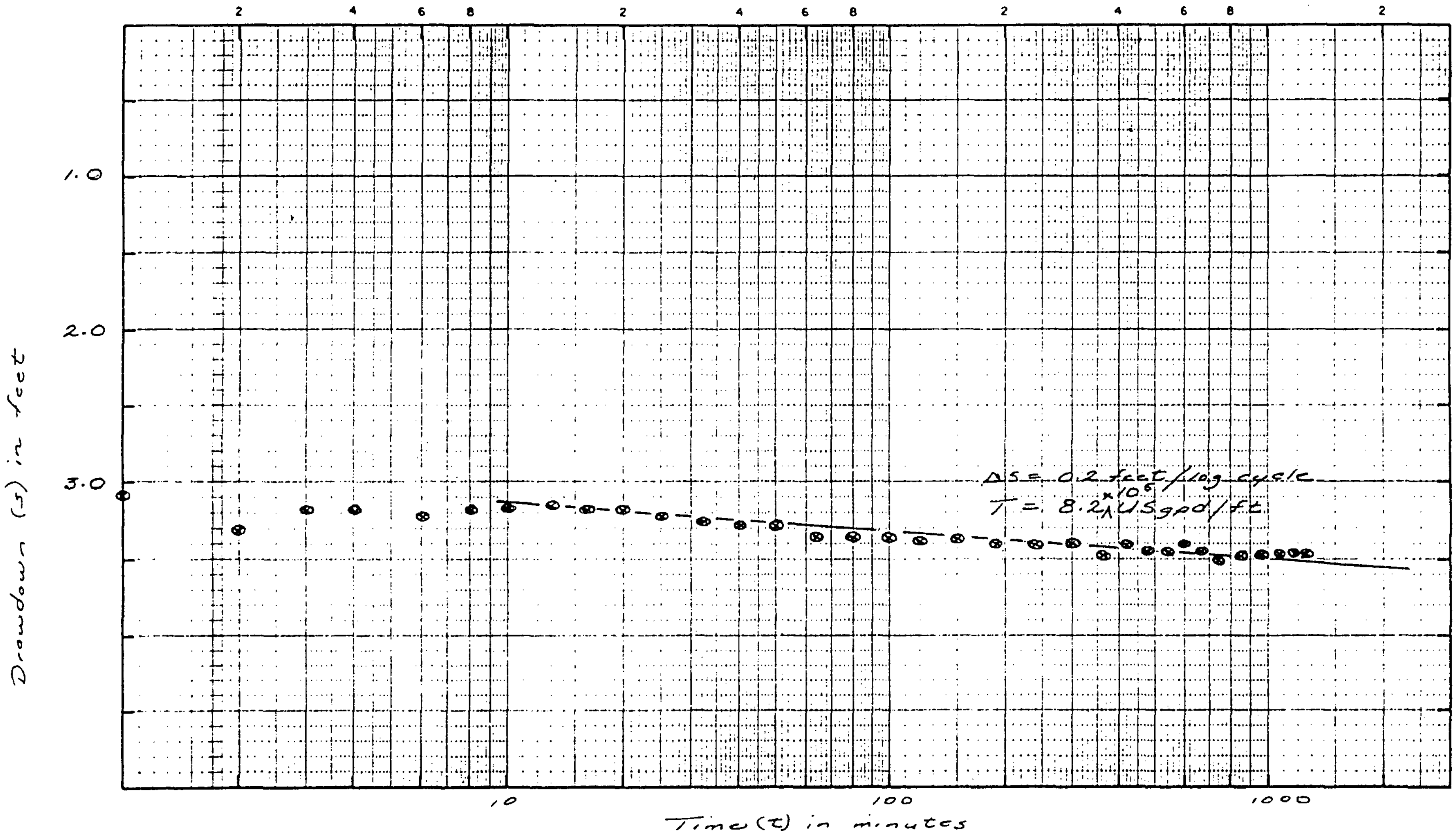
Time (t) since Pumping started in minutes	Depth to Water in Feet	Drawdown (s) in Feet	Remarks
1	16.21	3.08	Pumping rate 627 US gpm
2	16.44	3.31	
3	16.31	3.18	
4	16.31	3.18	
6	16.34	3.22	
10	16.29	3.17	
13	16.27	3.15	
16	16.31	3.18	
20	16.31	3.18	
25	16.34	3.22	
32	16.37	3.25	
40	16.41	3.28	
50	16.41	3.28	
64	16.47	3.35	
80	16.47	3.35	Pumping rate 627 USgpm
100	16.47	3.35	
120	16.50	3.38	
150	16.49	3.37	
190	16.52	3.40	
240	16.54	3.41	

Aquifer Test No. 2 Pumping Well (Cont'd.)

Time (t) since Pumping started in minutes	Depth to Water in Feet	Drawdown (s) in Feet	Remarks
300	16.52	3.40	
360	16.60	3.48	
420	16.54	3.41	
480	16.57	3.45	
540	16.59	3.46	
600	16.54	3.41	
660	16.57	3.45	Pumping rate 627 US gpm
720	16.63	3.51	
780	16.60	3.48	
840	16.60	3.48	
900	16.60	3.48	
960	16.60	3.48	
1020	16.57	3.45	
1080	16.60	3.48	
1140	16.60	3.48	
1200	16.57	3.45	
1260	16.60	3.48	
1320	16.60	3.48	Off Pump Start Recovery

Gro— wa— — lopment Program

Aquifer Test No. 2



Well No. (Status) : New Well (Pumping)

Date : October 27, 1982

Aquifer Test : No. 2 - Constant rate

Discharge (Q) : 627 USgpm

Pre-test Water Level : 13.12 feet

Reference Point : Top of casing 1.54 feet above surface

Remarks : Pumping rate monitored with orifice discharge
8-inch pipe
6-inch orifice

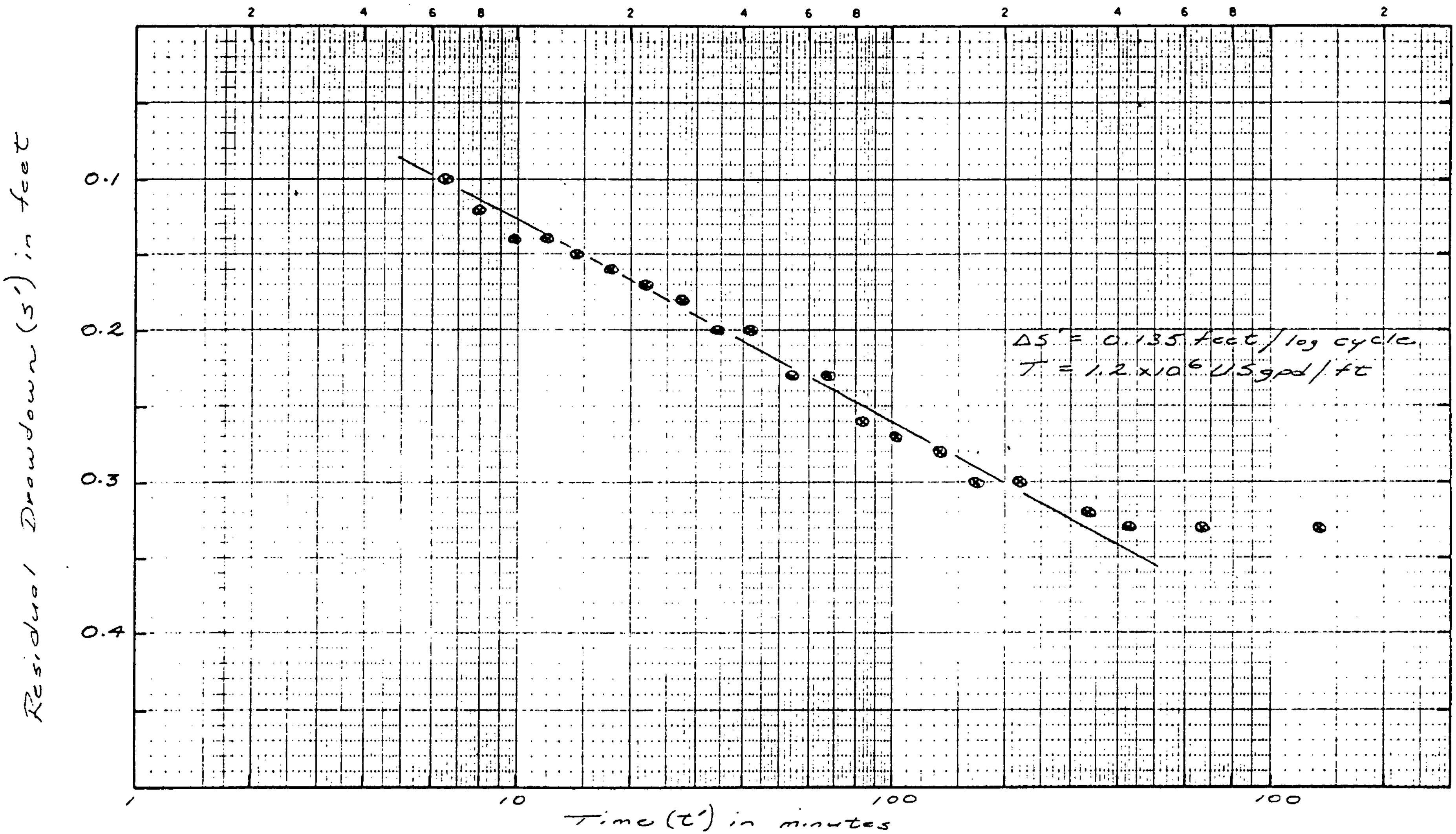
KALA GROUNDWATER CONSULTING LTD.

Aquifer Test No. 2, Pumping Well (Cont't.)

RECOVERY INTERVAL

Time (t) Since Pumping Stopped in Minutes	$\frac{t + t'}{t'}$	Depth to Water in Feet	Residual Drawdown (s') in Feet
1	1321	12.45	0.33
2	661	13.45	0.33
3	441	13.45	0.33
4	331	13.44	0.32
6	221	13.42	0.30
8	166	13.42	0.30
10	133	13.40	0.28
13	102.5	13.39	0.27
16	83.5	13.38	0.26
20	67	13.35	0.23
25	53.8	13.35	0.23
32	42.3	13.32	0.20
40	34	13.32	0.20
50	27.4	13.30	0.18
64	21.6	13.29	0.17
80	17.5	13.28	0.16
100	14.2	13.27	0.15
120	12	13.26	0.14
150	9.8	13.26	0.14
190	7.9	13.24	0.12
240	6.5	13.22	0.10

System No.: Extension
Groundwater Development Program
Aquifer Test No. 2 - Recovery Interval



Well No. (Status) : New Well

Aquifer Test : No. 2 (Recovery)

Pre-test Water Level : 13.12 feet

Remarks :

Date : Oct. 28, 1982

Discharge (Q) : ——

Reference Point : Top of casing 1.5 ft. above ground level

KALA GROUNDWATER CONSULTING LTD.

S.O.L.I.D.

System No. 3 Extension

Groundwater Development Program

AQUIFER TEST NO. 2 (Constant-rate)

Observation Well No. 1 (8-inch)

Date test started: Oct. 27, 1982

Pre-test water level: 10.08 feet

Pumping interval: 1320 minutes

Recovery interval: 240 minutes

Distance from pumping well: 44 feet

Completion details: See attached

Time test started: 3:30

Average pumping rate: 627 USgpm

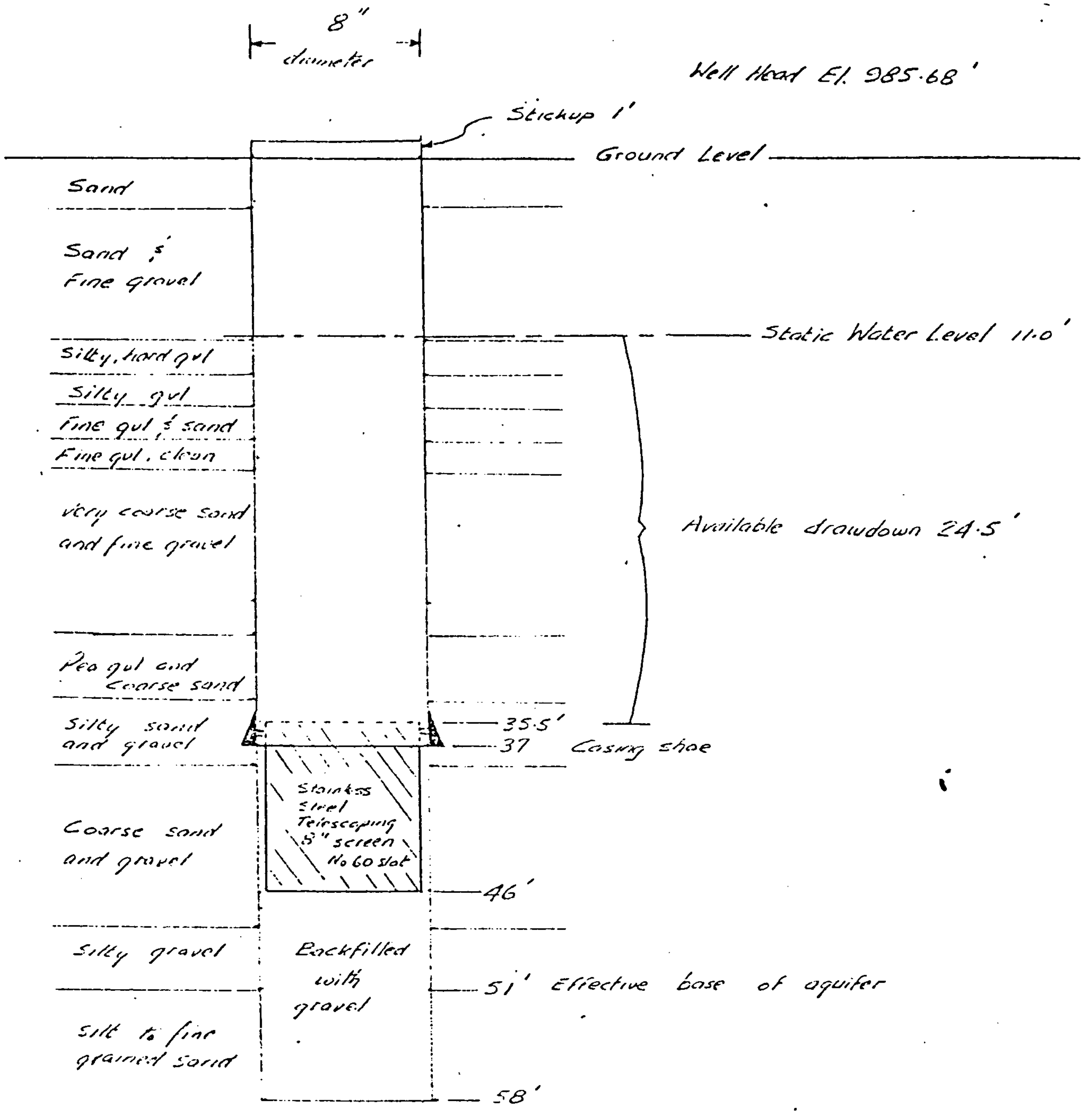
Reference point: Top of measuring tube-approx. 2 feet below ground level

PUMPING INTERVAL

Time (t) since Pumping started in minutes	Depth to Water in Feet	Drawdown (s) in feet	Remarks
1	10.33	0.25	Pumping rate 627 USgpm
2	10.33	0.25	
3	10.375	0.292	
4	10.33	0.25	
6	10.35	0.27	
8	10.375	0.292	
10	10.33	0.25	
13	10.375	0.292	
16	10.375	0.292	
20	10.396	0.313	
25	10.396	0.313	
32	10.42	0.33	
40	10.44	0.35	
50	10.46	0.38	
64	10.46	0.38	
80	10.48	0.40	
100	10.48	0.40	
120	10.54	0.46	
150	10.56	0.48	

Aquifer Test No. 2 Observation Well No. 1 (Cont'd.)

Time (t) since Pumping started in minutes	Depth to Water in Feet	Drawdown (s) in feet	Remarks
190	10.56	0.48	
240	10.56	0.48	
300	10.56	0.48	
360	10.56	0.48	
420	10.58	0.50	
480	10.58	0.50	Pumping rate
540	10.60	0.52	
600	10.60	0.52	
660	10.60	0.52	
720	10.60	0.52	
780	10.60	0.52	
840	10.60	0.52	
900	10.63	0.54	
960	10.63	0.54	
1020	10.63	0.54	
1080	10.63	0.54	
1140	10.65	0.56	
1200	10.63	0.54	
1260	10.65	0.56	
1320	10.65	0.56	

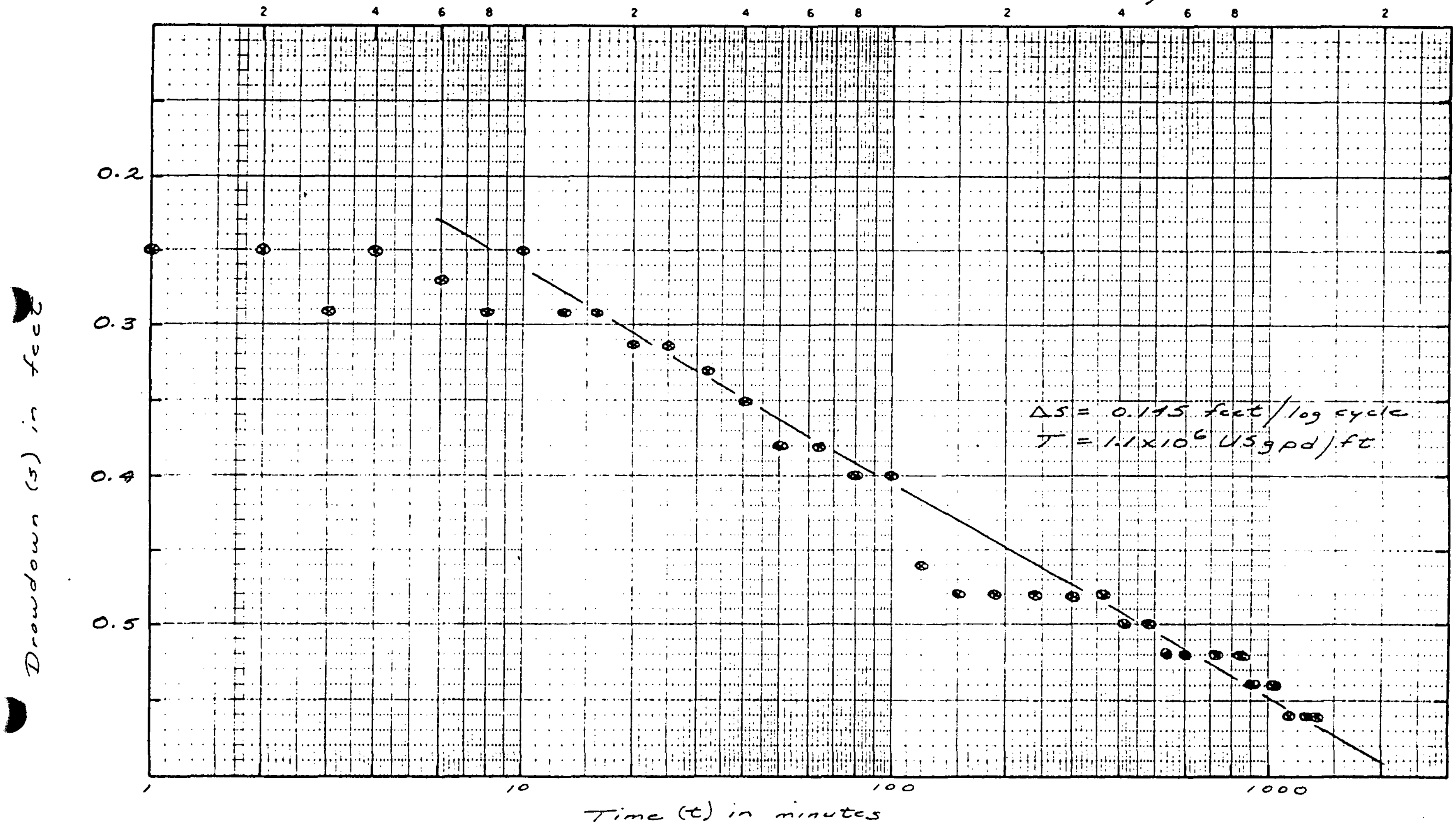


SKETCH OF WELL CONSTRUCTION
SOLID No 3 SYSTEM
WELL No 1

FIGURE 3

GROUNDWATER DIVISION
WATER I[illegible]STIGATIONS BRANCH
DEPT. OF LANDS, F[illegible]ESTS AND WATER RESOURCES
V[illegible]TORIA, B. C.

System No. 3 Extension
Groundwat. Development Program
Aquifer Test No. 2
Observation Well No. 1 (8-inch)



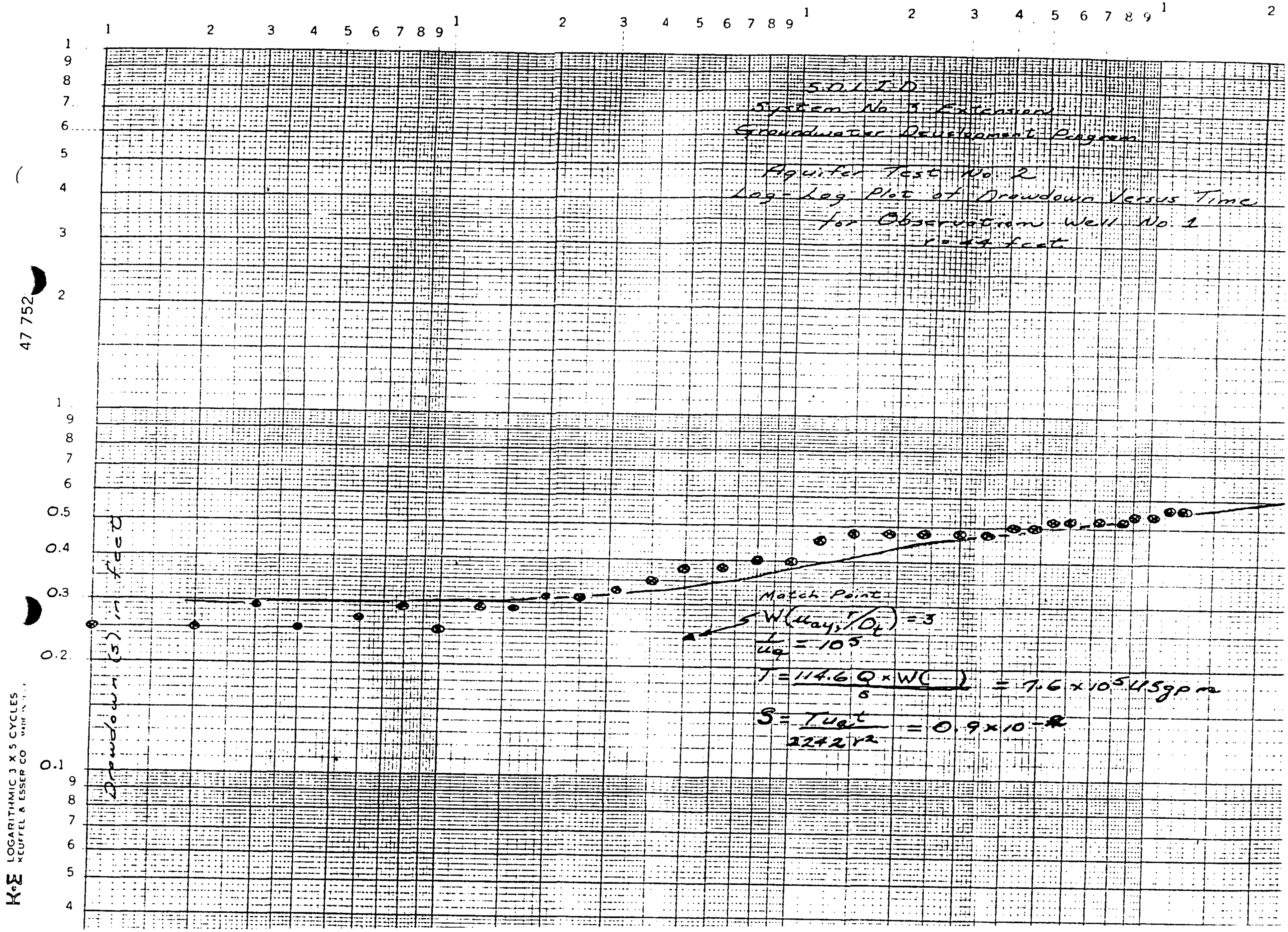
Well No. (Status) : Observation Well No. 1 Date : October 27, 1982

Aquifer Test : No. 2 - Contant rate Discharge (Q) : 627 USgpm

Pre-test Water Level : 10.08 feet Reference Point : Top of measuring tube ≈ 2 feet below ground level

Remarks : r = 44 feet

RALA GROUNDWATER CONSULTING LTD.


S.D.I.I.D.
System No 3 Extension
Groundwater Development Program
Aquifer Test No 2
Log-Log Plot of Drawdown Versus Time
for Observation Well No 1
r = 44 feet
Drawdown (s) in feet
0.5
0.4
0.3
0.2
0.1
Match Point
W(ua, r/D) = 3
1/ua = 10^5
T = 114.6 Q x W( ) / s = 7.6 x 10^5 USgpm
S = T ua t / 2242 r^2 = 0.9 x 10^-2
47 752
K+E LOGARITHMIC 3 X 5 CYCLES
KEUFFEL & ESSER CO

S.O.L.I.D.

System No. 3 Extension

Groundwater Development Program

AQUIFER TEST NO. 2 (Constant Rate)

Observation Well No. 2 (12-inch)

Date started: Oct. 27, 1982

Pre-test water level:10.67

Pumping interval: 1320 minutes

Recovery interval: 240 minutes

Distance from pumping well: 64 feet

Completion details: See attache

Time test started: 3:30 P.M.

Average pumping rate: 627 USgpm

Reference point: Top of measuri
tube-approximately ground level

PUMPING INTERVAL

Time (t) Since Pumping Started in minutes	Depth to Water in Feet	Drawdown (s) in Feet	Remarks
1	10.75	0.08	Pumping rate 627 USgpm
2	10.77	0.10	
3	10.79	0.12	
4	10.79	0.12	
6	10.79	0.12	
8	10.81	0.15	
10	10.83	0.17	
13	10.81	0.15	
16	10.81	0.15	
20	10.83	0.17	
25	10.83	0.17	
32	10.85	0.19	
40	10.88	0.21	
50	10.90	0.23	
64	10.90	0.23	
80	10.92	0.25	
100	10.92	0.25	
120	10.94	0.27	
150	10.92	0.25	
190	10.92	0.25	

Aquifer Test No. 2, Observation Well No. 1 (Cont'd.)

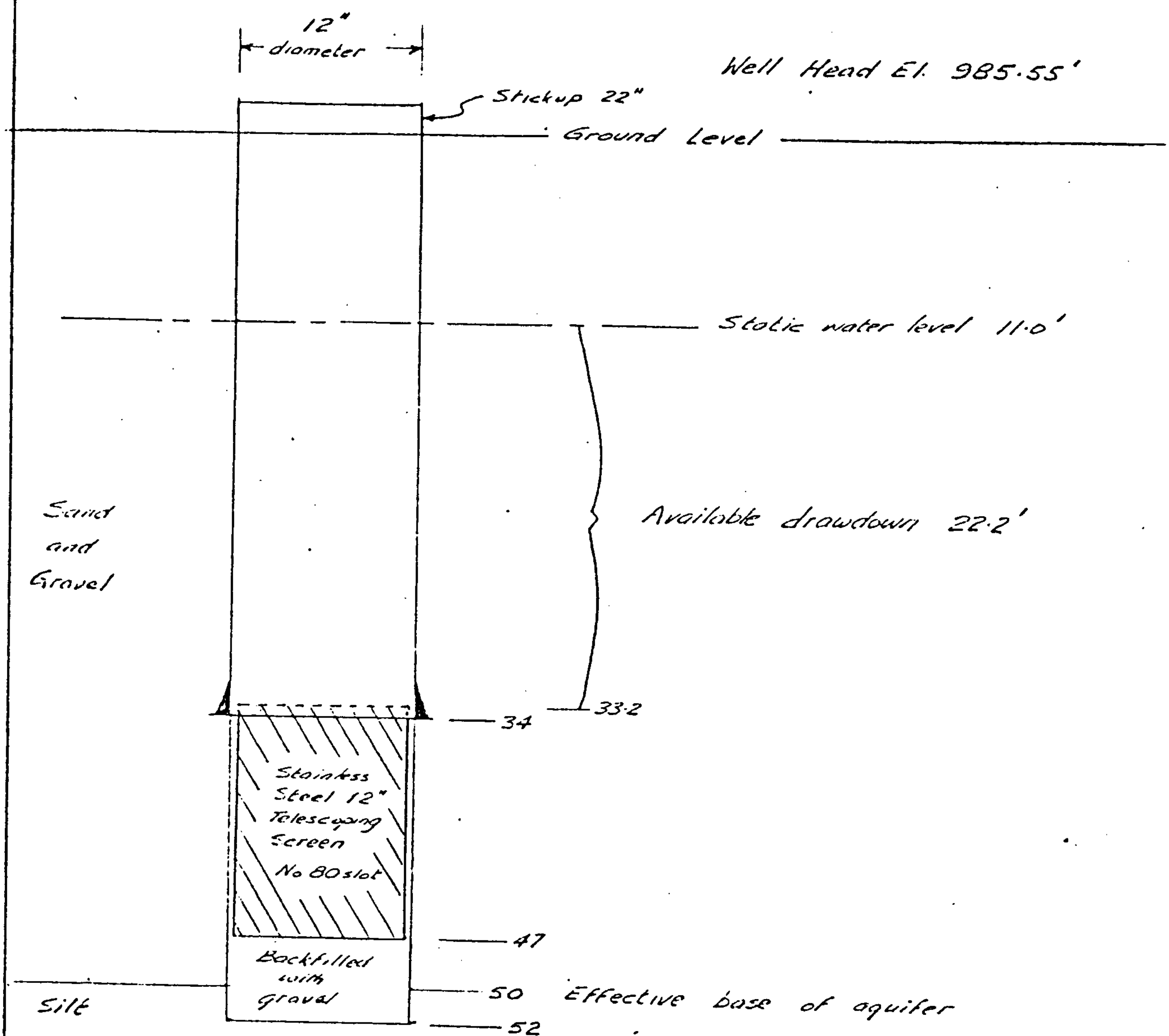
RECOVERY INTERVAL

Time (t') Since Pumping Stopped in Minutes	Depth to Water in Feet	Residual Drawdown (s) in Feet
1	10.48	0.40
2	10.46	0.38
3	10.44	0.36
4	10.42	0.34
6	10.40	0.32
8	10.38	0.30
10	10.38	0.30
13	10.38	0.30
16	10.35	0.27
20	10.35	0.27
25	10.31	0.23
32	10.29	0.21
40	10.27	0.19
50	10.23	0.15
64	10.23	0.15
80	10.23	0.15
100	10.23	0.15
120	10.21	0.13
150	10.21	0.13
190	10.17	0.09
240	10.17	0.09

Aquifer Test No. 2, Observation Well No. 2 (Cont'd.)

PUMPING INTERVAL

Time (t) Since Pumping Started in Minutes	Depth to Water in Feet	Drawdown (s) in Feet	Remarks
240	10.92	0.25	
300	10.94	0.27	627 USgpm
360	10.94	0.27	
420	10.94	0.27	
480	10.96	0.29	
540	10.98	0.31	
600	10.98	0.31	
660	10.98	0.31	
720	10.98	0.31	
780	11.00	0.33	
840	11.00	0.33	
900	11.00	0.33	
960	11.02	0.35	
1020	11.00	0.33	
1080	11.00	0.33	
1140	11.02	0.35	
1200	11.04	0.37	
1320	11.04	0.37	



SKETCH OF WELL CONSTRUCTION

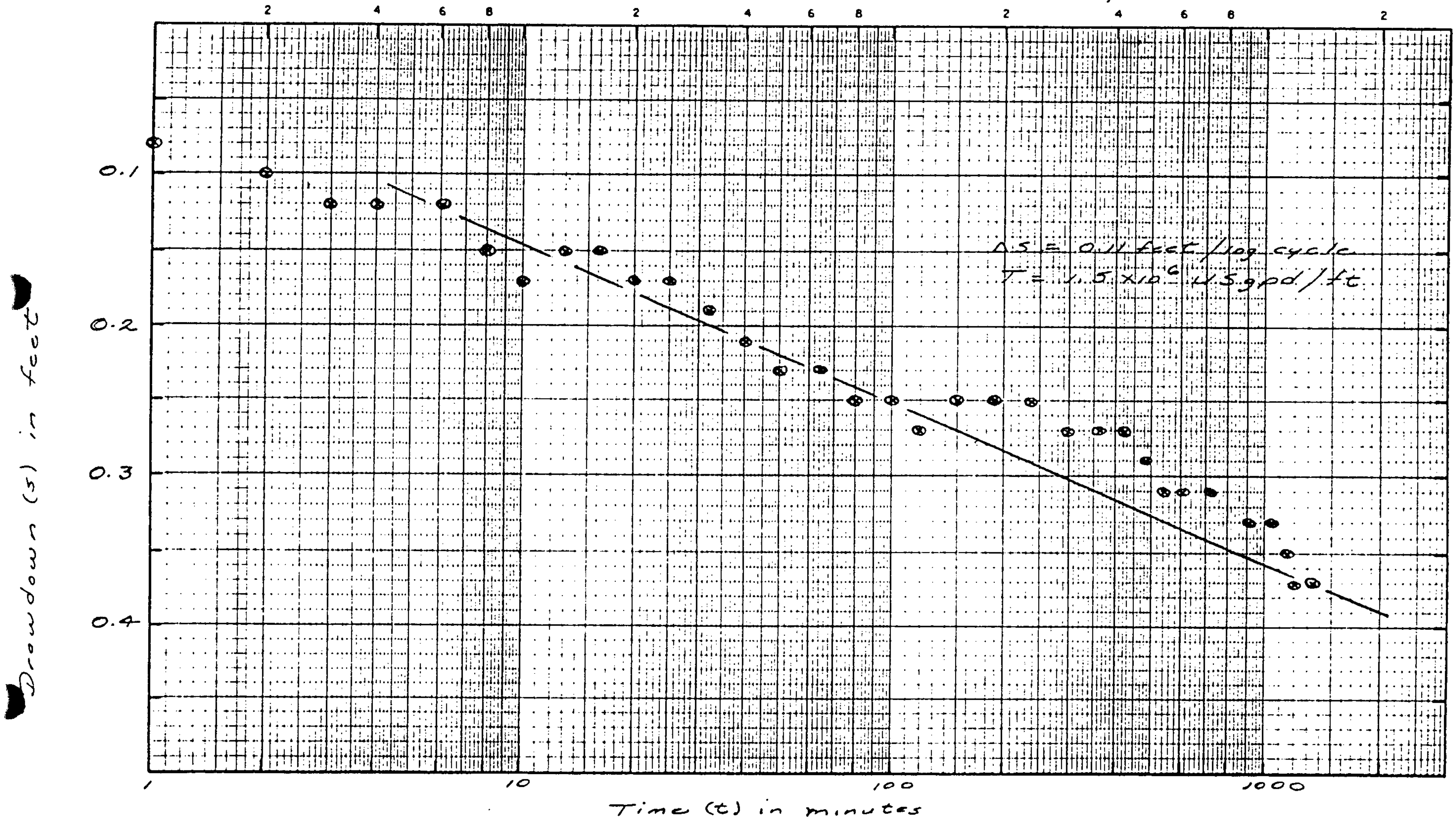
SOLID No 3 SYSTEM

WELL No 2

FIGURE 4

GROUNDWATER DIVISION
WATER INVESTIGATIONS BRANCH
DEPT. OF LANDS, FORESTS AND WATER RESOURCES
VICTORIA, B. C.

System No. 3 Extension
Groundwater D. lopment Program
Aquifer Test No. 2
Observation Well No. 2 (12-inch)



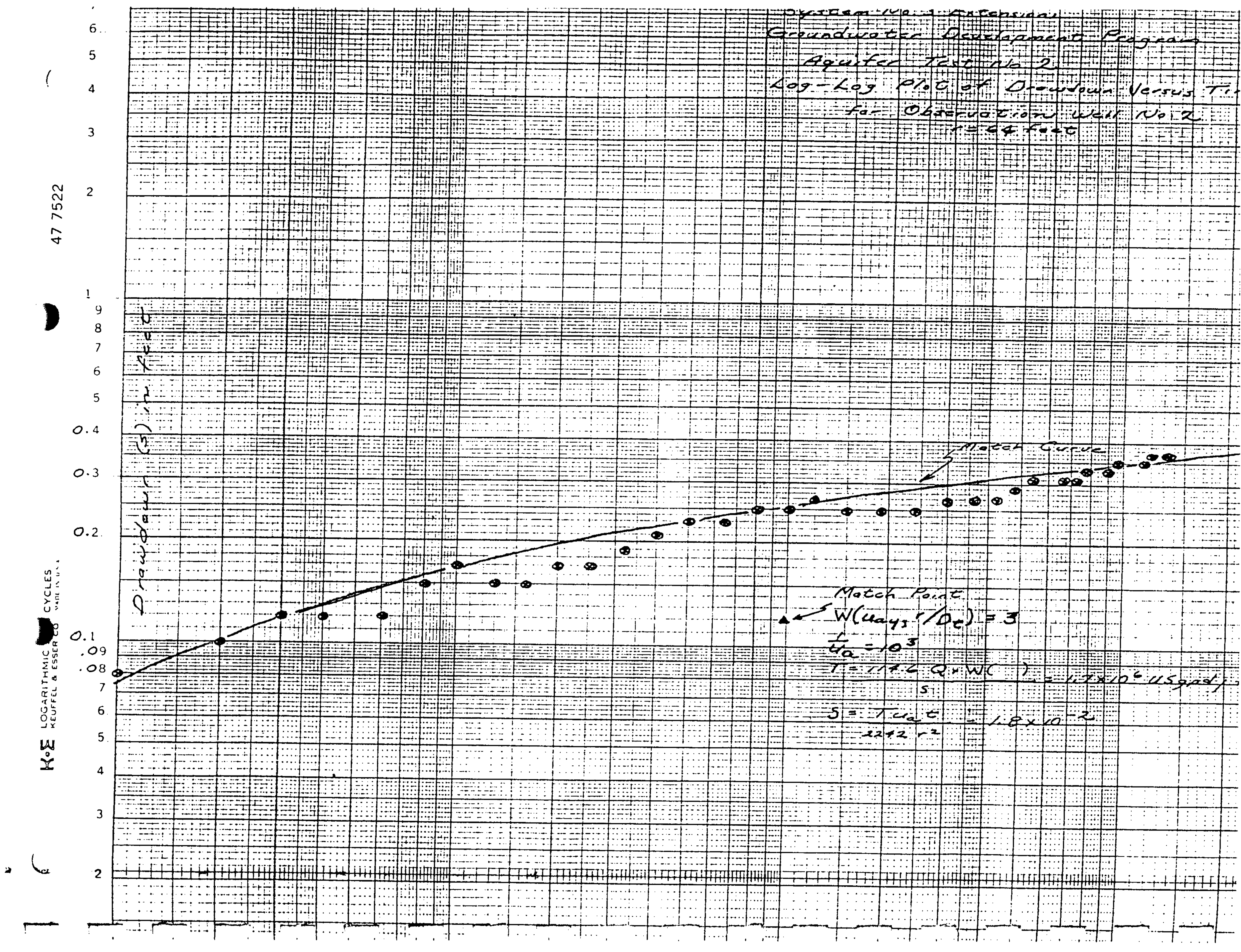
Well No. (Status) : Observation Well No. 2 Date : Oct. 27, 1982

Aquifer Test : No. 2 - Constant rate Discharge (Q) : 627 USgpm

Pre-test Water Level : 10.67 feet Reference Point : Top of measuring tube Approx. ground level

Remarks : r = 64 feet

KALA GROUNDWATER CONSULTING LTD.



Groundwater Development Program
Aquifer Test No 2
Log-Log Plot of Drawdown Versus Ti
for Observation Well No 2
r = 64 feet
Drawdown (s) in feet
0.4
0.3
0.2
0.1
.09
.08
Match Curve
Match Point
W(uays r/Dt) = 3
1/ua = 10^3
T = 114.6 Q × W( ) / s = 1.7×10^6 USgpd/
S = Tua t / 2242 r^2 = 1.8×10^-2
K+E LOGARITHMIC CYCLES
KEUFFEL & ESSER CO.
47 7522

Aquifer Test No. 2, Observation Well No. 2 (Cont'd.)

RECOVERY INTERVAL

Time (t') since Pumping Stopped in Minutes	Depth to Water in Feet	Residual Drawdown (s') in Feet
1	10.92	0.25
2	10.92	0.25
3	10.90	0.23
4	10.90	0.23
6	10.88	0.21
8	10.85	0.18
10	10.85	0.18
13	10.83	0.16
16	10.83	0.16
20	10.83	0.16
25	10.81	0.14
32	10.79	0.12
40	10.79	0.12
50	10.77	0.10
64	10.77	0.10
80	10.77	0.10
100	10.75	0.08
120	10.75	0.08
150	10.75	0.08
190	10.73	0.06
240	10.73	0.06

WELL SCREEN DESIGN INFORMATION

OLIVER TEST DRILLING 1980

Test Hole No. 3 - 11 ft of 16-inch nominal telescoping stainless steel screen

Screen Design	21 - 22 ft	120 slot
	22 - 24 ft	100 slot
	24 - 28 ft	200 slot
	28 - 30 ft	220 slot
	30 - 32 ft	160 slot

Transmitting capacity at entrance velocity of 0.1 fps = 938 Igpm

NB. Well drawdown at 1000 Igpm plus interference from existing well would likely necessitate installation of a pump in a tail pipe below screen.

Test Hole No. 5 - 15 ft of 16-inch nominal telescoping stainless steel screen

Screen Design	31 - 33 ft	100 slot
	33 - 37 ft	40 slot
	37 - 38 ft	80 slot
	38 - 39 ft	160 slot
	39 - 43 ft	225 slot
	43 - 46 ft	130 slot

Transmitting capacity at entrance velocity of 0.1 fps = 1023 Igpm

FLL ~~3/4~~ #2 → Test Hole No. 6 - 14.5 ft of 16-inch nominal telescoping stainless steel screen

CPR Well

Screen Design	30 - 34 ft	250 slot
	34 - 38 ft	185 slot
	38 - 44.5 ft	250 slot

Transmitting capacity at entrance velocity of 0.1 fps = 1149 Igpm

FLL #3 → Test Hole No. 7 - 16 ft of 16-inch nominal telescoping stainless steel screen

Lions Park Well.

Screen Design	60 - 63 ft	260 slot
	63 - 66 ft	80 slot
	66 - 68 ft	160 slot
	68 - 76 ft	260 slot

Transmitting capacity at entrance velocity of 0.1 fps = 1230 Igpm

N.B. An additional 7 ft of screen could be added between 53 and 60 feet (53 - 54 ft/250 slot, 54-57 ft/150 slot, 57-60 ft/260 slot) increasing transmitting capacity to 1776 Igpm, however in considering the capacities of existing supply system components and the likelyhood of needing the additional capacity, only 16 ft of screen will be installed.

WELL LOG CONSTRUCTION RECORD

OWNER

Address

Well Location Obs #7

Date Started ____ Date Completed ____

QUALITY WATER WELLS LTD.
OKANAGAN FALLS, B.C.
BOX 159, PH. 497-5557
V0H 1R0

Pg. 2.

Drilling Method ____

Driller ____ Helper ____

File ____ Folio ____

Signed By ____

LOG OF FORMATIONS

Depth			Descriptions
0	to		
48	to	50	PEBBLES PEAS & SM.
	to		GRAVEL LOOSE (VERY GOOD)
50	to	55	PEBBLES PEAS SMALL
	to		GRAVEL CLEAN & LOOSE
	to		ACTIVE WITH SOME FINES
55	to	60	SMALL GRAVEL & PEAS
	to		LOOSE & POLISHED GOOD
60	to	63	LARGE & SMALL GRAVEL
	to		WITH LITTLE SAND CLEAN (ACTIVE)
63	to	64	BIG GRAVEL WITH GREY
	to		SAND & STRIP OF
	to		CEMENTED GRAVEL WITH
	to		CLAY (DRILLED HARD)
64	to	68	COARSE SAND & BIG GRAVEL
	to		CLEAN WITH LITTLE FINES
68	to	72	LOOSE PEBBLES & PEAS
	to		LG & SM. GRAVEL VERY
	to		CLEAN WITH LITTLE FINES (ACTIVE POLISHED)
72	to	76	PEBBLE & PEAS COARSE SAND
	to		LG & SM. GRAVEL SOME FINES
76	to	78	GREY CLAY FIRM WITH GREY (MIXED)
76	to	85	GREY SAND PASTY
	to		WITH GRAVEL (DIRTY) (NOT MAKING WATER)
	to		
	to		
	to		

GENERAL REMARKS

* ATT.

~~38-63 GOOD MATL.~~

~~64-76 GOOD MATL.~~

CASING RECORD

Dia.____ins. Wt.____#/ft. From____to____

Dia.____ins. Wt.____#/ft. From____to____

Dia.____ins. Wt.____#/ft. From____to____

Shoe____ Welded____ Cemented____

SCREEN RECORD

Make____ Material____

Slot opening____ Length____

Top____ft. Bottom____ft.

Fittings Top____ Fittings Bottom____

Gravel Pack____ Natural____

Development Method____

ROCK WELL DATA

Open Bore Hole____ Dia.____ins.

From____ft. to____ft.

PRODUCTION DATA

Static Level____ft.

Measured from____

Pumping Level____ft. at____GPM

____ft. at____GPM

Bail Test____ft. at____GPH

____ft. at____GPH

Recommended Pump Setting____ft.

Recommended Max. Pump Output____ GPM GPH

Duration of Test____Hrs.

PUMP DATA

Make____ Type____

Model____ Serial No.____

Size____ HP____ Drop Pipe____ins.

GPM____ Head____ ft.____ RPM

Motor____ Volts____ PH____

Well Seal____

Water Analysis — Hardness____PPM

PH____ Iron____PPM

WELL LOG CONSTRUCTION RECORD

OWNER VILLAGE OF OLIVER
Address HOLE #7
Well Location 300' - N of #6 TEST HOLE
Date Started FEB 28/80 Date Completed MAR 4/80

QUALITY WATER WELLS LTD.
OKANAGAN FALLS, B.C.
BOX 159, PH. 497-5557
V0H 1R0
Pg. 1

Drilling Method CABLE
Driller KEITH ROBBINS Helper R. RHODES
File ______ Folio ______
Signed By ______

LOG OF FORMATIONS

Depth			Descriptions
0	to	6	COMPACT SAND &
	to		GRAVEL DIRTY
6	to	13	GREY SAND DIRTY
13	to	17	GREY SAND & GRAVEL
	to		CLEANER
17	to	20	LARGE & SMALL GRAVEL
	to		WITH BR. SAND
20	to	24	LARGE & SMALL GRAVEL
	to		WITH LITTLE SAND BR. (CLEAN)
24	to	28	LARGE & SMALL GRAVEL
	to		POLISHED (ACTIVE)
28	to	30	LARGE & SMALL GRAVEL
	to		TIGHT WITH FINE BR SAND
	to		POLISHED GRAVEL
30	to	32	PEBBLES & PEAS LG & SMALL
	to		GRAVEL WITH LITTLE SAND
	to		LOOSE & ACTIVE
32	to	36	COARSE SAND BR. LOOSE
	to		& CLEAN WITH LG. GRAVEL.
36	to	38	GREY SAND LITTLE DIRTY
	to		WITH SMALL GRAVEL
38	to	40	CLEAN PEBBLES & PEAS
	to		LOOSE & ACTIVE 5-10%
	to		SAND COARSE
40	to	48	PEBBLES & PEAS & SM.
	to		GRAVEL VERY LOOSE
	to		& POLISHED BIRDS EYES
			& LITTLE SAND.

GENERAL REMARKS

CASING RECORD

Dia. 6 ins. Wt. ____ #/ft. From 0 to 85
Dia. ____ ins. Wt ____ #/ft. From ____ to ____
Dia. ____ ins. Wt. ____ #/ft. From ____ to ____
Shoe ____ Welded ____ Cemented ____

SCREEN RECORD

Make ____ Material ____
Slot opening ____ Length ____
Top ____ ft. Bottom ____ ft
Fittings Top ____ Fittings Bottom ____
Gravel Pack ____ Natural ____
Development Method ____

ROCK WELL DATA

Open Bore Hole ____ Dia ____ ins
From ____ ft. to ____ ft

PRODUCTION DATA

Static Level 5' 11 ft
Measured from GROUND
Pumping Level ____ ft. at ____ GPM
____ ft. at ____ GPM
Bail Test ____ ft. at ____ GPM
____ ft. at ____ GPM
Recommended Pump Setting ____ ft
Recommended Max. Pump Output ____ GPM GPH
Duration of Test ____ Hrs

PUMP DATA

Make ____ Type ____
Model ____ Serial No. ____
Size ____ HP ____ Drop Pipe ____ ins
GPM ____ Head ____ ft. ____ RPM
Motor ____ Volts ____ PH ____
Well Seal ____
Water Analysis — Hardness ____ PPM
PH ____ Iron ____ PPM

OWNER V[illegible]LAGE OF OLIVER

Address TEST HOLE # 6

Well Location 250' N OF FILTRATION GALLERY

Date Started Feb. 21/80 Date Completed Feb. 22/80

QUALITY WATER WELLS LTD.
OKANAGAN FALLS, B.C.
BOX 159, PH. 497-5557
V0H 1R0

Drilling Method CABLE TOOL

Driller K. ROBBINS Helper R. RHODES

File ______ Folio ______

Signed By ______

LOG OF FORMATIONS

Depth		Descriptions	
0	to		
1	to 4	SAND & GRAVEL	
	to	COMPACT.	
4	to 9	GREY SAND PASTY	WATER BEARING
9	to 15	GREY SAND DIRTY	
	to	WITH PEBBLES	
15	to 23	LOOSE PEBBLES +	
	to	PEAS CLEAN BROWN	
	to	(ACTIVE)	
23	to 26	PEBBLES & PEAS VERY	
	to	CLEAN ACTIVE	
	to	POLISHED LITTLE SAND	
26	to 44½	PEBBLES & PEAS BIG	BEST
	to	GRAVEL POLISHED	
	to	ACTIVE VERY CLEAN	
44½	to 45	CLAY LENS	
45	to 50	GREY SILT WITH	
	to	PEBBLES DIRTY	

GENERAL REMARKS

CASING RECORD

Dia. 6 ins. Wt. ___ #/ft. From 0 to 50

Dia. ___ ins. Wt ___ #/ft. From ___ to ___

Dia. ___ ins. Wt. ___ #/ft. From ___ to ___

Shoe ___ Welded ___ Cemented ___

SCREEN RECORD

Make ___ Material ___

Slot opening ___ Length ___

Top ___ ft. Bottom ___ ft.

Fittings Top ___ Fittings Bottom ___

Gravel Pack ___ Natural ___

Development Method ___

ROCK WELL DATA

Open Bore Hole ___ Dia. ___ ins.

From ___ ft. to ___ ft.

PRODUCTION DATA

Static Level 3-11 ft.

Measured from GROUND

Pumping Level ___ ft. at ___ GPM

___ ft. at ___ GPM

Bail Test ___ ft. at ___ GPH

___ ft. at ___ GPH

Recommended Pump Setting ___ ft.

Recommended Max. Pump Output ___ GPM GPH

Duration of Test ___ Hrs.

PUMP DATA

Make ___ Type ___

Model ___ Serial No. ___

Size ___ HP ___ Drop Pipe ___ ins.

GPM ___ Head ___ ft. ___ RPM

Motor ___ Volts ___ PH ___

Well Seal ___

Water Analysis — Hardness ___ PPM

PH ___ Iron ___ PPM

TOWN OF OLIVER
GROUNDWATER DEVELOPMENT PROGRAM
WELL NO. 4

Prepared For

THE TOWN OF OLIVER

By

KALA GROUNDWATER CONSULTING LTD.

December, 1990

TABLE OF CONTENTS

LIST OF FIGURES

1 INTRODUCTION

The present program of drilling, well completion and pump testing has been conducted at the request of the Town of Oliver to provide an additional supply of groundwater for the municipality, with particular emphasis on supplying the subdivisions of Fairview and Rockcliffe. All services under the present program, including drilling, pump testing and hydrogeological consulting have been carried out on a sub-contracting and subconsulting basis to T.R. Underwood Engineering of Kamloops, B.C.

A proposal to supply Fairview-Rockcliffe with groundwater was considered by the Town of Oliver several years ago. In 1985 a testhole was drilled in the northeast corner of Lot 129, on the Posnikoff property under the supervision of Kala Groundwater Consulting Ltd. Results of the program indicated that the potential for groundwater development at this location was excellent. Early this year, the Town decided to implement their previous plans and complete a test/production well, which if successful would be designated Well No. 4.

The present program has involved the drilling of a 16-inch testhole, the completion of a test/production well with 30 feet (9.1 metres) of well screen and finally, a 24-hour pumping test. The following report outlines the nature of the drilling and testing program and provides a discussion of the results. In addition, recommendations are made with respect to a safe pumping rate, pump setting and water level monitoring to evaluate long term performance of the well and aquifer. In the section which follows, a brief account of the existing hydrogeological conditions is provided. Detailed information including, water quality, the driller's litholog and pump test data is attached to the Appendix of this report.

2 BACKGROUND

As previously noted in the introductory section of this report, the proposed drill site for the new well was selected on the basis of a testhole drilled in 1985. The site is located on D.L. 129, near the intersection of 11th Avenue and 5th Street (see Figure 1), which is situated approximately one block west of Highway 97, opposite the Town's airstrip.

With respect to topography, the drill site is situated on a relatively flat bench level which rises approximately 40 feet (12.2 metres) above river elevation, measured east of the site. Proceeding westward, the surface gradient begins to increase and eventually gives way to the bedrock upland area occurring on the north and west sides. This upland area is divided to some degree near Fairview, by a relatively broad and sloping valley containing Reed Creek. From air photos, the general area takes on the appearance of a large alluvial fan, with Fairview situated at the apex and the Okanagan River towards the base.

The surficial deposits and major landforms near the well site have been mapped by H. Nasmith (1975) as river channels and stream-cut terraces. Further west the deposits have been designated alluvial fans, deltas, associated gullies and stream channels. Proceeding in the opposite direction, east of the Okanagan River, the surficial deposits have been designated as glacial outwash terraces. In our opinion, the subsurface deposits occurring near the well site are comprised of alluvial fan and glacial outwash which have been re-worked by river action.

The subsurface materials encountered during the drilling of the testhole in 1985 consisted of sand and gravel to 80 feet (24.4 metres), underlain by grey silt. With respect to texture, the sand and gravel was medium to coarse in size and the gravel was fairly well rounded. Upon completion, the water level in the testhole was 20 feet (6.1 metres) below surface.

One final comment relates to our thoughts on possible sources of recharge to the local groundwater resources in the general vicinity. Groundwater occurring within the granular deposits near the drill site probably represents subsurface flows recharged from the Okanagan River. A small percentage of the recharge may result from surface water drainage originating in the upland area and also leakage from the irrigation canal located west of the well site.

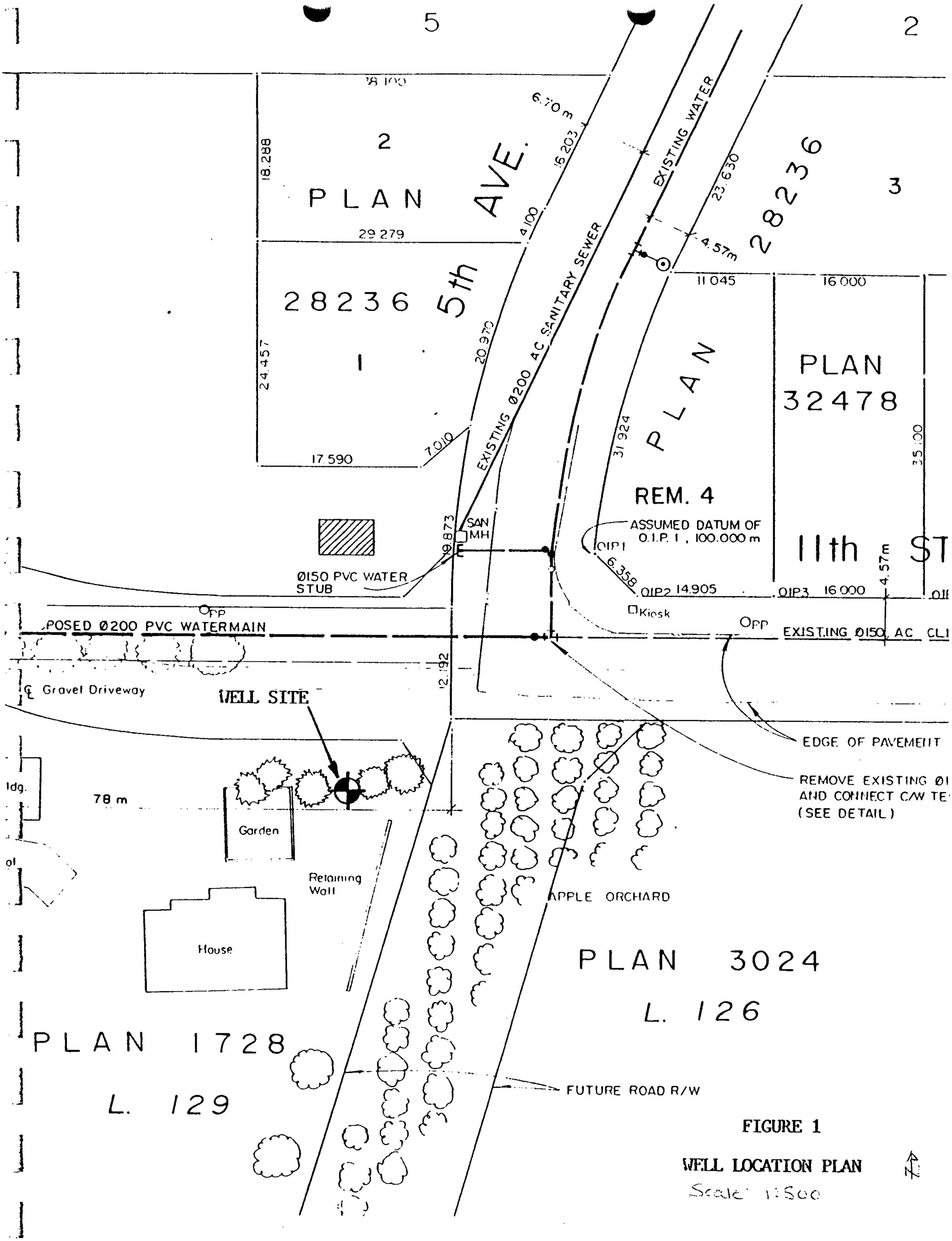


FIGURE 1

WELL LOCATION PLAN

Scale 1:500

3 DESCRIPTION OF PRESENT PROGRAM

3.1 DRILLING

Based on competitive price and availability, Robbins Water-well Drilling of Okanagan Falls was selected to complete the well construction program. Using the cable tool method, 20-inch (508 mm) surface casing was drilled and set to a depth of 20 feet (6.1 metres) below ground level. This was followed with the installation of 16-inch (406 mm) main-string casing, which was used for the remainder of the drilling project.

At a depth of 21 feet (6.4 metres), the first water-bearing material, comprised of coarse sand and gravel was encountered. The formation material was loose, allowing advancement of the casing by bailing and driving. As the drilling progressed, samples of the water-bearing material were obtained at 2-foot (0.6 metre) intervals for sieve analyses.

The water-bearing sand and gravels terminated at 80 feet (24.4 metres) and the formation changed to a grey silt mixed with some gravel. To ensure that the silt was not just a thin layer, underlain by additional sands and gravels, the drilling was continued. At a depth of 90 feet (27.4 metres), the formation was comprised entirely of silt and consequently it was decided to terminate drilling and complete a well in the water-bearing material encountered previously.

Based on the sieve analyses (see Appendix), a screen assembly was selected and set from 48.5 to 79.9 feet (14.8 to 24.4 metres) below ground surface. The casing was then pulled back to expose the screens and the well development process initiated. Most of the development was carried out by surging inside the screens, while pumping the fines to waste using a 5 HP submersible pump installed inside the 16-inch casing.

3.2 PUMPING TEST

In order to evaluate the capacity of the new well and hydrogeologic properties of the aquifer, a 24-hour pumping test was conducted upon completion of the well. For this phase of the program, Lingo Pump Services of Vernon, B.C. were subcontracted by Robbins Waterwell Drilling as part of the overall well construction contract.

The equipment utilized during the test included a vertical line-shaft turbine pump and gasoline driven power unit. Water from the test was discharged to waste through 8-inch aluminium irrigation pipe, into the irrigation canal located approximately 850 feet (260 metres) west of the drill site. The discharge rate was monitored by means of a standard circular orifice.

Based on the pump curve specifications for the test pump, there should have been no problems in reaching a pump rate of 1500 USgpm. As it turned out however, in order to attain even 1400 USgpm it required maximum output from the gasoline driven power unit. For this reason there was some fluctuation in the pumping rate, which ranged from a low of 1327 USgpm to a maximum of 1421 USgpm (see detailed pump test data in Appendix).

Near the end of the pumping interval, water samples were obtained for chemical and bacteriological analyses. Upon cessation of pumping, recovery measurements were taken for a two-hour period.

4 DISCUSSION OF RESULTS

4.1 WELL COMPLETION

The water-bearing formation encountered during the present program consisted of a coarse sand and gravel with cobbles in the upper portion of the aquifer, grading to mostly sand with some gravel towards the base. This is evident by the well screen selection, which contains 180 slot (180 thousandths of an inch openings) at the top, decreasing to 80 thousandths of an inch at the bottom. A more detailed description of the screen assembly, along with depth setting is as follows:

Depth Interval Feet	(Metres)	Description
48.5 - 49.1	(14.8 - 15.0)	Figure K packer
49.1 - 59.4	(15.0 - 18.1)	#180 slot, Johnson's stainless steel, 16-inch telescopic well screen
59.4 - 71.9	(18.1 - 21.9)	#140 slot, well screen
71.9 - 79.9	(21.9 - 24.4)	#80 slot, well screen
Bottom fitting		Steel plate welded on

As previously noted, most of the well development process was carried out inside the screens, while pumping the fines to waste using a 5 HP submersible pump. In addition, the contractor also swabbed the well during the early stages of development, using a one-way surge above the screen assembly.

Following development of the well, the annular space between the 20-inch surface casing and the 16-inch main-string was grouted with cement. A well completion diagram is shown in Figure 2.

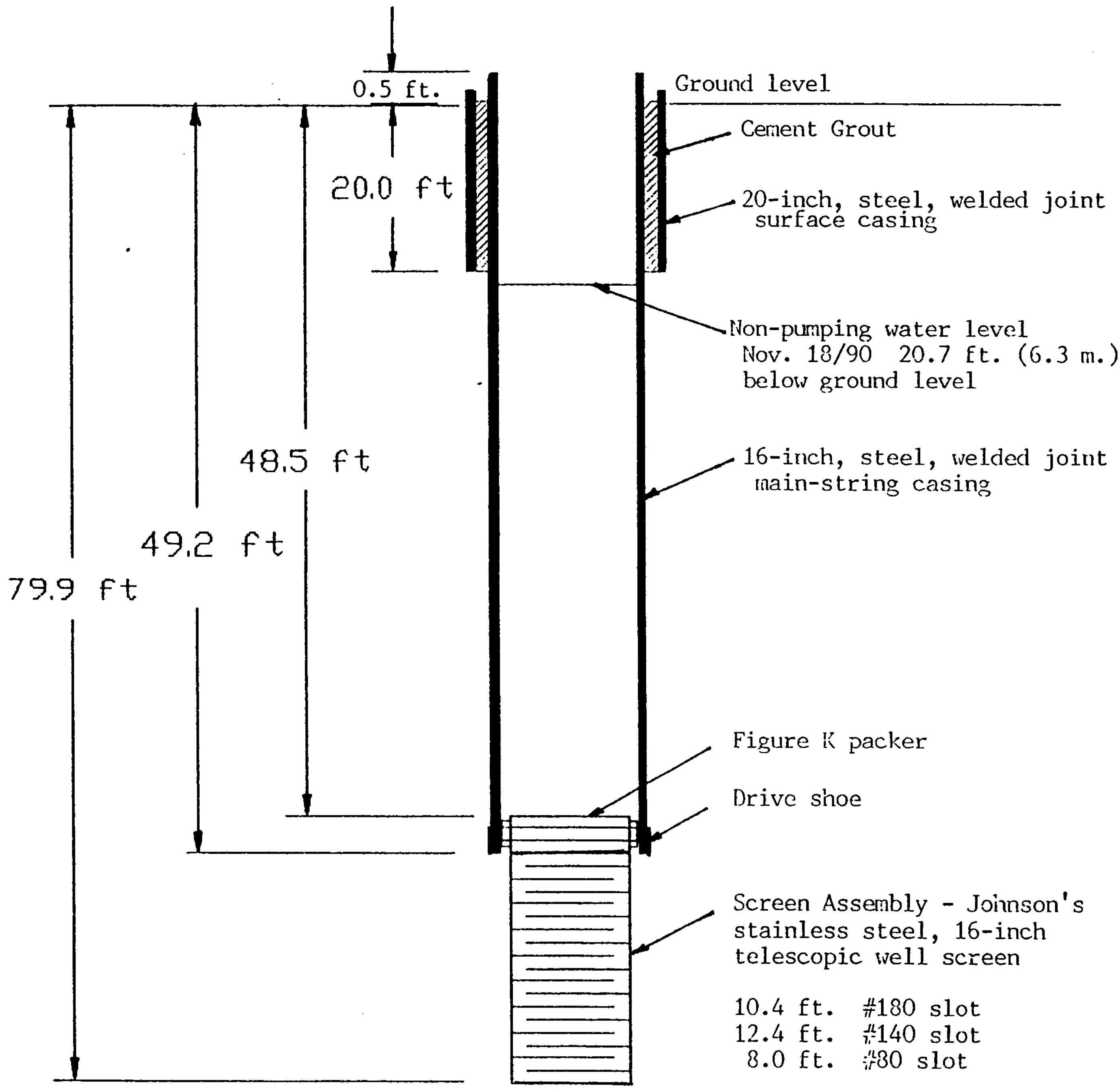


FIGURE 2

WELL COMPLETION DIAGRAM

4.2 PUMPING TEST

Results of the 24-hour pumping test have been plotted on a semi-log graph of drawdown versus time (see Appendix). During the first 200 minutes of the test, the pumping level was essentially stable with 1.28 feet (0.39 metres) of drawdown. Following the 200 minute interval, the pumping level began to drawdown at a steady rate of 0.3 feet (0.09 metres) per log cycle. Variations from this general trend can for the most part be accounted for by the fluctuating pumping rate, which was explained in Section 3.2 of this report.

The results are fairly typical for a water table aquifer which, due to the effects of delayed gravity drainage, does not show consistent drawdown until these effects have dissipated. A coefficient of transmissivity determination for the aquifer based on the results of the test is 9.5×10^5 Igpd/foot. This is fairly high and indicates that the aquifer has excellent prospects for further development. At this stage however, we do not have the necessary information to calculate a maximum safe yield for the aquifer. This will require the completion of additional wells and more extensive pump testing.

Based on the results of the present program, we would recommend a safe pumping rate of 1500 USgpm (1250 Igpm) for the new well. Also, in order to determine the long-term performance of the aquifer during extended periods of pumping, water levels should be monitored on a regular basis once the well is put into production.

4.3 WATER QUALITY

A copy of the water analysis report for the sample obtained during the pumping test is attached along with a partial analysis for a sample obtained during the early stages of well development. Generally speaking, the water quality is excellent and all parameters are within the acceptable limits for Canadian drinking Water Quality as recommended by the Department of National Health and Welfare.

The water is on the hard side and nitrate levels are somewhat elevated. It is interesting to note that while pumping the well at 100 USgpm during the development stage, the nitrate concentration was 5.36 PPM. During the pump test however, pumping the well at an average rate of 1375 USgpm, the nitrate level increased to 7.30 PPM. This change would be in our opinion, due to the larger cone of drawdown, which during the pumping test would have extended further into the orchard property. Nitrate levels are commonly high in the shallow to medium depth range wells throughout the Oliver-Osoyoos area, probably due to the application of fertilizer on orchards.

Some of the other key parameters such as iron and manganese showed a significant decrease during the main pumping test.

5 CONCLUSIONS AND RECOMMENDATIONS

The present groundwater development program has resulted in the successful completion of Well No. 4 for the Town of Oliver. Based on the results of the program, pertinent information relating to the new well and aquifer is summarized as follows:

1) The new well is completed in a water table aquifer comprised of coarse sand and gravel with cobbles.

2) In our opinion, the subsurface materials occurring in the general vicinity have been deposited as alluvial fan and glacial outwash, re-worked by river action.

3) A coefficient of transmissivity determination for the aquifer is 9.5 x 10^5 Igpd/foot, which is fairly high and indicates that the aquifer offers excellent prospects for further development.

4) The new well is completed to a total depth of 79.9 feet (24.4 metres) with a 31.4-foot (9.6 metre) screen assembly set from 48.5 to 79.9 feet (14.8 to 24.4 metres) below ground surface.

5) The following design parameters are recommended for the new well:

   Pump Setting: 40 feet (12.2 metres) below ground surface.
   Pumping Rate: 1500 USgpm (1250 Igpm).
   Projected Drawdown: 1.7 feet (0.5 metres) after 24 hours and 2.5 feet (0.75 metres) after 30 days of continuous pumping at 1500 USgpm.

6) With respect to water quality, all parameters are within the acceptable limits for Canadian Drinking Water as recommended by the Department of National Health and Welfare. The water is on the hard side and nitrate levels are somewhat elevated.

In order to determine the long-term performance of the aquifer during extended periods of pumping, it is recommended that water levels be monitored on a regular basis once the well is put into production. The water level records should be reviewed by a hydrogeologist at the end of the first season. Also it is recommended that the nitrate levels be monitored during the initial stages of production to determine any significant trends.

APPENDIX

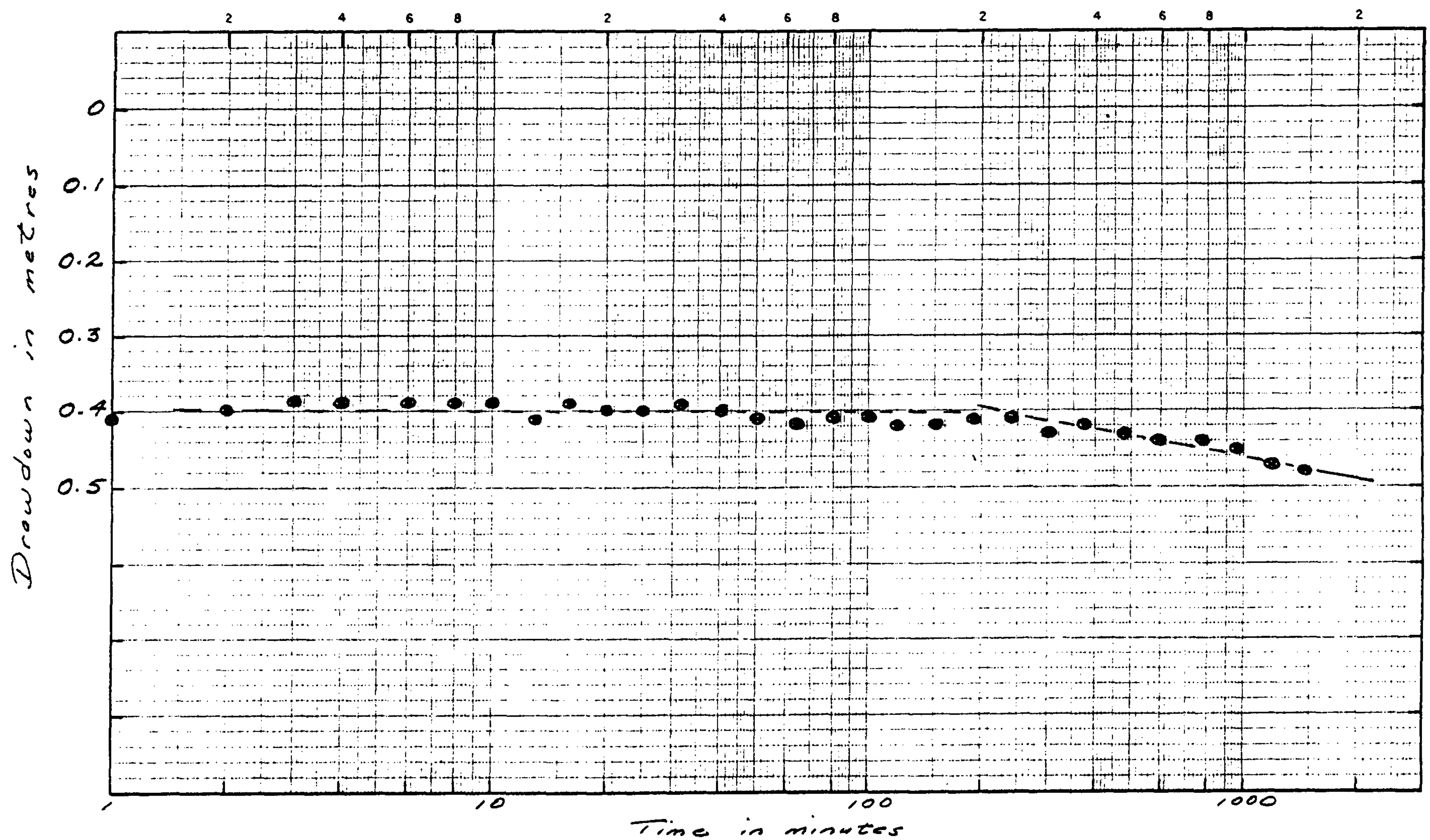
Town of Oliver

Well No. 4 (Fairview-Rockcliffe)

Pumping Test

Date Test Started:	Nov. 18/90	Reference pt:	Top of measuring tube
Time Test Started:	1:00 PM	Height of Ref:	0.28 metres
Ave. Pumping Rate:	1375 USgpm	Depth of Well:	24.4 metres
Pre-test Water Lev:	6.46 metres	Top of Screen:	14.8 metres

Time (t) since pumping started in minutes	Depth to water metres	Drawdown in metres	Comments
1	6.87	0.41	Pump rate: 1365 USgpm
2	6.86	0.40	
3	6.85	0.39	
4	6.85	0.39	
6	6.85	0.39	
8	6.85	0.39	
10	6.85	0.39	
13	6.87	0.41	
16	6.85	0.39	
20	6.86	0.40	Pump rate: 1347 USgpm
25	6.86	0.40	
32	6.85	0.39	Pump rate: 1365 USgpm
40	6.86	0.40	
50	6.87	0.41	Nitrate sample
64	6.88	0.42	Pump rate: 1365 USgpm
80	6.87	0.41	
100	6.87	0.41	Pump rate: 1405 USgpm
120	6.88	0.42	
150	6.88	0.42	Pump rate: 1405 USgpm
190	6.87	0.41	
240	6.87	0.41	Pump rate: 1327 USgpm
300	6.89	0.43	Pump rate: 1345 USgpm
380	6.88	0.42	
480	6.89	0.43	
600	6.90	0.44	
780	6.90	0.44	
960	6.91	0.45	
1200	6.93	0.47	Pump rate: 1421 USgpm
1440	6.94	0.48	Pump rate: 1421 USgpm



Well No. (Status) : Well No. 4 (Pumping)

Aquifer Test : No. 1 (Constant rate)

Pre-test Water Level : 6.46 metres

Remarks : Town of Oliver
Groundwater Development Program
Well No. 4

Date : Nov. 18/90

Discharge (Q) : 1375 USgpm

Reference Point : Top of measuring tube
0.2 m. above ground

KALA GROUNDWATER CONSULTING LTD.

Well No. 4, Pumping Test, Recovery Interval

Time (t) since pumping ended in minutes	Depth to water metres	Drawdown in metres	Comments
1	6.55	0.09	
2	6.52	0.06	
3	6.55	0.09	
4	6.57	0.11	
6	6.57	0.11	
8	6.57	0.11	
10	6.57	0.11	
13	6.56	0.10	
16	6.56	0.10	
20	6.56	0.10	
25	6.56	0.10	
32	6.56	0.09	
40	6.55	0.09	
50	6.55	0.09	
64	6.55	0.09	
80	6.55	0.09	
100	6.54	0.08	
120	6.54	0.08	

CHEMAC

CHEMAC ENVIRONMENTAL SERVICES
(A DIVISION OF CARO ENTERPRISES INC.)
#1 - 368 Industrial Avenue, Kelowna, British Columbia, Canada V1Y 7E8 • Telephone (604) 763-1535

CERTIFICATE OF ANALYSIS

November 23, 1990

T.R. Underwood Engineering
1012 Victoria Street
KAMLOOPS, BC V2C 2C4

Sample Identification: Town of Oliver Well #4, Nov.19/90

Date Sampled: Nov. 19, 1990 Date Received: Nov. 19, 1990

Alkalinity (Total)	239	mg/L as CaCO3
Aluminum	<0.2	mg/L
Arsenic	<0.01	mg/L
Barium	0.040	mg/L
Boron	<0.2	mg/L
Cadmium	<0.001	mg/L
Chloride	3.9	mg/L
Chromium	0.004	mg/L
Color (True)	<10	Color Units
Copper	<0.002	mg/L
Cyanide	<0.020	mg/L
Dissolved Solids(Total)	358	mg/L
Fluoride	0.4	mg/L
Hardness(Total)	312	mg/L as CaCO3
Iron	0.02	mg/L
Lead	<0.004	mg/L
Manganese	<0.01	mg/L
Mercury	0.0001	mg/L
Molybdenum	0.002	mg/L
Nitrate	7.30	mg/L as N
Nitrite	<0.01	mg/L as N
Sodium	12.1	mg/L
Sulphate	47	mg/L
pH	7.62	pH Units
Turbidity	0.11	N.T.U.
Uranium	0.0067	mg/L
Zinc	0.022	mg/L
Total Coliform	0	colonies/100mL
Fecal Coliform	0	colonies/100mL

Certified by:____________________

CHEMAC ENVIRONMENTAL SERVICES
Janice M. Fraser, B.Sc.

CHEMAC™

CHEMAC ENVIRONMENTAL SERVICES
(A DIVISION OF CARO ENTERPRISES INC.)
#1 - 368 Industrial Avenue, Kelowna, British Columbia, Canada V1Y 7E8 • Telephone (604) 763-1535

CERTIFICATE OF ANALYSIS

November 13, 1990

Kala Groundwater Consulting Ltd.
3103 - 28th Street
VERNON, BC
V1T 4Z7

Sample Identification: Oliver Well, Nov. 8/90, 8:40am

Date Sampled: Nov. 8, 1990 Date Received: Nov. 8, 1990

Alkalinity (Total)	249	mg/L as CaCO3
Calcium	77.4	mg/L
Chloride	6.5	mg/L
Color (True)	<10	Color Units
Dissolved Solids(Total)	325	mg/L
Fluoride	0.2	mg/L
Hardness(Total)	277	mg/L as CaCO3
Iron	0.44	mg/L
Magnesium	20.3	mg/L
Manganese	0.03	mg/L
Nitrate	5.36	mg/L as N
Nitrite	<0.01	mg/L as N
pH	7.47	pH units
Potassium	4.73	mg/L
Sodium	12.4	mg/L
Specific Conductance	596	umhos/cm
Sulphate	44	mg/L
Turbidity	20.5	N.T.U.

Certified by: [signature]

CHEMAC ENVIRONMENTAL SERVICES
Janice M. Fraser, B.Sc.

Note: mg/L = ppm

SIEVE ANALYSIS

PROJECT: [illegible]

REMARKS: Well No 4

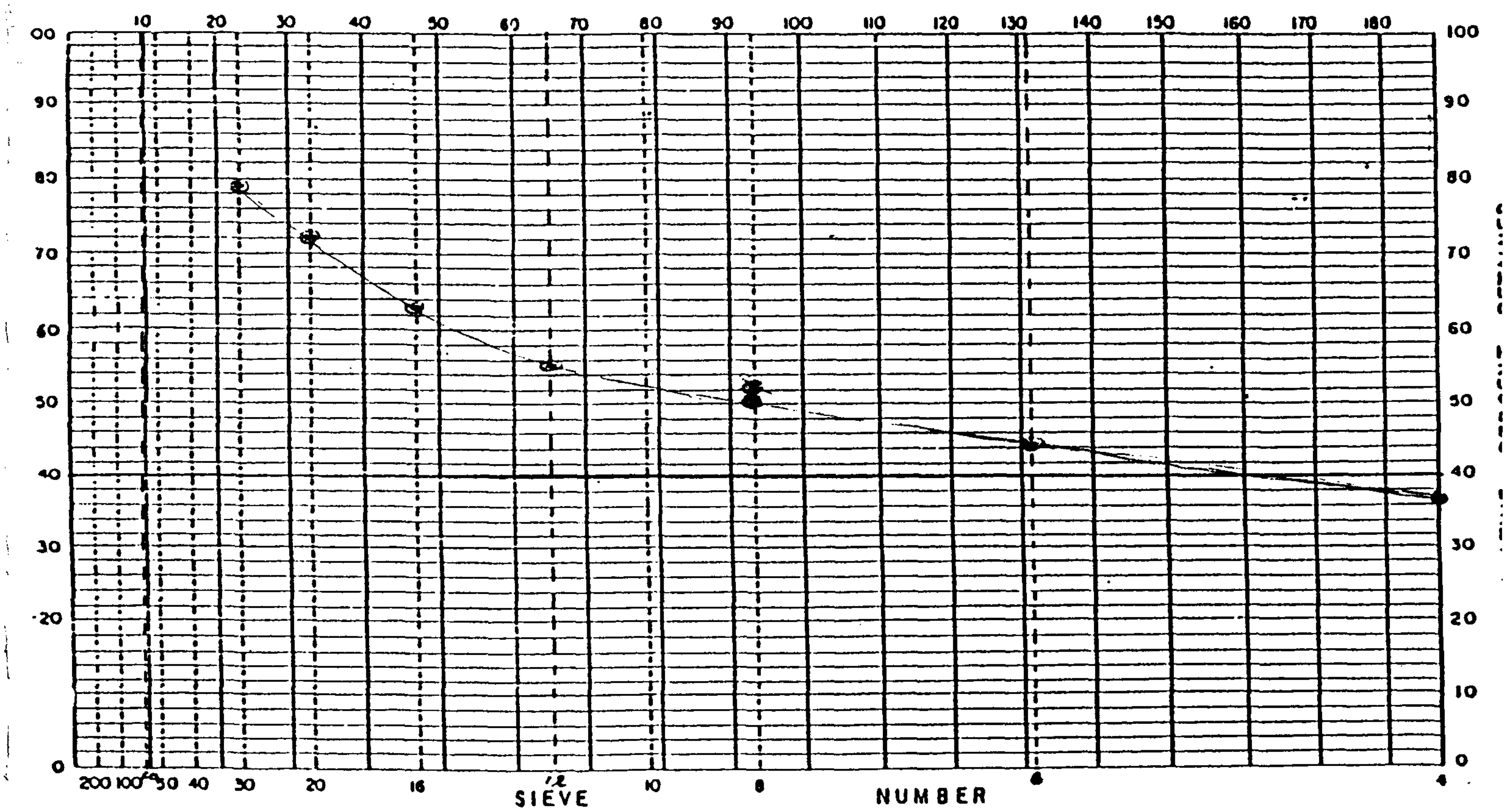
DEPTH: 55 - 55

SIEVE OPENNING INCH.	MM	U.S. SIEVE NO	CUMULATIVE % RETAINED WT RET.	% RET.	REMARKS
		1/2 Inch			
.265		.265			
.187		4	290	36.7	
.132		6	350	44.3	
.0937		8	400	50.6	
.0661		12	440	55.7	
.0469		16	500	63.3	
.0331		20	570	72.2	
.0234		30	625	79.1	
.0165		40			
.0098		60			
.0059		100			
.0029		200			
		PAN	790		

Total Wt: 790

1900 c pebbles > 1/2" (58%)
Large amount pebbles & cobbles

SIEVE OPENNING IN THOUSANDTHS OF AN INCH



SIEVE ANALYSIS

PROJECT: Oliver

REMARKS: Well No. 4

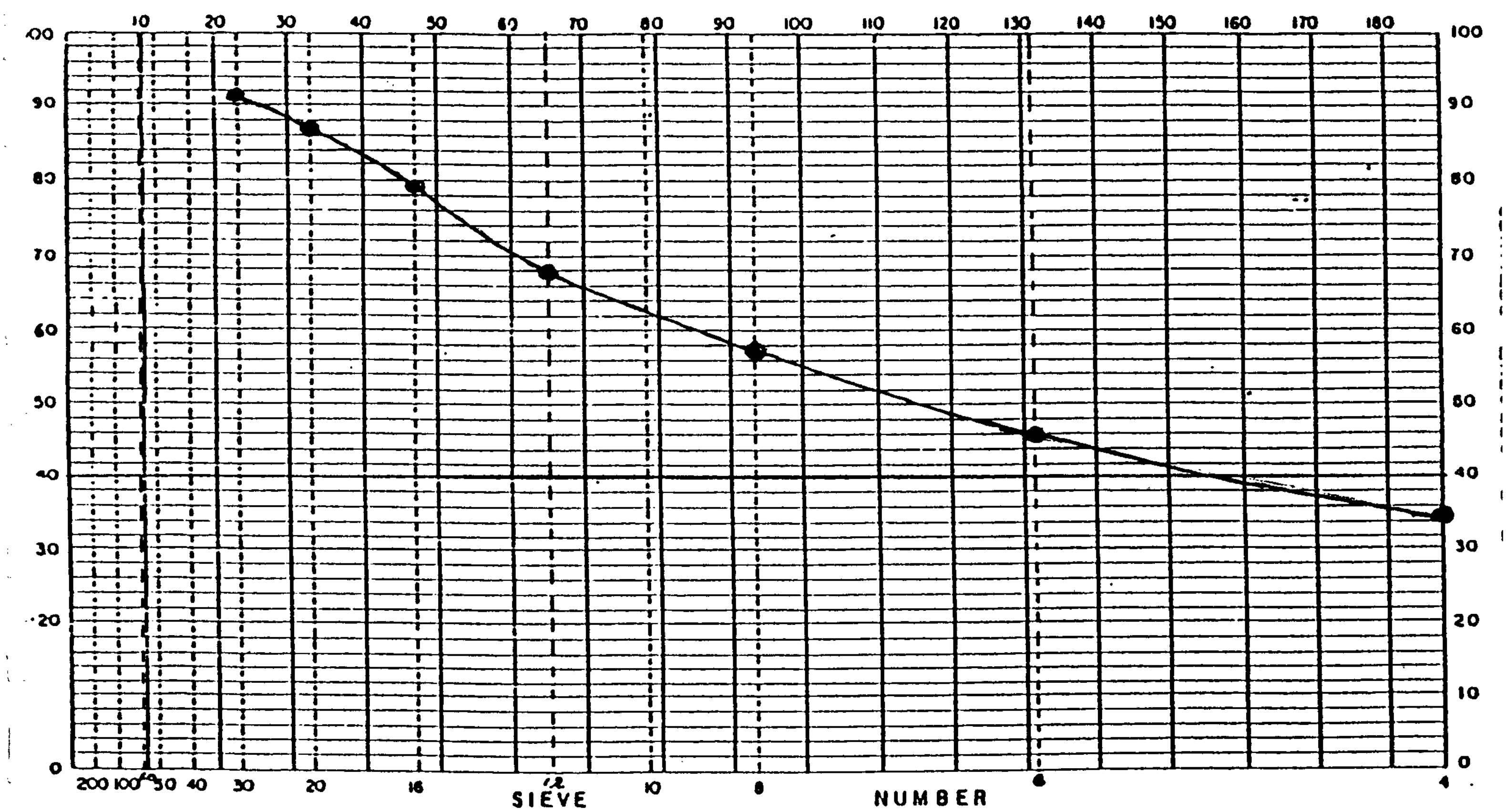
DEPTH: 45-47

SIEVE OPENNING INCH.	MM	U.S. SIEVE NO	CUMULATIVE % RETAINED WT RET.	% RET.	REMARKS
		1/2 inch			
.265		.265			
.187		4	360	35.0	
.132		6	475	46.1	
.0937		8	595	57.8	
.0661		12	700	68.0	
.0469		16	820	79.6	
.0331		20	900	87.4	
.0234		30	945	91.7	
.0165		40			
.0098		60			
.0059		100			
.0029		200			
		PAN	1030	100.0	

Total Wt: 1030

1850 c pebbles > 1/2" (44%)
Large amount of large pebbles

SIEVE OPENNING IN THOUSANDTHS OF AN INCH



SIEVE ANALYSIS

PROJECT: [illegible]

REMARKS: Well [illegible]

DEPTH: 49 - 51

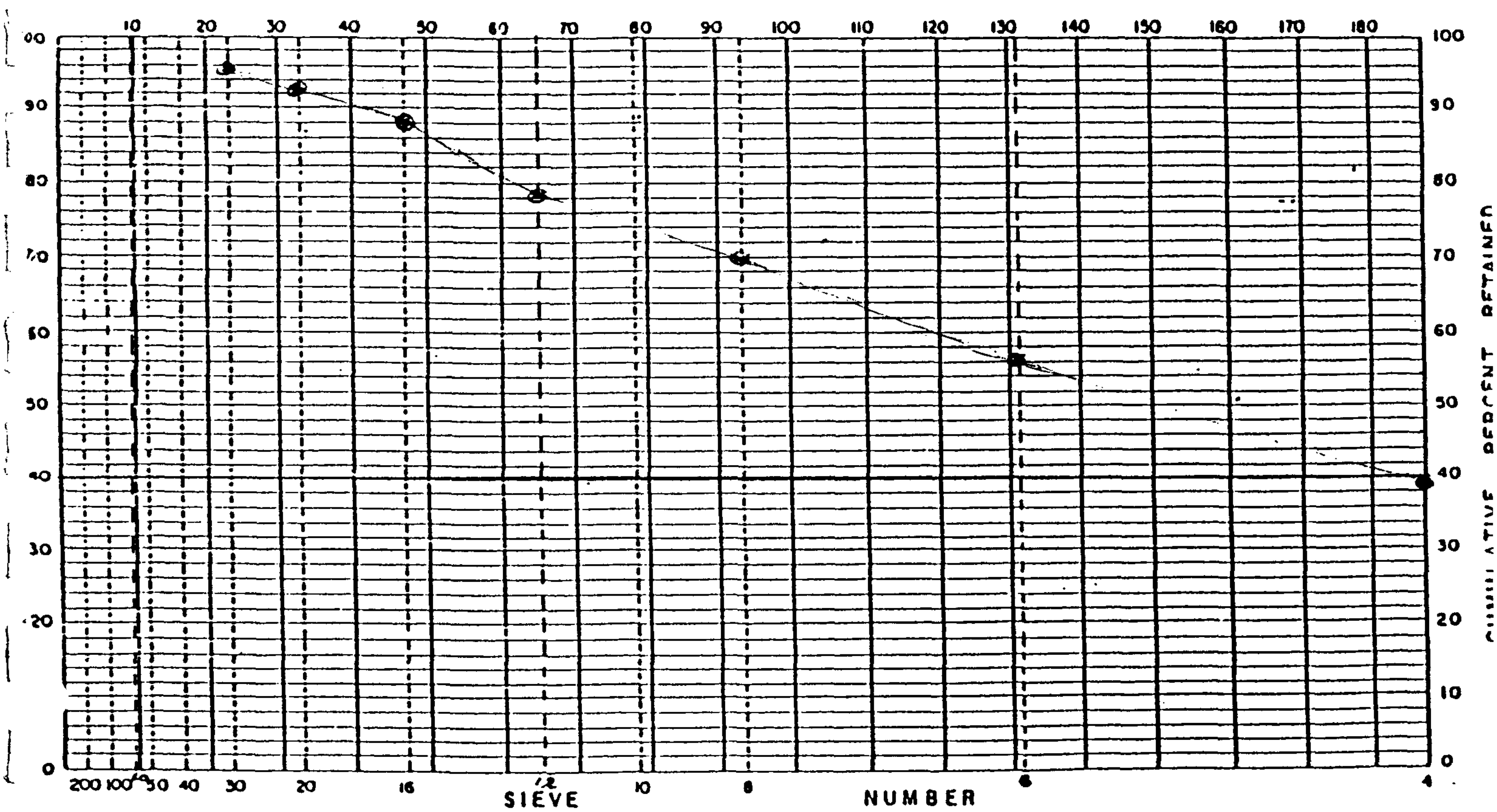
SIEVE OPENNING INCH.	MM	U.S. SIEVE NO	CUMULATIVE % RETAINED WT RET.	% RET.	REMARKS
		1/2 Inch			
.265		.265			
.187		4	465	39.2	
.132		6	670	56.5	
.0937		8	830	70.0	
.0661		12	930	78.5	
.0469		16	1045	88.2	
.0331		20	1100	92.8	
.0234		30	1135	95.8	
.0165		40			
.0098		60			
.0059		100			
.0029		200			
		PAN	1185	100.0	

Total Wt: 1185

1865 c̄ pebble > 1/2" (36%)

Large amount pebbles & cobbles

SIEVE OPENNING IN THOUSANDTHS OF AN INCH



SIEVE ANALYSIS

PROJECT: [illegible]

REMARKS: Well No. 4

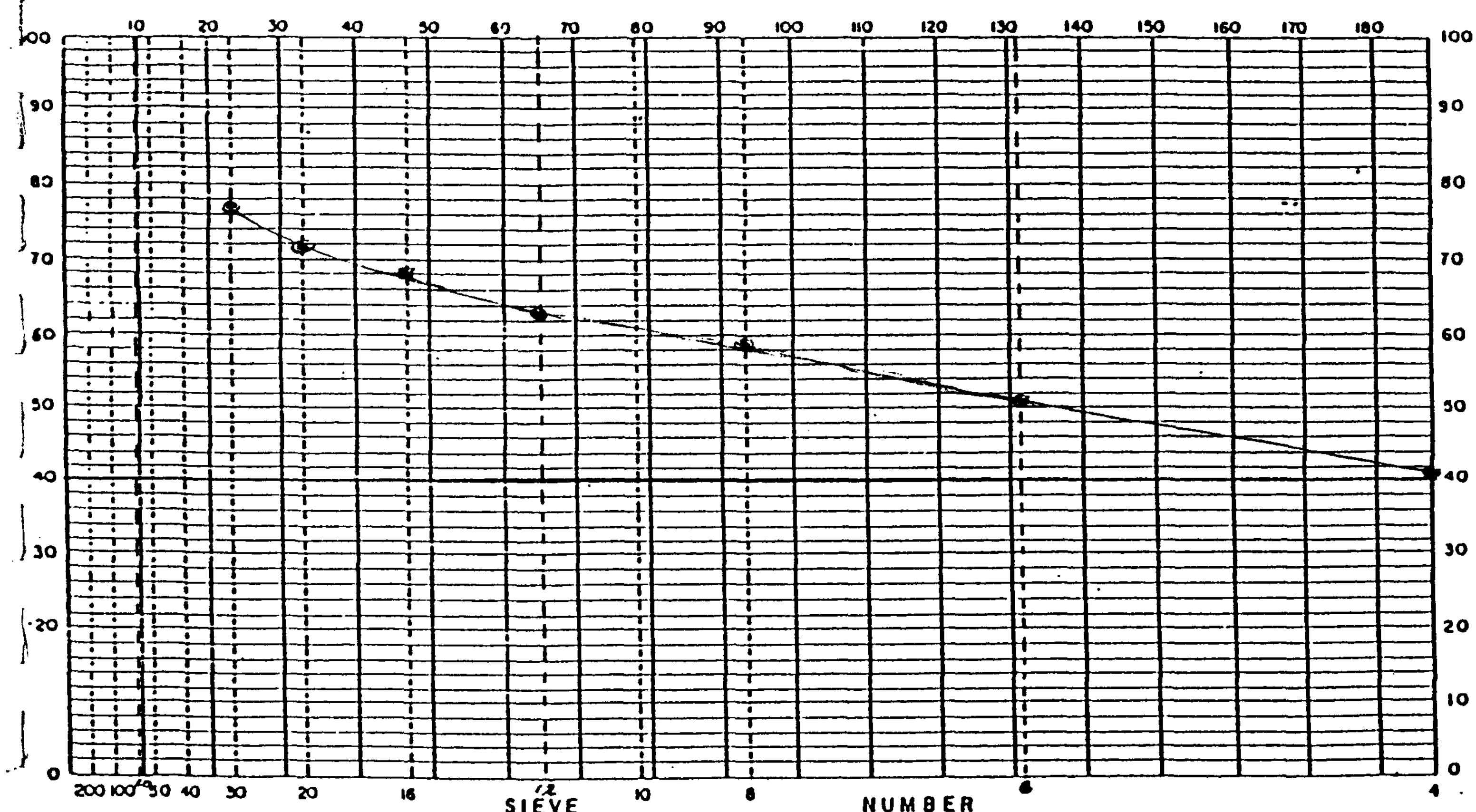
DEPTH: 55 57

SIEVE OPENNING		U.S. SIEVE	CUMULATIVE % RETAINED		REMARKS
INCH.	MM	NO	WT RET.	% RET.	
		1/2 Inch			
.265		.265			
.187		4	450	41.1	
.132		6	560	51.1	
.0937		8	645	58.9	
.0661		12	693	63.3	
.0469		16	745	68.0	
.0331		20	785	71.7	
.0234		30	840	77.1	
.0165		40			
.0098		60			
.0059		100			
.0029		200			
		PAN	1090		

Total Wt: 1095

2100 g pebbles over ½" (48%)
Large amount pebble & cobbles

SIEVE OPENNING IN THOUSANDTHS OF AN INCH



SIEVE ANALYSIS

PROJECT: Oliver

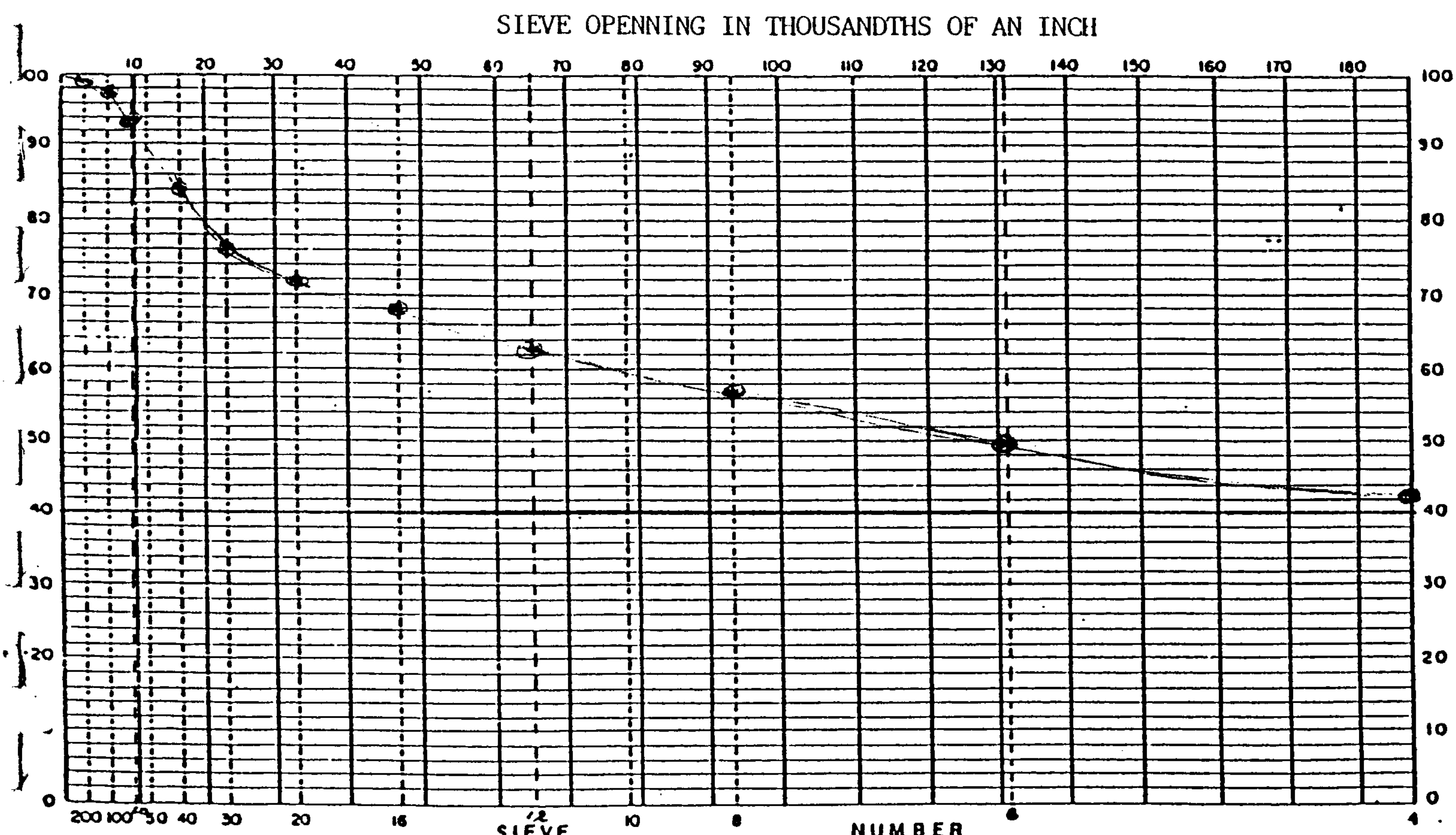
REMARKS: Well No 4

DEPTH: 57-59

SIEVE OPENNING INCH.	MM	U.S. SIEVE NO	CUMULATIVE % RETAINED WT RET.	% RET.	REMARKS
		1/2 inch			
.265		.265			
.187		4	415	43.2	
.132		6	480	50.0	
.0937		8	550	57.3	
.0661		12	605	63.0	
.0469		16	655	68.2	
.0331		20	690	71.9	
.0234		30	735	76.6	
.0165		40	810	84.4	
.0098		60	900	93.8	
.0059		100	940	97.9	
.0029		200	950	99.0	
		PAN	955	99.5	

Total Wt: 960

1990 c̄ pebbles > 1/2" (52%)
< med amount large pebbles



SIEVE ANALYSIS

PROJECT: [illegible]

REMARKS: Well No. 4

DEPTH: 59-61

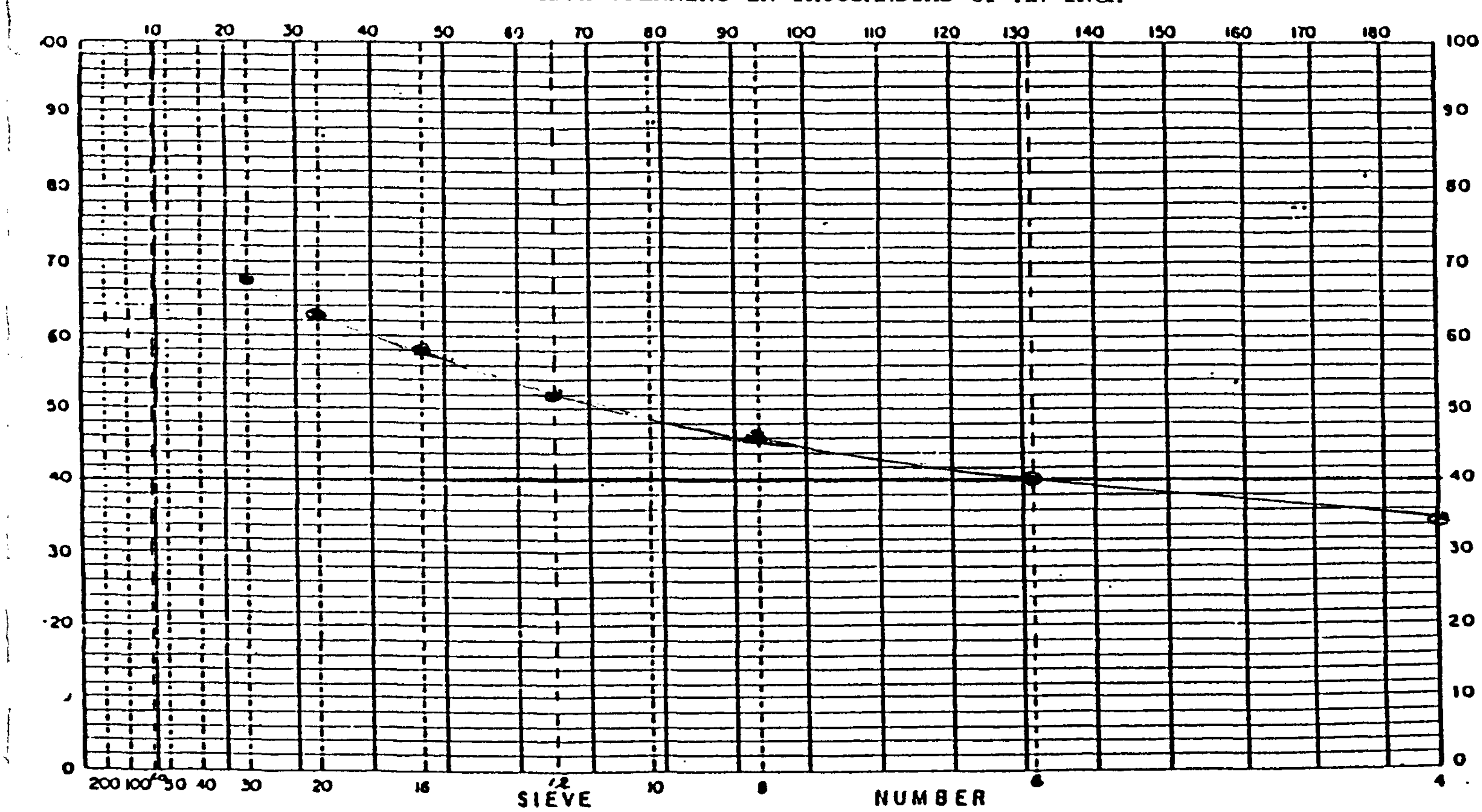
SIEVE OPENNING INCH.	MM	U.S. SIEVE NO	CUMULATIVE % RETAINED WT RET.	% RET.	REMARKS
.		1/2 inch			
.265		.265			
.187		4	280	34.4	
.132		6	330	40.5	
.0937		8	380	46.6	
.0661		12	425	52.1	
.0469		16	475	58.3	
.0331		20	515	63.2	
.0234		30	550	67.5	
.0165		40			
.0098		60			
.0059		100			
.0029		200			
		PAN	815	Note	0% sand.

Total Wt: 815

2085 c̄ pebbles over 1/2" (6

Med amount of pebbles.

SIEVE OPENNING IN THOUSANDTHS OF AN INCH



150'

SIEVE ANALYSIS

PROJECT: Chico

REMARKS: Well No. 4

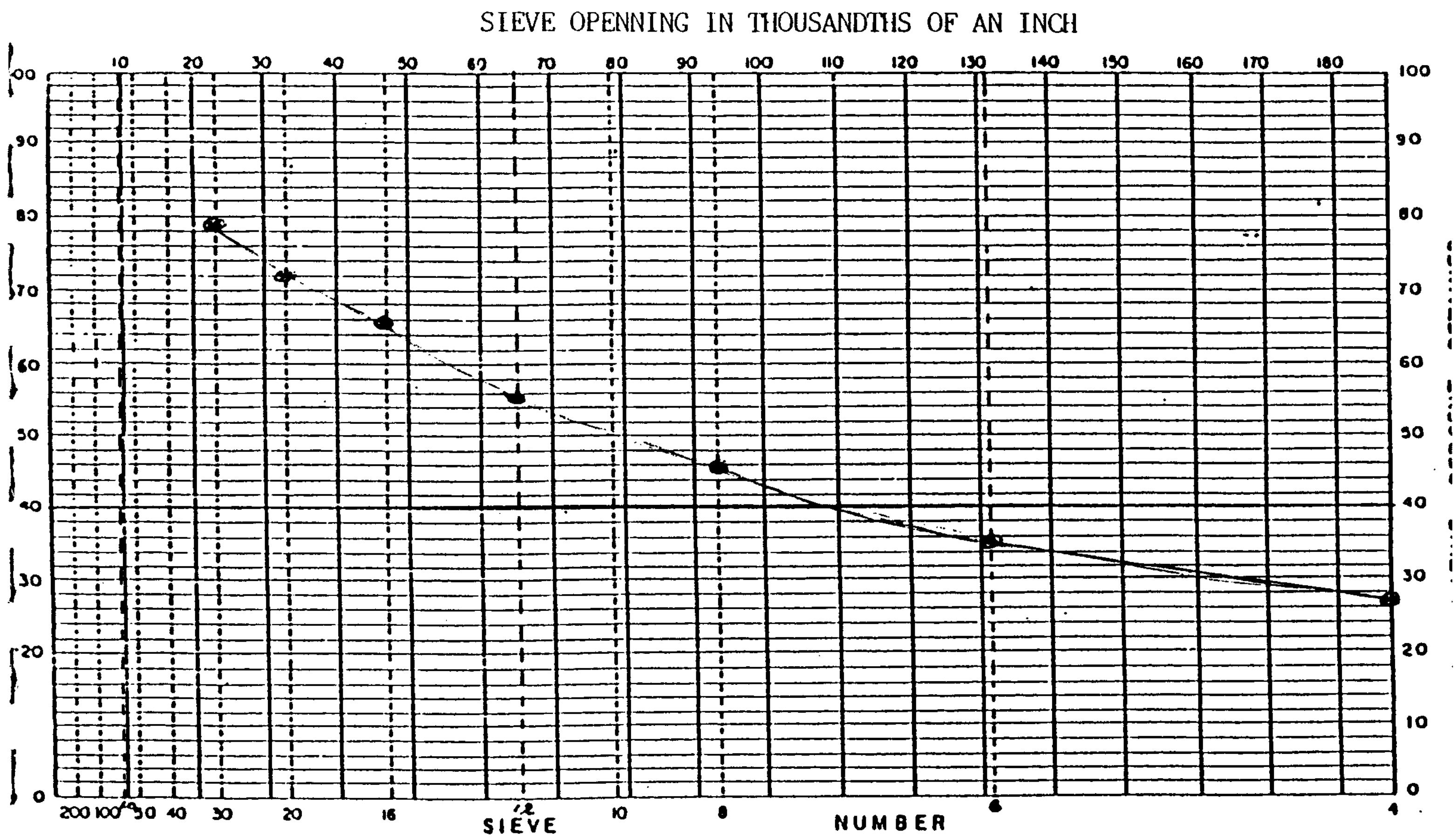
DEPTH: 61-63

SIEVE OPENNING INCH.	MM	U.S. SIEVE NO	CUMULATIVE % RETAINED WT RET.	% RET.	REMARKS
		1/2 inch			
.265		.265			
.187		4	275	26.8	
.132		6	365	35.6	
.0937		8	470	45.9	
.0661		12	570	55.6	
.0469		16	675	65.9	
.0331		20	740	72.2	
.0234		30	810	79.0	
.0165		40			
.0098		60			
.0059		100			
.0029		200			
		PAN	1025		

Total Wt: 1025

2000 c̄ pebbles > 1/2" (50%)

Large amount pebble & large pebbles



SIEVE ANALYSIS

PROJECT: Oliver

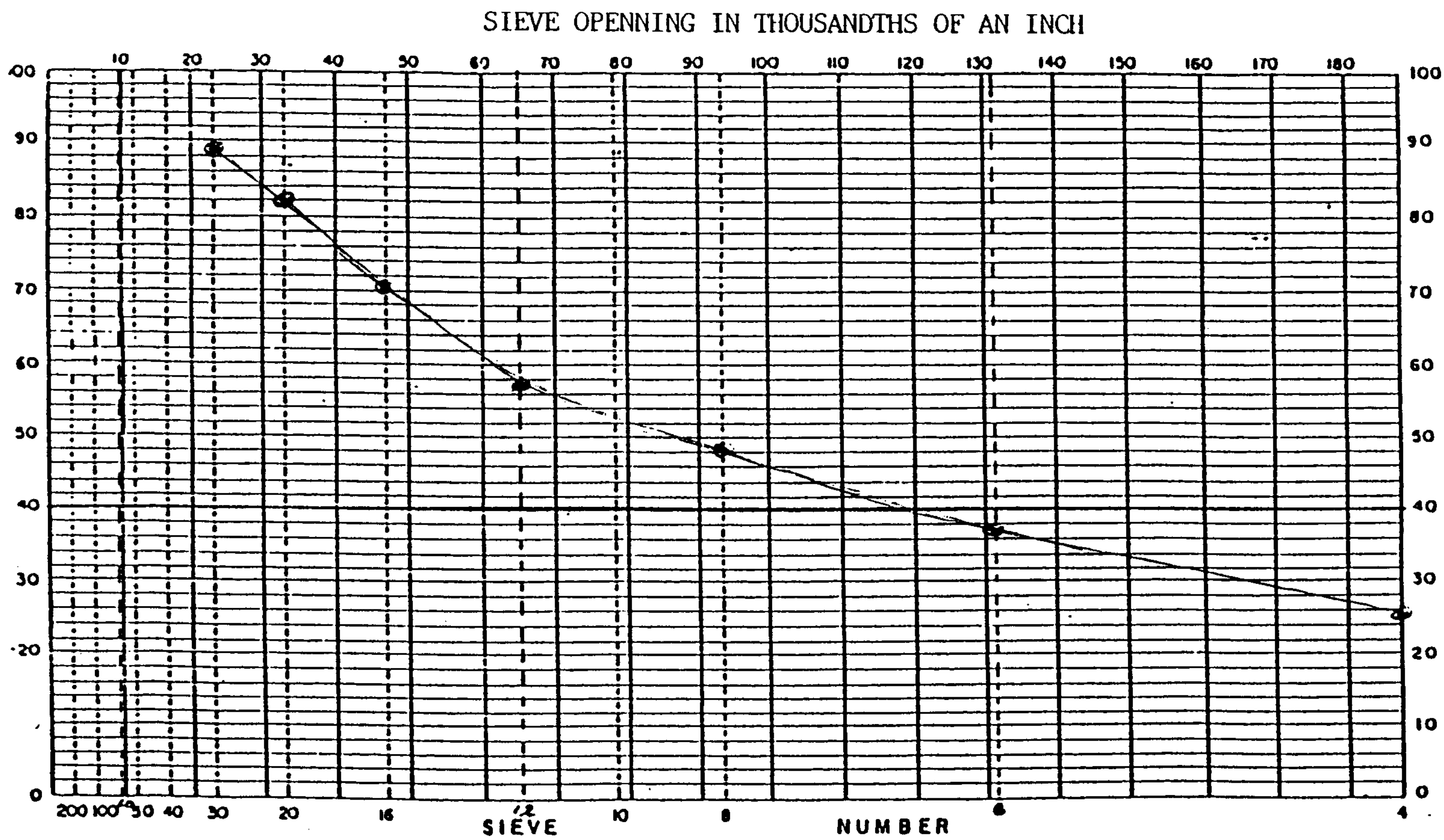
REMARKS: Well No 4

DEPTH: 63 - 65

SIEVE OPENNING INCH.	MM	U.S. SIEVE NO	CUMULATIVE % RETAINED WT RET.	% RET.	REMARKS
		1/2 inch			
.265		.265			
.187		4	360	25.4	
.132		6	525	37.1	
.0937		8	685	48.4	
.0661		12	815	57.6	
.0469		16	1000	70.7	
.0331		20	1160	82.0	
.0234		30	1260	89.0	
.0165		40			
.0098		60			
.0059		100			
.0029		200			
		PAN	1415		

Total Wt: 1415

1625 c̄ pebble > 1/2" (13%)
small amount of pebbles



SIEVE ANALYSIS

PROJECT: Oliver

REMARKS: Well No 4

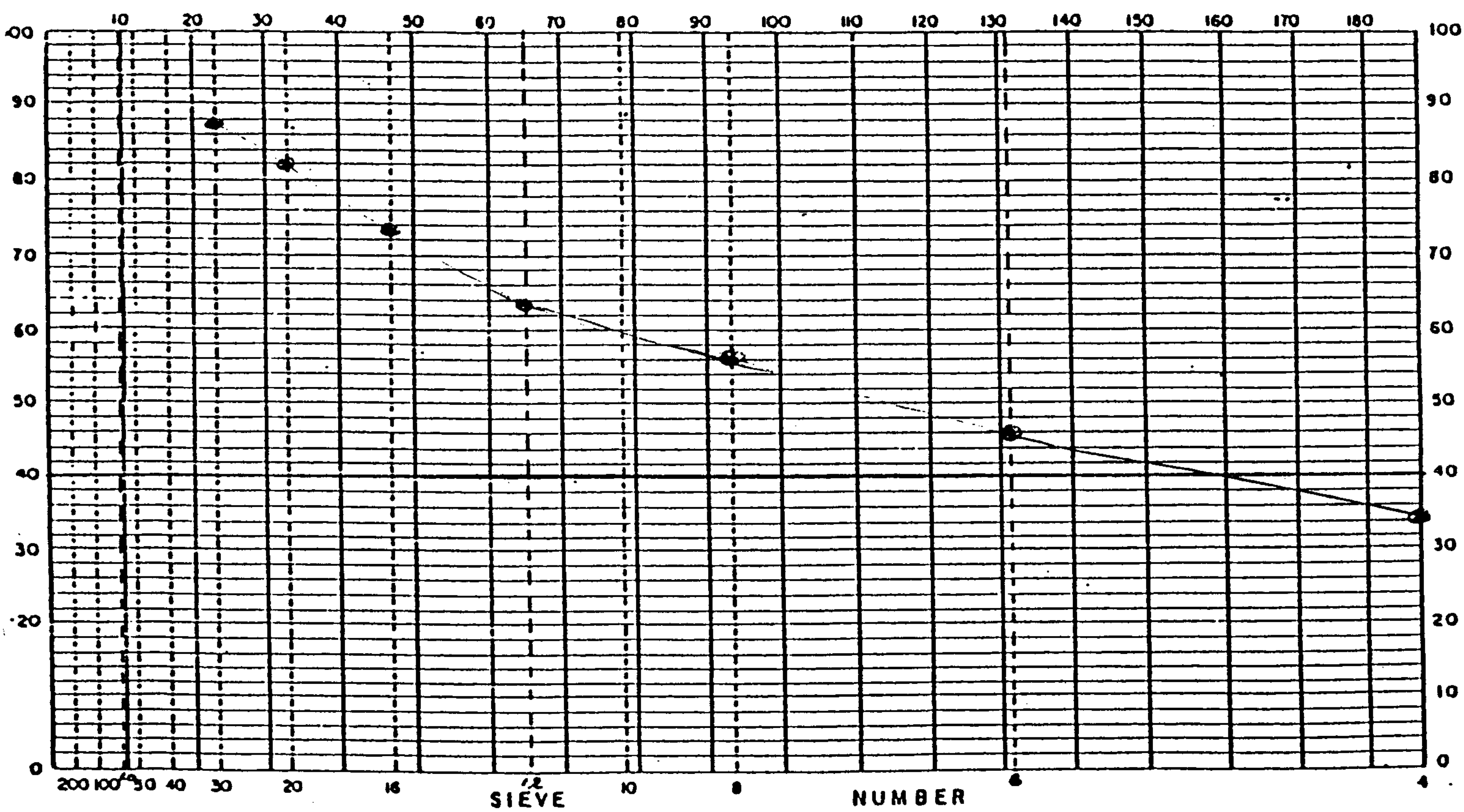
DEPTH: 65-67

SIEVE OPENNING INCH.	MM	U.S. SIEVE NO	CUMULATIVE % RETAINED WT RET.	% RET.	REMARKS
		1/2 inch			
.265		.265			
.187		4	550	34.3	
.132		6	740	46.1	
.0937		8	905	56.4	
.0661		12	1025	63.9	
.0469		16	1180	73.5	
.0331		20	1320	82.2	
.0234		30	1405	87.5	
.0165		40			
.0098		60			
.0059		100			
.0029		200			
		PAN	1605		

Total Wt: 1605

2000 c̄ pebble > 1/2" (20%)
small amount of pebbles.

SIEVE OPENNING IN THOUSANDTHS OF AN INCH



SIEVE ANALYSIS

PROJECT: C[illegible]

REMARKS: Well No. 4

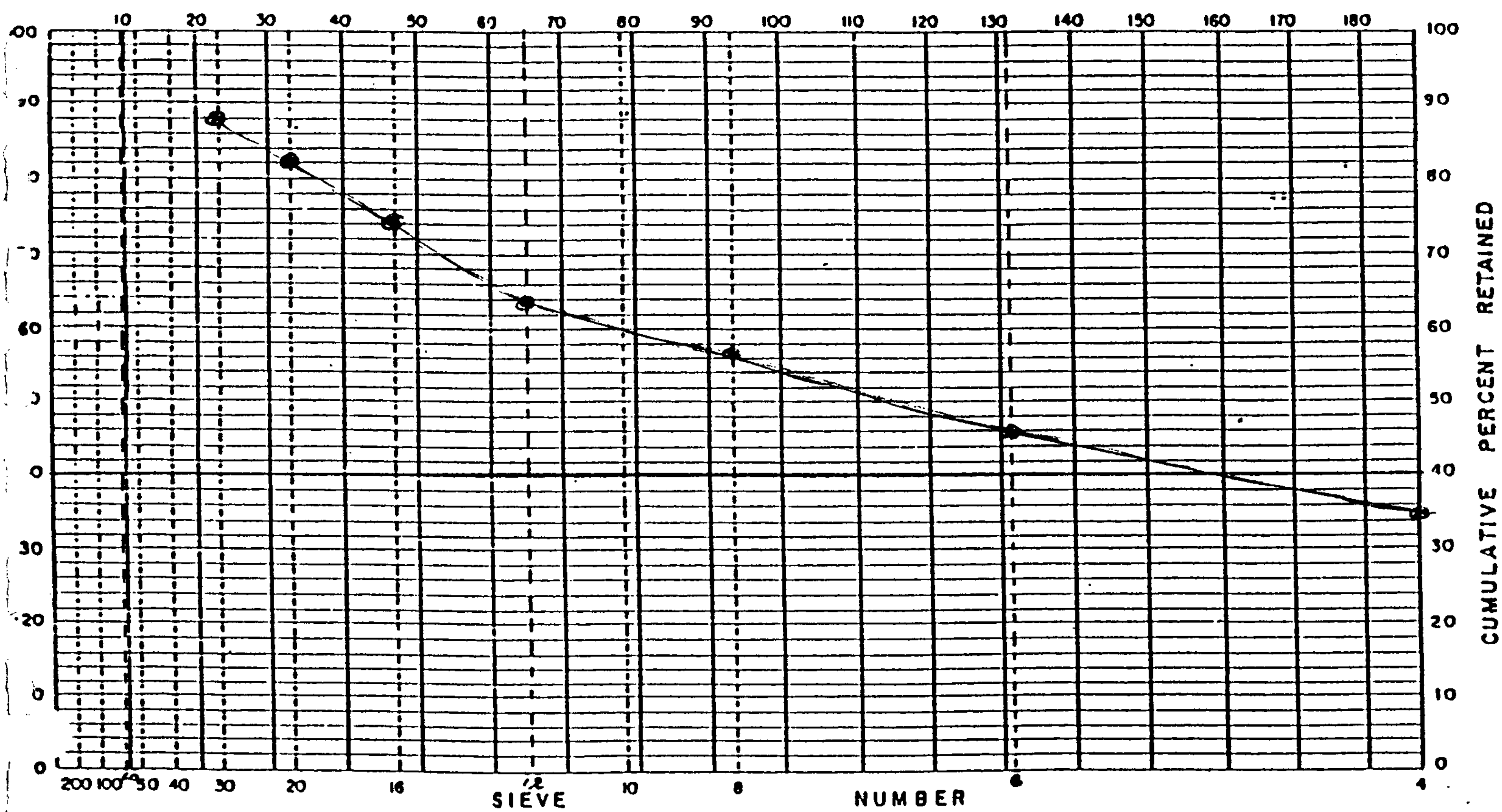
DEPTH: 61-69

SIEVE OPENNING INCH.	MM	U.S. SIEVE NO	CUMULATIVE % RETAINED WT RET.	% RET.	REMARKS
		1/2 inch			
.265		.265			
.187		4	325	35.1	
.132		6	425	45.9	
.0937		8	525	56.8	
.0661		12	590	63.8	
.0469		16	690	74.6	
.0331		20	765	82.7	
.0234		30	815	88.1	
.0165		40			
.0098		60			
.0059		100			
.0029		200			
		PAN	925		

Total Wt: 925

1600 c̄ pebbles > 1/2" (42%)
Med amount large pebbles

SIEVE OPENNING IN THOUSANDTHS OF AN INCH



SIEVE ANALYSIS

PROJECT: [illegible]

REMARKS: Well No 4

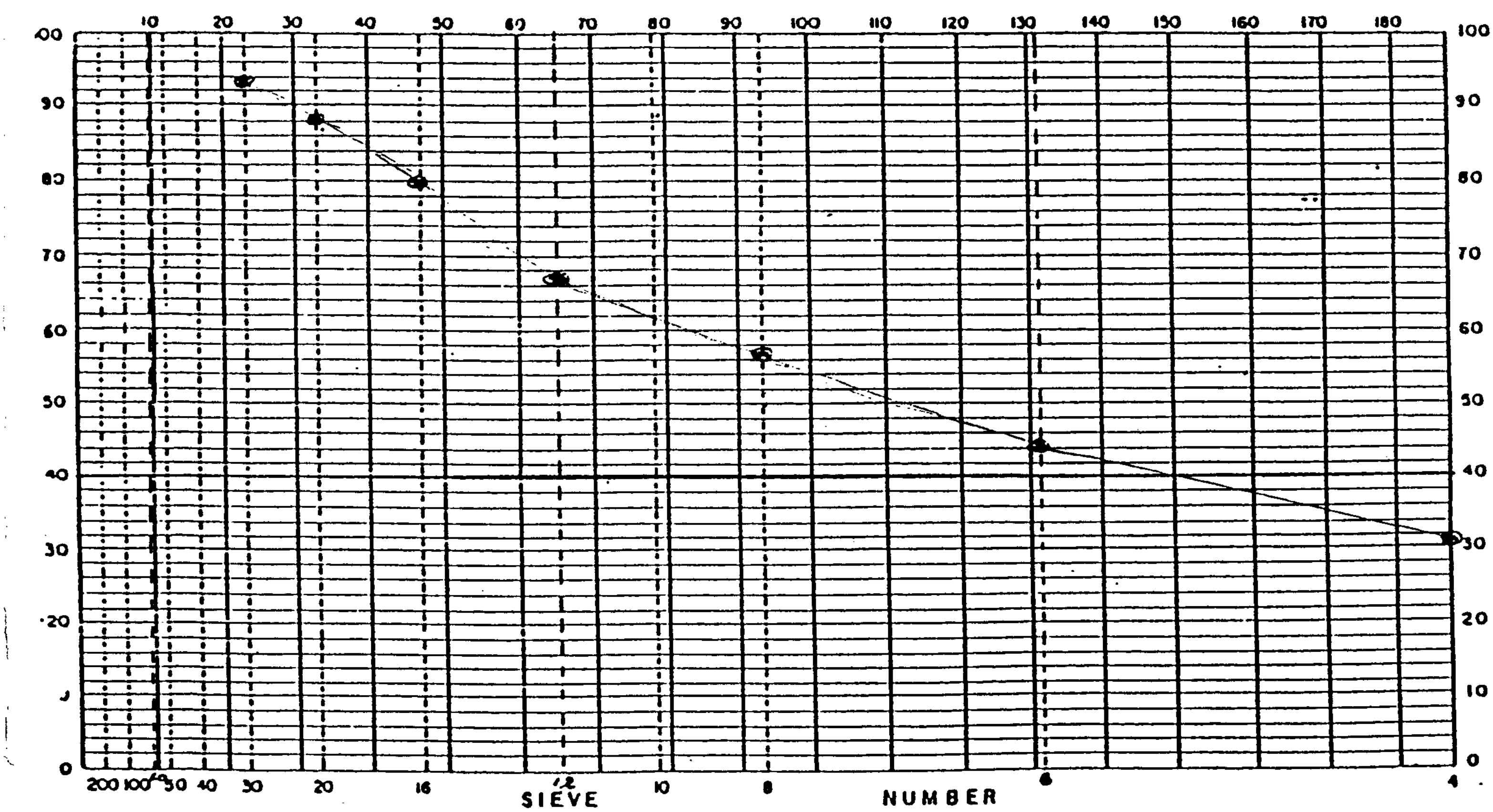
DEPTH: 69-71

SIEVE OPENNING INCH.	MM	U.S. SIEVE NO	CUMULATIVE % RETAINED WT RET.	% RET.	REMARKS
		1/2 inch			
.265		.265			
.187		4	435	30.9	
.132		6	625	44.5	
.0937		8	800	56.9	
.0661		12	940	66.9	
.0469		16	1125	80.1	
.0331		20	1245	88.6	
.0234		30	1315	93.6	
.0165		40			
.0098		60			
.0059		100			
.0029		200			
		PAN	1405		

Total Wt: 1405

1925 c̄ pebbles > 1/2" (27%)
med. amount large pebbles

SIEVE OPENNING IN THOUSANDTHS OF AN INCH



SIEVE ANALYSIS

PROJECT: Oliver

REMARKS: Well No 4

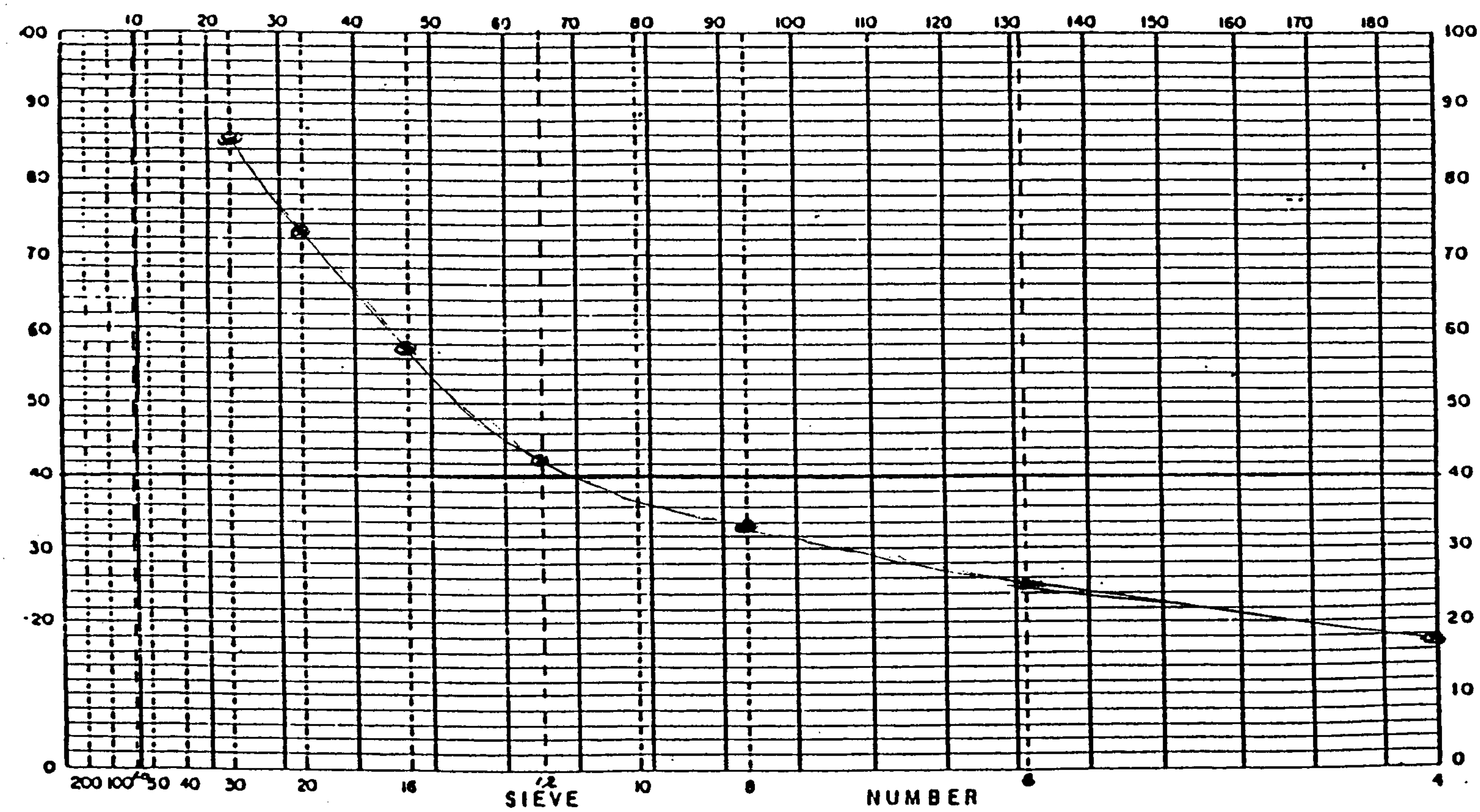
DEPTH: 71-73

SIEVE OPENNING INCH.	MM	U.S. SIEVE NO	CUMULATIVE % RETAINED WT RET.	% RET.	REMARKS
.		1/2 inch			
.263		.263			
.187		4	220	17.6	
.132		6	315	25.2	
.0937		8	420	33.6	
.0661		12	535	42.8	
.0469		16	720	57.6	
.0331		20	910	72.8	
.0234		30	1065	85.2	
.0165		40			
.0098		60			
.0059		100			
.0029		200			
		PAN	1250		

Total Wt: 1250

1600 c̄ pebble > 1/2" (22%).
Limited amount pebbles

SIEVE OPENNING IN THOUSANDTHS OF AN INCH



SIEVE ANALYSIS

PROJECT: Oliver

REMARKS: Well No. 4

DEPTH: 73 - 75

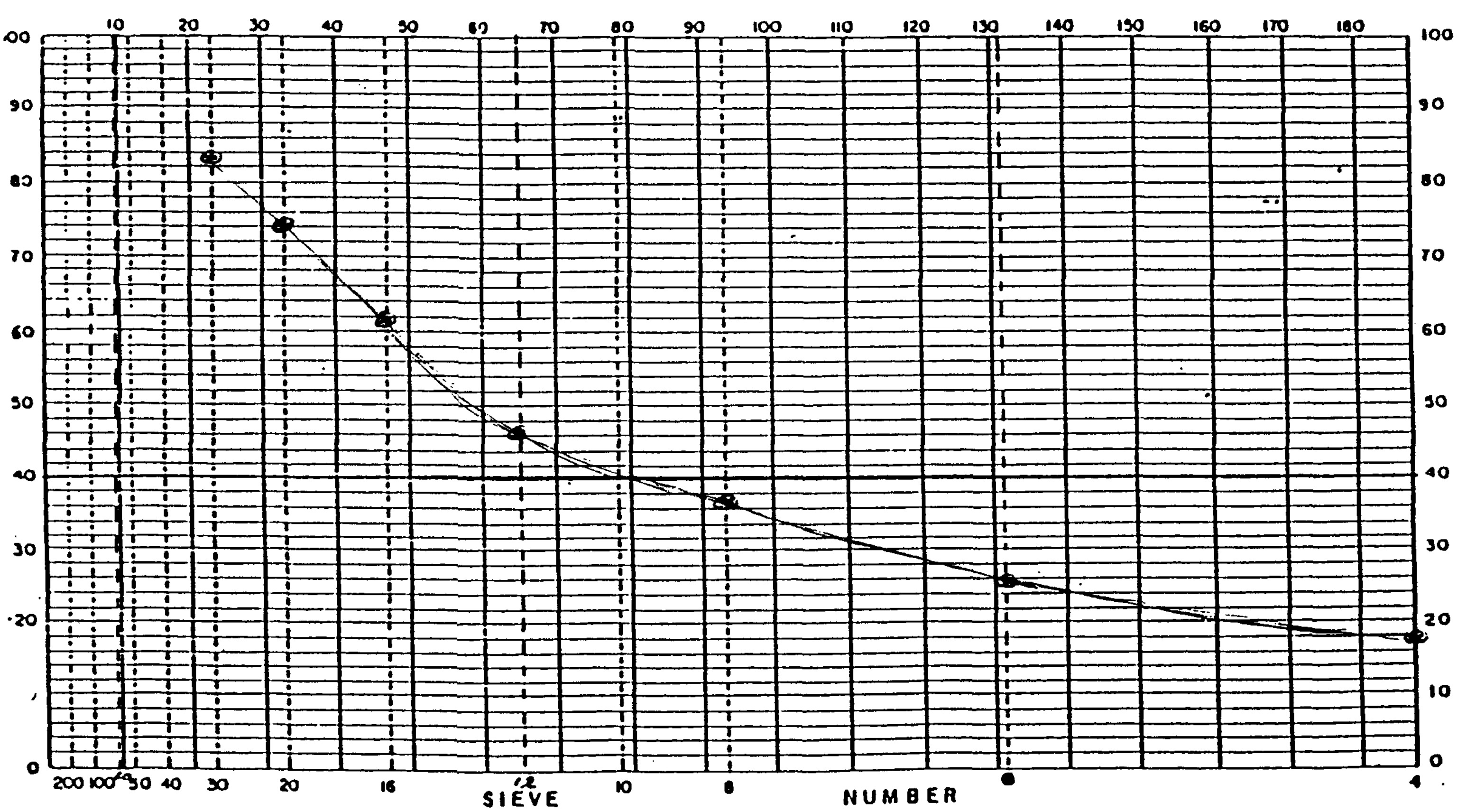
SIEVE OPENNING INCH.	MM	U.S. SIEVE NO	CUMULATIVE % RETAINED WT RET.	% RET.	REMARKS
.		1/2 inch			
.265		.265			
.187		4	265	17.5	
.132		6	390	25.7	
.0937		8	560	37.0	
.0661		12	705	46.5	
.0469		16	935	61.7	
.0331		20	1120	73.9	
.0234		30	1265	83.4	
.0165		40			
.0098		60			
.0059		100			
.0029		200			
		PAN	1515		

Total Wt: 1515

1700 ē pebbles > 1/2" (11%).

Very small amounts of pebbles.

SIEVE OPENNING IN THOUSANDTHS OF AN INCH



SIEVE ANALYSIS

PROJECT: Oliver

REMARKS: Well No 4

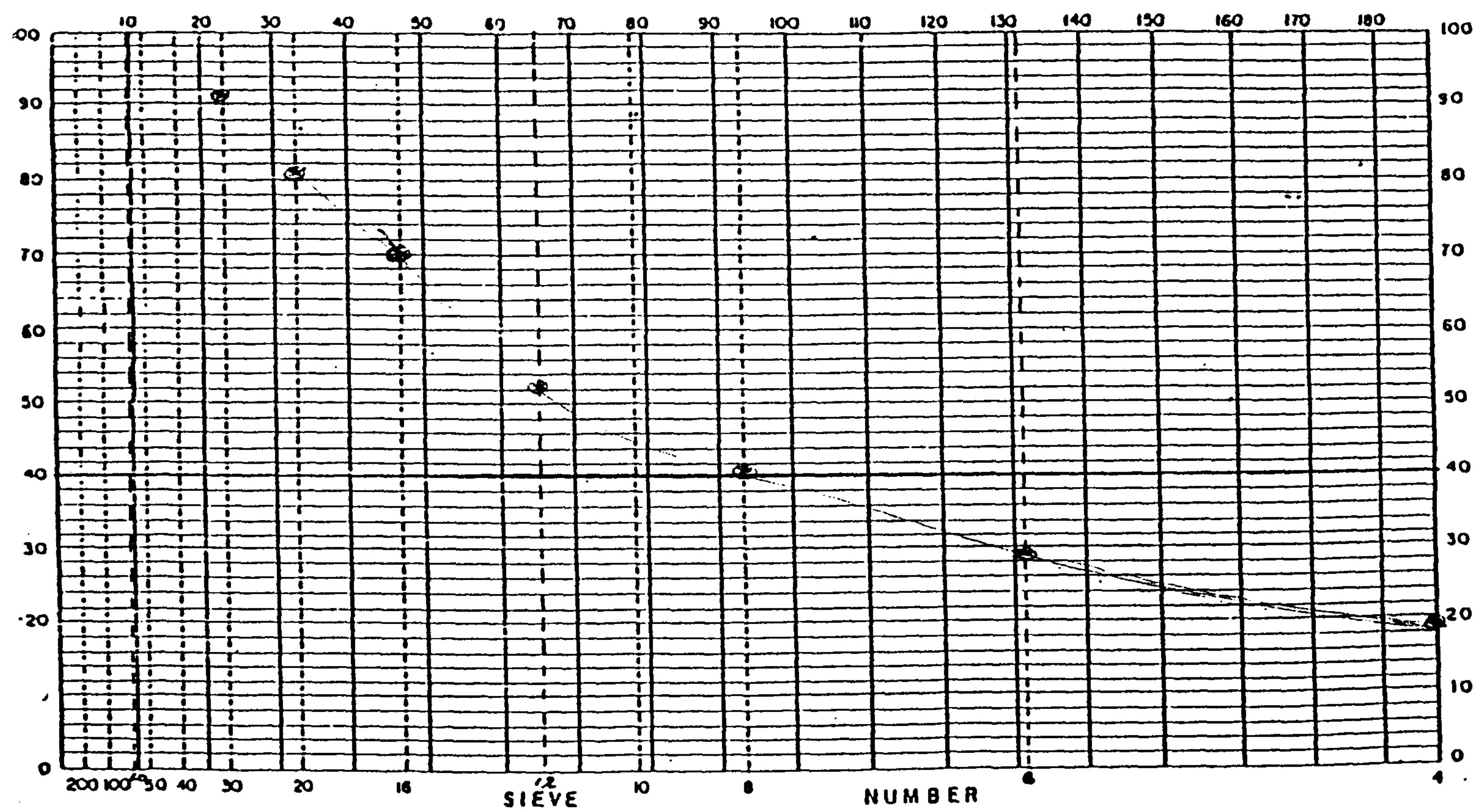
DEPTH: 75 - 77

SIEVE OPENNING INCH.	MM	U.S. SIEVE NO	CUMULATIVE % RETAINED WT RET.	% RET.	REMARKS
.		1/2 inch			
.265		.265			
.187		4	235	19.1	
.132		6	360	29.3	
.0937		8	505	41.1	
.0661		12	650	52.8	
.0469		16	865	70.3	
.0331		20	1000	81.3	
.0234		30	1125	91.5	
.0165		40			
.0098		60			
.0059		100			
.0029		200			
		PAN	1235		

Total Wt: 1230

1460 c pebbles over 1/2" (18%)

Limed amount large ~~cobbles~~ pebbles + cobble



SIEVE ANALYSIS

PROJECT: [illegible]

REMARKS: Well No 4

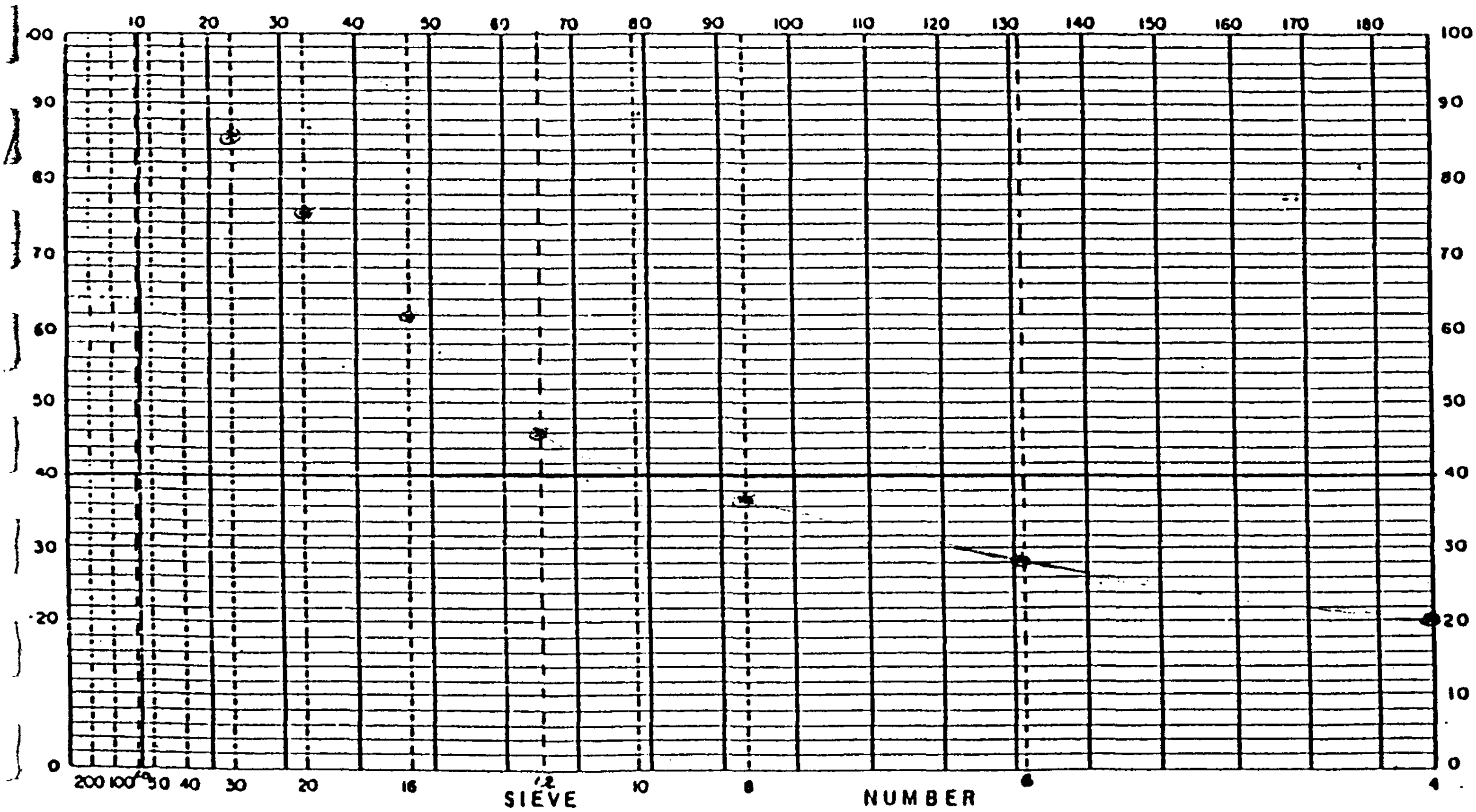
DEPTH: 77-79

SIEVE OPENNING INCH.	MM	U.S. SIEVE NO	CUMULATIVE % RETAINED WT RET.	% RET.	REMARKS
.		1/2 inch			
.265		.265			
.187		4	240	20.2	
.132		6	340	28.6	
.0937		8	445	37.4	
.0661		12	550	46.2	
.0469		16	740	62.2	
.0331		20	900	75.6	
.0234		30	1025	86.1	
.0165		40	1125		
.0098		60	1170		
.0059		100	1185		
.0029		200	1190		
		PAN	1190		

Total Wt: 1190

1525 = pebbles > 1/2
Med amount large size pebbles

SIEVE OPENNING IN THOUSANDTHS OF AN INCH



SIEVE ANALYSIS

PROJECT: Oliver

REMARKS: Well No. 4

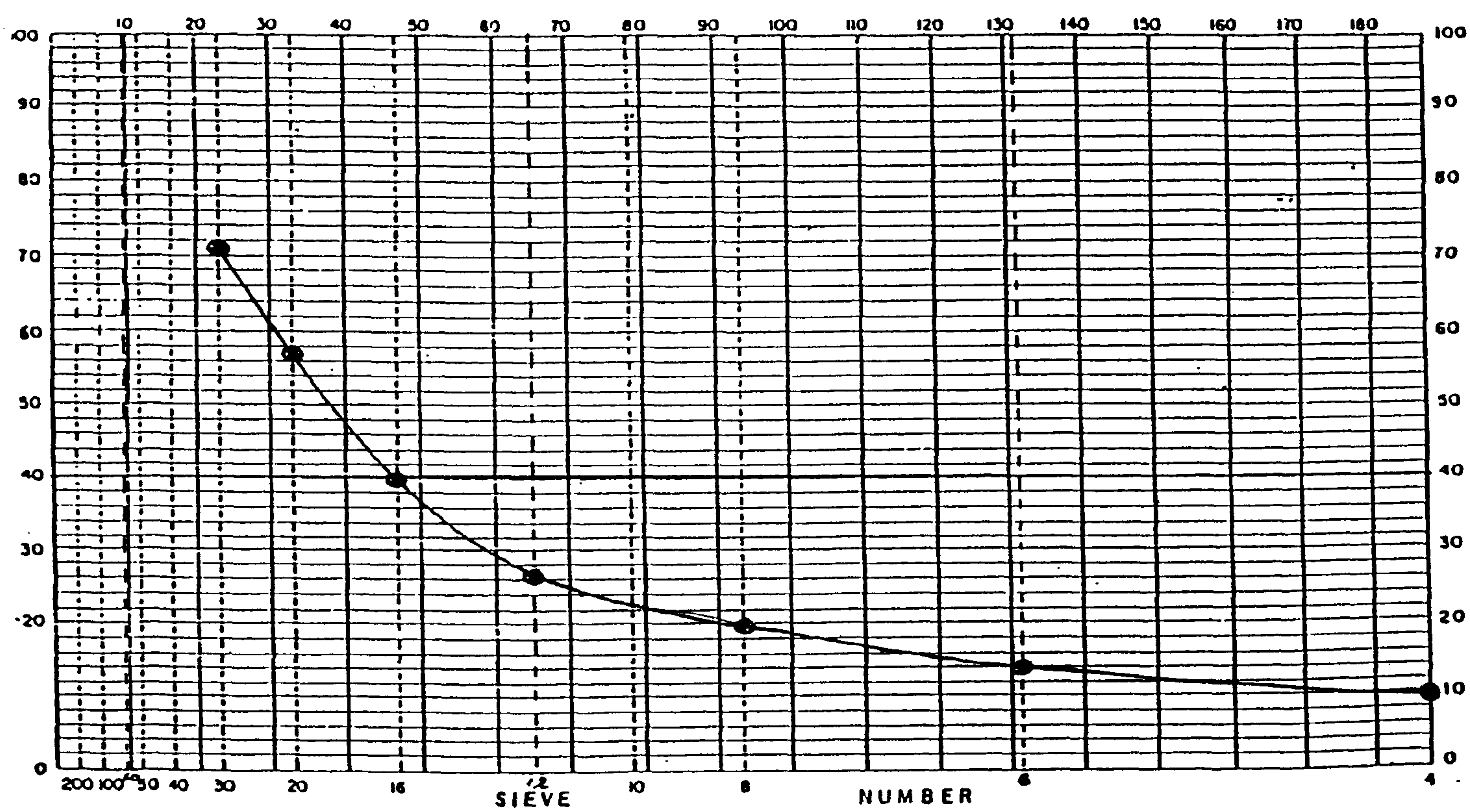
DEPTH: 79-81

SIEVE OPENNING INCH.	MM	U.S. SIEVE NO	CUMULATIVE % RETAINED WT RET.	% RET.	REMARKS
.		1/2 Inch			
.265		.265			
.187		4	95	9.5	
.132		6	140	13.9	
.0937		8	200	19.9	
.0661		12	265	26.4	
.0469		16	400	39.8	
.0331		20	575	57.2	
.0234		30	715	71.4	
.0165		40			
.0098		60			
.0059		100			
.0029		200			
		PAN	1005		

Total Wt: 1005

1405 c̄ pebble > 1/2"
Large amount of cobbles
& pebbles

SIEVE OPENNING IN THOUSANDTHS OF AN INCH



1994

ROBBINS WATERWELL DRILLING
& PUMP SERVICE
BOX 117
OKANAGAN FALLS, B.C.
VOH 1RO

Town of Oliver
Box 638
Oliver, B.C.
VOH 1TO

Attention - Mr. J. Bruce Hamilton

Re: Pump System 2 - Well No. 1

In brief: On upon arriving on Site Thursday March 3, evaluation was taken of the site. First thing I noticed was the 16" casing was below the concrete floor and the 20" service casing was no longer in site. There fore it was important that a piece of 16" had to be welded on. The town yard had no casing in stock, so trip was made to Ok Falls to cut a piece off a ten foot lenght. Returning to Site in Oliver and welding on casing and setting up rig and putting on appropriate surge blocks. First step : to measure the static level in well and measure water level in oxbow and river. Figures will be shown later in report.

March 4 - 7 1\2 H.P. Sub. pump was installed to do a pump test on the well. The well was pumped for 1\2 hr. recording drawdown and flow rates. Measured by means of a piezometer tube. After 1\2 hr. test, drawn down was 12" with flow rate of 160 us gpm. With those figures it showed that the production has dropped off by about 50%. With those figures it showed the well was getting 160 gallons to foot of draw down.

The pump was polled and bailer installed in well to check for sand. Two feet of dark rusty sand and concrete chunks and small rocks was at the bottom of well. After cleaning the sand out, surge was installed in well. Surging was started at top of first set of screens. The weight of stem with surge block fell slowly indicating right away there was definetly blockage. Surging was continued and contractor pump was installed to pump water while surging. While pumping the water was dark rusty brown. Surging and pumping continued for day, showing vast improvement in the well. Testing was done every morning and reading of the river and oxbow was taken. After days of developing and pumping the well improved to a point of 4 1\2" of draw down, with flow rate of over 320 gpm. per ft. of draw down indicating the well is back to original condition.

Summary - I feel the well problem started when the well is pumped at a high rate and flow of water is in one direction, it moves small particles and bridges against large particles across screen opening slowing the flow of water. By reversal of the flow of water through the screens and the removal of small particles, returns the well back to orignal condition when it was first drilled.

Conclusion: I feel the well should be pumped at a higher rate with pump test to exceed 1400 gpm per min. and record draw down in well before hooking to serve the system.

Pumping Data for Pump System Well 1

March 4, 1994	
Static	9.5 in well
Drawdown	12" x 160 gpm.
Oxbow	932.70
River	932.80

March 7, 1994	
Static	8.9
Oxbow	932.9
River	932.9
Draw down	6" x 160 gpm.

March 8, 1004	
Static	8.9
Oxbow	932.9
River	933.0
Draw down	4 1\4" x 160 gpm.

March 9, 1994	
Static	8.7 1\2
Oxbow	932.9
River	932.9
Draw down	4 3\4" x 176 gpm.

March10, 1994	
Static	8.7 1\4
Oxbow	932.9
River	932.9
Draw down	4 1\2" x 165 gpm.

Bottom of well 90 2 1\2
Stickup of 16" Casing - 1 10 1\2
Top of First Screen - 41 3 1\4

Mould Engineering

January 12, 1993

Our File: PS2.TOL

Town of Oliver
Box 638
Oliver, BC
V0H 1T0

Attention: J. Bruce Hamilton
Public Works Superintendent

Dear Sir;

Re: Pump Station No.2 / VDS #5

The correspondence and data that you forwarded at various times over the past month has been reviewed as requested. A copy of a letter to the Town of Oliver from Mr. R. Jubb of the Ministry of Environment in Penticton was also reviewed and the well information was discussed with Larry Topp of Kala Groundwater Consultants.

The review, as I understand it, was to ascertain:

a) If the water table in the groundwater aquifer supplying the Pump System No.2 wells is affected by water levels in Okanagan River.

b) Whether stoplogging of VDS #5 is necessary to operate the pumps at low river levels.

c) If stoplogging is necessary to operate the present system, what measures need to be implemented to determine whether the pumps can be operated without stoplogging of VDS #5.

d) Whether further pump tests need to be carried out during low flows this winter to verify the effect of river levels on well levels.

The analysis was made complicated by variations in pumping rates; changes in river and oxbow levels; changes in well efficiency and changes in pump sizes. The fact that only total flows from the pumping site are measured by the flow meter and not flows from individual pumping units is a possible limitation on results. The assumption was made that the percentage of the total flow coming from each well is proportional to the pump horsepower.

To eliminate the pumping rate variable, tables were drawn up showing well and river levels for several flow rates. These tables are appended to this letter report.

.../2

1770 Chamberlain Road, Kelowna, British Columbia V1Y 3P4 Telephone 763-6036

The following observations were made from the review:

1. Water levels in the wells are clearly influenced by river levels. There have been differences of opinion between groundwater geologists over the years about the hydraulic connection between the river and groundwater aquifer but the recent data clearly indicates that river and/or oxbow levels do affect aquifer levels. The relationship appears to be on a 1:1 basis, i.e. a one foot increase in river levels will increase the groundwater level by one foot which is what would normally be expected with reasonable hydraulic connection.

2. It has been the opinion of various operators of the pumping system that there is a threshold or minimum river level below which aquifer recharge is severely restricted. This belief has resulted in stoplogging of VDS #5 to maintain river levels higher than would occur otherwise. The well and river level information does not support the 'barrier' theory but since the river is seldom allowed to drop to low levels under high pumping rates the theory cannot be fully evaluated and cannot be completely discounted.

* 3. The operation of Pump No.3 (10 hp) has been the principal consideration in stoplogging. When the pump was originally installed, it was intended only to be used for a winter domestic supply with no other wells in use. In peak summer demand conditions the two larger pumps cannot meet the demand and Pump No.3 has been turned on to supplement the supply. The well levels are considerably lower with the other units in operation and when the water level is drawn down to 27 feet below the top of the casing, the pump draws air and must be turned off. To allow the pump to operate, stoplogging of VDS #5 is implemented. The top of the well screens are about 77 feet below the top of the screens and the bottom of the pump is 29 feet below the top of the well. The pump could be lowered considerably to gain more submergence and allow for more drawdown.

4. In 1992, Pump No.1 was close to being inoperable due to low water levels in the well. On June 4, the water level was 23' 9" below the top of the casing and the minimum level this pump can operate without a submergence problem is 26 feet. One row of stoplogs was in place at the time so the water table was artificially high. Without the stoplogs, the pump would have had very close to minimum submergence and the operators felt it was essential to maintain some factor of safety. This was particularly important since the water level was below the low water level cut-out switch and the electrical circuit was jumpered to keep the pump running.

.../3

5. Well No.1 is gradually losing efficiency. The drawdown in 1985, when the well was reconstructed, was 4.5 feet at 1200 USgpm. In 1992, the drawdown at 1200 USgpm was 9 feet, which shows a 50% reduction in specific capacity. This reduction in specific capacity is not totally unexpected. An unusual form of construction was used with one screen fitted inside of another and Larry Topp has suggested it is likely the annular space between the two screens may be plugging up with fine sand which would increase head losses and reduce efficiency.

6. Well No.1 has a history of producing sand. Reports of sand in water systems were made by landowners as recent as 1992. The sand problem likely coincides with high pumping rates. The production of sand is more likely attributed to high flow rates than to low aquifer levels. The only solutions to the sand problem are a sand trap or a new well.

7. The bottom of the pump in Well No.1 is reported by Richards Hydro-Tech to be 29' 0 5/8" below the top of the casing and the top of the screen is apparently set at 38 feet below the casing. The pump could be lowered closer to the screen to allow for operation at lower water levels in the well. A lower pump inlet should not have an adverse impact on sand production.

   There may be a problem with straightness of the well which could prevent lowering of the pump. Operators report some difficulty with installation of the pump and feel that the well alignment may prevent further lowering.

8. Well No.2 may have decreased slightly in specific capacity but the pump still has considerably more submergence than the minimum required for successful operation. This pump should function at low well and river levels with no problems.

9. The efficiency of the pumps was checked to determine whether pumping rates had declined since installation. The overall efficiency of Pumps No.1 & 2 together calculates to be between 71 - 75% at various flows. The Manufacturer's pump curves show the efficiency of each pump should be about 80%. From the limited flow data available on each pump operating separately, it appears that Pump No.2 is pumping significantly less volume than when originally installed. Further testing is needed to verify this.

.../4

My conclusions and recommendations based on the preceding analysis and observations are as follows:

1. There is a direct hydraulic connection between the river and water levels in the wells. Stoplogging of VDS #5 increases water levels in the wells by the height of the stoplogs.

2. Pump No.3 cannot operate during peak demands when the river is low due to low well levels. A significant amount of stoplogging is required to allow the pump to operate satisfactorily. The pump can be lowered considerably at a reasonable cost which should resolve the water level problem in this well.

3. Pump No.2 has considerable submergence and should operate successfully at low river levels without stoplogs. The pump needs to be checked for pumping rates which may have decreased since installation.

4. Pump No.1 is close to being a problem at low river levels. Well efficiency is declining which will result in the pump being unable to operate at low river levels in the very near future. The pump in this well is the largest of the three and vital to the operation of the system.

Providing that the well alignment is not a problem, the pump could be lowered to gain some time before the pump cannot operate. The well alignment must be checked before adding any pump column and the pump has to be removed to do a proper alignment test. Consideration should also be given to improving the well efficiency when the pump is removed. The nature of the aquifer and the type of well construction will make this a delicate operation. Rehabilitation should be restricted to removing the inner screen and any sand that has accumulated. The inner screen can then be replaced with no further re-development. This procedure should restore the well back to the original capacity. Any attempt at further re-development could make the sand problem worse.

If the specific capacity cannot be improved, the well will have to be replaced at some time in the future. How soon will depend on the rate of decline in efficiency and whether the pump can be lowered.

.../5

5. Testing of either the existing wells and pumps or with modified pumps before the 1993 irrigation season depends on how important it is to know before the season begins if well re-development and lowering of pumps will accomplish the objective of no stoplogging. Testing in the off-season is quite expensive, whereas the information can be obtained at very little cost during the irrigation period.

Without testing, there is some risk that stoplogs will be necessary if lowering of the pumps and removing sand from Well No.1 does not work. There may be some merit in knowing this information before the irrigation season starts.

In summary, it is my opinion, based on the information supplied, that Pump System No.2 can be operated at low flows in Okanagan River without stoplogs in VDS #5 provided that:

1. The pumps in Well No.1 (125hp) and Well No.3 (10hp) are extended to lower the pump inlets. If the pump in Well No.1 cannot be lowered due to misalignment of the well, either the well will have to be abandoned and a new well drilled, or the pump replaced with a submersible pump.

2. The inside screen in Well No.1 is removed, sand removed and the screen replaced.

3. The Town accepts the fact that these wells will require more maintenance than wells normally require and significantly more attention needs to be paid to data collection and analysis.

If there are any questions regarding the foregoing, please advise.

Your's truly,

S.B.Mould, P.Eng.

SBM/dw

encl.

cc. 1. Ministry of Environment, Penticton
2. Kala Groundwater Consultants

SOLID SYSTEM NO. 2
16-INCH WELL
WATER WELL RENOVATION PROGRAM

Prepared For

The Southern Okanagan Lands Irrigation District

By

KALA GROUNDWATER CONSULTING LTD.

February, 1985

KALA GROUNDWATER CONSULTING LTD.
8204 Tebo Drive • Vernon, B.C. • V1B 1V3
Phone (604) 545-1720

February 25th, 1985

LETTER OF TRANSMITTAL

Mr. W. S. Ross
Manager
Southern Okanagan Lands Irrigation District
Box 788,
Oliver, B.C.
V0H 1T0

Dear Sir:

Reference: S.O.L.I.D.
System No. 2 - 16-inch Well
Water Well Renovation Program

We are pleased to submit our report outlining the work undertaken to stop the production of sand in the 16-inch well at System No. 2.

A discussion of possible reasons for the production of sand in this well, is presented in Section 4 of the report.

If you have any questions, or wish to discuss any aspect of the report, please feel free to contact our office.

Yours very truly,

KALA GROUNDWATER CONSULTING LTD.

L.C. Topp
Hydrogeologist

LCT/ct

1 INTRODUCTION

The present program of water well renovation, was undertaken for the South Okanagan Lands Irrigation District, at their No. 2 System, located south of Oliver. The renovation work was carried out with the 16-inch well, which was completed in 1981, but began to produce sand during the 1984 operating season.

The overall program involved an initial probing phase to determine the nature of the sand problem, an extensive period of redevelopment by surging, and finally, when it became evident that surging of the existing screens would not entirely solve the problem, smaller sized screens were installed inside the bottom portion of the well. Upon completion of the renovation work, a short pumping test was conducted to determine the capacity of the new well. All of the water well renovation work, including surging and installation of new screens, was conducted by JMS Water Well Drilling and Servicing of Okanagan Falls, British Columbia.

The following report includes background information with respect to the 16-inch well, a description of the present program, followed by a discussion of the results and recommendations for continued operation. Detailed information, including sieve analysis and pumping test data, are included in the Appendix.

2 BACKGROUND INFORMATION

S.O.L.I.D. System No. 2, which is supplied entirely by groundwater, is located approximately 5 km south of Oliver, along the east side of the Okanagan River. The well field at System No. 2 is situated adjacent to a small oxbow associated with the Okanagan River drainage system. The renovation program was carried out with the newest well completed in the well field, which is a 16-inch well providing the majority of water supply.

The 16-inch well was constructed by Quality Water Wells Ltd. of Okanagan Falls in October 1981, and the well was pump tested in December of the same year. The aquifer material is designated by Pacific Hydrology Consultants Ltd. (January, 1982) as a "single loose permeable aquifer which is probably of a torrential gravel origin". During drilling, a bit was not required to advance the casing through the water-bearing section from 25 to 90.5 feet (7.6 to 27.6 metres), indicating that the material is very loose and permeable.

The driller's litholog (see Appendix) of the well, indicates that the formation is comprised of fine to medium, polished gravel, with some fine sand in the upper portion of the aquifer, and coarse sand and gravel in the basal portion. An interval of clean fine brown sand was encountered from 49 to 62 feet (14.9 to 18.9 metres).

The well is completed with 16-inch telescoping, Johnson's stainless steel screen, of 0.250 inch (6.35 mm) slot size, from 38 to 88 feet (11.6 to 26.8 metres). The screen assembly includes a blank section, installed from 46.5 to 75.5 feet (14.2 to 23.0 metres) below ground level.

A pumping test was conducted with the well on December 10, 1981. The pumping rate was started at 1408 USgpm, and increased to 2170 USgpm at 400 minutes after the start. This higher pumping rate was maintained until the end of the test, which was terminated after 1680 minutes of pumping. Based on the test results, the Specific Capacity of the well, pumping at a rate of 1408 USgpm was 261 USgpm/foot of drawdown, and this decreased to 137 USgpm/ foot, pumping at a rate of 2170 USgpm. The capacity of the new well for individual pumping was designated by Pacific Hydrology Consultants Ltd. as 2550 USgpm.

During the 1984 operating season, complaints were expressed by water users regarding the occurrence of sand in their individual systems. A sand trap was installed on the discharge line from the well head, and a sand problem was confirmed.

3 DESCRIPTION OF PRESENT PROGRAM

The present program involved an initial probing phase to determine the nature of the sand problem, followed by a developing and screen installation phase to eliminate further sand production.

To start with, the 100 HP turbine pump was pulled and measurements taken to determine the amount of sand accumulation. These measurements showed that approximately 6 feet (1.8 metres) of sand had accumulated in the bottom of the well. After bailing out the sand, the bottom of the well was measured at 87.8 feet (26.8 metres) below the top of the 16-inch casing. The sand consisted of a fine to medium grained material. There was no evidence of gravel sized material in the bail samples.

Following the preliminary measurements, the well was developed by surging, running the surge blocks in the 16-inch casing, immediately above the screen assembly. Measurements were taken of the amount of sand accumulation per 3 minute interval during development (see Figure 1). Results showed that, although the majority of sand was entering through the bottom portion of the screened section (i.e. 75.5 to 88 feet), some sand was also entering the top screens.

Leaving the accumulated sand in the bottom of the well, development by surging continued on the upper screens. After approximately six days of surging above and inside the screens, the top portion of the screen assembly was developed to an acceptable condition.

An attempt was then made to develop the lower screens, but it was soon evident that the sand could not be stopped by conventional surging methods. It was therefore decided to install screens of smaller slot size, inside the bottom portion of the original screen assembly. Based on sieve analyses of sand obtained from inside the well, a 0.020-inch slot openning was selected, and an assembly consisting of 18 feet (5.5 metres) of 12-inch telescoping, Johnson's stainless steel screen was set from 66.2 to 84.4 feet (20.1 to 25.7 metres). A 2-foot (0.6 metres) blank section is attached to the bottom of the screens, and a Figure "K" packer creates a sand-tight seal at the top of the assembly (see Figure 2). The new screens were then developed for approximately 8 hours by surging.

In order to determine the capacity of the renovated well, a six hour pumping test was conducted, pumping the well at a constant rate of 1425 USgpm. At the end of the six hour test, the gate valve which controls the discharge rate, was openned full, and a pumping rate of 1650 USgpm was measured on the orifice tube. Prior to conducting the six hour test, a step drawdown test was carried out, pumping the well at increasingly higher rates for three successive forty minute intervals. Results of the test are discussed in the section which follows, and detailed information is included in the Appendix.

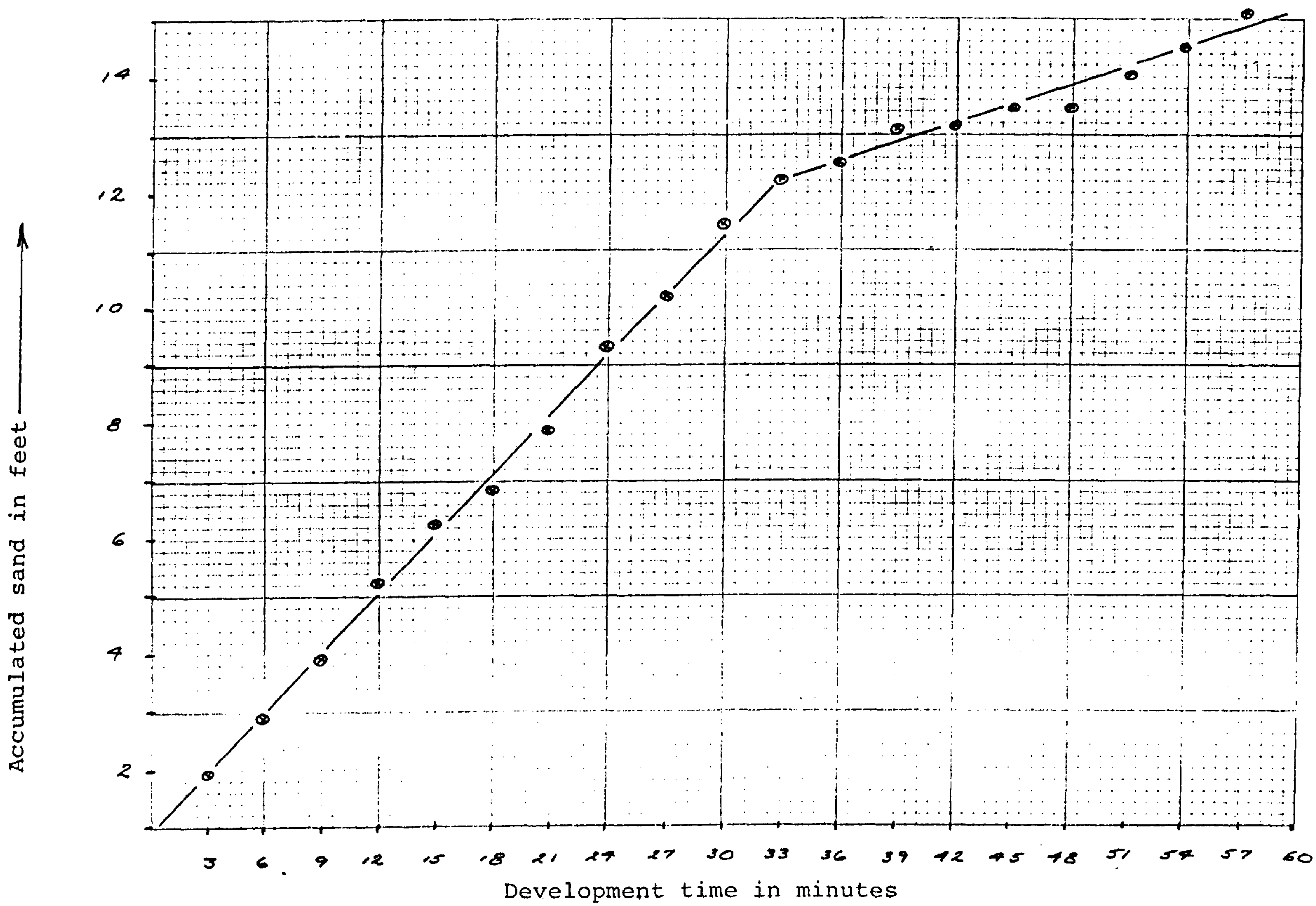


Figure 1

Sand Accumulation During Development

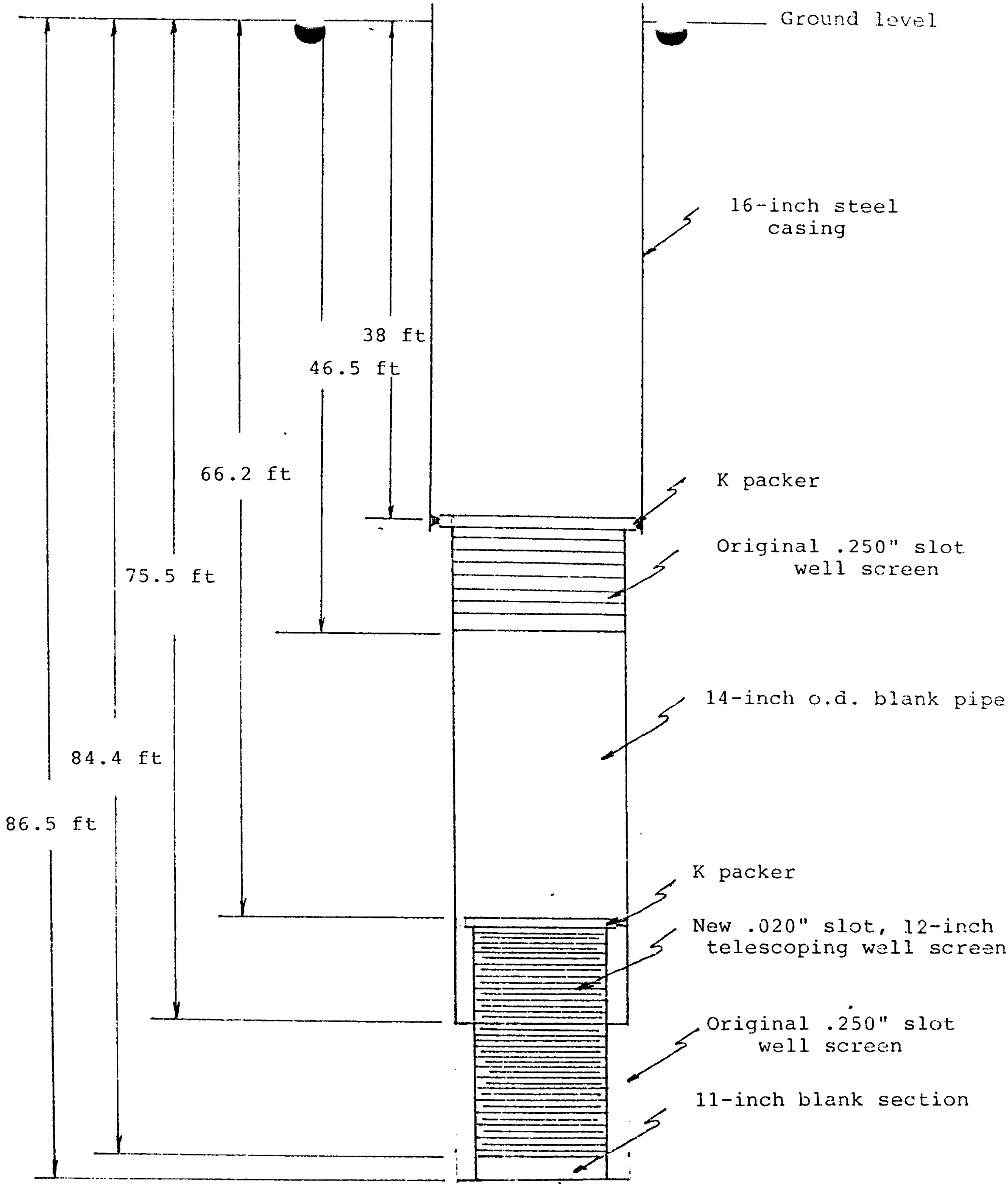


Figure 2
Well Completion Diagram

4 DISCUSSION OF RESULTS

Sand production from a well which has been fully developed, and has pumped sand free water for at least a one year period, is an unusual occurrence. In cases where the screen or packer is damaged, sand production may occur, but there was no evidence for damage to either of these components at System No. 2.

In our opinion there are two possible explanations for the sand problem, which are briefly outlined as follows:

1) As indicated in the report prepared by Pacific Hydrology Consultants Ltd. (January, 1982), the water- bearing formation is very loose. It is therefore possible that during development of the original well, a large portion of the lower formation material entered the well screens. This in turn would allow the finer sand, which occurs between 47 and 67 feet (14.3 and 20.4 metres), to migrate downwards. With continued use of the well, and further settlement of the lower aquifer material, the finer sand would enter the lower screens. The concrete pad around the casing has settled some six to eight inches, which would indicate that some settlement has occurred in the underlying formation.

2) A second possibility relates to the gradation of the aquifer material. If for example, the aquifer material is poorly graded, consisting only of fines and coarse gravel, without a significant amount of medium ranged material present, a problem could result. In this particular case, there would not be sufficient medium grained material present, to create a natural pack, preventing the fine sand from migrating into the well intake. During development of the original well, a bridging of the sand material may have occurred, which in time would breakdown, allowing sand to enter the well.

In either case it is obvious that the well was designed to maximize capacity, and it is also evident, that the original design was not effective with respect to stopping sand production. Hopefully, with the installation of the new screens, the problem has been rectified.

4.1 Pumping Test Results

The specific capacity of the well at varying pumping rates, based on the results of the step drawdown test is summarized as follows:

Pumping Rate USgpm	Drawdown (feet)	Specific Capacity USgpm/ft. of d.d.
508	1.35	376 USgpm/ft
1029	3.36	306 USgpm/ft
1420	5.28	269 USgpm/ft

This is comparable to the 261 USgpm/ft, which was determined during the original pumping test (December, 1981), with a discharge rate of 1408 USgpm.

Results of the 6-hour pumping test have been plotted on a semi-log graph of drawdown versus time (see Appendix). The drawdown after 200 minutes of pumping at a constant rate of 1425 USgpm, was 5.61 feet (1.7 metres), which compares to the 5.39 feet (1.6 metres) of drawdown, observed during the original test, pumping at a rate of 1408 USgpm. A boundary condition was observed after 60 minutes of pumping, where the drawdown increased from 0.32 feet (0.1 metres) per log cycle, to 0.64 feet (0.2 metres) per log cycle. Based on the test results, our projection for a long-term, safe yield for the renovated well is 2000 USgpm. This is allowing for 70 percent of the available drawdown to be utilized.

5 RECOMMENDATIONS

During the pumping test with the 16-inch well, following renovation, only a few grains of sand were observed in the discharge water. However, in view of the previous problems experienced with the well, we would make the following recommendations:

1) During the 1985 operating season, the well should not be pumped in excess of 1400 USgpm.

2) Periodic checks should be made for sand accumulation, by sounding the depth of the well.

3) In addition, a sand trap should be installed on the discharge line, to monitor sand production.

4) At the end of the 1985 operating season, the pump should be removed and inspected, and a check made for sand accumulation in the bottom of the well.

Following installation of the new screens, we do not expect a sand problem to occur with the bottom screen section, but there is still some doubt with respect to the upper screens. During Spring thaw, further settlement of the concrete pad around the well head will likely occur. We do not expect a large amount of settlement beyond this period.

We trust the above report provides the information required. If you have any questions, please feel free to contact our office.

Yours very truly,

KALA GROUNDWATER CONSULTING LTD.

L.C. Topp, Hydrogeologist

APPENDIX

SOLID SYSTEM NO. 2

16-INCH WELL

WATER WELL RENOVATION PROGRAM

STEP DRAWDOWN TEST

Date of test: Feb. 11, 1985

Time test started: 3:00 PM

Pre-test water level: 2.81 metres

Reference point: top of 16-inch casing

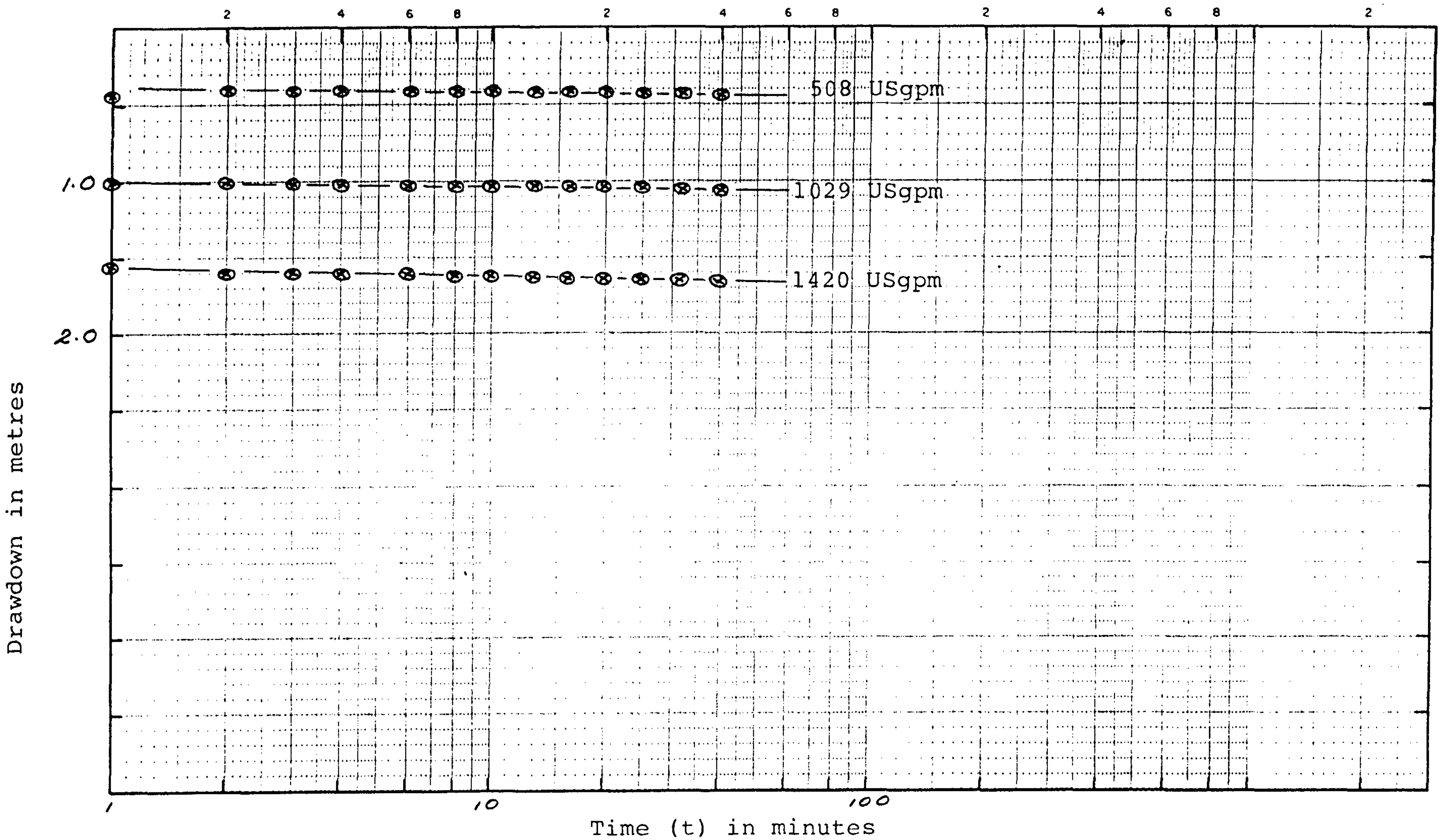
Pumping rate: 508,1029 & 1420 USgpm

PUMPING INTERVAL

Time (t) since pumping started in minutes	Depth to water (metres)	Drawdown in metres	Remarks
Step No. 1			
1	3.26	0.45	508 USgpm
2	3.21	0.40	
3	3.215	0.405	
4	3.215	0.405	
6	3.22	0.41	
8	3.22	0.41	
10	3.22	0.41	
13	3.225	0.415	
16	3.23	0.42	
20	3.23	0.42	
25	3.235	0.425	
32	3.24	0.43	
40	3.245	0.435	
Step No. 2			
1	3.82	1.01	1029 USgpm
2	3.82	1.01	
3	3.825	1.015	
4	3.83	1.02	
6	3.83	1.02	
8	3.83	1.02	
10	3.835	1.025	

SOLID System No. 2, 16-inch Well, Step Drawdown Test (Cont'd)

Time (t) since pumping started in minutes	Depth to water (metres)	Drawdown in metres	Remarks
Step No. 2 Cont'd			
13	3.84	1.03	1029 USgpm
16	3.84	1.03	
20	3.85	1.04	
25	3.85	1.04	
32	3.86	1.05	
40	3.86	1.05	
Step No. 3			
1	4.38	1.57	1420 USgpm
2	4.40	1.59	
3	4.405	1.595	
4	4.41	1.60	
6	4.41	1.60	
8	4.42	1.61	
10	4.42	1.61	
13	4.43	1.62	
16	4.43	1.62	
20	4.435	1.625	
25	4.44	1.63	
32	4.45	1.64	
40	4.46	1.65	



Well No. (Status) : 16-inch

Date : Feb. 11, 1985

Aquifer Test : Step Drawdown

Discharge (Q) : see above

Pre-test Water Level : 2.81 metres

Reference Point : Top of 16-inch casing

Remarks :

SOLID System No. 2

16-inch Well

KALA GROUNDWATER CONSULTING LTD.

SOLID SYSTEM NO. 2

16-INCH WELL

WATER WELL RENOVATION PROGRAM

CONSTANT RATE TEST

Date of test: Feb. 12, 1985

Time test started: 9:00 PM

Pre- test water level: 2.81 metres

Reference point: top of 16-inch casing

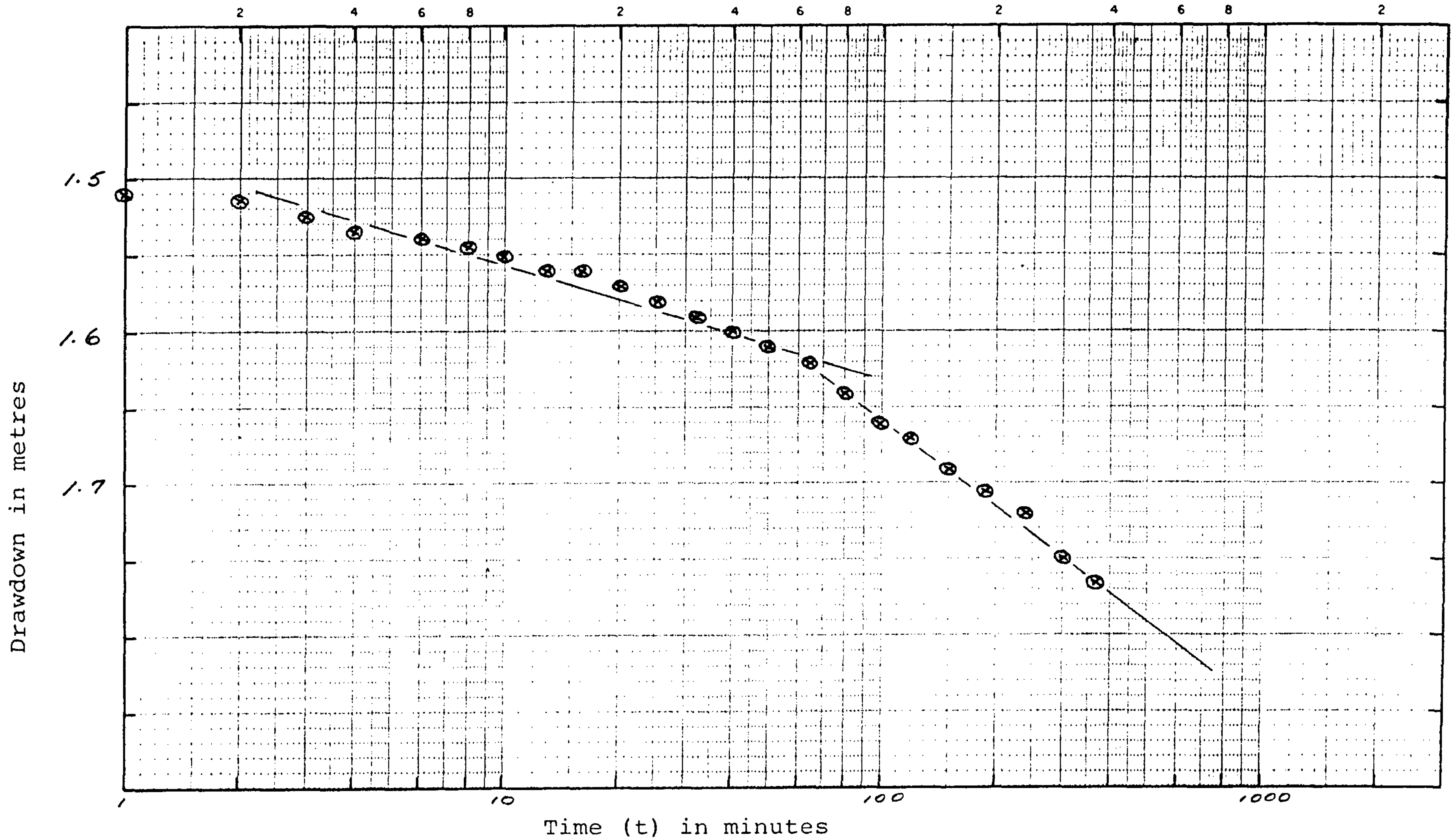
Ave. pumping rate: 1425 USgpm

PUMPING INTERVAL

Time (t) since pumping started in minutes	Depth to water (metres)	Drawdown in metres	Remarks
1	4.32	1.51	1425 USgpm
2	4.325	1.515	
3	4.335	1.525	
4	4.345	1.535	
6	4.35	1.54	
8	4.355	1.545	
10	4.36	1.55	
13	4.37	1.56	
16	4.37	1.56	
20	4.38	1.57	
25	4.39	1.58	
32	4.40	1.59	
40	4.41	1.60	
50	4.42	1.61	
64	4.43	1.62	
80	4.45	1.64	
100	4.47	1.66	
120	4.48	1.67	
150	4.50	1.69	
190	4.515	1.705	
240	4.53	1.72	
300	4.56	1.75	
360	4.575	1.765	

SOLID System No. 2, 16-inch well, Constant Rate Test (Cont'd)

Time (t) since pumping started in minutes	Depth to water (metres)	Drawdown in metres	Remarks
1	4.83	2.02	1650 USgpm
2	4.91	2.10	
3	4.91	2.10	
4	4.91	2.10	
12	4.93	2.12	
30	4.95	2.14	



Well No. (Status) : 16-inch

Date : Feb. 12, 1985

Aquifer. Test : Constant Rate

Discharge (Q) : 1425 USgpm

Pre-test Water Level : 2.81 metres

Reference Point : Top of 16-inch casing

Remarks :

SOLID System No. 2

16-inch Well

KALA GROUNDWATER CONSULTING LTD.

SOLID System No. 2

16-inch Well

Water Well Renovation Program

Driller's Litholog

0 - 3 ft	(0 - 0.9 m)	brown sand
3 - 11.5 ft	(0.9 - 3.5 m)	brown sand and gravel, dirty
11.5 - 13 ft	(3.5 - 4.0 m)	tight sand and gravel
13 - 20 ft	(4.0 - 6.1 m)	large and small gravel with medium to fine sand,clean,loose,grey
20 - 23.5 ft	(6.1 - 7.2 m)	polished gravel with fine sand, loose
23.5 - 25 ft	(7.2 - 7.6 m)	tight sand and gravel
25 - 30 ft	(7.6 - 9.1 m)	brown pebbles and peas, loose, with fine grey sand
30 - 36 ft	(9.1 - 11.0 m)	pebbles and peas with clean sand,loose,brown
36 - 40 ft	(11.0- 12.2 m)	brown sand,pebbles and peas, loose, some fines, gravel is polished
40 - 44 ft	(12.2- 13.4 m)	pebbles and peas, clean, with brown sand
44 - 47 ft	(13.4- 14.3 m)	polished pebbles and peas, some fine sand, clean, loose
47 - 49 ft	(14.3- 14.9 m)	brown sand, some pebbles, clean
49 - 62 ft	(14.9- 18.9 m)	clean fine brown sand
62 - 67 ft	(18.9- 20.4 m)	medium to coarse sand, some fines, some gravel
67 - 69 ft	(20.4- 21.0 m)	coarse clean brown sand with more gravel
69 - 73 ft	(21.0- 22.3 m)	brown sand, pebbles and peas, some fines
73 - 77 ft	(22.3- 23.5 m)	coarse sand and pebbles with some gravel
77 - 79 ft	(23.5- 24.1 m)	coarse brown sand with pebbles and small to medium gravel
79 - 81 ft	(24.1- 24.7 m)	brown sand with polished pebbles and peas, small gravel, clean
81 - 86 ft	(24.7- 26.2 m)	brown sand and gravel with some fines
86 - 90.5 ft	(26.2- 27.6 m)	clean brown sand and gravel
90.5 - 91 ft	(27.6- 27.7 m)	silty clay
91 - 110 ft	(27.7- 33.5 m)	grey clay and silt

MECHANICAL ANALYSIS

Wt. of Dry Sample —

Screen	Wt. Ret.	% Ret.	% Pass
2"			
1-1/2"			
1"			
3/4"			
1/2"			
.265			
4	0	0	
6	.7	.2	
8	2.5	.7	
12	7.2	2.0	

(a) Wt. Qtr'd Sample Pass #4 =

(b) Washed Fines =

(c) Total (a) + (b) =

Screen	Wt. Ret.	% Ret.	% Pass
16	18.3	5.2	
20	44.2	12.5	
30	114.0	32.3	
40	204.5	58.0	
60	303.0	86.0	
100	343.8	97.6	
200	351.4	99.7	
Pan	352.2	100.0	
Total			

REMARKS

Igneous Rock
Sedimentary Rock
Metamorphic Rock
Fines

WASH TEST

Dry Wt. of Sample	352.2
Dry Wt. after Washing	
Loss In Wt.	
% Finer than #200 Sieve	

IDENTIFICATION

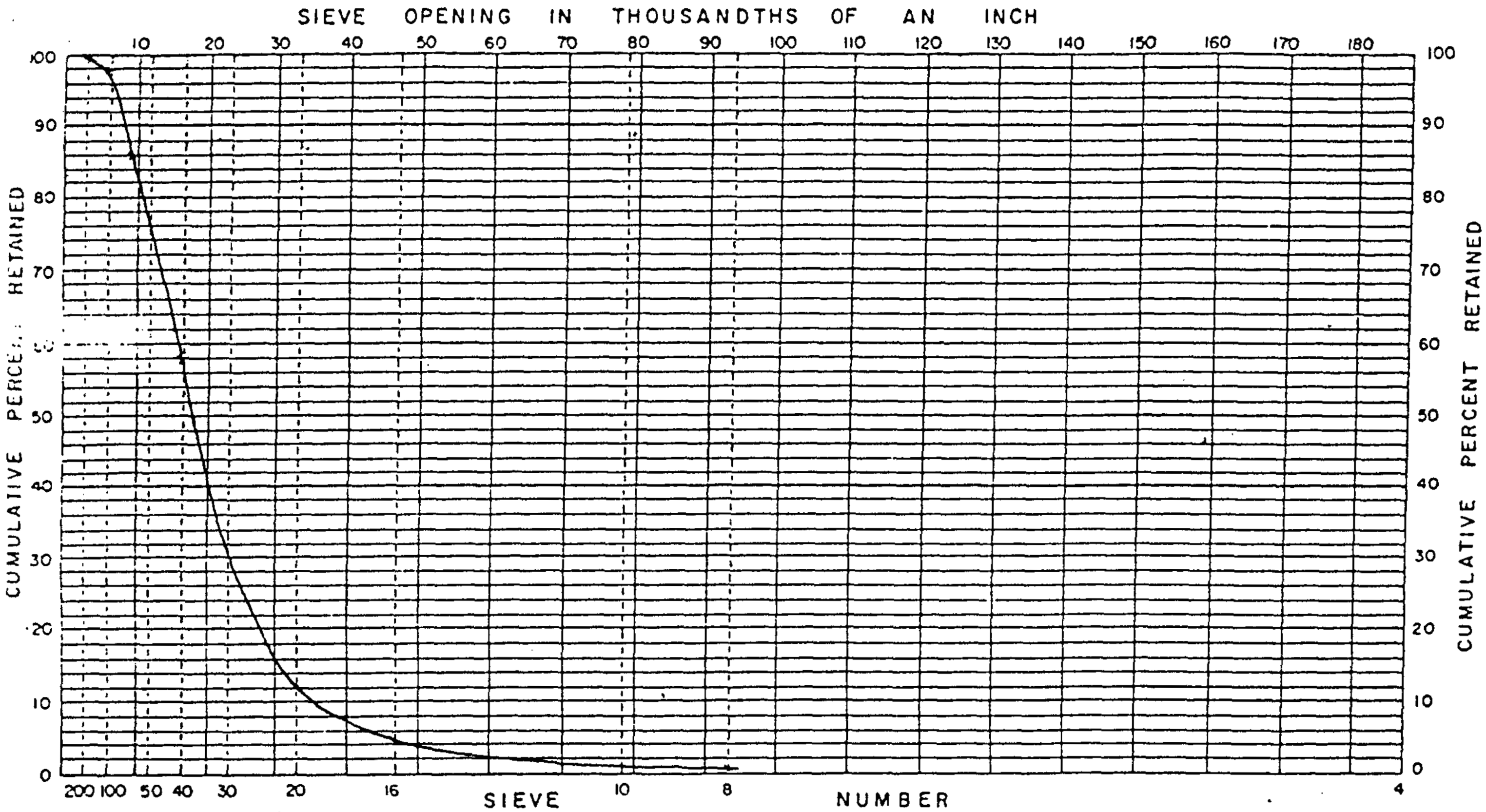
Project	Kala Groundwater		
Location	S.O.L.I.D		
Station	16" Well System #2		
Sample No.		Depth	
Sampled By	Client	Date	28-1-85
Tested By	R.W.	Date	29-1-85

TOP SCREEN

INTERIOR TESTING SERVICES LTD.

SOILS — CONCRETE — ASPHALT — FIELD SUPERVISION

KELOWNA, B.C.



SAMPLE DEPTH FEET	PERCENT RETAINED			
	90 %	50 %	40 %	30 %

Screen Opening Thousandths of an Inch

SAMPLE DEPTH		FEET	
OPENING	RET. ON	WT. RET.	CUM. % RET.

Percent of sample not sieved 1/2" or over ______%

SAMPLE DEPTH		FEET	
OPENING	RET. ON	WT. RET.	CUM. % RET.

Percent of sample not sieved 1/2" or over ______%

SAMPLE DEPTH		FEET	
OPENING	RET. ON	WT. RET.	CUM. % RET.

Percent of sample not sieved 1/2" or over ______%

Sand Entering Top Screen

SIEVE ANALYSIS

PROJECT: SOLID

LOCATION: System No. 2 16-inch Well

WELL No.

SAMPLED BY: L. C. Todd

SIEVE ANALYSIS BY:

DATE:

MECHANICAL ANALYSIS

Wt. of Dry Sample —			
Screen	Wt. Ret.	% Ret.	% Pass
2"			
1-1/2"			
1"			
3/4"			
1/2"			
.265			
4			
6			
8			
12	0	0	

(a) Wt. Qtr'd Sample Pass #4 =

(b) Washed Fines =

(c) Total (a) + (b) =

Screen	Wt. Ret.	% Ret.	% Pass
16	1.4	.4	
20	13.9	3.9	
30	85.0	23.6	
40	204.8	56.9	
60	320.9	89.0	
100	355.9	98.8	
200	360.0	99.9	
Pan	360.2	100.0	
Total			

WASH TEST

Dry Wt. of Sample	360.2
Dry Wt. after Washing	
Loss in Wt.	
% Finer than #200 Sieve	

REMARKS

- Igneous Rock
- Sedimentary Rock
- Metamorphic Rock
- Fines

IDENTIFICATION

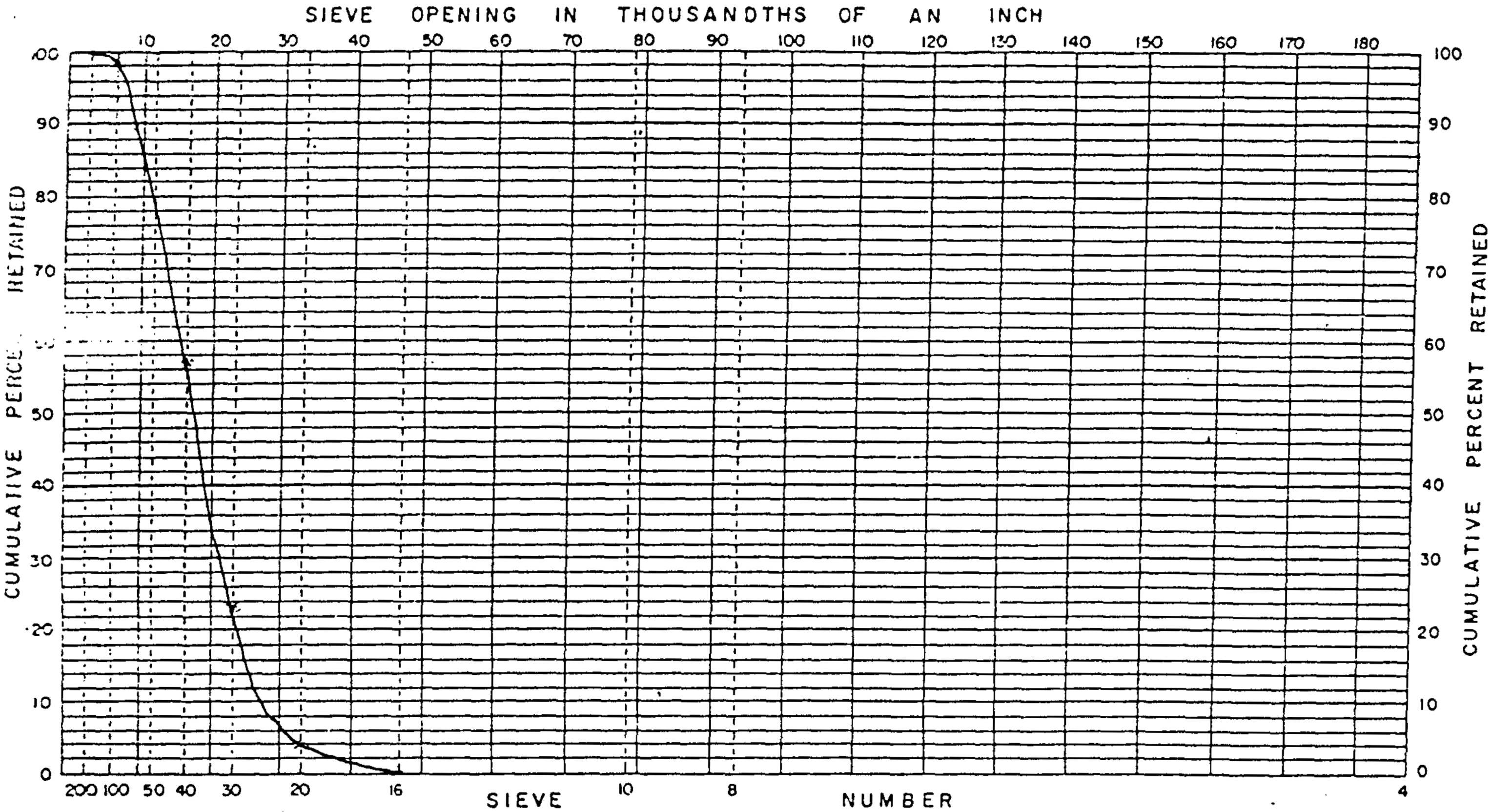
Project	Kala Groundwater		
Location	S.O.L.I.D.		
Station	16" Well System #2		
Sample No.		Depth	
Sampled By	Client	Date	28-1-85
Tested By	R.W.	Date	29-1-85

BOTTOM SCREEN

INTERIOR TESTING SERVICES LTD.

SOILS — CONCRETE — ASPHALT — FIELD SUPERVISION

KELOWNA, B.C.



SAMPLE DEPTH FEET	PERCENT RETAINED			
	90 %	50 %	40 %	30 %

Screen Opening Thousandths of an Inch

SAMPLE DEPTH		FEET	
OPENING	RET. ON	WT. RET.	CUM. % RET.

Percent of sample not sieved 1/2" or over ______%

SAMPLE DEPTH		FEET	
OPENING	RET. ON	WT. RET.	CUM. % RET.

Percent of sample not sieved 1/2" or over ______%

SAMPLE DEPTH		FEET	
OPENING	RET. ON	WT. RET.	CUM. % RET.

Percent of sample not sieved 1/2" or over ______%

Sand Entering
Bottom Screen

SIEVE ANALYSIS

PROJECT: 5042D

LOCATION: System No. 2
16-inch Well

WELL No.

SAMPLED BY:

SIEVE ANALYSIS BY:

DATE:

Province of British Columbia · Ministry of Environment · WATER MANAGEMENT BRANCH

MEMORANDUM

SOUTHERN OKANAGAN LANDS IRRIGATION DISTRICT
Box 788 OLIVER, B.C.

To: A.P. Kohut
Senior Geological Engineer
Groundwater Section
Water Management Branch

Date: August 16, 1985

Our File: 82 E/4

RECEIVED SEP 13 1985

BILL ROSS
P.O. BOX 1151
OLIVER, B.C. V0H 1T0
498-4325

Re: S.O.L.I.D. System Study

Introduction

As requested by Jack Eby, Head, Water Supply Section, a review of the groundwater conditions for the above has been completed. The purpose is to investigate the feasibility of supplying groundwater to S.O.L.I.D. Systems 1,4,5,6 and 7 presently being supplied from the S.O.L.I.D. Canal (Figure 1). The ultimate peak water requirements, according to Eby (1985), are:

System	Requirements (USgpm)
1	6,200
4	8,355
5	4,700
6	4,840
7	4,900

The requirements total 28,995 USgpm. Areas where groundwater sources can be conveniently connected to the existing systems have been outlined by Eby (1985). These are designated Areas 1 to 6 (Figure 1). Where possible, groundwater sources in the areas along Highway 97 would also be desirable. The study area covers the Okanagan River Valley from Deadman Lake northwards to Orofino Creek (Figure 1). Available air photos, well log data, topographic and geologic maps, and geologic reports were reviewed. This memo summarizes the surficial geology, groundwater conditions, and groundwater potential areas and outlines an exploration program and associated costs.

Surficial Geology

Five, possibly six, types of surficial deposits underlie the area. They are from youngest to oldest:

1. Fluvial deposits
2. Alluvial deposits
3. Older Alluvial deposits
4. Glaciofluvial deposits
5. Glaciolacustrine deposits
6. Morainal deposits (?)

APK

Their known areal and subsurface distribution is shown in Figures 2 to 11. A brief description of each of these deposits is as follows:

Fluvial deposits occupy the floodplain forming a continuous strip of uniform width except where it constricts between Areas 2 and 3 and at Oliver. They consist of sand and gravel with some silt and clay and are likely very permeable. These deposits appear <50 feet thick but may increase up to 100 feet in Area 2 and 70+ feet in Area 6 (Figures 4 and 10). Except for the top few feet, the whole section is saturated. Fluvial deposits were formed from deposition of sediments by the Okanagan River.

Alluvial deposits occur as fans mostly west of the river between Areas 1 and 5 and consist of sand, gravel, boulders, and clay. The deposits slope from the valley side (Elevation 1,050 to 1,300 feet) east to the floodplain (Elevation 930 to 970 feet) where they generally decrease in thickness and grain size. The Testalinden Creek fan and the Reed Creek fan are the largest and may be up to 120 feet thick near their apexes (Figures 4, 7, and 8). The lower part of Testalinden Creek fan appears saturated but the Reed Creek fan seems to be located too high above the valley floor and is likely unsaturated. The fans in between are likely <40 feet thick and only their lower edges along the valley floor are saturated (Figures 5 and 6). Alluvial deposits form from deposition of sediments by tributary streams entering the main valley.

Older alluvial deposits occur as fans above the alluvial deposits and are "stranded" about 200 to 300 feet above the valley floor. These deposits appear to be as much as 85 feet thick but are dry (Figures 5 and 6). Older alluvial deposits are similar to alluvial deposits except that they are older, deposited with respect to a higher previous river or lake level.

Glaciofluvial deposits occur mostly as outwash terraces and channels in the area (see Nasmith, 1962). Kame deposits occur along Highway 97 near Deadman Lake. These deposits consist of sand and gravel with some silt and clay and are likely permeable. Thick sections occur along the east side of the valley up to elevation 1,300 feet (Figures 3,4,9,10, and 11). The areas where glaciofluvial deposits occur along the west bank are near Deadman Lake southwest of Area 1, along the bench area northwest of Area 4 where they may reach 200 feet thick, and west of Area 6 where they may reach over 70 feet thick (Figures 3,7,8,10, and 11).

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These deposits also occur in Area 5 at the Oliver Airport but appear thin - less than 15 feet thick (Figure 9). Glaciofluvial deposits were formed from deposition of sediments by glacial rivers.

Glaciolacustrine deposits underlie all the above deposits and occur entirely at depth in the area. The fact that several wells along the valley encountered these deposits at depth including the Seventh Day Adventist well and Boake well which encountered 410 feet and 452 feet respectively of these materials suggest glaciolacustrine deposits are thick (>400 feet) and extensive in the area (Figures 3 and 6). These deposits consist of fine sand, silt, and clay and likely have very low permeabilities. The surface of the deposits slopes south from Area 6 (Elevation 950 feet) to Area 1 (Elevation 820 feet). Sand and gravel sections occur in the deposits (Boake well - Figure 6) but their extent is unknown. Glaciolacustrine deposits were formed from accumulation of fine sediments in glacial lakes.

The log of the Fatur well implies till (morainal deposits) may underlie the glaciolacustrine deposits (Figure 5). There may also be sand and gravel outwash deposits associated with the till but these deposits, if existent, are likely located 300 feet to 500 feet below the valley floor.

Depth to bedrock from the valley floor is unknown but is speculated to be over 500 feet (Figures 3 and 4). Metamorphic and some igneous rocks underlie the area (Bostock, 1939). These rocks have likely very low permeabilities.

Groundwater Conditions

There are more than 400 wells in the area on Groundwater Section files. One-third of these are drilled wells and the rest are dug wells (Figures 12 and 13). Most wells (83%) are shallow - <50 feet deep - located in the floodplain and adjacent lowlands completed in the fluvial and lowlying alluvial and glaciofluvial deposits. Most of these wells lie within 3½ miles of Oliver. There are few reported wells south of Area 3. Water level in the shallow wells are <20 feet and most are <10 feet below ground. Moderate to high capacity wells (100 to 1,000 gpm) have been completed in these deposits (Table 1). Specific capacity of these wells range between 9.8 USgpm/ft. to 445 USgpm/ft. Aquifer transmissivity and storativity derived from pump test data of some of the S.O.L.I.D. wells and the B.C.F.G.A. wells are $T = 10^4$ USgpd/ft. to 10^6 USgpd/ft. and $S \approx 0.1$. These values are from high capacity wells and correspond to the higher permeable sections of the aquifers. Some of the moderate capacity 6-inch and 8-inch diameter wells exhibited a low percentage of drawdown and high specific capacity during well testing and imply the aquifers in which these wells are drilled may be able to yield higher quantities to larger diameter (12-inch) wells (Hewitt (1¼"Ø) and S.O.L.I.D. wells northwest of Area 4, City well at Oliver, and Skukala, Levant, S.O.L.I.D. and Dutton wells at and near Area 6).

Some wells (14%) are moderately deep - 51 to 200 feet - and a few (3%) are deep - >200 feet. Most deep wells are located south of Oliver on the valley side where the water level is deep (Busnardo, Poturica, Thurser, Fatur, and Boake wells). These wells are completed in glaciolacustrine (and morainal?) deposits or bedrock. Their specific capacity and capacity (except for the Boake well) are low (<1 USgpm/ft. and <<100 USgpm respectively). Inspection of well water levels and surface water levels indicate the surface water and groundwater are hydraulically connected and that groundwater flows generally south along the valley. The recorded rise in water level during drilling of the S.O.L.I.D. wells northwest of Area 4 and in Area 6 suggest these wells are located in groundwater discharge areas. This may be representative of the conditions of the whole valley floor. Recharge likely comes from the Okanagan River and from the valley sides.

Sand and gravel sections in the fluvial and low lying glaciofluvial and alluvial deposits form the major shallow aquifers in the area. These aquifers are capable of supplying several hundred to over 1,000 USgpm to industrial wells. However, the capacity of these aquifers to supply the 29,000 USgpm total requirements would likely depend upon receiving recharge from the Okanagan River. Groundwater exploration is needed to assess this at various sites in the valley. Based on existing data it is highly likely that these aquifers could supply a significant portion of the supply requirements (10 to 20 percent or 3,000 USgpm to 6,000 USgpm).

Sand and gravel sections in glaciolacustrine deposits form the only other aquifer known in the area. This aquifer lies deep beneath ground surface, has not been well delineated, and is likely capable of up to only a couple of hundred USgpm. This aquifer is an unlikely source for the S.O.L.I.D. Systems at present.

Five laboratory samples and 43 field analyses of groundwater from the shallow aquifers are available on Groundwater Section files (Table 2). Water quality ranges from moderately soft to moderately hard (hardness = 119 mg/L to 442 mg/L) - generally harder south of Oliver - and moderate in dissolved mineralization (TDS = 181 mg/L to 396 mg/L). The water is suitable for irrigation (SAR = 0.3 to 0.7), not encrustive nor corrosive (Ryznar Index = 6.6 to 7.8; Aggressive Index = 11.8 to 12.7) and is classified as a Calcium-Bicarbonate type water (Figure 14). The relatively high amounts of iron found in some of the wells from field analyses may represent particulate iron in the sample and may not be indicative of the dissolved iron concentration in the water which is expected to be lower. However, there are reported cases of poor water quality with high iron particularly near Area 6 along the CPR railway and very hard water in a few wells south of Area 3. Chemical analyses of water from B.C.F.G.A. Well #1 and 3 show Manganese contents slightly above that recommended in B.C. Drinking Water Quality Standards, 1982. An update on the water chemistry is necessary

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to evaluate recent trends - both natural and man-induced - in the groundwater quality of the area.

Groundwater Potential Areas

Groundwater potential areas are outlined in Figure 2. These areas are restricted to the west side of the Okanagan River because of the problem of bringing the groundwater across the river. They were picked from the cross-sections where shallow, likely permeable deposits of sufficient saturated thickness are located and where water level of <50 feet is expected. These areas are then interpolated between cross-sections and outlined in Figure 2. The potential areas cover the floodplain and adjacent low lying areas (west of Areas 1,4, and 6) occupied by the fluvial, alluvial, and glaciofluvial deposits. A brief summary of the groundwater potential of the six areas is presented below:

- Areas 1 and 2 - good potential; few reported wells in Area 1 but some high capacity wells nearby; the fluvial deposits are apparently >50 feet.
- Area 3 - moderate potential; some moderate capacity wells in the Area but the fluvial floodplain is narrow and thin except at the north end.
- Area 4 - good potential; some shallow wells at the north end but none appear to penetrate the entire fluvial section which is expected to be >50 feet; no reported high capacity wells in the Area.
- Area 5 - poor potential; few reported wells in the Area including two low capacity wells; thickness of the glaciofluvial deposits appears <15 feet.
- Area 6 - good potential; moderate and high capacity wells in and near the Area; thickness of the fluvial section may be up to 70 feet.

In addition, areas along Highway 97 south and west of Area 1, northwest of Area 4, and west of Area 6 have good potential (Figure 2).

Groundwater Exploration

Groundwater exploration should be concentrated in the shallow aquifers within the potential areas. Exploration should include a (1) preliminary field survey, (2) geophysical surveys, and (3) test drilling. A field survey is necessary to update well inventory, check local geology, perform short term well tests and water quality analyses on selected wells to pin down the exploration areas and to establish existing groundwater conditions prior to test drilling, and pick out drill sites.

. . . 6

It may be possible to delineate areas where the shallow floodplain and adjacent low lying deposits may be thicker and more permeable using seismic reflection and radar surveys (Brown, Geophysical Surv. Eng., Ministry of Transportation and Highways, 1985 pers. comm.). These geophysical surveys can be carried out along lines across parts of the valley floor, in particular, where the hydrogeology is not well understood and where subsurface information is lacking (Area 1, Area 4 and northwest, and Area 6 and west). Estimated cost for 5 line miles is roughly $70,000 to $80,000 (Brown, 1985, pers. comm.). It is also possible to use geophysics to explore for aquifers at depth.

Up to 16 8-inch diameter testholes capable of up to 400 USgpm is recommended to assess the capacity of the shallow aquifers in the area. The testholes are likely to range in depth between 75 and 150 feet. Their proposed locations are shown in Figure 2. Exact locations will depend upon the preliminary field and geophysical surveys. The testholes should be drilled by the cabletool method. Representative samples should be taken every 1 to 2 feet across the aquifer section. The testhole should then be completed with a properly designed screen and pump tested to assess its capacity and obtain aquifer parameters. The pump test should be of constant rate and of minimum 24-hour duration. Water samples should also be collected to check water quality. Water levels in the Okanagan River and nearby wells should, if possible, be monitored during the pump test to assess the effects of interference. The test well should be constructed with a surface sanitary seal to minimize flooding of the well head and contamination of the well by any polluted runoff. Where drilling results are favourable, the groundwater resource in that area can be developed before test drilling in other areas is continued. For example, if test drilling is started in Area 1 with good results, the test wells can be completed as production wells and other production wells of 12-inch or 16-inch diameter can be completed in the area to serve System 7 before further test drilling is continued in other areas. Cost to construct and test 16 8-inch wells of 75 to 150 feet depths would be $210,000 excluding engineering supervision (Table 3). If S.O.L.I.D. could find a spare pump of sufficient capacity to do the pump testing, the costs could be reduced by about 35%. Ultimate cost for supplying the S.O.L.I.D. Systems #1,4,5,6, and 7 on groundwater, if possible, may theoretically require 30 wells of 12-inch and 16-inch diameter costing up to $640,000 excluding engineering supervision (Table 3). Drilling, construction, design, and pump testing of the wells should be carried out under the supervision of a groundwater engineer.

Conclusions

1. Moderate to high capacity wells have been completed in fluvial floodplain and adjacent low lying glaciofluvial deposits and some in low lying alluvial deposits. These deposits form the major shallow aquifers in the area.

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2. In general, water quality of the shallow aquifers is moderately soft to moderately hard, moderate in dissolved mineralization, suitable for irrigation, and not encrustive nor corrosive. The water is classified as a Calcium-Bicarbonate type water.

3. Groundwater exploration for S.O.L.I.D. Systems #1,4,5,6, and 7 should be concentrated in the shallow aquifers west of the Okanagan River. Exploration should include a (1) preliminary field survey, (2) geophysical surveys, and (3) test drilling.

4. Costs for 5 line miles of geophysical surveys could amount to $80,000.

5. Up to 16 8-inch diameter testholes are recommended for the test drilling. The testholes should be drilled by the cabletool method. Cost for 16 8-inch diameter test production wells would be $210,000 excluding engineering supervision.

6. Drilling, design, construction, and testing of wells should be carried out under the supervision of a groundwater engineer.

References

Bostock, H.S. 1939. Keremeos Map 341A. Department of Mines and Resources.

Eby, J.V. 1985. S.O.L.I.D. - System Study. Ministry of Environment, Water Supply Section, Victoria, B.C. File 0242512-7.

Nasmith, H. 1962. Late Glacial History and Surficial Deposits of the Okanagan Valley, British Columbia. B.C. Department of Mines and Petroleum Resources, Bulletin No. 46.

Mike Wei

Mike Wei
Geological Engineer
Groundwater Section
Water Management Branch
387-1115

MW/dma

INTERPRETATION OF HYDROGEOLOGY ACROSS $X_1 - X_1'$

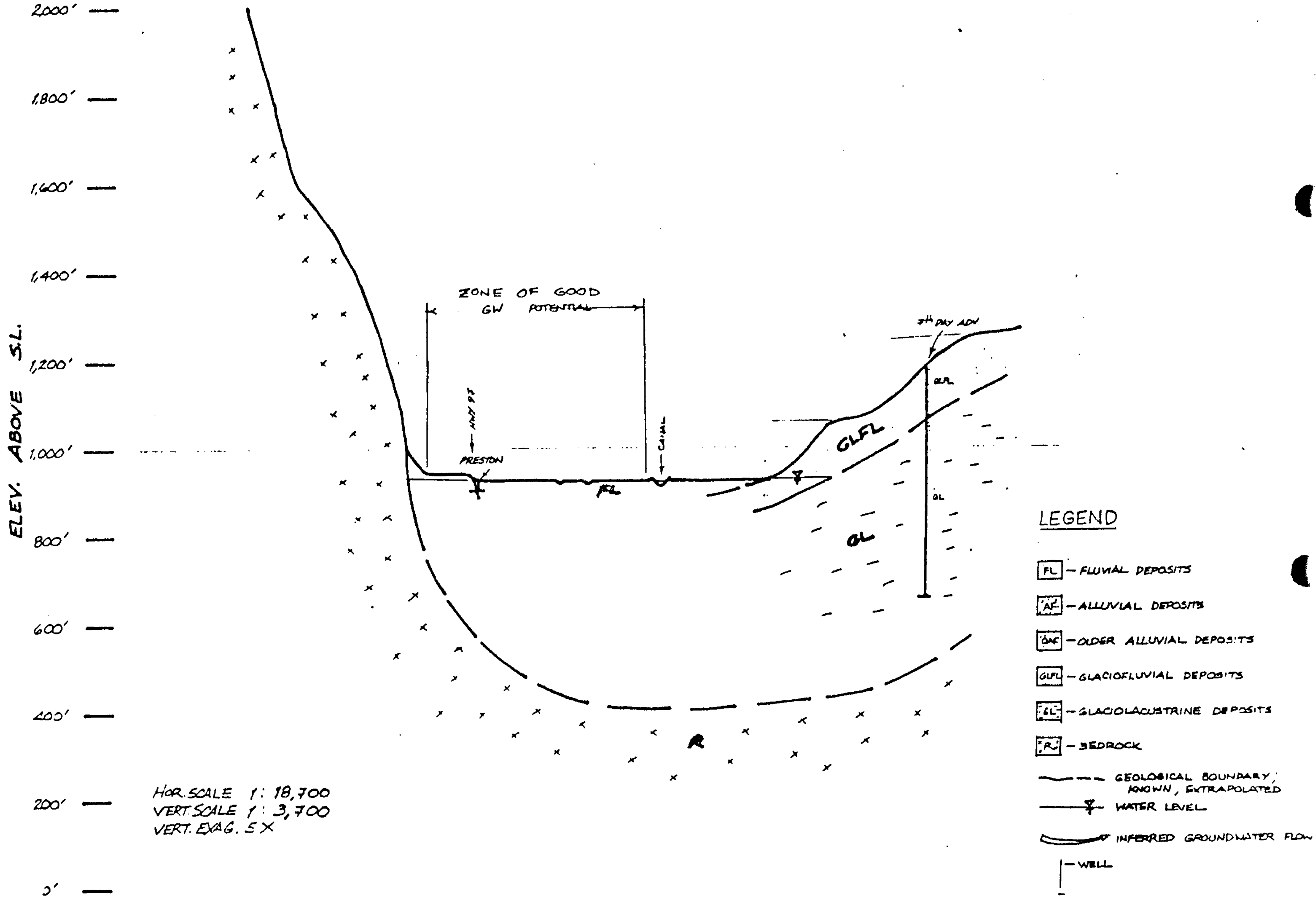
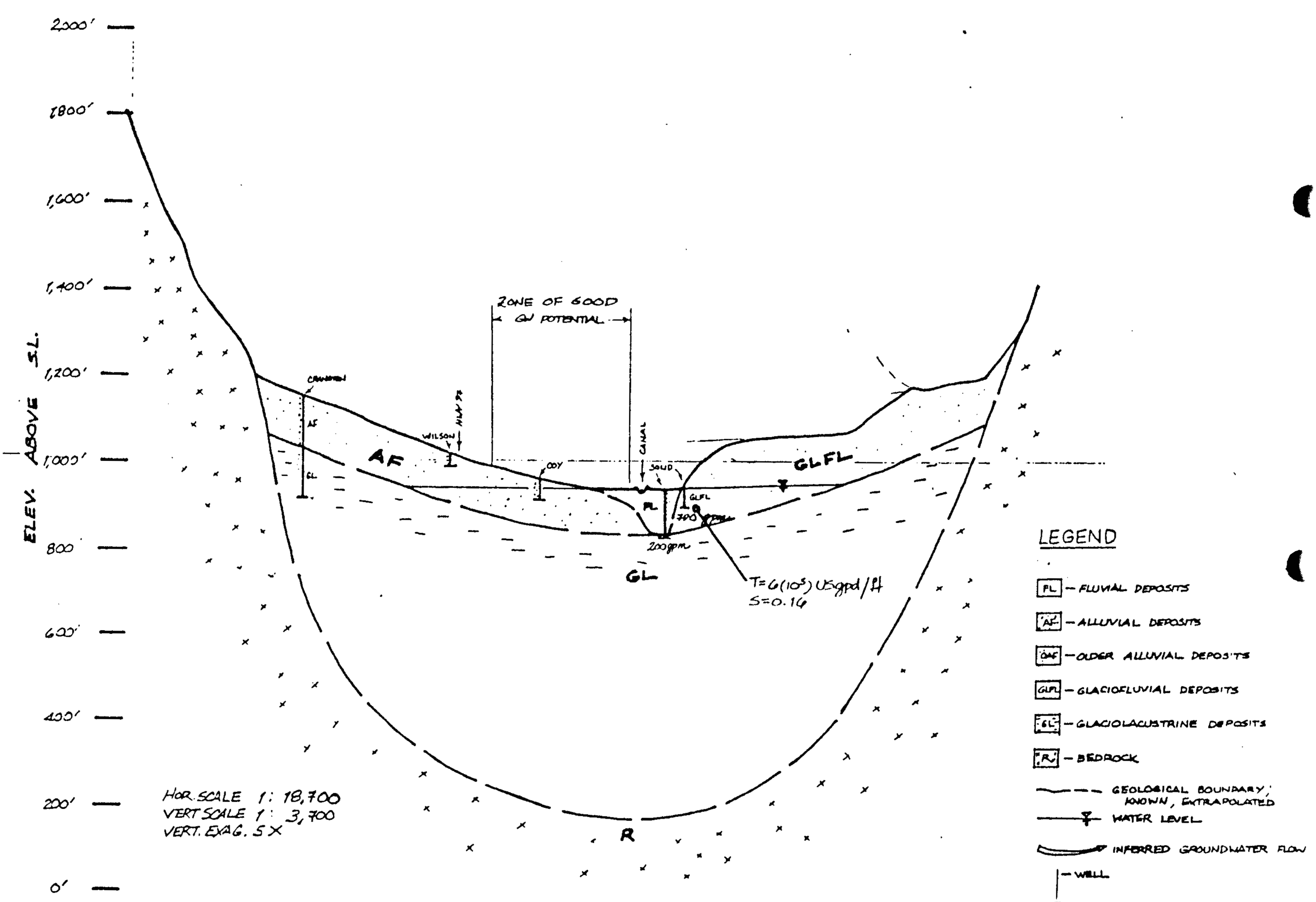


FIGURE 3

INTERPRETATION OF HYDROGEOLOGY ACROSS $X_2 - X_2'$



INTERPRETATION OF HYDROGEOLOGY ACROSS $X_3 - X_3'$

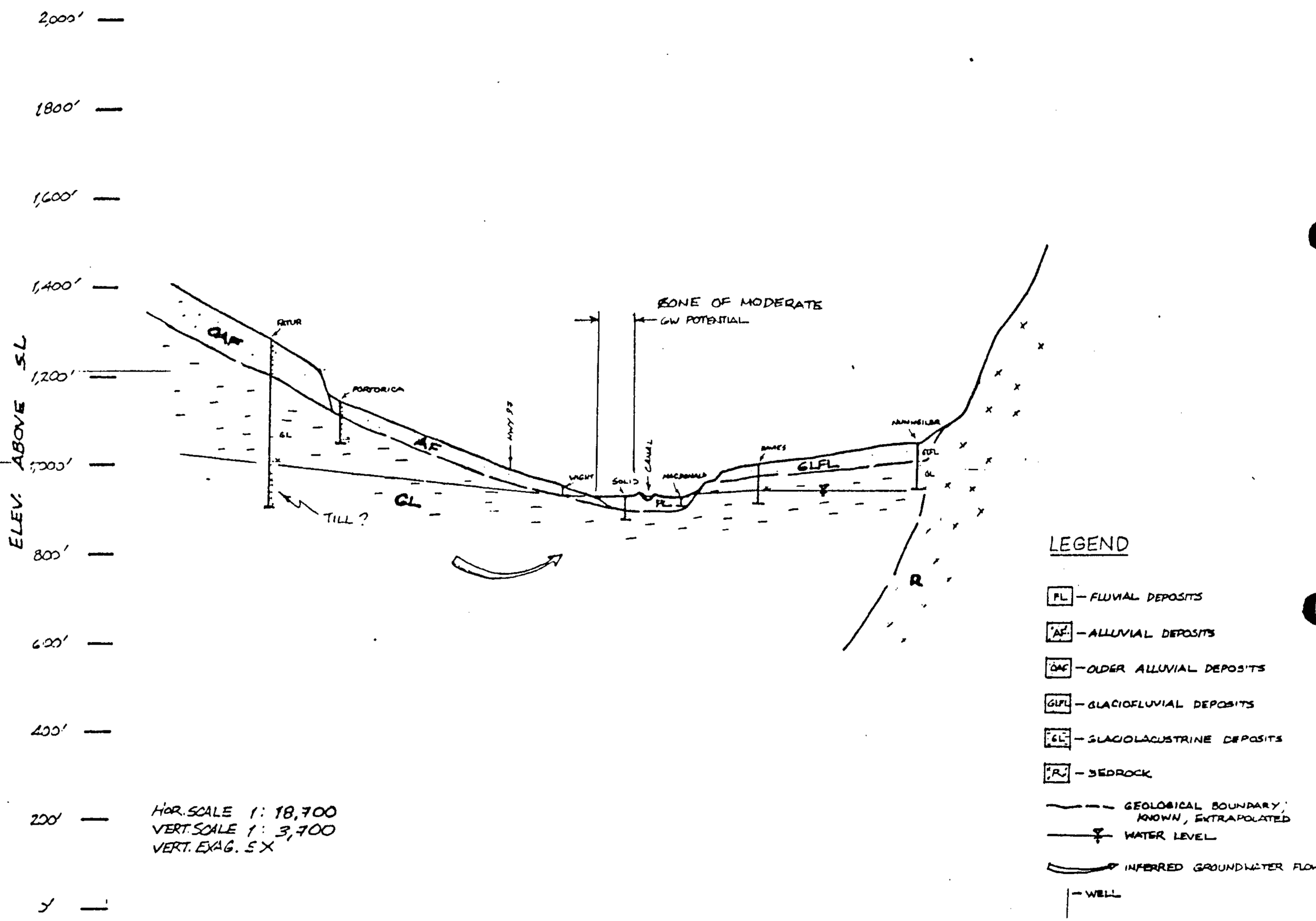


FIGURE 5

INTERPRETATION OF HYDROGEOLOGY ACROSS X_4-X_4'

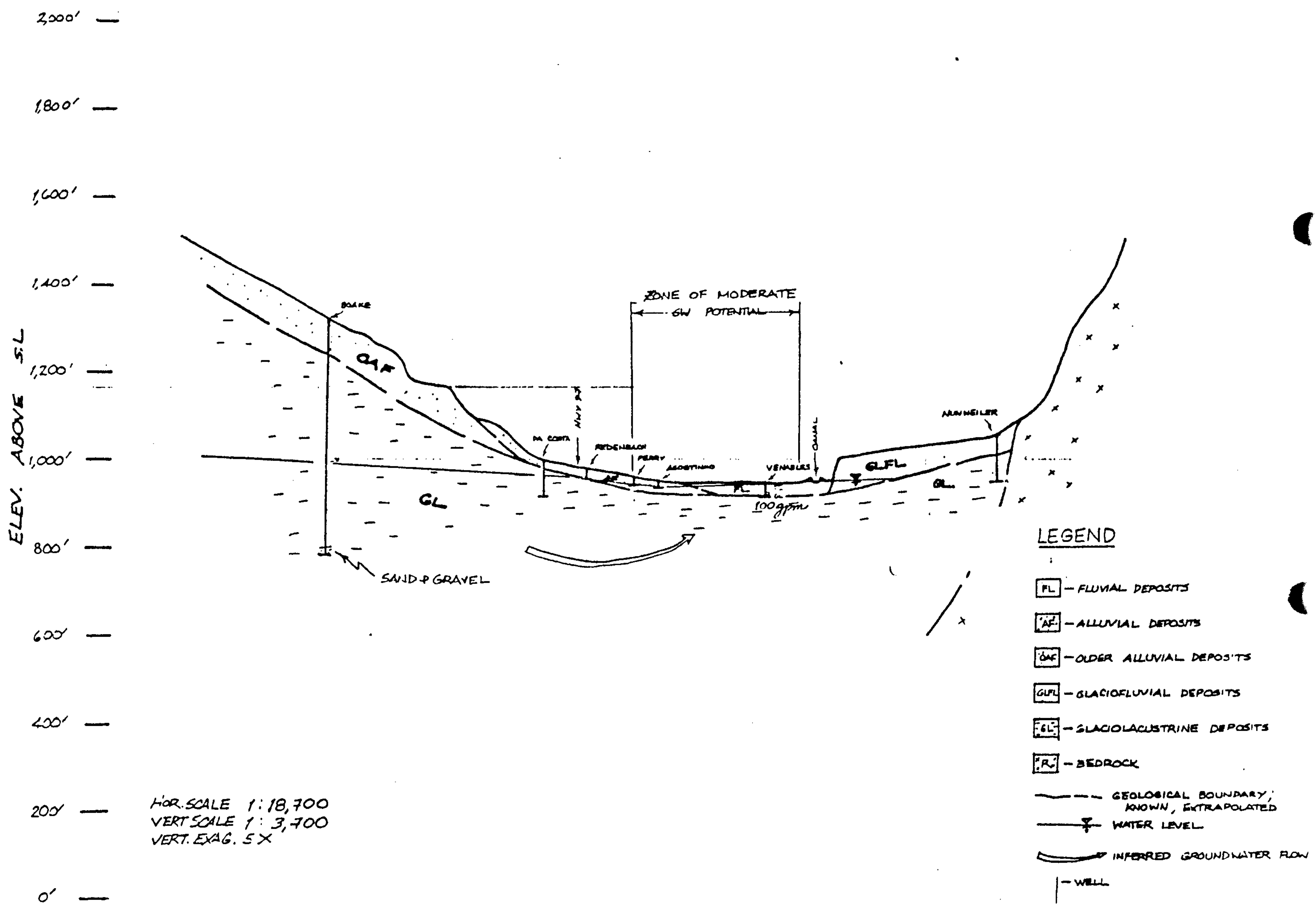


FIGURE 6

INTERPRETATION OF HYDROGEOLOGY ACROSS $X_5 - X_5'$

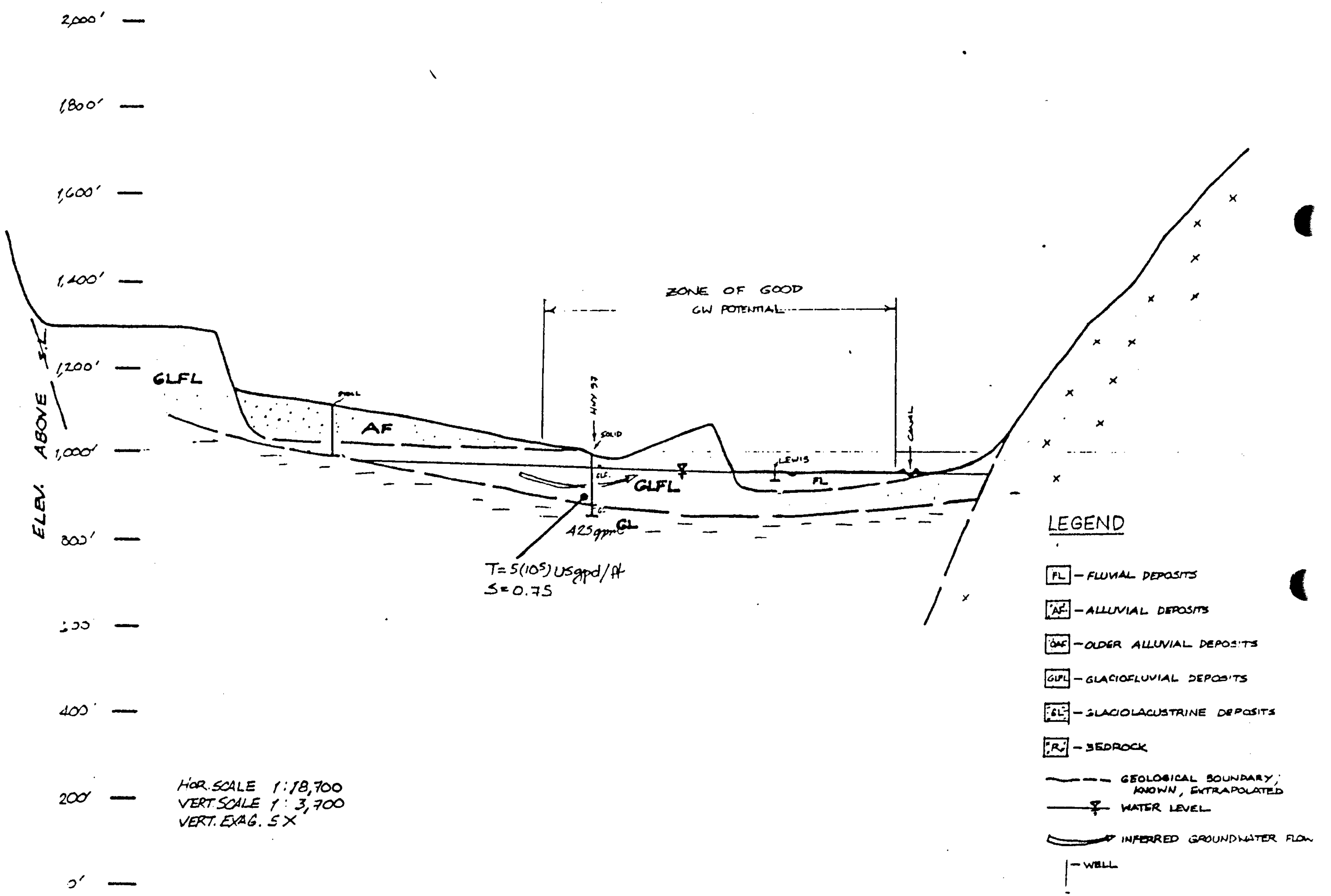


FIGURE 7

INTERPRETATION OF HYDROGEOLOGY ACROSS $X_6 - X_6'$

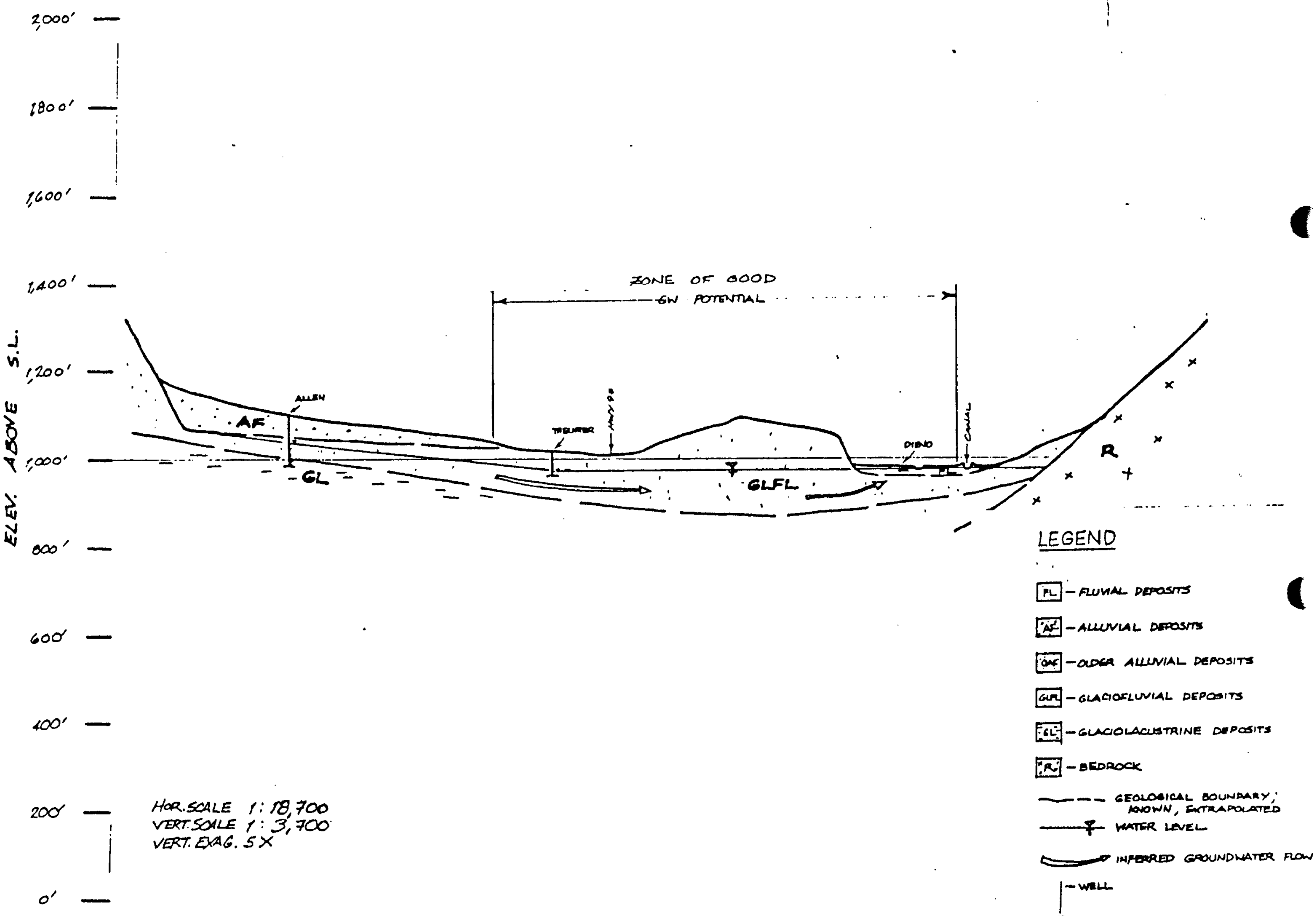


FIGURE 8

INTERPRETATION OF HYDROGEOLOGY ACROSS $X_7 - X_7'$

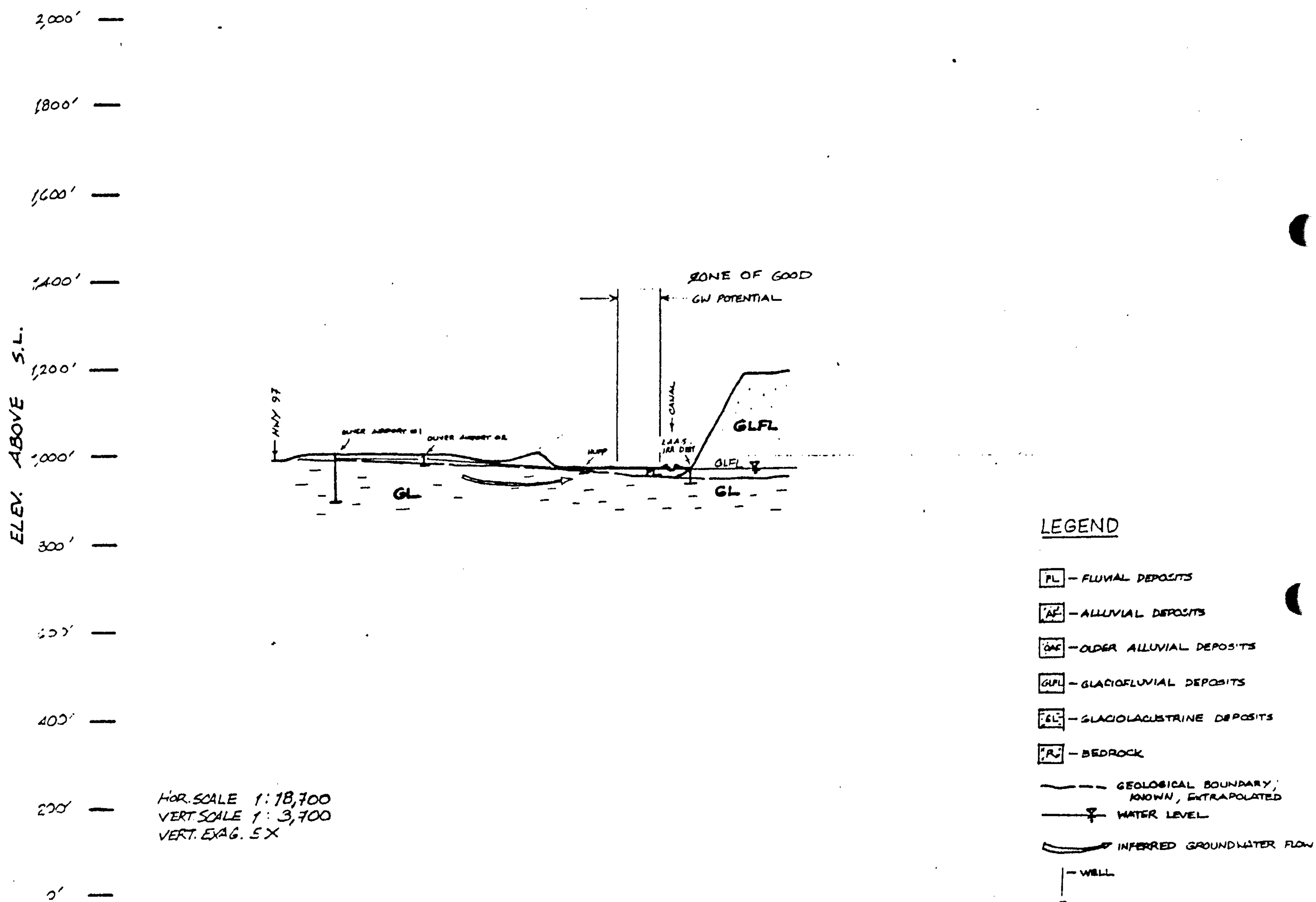


FIGURE 9

INTERPRETATION OF HYDROGEOLOGY ACROSS $X_8 - X_8'$

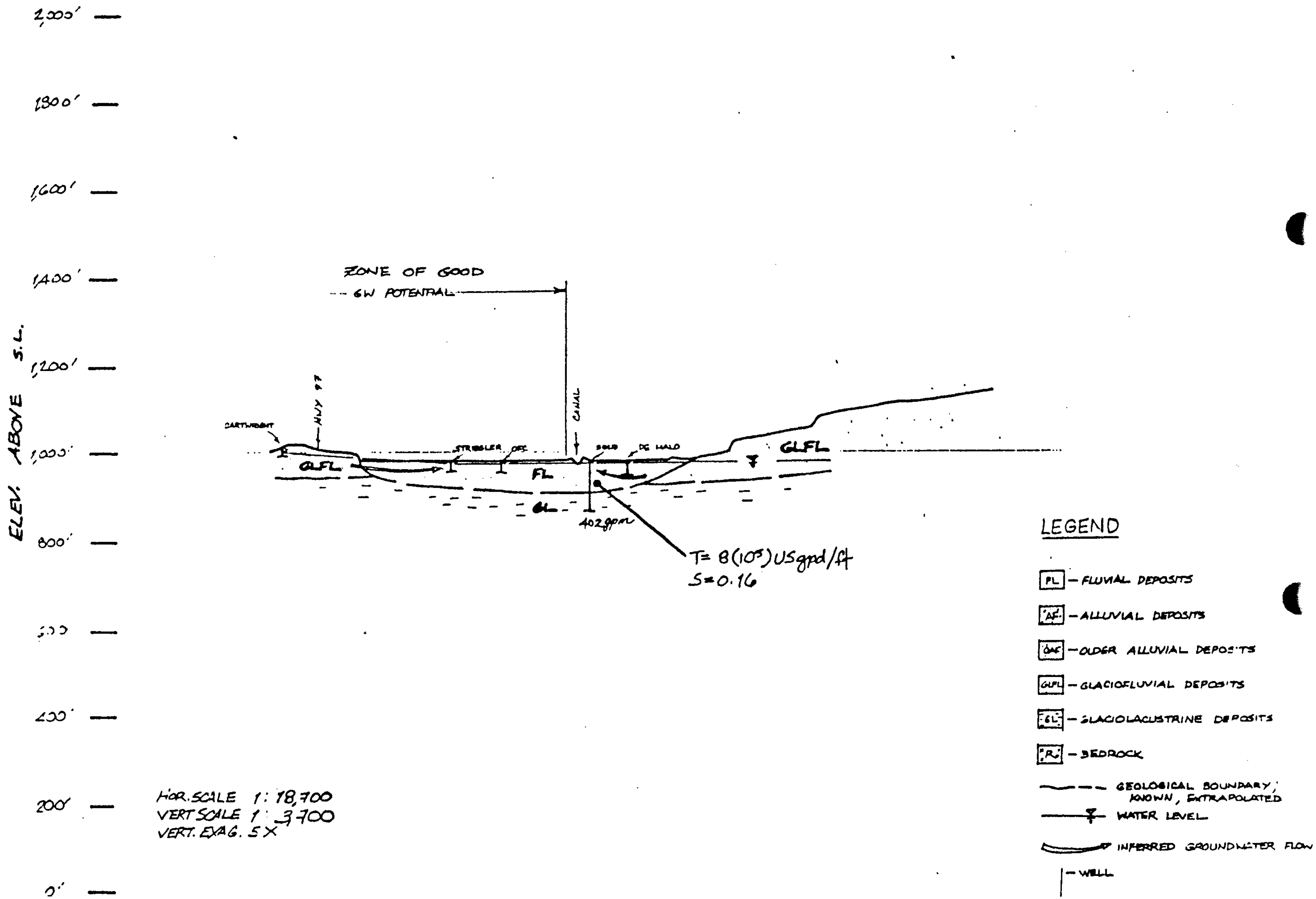


FIGURE 10

INTERPRETATION OF HYDROGEOLOGY ACROSS $X_5 - X_5'$

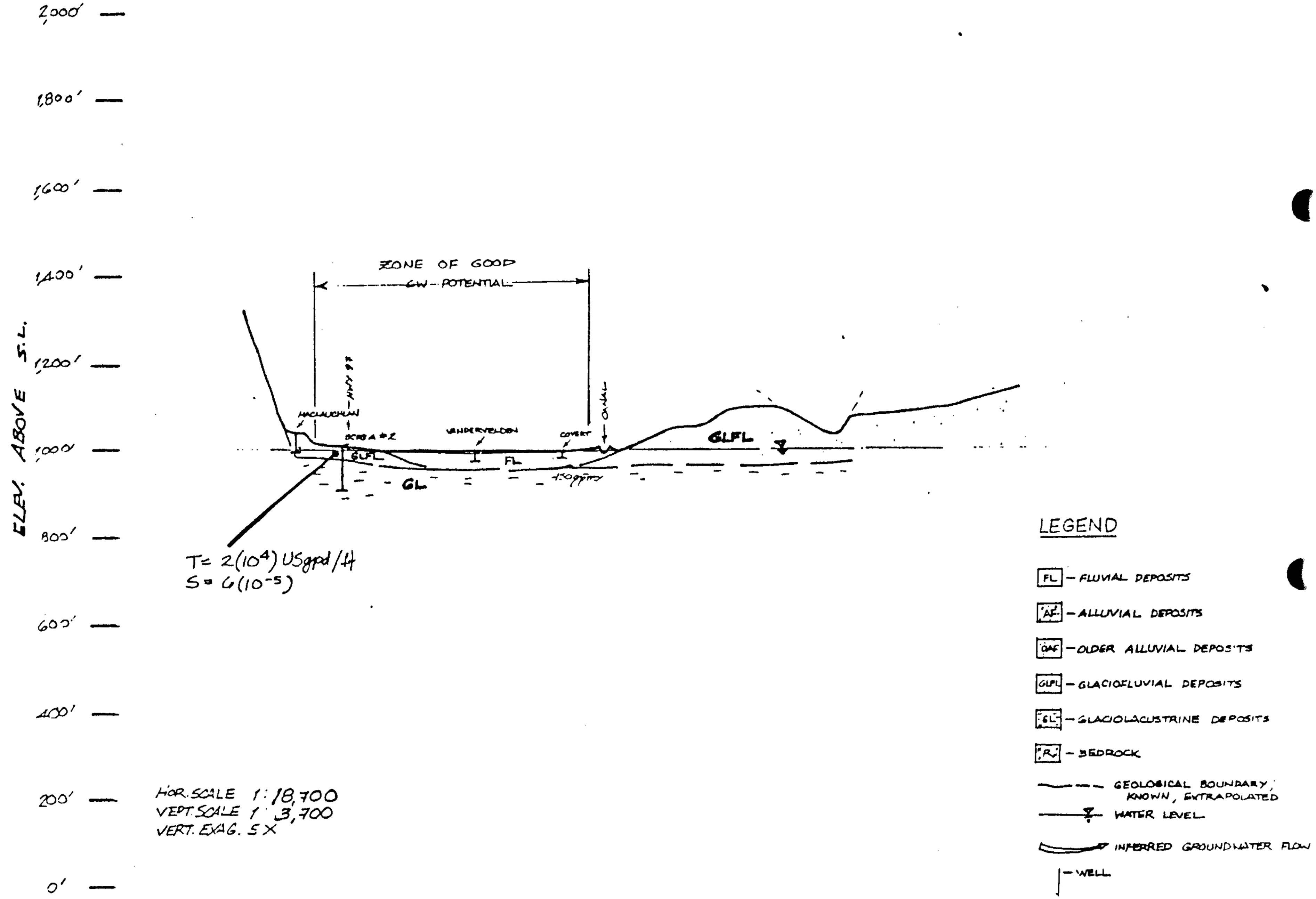
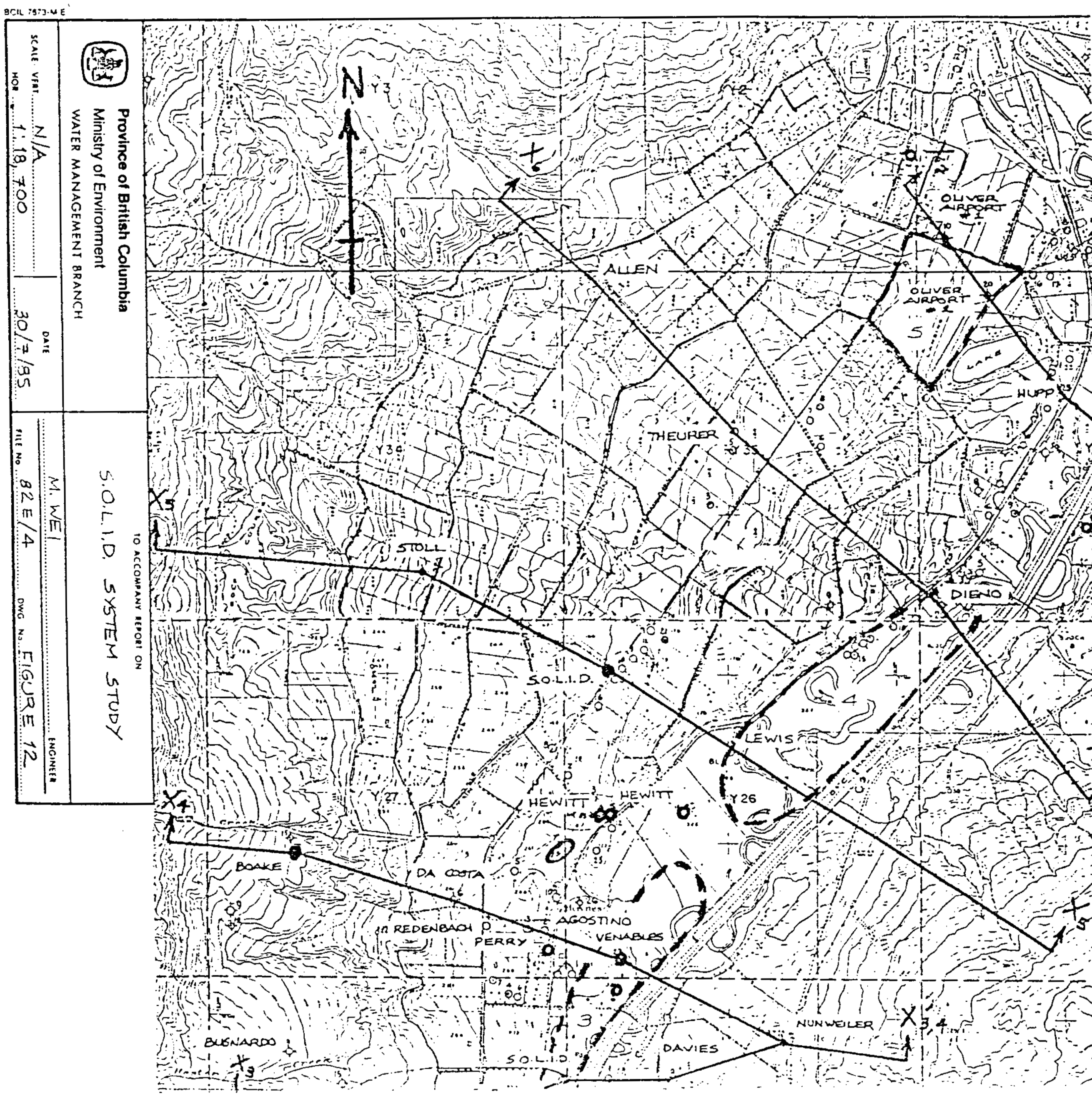


FIGURE 11


BCIL 7573-M E
Province of British Columbia
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TO ACCOMPANY REPORT ON
S.O.L.I.D. SYSTEM STUDY
SCALE VERT. N/A
HOR. 1:18,700
DATE 30/7/85
ENGINEER M. WEI
FILE No. 82E/4
DWG. No. FIGURE 12
N
ALLEN
OLIVER AIRPORT #1
OLIVER AIRPORT #2
LAKE
HUPP
THEURER
STOLL
DIENO
S.O.L.I.D.
LEWIS
HEWITT
HEWITT
BOAKE
DA COSTA
AGOSTINO
REDENBACH
PERRY
VENABLES
NUNWEILER
BUGNARDO
S.O.L.I.D
DAVIES

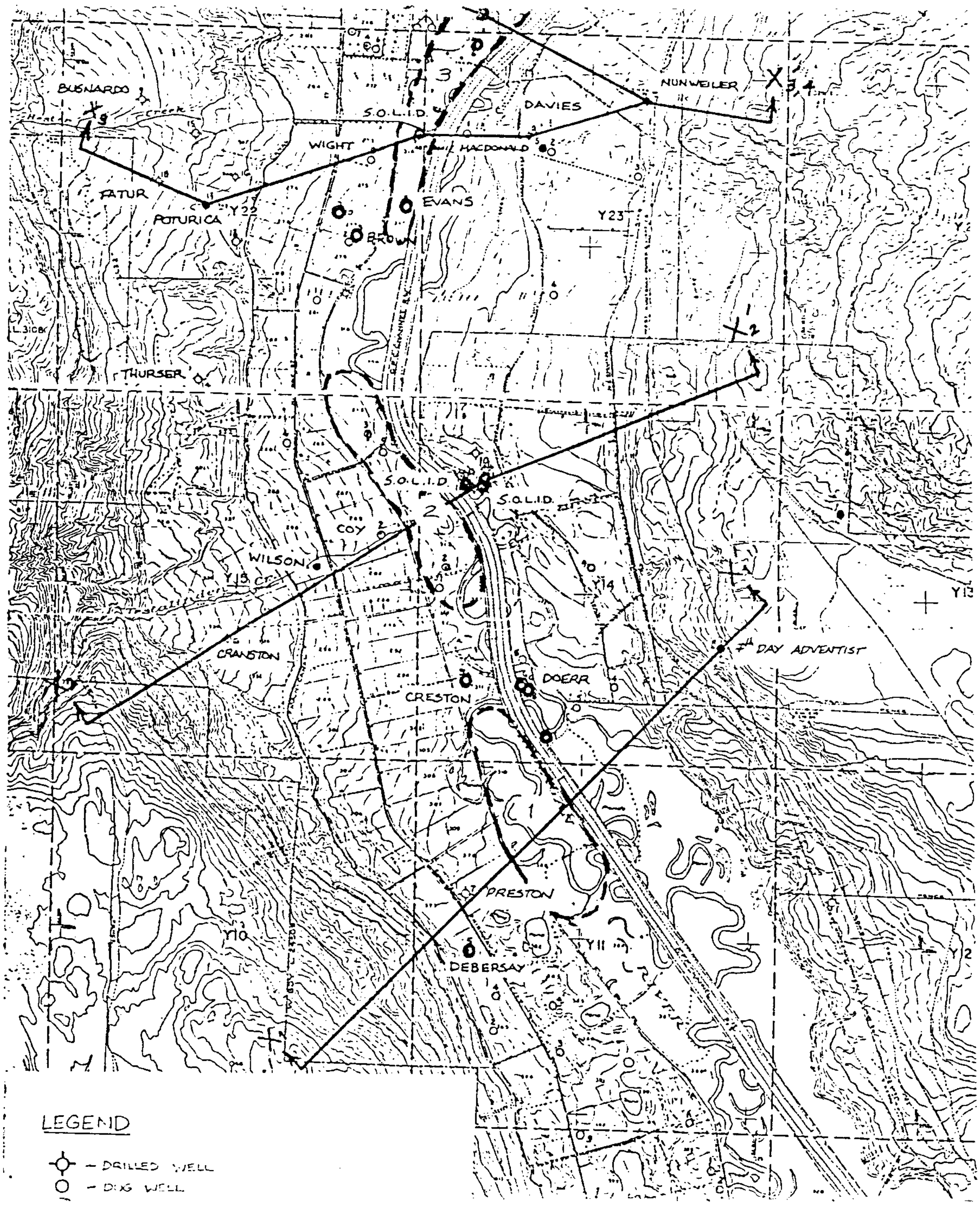
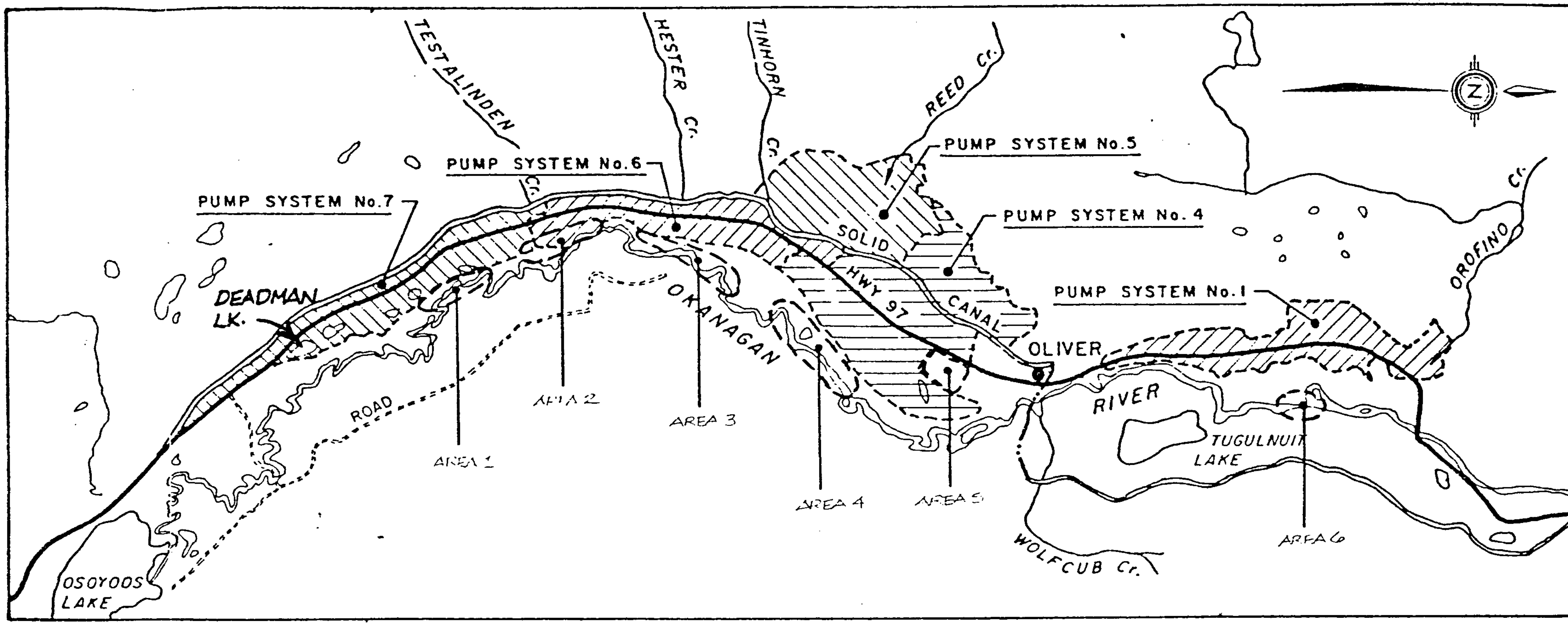

BUSNARDO
FATUR
POTURICA
Y22
WIGHT
S.O.L.I.D.
MACDONALD
DAVIES
NUNWEILER
EVANS
BROWN
Y23
THURSER
S.O.L.I.D.
S.O.L.I.D.
COY
WILSON
Y13
CRANSTON
CRESTON
DOERR
7th DAY ADVENTIST
Y14
PRESTON
DEBERSAY
Y10
Y11
LEGEND
DRILLED WELL
DUG WELL

TABLE 2 - SUMMARY OF REPORTED WELL WATER CHEMISTRY DATA

WELL COORD. Z	X	Y	NO.	OWNER	FIELD ANAL.	LAB ANAL.	SPEC. COND. (umhos/cm)	pH	TDS (mg/l)	HD. (mg/l)	Ca^{+2} (mg/l)	Mg^{+2} (mg/l)	$Na^{+1}+K^{+1}$ (mg/l)	Cl^{-1} (mg/l)	SO_4^{-2} (mg/l)	HCO_3^{-1} (mg/l)	Fe (mg/l)	SAR	RI	
2	8	1	2	JANSSEN						V. HARD										
2	8	11	5	M. DEBERSAY	✓			7.5		>1,000							0.6			
2	8	14	2	F. KEMPF	✓			6.9		374							0.6			
2	8	14	3	E.B. CRESTON						HARD							HIGH			
2	8	14	11	S.O.L.I.D.	✓	✓	575	7.8	356	283	59.8	32.3		0.9	75.0	291.6	0.12		7.0	1:
2	8	14	15	S.O.L.I.D.		✓	486	7.2	264	215	61.0	15.1	10.5+3.7	1.7	45.5	225.7	<0.02	0.3	7.8	1.
2	8	15	3	J. COCHET	✓			7.0	238								TR.			
2	8	22	3	A.E. BROWN						V. HARD										
2	8	22	4	W. VITTERMAN	✓			7.2		272							NIL			
2	8.	22	7	E.J.W. TASKER	✓					>200										
2	8	26	4	HEWITT	✓			7.3		289							NIL			
2	8	26	7	S.O.L.I.D.	✓			7.7		340				<12.5			0.3			
2	8	26	15	W ARIC	✓					409?										
2	8	26	17	P.D. TOEWS	✓			7.2		300							NIL			
2	8	26	21	OFC	✓			7.5		442							0.2			
2	8	26	27	R. VENABLES	✓					188										
2	8	27	1	V. BOLENBACK						V. HARD										
2	8	27	8	KELLER	✓			7.1		289							NIL			
2	8	35	5	A. THEURER	✓			8.7									NIL			
2	8	35	8	G. WILLIAMS	✓			7.3		238							NIL			
2	8	36	2	N. BESLER	✓			7.2		289							TR.			
2	8	36	9	J. FISCHER	✓			7.2		340							<0.6			
2	8	36	13	P. VANDENBOSCH	✓			6.8		323							<0.6			
2	8	36	20	OLIVER AIRPORT #2	✓			7.52	181	766							0.9			
3	8	1	2	T. JOHNSON	✓												0.6			
3	8	1	3	KONKE	✓			7.2		340							NIL			
3	8	12	1	McLEAN & FITZPATRICK	✓					255										
3	8	12	2	McLEAN & FITZPATRICK	✓			7.1		238							NIL			
3	8	12	3	PETERMAN	✓			7.8		374							<0.6			
3	8	12	5	NAUMAN	✓			7.1		187							NIL			
3	8	12	7	W. KOOT. POWER.						V. HARD										
3	8	12	12	J.P. HARRISON	✓			7.2		204							NIL			
3	8	12	23	F. CONNIFF	✓			7.5		221							NIL			

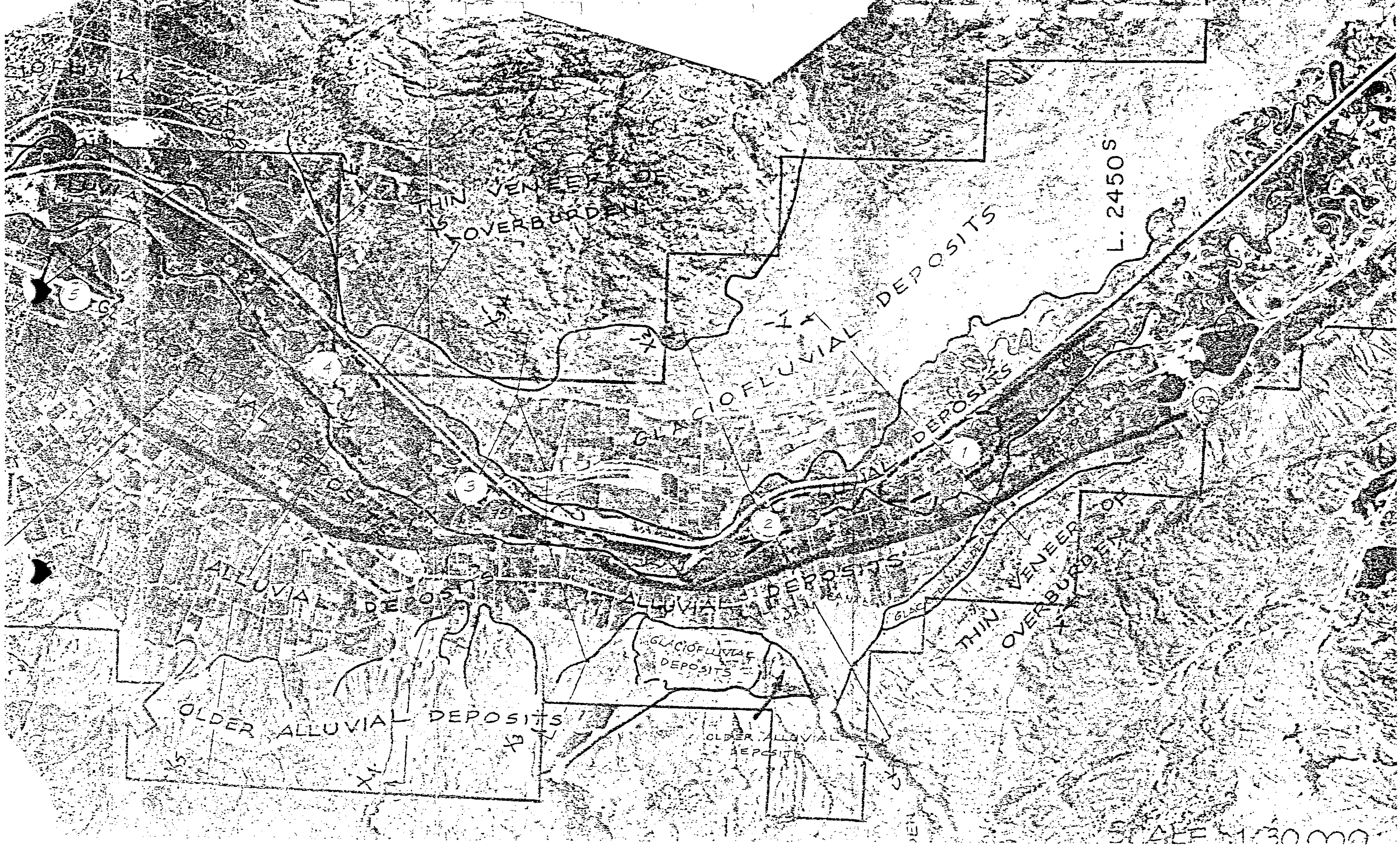
2	8	27	1	V. BOLENBACK						V. HARD										
2	8	27	8	KELLER	✓			7.1		289							NIL			
2	8	35	5	A. THEURER	✓			8.7									NIL			
2	8	35	8	G. WILLIAMS	✓			7.3		238							NIL			
2	8	36	2	N. BESLER	✓			7.2		289							TR.			
2	8	36	9	J. FISCHER	✓			7.2		340							<0.6			
2	8	36	13	P. VANDENBOSCH	✓			6.8		323							<0.6			
2	8	36	20	OLIVER AIRPORT #2	✓			7.52	181	766							0.9			
3	8	1	2	T. JOHNSON	✓												0.6			
3	8	1	3	KONKE	✓			7.2		340							NIL			
3	8	12	1	McLEAN & FITZPATRICK	✓					255										
3	8	12	2	McLEAN & FITZPATRICK	✓			7.1		238							NIL			
3	8	12	3	PETERMAN	✓			7.8		374							<0.6			
3	8	12	5	NAUMAN	✓			7.1		187							NIL			
3	8	12	7	W. KOOT. POWER.						V. HARD										
3	8	12	12	J. P. HARRISON	✓			7.2		204							NIL			
3	8	12	23	F. CONNIFF	✓			7.5		221							NIL			
3	8	12	28	R. SACHS	✓					374							NIL			
3	8	12	34	WIGGINS	✓			7.87		289							—			
3	8	12	35	L. A. PINSKE	✓			7.9		289							NIL			
3	8	13	4	SEIDEL	✓			7.0		170							NIL			
3	8	13	6	J. LITTLE													✓			
3	8	13	9	J. SZALAY	✓			7.0		136							<0.6			
3	8	13	12	J. GIESBRECHT	✓			8.2		136							NIL			
3	8	13	16	R. PRZYBILLA	✓			7.9		204							NIL			
3	8	13	24	W. G. KARRAN	✓			7.5		204							NIL			
3	8	13	48	J. NITSCH													8.26			
3	8	14	2	R.E. SODERBERG	✓			7.2		340							NIL			
3	8	23	10	OGSTON	✓			7.3		265							NIL			
3	8	23	18	BCFGA # 1		✓	602	7.8	286	279	66.5	27.4	25.9+33	3.3	78.0	301	5.0	0.62	6.9	12.
3	8	23	19	BCFGA # 2	✓	✓	621	7.7	378	320	79.0	29.7	14.5+3.3	3.6	23.3	323	0.5	0.35	6.6	127
3	8	23	20	BCFGA # 3	✓	✓	630	5.5-6.0	396	289	70.0	27.2	12.3+0.09	3.5	80.4	1,981	0.2	0.7		
3	8	24	9	SCOTT	✓			7.1		425							3			
3	8	24	20	C.C. THOMAS	✓			7.1		119							70.6			
3	8	24	23	P. VANDERVELDEN	✓			6.8		119							0.6			
3	8	24	27	R. EDWARDS	✓			8.1		119							NIL			
3	8	24	51	P. DUMORET													✓			

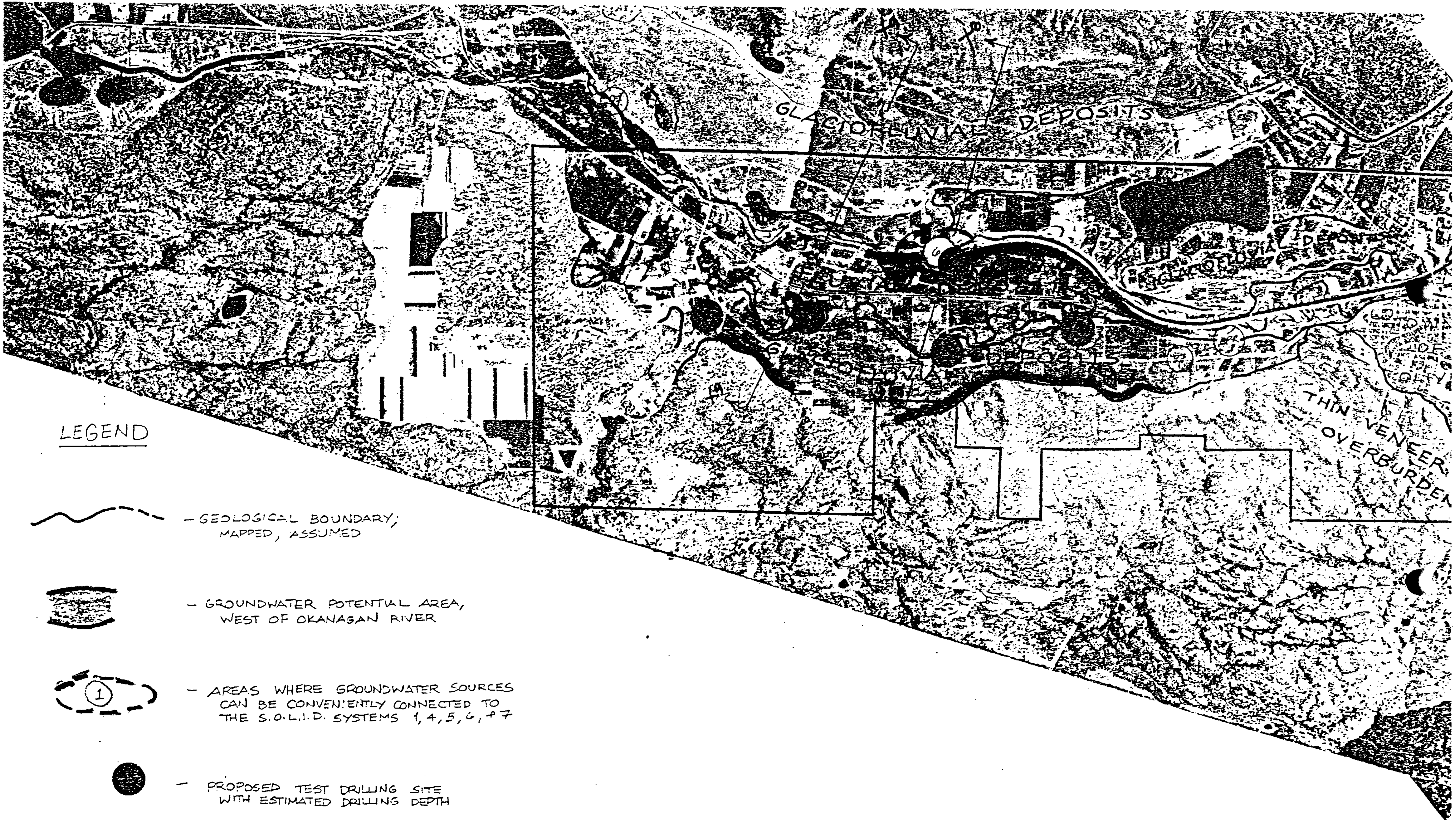
LOCATIONS OF THE S.O.L.I.D. SYSTEMS



Province of British Columbia Ministry of Environment WATER MANAGEMENT BRANCH	TO ACCOMPANY REPORT ON S.O.L.I.D. SYSTEM STUDY	SCALE: VERT. N/A HOR. 1:73,000	DATE 29/7/85
		M. WEI ENGINE	
		FILE No. 82E/4	DWG No. FIGURE 1

VANCAL-10283


THIN VENEER OF OVERBURDEN
GLACIOFLUVIAL DEPOSITS
L. 2450S
ALLUVIAL DEPOSITS
ALLUVIAL DEPOSITS
GLACIOFLUVIAL DEPOSITS
OLDER ALLUVIAL DEPOSITS
OLDER ALLUVIAL DEPOSITS
THIN VENEER OF OVERBURDEN
1
2
3
4
5
9



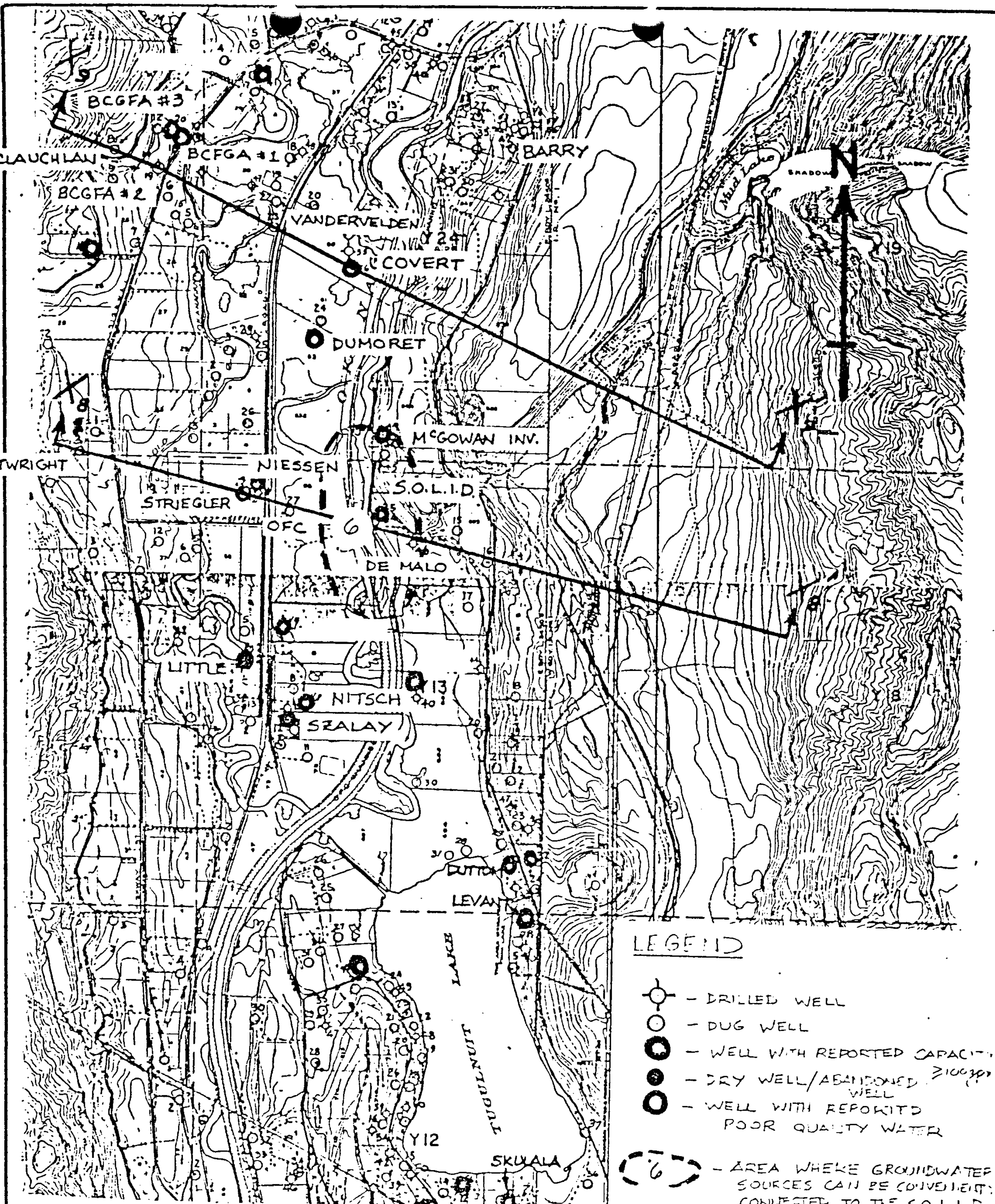
LEGEND

– GEOLOGICAL BOUNDARY; MAPPED, ASSUMED

– GROUNDWATER POTENTIAL AREA, WEST OF OKANAGAN RIVER

– AREAS WHERE GROUNDWATER SOURCES CAN BE CONVENIENTLY CONNECTED TO THE S.O.L.I.D. SYSTEMS 1, 4, 5, 6, & 7

– PROPOSED TEST DRILLING SITE WITH ESTIMATED DRILLING DEPTH



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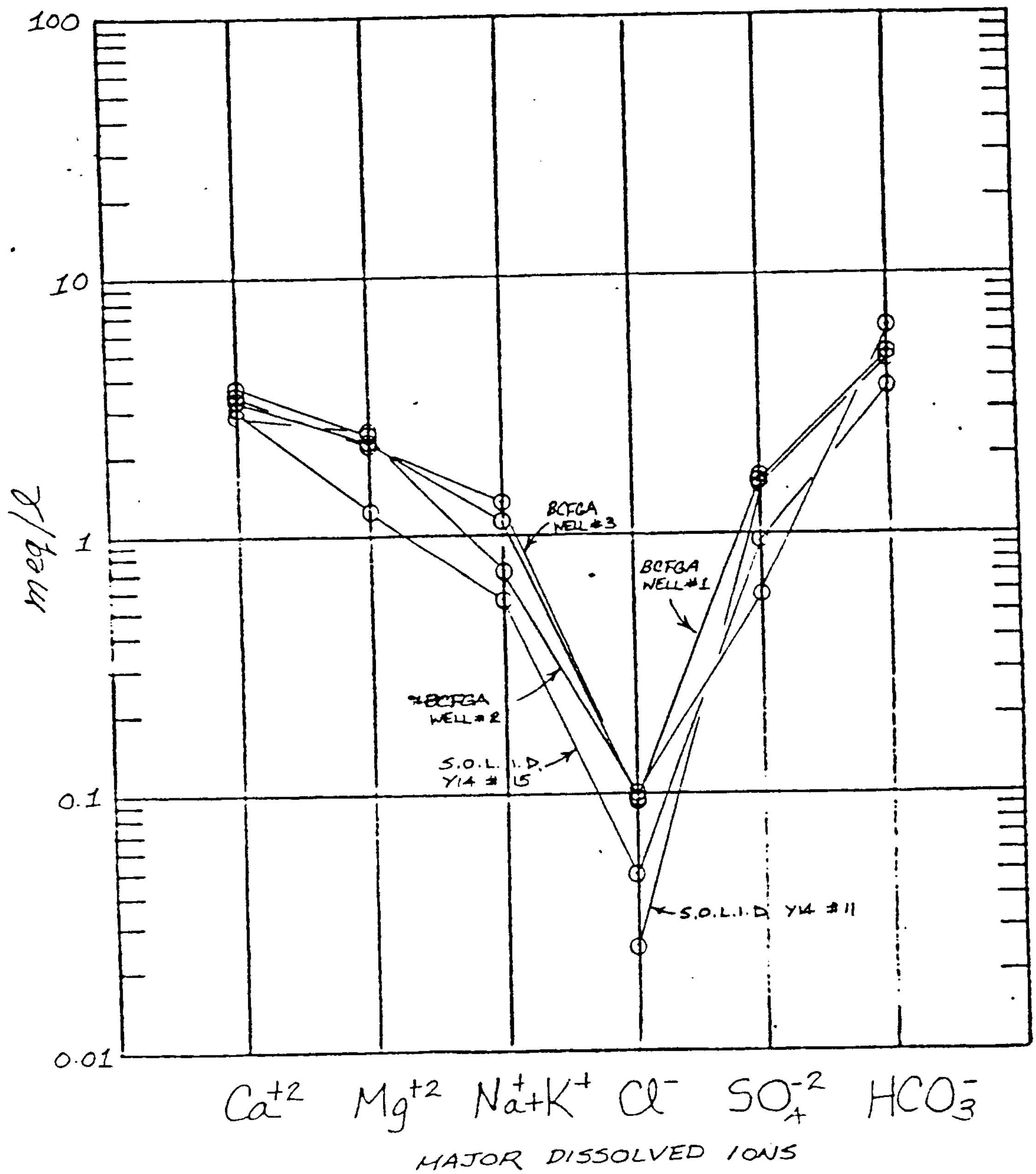
TO ACCOMPANY REPORT ON

S.O.L.I.D. SYSTEM STUDY

SCALE VERT. N/A	DATE	M. WEI ENGINEER
HOR. 1:18,700	30/7/85	FILE No. 83 E/4 FIGURE 13

GENERAL WATER CHEMISTRY REPRESENTED ON SCHOELLER DIAGRAM



Province of British Columbia
Ministry of Environment
WATER MANAGEMENT BRANCH

TO ACCOMPANY REPORT ON

S.O.L.I.D. SYSTEM STUDY

SCALE VERT. N/A	DATE	M. WEI ENGINEER
N/A	30/7/85	FILE No. 82E/4 DWG No. FIGURE 14

TABLE 1 – WELL LOG SUMMARY OF REPORTED MODERATE→HIGH CAPACITY WELLS

WELL COORD Z	X	Y	No.	OWNER	Φ (in)	DEPTH (ft)	SCRN ASSEMB. LOCATION (ft)	AQ.	SWL (ft)	Av.D.D. (ft)	Q (gpm)	TIME (hrs)	D.D. (ft)	% D.D.	SC (gpm/ft)	T (gpd/ft)	S	CAP. (gpm)
2	8	14	11	S.O.L.I.D.	2	109	74.75 → 84.75	S+G	6	68.8	200	24	20.4	29.7	9.8			
2	8	14	12	S.O.L.I.D.	16	50	29? → 49	GLFL	8	21	1200		2.7?	12.9?	445	4.2(10^5)	0.2	
2	8	14	15	S.O.L.I.D.	12	48	30 → 47		8	22	795		4.4?	20.0?	181	5(10^5)	0.12	
2	8	14	18	L. DOERS	8	25	15.33 → 24.5	G										800
2	8	14	19	L. DOERR	36	30		G	22		80		4		20			700
2	8	14	20	L. DOERR	8	40	33 → 39.5	G	7.21	25.8	90		7.02	27.2	12.8			200
2	8	22	8	D. EVANS		16		S+G	5		160	5?	4		40			
2	8	22	10	P. FALKENHOLT		50		G	42		100							
2	8	23	6	L. TANNER		18		G	5		143	??	6		24			
2	8	26	4	HEWITT	1¼	22.5		G	2		100+		2		50			500
2	8	26	5	HEWITT														700
2	8	26	7	S.O.L.I.D.	8	140	88 → 112	S+G	29.90	58.1	425	60	9.10	15.7	46.7	5.3(10^5)	0.75?	
2	8	26	25	E. HINTZ	36	18		S+G	6		120		2		60			200
2	8	26	27	R. VENABLES	6	34	16.83 → 26	S+G	2	14.8	100	3	7.04	47.6	14.2			
2	8	27	7	HAYNES CO-OP		20?												300
2	8	27	11	E. BOAKE	8	538	527 → 537	S+G	326	192	90	24	60	31.3	1.5			150
2	8	36	28	M. DUTRA	6	35	11 → 14	G	4	7	120	2.5	4.25	60.7	28.2			130
3	8	1	20	VILL. OF OLIVER	36	24		G	7		200		1		200			500
3	8	1	24	VILL. OF OLIVER	12				8.08						114.5			1,000
3	8	1	26	VILL. OF OLIVER	12	35	24 → 35	S+G	8	[illegible]	636?	6	5?	31?	127?			1,000
3	8	1	27	VILL. OF OLIVER	6	49	27 → 35	S+G	7.21	19.8	192	3	1.8	9.1	106.7			
3	8	1	30	S. TYPUSIAK	36	16		G	6		100		4		25			
3	8	2	1	J. WALKER		16		G	6		167							
3	8	12	41	J. KNODEL		14		G+CL	5		154		—		HIGH			
3	8	12	44	N. WHEELER	36	26		S+G	17		100		1		100			250
3	8	12	51	S.O.L.I.D.		52		GLFL	11									700
3	8	12	56	F. SKUKALE	6	49	39.5 → 48	S+G	8.17	31.3	100	2	9.75	31.2	10.3			
3	8	12	57	F. SKUKALA	6	86	71.83 → 85.77	S+G	9	62.2	100	3	0.25	0.4	400			200
3	8	12	58	LEVANT	6	40	34 → 39	G	14	20	100	3	0.29	1.5	345			100
3	8	12	62	B. WIENS	6	21	15 → 19.5	S+G	2.5	12.5	100	1.5	3.5	28	28.6			200

2	8	27	11	E. BOAKE	8	538	527→537	S+G	326	1.92	90	24	60	31.3	1.5			150
2	8	36	28	M. DUTRA	6	35	11→14	G	4	7	120	2.5	4.25	60.7	28.2			130
3	8	1	20	VILL. OF OLIVER	36	24		G	7		200		1		200			500
3	8	1	24	VILL. OF OLIVER	12				8.08						114.5			1,000
3	8	1	26	VILL. OF OLIVER	12	35	24→35	S+G	8	10	630	6	5?	31?	127?			1,000
3	8	1	27	VILL. OF OLIVER	6	49	27→35	S+G	7.21	19.8	192	3	1.8	9.1	106.7			
3	8	1	30	S. TYPUSIAK	36	16		G	6		100		4		25			
3	8	2	1	J. WALKER		16		G	6		167							
3	8	12	41	J. KNODEL		14		G+CL	5		154		—		HIGH			
3	8	12	44	N. WHEELER	36	26		S+G	17		400		1		100			250
3	8	12	51	S.O.L.I.D.		52		GLFL	11									700
3	8	12	56	F. SKUKALE	6	49	39.5→48	S+G	8.17	31.3	100	2	9.75	31.2	10.3			
3	8	12	57	F. SKUKALA	6	26	71.83→75.77	S+G	9	62.2	100	3	0.25	0.4	400			200
3	8	12	58	LEVANT	6	40	34→39	G	14	20	100	3	0.27	1.5	345			100
3	8	12	62	B. WIENS	6	21	15→19.5	S+G	2.5	12.5	100	1.5	3.5	28	28.6			200
3	8	13	34	S.O.L.I.D.	8	144	57→72.4	S+G	6.73	50.3	402	24	6.48	129	62	$8.4(10^5)$	0.16?	
3	8	13	37	A. TRENIAR	6	112	41.5→46		19.4	22.1	100	2.5						
3	8	13	38	K. DUTTOM	6	42	30→34?	S+G	15	15	75	2	0.4	2.8	1875			100
3	8	13	42	L. STRIEGLER	6	23	15.58→20.25	S+G	5.75	4.8	80	3	2.75	28.1	29.1			100
3	8	13	50	G.E. NIESSEN	6	24	17.3→22	S+G	4.9	12.4	100	3	3.6?	29.0?	27.8?			100
3	8	23	16	M. PHELPS		25		G	20									500
3	8	23	18	BCFGA #1	8	110	60→71	S+G	7	46	400	24	345	75	11.2	$1.3(10^4)$		370
3	8	23	20	BCFGA #3	8	73	59→69	S+G	6.33	36.9	730	24	21.9	59.3	33.3	$2.6(10^4)$	$5.7(10^5)$	1,228
3	8	24	36	B. COVERT	36	18		G	5		150	1						
3	8	24	41	L. SCHONBERGER	36	14		S+G	6		100		2		50			100
3	8	24	49	McGOWAN INVEST.	48	28			8		100-120	9/6	8-9		≥11			

TABLE 3 – DRILLING COST ESTIMATES. – AUG. 1985

ITEM	UNIT COST	8″ϕ 75′	8″ϕ 100′	8″ϕ 125′	8″ϕ 150′	12″ϕ 75′	12″ϕ 100′	12″ϕ 125′	12″ϕ 150′	16″ϕ 75′	16″ϕ 100′	16″ϕ 125′	16″ϕ 150′
1. MOB. & DEMOB.	$3,000												
2. MOVE BTWN SITES	$200	200	200	200	200	200	200	200	200	200	200	200	200
3. 8″ϕ CASED DRILLING	$32/ft	1,920	2,720	3,520	4,320								
4. 12″ϕ CASED DRILLING	$53/ft.	795	795	795	795	3,180	4,505	5,830	7,155				
5. 16″ϕ CASED DRILLING	$70/ft					1,050	1,050	1,050	1,050	4,200	5,950	7,700	9,450
6. 20″ϕ CASED DRILLING	$85/ft.									1,275	1,275	1,275	1,275
7. 8″ϕ OVERLAP CASING	$16/ft.	240	240	240	240								
8. 12″ϕ OVERLAP CASING	$34/ft.					510	510	510	510				
9. 16″ϕ OVERLAP CASING	$50/ft.									750	750	750	750
10. 8″ϕ DRIVE SHOE	$225	225	225	225	225								
11. 12″ϕ DRIVE SHOE	$500					500	500	500	500				
12. 16″ϕ DRIVE SHOE	$1,200									1,200	1,200	1,200	1,200
13. HOURLY WORK	$100/hr.	800	800	800	800	800	800	800	800	800	800	800	800
14. STANDBY	$50/hr.	400	400	400	400	400	400	400	400	400	400	400	400
15. WELL CAP	$50	50	50	50	50	50	50	50	50	50	50	50	50
16. 8″ϕ CASING REBATE	–$5/ft.	–40	–40	–40	–40								
17. 12″ϕ CASING REBATE	–$12/ft.	–180	–180	–180	–180	–120	–120	–120	–120				
18. 16″ϕ CASING REBATE	–$18/ft.					–270	–270	–270	–270	–180	–180	–180	–180
19. 20″ϕ CASING REBATE	–$21/ft.									–315	–315	–315	–315
20. SCREENS & FITTINGS	VARIES	1,300	1,300	1,300	1,300	2,200	2,200	2,200	2,200	4,200	4,200	4,200	4,200
SUBTOTAL – ITEMS 2 → 20		5,710	6,510	7,310	8,110	8,500	9,825	11,150	12,475	12,580	14,330	16,080	17,83
21. MOB & DEMOB PUMP EQUIP.	$1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
22. INSTALL & REMOVE PUMP	$800→1,000	800	800	800	800	800	800	800	800	1,000	1,000	1,000	1,000
23. HOURLY PUMPING	$70→100/hr.	1680	1,680	1,680	1,680	1,680	1,680	1,680	1,680	2,400	2,400	2,400	2,40
24. HOURLY RECOVERY	$40/hr.	80	80	80	80	80	80	80	80	80	80	80	80
25. RENT OF DISCH. PIPE	$1/ft	500	500	500	500	500	500	500	500	500	500	500	500
SUBTOTAL – ITEMS 2 → 25		9,770	10,570	11,370	12,170	12,560	13,885	15,210	16,535	17,560	19,310	21,060	22,81

TEST DRILLING : 16 8″ϕ WELLS 3(75′) + 7(100′) + 4(125′) + 2(150′)

[$9,000 (MOB & DEMOB) + $29,310 + $73,990 + $45,480 + $24,340] × 1.15 = $209,438

(1.15 ← 15% CONTINGENCIES)

14. STANDBY	$50/hr.	400	400	400	400	400	400	400	400	400	400	400	400
15. WELL CAP	$50	50	50	50	50	50	50	50	50	50	50	50	50
16. 8"ϕ CASING REBATE	−$5/ft.	−40	−40	−40	−40								
17. 12"ϕ CASING REBATE	−$12/ft.	−180	−180	−180	−180	−120	−120	−120	−120				
18. 16"ϕ CASING REBATE	−$18/ft.					−270	−270	−270	−270	−180	−180	−180	−180
19. 20"ϕ CASING REBATE	−$21/ft.									−315	−315	−315	−315
20. SCREENS + FITTINGS	VARIES	1,300	1,300	1,300	1,300	2,200	2,200	2,200	2,200	4,200	4,200	4,200	4,200
SUBTOTAL — ITEMS 2 → 20		5,710	6,510	7,310	8,110	8,500	9,825	11,150	12,475	12,590	14,330	16,080	17,830
21. MOB + DEMOB PUMP EQUIP.	$1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
22. INSTALL + REMOVE PUMP	$800 → 1,000	800	800	800	800	800	800	800	800	1,000	1,000	1,000	1,000
23. HOURLY PUMPING	$70 → 100/hr.	1680	1,680	1,680	1,680	1,680	1,680	1,680	1,680	2,400	2,400	2,400	2,400
24. HOURLY RECOVERY	$40/hr.	80	80	80	80	80	80	80	80	80	80	80	80
25. RENT OF DISCH. PIPE	$1/ft	500	500	500	500	500	500	500	500	500	500	500	500
SUBTOTAL — ITEMS 2 → 25		9,770	10,570	11,370	12,170	12,560	13,885	15,210	16,535	17,560	19,310	21,060	22,810

TEST DRILLING: 16 8"ϕ WELLS 3(75') + 7(100') + 4(125') + 2(150')

[$9,000 (MOB + DEMOB) + $29,310 + $73,990 + $45,480 + $24,310] × 1.15 = $209,439 (15% CONTINGENCIES)

PRODUCTION WELL DRILLING: 15 12"ϕ WELLS + 15 16"ϕ WELL FOR EXAMPLE, AVE 125'

[$9,000 + $228,150 + $315,900] × 1.15 = $636,008