WTN 82388 - Production Well - 82E032224
WTN 82389 - Test Hole #1 - 82E032224
Vernon - Kamloops

Kala Groundwater Consulting Ltd.

Water Supply and Environmental Assessments

PRIVILEGED AND CONFIDENTIAL INFORMATION

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REPORT OF FINDINGS

DOMINION RADIO ASTROPHYSICAL OBSERVATORY GROUNDWATER DEVELOPMENT PROGRAM CONSTRUCTION OF 8-INCH PRODUCTION WELL

Prepared for:
The National Research Council of Canada

Attn: Bruce Veidt

Report Prepared by:
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Distribution: 2 Copies ***National Research Council***
1 Copy ***Kala Files***

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1.0 INTRODUCTION

The present program of water well construction and testing has been carried out at the request of the National Research Council of Canada (***NRC***) to develop an 8-inch production well for ***NRC***'s Dominion Radio Astrophysical Observatory (***DRAO***) site, located along White Lake Road, near Penticton, B.C. (see Figure 1). The new well will be used to augment the existing water supply obtained from a large diameter dug well. Verbal confirmation to proceed with the well completion program was provided during the latter part of January, 2001, by Mr. Bruce Veidt, of the National Research Council.

The existing source of water supply at the Observatory is obtained from a large diameter dug well completed to a depth of 4.64 metres (15.2 metres) below ground level. The well has been used for both potable and irrigation water during past years. Based on a pumping test program conducted under the supervision of Kala Groundwater Consulting Ltd. (***Kala***) in November, 2000, a safe yield projection for this well was 75 USgpm. Because of the shallow nature of the source however, some concerns have been expressed regarding water quality and also, the reliability of the source during warm dry periods. The present groundwater development program has been carried out based to a large extent on recommendations contained in ***Kala***'s water supply evalution report dated December 4, 2000.

Following the completion of an unsuccessful testhole, the present program involved the drilling of an 8-inch (203 mm) diameter production well, at the second test drilling site. The new well is completed with 10 feet (3.0 metres) of 8-inch telescopic well screen, set opposite an aquifer comprised of medium to coarse grained sand with some gravel. Upon completion of the well, a 24-hour pumping test was conducted and water samples collected for a chemical and bacteriological analysis. 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 conditions is provided. Detailed information including water quality, the driller's litholog, sieve analysis and pump test data is attached to the Appendices of this report.

2.0 BACKGROUND

2.1 Site Description

The Observatory site is located along White Lake Road approximately 5 kilometers southwest of Okanagan Falls. Access cannot be gained directly to the site from Okanagan Falls because of the mountainous upland area, including Mount McLellan and Mount Hawthorne, which separates the Okanagan and White Lake valley systems.

With respect to topographic expression the site is situated on a bench area which occurs at an average elevation of 570 metres AMSL. The bench level has been formed by glacial outwash and extends from the upland area to the east, in a southwest direction towards White Lake. Drainage is provided by Keains Creek which flow from north to south near the access gate and then eastward along the south perimeter of the property. There is at least one tributary channel to Keains Creek which is located east of the building complex. Along the main drainage course of Keains Creek, the surface gradient slopes towards the creek. Beyond the site, Keains Creek continues its drainage course a considerable distance south and east towards Mahoney Lake.

Based on a surficial geology map (see Figure 2), the unconsolidated deposits overlying bedrock at the site are comprised of glacial-fluvial material formed by outwash from receding glacial ice masses. This type of material is generally comprised of sand and gravel with varying amounts of silt. The depth of these deposits at the site is unknown but some of the former geotechnical boreholes at the Observatory have been drilled to a depth of 48 feet (14.6 metres) without encountering bedrock.

2.2 Description of Existing Well

The existing well is a large diameter dug well completed to a depth of 4.64 metres (15.2 metres) below ground level. The well is constructed with 1.2-metre diameter cement culvert and very likely a gravel envelop has been placed around the outside of the cement cribbing. It is covered with a cement lid and access is gained through a steel manhole cover. The well is used for both potable and irrigation water at the Observatory. Previous bacteriological tests show that the water is acceptable with respect to coliform counts.

A pumphouse facility, which houses a centrifugal lift pump and a large storage tank (1000 Imperial gallons plus) has been constructed immediately north of the well. Water is fed to the building complexes and irrigation system from the storage tank, which is pressurized.

3.0 DESCRIPTION OF PRESENT PROGRAM

3.1 Drilling and Well Completion

Based on competitive price and availability, Robbins Water Well Drilling of Okanagan Falls, B.C. was selected for the drilling project. All of the drilling was conducted with a cable tool drilling rig, using 8-inch casing. With this type of drilling equipment, the casing is advanced as drilling proceeds, and the nature of the subsurface material is determined by examining drill cuttings lifted to surface with a bailer.

During the exploratory program it required the drilling of two testholes before favourable conditions, suitable for the completion of a production well, were encountered. At the site of Testhole No. 1, drilled northwest of the existing pumphouse facility (see Figure 3 for testhole locations), the majority of the subsurface material encountered consisted of fine silty sand, which was too fine for the installation of a well screen and proper development of a well. At the second site, a water-bearing zone comprised of medium to coarse sand and gravel was encountered and a production well completed. After installing a well screen assembly, designed on the basis of sieve analyses, the casing was pulled back to expose the screens and the well was development by surging and pumping the fines to waste.

3.2 Aquifer Testing

In order to evaluate the safe yield of the new well, a 24-hour pumping test was conducted starting on March 24th, 2001. Pump testing services were provided by Robbins Water Well Drilling, working under the supervision of ***Kala***.

During the test, water pumped from the new 8-inch test well was conveyed through solid 4-inch PVC pipe and discharged to waste onto sloping terrain, which conducted the flow of water southward from the site. The discharge rate was monitored using a conventional circular orifice meter and water levels in the production well were measured with an electric well sounder. Near the end of the pumping interval, water samples were obtained and forwarded to Caro Environmental Services for a water quality analysis. Upon cessation of pumping, recovery was measured in the production well for a two-hour period.

4.0 PROGRAM FINDINGS

4.1 Drilling

4.1.1 Testhole No. 1

As noted in the previous section, it required the drilling of two testholes before favourable conditions, suitable for the completion of a production well, were encountered. At the site of Testhole No. 1, the majority of the subsurface material consisted of fine silty sand, which was too fine for the installation of a well screen and proper development of a well. A summary of the basic hydrogeologic units encountered in TH#1 is as follows:

Table 1 – Testhole No. 1 – Lithologic Summary

Depth Interval	Lithologic Description
0 to 21 feet	Medium to coarse grained sand with gravel
21 to 96 feet	Fine silty sand
96 to 139 feet	Grey clay
139 to 142 feet	Bedrock, siltstone

During the drilling of TH#1, the 8-inch casing was driven to a total depth of 139 feet. Upon completion of the unsuccessful testhole, the contractor made an attempt to pull the casing but because of wet ground conditions around the site, it proved impossible at the time. The casing has been capped and left in place, with future plans to return and pull the casing when ground conditions are more suitable.

4.1.2 Testhole No. 2

At the second location, conditions were favourable for the completion of a production well. A summary of the basic hydrogeologic units encountered in TH#2 is shown in Table 2.

Table 2 – Testhole No. 2 – Lithologic Summary

Depth Interval	Lithologic Description
0 to 20 feet	Medium to coarse grained sand and gravel
20 to 76 feet	Fine brown sand
76 to 89 feet	Medium to coarse sand with some angular gravel, water-bearing
89 to 90 feet	Grey clay

4.2 Well Completion

Following completion of the exploratory drilling to the base of the aquifer (89 feet), a production well was completed with 10 feet (3.0 metres) of 8-inch (203 mm) telescopic well screen set from 77.8 to 88.3 feet (23.7 to 26.9 metres) below surface as shown in Figure 4. In addition a 2- foot riser and "Figure K" packer is attached to the top of the well screens, bringing the top of the assembly to 75.8 feet (23.1 metres) below ground level. Based on results of the sieve analyses, the screen slot size selected consists of #30 slot (30 thousandths of an inch openings) set from 77.8 to 83.1 feet and #20 slot set from 83.1 to 88.3 feet below surface. Following installation of the well screen assembly, the well was developed by surging, while pumping the fines to waste until a sand/silt free condition was achieved.

4.3 Results of Pumping Test

Results of the pumping and recovery tests have been plotted on semi-log graphs of drawdown versus time (residual drawdown versus time for recovery) and an interpretation of the aquifer parameters and sustainable yield made on this basis. Detailed pumping test data and plots are included in Appendix B of this report.

While pumping at a constant rate of 245 USgpm, the total drawdown observed in the new 8-inch production well was 22.28 feet (6.79 metres) after 24 hours. This represents only 33.5 percent of the total available drawdown in the well. It was also noted that after 16 minutes of pumping, steady-state conditions were achieved were the pumping rate is balanced by the rate of recharge to the aquifer and no further drawdown is observed.

Following cessation of pumping the 8-inch well recovered to within 99 percent of full recovery in 120 minutes. A determination and discussion of safe sustainable yield for the 8-inch production well is included in Section 5.0 of this report.

4.4 Water Quality

A copy of the certificate of analysis for water quality is attached to the Appendices of this report. Based on the results, the water quality for all parameters tested meets the "*Guidelines for Canadian Drinking Water Quality*" with respect to all health related parameters (MAC). A comparison of water quality for the new well and the existing large diameter dug well is shown in Table 3.

Table 3 – Summary of Water Quality			
Parameter	***New 8-Inch Well***	***Existing Dug Well***	****GCDWQ***
Alkalinity (Total) mg/L as $CaCO_3$	293	292	-
Chloride mg/L	15.5	13.8	250
Coliform (Fecal) colonies/100ml	0	0	0
Coliform (Total) colonies/100ml	0	0	<10
Color (True) Color Units	<5	<5	< 15
Conductivity umhos/cm	636	675	-
Cyanide mg/L	<0.010	<0.010	0.2
Dissolved Solids (Total) mg/L	441	407	500
Fluoride mg/L	1.2	1.2	1.5
Hardness (Total) mg/L as $CaCO_3$	275	274	-
Nitrate mg/L as N	0.09	0.16	10
Nitrite mg/L as N	<0.01	<0.01	1.0
pH	7.4	8.0	6.5-8.5
Sulphate mg/L	69	60	500
Turbidity N.T.U.	170	0.15	1
TOTAL METALS (mg/L)			
Aluminum	3.8	<0.2	-
Arsenic	<0.01	<0.01	0.054
Barium	0.12	0.06	1.0
Boron	<0.1	<0.1	5.0
Cadmium	<0.0002	<0.0002	0.005
Calcium	62.9	64.3	-
Chromium	<0.01	<0.01	0.05
Copper	<0.01	<0.01	< 1
Iron	5.5	<0.03	0.3
Lead	0.004	0.001	0.01
Magnesium	28.6	27.5	-
Manganese	0.190	<0.005	0.05
Mercury	<0.00005	<0.00005	0.001
Molybdenum	<0.03	<0.03	-
Potassium	1.98	1.87	-
Sodium	42.4	36.9	200
Uranium	0.0118	0.0115	0.02
Zinc	0.54	0.007	< 5.0
* Guidelines for Canadian Drinking Water Quality - No limits established at the present time Shaded cells – above AO			

Upon inspection, the two water qualities are very similar with respect to most parameters. The main difference relates to some of the metal concentrations in the new well, including iron, manganese and alluminum, which all exceed the aesthetic objectives (AO). In Kala's opinion the reason for the elevated concentrations of these parameters is the turbidity in water at the time of sampling, which was very high

(170 NTU). It was noted that during the latter stages of the pumping test, the water became a little milky in color. Also in a discussion with Caro Environmental, the sample contained a fair amount of sediment in the bottle, but there was no yellow or brown color, meaning that the high readings for iron and manganese shown in the Certificate of Analysis, are probably miss-leading and not totally accurate, because of the high turbidity in the sample. ***Kala*** suggests that the drilling contractor be contacted and that some further development be conducted with the new well prior to final pump installation.

5.0 *DISCUSSION OF RESULTS*

5.1 Sustainable Safe Yield of 8-Inch Production Well

The long term yield of a production well is dependent upon a number of factors, the most important being the hydraulic properties of the aquifer (transmissivity and storativity), availability of recharge to the aquifer and the number of, distance between and pump rate of other wells in the same aquifer.

The long term yield of the new 8-inch production well at the Dominion Radio Astrophysical Observatory over a 20 year period assuming no interference from other wells and 70 percent consumption of available drawdown may be expressed by the following:

$$\mathbf{Q_{20} = 0.70 \times Sa(Q)/(S_{100} + 5\Delta S)}$$

Where

Q_{20} = 20 year continuous pumping rate

Sa = total available drawdown (66.7 feet)

Q = aquifer test rate (245 USgpm)

S_{100} = drawdown in pumped well at t=100 minutes (22.18 feet)

ΔS = drawdown over one log cycle (0.10 feet)

Applying this formula Q_{20} = 500 USgpm.

This is a theoretical safe yield and other factors must be taken into consideration. For example, it is important to note that the well screen assembly as installed is designed to transmit 200 USgpm at an entrance velocity of 0.1 feet per second, which is recommended. Secondly, during the 24-hour pumping test, while pumping at a constant rate of 245 USgpm, the water became a little milky in color near the latter stages of the test. We do however expect that the milky color will disappear with extended pumping, particularly if the pumping rate does not exceed 200 USgpm.

Finally seasonal fluctuations in the water table must be taken into consideration. During extended dry spells, we can expect a decline in the water table elevation or static water level in the well, which of course will mean a decrease in the safe yield projection. We do not expect that the safe yield will decline below 200 USgpm.

5.2 Pumping Level Projections

In order to aid in pump design and selection, ***Kala*** provides a series of pumping level projections in Table 4 which follows. These projections are all based on continuous pumping for a seven day period.

Table 4 – Projected Pumping Levels		
Pumping Rate (USgpm)	***Drawdown in Well***	***Pumping Level from top of casing***
50	4.6 feet	14.7 feet
100	9.2 feet	19.3 feet
200	18.2 feet	28.3 feet

At the time of preparing this report the top of casing was 1.0 feet above ground level at the site of the new 8-inch production well.

It is currently recommended that a pump setting for the new well be 65 to 70 feet below the top of casing. The pump motor should not extend inside the well screen assembly. All depths including the top of the screen assembly should be confirmed by the pump contractor prior to installation.

6.0 SUMMARY AND CONCLUSIONS

Based on the results of the present groundwater exploration and evaluation program, ***Kala*** provides the following conclusions for the Clients consideration.

- The present program of water well construction and testing has been carried out at the request of the National Research Council of Canada (***NRC***) to develop an 8-inch production well for ***NRC***'s Dominion Radio Astrophysical Observatory (***DRAO***) site, located along White Lake Road, near Penticton, B.C.

- It required the drilling of two exploratory testholes before favourable conditions were encountered at the second location. . A summary of the basic hydrogeologic units encountered in TH#2 is shown in Table 2.

Table 2 – Testhole No. 2 – Lithologic Summary

Depth Interval	***Lithologic Description***
0 to 20 feet	Medium to coarse grained sand and gravel
20 to 76 feet	Fine brown sand
76 to 89 feet	Medium to coarse sand with some angular gravel, water-bearing
89 to 90 feet	Grey clay

- Following completion of the exploratory drilling to the base of the aquifer (89 feet), a production well was completed with 10 feet (3.0 metres) of 8-inch (203 mm) telescopic well screen set from 77.8 to 88.3 feet (23.7 to 26.9 metres) below surface as shown in Figure 4. In addition a 2- foot riser and "Figure K" packer is attached to the top of the well screens, bringing the top of the assembly to 75.8 feet (23.1 metres) below ground level.

- During the 24-hour pumping test, while pumping at a constant rate of 245 USgpm, the total drawdown observed in the new 8-inch production well was 22.28 feet (6.79 metres) after 24 hours. This represents only 33.5 percent of the total available drawdown in the well. It was also noted that after 16 minutes of pumping, steady-state conditions were achieved were the pumping rate is balanced by the rate of recharge to the aquifer and no further drawdown is observed.

- The new well has a theoretical safe yield of 500 USgpm. The well screen however is designed to transmit 200 USgpm at an entrance velocity of 0.1 feet per second, which is the recommended maximum.

- A copy of the certificate of analysis for water quality is attached to the Appendices of this report. Based on the results, the water quality for all parameters tested meets the "*Guidelines for Canadian Drinking Water Quality*" with respect to health related parameters. The water did however exceed the aesthetic objectives (AO) with respect to some of the metal parameters including iron, managanese, alluminum and turbidity. In Kala's opinion the reason for the elevated concentrations of these parameters is the turbidity in water at the time of sampling, which was very high (170 NTU). It was noted that during the latter stages of the pumping test, the water became a little milky in color. Also in a discussion with Caro Environmental, the sample contained a fair amount of sediment in the bottle, but there was no yellow or brown color, meaning that the high readings for iron and manganese shown in the Certificate of Analysis, are probably miss-leading and not totally accurate, because of the high turbidity in the sample. ***Kala*** suggests that the drilling contractor be contacted and that some further development be conducted with the new well prior to final pump installation.

7.0 RECOMMENDATIONS

The following recommendations regarding the new 8-inch production well are made for the Clients consideration.

- Because of the high turbidity in the water, ***Kala*** recommends that the drilling contractor be contacted and that some further development be conducted with the new well prior to final pump installation. Following re-development, a water sample should be obtained with the drilling contractor's submersible pump and analyzed for iron, manganese, turbidity and alluminum.

- ***Kala*** is recommending that a pump capable of delivery somewhere between 50 and 200 USgpm be installed in the new 8-inch production well.

- It is currently recommended that a pump setting for the new well be 65 to 70 feet below the top of casing. The pump motor should not extend inside the well screen assembly. All depths including the top of the screen assembly should be confirmed by the pump contractor prior to installation.

- In order to aid in pump design and selection, ***Kala*** provides a series of pumping level projections in Table 4, which follows. These projections are all based on continuous pumping for a seven day period.

Table 4 – Projected Pumping Levels

Pumping Rate (USgpm)	***Drawdown in Well***	***Pumping Level from top of casing***
50	4.6 feet	14.7 feet
100	9.2 feet	19.3 feet
200	18.2 feet	28.3 feet

- At no time should the new well be backwashed (allowing a sudden surge of water back through the drop pipe and pump). This is because of the fine sand component comprising the aquifer and consequently it is recommended that a check valve be installed above the pump;

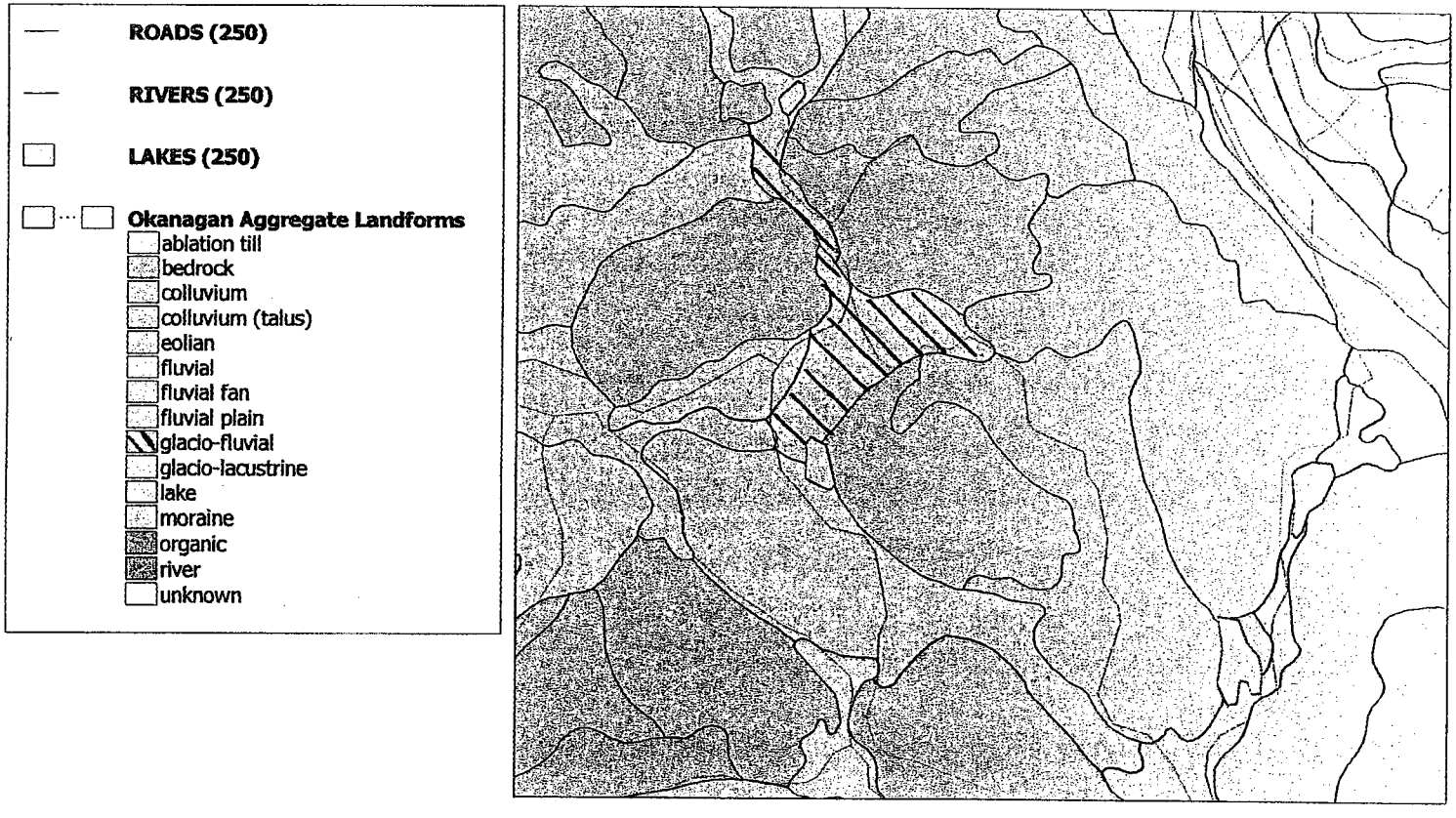
- The aquifer is partially protected from surface contamination by layers of silty fine sand, but we do recommend that a well head protection plan be adopted. Owners of land located within the well capture zone should be informed, and they should be encouraged to take all measures necessary to contain any large volumes of potential contaminants;

- Finally with respect to the new production well, provision should be made to include a water meter for measuring production and also allowance should be made for measuring pumping and non-pumping water levels in the well.

APPENDIX A

Report Figures

KALA GROUNDWATER CONSULTING LIMITED



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MILES

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Client:	National Research Council	
Title:	*Water Supply Evaluation* *Dominion Radio Astro Observatory* **Surficial Geology**	
File: Casorso.Doc	Date: Dec., 2000	FIGURE 2

KALA GROUNDWATER
CONSULTING LIMITED

aled to fit

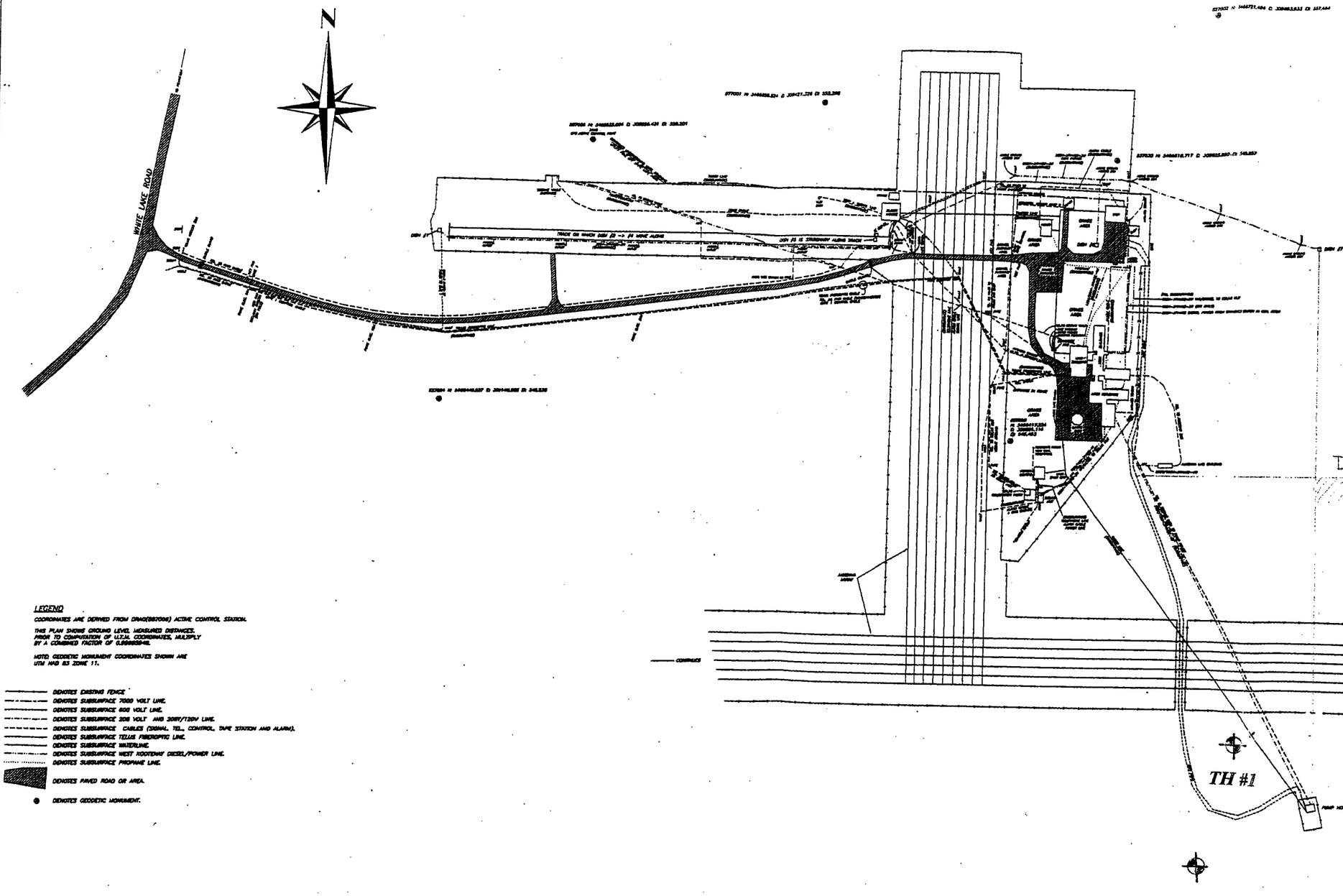
SKETCH PLAN OF THE DOMINION RADIO ASTROPHYSICAL OBSERVATORY SITE (White Lake Road)
SHOWNG SURFACE AND SUBSURFACE FEATURES.

B.C.G.S. 82E.032

THIS PLAN IS TO BE USED FOR PRELIMINARY PURPOSES AND IS NOT TO BE USED TO LOCATE SUBSURFACE FEATURE LOCATIONS. FEATURES ARE TO BE FIELD VERIFIED PRIOR TO ANY EXCAVATION.

CIVIC ADDRESS
WHITE LAKE ROAD
KALEDON, B.C.

SCALE 1:1000



TH #2 (Production Well)

LEGEND

COORDINATES ARE DERIVED FROM DRAO(8821006) ACTIVE CONTROL STATION.

THIS PLAN SHOWS GROUND LEVEL MEASURED DISTANCES. PRIOR TO COMPUTATION OF U.T.M. COORDINATES, MULTIPLY BY A COMBINED FACTOR OF 0.9996539+40.

NOTE: GEODETIC MONUMENT COORDINATES SHOWN ARE UTM NAD 83 ZONE 11.

- DENOTES EXISTING FENCE
- DENOTES SUBSURFACE 7000 VOLT LINE.
- DENOTES SUBSURFACE 600 VOLT LINE.
- DENOTES SUBSURFACE 208 VOLT AND 208Y/120V LINE.
- DENOTES SUBSURFACE CABLES (SIGNAL, TEL., CONTROL, TAPE STATION AND ALARM).
- DENOTES SUBSURFACE TELUS FIBEROPTIC LINE.
- DENOTES SUBSURFACE WATERLINE.
- DENOTES SUBSURFACE WEST KOOTENAY DIESEL/POWER LINE.
- DENOTES SUBSURFACE PROPANE LINE.
- DENOTES PAVED ROAD OR AREA.
- DENOTES GEODETIC MONUMENT.

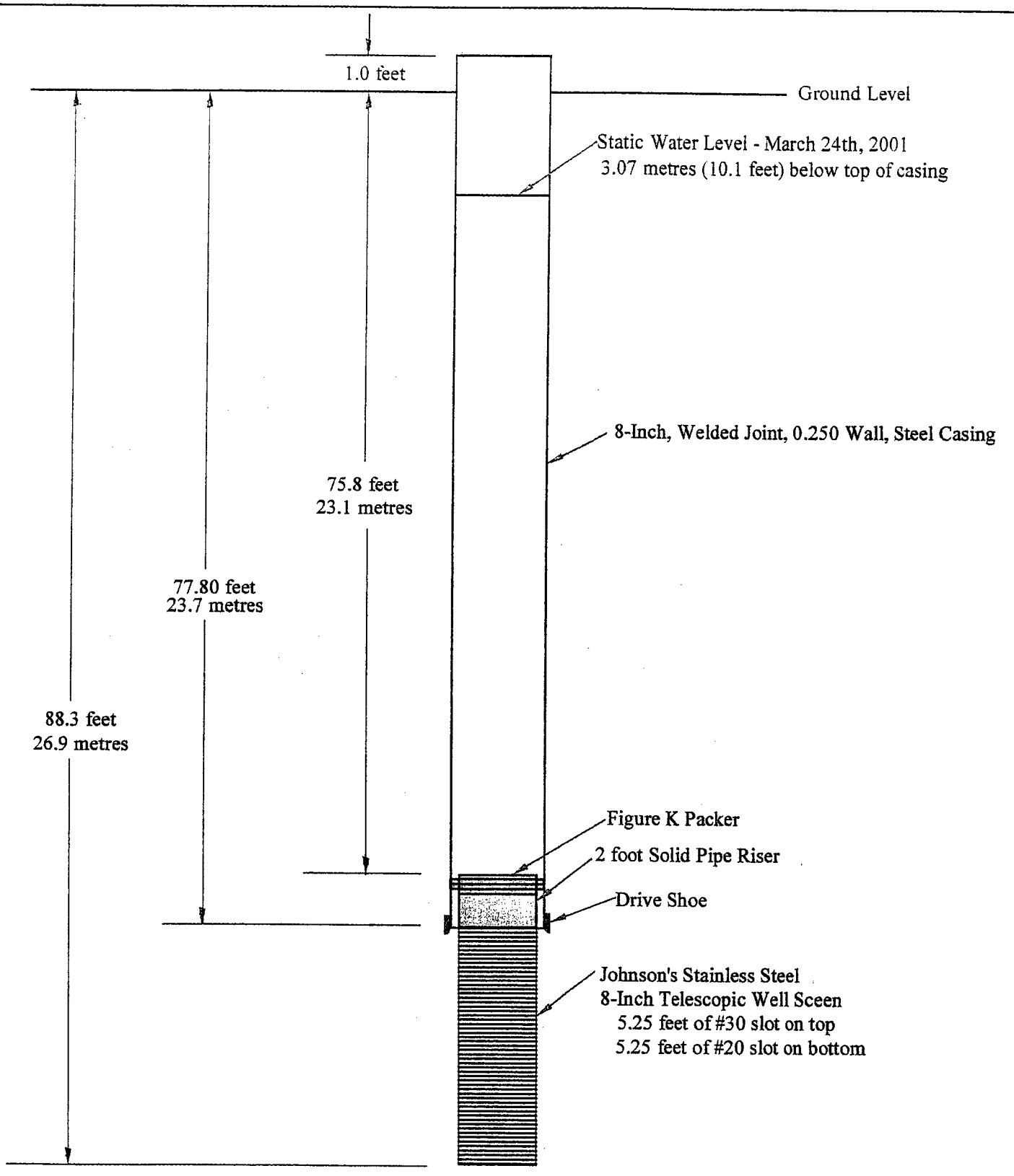
CANADA NATIONAL RESEARCH COUNCIL OF CANADA
PLAN NUMBER : 228097

CERTIFIED CORRECT

B.C.L.S. C.L.S.

Dated this 19th day of January, 2005.
THIS DOCUMENT IS NOT VALID UNLESS ORIGINALLY SIGNED AND SEALED.

Figure 3
Dominion Radio Astrophysical Observatory
Testhole Location Plan



Note: Not to scale

Figure 4

Dominion Radio Astrophysical Observatory
Well Completion Diagram

APPENDIX B

Pump Test Data

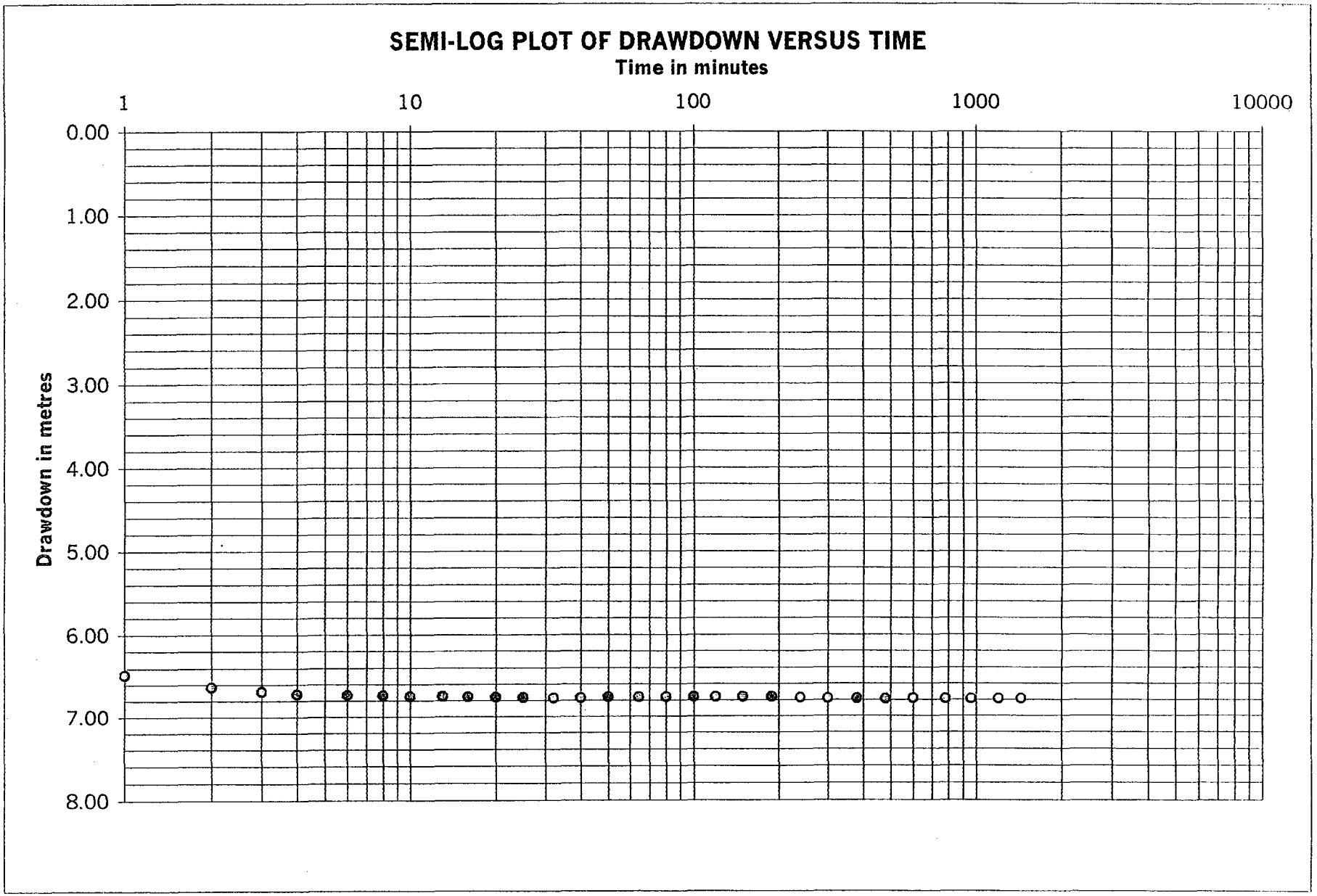
PUMPTEST (Drawdown) **NRC - Dominion Radio Astrophysical Observatory**

New 8-Inch Production Well (Testhole #2)

Date test started: March 24th, 2001
Time test started: 11:30 AM
Ave. pumping rate: 245 USgpm
Pre-test water level: 3.07 metres

Reference Point: Top of casing
Height of ref. point: 0.30 metres above grade
Depth of well: 26.5 metres
Screen Interval: 23.5 to 26.5 metres

Time (t) since pumping started in minutes	Depth to water in metres	Drawdown in metres	Comments
0	3.07	0.00	
1	9.55	6.48	Pumping rate: 245 Usgpm
2	9.70	6.63	16.5 inches on 8" x 4" orifice
3	9.76	6.69	
4	9.79	6.72	
6	9.80	6.73	Water clean after 5 minutes
8	9.81	6.74	
10	9.82	6.75	16.5 "
13	9.82	6.75	
16	9.825	6.76	
20	9.830	6.76	
25	9.835	6.77	
32	9.84	6.77	
40	9.84	6.77	
50	9.83	6.76	
64	9.83	6.76	Pumping Rate: 245 USgpm
80	9.83	6.76	
100	9.83	6.76	16.5"
120	9.83	6.76	
150	9.83	6.76	
190	9.83	6.76	
240	9.84	6.77	
300	9.85	6.78	
380	9.85	6.78	
480	9.86	6.79	
600	9.85	6.78	
780	9.86	6.79	
960	9.86	6.79	Water little milky
1200	9.86	6.79	Obtain water samples
1440	9.86	6.79	Pumping rate: 245 Usgpm


SEMI-LOG PLOT OF DRAWDOWN VERSUS TIME
Time in minutes
1
10
100
1000
10000
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Drawdown in metres

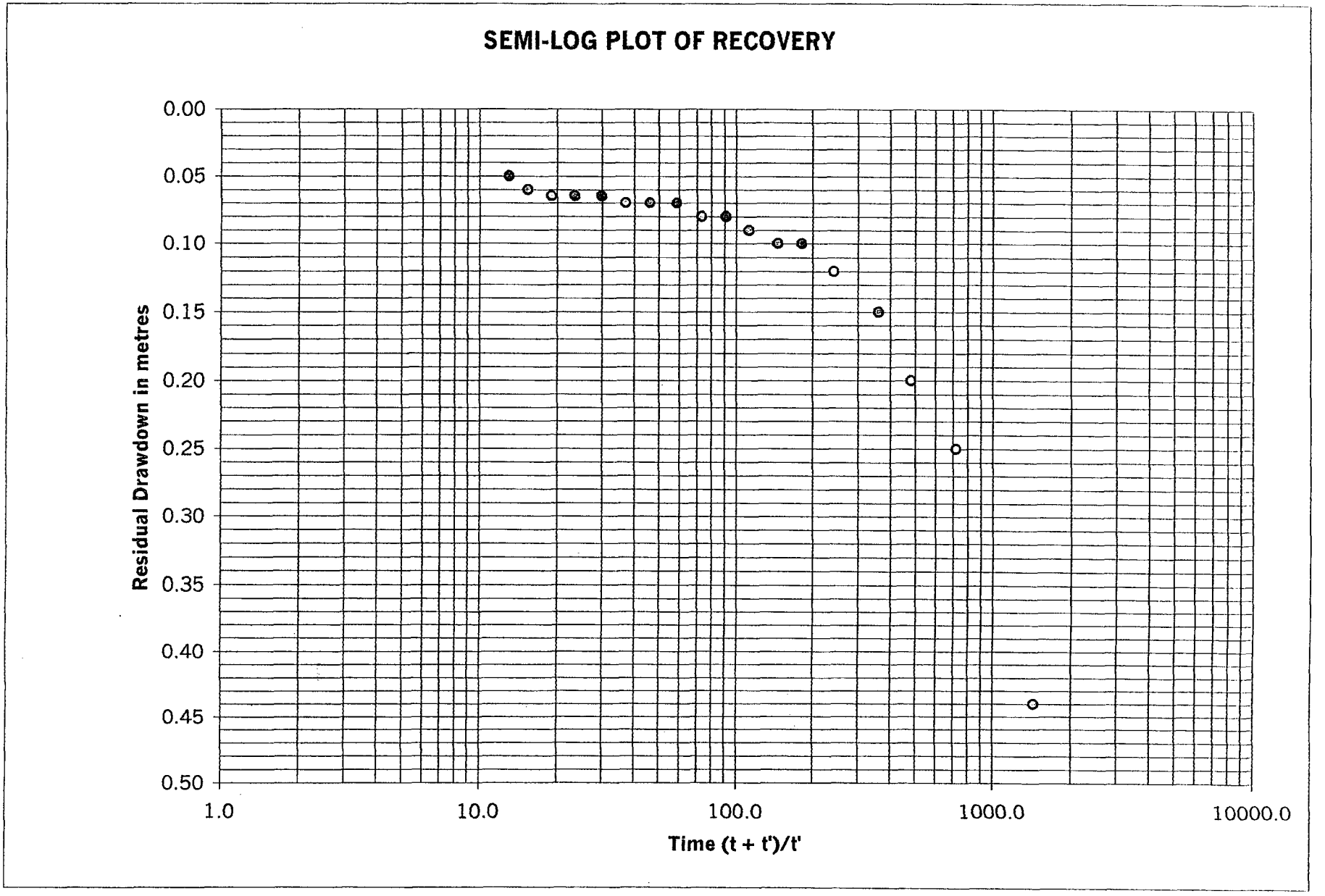
PUMPTEST (RECOVERY)

NRC - Dominion Radio Astrophysical Observ.
New 8-Inch Well - Recovery

Date test started: March 25th, 2001
Time test started: 11:30 AM
Ave. pumping rate: 245 USgpm
Pre-test water level: 3.07 metres

Reference point: Top of casing
Height of reference: 0.3 metres
Depth of well: 26.5 metres
Top of screen: 23.1 metres

Time t' since pumping stopped in minutes	(t + t')/t'	Depth to water in metres	Residual Drawdown in metres	Comments
0	1440.0	9.86	6.79	
1	1441.0	3.51	0.44	
2	721.0	3.32	0.25	
3	481.0	3.27	0.20	
4	361.0	3.22	0.15	
6	241.0	3.19	0.12	
8	181.0	3.17	0.10	
10	145.0	3.17	0.10	
13	111.8	3.16	0.09	
16	91.0	3.15	0.08	
20	73.0	3.15	0.08	
25	58.6	3.14	0.07	
32	46.0	3.14	0.07	
40	37.0	3.14	0.07	
50	29.8	3.135	0.06	
64	23.5	3.135	0.06	
80	19.0	3.135	0.06	
100	15.4	3.13	0.06	
120	13.0	3.12	0.05	


SEMI-LOG PLOT OF RECOVERY
Residual Drawdown in metres
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
1.0
10.0
100.0
1000.0
10000.0
Time (t + t')/t'

APPENDIX C

Water Quality Analysis

CARO ENVIRONMENTAL SERVICES

102 - 3677 Highway 97N
Kelowna, B.C. V1X 5C3

Telephone (250) 765-9646
Fax (250) 765-3893

CERTIFICATE OF ANALYSIS

April 10, 2001

National Reserarch Council Canada
P.O. Box 248
PENTICTON, BC V2A 6K3
Attention: Ron Casorso

Sample ID: **New Production Well via Kala Groundwater**

Date sampled: **March 25/01** **Received: March 26/01**

Parameter	units	Result
Alkalinity (total)	mg/L as CaCO3	293
Aluminum (total)	mg/L	3.8
Arsenic (total)	mg/L	<0.01
Barium (total)	mg/L	0.12
Boron	mg/L	<0.1
Cadmium (total)	mg/L	<0.0002
Calcium (total)	mg/L	62.9
Chloride	mg/L	15.5
Chromium (total)	mg/L	<0.01
Colour (true)	colour units	<5
Conductivity	umhos	686
Copper (total)	mg/L	<0.01
Cyanide	mg/L	<0.010
Fluoride	mg/L	1.20
Hardness	mg/L as CaCO3	275
Iron (total)	mg/L	5.50
Lead (total)	mg/L	0.004
Magnesium (total)	mg/L	28.6
Manganese (total)	mg/L	0.190
Mercury (total)	mg/L	<0.00005
Molybdenum (total)	mg/L	<0.03

...2

Page 2
National Reserarch Council Canada
April 10, 2001 (cont)

Sample ID: New Production Well

Parameter	units	Result
Nitrate	mg/L as N	0.09
Nitrite	mg/L as N	<0.01
pH	pH units	7.4
Potassium (total)	mg/L	1.98
Sodium (total)	mg/L	42.4
Sulphate	mg/L	69
Total Dissolved Solids	mg/L	441
Turbidity	NTU	170
Uranium (total)	mg/L	0.0118
Zinc (total)	mg/L	0.054
Total Coliform	Colonies/100mL	0
Fecal Coliform	Colonies/100mL	0

Certified by: _____
CARO Environmental Services
Janice M. Fraser, B.Sc., Lab Manager
Enclosure
FAX (250)493-7767, also
cc FAX (250)545-1720, Kala Groundwater Consulting

CARO ENVIRONMENTAL SERVICES

CARO ENVIRONMENTAL SERVICES

102 - 3677 Highway 97N
Kelowna, B.C. V1X 5C3

Telephone (250) 765-9646
Fax (250) 765-3893

CERTIFICATE OF ANALYSIS

November 23, 2000

National Research Council of Canada
P.O. Box 248
PENTICTON, BC V2A 6K3
Attention: Ron Casorso

Sample ID: **NRC Existing Dug Well, via Kala Groundwater & Robbins Water Well Drilling**

Date sampled: **Nov. 12/00** **Received: Nov. 14/00**

Parameter	units	Result
Alkalinity (total)	mg/L as CaCO3	292
Aluminum (total)	mg/L	<0.2
Arsenic (total)	mg/L	<0.01
Barium (total)	mg/L	0.06
Boron	mg/L	<0.1
Cadmium (total)	mg/L	<0.0002
Calcium (total)	mg/L	64.3
Chloride	mg/L	13.8
Chromium (total)	mg/L	<0.01
Colour (true)	colour units	<5
Conductivity	umhos	675
Copper (total)	mg/L	<0.01
Cyanide	mg/L	<0.010
Fluoride	mg/L	1.2
Hardness	mg/L as CaCO3	274
Iron (total)	mg/L	<0.03
Lead (total)	mg/L	0.001
Magnesium (total)	mg/L	27.5
Manganese (total)	mg/L	<0.005
Mercury (total)	mg/L	<0.00005
Molybdenum (total)	mg/L	<0.03

...2

Sample ID: **NRC Existing Dug Well, via Kala Groundwater**

Parameter	units	Result
Nitrate	mg/L as N	0.16
Nitrite	mg/L as N	<0.01
pH	pH units	8.0
Potassium (total)	mg/L	1.87
Sodium (total)	mg/L	36.9
Sulphate	mg/L	60
Total Dissolved Solids	mg/L	407
Turbidity	NTU	0.15
Uranium (total)	mg/L	0.0115
Zinc (total)	mg/L	0.007
Total Coliform	Colonies/100mL	0
Fecal Coliform	Colonies/100mL	0

Certified by: _____

CARO Environmental Services
Janice M. Fraser, B.Sc., Lab Manager

Enclosure
FAX (250)493-7767
cc FAX (250)545-1720, Kala Groundwater Consulting

CARO

APPENDIX D

Driller's Lithologs and Sieve Analysis

National Research Council
Dominion Radio Astrophysical Observatory
Groundwater Development Program
Driller's Lithologs

Depth Interval In feet	Lithologic Description
TH#1	
0 – 2.5 ft.	Topsoil
2.5 – 6	Tight sand and gravel
6 – 10	Brown sand and gravel with medium sized rocks
10 – 14	Clean gravel and sand
14 – 16	Brown sand
16 – 18	Brown sand and gravel, clean
18 – 21	Coarse sand
21 – 31	Fine silty sand, grey-brown
31 – 48	Fine silty sand, brown
48 – 50	Fine silty sand, dark brown in color
50 – 60	Fine brown sand, silty
60 – 70	Fine grey sand, coarser and little cleaner
70 – 80	Fine brown sand, silty with few pebbles
80 – 89	Fine brown sand, dirty
89 – 96	Fine brown silty sand
96 – 107	Grey clay
107 – 110	Compact silt
110 – 119	Grey clay
119 – 126	Grey clay soft, drilled
126 – 133	Grey clay, firm, drilled
133 – 138	Tight clay, drilled
138 – 139	Tight till, hard
139 – 142	Bedrock, siltstone

(Driller's lithologs – Cont'd)

Depth Interval In feet	Lithologic Description
TH#2 (Production Well)	
0 – 2 ft.	Topsoil with gravel
2 – 4	Sand and gravel, brown
4 – 9	Clean brown sand
9 – 18	Coarser sand, brown
18 – 20	Coarser sand with some gravel
20 – 22	Fine brown sand
22 – 28	Fine brown sand, clean
28 – 30	Fine brown sand, light in color
30 – 50	Fine brown sand
50 – 65	Fine brown sand with few pebbles and rocks
65 – 70	Fine brown sand with broken rocks
70 – 76	Fine brown sand with few pebbles
76 – 80	Coarse sand with pebbles, clean
80 – 84	Clean coarse sand
84 – 89	Sand clean, finer with few rocks
89 -	Grey clay

SIEVE ANALYSIS

PROJECT: Dominion Radio Astro. Observatory

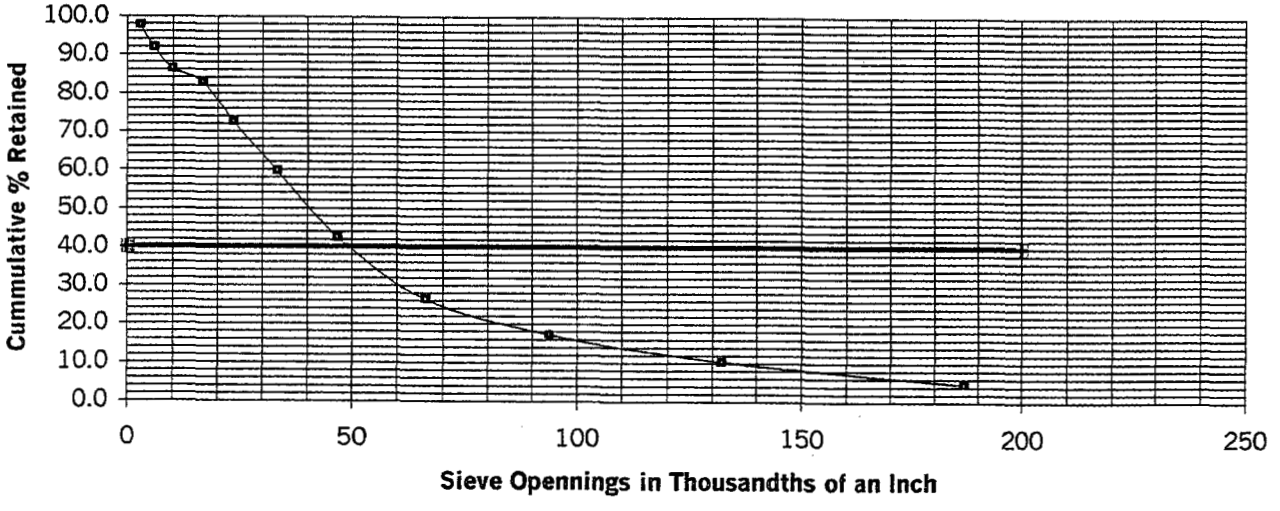
REMARKS: Testhole No. 2

DEPTH: 76 - 78 feet

SIEVE OPENNING		U.S. SIEVE	CUMMULATIVE % RETAINED		REMARKS
INCH	1000ths"	NO.	WT. RET.	% RET.	
		1/2 Inch			
0.265	265	0.265		0.0	
0.187	187	4	20	4.6	
0.132	132	6	45	10.3	
0.0937	93.7	8	75	17.2	
0.0661	66.1	12	115	26.4	
0.0469	46.9	16	185	42.5	
0.0331	33.1	20	260	59.8	
0.0234	23.4	30	315	72.4	
0.0165	16.5	40	360	82.8	
0.0098	9.8	60	375	86.2	
0.0059	5.9	100	400	92.0	
0.0029	2.9	200	425	97.7	
		Pan	435	100.0	

Total Wt: 435.0

SIEVE ANALYSIS PLOT



SIEVE ANALYSIS

PROJECT: Dominion Radio Astro. Observatory

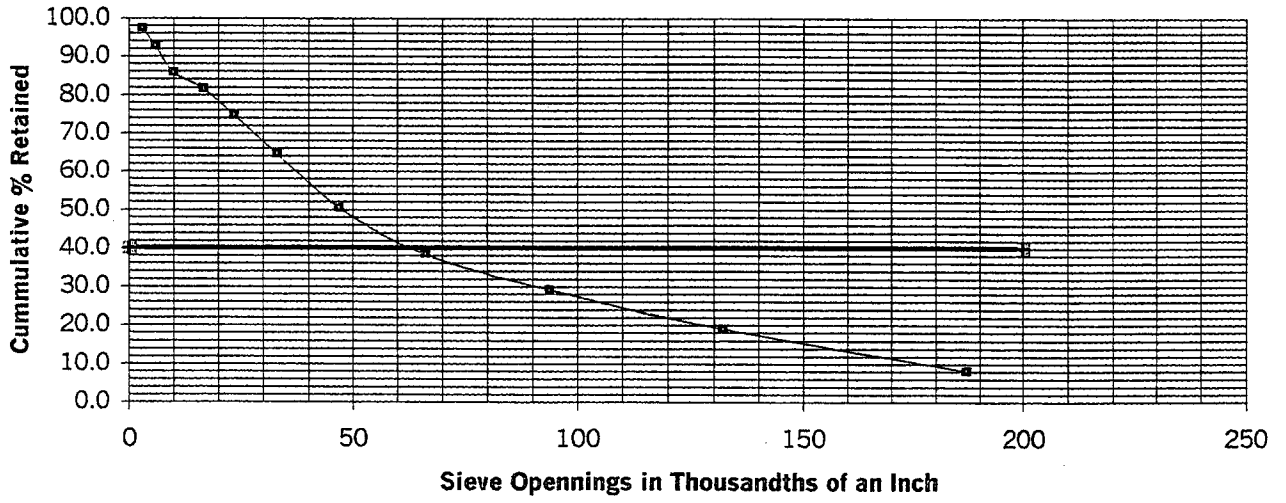
REMARKS: Testhole No. 2

DEPTH: 78 - 80 feet

SIEVE OPENNING		U.S. SIEVE	CUMMULATIVE % RETAINED		REMARKS
INCH	1000ths"	NO.	WT. RET.	% RET.	
		1/2 Inch			
0.265	265	0.265		0.0	
0.187	187	4	40	8.1	
0.132	132	6	95	19.2	
0.0937	93.7	8	145	29.2	
0.0661	66.1	12	190	38.3	
0.0469	46.9	16	250	50.4	
0.0331	33.1	20	320	64.5	
0.0234	23.4	30	370	74.6	
0.0165	16.5	40	405	81.7	
0.0098	9.8	60	425	85.7	
0.0059	5.9	100	460	92.7	
0.0029	2.9	200	483	97.4	
		Pan	496	100.0	

Total Wt: 496.0

SIEVE ANALYSIS PLOT



SIEVE ANALYSIS

PROJECT: Dominion Radio Astro. Observatory

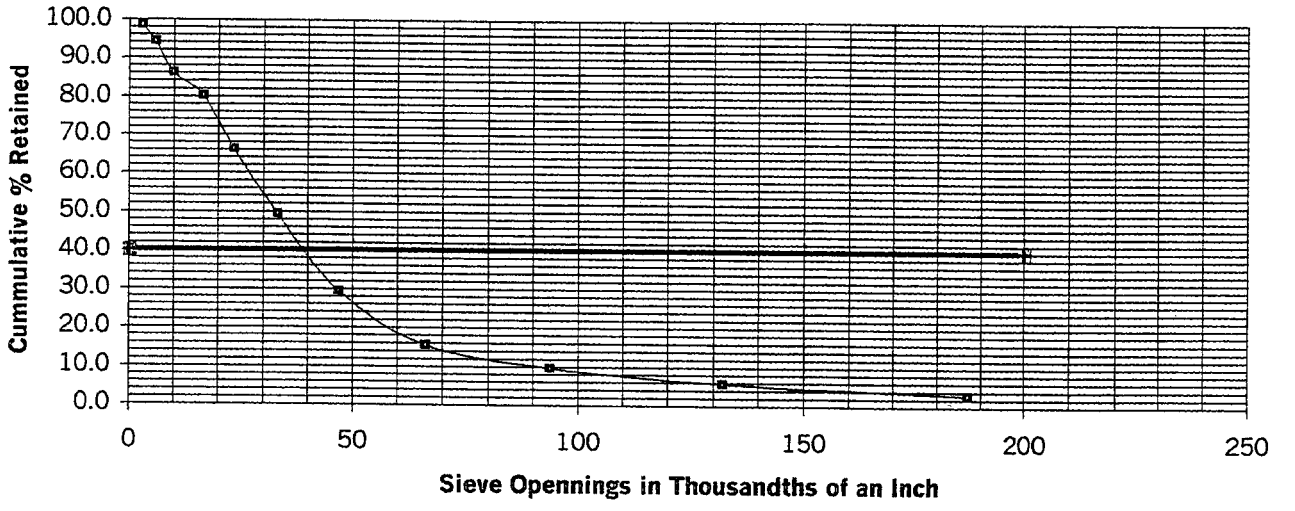
REMARKS: Testhole No. 2

DEPTH: 80 - 82 feet

SIEVE OPENNING		U.S. SIEVE	CUMMULATIVE % RETAINED		REMARKS
INCH	1000ths"	NO.	WT. RET.	% RET.	
		1/2 Inch			
0.265	265	0.265		0.0	
0.187	187	4	20	2.9	
0.132	132	6	38	5.6	
0.0937	93.7	8	65	9.6	
0.0661	66.1	12	105	15.4	
0.0469	46.9	16	200	29.4	
0.0331	33.1	20	335	49.3	
0.0234	23.4	30	450	66.2	
0.0165	16.5	40	545	80.1	
0.0098	9.8	60	585	86.0	
0.0059	5.9	100	640	94.1	
0.0029	2.9	200	670	98.5	
		Pan	680	100.0	

Total Wt: 680.0

SIEVE ANALYSIS PLOT



SIEVE ANALYSIS

PROJECT: Dominion Radio Astro. Observatory

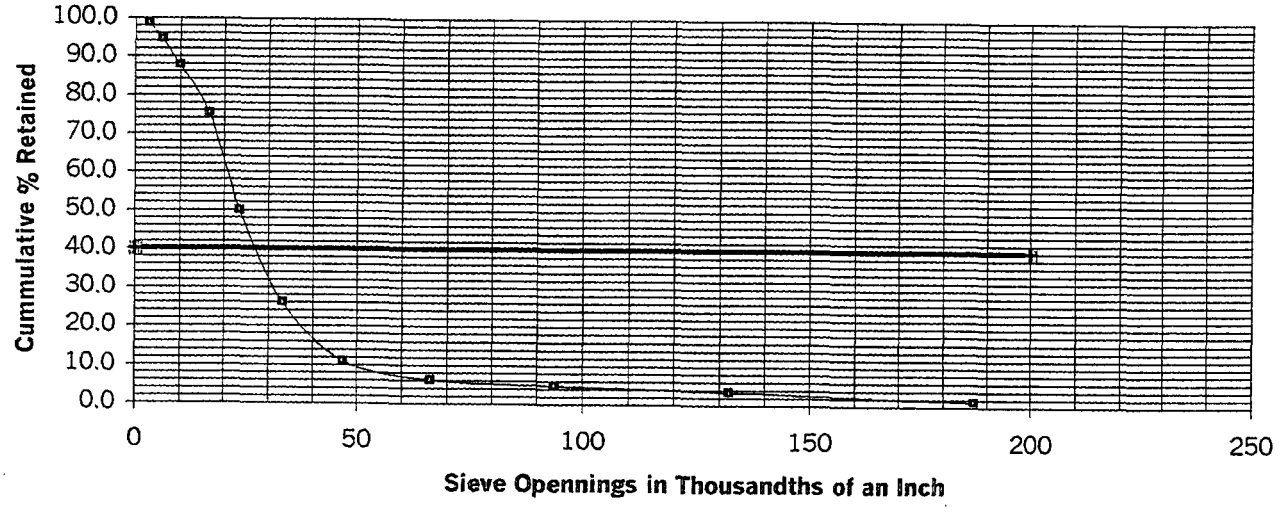
REMARKS: Testhole No. 2

DEPTH: 82 84 feet

SIEVE OPENNING		U.S. SIEVE	CUMMULATIVE % RETAINED		REMARKS
INCH	1000ths"	NO.	WT. RET.	% RET.	
		1/2 Inch			
0.265	265	0.265		0.0	
0.187	187	4	10	1.4	
0.132	132	6	25	3.4	
0.0937	93.7	8	35	4.8	
0.0661	66.1	12	45	6.2	
0.0469	46.9	16	80	11.0	
0.0331	33.1	20	190	26.0	
0.0234	23.4	30	365	50.0	
0.0165	16.5	40	550	75.3	
0.0098	9.8	60	640	87.7	
0.0059	5.9	100	690	94.5	
0.0029	2.9	200	720	98.6	
		Pan	730	100.0	

Total Wt: 730.0

SIEVE ANALYSIS PLOT



SIEVE ANALYSIS

PROJECT: Dominion Radio Astro. Observatory

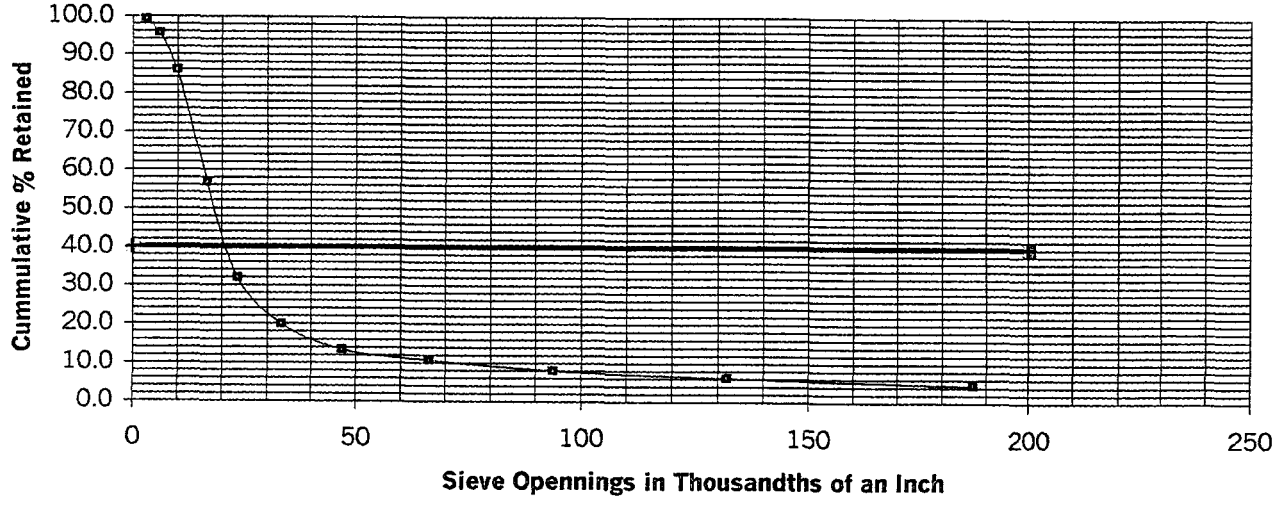
REMARKS: Testhole No. 2

DEPTH: 84 - 86 feet

SIEVE OPENNING		U.S. SIEVE	CUMMULATIVE % RETAINED		REMARKS
INCH	1000ths"	NO.	WT. RET.	% RET.	
		1/2 Inch			
0.265	265	0.265		0.0	
0.187	187	4	25	4.4	
0.132	132	6	35	6.2	
0.0937	93.7	8	45	8.0	
0.0661	66.1	12	60	10.6	
0.0469	46.9	16	75	13.3	
0.0331	33.1	20	112	19.8	
0.0234	23.4	30	180	31.9	
0.0165	16.5	40	320	56.6	
0.0098	9.8	60	485	85.8	
0.0059	5.9	100	540	95.6	
0.0029	2.9	200	560	99.1	
		Pan	565	100.0	

Total Wt: 565.0

SIEVE ANALYSIS PLOT



SIEVE ANALYSIS

PROJECT: Dominion Radio Astro. Observatory

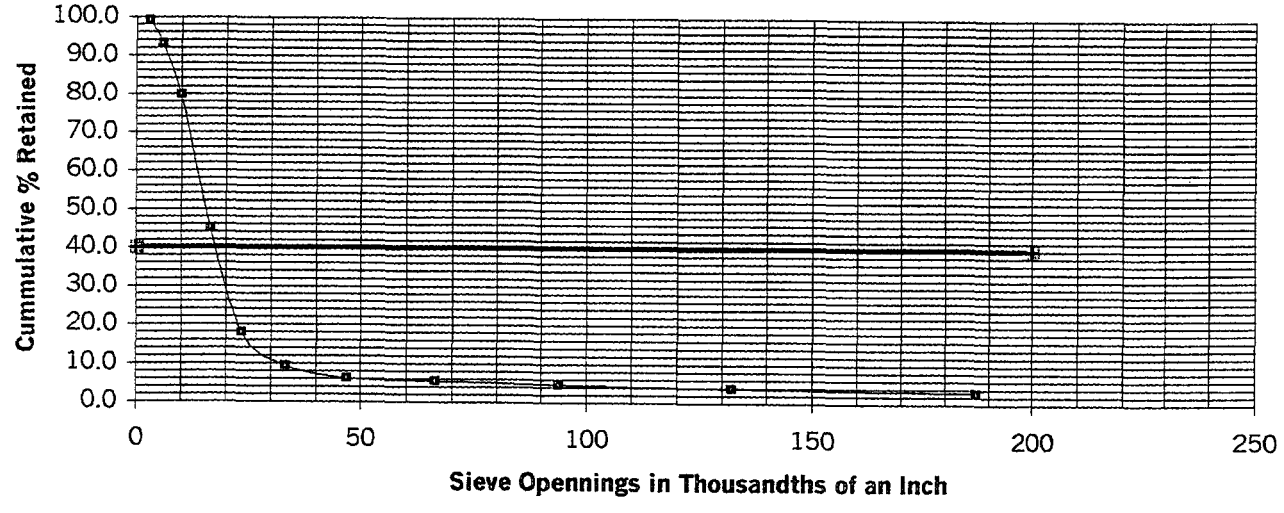
REMARKS: Testhole No. 2

DEPTH: 86 - 88 feet

SIEVE OPENNING		U.S. SIEVE	CUMMULATIVE % RETAINED		REMARKS
INCH	1000ths"	NO.	WT. RET.	% RET.	
		1/2 Inch			
0.265	265	0.265		0.0	
0.187	187	4	20	3.1	
0.132	132	6	25	3.9	
0.0937	93.7	8	30	4.7	
0.0661	66.1	12	35	5.4	
0.0469	46.9	16	40	6.2	
0.0331	33.1	20	60	9.3	
0.0234	23.4	30	115	17.8	
0.0165	16.5	40	290	45.0	
0.0098	9.8	60	515	79.8	
0.0059	5.9	100	600	93.0	
0.0029	2.9	200	640	99.2	
		Pan	645	100.0	

Total Wt: 645.0

SIEVE ANALYSIS PLOT



Safe Yield Calculation Q_{20} for Water Wells

1) Safety Factor

70 Percent of available drawdown (ie 0.7)

2) Total Available Drawdown in Well (top of screen minum static water level

$Sa := 66.7ft$

3) Aquifer Test Rate

$$Q := \frac{245gal}{min}$$

4) Drawdown in Pumped Well at 100 minutes

$S_{100} := 22.18ft$

5) Drawdown per log cycle

$dS := 0.1ft$

The 20 year safe yield of the well is given by the following:

$$Q_{20} := \frac{(0.7 \cdot Sa \cdot Q)}{(S_{100} + 5dS)}$$

$$Q_{20} = 504.367 \frac{gal}{min}$$