WATER INVESTIGATIONS BRANCH

B. C. Water Resources Service.

Department of Lands, Forests and Water Resources

PRELIMINARY REPORT ON GROUNDWATER EXPLORATION AT POINT GREY, UNIVERSITY ENDOWMENT LANDS

May 28, 1963

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E. Livingston
Geological Engineer

The groundwater exploration work described in this report forms a part of an investigation into erosion of bluffs at Point Grey. The drilling and pumping of a test well was undertaken for the purpose of finding suitable water for the raising of fish by the Biology Department and at the research facilities of the Federal Fisheries Department

The drilling and test well pumping was carried out by the Pacific Water Wells Ltd. of Nanaimo. Professor W. H. Mathews, Department of Geology, and Mr. T. S. Hughes, Superintendent of Buildings and Grounds, both of the University of British Columbia, co-operated with the writer in carrying out the program.

CONTENTS

The program of drilling on Point Grey was completed in April. The pump test of the test well was completed in May.

The drilling consisted of five test holes as shown on the map. Piezometers constructed of $1\frac{1}{4}$" plastic pipe were installed in all holes. In Holes 3 and 5, two piezometers were placed in each hole, one above the silty beds and one below the silty beds. In the other three holes, the piezometers were located above the silts in order to determine the level of the water above the silty beds; this water was thought to be one of the causes of bank erosion on Point Grey.

The logs of all the holes are given in Appendix I. The results generally confirm the results of the mapping included in the writer's first report of May 1962. Holes 1 and 2, however, did not encounter any marine drift or till over the main sand member. This indicates that there are probably large areas favourable for rapid ground water recharge on Point Grey. These glacial deposits were found to be present in all the other holes. The top of the silty beds was found to be at a fairly uniform elevation (35' to about 80') in all the holes although in holes 1, 5 and the well, it was found to consist mostly of sand with very little silt.

The piezometer data did not confirm the conclusion of previous investigations, namely that water is perched on top of the silty beds. Piezometers placed at the top of the silty beds, in Holes 4 and 5, showed no water on top of the silt. In Hole 1, the whole section is believed to be saturated to an elevation above the top of the silt. Hole 2 shows about 15' of water on top of the silt while Hole 3 shows only about 7' of water above the silt. As mentioned earlier, two peizometers were placed in Hole 3, one at an elevation of about 85', the other at an elevation of about 23'. These showed that the elevation of the top piezometric surface is at about 87' while the lower piezometric surface below the silty section is at an elevation of about 53'.

It is interesting to note that at the two places where there is an appreciable amount of water above the silt, namely at Holes 1 and 2, the permeable sand extends to surface so these high water levels may represent "mounds" of water formed by rapid recharge. Where relatively impermeable glacial deposits overlie the sand, there is little or no water on top of the silt. Occasional observations of these wells over a year might confirm this idea.

In the rotary drilling which was done using drilling mud, it was difficult to log thin silt beds in fairly fine sand. However, it seems that the silty beds in some places are quite sandy with only a few silt beds. In such places, especially where recharge is rather slow, the water moving down or laterally in the overlying sand can leak through the silty beds fast enough to prevent it from accumulating on top of the silt.

We must, of course, explain the source of the water which is seen running out at the beach bluffs along the top of the silty section. It is probably the result of local recharge in areas where the main sand member extends to surface or where the cover of less permeable material is very thin.

The idea proposed by the writer in the earlier report that water seen running across the beach on the southwest shore of Point Grey comes from above the silt seeping down to beach level through the accumulation of slumped sand on the slope is probably incorrect. Most of this water is probably reaching the beach at or near the high water line within or below the main silty section.

The water elevation of about 53' shown by the lower piezometer in Hole 3 seems quite high in relation to the level of about 21' in Hole 5 and the well. It is possible that the piezometric surface in the aquifer below the silty beds may be controlled in part by local variations in transmissibility and anisotropy. In the mapping of exposures along the beach the section on Spanish Banks near Hole 3 shows dipping beds and local variations in stratigraphy which were not found elsewhere on Point Grey.

Hole 3 was drilled down to about 100' below sea level. From sea level, the drilling showed alternating sandy and silty beds with a few gravelly interbeds. Hole 2 encountered a boulder $1\frac{1}{2}$' in diameter near the top of the silty beds. This may be related to a till which, according to Messrs. Armstrong and Halstead, occurs at this horizon. About 10' below sea level in the well, pumice fragments began to appear in the bailer samples. This continued in diminishing amounts to about 340'. Some wood fragments were also found at about 10' below sea level. This pumice horizon may be the same as that found in the Highbury Street sewer drilling where the pumice horizon was encountered by several holes on the south slope.

This pumice is the only marker bed below the main sand member which enables one to correlate the Point Grey geology with that at Highbury Street. This suggests that much of the section below the main sand member at Highbury Street has been cut out to the west at Point Grey. Thus, the aquifer below the silty beds may be below an important erosional unconformity.

Test Well

The test well drilled by Pacific Water Wells was completed in May. The log of this hole is given in Appendix I.

Sand samples were taken from about 285' to the bottom of the hole. The material became very fine below 328' so it was decided to set 20' of screen between 308' and 328'. This was developed by several days of surging at which time about 1' of sand could be produced by about half an hour of surging. An attempt was made to test the well with a small submersible pump but this failed due to a pump breakdown.

A successful pump test was conducted on May 8th and 9th. The data obtained are given in Appendix II; results are discussed below.

Since the test indicated a high transmissibility, it was decided to try to improve the well performance by additional well development. This was done by surging for less than one day at which time very little sand was being produced. The pump was again placed in the well and the result of pumping was compared with the original test data. This showed an improvement of about 10% in the well capacity. It seems improbable that further work other than addition of more screen below the present screen will significantly improve this well so the well is considered complete. At a discussion with Dr. Mathews, Mr. Bayley and the writer, it was agreed that the University of British Columbia would take over the well.

As discussed in the Appendix II, the test results are uncertain because of the location of the observation hole. However, the safe capacity of the well is estimated to be 75 gallons per minute. (Imperial)

Conclusions

If the interpretation of the test data presented in this report is correct, certain conclusions may be drawn.

1. The transmissibility of the aquifer is quite high and it should be capable of yielding water to properly constructed wells.
2. The performance of the test well is not good if the computed transmissibility is correct. This is probably due in part to the fact that the well only partially penetrates an anisotropic aquifer.
3. Future wells, where a high yield is desired, should be constructed as fully penetrating wells i.e. longer screens should be used. In conditions encountered in the test well gravel pack type well construction would be necessary below about 330' because of the very fine-grained nature of the aquifer.
4. It would be desirable to locate any such wells further east where the water table is higher thus taking advantage of the coarser part of the aquifer. The upper part is probably more isotropic; this would probably improve well performance. Under these conditions, it is likely that wells capable of yielding one c.f.s. or more could be constructed.
5. In the Swan, Wooster Engineering Co.'s Report on bankerosion, the proposal that wells be used to intercept water flowing along the top of the silty beds before it reaches the beach bluffs, has been shown to be impractical. There is not enough saturated material above the silty beds to serve as an aquifer for wells.
6. The idea proposed by the writer in the earlier report, that removal of water from below the silty beds might increase downward leakage through the silty beds thus reducing the flow at the beach bluffs is also invalid as it was based on the idea that there might be a considerable thickness of perched water. Since this has not found to be the case, this probably would be ineffective.

May 28, 1963

E. Livingston
Geological Engineer


UNIVERSITY ENDOWMENT LANDS
POINT GREY B.C.
BEING A PART OF
LOT 140 GROUP I N.W.D.
Scale 1 Inch = 800 Feet
References
Former General Index · · · 17T295
General Index Point Grey · · · 9T133
Topographic and Contour Plan (1923) · · · 10T254
Obsolete General Arrangment of Blocks & Roads (1926) 6T176
Contour Overlay to above · · · 6^T176
Low level Air Photographs (1949) · BC728 5-10, 78-82; BC737 59-65; BC790 33-37; BC792 4-10; BC818 18-20.
Vancouver City Boundary · · · Statutes of 1928 Chap. 58
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B.C. University Site Act 1918 Chap. 94
ENGLISH BAY
SPANISH BANK
MARINE DRIVE
N
L540
L139
L2027
L320
L.140
O in C. 553/25
May 15th 1925
CAMOSUN BOG WELL
KING EDWARD AVE
BOUNDARY OF THE CITY OF VANCOUVER
TEST HOLE 1
TEST HOLE 2
TEST HOLE 3
TEST HOLE 4
TEST HOLE 5
WESTWARD HO
GOLF COURSE
CHANCELLOR BOULEVARD
BOULEVARD
KING EDWARD BOULEVARD
ACADIA CAMP
WELL
PARKWAY
EAST MALL
MAIN MALL
WEST MALL
L3044
L4804
L4805
L 6494
L3045A
PLAN 6992
146
PLAN 6373
292
275
Historical Monument
CAMOSUN ST
COURTENAY ST
IMPERIAL ST
TRIMBLE ST
SASAMAT ST
TOLMIE ST
DRUMMOND DRIVE
BELMONT AVE
SIMPSON ST

DRILLING RESULTS - POINT GREY

Test Hole No.	Elevation, Ft. (Approx.)	Static Water Level, Ft.	Drill Log, Feet From	To	
1	190	110½	0	2	Soil
			2	18	Brown Sand
			18	160	Grey Sand, gravel at 149' (some silty layers from 150')
2	300	222	0	3	Soil
			3	238	Sand, hard packed
			238	242½	Boulder (probably sandstone)
			242½	260	Gravelly sand
3	225	piezometer 158 set at 160'	0	11	Sand
			11	62	Marine drift ?
			62	85	Sand
		piezometer 192 set at 222'	85	165	Gravelly sand
			165	188	Sandy silt
			188	223	Sandy silt, with gravel
			223	260	Sand
			260	265	Sandy silt
			265	275	Sand with gravel
			275	278	Silt
			278	281	Sandy gravel
			281	284	Sandy silt
			284	291	Gravelly sand
			291	295	Sandy silt
			295	300	Sandy gravel
4	275	more than 228	0	1	Soil
			1	97	Till
			97	132	Sand
			132	208	Sand, very compact
			208	225	Silty sand
			225	230	Sand with gravel
			230	237	Silt
			237	241	Silty sand with little gravel.
5	303	piezometer dry set at 276'	0	48	Till or marine drift
			48	270	Compact gravelly sand, gravel lenses in upper part
		piezometer 283 set at 320'	270	320	Sand with few silty layers
			320	341½	Very fine sand
Test Well	305	285	0	4	Soil
			4	48	Till or marine drift
			48	271	Sand and Gravel
			271	273	Silty clay
			273	310	Sand and gravel
			310	314	Med. to fine silty sand, some clay
			314	328	Med. to fine silty sand, rounded pumice grains from about 325'.
			328	346	Very fine silty sand with some fine pumice particles. Dark brown compact clay silt at 346'.

Analysis of Pumping Test Data at Point Grey

This pumping test was not carried out under ideal conditions as the observation well, Hole 5 of the test drilling program was too far from the test well to show appreciable drawdown. This was the fault of the writer who laid out the holes. If the pumping test had been carried out at a higher pumping rate, the hole spacing would have been acceptable.

The pumping test was carried out using a small Monarch submersible pump run on power from a portable engine generator set. The pump was placed in the well at the top of the screen riser on 2" pipe. The pumping rate was measured using a watch and a five gallon (Imperial) pail. The rate was constant throughout the test. The engine generator was shut off for about 30 seconds about midway in the test in order to check the oil in the engine. This did not disturb the test results.

Under these conditions namely, negligible drawdown in the observation hole, the best method of analysis of the data is by using the Theis modified recovery formula. This method uses a model in which the recovering well after stopping pumping is equivalent to a recharging well at the same location recharging at the same rate. Under these conditions, the equation for residual drawdown is an exponential differential equation which may be represented by an infinite series in which all but the first two terms become very small after times t and t' become large. t and t' are the times from the start and end of pumping respectively.

The approximation is $T = 264\,Q \dfrac{\log_{10} \frac{t}{t'}}{s'}$

in which

- T = transmissibility of the aquifer in gal/day/ft width
- Q = pumping rate in gal/min.
- s' = residual drawdown at any time in ft.
- t = time since pumping started in days
- t' = time since pumping stopped in days

By plotting $\log_{10} \frac{t}{t'}$ versus s', the slope of the curve = $\dfrac{T}{264Q}$

This is most easily done using semi log paper when for one log cycle $T = \dfrac{264Q}{\Delta s'}$

The recovery data for the well have been plotted on Sheet I. The part of the curve when the quantity $\frac{t}{t'}$ is less than 250 is a straight line, the slope of which is related to T.

From this

$$T = \frac{264Q}{\Delta s'} = \frac{(264)(27)}{.05} = 1.43 \times 10^5.$$

This is a fairly high transmissibility but is reasonable.

By this method S, the coefficient of storage may not be determined.

The data from the observation hole have been plotted on Sheet II. During the test, the level in this hole increased. This increase is believed to be due to an increase which was underway before pumping started. Unfortunately, we have no observations for the period before the test started or for long after the pumping was stopped so there is some uncertainty about this. However, curve A has been drawn to represent the assumed natural trend of the water level in this hole. Curve B has been drawn to represent the assumed effect of pumping. The drawdown due to pumping at any time will, therefore, be the difference between these two curves. If these assumptions are correct, curve B shows the expected response to stopping of the pumping.

An attempt was made to use these data to determine T using the Theis modified non equilibrium formula which is similar to that used in the analysis of the recovery data. This is:

$$T = \frac{264Q \left(\log_{10} \frac{t_2}{t_1}\right)}{s_2 - s_1}$$

where s_1 is the drawdown in the observation well at time t_1 and s_2 is the drawdown in the observation well at time t_2.

By plotting log t versus s or t versus s on semi-log paper $T = \dfrac{264Q}{\Delta s}$ where Δs is changed to s when $\log_{10} \frac{t_2}{t_1} = 1$, i.e. over one log cycle.

See sheet III

$$T = \frac{(264)(27)}{(.063)} = 1.12 \times 10^5$$

This is very close to the value of T computed from the recovery data which is 1.43×10^5.

The equation for drawdown for equilibrium conditions which approximately prevail after a long period of pumping is:

$$s = \frac{Q}{4\pi T} \log_{10} \frac{(.3)\ Tt}{r^2 s}$$

where r = distance of observation well from pumped well in feet and s = coefficient of storage for aquifer expressed as decimal fraction projecting the line back to s = 0

$$s = 0 = \frac{Q}{4\pi T} \log_{10} \frac{.3T\ t_o}{r^2 s}$$

$$\frac{.3\ T\ t_o}{r^2 s} = 1 \qquad S = \frac{.3\ T\ t_o}{r^2} = \frac{(.3)(1.4)\ 10^5\ \frac{(370)}{(1440)}}{(225)^2}$$

S = .21 which is reasonable for porosity of sands.

Using the non-equilibrium formula, $s = \left[\frac{114.6\ Q}{T}\right] Wu$

where Wu is the "well function of u" and $u = \frac{1.87\ r^2 s}{Tt}$ the calculated drawdown is much less than that encountered in the well indicating that well losses are fairly high. This may be explained in a number of ways.

This well is only a partly penetrating well so that vertical flow becomes important lengthening the flow path causing additional drawdown. In the mathematical model the ideal aquifer is assumed to the isotropic. The well log and an examination of the exposures along the beach bluffs indicates that the aquifer is probably quite anisotropic, the vertical permeability being much lower due to the presence of numerous silt and clay silt layers of low permeability. In the case of a partially penetrating well where vertical flow becomes important, this anisotropy probably causes high head losses near the well.

The total thickness of the aquifer is unknown. We know that there are compact silt beds at about 346 but these may be thin and the total aquifer may extend well below this depth; this could account for the high transmissibility.

From this analysis, we may conclude that the well will safely produce whatever amount of water will not cause excessive drawdown in the well. The maximum drawdown should probably not be below the top of the screen at 308'. With a normal static level of about 285' this gives a permissible drawdown of 23'. Pumping at 27 gallons per minute (Imperial) caused a drawdown after the second period of development of about 4½' so the yield at 23' of drawdown would probably be about 135 gallons per minute.

In order to allow an adequate factor of safety the capacity of the pump should not be more than 75 gallons per minute (Imperial).

As mentioned earlier, this pump test was considered a preliminary test as the capacity of the well was unknown and the large test pump owned by Pacific Water Wells was in use elsewhere. If only 75 gallons per minute is sufficient, production from this well the test described in this report is sufficient. If larger production in the order of 100 gallons per minute is desired, the well should be tested at a higher rate before selecting a production pump.

May 28, 1963

E. Livingston
Geological Engineer

PUMPING TEST DATA - POINT GREY WELL - May 8/9, 1963

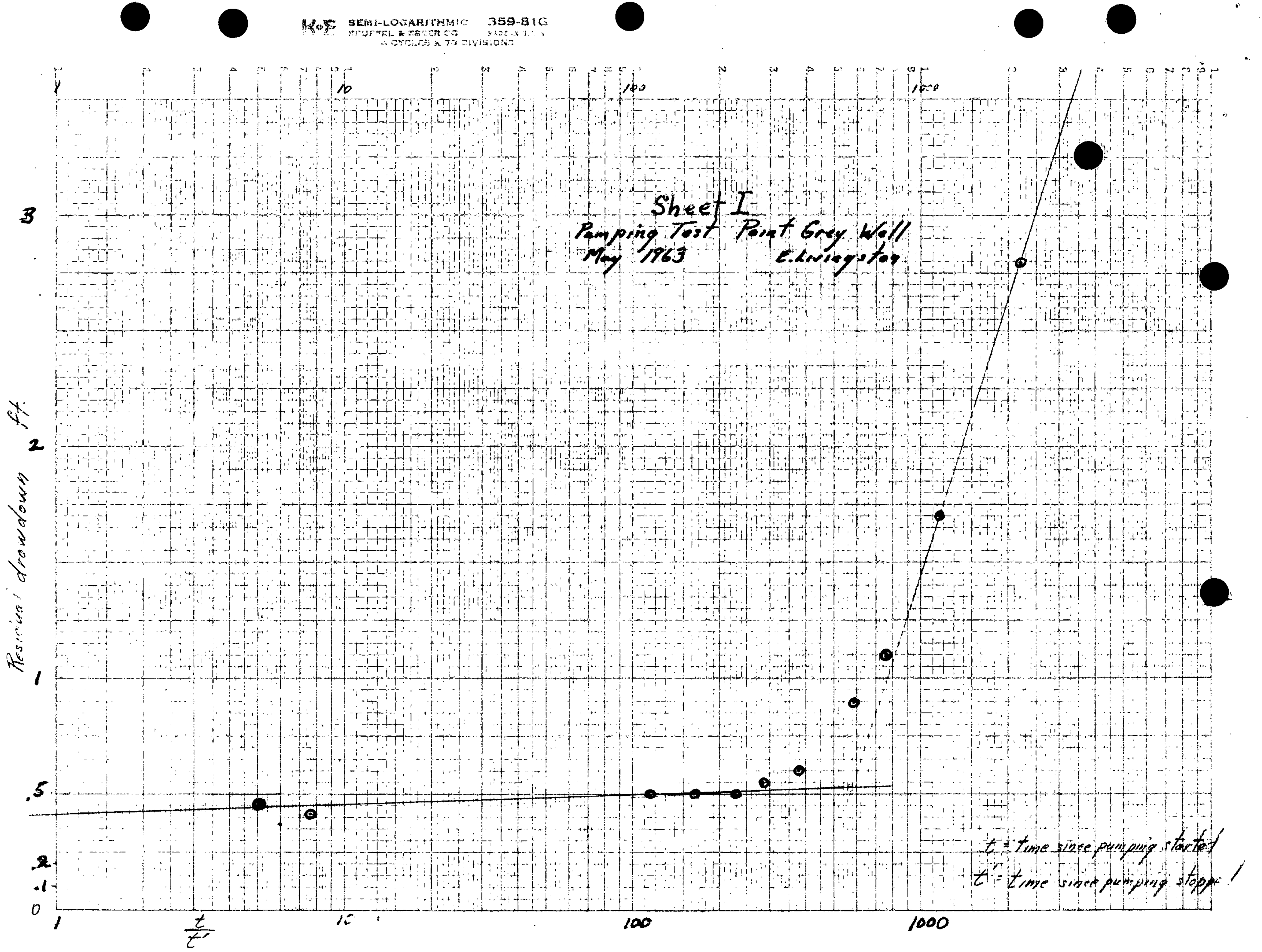
Time	Time since start, min.	Level Well	Level Hole 5	Drawdown Well	Time since stop	Residual Drawdown	Time-start Time-stop	Adjusted drawdown Hole 5
1:29 PM		285.2	283.76	0				0
1:30	0	285.2		0				
1:31	1	288.1		2.9				
1:32	2	289.0		3.8				
1:33	3	289.4		4.2				
1:34	4	289.5		4.3				
1:35	5	.6		4.4				
1:37	7		283.75					
1:39	9	.8		4.6				
1:43	13	.85		4.65				
1:46	16	.85						
1:49	19	.85		4.7				
1:58	28		283.75					
2:02	32	.90		.70				
2:04	34	.90						
2:15	45	.95		.75				
2:25	55	.95						
2:35	65	90.00		4.8				
2:45	75	.00						
2:50	80	.00						
3:00	90	90.05		4.85				
3:15	105	.05						
3:30	120	.10		4.90				
3:45	135	.10	283.74					
4:00	150	.10						
4:30	180	.10	283.73					
6:00	270	.10	.73					
7:15	345	.13	.71	4.93				
7:45	375	.15	.72	4.95				
8:30	420	.10	.72	4.90				
10:00	510	.15	.72	4.95				
11:00	570	.15	.72	.95				.01

Pumping rate
continuous
27 g.p.m.
(Imperial)

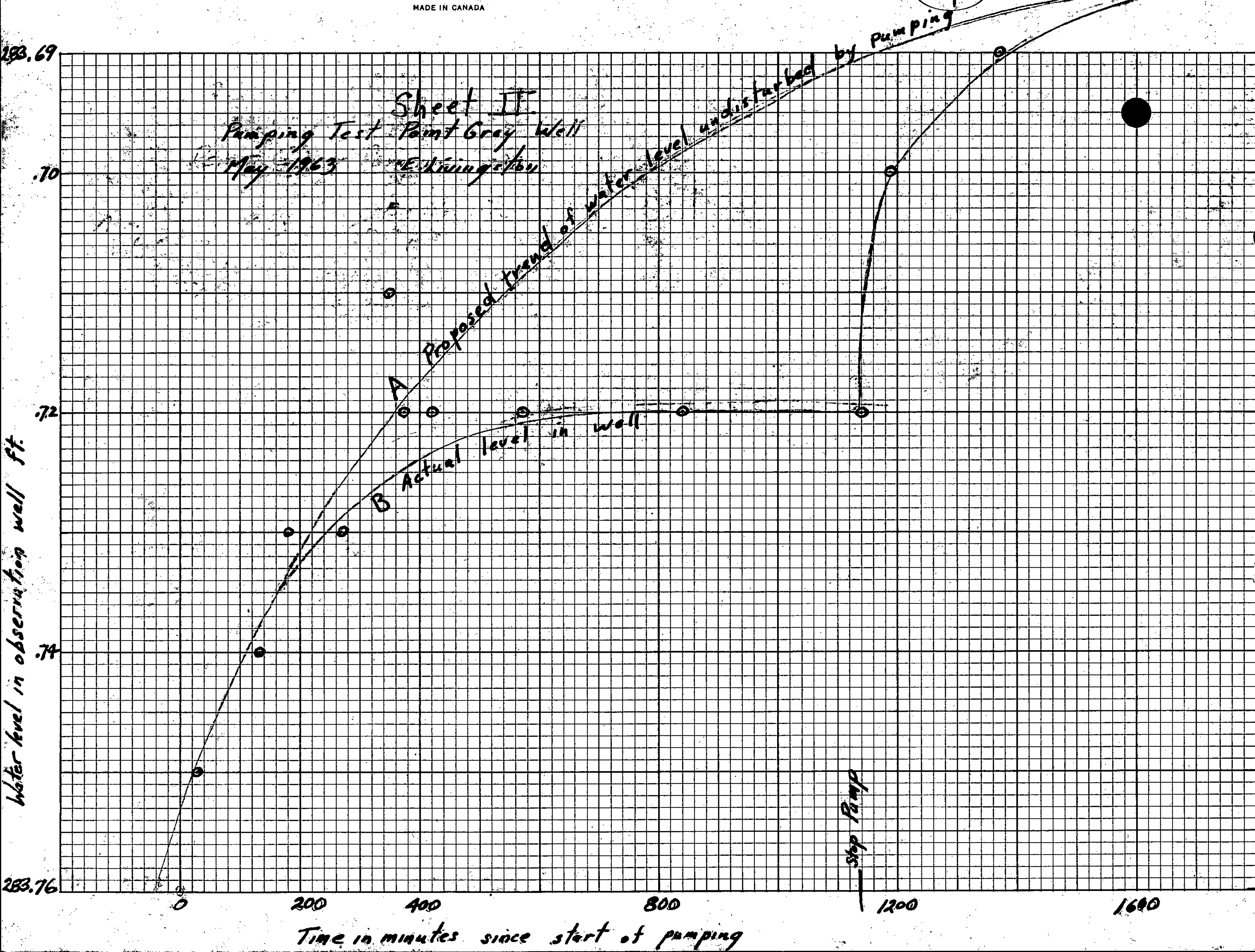
Time	Time since start, min.	Level Well	Level Hole 5	Drawdown Well	Time since stop	Residual Drawdown	Time-start Time-stop	Adjusted draw-down Hole 5	
12:30 AM	660	.20	.72	5.00					
2:30	780	.15	.72	4.95				.02	Pumping rate contin-
3:00	810	.20	.72	5.00					
3:30	840	.25	.72	5.05				.025	uous 27 g.p.m. (Imp-
5:00	930	.30	.72	5.1					
8:00	1110	.30	.72	5.1				.029	erial)
8:30	1140	.30	.72	5.1				.03	
									Stop Pump
8:30½	1140½	288.0			½	2.8	2280		
8:31	1141	286.9			1	1.7	1141		
8:31½	1141½	286.3			1½	1.1	760		
8:32	1142	286.0			2	.8	571		
8:33	1143	285.8			3	.6	380		
8:34	1144	285.75			4	.55	286		
8:35	1145	.70			5	.50	229		
8:37	1147	.70			7	.50	163		
8:40	1150	.70			10	.50	115		
11:05	1175	.64			155	.42	7.6		
11:15	1185		283.70						
12:45 PM	1275	.67			255	.47	5.		
2:15	1365		283.69						

APPENDIX II (cont'd)

11


K&E SEMI-LOGARITHMIC 359-81G
KEUFFEL & ESSER CO. MADE IN U.S.A.
4 CYCLES X 70 DIVISIONS
Sheet I
Pumping Test Point Grey Well
May 1963
E. Livingston
Residual drawdown ft.
3
2
1
.5
.2
.1
0
1
10
100
1000
t/t'
t = time since pumping started
t' = time since pumping stopped

G9-5D
10 X 10 TO THE INCH
MADE IN CANADA



MICROGRAPH

G9-71
SEMI LOGARITHMIC
3 CYCLES X 70 DIVISIONS