926-7-22

COPY

February 12, 1992

MacLeod Geotechnical Ltd.
Suite G - 1451 Marine Drive
West Vancouver, B.C.
V7T 1B8

Attention: Mr. Ernie Naesgaard, P. Eng.

Subject: Lakeside Terrace Development
Lot A, 1189 Westwood
Coquitlam, British Columbia
Dewatering Testing and System Design

Dear Sirs:

An 8-inch diameter dewatering test well has been drilled, screened, developed (cleaned) and tested. This well is located in the centre and slightly inside of the north boundary of the subject site. It was drilled to a depth of 46 feet. Please see the log of this well attached.

A 550 minute pump test was conducted at a constant rate of 143 U.S. gpm. Water level drawdown measurements were taken and recorded during pumping and recovery water levels were measured and recorded for 100 minutes after pumping was terminated. Semi-logarithmic plots of the readings taken in the pumping well and in six piezometers located in the northern part of the site showed that the effective transmissivity (field permeability) of the main water-bearing zone lying between depths of 20 and 38 feet was approximately:

Transmissivity T = 20,000 U.S. gallons per day per foot
Permeability K = $20,000/18 \times 4.716 \times 10^{-5}$
= 0.052 centimeters per second

Much higher transmissivities in the 50,000 to 100,000 U.S. gpd/ft range were present within the first hour of the test before the drawdown cone of influence around the pumping well was widely established.

The drawdown water levels in the piezometer located approximately 32 feet from the pumping well showed that the storativity of the water-bearing zone was 0.12. This shows that the effective porosity and water content of the water-bearing zone approximates 12%.

The construction dewatering system must produce a groundwater drawdown of 12.5 feet as calculated below:

Measurements of groundwater levels taken during the winters of 1990-91 and 1991-92 indicate:

Rain Conditions	Groundwater Elevations Feet		
	North-east Corner	North Central	North-west Corner
Winter Storm (estimate)	106	106	103
Winter Rainy Season (measured)	104	104	101
Summer-Fall Season	Below 98	Below 98	Below 98

From the above the required drawdowns can be calculated:

Winter Storm Groundwater Level	Elevation Feet		106.0
Top of Floor Slab	Elevation		98.5
Maximum Depth of Winter Storm Caused Groundwater			7.5
Plus - Thickness Floor Slab and drainage layer		1.0	
- Depth of drainage trench		4.0	5.0
Total Drawdown required after Winter Storms	Feet		12.5

The transmissivity and storativity calculations derived from the pump test data indicate that seven dewatering wells each discharging at a rate of 106 U.S. gpm for a total discharge of 742 U.S. gpm (618 Igpm or 47 l/sec.) will achieve the 12.5 feet of drawdown required after winter storms.

The drawdown required during the winter rainy season will be two feet shorter at 10.5 feet. The discharge needed to achieve this amount of groundwater lowering will be:

Each Well	89 U.S. gpm
Seven Well System	623 U.S. gpm (519 Igpm or 39 l/sec.)

A further refinement of these discharge figures can be made by assuming that the drawdowns required from the three western dewatering wells will be three feet lower than those required for the four eastern wells (please see estimated and measured groundwater elevations above). Thus to obtain the 12.5 feet of drawdown from the four eastern wells and 9.5 feet of drawdown from the three western wells the total discharge from the system would become:

106.0 x 4 =	424.0
80.5 x 3 =	241.5
Total	665.5 U.S. gpm (555 Igpm or 42 l/sec.)

We do not believe that existing hydrogeologic data is sufficient to warrant the use of the above 665.5 U.S. gpm figure. For planning purposes the 742 U.S. gpm figure should be used until the result of contruction dewatering becomes available.

The 12.5 feet of drawdown with a total discharge of 742 U.S. gpm (106 x 7) during storm high groundwater levels assumes that the transmissivity (field permeability) of the water-bearing zone along the north boundary is constant at 20,000 U.S. gpd/ft. It would be prudent to locate the first two wells of the construction dewatering system at each end of the north side of the site to evaluate any hydrogeologic changes so that the number and locations of the remaining wells can be set to conform with the actual detailed field conditions across the full width of the site.

Based upon information and data presently available seven wells each discharging at a rate of 106 U.S. gpm for a total discharge of 742 U.S. gpm will lower the winter storm caused high groundwater level the required 12.5 feet and provide a "workably dry" excavation including five foot deep trenches.

Drainage pipes located five feet below the floor slab will keep the basement "dry" on a "permanent" basis. The drainage pipes should be contained within three, drain gravel filled trenches located close to the north boundary and on one hundred foot

centres south of the boundary of the site. This spacing might change after groundwater conditions and the transmissivity (field permeability) across the whole north side of the site are known.

After the drainage trench and piping systems are in place and operating properly the required winter storm induced drawdown to the Floor Slab will drop to 7.5 feet. The discharge rate needed to maintain this groundwater level has been calculated to be:

445 U.S. gpm (371 Igpm or 28 l/sec.)

This should be the total maximum discharge from the long term "permanent" dewatering system required to control the groundwater levels caused by winter rain storms.

The drilling and testing of the next two wells and the drilling of the remaining four wells will take an estimated one month to complete on a one rig one shift per day basis.

If any of the above needs amplification or clarification please do not hesitate to call the writer at 926-0184.

Yours truly,

BROWN, ERDMAN & ASSOCIATES

W.L. Brown, P. Eng.

WLB/mt
Encl.

WTN 108060

LAKESIDE TERRACE DEVELOPMENT

DEWATERING WELL

COQUITLAM, BRITISH COLUMBIA

Ground Surface Elevation: 107.2 feet

Depth Feet	**Lithology**
0 - 20	Sand and gravel
20 - 38	Sand, medium to coarse grained and gravel, fine, water-bearing static water level 6.1 feet below ground
38 - 46	Sand, fine to medium, silty water-bearing

Casing and Screen Record

Depth Feet	**Casing and Screen**
+2 to 28.25	8-inch diameter casing
28.25 to 30.25	7-inch diameter casing
30.25 to 35.50	8-inch telescopic diameter screen with 60/1000 inch slots
35.50 to 38.50	7-inch diameter casing
38.50 to 43.75	8-inch telescopic diameter screen with 10/1000 inch slots

Feb 10-11, 1992

LAKESIDE TERRACE

Pump Test Feb 6, 1992.

Use $T = 20{,}000$ US gpd/ft Sp Cap 5.3 USgpm/ft dd

$S = 0.12$

$Q = 100$ US gpm

$t = 10$ days

$S/T = 0.12/20000 = 6 \times 10^{-6}$

$Q/T = 100/20000 = 0.005$

u	K	DD
1	1520	7.6
10	1000	5.0
100	470	2.9

Use $T = 10000$ US gpd/ft

$S = 0.1$

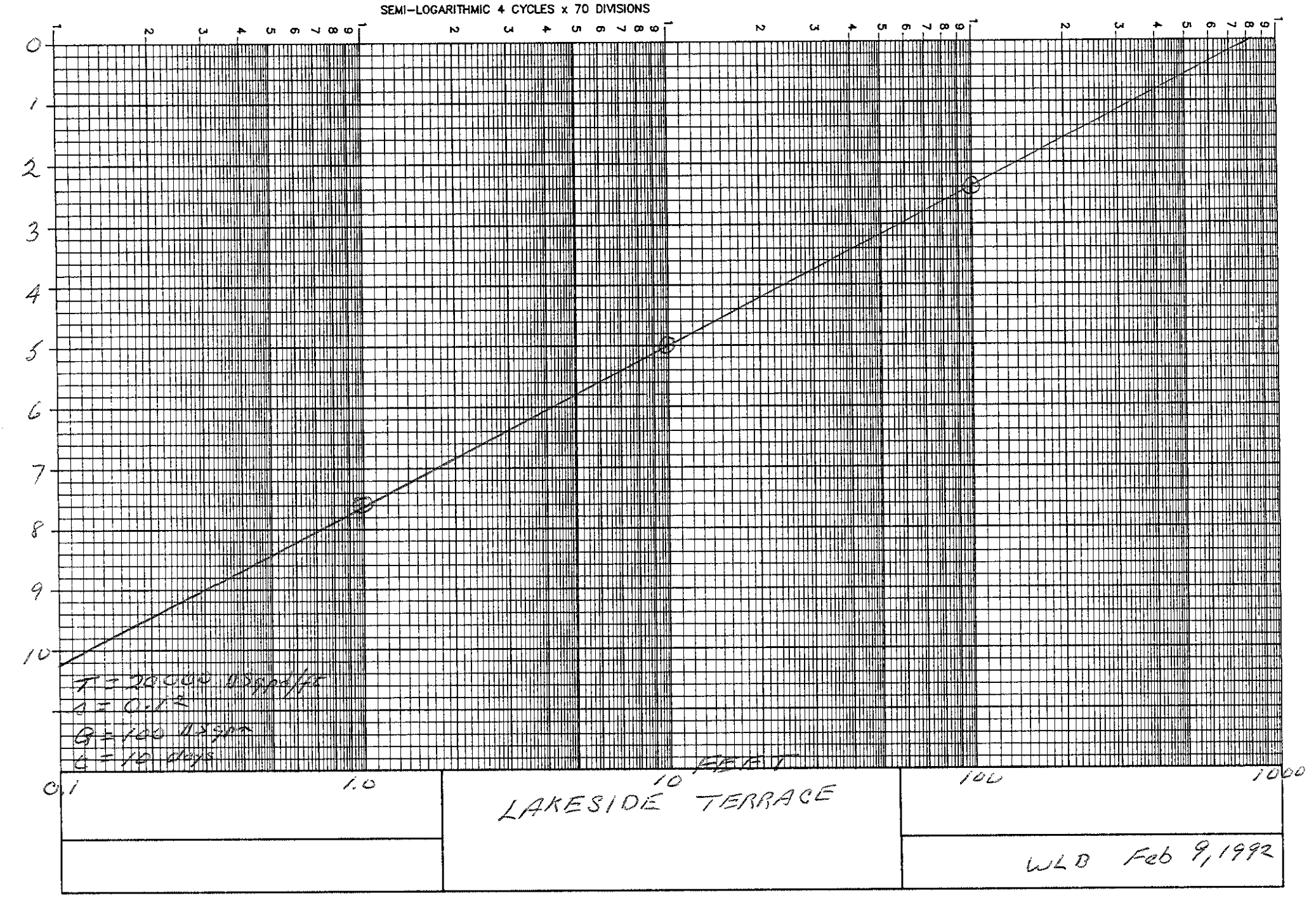
$Q = 100$ US gpm

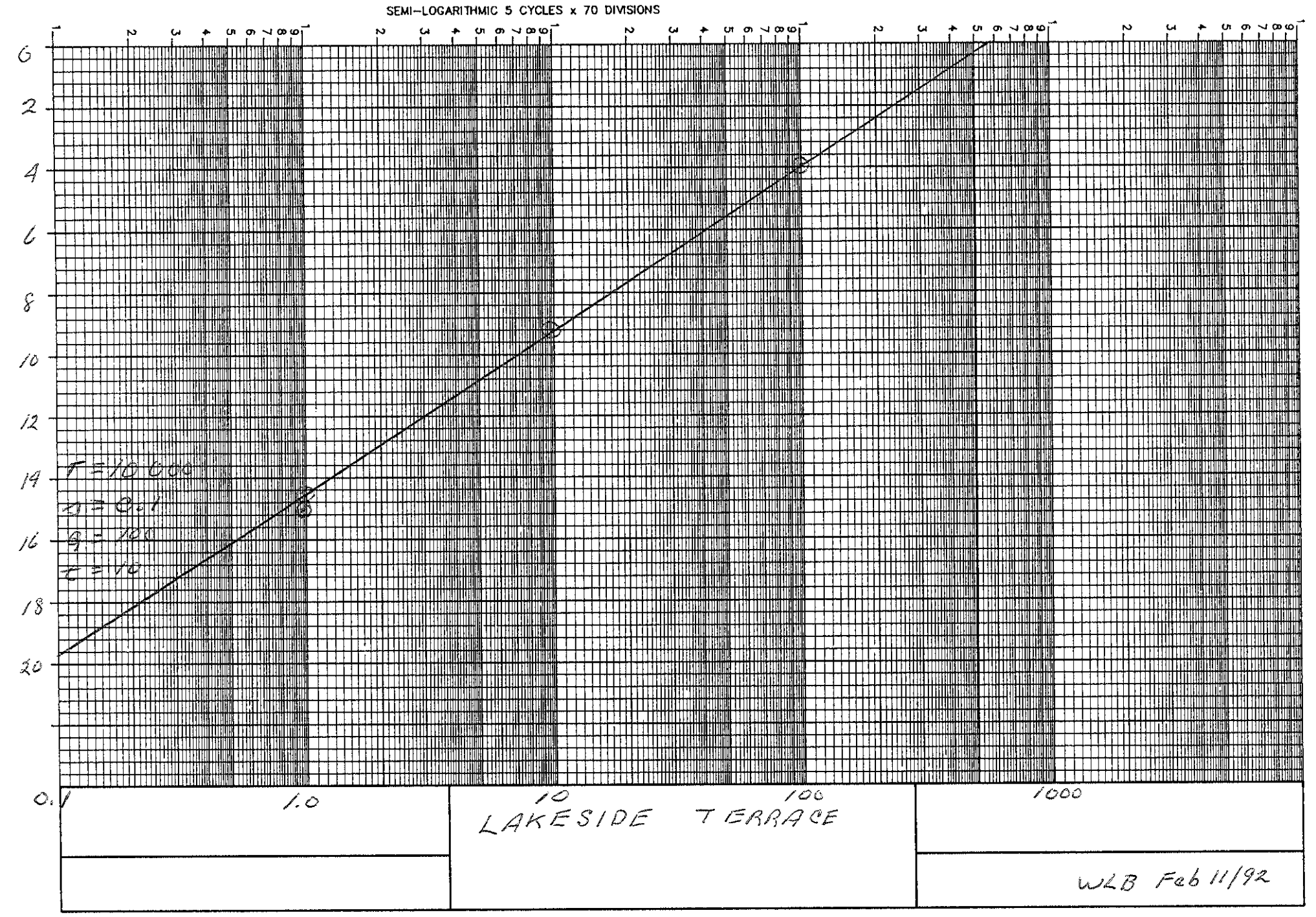
$t = 10$ days.

$S/T = 0.1/10000 = 1 \times 10^{-5}$

$Q/T = 100/10000 = 0.01$

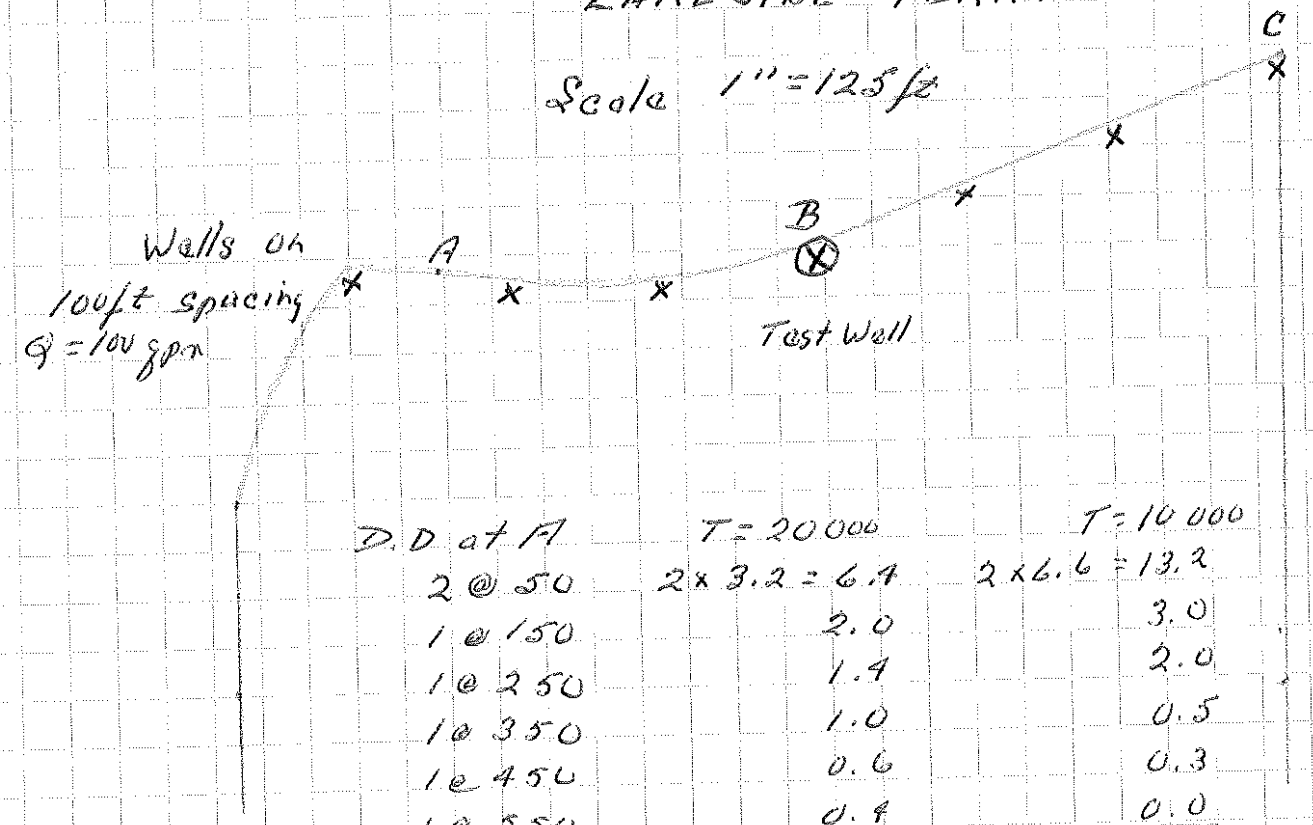
u	K	DD
1	1450	14.5
10	920	9.2
100	390	3.9


SEMI-LOGARITHMIC 4 CYCLES x 70 DIVISIONS
T = 20,000 USgpd/ft
S = 0.1 ±
Q = 100 USgpm
t = 10 days
0.1
1.0
10
100
1000
LAKESIDE TERRACE
WLD Feb 9, 1992


SEMI–LOGARITHMIC 5 CYCLES x 70 DIVISIONS
0
2
4
6
8
10
12
14
16
18
20
T = 10 600
η = 0.1
S = 10⁻⁶
r = 10
0.1
1.0
10
100
1000
LAKESIDE TERRACE
WLB Feb 11/92

LAKESIDE TERRACE

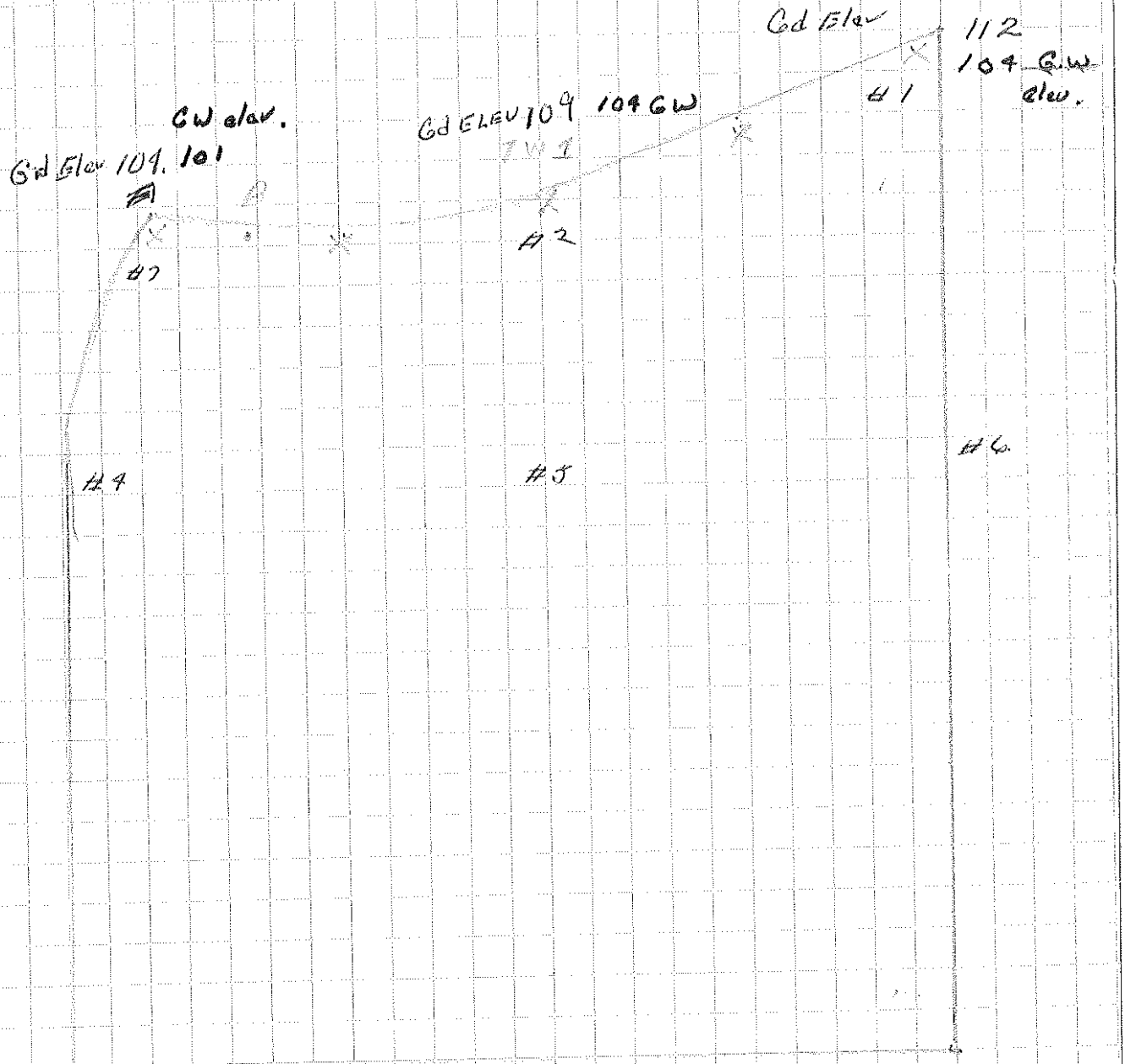
Scale 1" = 125 ft



D.D at A	T = 20 000	T = 10 000
2 @ 50	2 x 3.2 = 6.4	2 x 6.6 = 13.2
1 @ 150	2.0	3.0
1 @ 250	1.4	2.0
1 @ 350	1.0	0.5
1 @ 450	0.6	0.3
1 @ 550	0.4	0.0
	11.8 ft	19.0 ft.

D.D @ B	T = 20000	T = 10,000
2 @ 100	2 x 2.4 = 4.8	2 x 4 = 8.0
2 @ 200	2 x 1.6 = 3.2	2 x 2.4 = 4.8
2 @ 300	2 x 1.2 = 2.4	2 x 1.6 = 3.2
	10.4 ft	16.0 ft.

D D @ C	T = 20 000	T = 10 000
1 @ 100	2.4	4.0
1 @ 200	1.6	2.4
1 @ 300	1.2	1.6
1 @ 400	0.8	0.8
1 @ 500	0.6	0.4
1 @ 600	0.4	0.0
	7.0 ft	9.2 ft



			OD
A	2@ 0.6 inches x 125 scale	2@ 75 ft	2 x 2.7 = 5.4
	1@ 1.9 x 125	238	1.4
	1@ 3.1 x 125	388	0.8
	1@ 4.3 x 125	538	0.4
			8.0 ft.

8" OD at 100 USgpm

Elev W.T - 104 ft
floor 98.5
5.5 ft

High G.WT - 106.5 (104 + 2.5)
floor 98.5
8.0 ft.

Trench 5 ft
13.0 ft

Feb. 10, 1992

LAKESIDE
TERRACE

Scale 1" = 125.0"

High Groundwater ± Elevation — 106.5 feet

Elevation ~~Floor~~ Top Floor Slab — 98.5

Depth Groundwater above Floor Slab — 8.0 feet

Thickness Floor slab and drainage layer — 2.0 feet

Depth of Drainage Trench — 5.0

7.0

Total Amount Drawdown — 15.0 feet

Discharge per well

T = 20,000 — 15/11.8 × 100 = 127 US gpm

T = 10,000 — 15/19.0 × 100 = 79 US gpm

TOTAL DISCHARGE From 7 wells. T = 20000 — 7 × 127 = 889 US gpm

T = 10000 — 7 × 79 = 553 US gpm

Average 720 US gpm

K cm/sec. — 20 000/18 × 4.716 × 10^{-5} = 0.052 cm/sec

10,000/18 × 4.716 × 10^{-5} = 0.026 cm/sec

BROWN, ERDMAN & ASSOCIATES LTD.
NORTH VANCOUVER, BRITISH COLUMBIA

WELL RECORD

OWNER LAKE SIDE TERRACE
ADDRESS
LOCATION
LEGAL
DATE: Start JAN 29 Complete
ELEVATION

FORMATION LOG

FROM	TO	TIME	Q	DESCRIPTION
0	20			SAND n gravel with cobbles Dry
20	38			SAND m/crs GRAVEL Fine w.b. 8.1 fc
38	46			SAND f/crs silty WB 8.1
				Water level From ground 8.1 feet
				OR Elevation 101.1 feet
				Top Screen 30.2 fc
				SWL 8.1
				TADD 22.1
				Pumping Level 34.24
				SWL 7.85
				DD 26.39
				Q = 143 US gpm Sp Cap 143/26.9 = 5.3 US gpm/ft DD

CASING TALLY

LENGTH	TOTAL	LENGTH	TOTAL	LENGTH	TOTAL

SCREEN

TYPE	SS	SS			
LENGTH	5' 2"	5' 3"			
DIA.	8" TS	8" TS			
SLOT	60	10			
FROM	30' 3"	38' 6"			
TO	35' 5"	43' 9"			

PACKER: Depth Top Type
RISER: Dia. From To
SAND PACK
CEMENT
DEVELOP
STATIC WATER LEVEL

CONTRACTOR
DRILLER
RIG
HYDROGEOLOGIST

LAKESIDE TERRACE 6/2/92 PUMPING TEST

SUMMARY

Obs Well	Drawdown T usgpd/ft	Recovery T usgpd/ft	storage
	151,000	80,300	
	40,600	36,300	
	25,000 ←		
	18,000 ←		
P_1	13,600 ← *	X north side	
P_2	125,000	X north side	1.2×10^{-1}
	14,200 *		1.3×10^{-3}
P_3	58,000 ← *	X north side	4.1×10^{-3}
P_4	20,700 ← X		
P_5	68,600 ←		
P_6	44,400		

AVERAGE T = 56,100 USGPD

S in Lower material = 1.2×10^{-1} (Water table)

S in upper material = 1.3×10^{-3} & 4.1×10^{-3} (CONFINED)

BROWN, ERDMAN & ASSOCIATES LTD.
NORTH VANCOUVER, BRITISH COLUMBIA

WELL #1
PROJECT LAKESIDE TERRACE

6 2 92
DAY MO YR

TIME	ELAPSED TIME MINUTES	DEPTH TO WATER ☒ FEET ☐ METERS	DRAWDOWN ☐ FEET ☐ METERS	RATE ☒ USGPM ☐ IGPM ☐ LPS	P_2	P_3	REMARKS P_4	P_5	P_6	P_1
08:00		7.85	S.W.L 5/2/92		8.30	7.50	20.41	19.62	11.95	11.12
08:30	0	8.10			9.06	8.13	21.16	20.12	12.58	11.83
	.5	29.50								
08:31	1	31.10								
	1.5	32.20								
08:32	2	32.40								
	2.5	32.40								
08:33	3	32.45								
	3.5	32.54								
08:34	4	32.50		143						
	4.5	32.60								
08:35	5	32.64								
08:36	6	32.70			9.70					
08:37	7	32.70								
08:38	8	32.72								
08:39	9	32.75								
08:40	10	32.76								
08:42	12	32.77								
08:44	14	32.80			9.75					
08:46	16	32.80								
08:48	18	32.84								
08:50	20	32.80		143						
08:55	25	32.84								
09:00	30	32.90			9.85					
09:05	35	32.88								
09:10	40	32.88			9.89					
09:15	45	33.00								
09:20	50	33.00								
09:30	60	33.04			9.95	8.30	21.65	20.15	12.66	12.20
09:40	70	33.20								
09:50	80	33.18								
10:00	90	33.21								
10:10	100	33.28								
10:35	125	33.31								
11:00	150	33.41			10.50	8.50	21.32	20.16	12.64	12.70

BROWN, ERDMAN & ASSOCIATES LTD.
NORTH VANCOUVER, BRITISH COLUMBIA

WELL #1
PROJECT LAKESIDE TERRACE

6 2 92
DAY MO YR

TIME	ELAPSED TIME MINUTES	DEPTH TO WATER ☑ FEET ☐ METERS	DRAWDOWN ☐ FEET ☐ METERS	RATE ☑ USGPM ☐ IOPM ☐ LPS	P_2	P_3	REMARKS P_4	P_5	P_6	P_7
11:50	200	33.50		143						
12:40	250	33.67			10.74	8.51	21.18	20.10	12.71	12.91
13:30	300	33.72								
14:20	350	33.90			11.06	8.68	21.23	20.16	12.84	13.00
15:10	400	33.92								
16:00	450	34.13			11.30	8.93	21.30	20.20	12.91	13.24
16:50	500	34.16								
17:40	550	34.24			11.50	8.76	21.32	20.25	13.00	13.36

ELEVATIONS
GROUND 107.2
Top of Casing 109.3
M.P. 109.9

BROWN, ERDMAN & ASSOCIATES LTD.
NORTH VANCOUVER, BRITISH COLUMBIA

WELL #1
PROJECT LAKESIDE TERRACE

6 2 92
DAY MO YR

TIME	ELAPSED TIME MINUTES	DEPTH TO WATER ☒ FEET ☐ METERS	DRAWDOWN ☐ FEET ☐ METERS	RATE ☒ USGPM ☐ IGPM ☐ LPS			REMARKS
17:40	550	34.24		143			
	PUMP OFF	T/T'					
	0.5	14.80	1101				
17:41	1	10.92	551				
	1.5	10.32	368				
17:42	2	10.24	276				
	2.5	10.12	221				
17:43	3	10.08	184				
	3.5	10.02	158				
17:44	4	10.00	138				
	4.5	9.94	123				
17:45	5	9.94	111				
17:46	6	9.92	93				
17:47	7	9.90	79				
17:48	8	9.88	70				
17:49	9	9.86	62				
17:50	10	9.82	56				
17:52	12	9.82	47				
17:54	14	9.78	40				
17:56	16	9.80	35				
17:58	18						
18:00	20	9.75	28				
18:05	25	9.71	23				
18:10	30	9.68	19				
18:15	35	9.66	17				
18:20	40	9.64	15				
18:25	45	9.62	13				
18:30	50	9.60	12				
18:40	60	9.56	10				
18:50	70	9.54	8.8				
19:00	80	9.50	7.9				
19:10	90	9.48	7.0				
19:20	100	9.46	6.5				

LAKE SIDE TERRACE

WATER Levels (static 6-2-92) Elevations

P_1	101.77'	
P_2	101.64'	$\sim$ = 32'/r to purged well
P_3	97.67'	$\sim$ = 27'/r to purged well.
P_4	84.64'	
P_5	86.78'	
P6	98.67'	
Well	101.8'	

LAKESIDE TERRACE, COQUITLAM

PRELIMINARY PIEZOMETER READINGS (January 9, 1992

Piezometer Number	Collar Elevation (feet)	Depth from collar to water level, feet			Groundwater Elevation (feet)		
		Dec 6 91	Dec 19 91	Dec 29 91	Dec 6 91	Dec 19 91	Dec 29 91
1	113.6	9.42	9.58	11.25	104.18	104.02	102.35
2	110.7	6.67	6.83	9.17	104.02	103.85	101.53
3	105.9	4.88	5.25	7.33	101.02	100.65	98.57
4	104.4	8.83	9.25	13.00	95.57	95.15	91.40
5	[illegible]	11.29	11.67	15.67	95.57	95.19	91.19
6	110.5	9.17	9.42	n/a	101.33	101.04	n/a

well GROUND 109.2
top of casing 109.8
measuring point 109.9

Lakeside Terrace
Observation Pumping well
6/2/92
RBC

$T = \frac{264 \times 143}{0.93} = 40,600$ USgpd/ft

$T = \frac{264 \times 143}{0.65} = 151,000$ USgpd/ft

$T = \frac{264 \times 143}{2.1} = 18000$

$T = \frac{264 \times 143}{1.5} = 25,000$ USgpd/ft

DEPTH TO WATER (FEET)

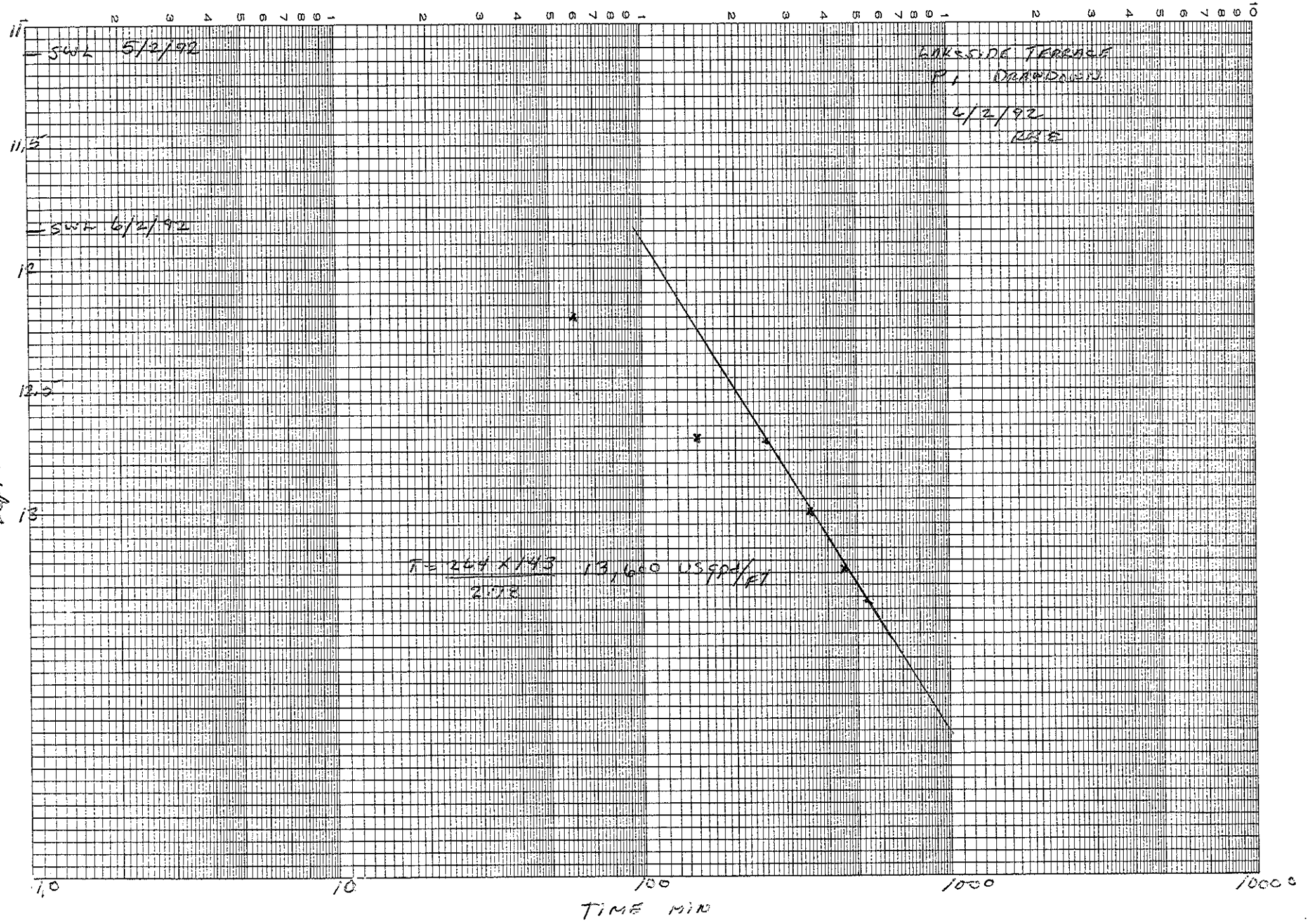
29
30
31
32
33
34
35

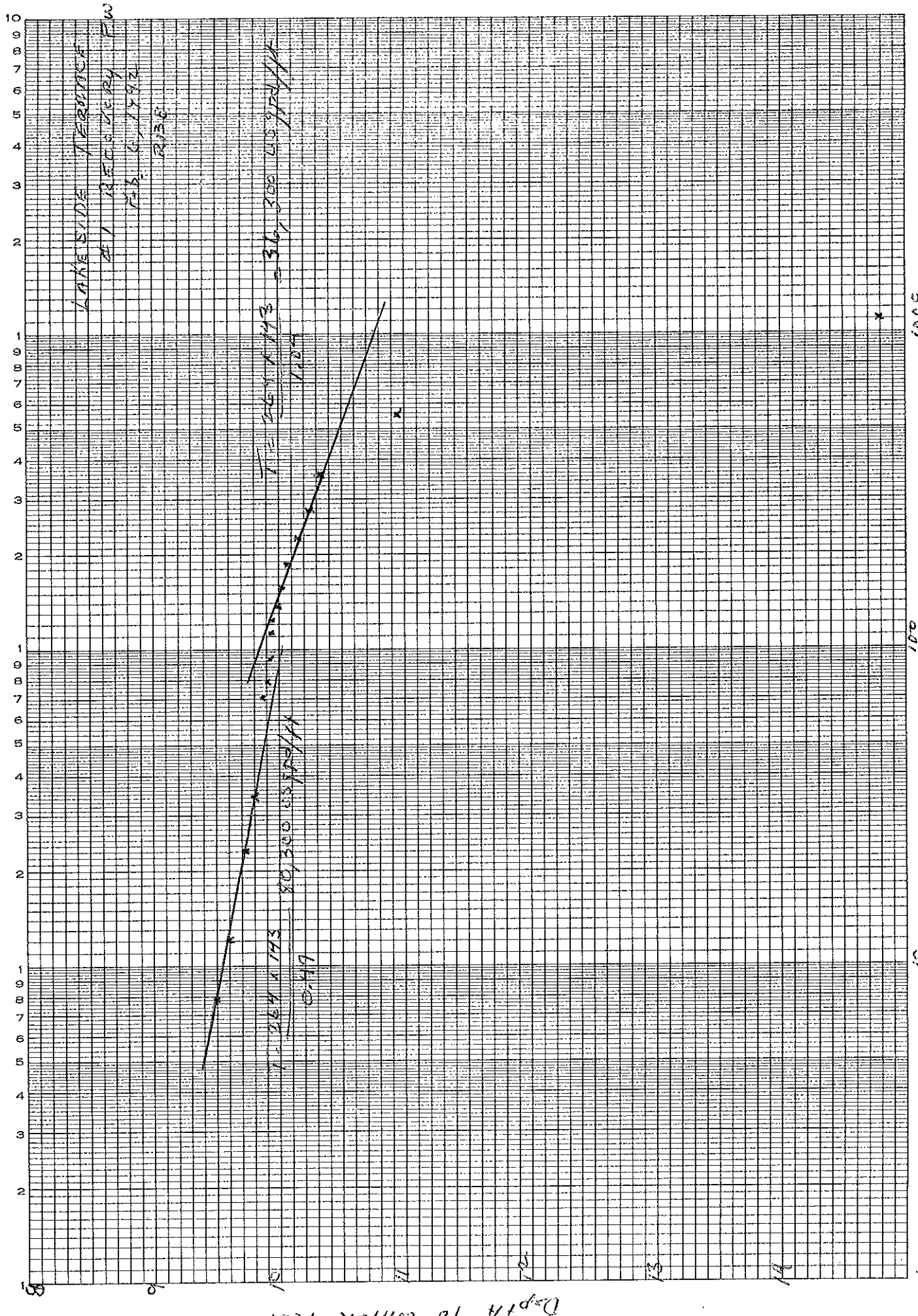
1.0
10
100
1000

TIME MIN

NO. 340-L410 DIETZGEN GRAPH PAPER
SEMI-LOGARITHMIC
4 CYCLES X 10 DIVISIONS PER INCH

DIETZGEN CORPORATION
MADE IN U.S.A.





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4 CYCLES X 10 DIVISIONS PER INCH

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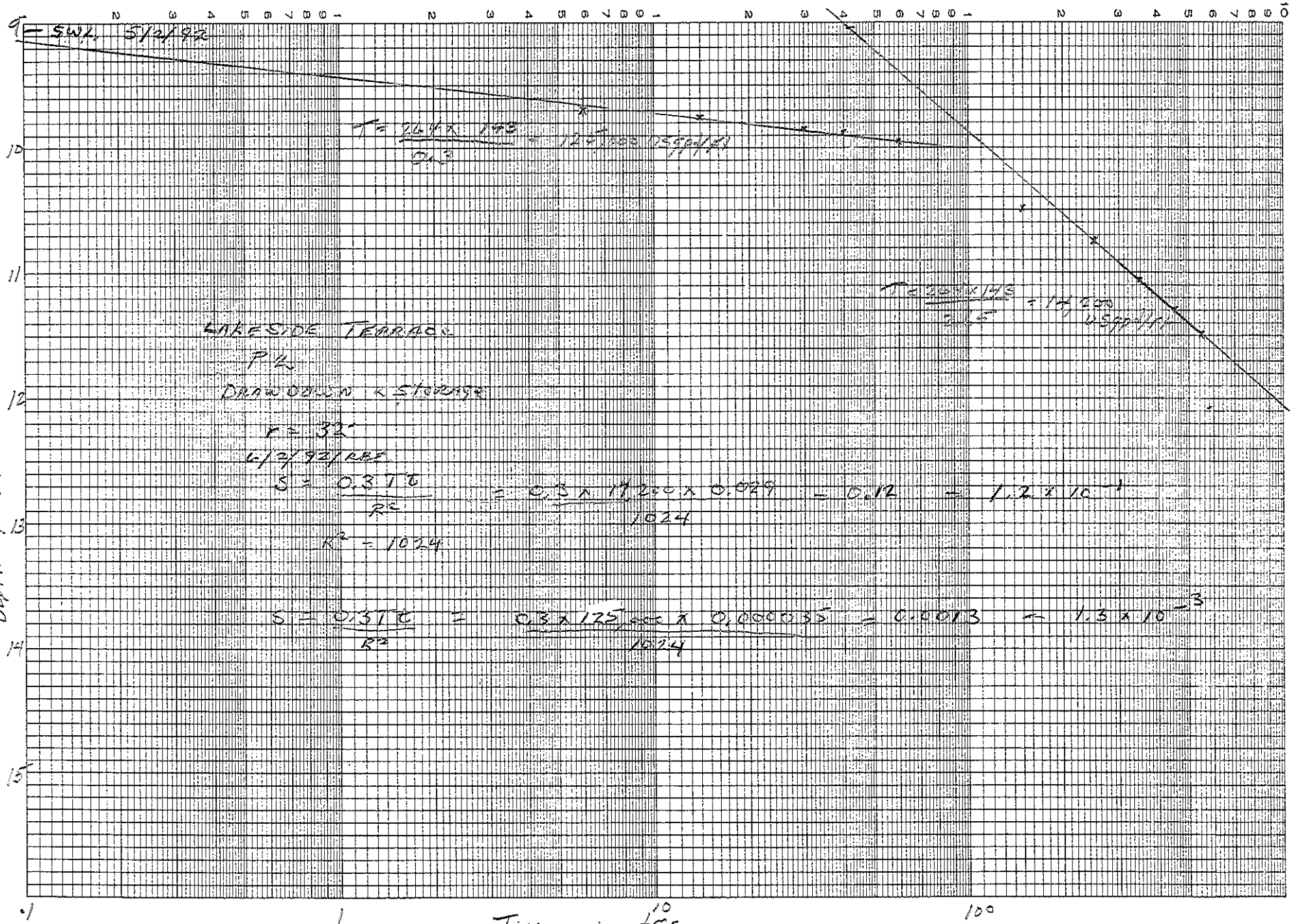
SWL 8.3 6/2/92



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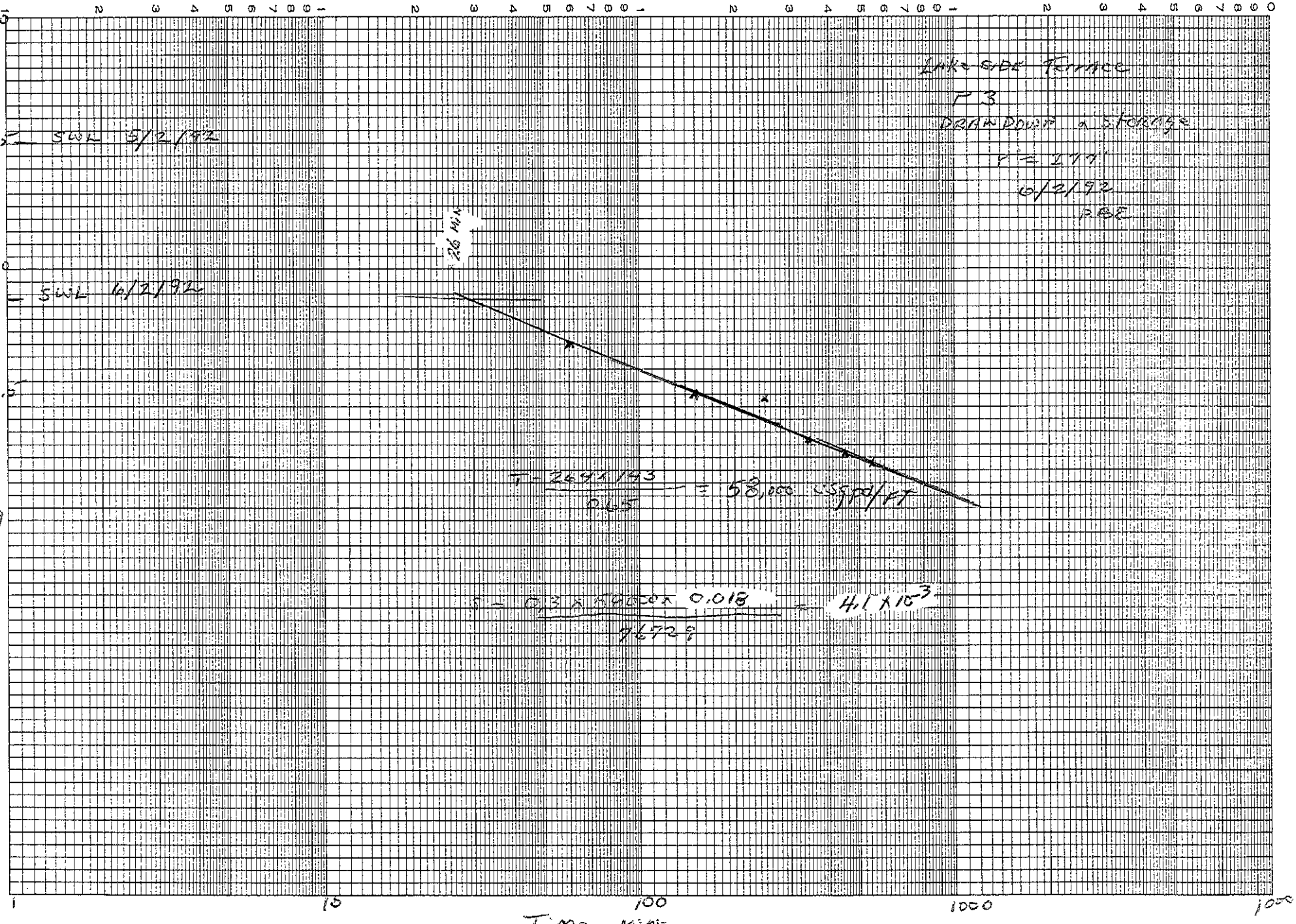

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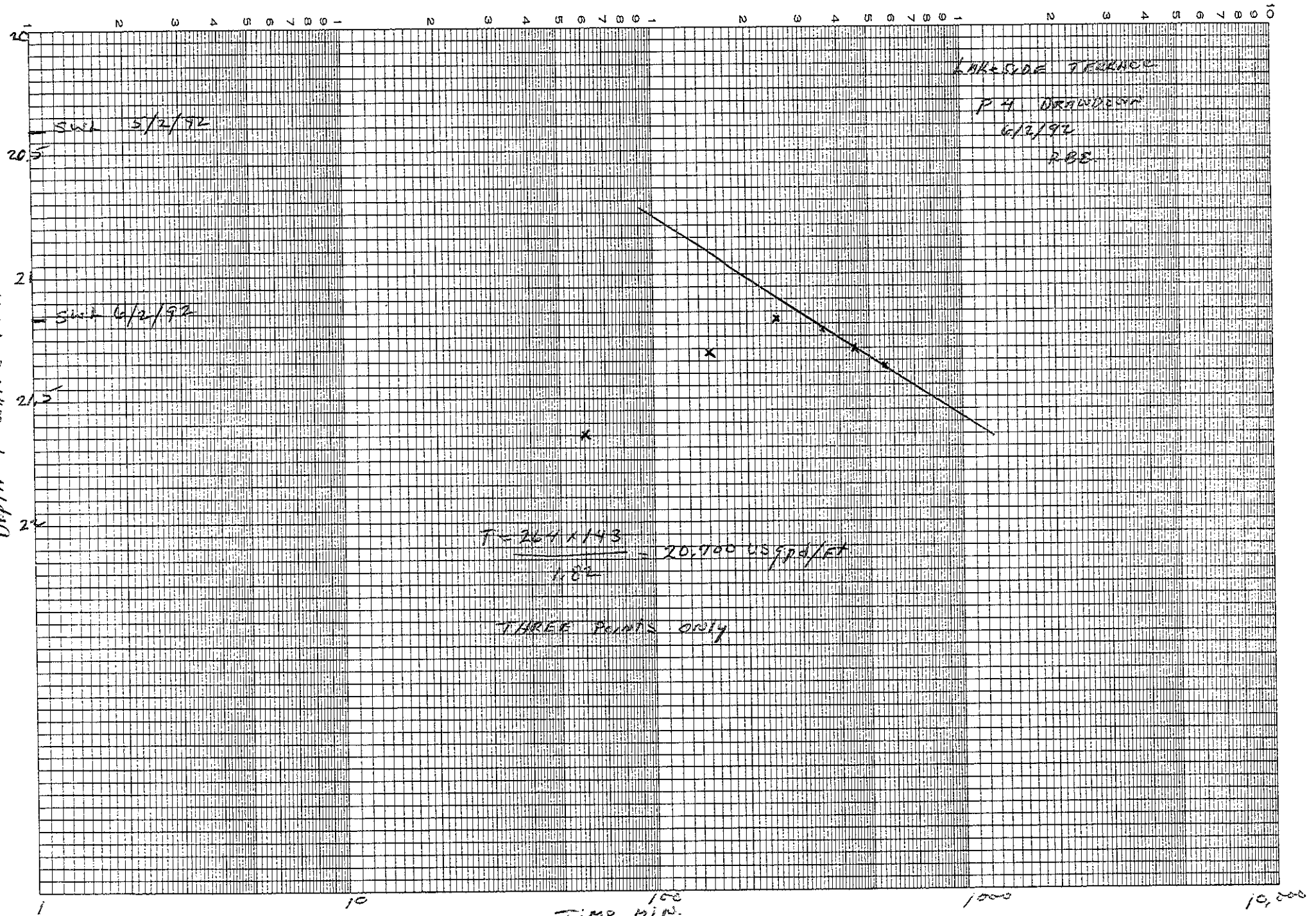

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