1985-10-01

DRAFT

AQUIFER TESTING AT PERSON STATION
JULY AND AUGUST, 1985

PREPARED FOR

PUBLIC SERVICE COMPANY OF NEW MEXICO
ALBUQUERQUE, NEW MEXICO

PREPARED BY

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OCTOBER, 1985

SUPPLEMENTAL INFORMATION ON PUMP TESTING AT
PERSON STATION DECEMBER 1984 AND JAUNARY 1985

Supplemental analyses have been performed on the pump test data (previously submitted) from five of the monotor wells at Person Station. The wells (PSMW-1, PSMW-2, PSMW-3, PSMW-6, and PSMW-8A) are all completed in the upper 20 feet of the saturated zone.

Subsequent analyses of the data used to determine the hydraulic conductivities of the upper 20 feet of the aquifer at Person Station indicate that these data were affected by casing storage.

Schafer (1978) provides a means of determining what portion of a set of pump dest data is casing-storage affected, and subquently adjusting such data. The Time-Drawdown curve for each of the five pump tests (Appendix, FIGURES 1 through 5) displays an early steep slope and a late flat slope. It was assumed that the early steep slope was affected by casing storage, and the assumption was checked using Schafer's (1978) equation 3. The computations are displayed in TABLE 1. Since the calculated t_c (critical time) is equal to or greater than that assumed (see TABLE 1), it is concluded that the early steep slopes in FIGURES 1 through 5 are affected by casing storage.

One might then conclude that the later flat slope portions of the Time-Drawdown curves (FIGURES 1 through 5) represent the true transmissivities of the aquifer material adjacent to the wells. However, analysis of the Residual-Drawdown curves (FIGURES 6 through 10) shows an intercept of the curves at zero drawdown greater than two, indicating that "some recharge water

TABLE 1

CRITICAL CASING STORAGE TIMES
April 9, 1985

Well	Q (gpm)	Assumed t_c (min)	S (At Assumed t_c) (ft)	Q/s (gpm/ft)	Calculated t_c (min)
PSMW-1	0.22	6.0	2.8	0.079	11.5
PSMW-2	0.068	18.0	3.0	0.023	39.6
PSMW-3	1.3	0.9	4.1	0.317	2.9
PSMW-6	1.05	3.5	2.9	0.362	2.5
PSMW-8A	2.28	0.65	2.0	1.14	0.8

$$t_c = 0.6 \frac{(d_c^2 - d_p^2)}{Q/s} = \frac{0.910}{Q/s}$$

D_c = 2.067 in.

D_p = 1.66 in.

reached the aquifer during the pumping period" (Johnson Division, 1974, p.42).

TABLE 2 shows the zero drawdown intercepts ranging from 4.0 to 134. Since all of the five wells exhibited the recharge effect, it is felt that the later flat portions of the time-drawdown data were affected by a vertical component of flow (such as vertical leakage, partial penetration, or delayed drainage) rather than a classic lateral recharge boundary.

Since the early time-drawdown data is casing storage affected and late time-drawdown data is "recharge" affected, the best estimate of aquifer transmissivity might be determined by adjusting the early time-drawdown data to compensate for the casing storage effect using Shafer's (1978) equation 4. In order to use the equation, however, it is necessary to establish that the well efficiencies approach 100 percent.

Pumped well efficiency is defined as the drawdown in the aquifer just outside the well divided by the drawdown inside the well at a particular discharge. Well efficiencies might be reduced by two factors. One factor is a well screen with insufficient open area resulting in high-entrance velocities which produce high well loss. The second factor is the reduction in hydraulic conductivity of the aquifer adjacent to the well caused by drilling mud remaining in the formation after inadequate development.

The wells pump tested at Person Station are all equipped with wire wound stainless steel screens. TABLE 3 shows that the entrance velocities range from 0.002 fps to 0.005 fps, all much less than the recommended velocity of 0.1 fps which will result in negligible losses (Johnson Division, 1974, p.193). Roscoe Moss Company (1982, p.36) indicates that entrance velocities as high as 2 fps can still result in well efficiences greater than 98 percent.

TABLE 2

ZERO DRAWDOWN INTERCEPT
April 10, 1985

Well	t/t' (Min.)
PSMW-1	10.4
PSMW-2	4.0
PSMW-3	134.0
PSMW-6	35.0
PSMW-8A	28.0

TABLE 3

ENTRANCE VELOCITY
THROUGH SCREENS
April 10, 1985

Well	Q (gpm)	b (ft)	A (in^2)	Ve (fps)
PSMW-1	0.22	14.9	139	.0005
PSMW-2	0.068	15.4	143	.0002
PSMW-3	1.30	13.6	126	.003
PSMW-6	1.05	9.2	86	.004
PSMW-8A	2.28	16.2	151	.005

$$A = \frac{9.3\ in^2}{ft} \times b(ft)$$

$$Ve = \frac{Q\ \frac{gal}{min}}{A\ in^2} \times \frac{1\ ft^3}{7.48\ gal} \times \frac{144\ in^2}{1\ ft^2} \times \frac{1\ min}{60\ sec}$$

$$Ve = \frac{0.321\ Q}{A}$$

where

Q = pumping rate, in gpm

A = entrance area in screen, in square inches

Ve = entrance velocity, in fps

Note: Pipe base has 84-3/8 dia. holes 1 foot = 9.3 in^2/ft.
Wire wrap has 10.8 in^2/ft at .010" slots.

The possibility that the hydraulic conductivity of the aquifer adjacent to any of the wells is reduced, is very remote, since the portion of the wells that is below the water table was installed without the use of any drilling muds or even water. The well screens were installed by air-rotary and/or driving methods. Each of the wells was subsequently developed with a bailer removing several casing volumes of very fine sand prior to any pump testing.

It is concluded, therefore, that the monitor wells at Person Station are very nearly 100 percent efficient, and that Schafer's (1978) equation 4 can be reliably used to adjust the casing storage affecting time-drawdown data. It can also be noted that slopes of the steep portions of the time-drawdown and residual-drawdown curves for each of the pump tests (FIGURES 1 through 10) are in general agreement, further indicating the wells are highly efficient.

TABLE 4 contains the adjusted and selected transmissivity values. For wells PSMW-1, 2, and 3, the adjusted T_1 value was selected because the T_2 value was obscured by casing storage effects in the early data and vertical flow effects in the late data. For wells PSMW-6 and 8A, the T_2 value was selected since it is little different from the adjusted T_1 value indicating that the vertical flow effects were not great. These selected transmissivities are consistent with the specific capacities (Q/s) reported in the last column of TABLE 4, i.e., observed specific capacities correlate directly with the selected transmissivities.

The validity of using the Jacob solution was checked for the range of data used in determining the selected transmissivities in TABLE 4. The calculations are presented in TABLE 5, showing the smallest drawdown (s) for which the Jacob solution is valid. As shown in FIGURES 1-5, sufficient data exists to perform the analysis using drawdown observations that are greater than those listed in TABLE 5.

TABLE 4

ADJUSTED TRANSMISSIVITY VALUES
April 9, 1985

Well	T_1 (gpd/ft)	"Adjusted T_1" (gpd/ft)	T_2 (gpd/ft)	Selected T (gpd/ft)	Q/s (gpm/ft)
PSMW-1	27 6/	108	4/	108 2/	0.079
PSMW-2	6 6/	24	4/	24 2/	0.023
PSMW-3	100 6/	400	858 1/	400 2/	0.317
PSMW-6	100 6/	400	480 3/	480 3/	0.362
PSMW-8A	365 5/	1460	1505 3/	1505 3/	1.14

Adjusted $T_1 = \frac{4T_1}{E}$

E = 100% = 1.00; therefore, "Adjusted T_1" = $\frac{4T_1}{E}$

1/ Recharge affected

2/ Adjusted T_1

3/ T_2 from time-drawdown curve after time t_c

4/ Approaches Infinity

5/ Rounded from Time-Drawdown curve

6/ Rounded from Residual-Drawdown curve

TABLE 5

VALIDITY OF JACOB SOLUTION
April 10, 1985

Well	Q	T	S (ft)
1	.22	108	0.9
2	.068	24	1.3
3	1.3	400	1.5
6	1.05	480	1.0
8A	2.28	1505	0.7

$u \leq 0.01$ (Acceptable criterion for validity of Jacob solution)

$W(u) = 4.04$ (From Thies well function tables; i.e., W as function of u)

$sT = W(u)\ (114.6)(Q)$

$$s = \frac{W(u)\ (114.5)(Q)}{T} = \frac{4.04\ (114.6)(Q)}{T} = \frac{463Q}{T}$$

Hydraulic conductivities were computed from the adjusted transmissivities. The results are presented in TABLE 6. The b values in the third column represent the average length of screen below the water level during the pump test period. The previous hydraulic conductivities were calculated using b values that represent the total length of screen below the static water level. The last column of TABLE 6 contains the previously used unadjusted hydraulic conductivities. The combined casing storage adjustment and minimization of the b values have increased the hydraulic conductivities by a factor of 5 at the low end of the range and a factor of 2 on the high end of the range.

A comparison of the Person Station pump testing results with published values indicates that the Person Station hydraulic conductivities are generally one order of magnitude less than values reported by Bjorklund and Maxwell (1961 p.24) for the Santa Fe group in the Albuquerque Area (see TABLE 7). This difference is certainly understandable since the values reported in Bjorklund and Maxwell (1961) are for large production wells intentionally screened opposite the most permeable zones encountered in wells several hundreds of feet deep. Whereas, the Person Station wells are nominally screened in the first 18-20 feet below the water table. Additionally, Bjorklund and Maxwell (1961, p.22) recognized the presence of low permeability materials in Santa Fe and Bajada deposits.

Although PSMW-4 was not pump tested, it has a much lower capacity (and probably lower hydraulic conductivity) than even PSMW-2, as exhibited by the fact that it takes several times as long to recover from development or sampling bailing as does PSMW-2.

Each of the Person Station Monitor Wells was subjected to informal step testing to determine an appropriate rate at which to perform the constant rate pump test. TABLE 8 displays the

TABLE 6

HYDRAULIC CONDUCTIVITIES ADJUST FOR
CASING STORAGE
April 9, 1985

Well	T (gpd/ft)	b[1/] (ft)	K (ft/day)	Previous K (ft/day)
PSMW-1	108	14.9	0.97	0.20
PSMW-2	24	15.4	0.21	0.04
PSMW-3	400	13.6	3.9	0.71
PSMW-6	480	9.2	7.0	1.1
PSMW-8A	1505	16.2	12.4	5.7

1/ Average during test

$$T \frac{gal}{day\ ft} \times \frac{ft^3}{7.48\ gal} \times \frac{1}{b\ ft} \times \frac{K\ ft}{day}$$

TABLE 7

HYDRAULIC CONDUCTIVITIES

Bjorklund and Maxwell, 1961		
12 $\frac{gpd}{ft^2}$	-	840 $\frac{gpd}{ft^2}$
	or	
1.6 ft/day	-	112 ft/day
Person Station Aquifer Test Values		
0.21 ft/day	-	12.4 ft/day
Previous Unadjusted Aquifer Test Values		
0.04 ft/day	-	5.9 ft/day

TABLE 8

STEP TEST DATA

Well	Available Drawdown b (ft)	Q (gpm)	s@t (ft)	t (min)	s/b (%)
PSMW-1	18.0	0.14	1.04	6.0	6
		*0.22	2.8 2/	12.0	16
		1.60	13.9 1/	1.0	77
PSMW-2	18.6	*0.068	3.0 2/	20.0	16
		0.40	13.05	1.0	70
		1.48	13.05 1/	6.0	70
PSMW-3	18.1	1.12	3.93	110.0	22
		*1.3	4.1 2/	0.9	23
		1.73	5.66	25.0	31
		2.21	10.74	20.0	59
PSMW-6	12.6	*1.05	3.9	3.5	31
		1.6	9.01	5.0	72
PSMW-8A	18.7	1.48	1.73	2.5	9
		1.74	2.08	2.0	11
		1.86	2.19	2.0	12
		1.98	2.43	2.0	13
		2.10	2.54	1.0	14
		*2.28	3.0	0.65	16

*Constant Rate Test

1/ Not Stabilized

2/ For portion of curve used

results of the step testing. The constant rate tests were performed at a rate which would produce a drawdown of about 25 percent of the total available drawdown. The actual percentage ranges from 16 percent to 31 percent as shown in the last column of TABLE 8. The resulting pumping rates stress the aquifer as much as is reasonably possible given the low permeability materials in the upper 20 feet of the aquifer at Person Station. If larger drawdown had been produced by higher pumping rates, the data would have become invalid because of large reduction in saturated thickness.

In conclusion, the results appear to be reasonable and internally consistent when compared to published data and considering the aquifer materials.

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Schafer, David C., 1978. Casing Storage Can Affect Pumping Test Data. The Johnson Drillers Journal, 11p.

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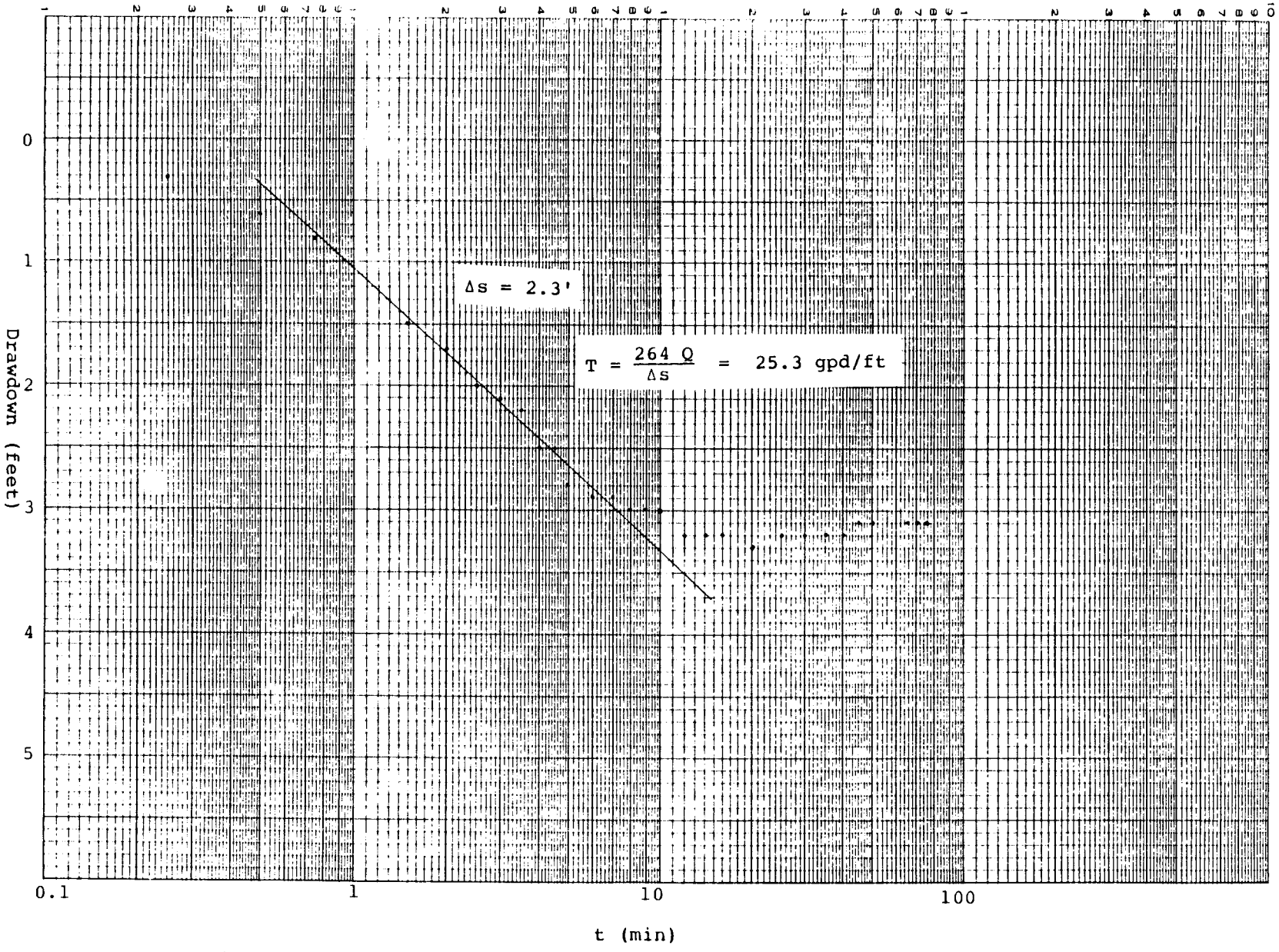
APPENDIX

METRIC Corporation
Date: 1-17-85

Time-Drawdown
Q = 0.22 gpm

Pumped Well - PSMW-1
Observations at Well - PSMW-1

FIGURE 1

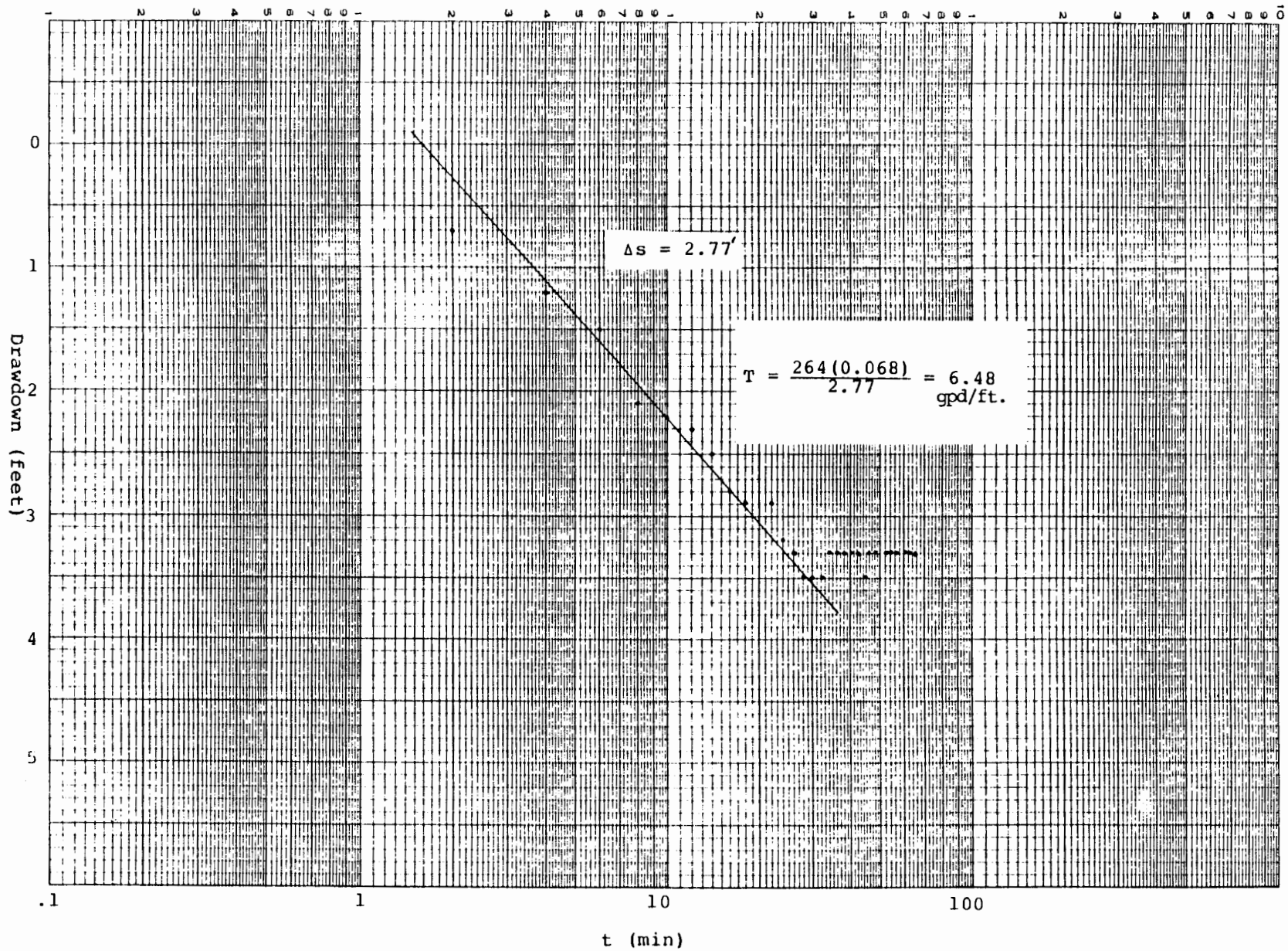


METRIC Corporation
Date: 1-10-85

Time-Drawdown
Q = 0.068 gpm

Pumped Well - PSMW-2
Observations at Well - PSMW-2

FIGURE 2

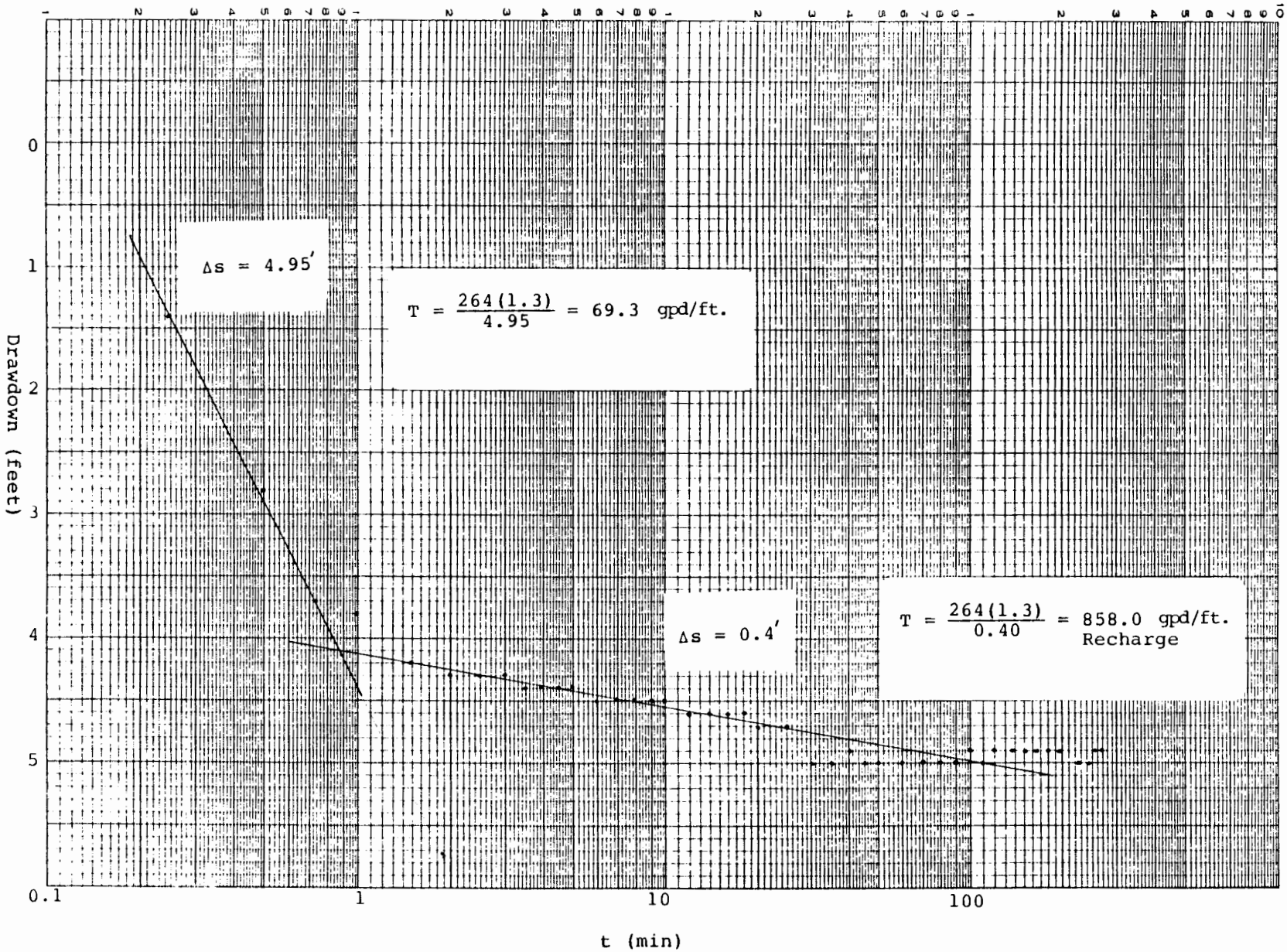


METRIC Corporation
Date: 1-9-85

Time-Drawdown
Q = 1.3 gpm

Pumped Well - PSMW-3
Observations at Well PSMW-3

FIGURE 3

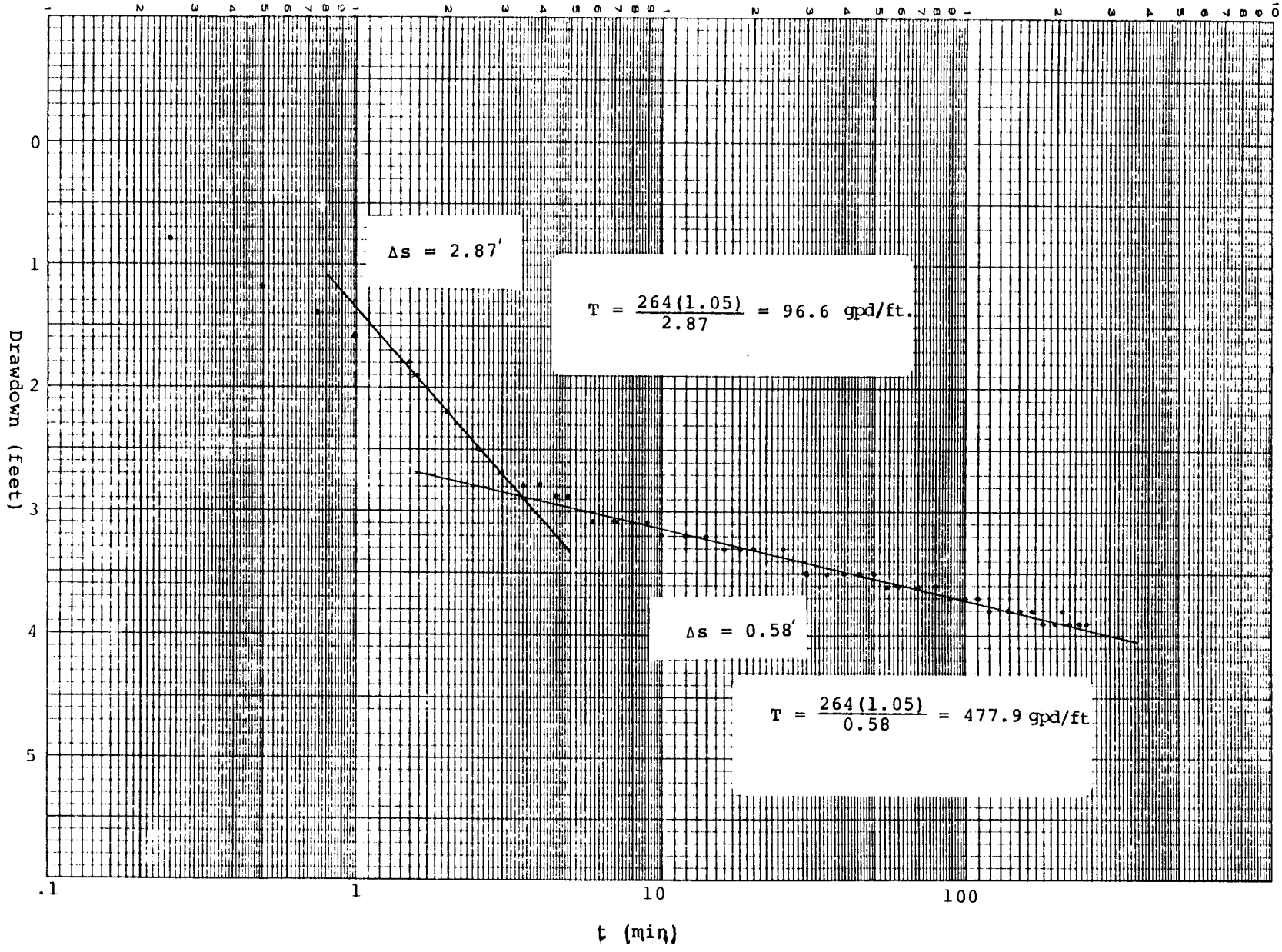


METRIC Corporation
Date: 1-14-85

Time-Drawdown
Q = 1.05 gpm

Pumped Well - PSMW-6
Observations at Well - PSMW-6

FIGURE 4

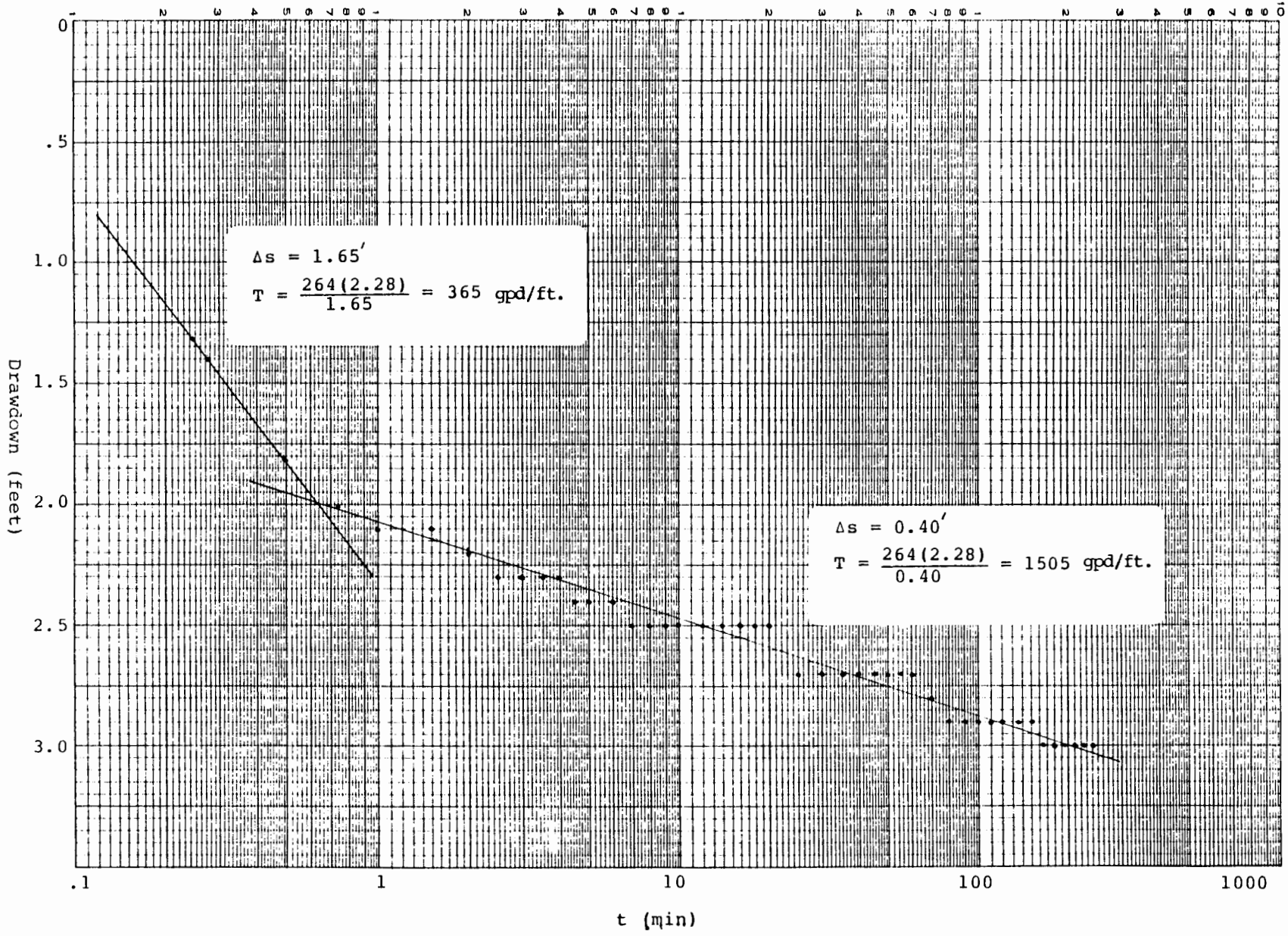


METRIC Corporation
Date: 1-15-85

Time-Drawdown
Q = 2.28 gpm

Pumped Well - PSMW-8A
Observations at Well - PSMW-8A

FIGURE 5

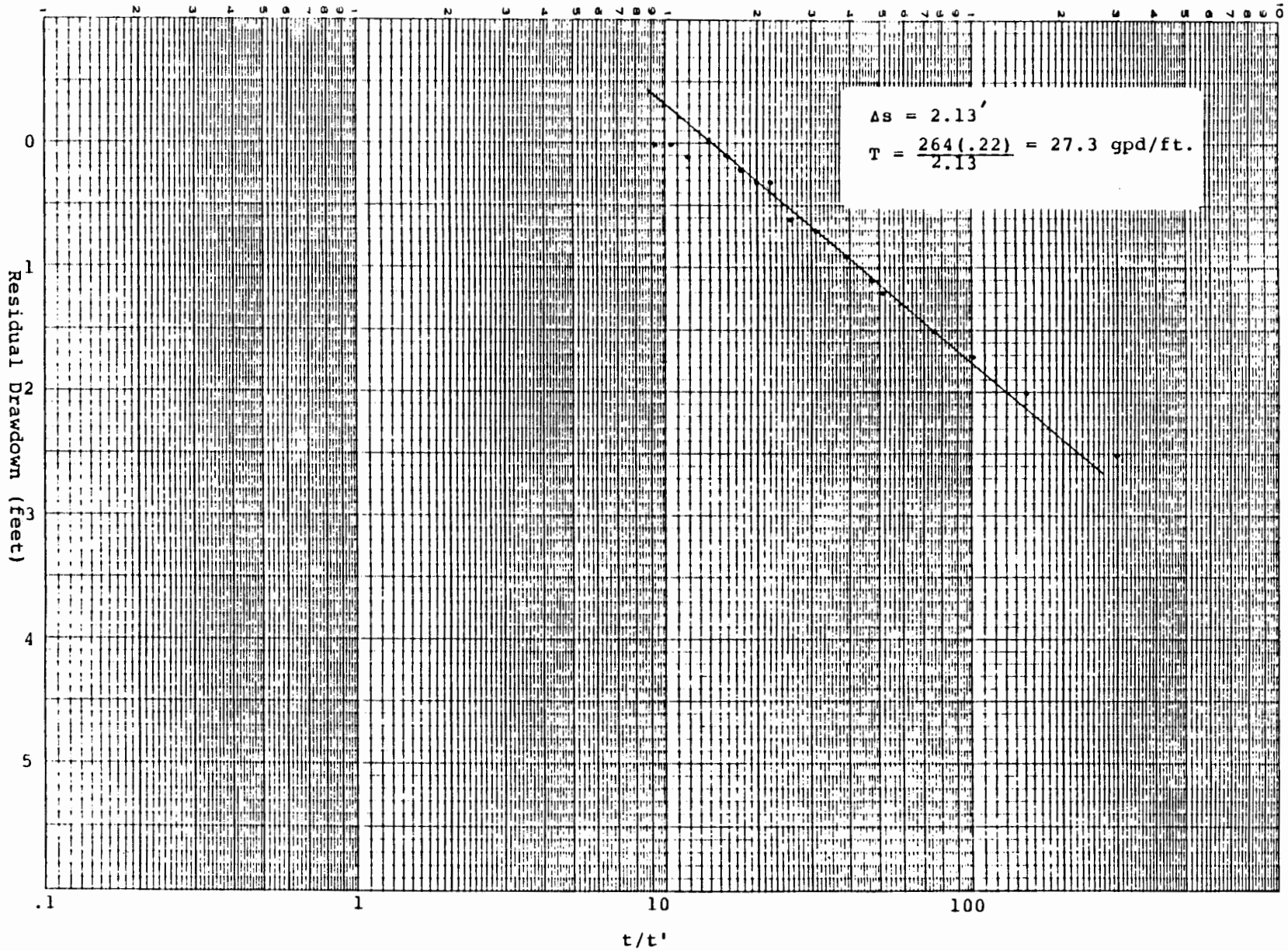


METRIC Corporation
Date: 1-17-85

Residual-Drawdown
Q = 0.22 gpm

Pumped Well - PSMW-1
Observations at Well - PSMW-1

FIGURE 6

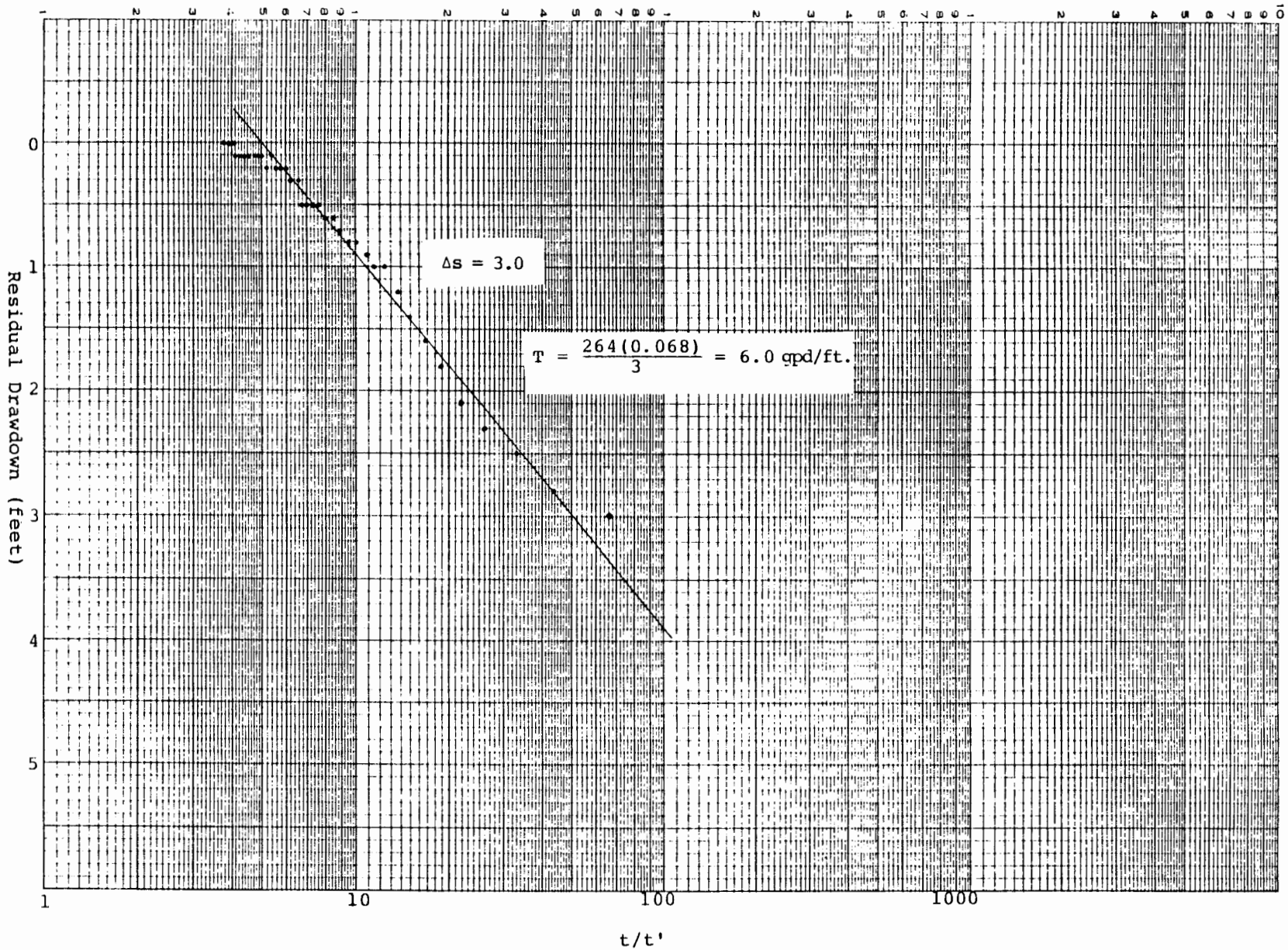


METRIC Corporation
Date: 1-10-85

Residual-Drawdown
Q = 0.068 gpm

Pumped Well - PSMW-2
Observations at Well - PSMW-2

FIGURE 7

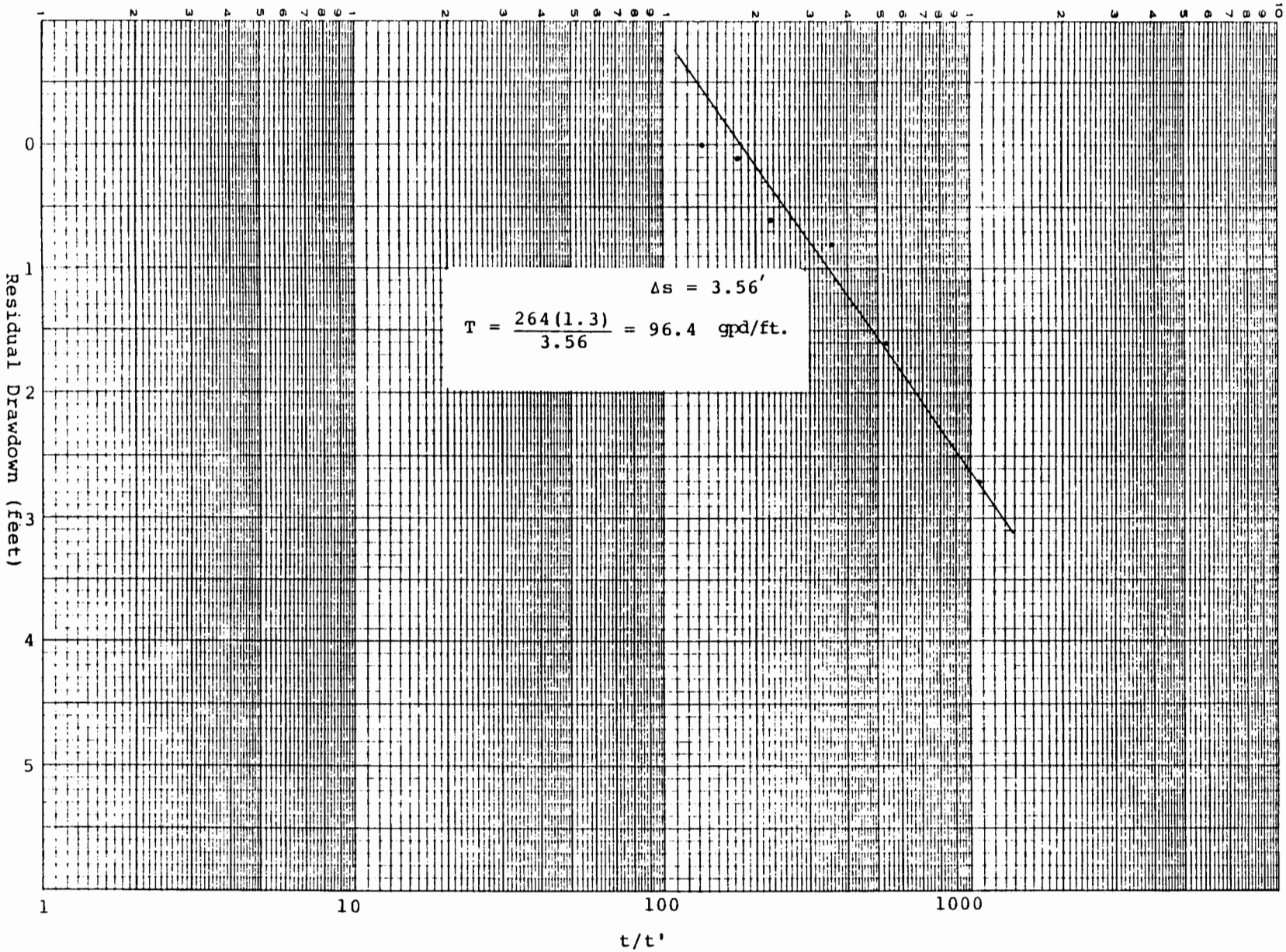


METRIC Corporation
Date: 1-9-85

Residual-Drawdown
Q = 1.30 gpm

Pumped Well - PSMW-3
Observations at Well - PSMW-3

FIGURE 8

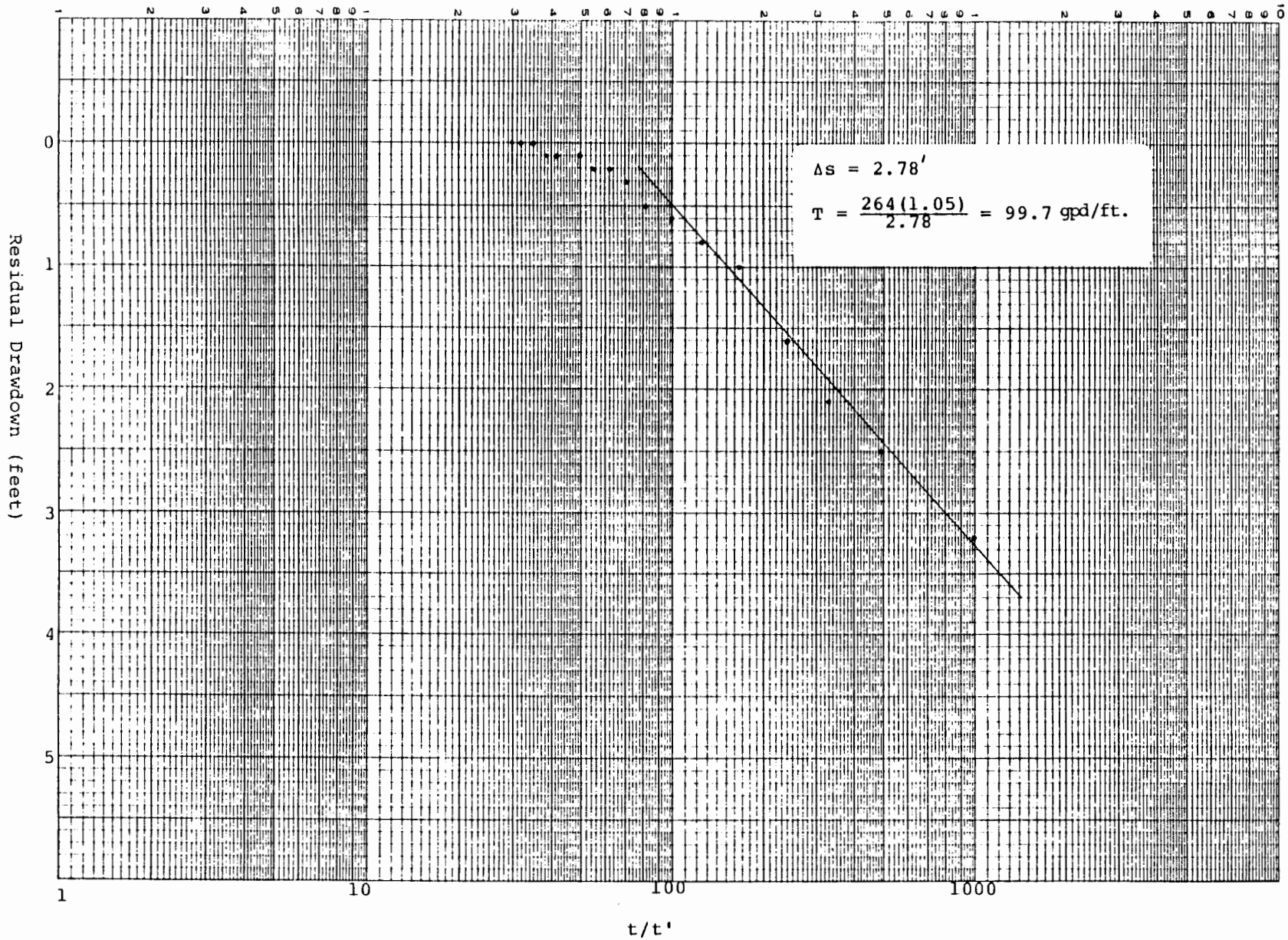


METRIC Corporation
Date: 1-14-85

Residual-Drawdown
Q = 1.05 gpm

Pumped Well - PSMW-6
Observations at Well - PSMW-6

FIGURE 9

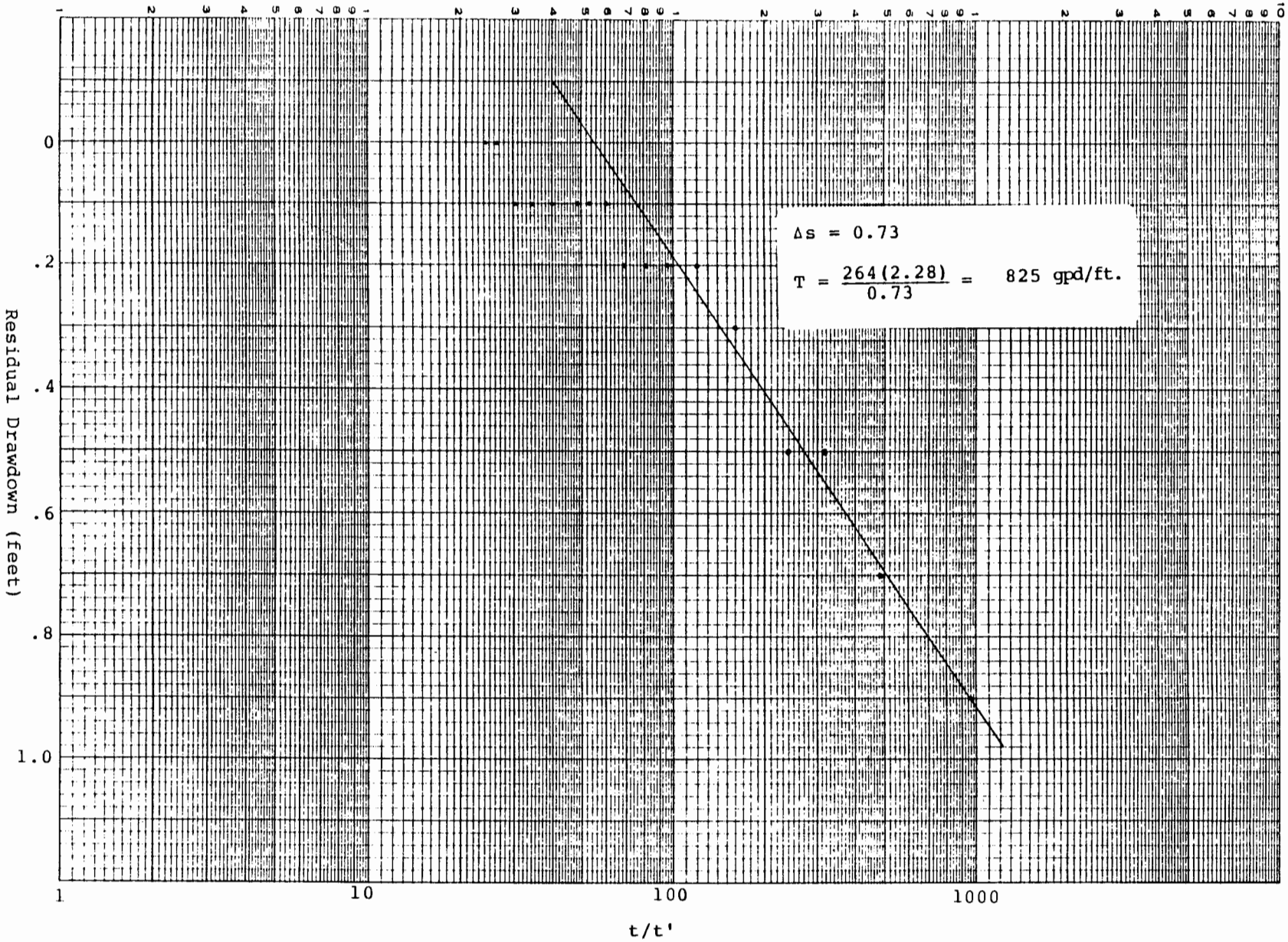


METRIC Corporation
Date: 1-15-85

Residual-Drawdown
Q = 2.28 gpm

Pumped Well - PSMW-8A
Observations at Well - PSMW-8A

FIGURE 10

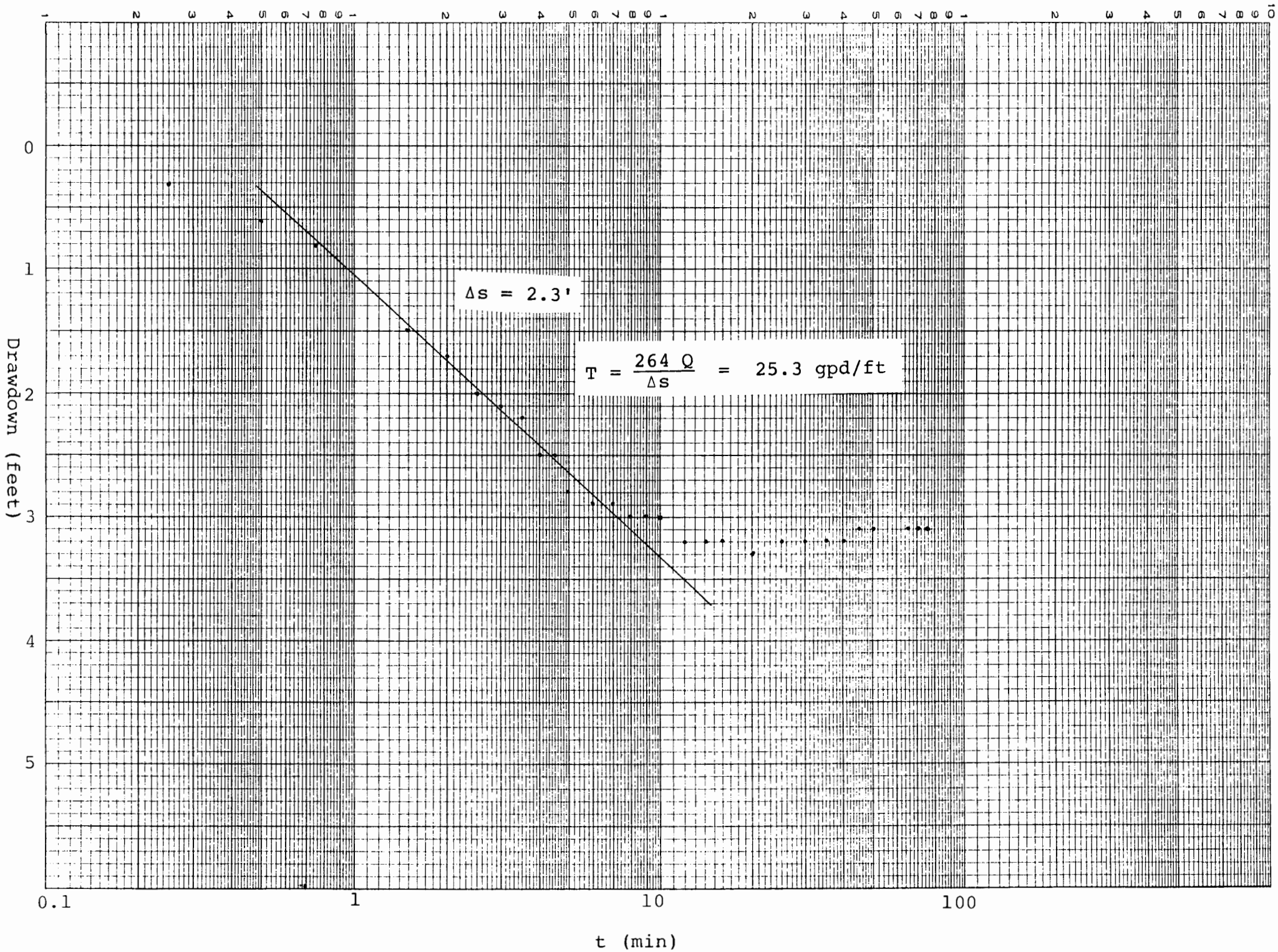


METRIC Corporation
Dat 1-17-85

Time-Drawdown
Q = 0.22 gpm

Pumped Well - PSMW-1
Observations at Well - PSMW-1

FIGURE

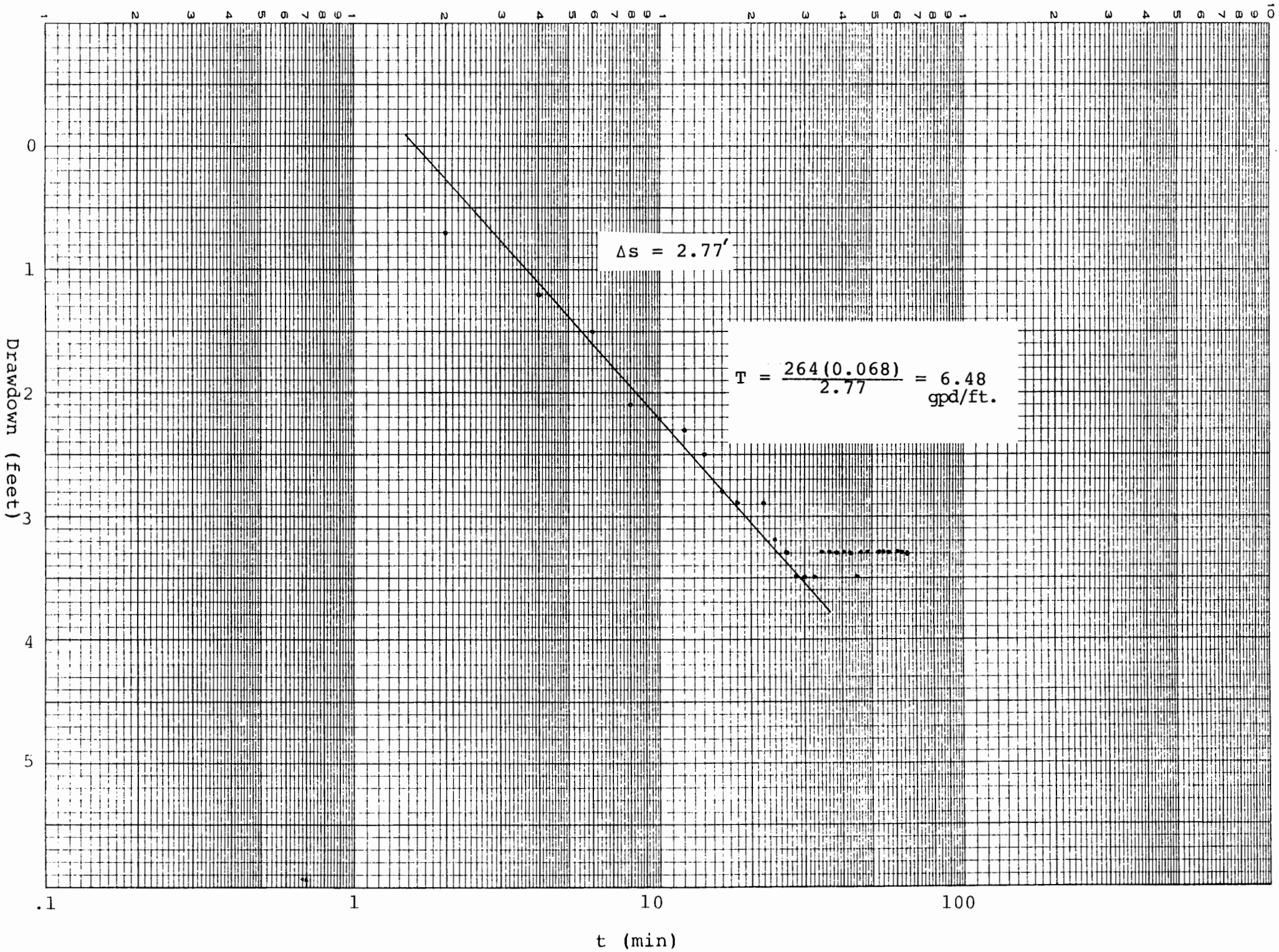


METRIC Corporation
Dat 1-10-85

Time-Drawdown
Q = 0.068 gpm

Pumped Well - PSMW-2
Observations at Well - PSMW-2

FIGURE 2

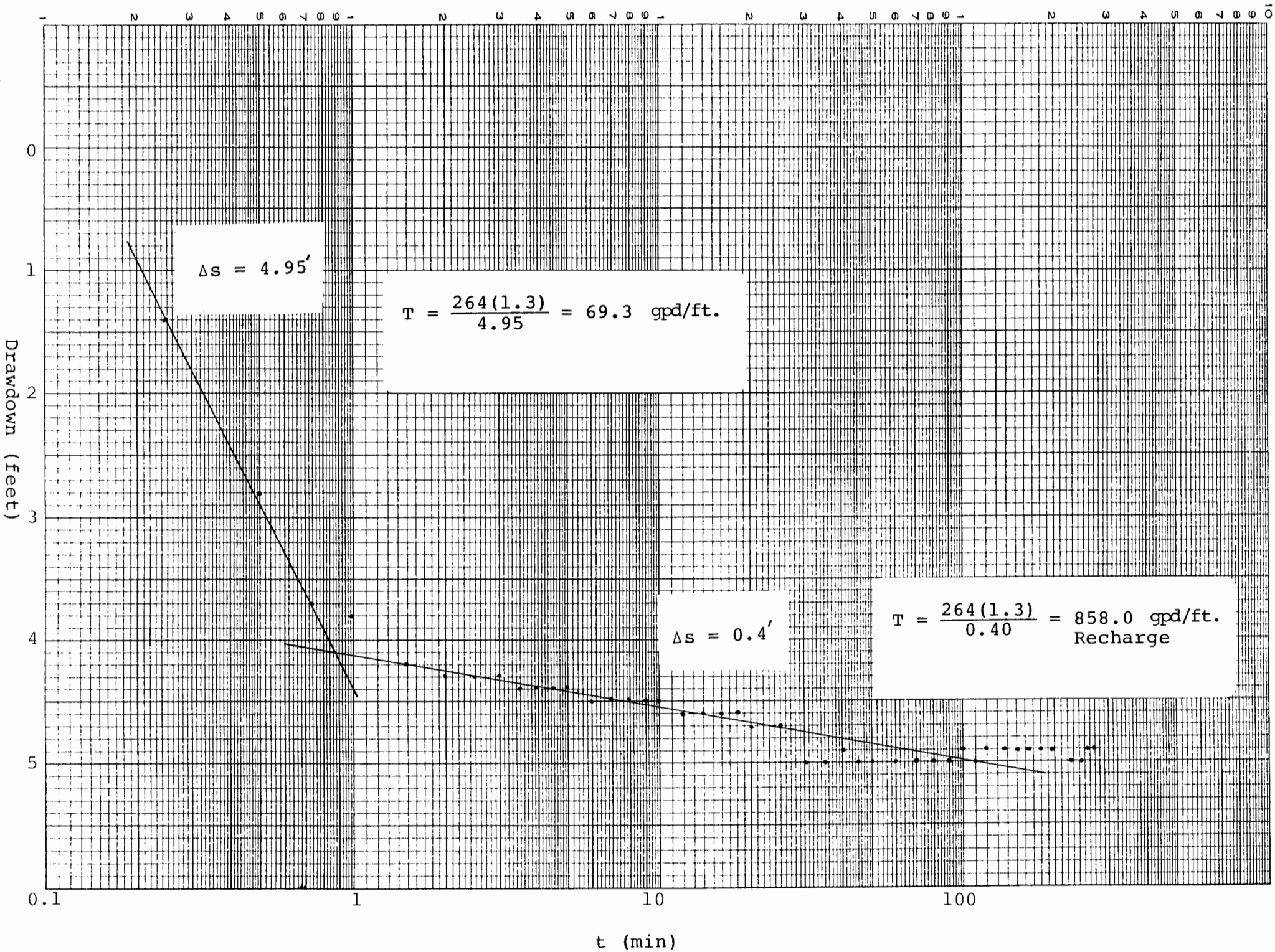


METRIC Corporation
Dat 1-9-85

Time-Drawdown
Q = 1.3 gpm

Pumped Well - PSMW-3
Observations at Well PSMW-3

FIGURE 3

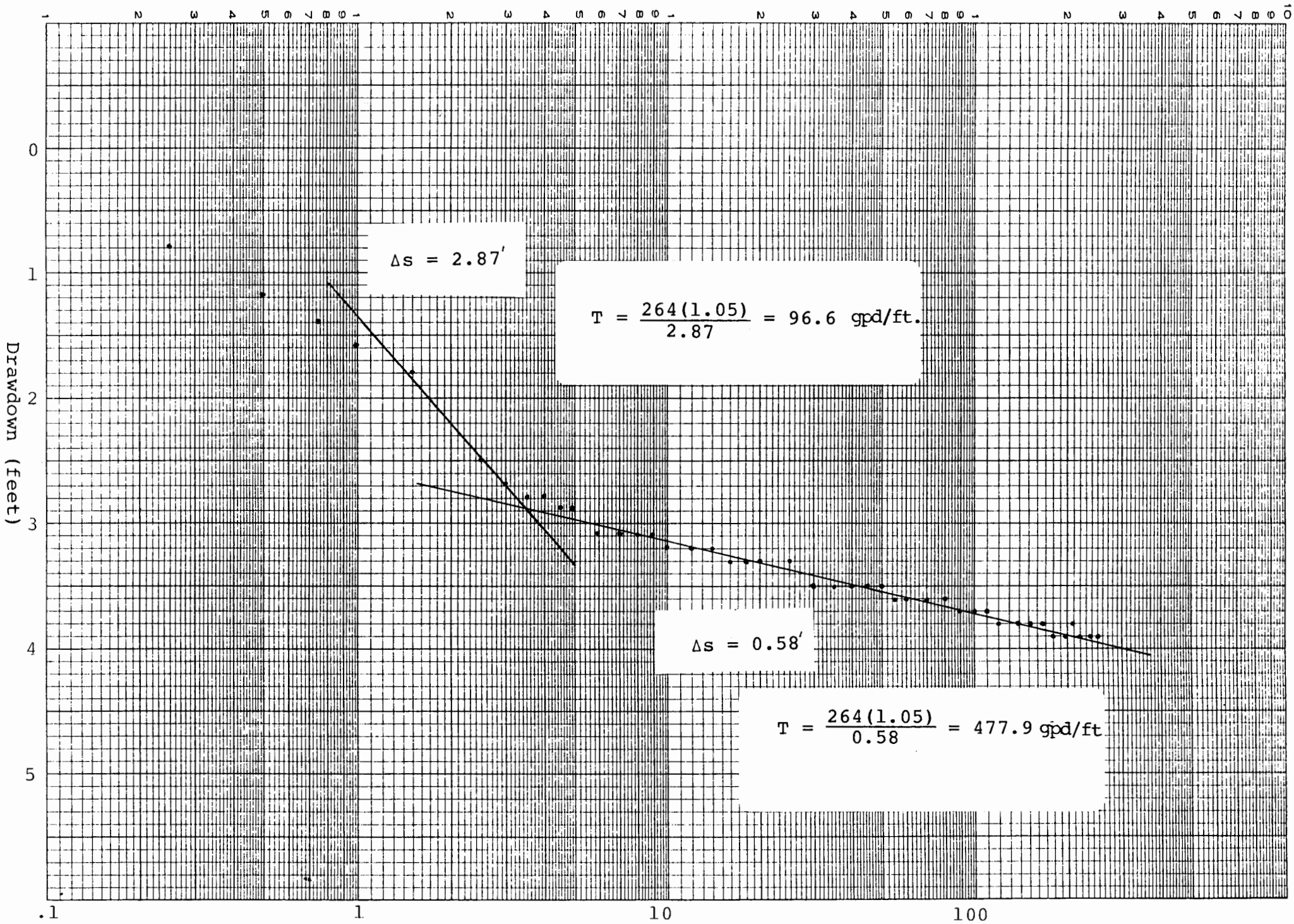


METF[illegible] Corporation
Date 1-14-85

Time-Drawdown
Q = 1.05 [illegible]n

Pumped Well - PSMW-6
Observations at Well - [illegible]MW-6

FIGURE 4

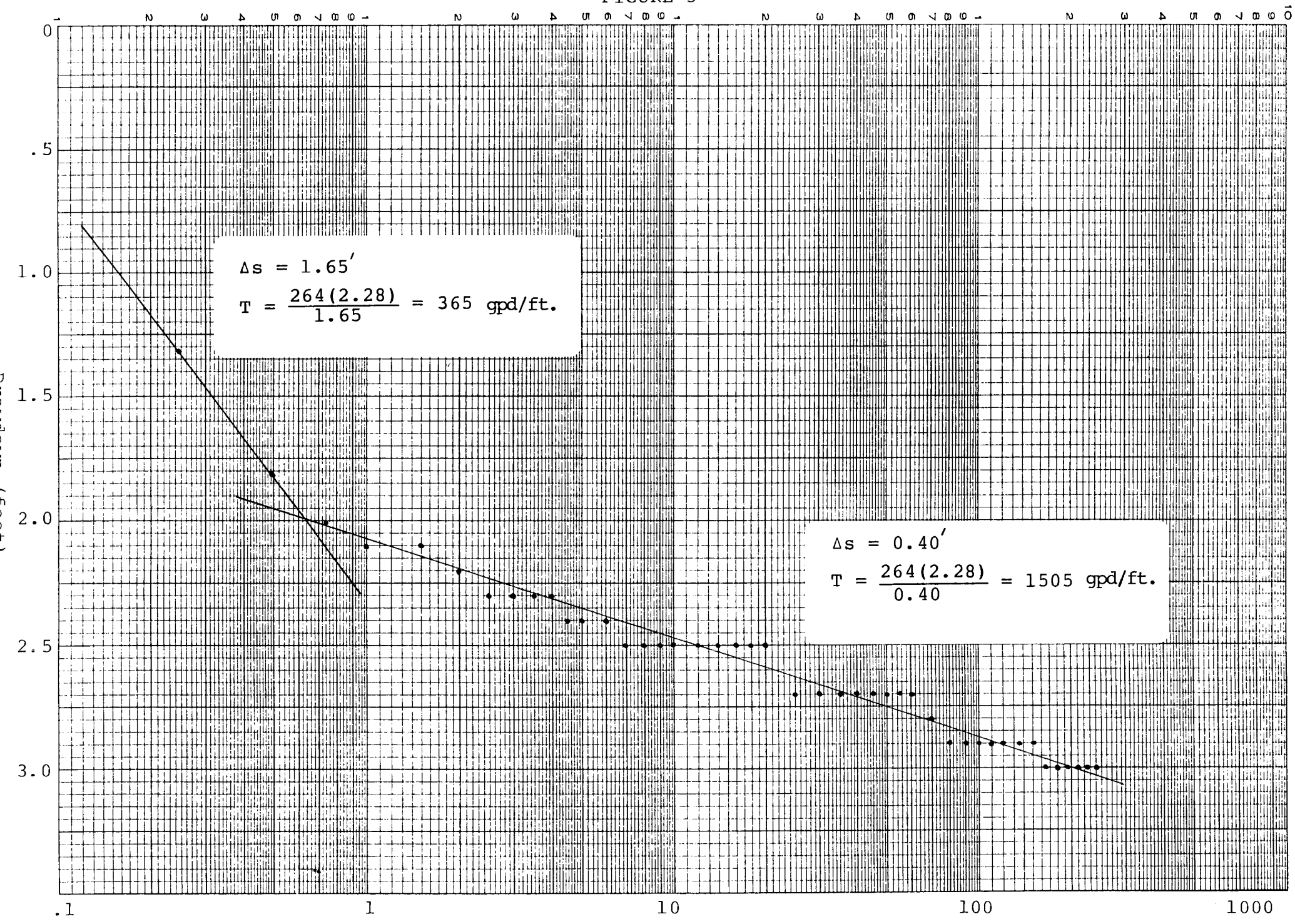


MET[illegible] Corporation
Dat[illegible] 1-15-85

Time-Drawdown
Q = 2.28 [illegible]n

Pumped Well - PSMW-8A
Observations at Well - [illegible]MW-8A

FIGURE 5

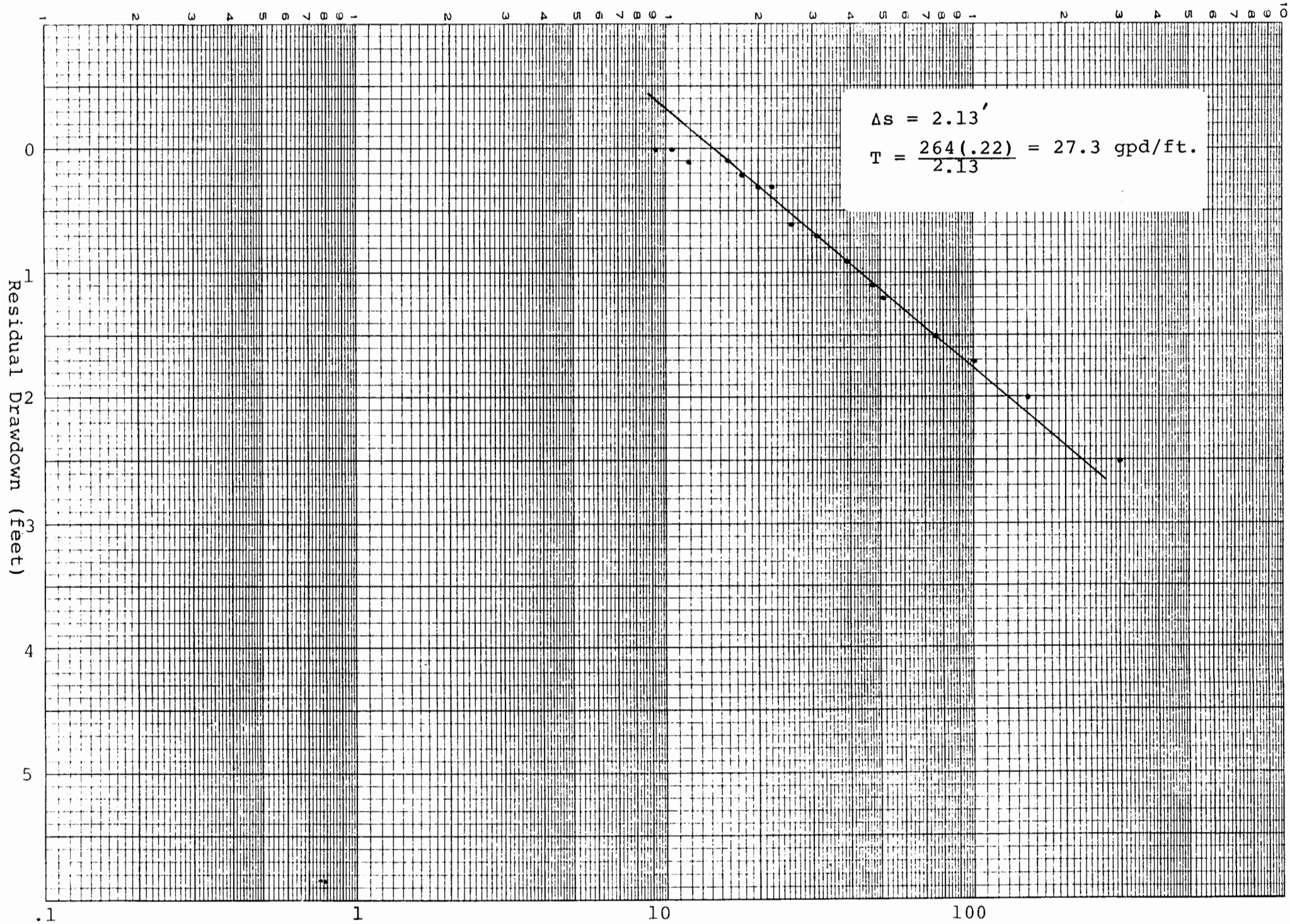


METRIC Corporation
Dat 1-17-85

Residual-Drawdown
Q = 0.22 g

Pumped Well - PSMW-1
Observations at Well - PSMW-1

FIGURE 6

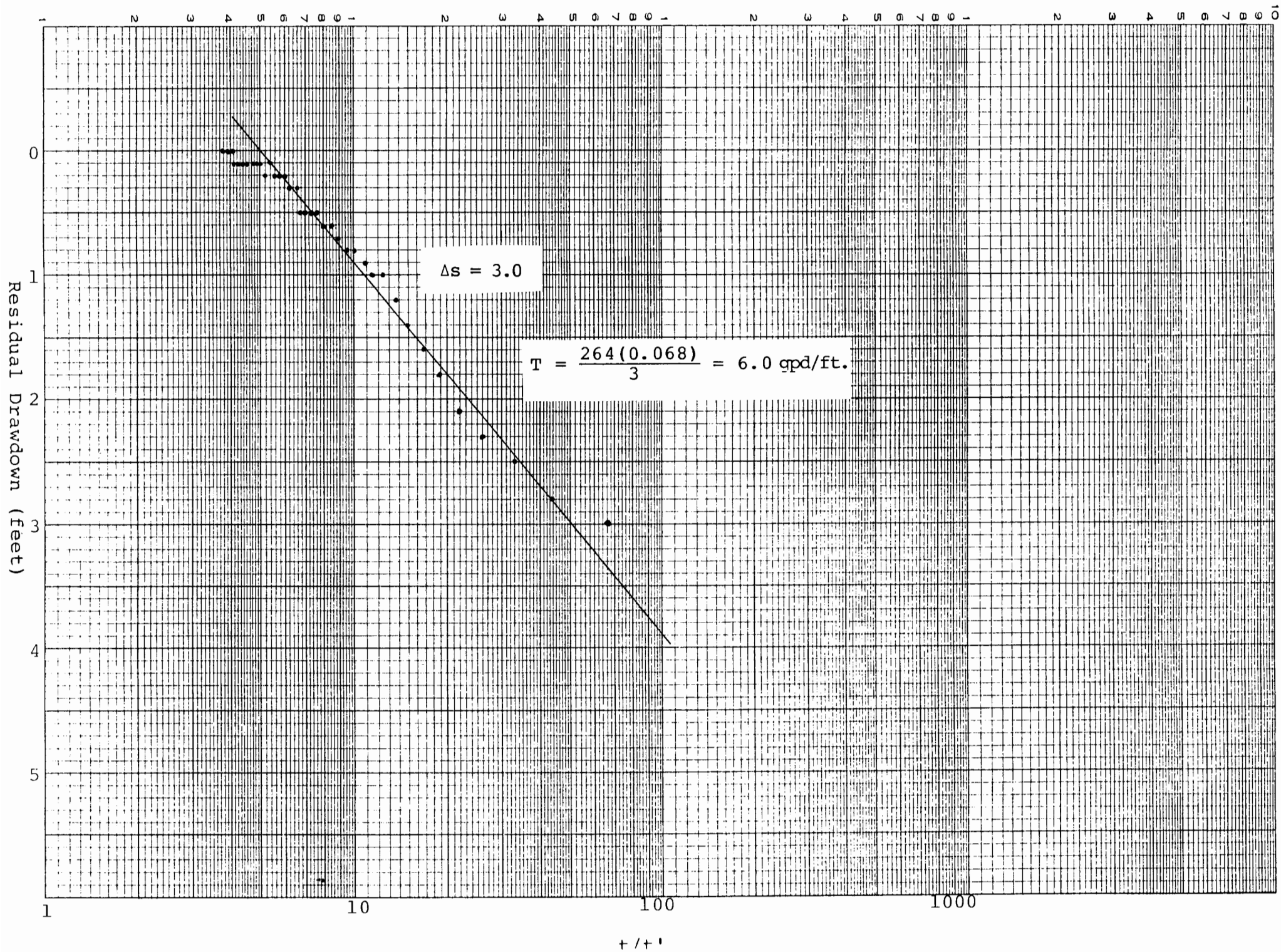


METRIC Corporation
Dat 1-10-85

Residual-Drawdown
Q = 0.068 gpm

Pumped Well - PSMW-2
Observations at Well - PSMW-2

FIGURE 7

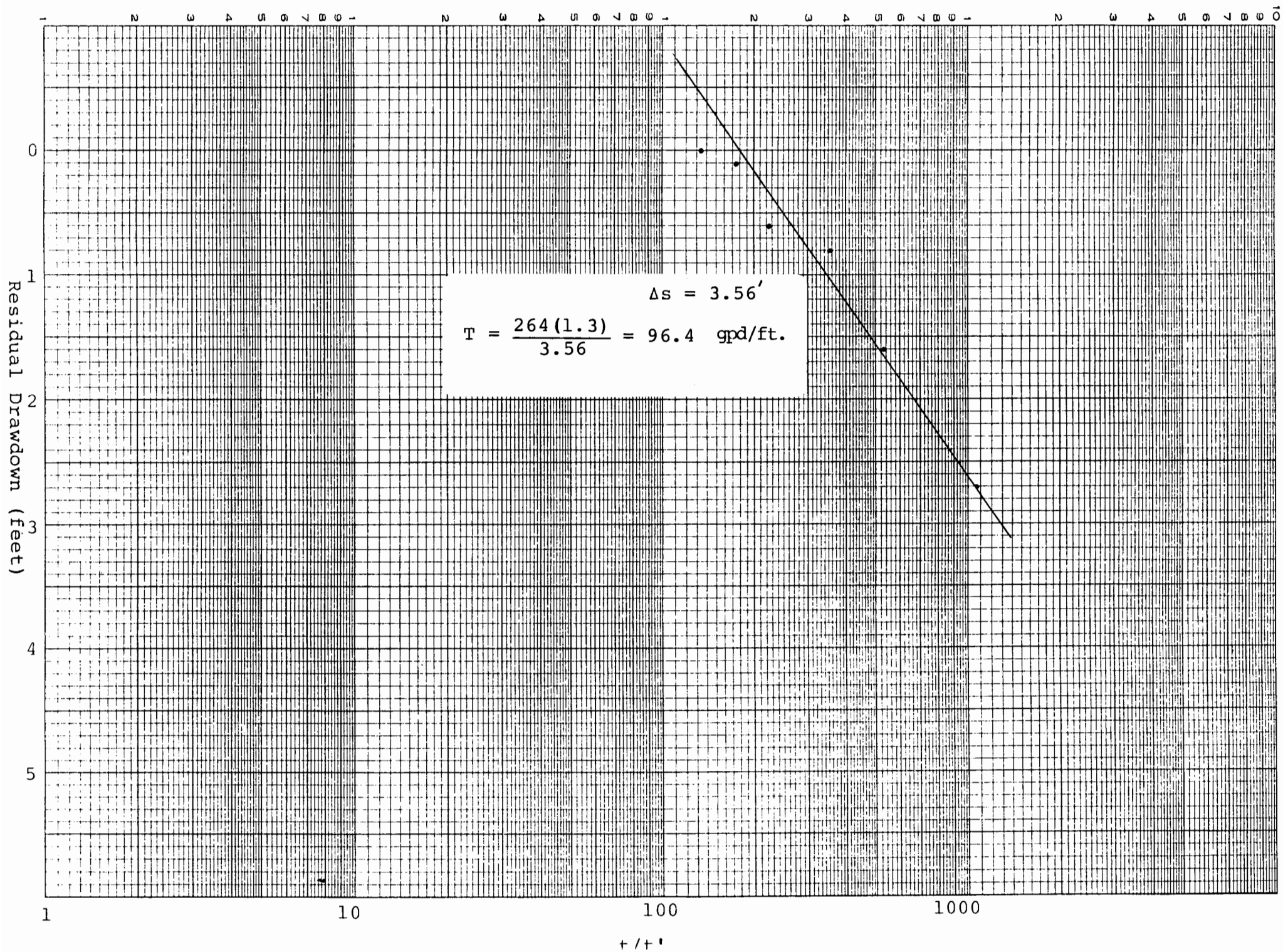


METRIC Corporation
Date 1-9-85

Residual-Drawdown
Q = 1.30 gpm

Pumped Well - PSMW-3
Observations at Well - PSMW-3

FIGURE 8

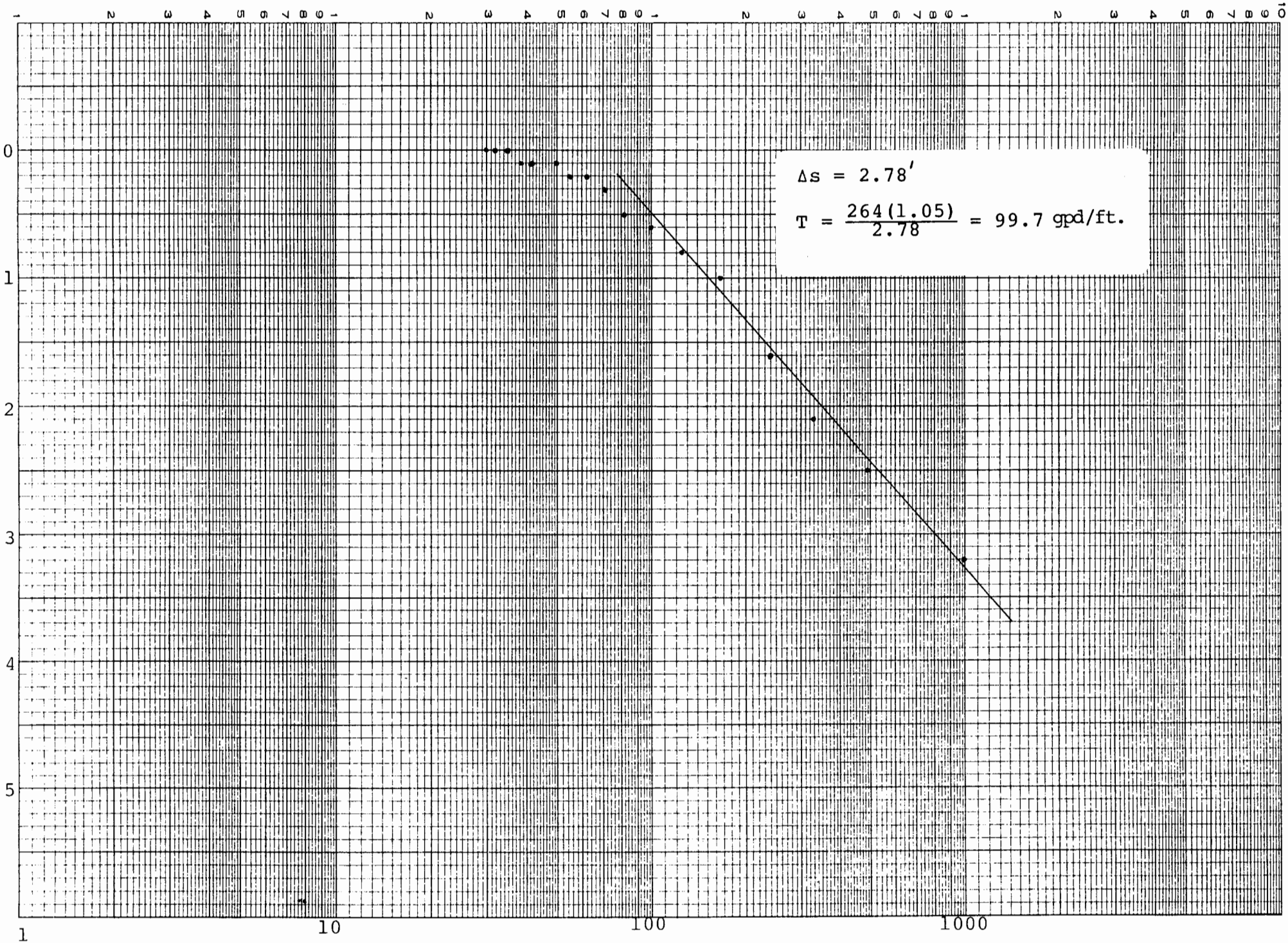


METRIC Corporation
Date 1-14-85

Residual-Drawdown
Q = 1.05 gpm

Pumped Well - PSMW-6
Observations at Well - PSMW-6

FIGURE 9



METRIC Corporation
Date 1-15-85

Residual-Drawdown
Q = 2.28 g

Pumped Well - PSMW-8A
Observations at Well - PSMW-8A

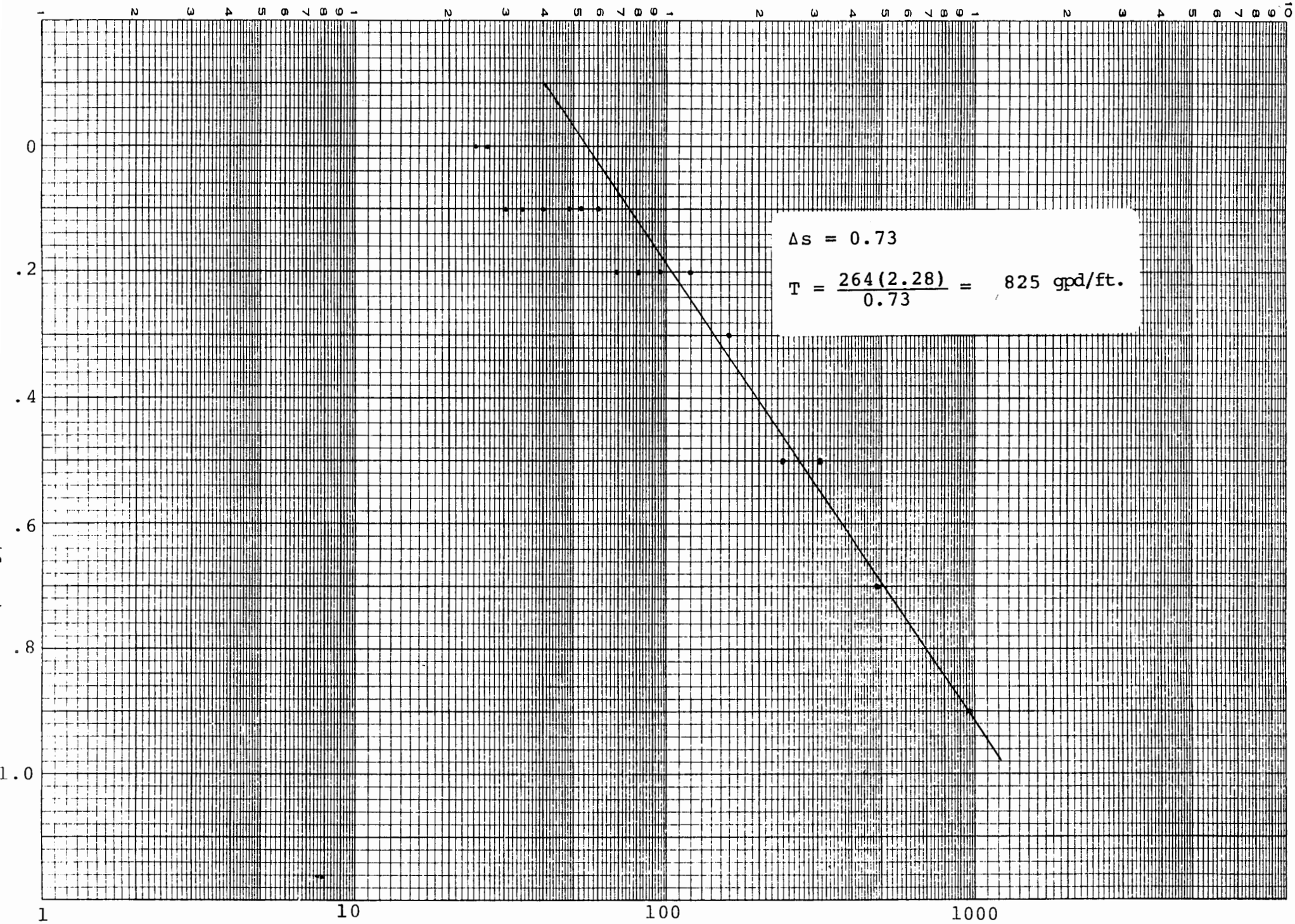



FIGURE 10