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AQUIFER RECOVERY TEST DATA AND ANALYSES FOR THE FLORIDAN AQUIFER SYSTEM IN THE UPPER EAST COAST PLANNING AREA SOUTH FLORIDA WATER MANAGEMENT DISTRICT

by

Michael P. Brown

ABSTRACT

The Floridan aquifer system in the Upper East Coast Planning Area (UECPA) of Martin County, St. Lucie County and eastern Okeechobee County produces large quantities of water for agricultural irrigation via free flowing wells. In the UECPA the Floridan aquifer system consists of a number of stratigraphically controlled producing zones separated by semi-permeable zones made up of marine limestones ranging in age from Oligocene and/or lower Miocene to upper middle Eocene.

Aquifer recovery test data collected from 16 selected wells and drawdown data from 2 wells were analyzed by the modified non-equilibrium formula for transmissivity. Two tests where an observation well was available were used to calculate storage coefficients. Transmissivities range from 956,700 gpd/ft. to 24,600 gpd/ft. Storage coefficient analyses from three wells indicate an approximate value of 5.0 X 10^{-4}. Percent flow contributions to the open borehole were calculated from corrected flow logs.

INTRODUCTION

Location

The South Florida Water Management District's (SFWMD) Upper East Coast Planning Area encompasses approximately 1,304 miles^2 in Martin County, St. Lucie County and eastern Okeechobee County on the east coast of Florida (Figure 1). Principal communities within the area consist of Stuart and Fort Pierce, although potable water used in these communities is withdrawn from the shallow aquifer. Land use within the area is (in descending order of use): (1) improved pasture, (2) citrus, (3) unimproved pasture, (4) urban, (5) truck crops, and (6) sugar cane (personal communication, Brown, B., 1979). Climate is humid - subtropical with warm wet summers and mild, dry winters. The northern portion of the area is drained by SFWMD primary canals C-23, C-24, and C-25 with many interconnected secondary and tertiary canals. In Martin County, the St. Lucie Canal (C-44), the Loxahatchee River and Lake Okeechobee are the primary drainage features.

Purpose and Scope

Large quantities of water for irrigation are taken from the Floridan aquifer system via free flowing wells into ditches and transported where mixing occurs with surface and shallow groundwaters of generally higher quality. Also, over the past few years, along the coast of Hutchinson Island, Floridan aquifer system waters are being increasingly utilized for potable water following reverse osmosis treatment. As of February 1979, the SFWMD issued water use permits for 140,000 acre-feet/year of Floridan aquifer water servicing 66,000 acres. An additional 210,000 acre-ft. is withdrawn from a combined source of the Floridan aquifer, surface water, and shallow groundwater system serving 100,000 acres. These types of large withdrawals of water from the Floridan aquifer system to meet present and future demands need to be evaluated through a predictive mathematical model to efficiently manage the area's water resources. Mathematical models in general depend on an accurate assessment of the hydraulic characteristics of the aquifer system. This report presents aquifer test data and analyses along with the documentation of well construction and borehole

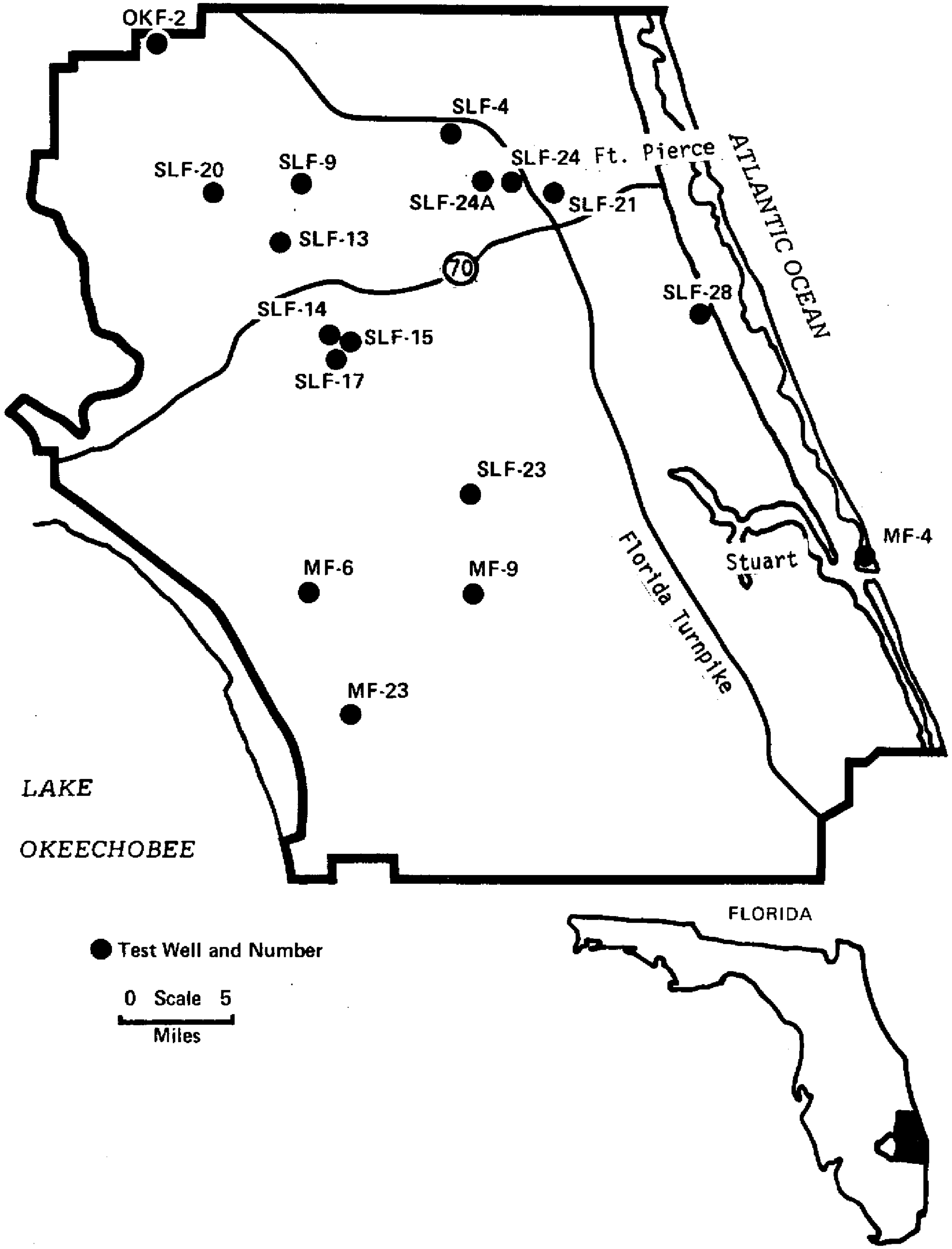

Figure 1 - Location of Upper East Coast Planning Area and Aquifer Test Sites

hydrologic conditions which can be used by modelers as input parameters for modeling purposes.

Previous Investigations

Geologic and geophysical logs collected in the area of study by the Florida Bureau of Geology over the last thirty years have been used throughout this study. Lichtler (1960) described the geology and groundwater resources of Martin County.

Engineering reports useful in this study included: Drilling and Testing of Deep Disposal and Monitoring Wells in Stuart, Martin County, by Black, Crow & Eidsness, Inc., 1975, and Nuclear Power Plant Siting Phase I, by Law Engineering, 1976. Regional geology has been worked by many researchers; of importance is Applin and Applin, 1944, Regional Subsurface Stratigraphy and Structure of Florida and Southern Georgia, Bulletin of AAPG; Chen, 1965, The Regional Lithostratigraphic Analysis of Paleocene and Eocene Rocks of Florida, Florida Geological Survey Bulletin 45; Parker, et al., 1955, Water Resources of Southern Florida, U. S. Geological Survey, WSP 1255; Stringfield, 1966, Artesian Water in Tertiary Limestone in the Southeastern States, U. S. Geological Survey, Prof. Paper No. 517. More recent work by Brown and Reece, 1979, describes the Floridan aquifer system in the UECPA, SFWMD Technical Map Series No. 79-1.

Acknowledgements

All work was completed under the supervision of Abe Kreitman, Director, Groundwater Division, Resource Planning Department, South Florida Water Management District. Acknowledgements go to Lauran Howard and Dr. George Shih for their time in discussing aspects of this work. Also, thanks go to Dr. Daniel P. Spangler for his critical review of this manuscript.

HYDROGEOLOGIC SETTING

The Floridan aquifer system in the area of investigation consists of a number of producing zones separated by semi-permeable zones in a sequence of Oligocene and/or lower Miocene to upper and middle Eocene carbonate sediments*. The base of the aquifer system could not be determined, as total depths of wells used in data collection limited the depth of exploration. The Floridan aquifer, as defined by Parker on a more regional basis, includes "parts or all of the middle Eocene (Ocala Limestone), Oligocene (Suwannee Limestone), and Miocene (Tampa Limestone) and permeable parts of the Hawthorn formation that are in hydrogeologic contact with the rest of the aquifer." (Parker, et al., 1955). The area's hydrogeology was described in detail by Brown and Reece (1979), portions of which are described in the following text.

Throughout the UECPA major producing zones within the Floridan aquifer system were stratigraphically confined to characteristic rock types, although the amount of contribution and quality of water to the open borehole varied areally. Four producing zones were identified as having differing hydrogeologic characteristics (Brown and Reece, 1979). Generalized hydrogeologic cross sections are shown in Figure 3. In general, the top of the Floridan aquifer system dips to the south; depth to the top is approximately -350 ft. msl. in northwestern St. Lucie County and -850 ft. msl. in southeastern Martin County. Over 300 ft. of Miocene sediments confine the Floridan aquifer system from the shallow aquifer system throughout the area.

The potentiometric surface of the Floridan aquifer system in the UECPA during May 1978 ranged from a high of +48 ft. msl. in north-central Martin County to a low of +30.0 ft. msl. in northeast St. Lucie County (Brown and Reece, 1979).

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*Classification and nomenclature conform to the usage of the Florida Bureau of Geology.

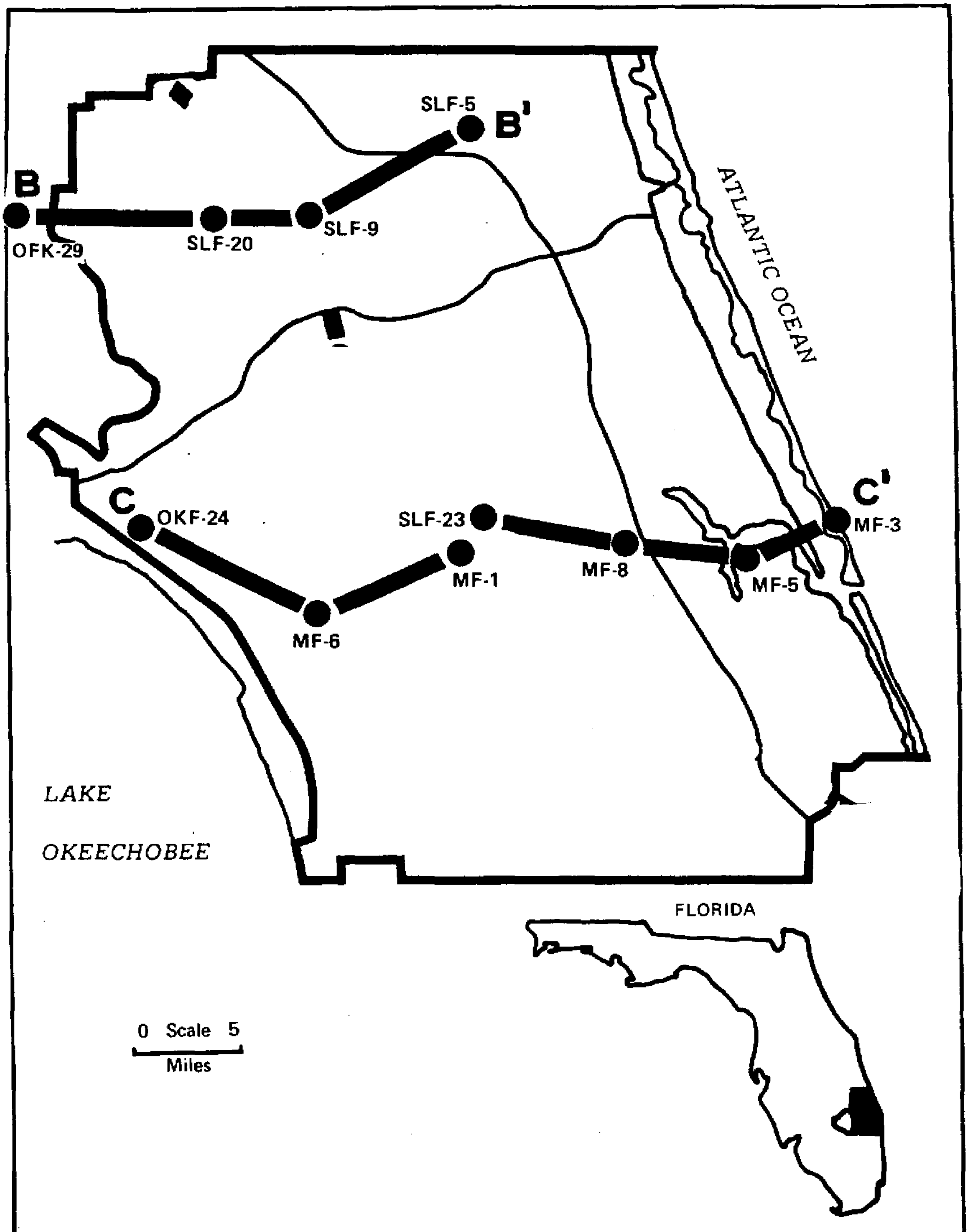


Figure 2 - Locations of Generalized Hydrogeologic Cross Sections, Upper East Coast Planning Area

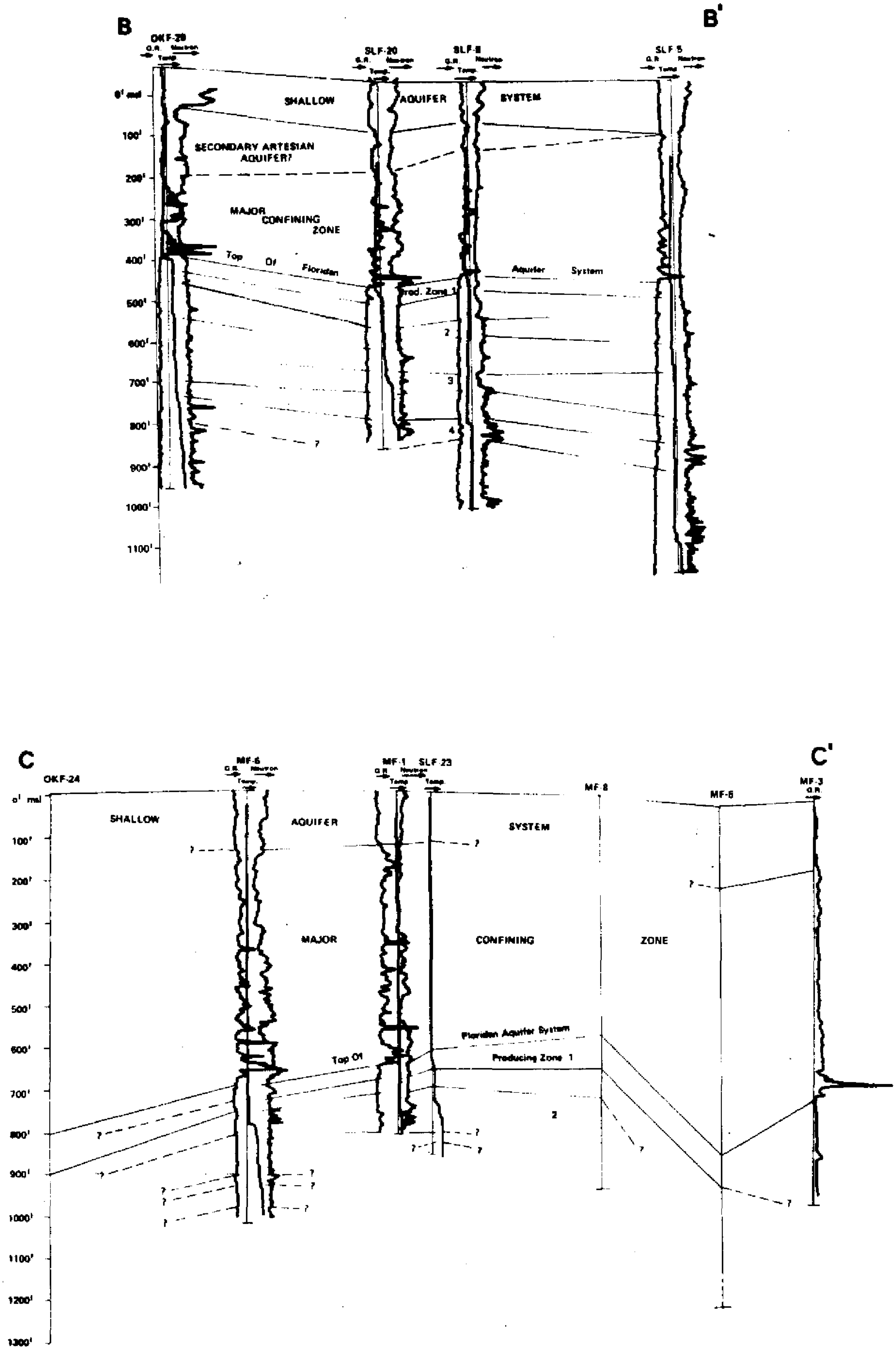


Figure 3 - Generalized Hydrogeologic Cross-Sections, Upper East Coast Planning Area (taken from Brown and Reece, 1979).

Generally, wells which penetrate the Floridan aquifer system in the UECPA are cased from land surface to approximately the top of the first competent bed, probably a lower Miocene or Hawthorn formation. The remainder of the hole is left open to differing producing zones.

METHODS OF INVESTIGATION

Throughout the study area, existing privately owned wells were utilized in data collection efforts. An extensive inventory of wells penetrating the Floridan aquifer system in the UECPA identified wells for use in a previous study (Brown and Reece, 1979) of which 16 wells were selected in this study for aquifer tests. Most wells were geophysically logged with calibrated surveys including: natural gamma ray, neutron porosity, 16 and 64 inch normal and 6 ft. lateral resistivities, caliper, flow meter, borehole fluid temperature and resistivity surveys. A typical suite of borehole geophysical surveys is shown in Figure 4 for SLF-14 along with a geologic section. Well construction configurations for test wells, as determined from the geophysical logs and elevations referenced to msl, are shown in Table 1. Most field data were collected during the wet season, assuming that lower than normal withdrawals from the Floridan aquifer system occurred in the surrounding area, thus decreasing the possibilities of interference from other wells.

As previously discussed, all wells used throughout this study are natural flowing artesian wells discharging at rates from 900 to 28 gallons per minute (gpm) - averaging 400 gpm. Shut-in pressure heads varied areally, controlled by the potentiometric surface and elevation at the well site. Pressure heads for the wells tested averaged approximately 15 ft. above land surface. Since these were flowing wells, drawdown data would be difficult to measure in the discharge well, thus the

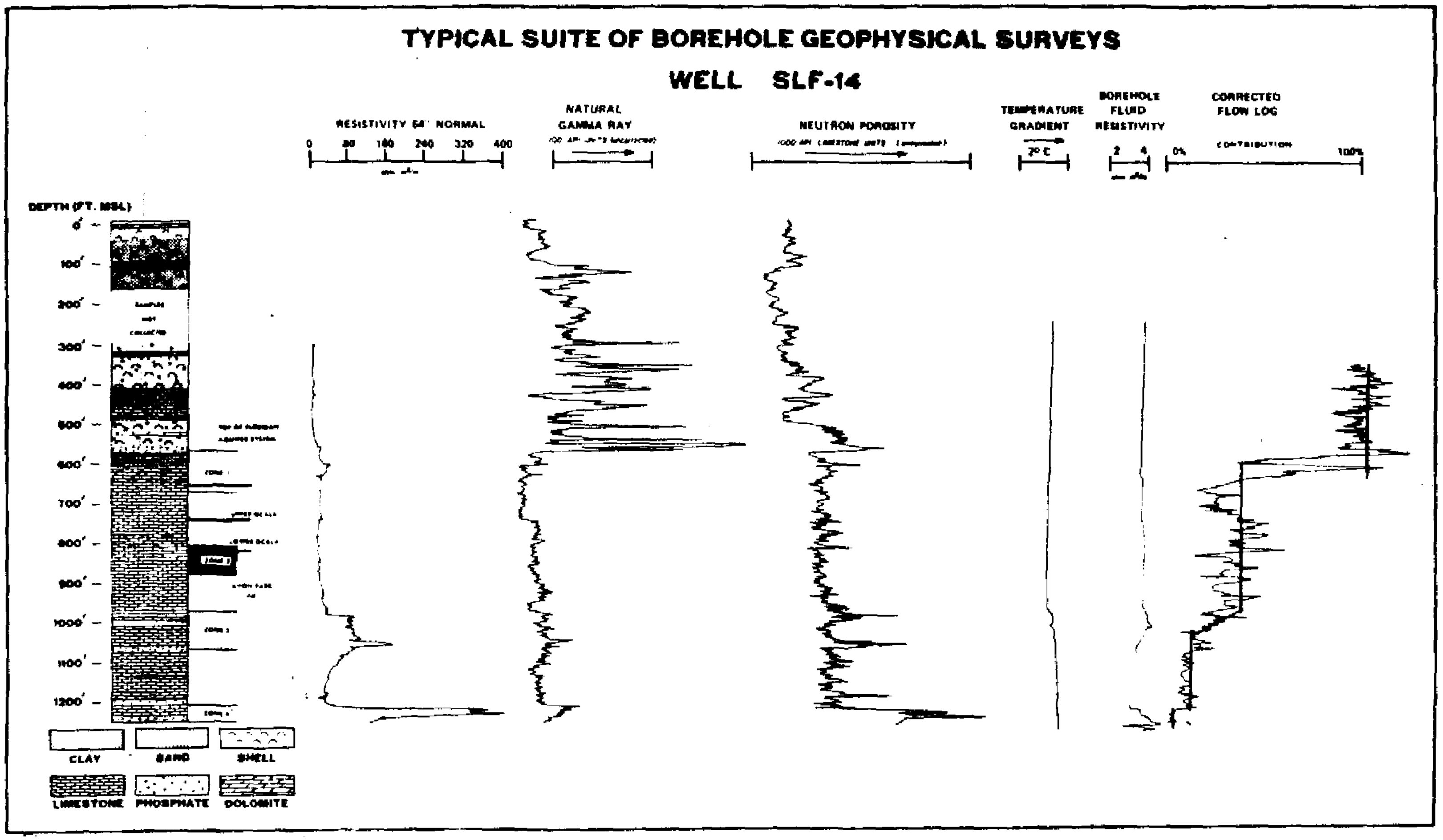


Figure 4 - Typical Suite of Borehole Geophysical Surveys and Geologic Section (taken from Brown and Reece, 1979)

TABLE 1

LOCATION AND CONSTRUCTION OF

WELL NO.	COUNTY	LATITUDE	LONGITUDE	ELEV.(MSL)
MF-9	Martin	27°10' 03.00"	80° 28' 00.00"	35.00'
OKF-2	Okeechobee	27°32'38.05"	80°42'42.14"	28.07'
SLF-4	St. Lucie	27°28'23.25"	80°29'02.01"	27.50'
SLF-20	St. Lucie	27°26'03.95"	80°40'40.00"	26.69'
MF-6	Martin	27°09'39.00"	80°35'00.00"	35.40'
MF-23	Martin	27°04'25.30"	80°33'47.00"	33.35'
SLF-17	St. Lucie	27°19'33.80"	80°34'18.03"	26.38'
SLF-24	St. Lucie	27°25'44.87"	80°25'32.34"	24.42'
SLF-24a	St. Lucie	27°25'44.61"	80°26'41.33"	23.00'
SLF-13	St. Lucie	27°24'12.32"	80°36'47.58"	27.33'
SLF-14	St. Lucie	27°20'14.11"	80°34'17.54"	26.32'
SLF-9	St. Lucie	27°26'50.15"	80°35'28.10"	25.56'
SLF-21	St. Lucie	27°25'36.55"	80°24'09.04"	21.05'
SLF-28	St. Lucie	27°20'27.93"	80°16'35.17"	31.38'
SLF-15	St. Lucie	27°20'00.10"	80°34'18.15"	27.96'
SLF-23	St. Lucie	27°13'11.00"	80°28'11.00"	32.37'

TEST WELLS

TOTAL DEPTH(LAND SUR.)	CASING DEPTH(LAND SUR.)	CASING I.D. (IN.)
880'	342'	6.00
686'	218'	6.00
993'	482'	9.25
896'	311'	5.00
1052'	399'	5.25
1119'	456'	5.50
1286'	320'	10.00
-	-	10.00
-	-	10.00
1238'	344'	12.00
1286'	318'	7.75
1058'	263'	10.00
700'	156'	3.50
883'	200'	4.00
-	-	-
894'	350'	6.00

water level recovery method was utilized. This recovery method allowed for the use of the natural flow for the drawdown phase. Moreover, the recovery method has the advantage that the rate of recharge Q is constant and equal to the mean rate of discharge (Q) during pumping. This means that drawdown variations resulting from slight differences in the rate of discharge do not occur during recovery (Kruseman and DeRidder, 1970).

If a well is discharged for a known time period and then shut off, the recovery curve is essentially an inverted image of the drawdown curve. The exact shape of each curve is influenced by the hydrologic characteristics of the aquifer. The analysis which computes these characteristics is based on detailed examination of the time-recovery curve. The nonequilibrium equation is applicable for analysis of the recovery of a discharging well (Todd, 1959). The residual drawdown ($h_o - h_1$) where h_1 is the head during the recovery period, can be given as:

(1)
$$h_o - h_1 = \frac{Q}{4\pi T} \left\{ \int_{r^2S/4Tt}^{\infty} \frac{e^{-u}\,du}{u} - \int_{r^2S/4Tt'}^{\infty} \frac{e^{-u}\,du}{u} \right\}$$

Where

t = time since discharging started (day)

t' = time since discharging stopped (day)

r = distance from discharge well to observation point (in ft.)

Q = discharge rate (gpd)

S = storage coefficient

T = transmissivity (gpd/ft.)

$u = r^2S/4Tt$

h_o = initial head (ft.)

h_1 - head at time t' (ft.)

For r small and t' large, the exponential integrals can be approximated by the first two terms of a power series and the transmissivity is given by:

$$(2)\quad T = \frac{2.30Q}{4\pi\,(h_0-h_1)} \log t/t'$$

By measuring the rate of recovery of water level in a discharging well, T can be determined. For convenience in obtaining a solution, residual drawdowns h_0-h_1, should be plotted on a linear scale against t/t' on a logarithmic scale. Also $(t/t')_1$, and $(t/t')_2$ are chosen one log cycle apart to make the log of $(t/t')_2$ / $(t/t')_1$ equal to one. Transmissivity can then be calculated from:

$$(3)\quad T = \frac{264Q}{\Delta h}$$

Where,

T = gallons/day/ft.

Q = gallons/min.

Δh = change in residual drawdown in feet per log cycle of time.

If measurements are made in at least one observation well during the recovery period, the storage coefficient can be calculated, by the equation:

$$(4)\quad S = \frac{0.3Tt_0}{r^2}$$

Where,

S = coefficient of storage (unitless)

t_0 = intercept of the straight line at zero drawdown (in days)

r = distance, in ft., from pumped well to observation well where drawdown or recovery measurements were made.

The above modified non-equilibrium formula is based on the following assumptions (Johnson, 1966):

(a) Water bearing formation(s) are homogeneous and isotropic.

(b) Formation(s) have uniform thickness and are infinite in areal extent.

(c) Formations receive no recharge from any source.

(d) The pumped well penetrates and receives water from the full thickness of water bearing formations.

(e) Water removed from storage is discharged instantaneously with lowering of the head.

Assumptions (a) and (d) above are not met.

Since all wells were privately owned, some of the wells used in this study were turned on by other than project personnel, thus values of t could not be calculated in all cases. Observation of plots t' vs residual drawdown and t/t' vs residual drawdown for the same test shows similar slopes (changes in head per log cycle). Thus, plots of t'vs residual drawdown (recovery) were used to calculate transmissivities. Recovery pressure data collected at each test well was referenced to the spigot an arbitrary datum. This condition does not change any calculated values of transmissivity since differences in head (Δh) are used in the calculations and not absolute values of head. Plots of t' vs residual drawdown (recovery referenced to the arbitrary datum) and t/t' vs residual drawdown for all wells are shown in the Appendix. For these recovery curves, 0 feet is used in all cases to indicate maximum recorded drawdown at t' = 0. Increasing numbers when t' > 0 reflect actual recovery (residual drawdown) in feet.

Most of the aquifer tests were made without the aid of an observation well at some distance away from the discharged well; in these cases, the discharge well served as the observation well. Flow measurements were determined from both a calibrated flow meter (spinner tool) and the volumetric method which records the time it takes to fill a known volume. Discharges did not significantly vary through the drawdown phase of the tests. Water level recovery data were collected via both a calibrated mechanical pressure gage and a continuous recorder, simultaneously (Figure 5). The two pressure measuring devices were attached to the wellhead in parallel thus having two sets of recovery data to be matched for quality control purposes. The mechanical pressure gage was read to the nearest inch of head and manually recorded against its associated time.

The pressure measuring element for the recorder is factory calibrated to an accuracy of .5% of full scale with a total span of 50 inches of head. Variable chart speeds were utilized during each test. Early recovery data was recorded at a chartspeed of 12 inches per minute, after which 12 inches per hour was used. Strip charts were digitized and tabulated at varying time intervals of 0.5 sec., 2.5 sec., and 1 minute. Figure 6 shows a typical strip chart for test results digitized at the above variable frequency. Data collected from the recording pressure gage was considered to be more consistent and was therefore used for most analyses.

As an additional aid to the user, relative flow contribution into the open borehole from individual producing zones was calculated from corrected borehole flow logs. Figure 7 shows for a typical well in the UECPA, a caliper and flow meter survey with a computed corrected flow log. Flow is calculated from these data by using the equation:

(5) $Q = A'V$

Where

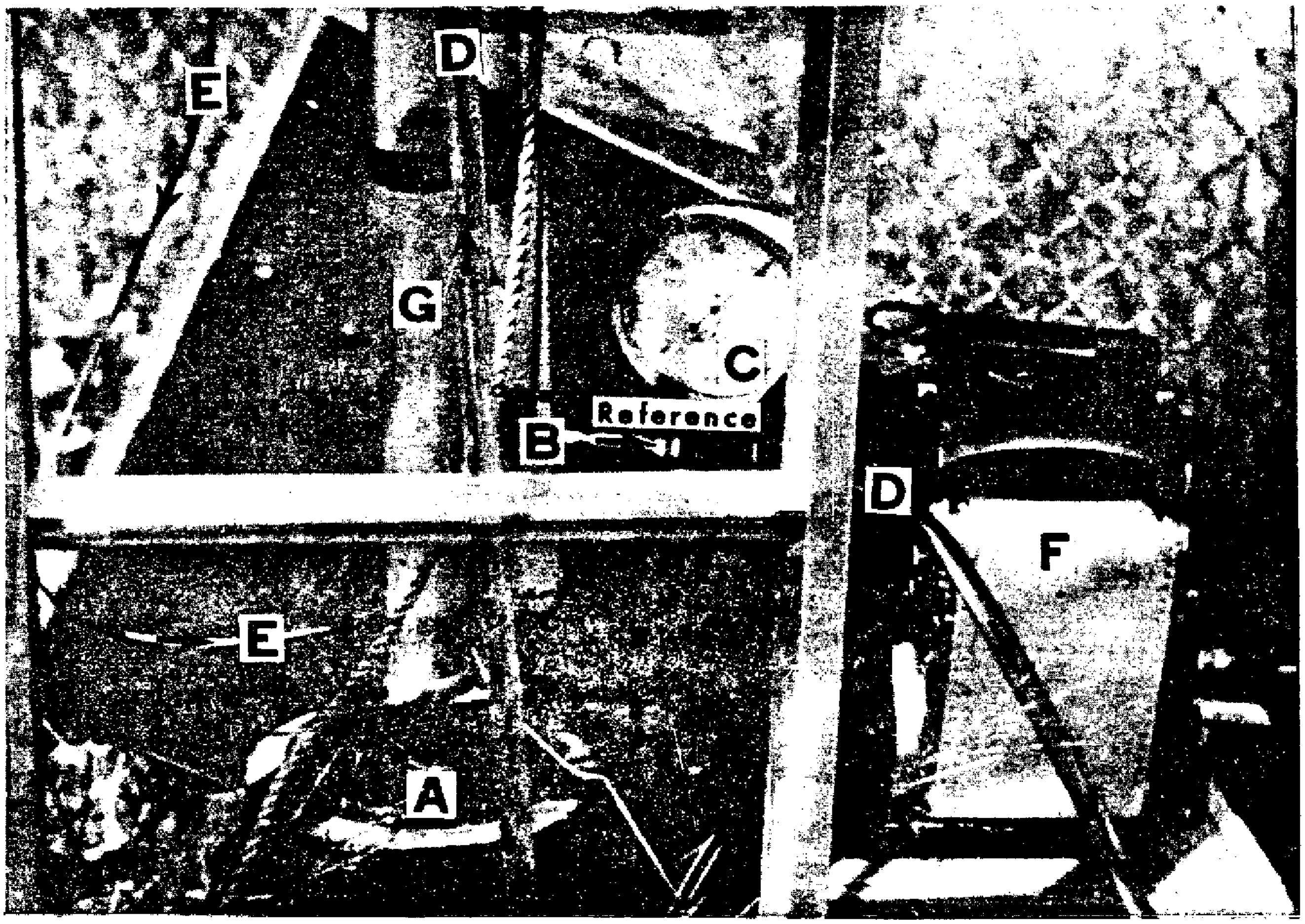
Q = flow (relative units) of cps-in.^{2}

A' = area (in.^{2})

V = velocity (relative units) counts per second (cps)

Area of the borehole is calculated by assuming spherical borehole conditions where the area of the borehole equals:

$A' = 1/4\ \pi d^2$



EXPLANATION

A Wellhead

B Spigot (Reference Point)

C Mechanical Pressure Gage

D Plastic Hose To Diaphragm (Not Shown)

E Copper Tubing To Recording Pressure Gage

F Recording Pressure Gage

G PVC Pipe Holding Diaphragm

→ Direction Of Pressure Flow

Figure 5 - Recovery Test Equipment Set-Up

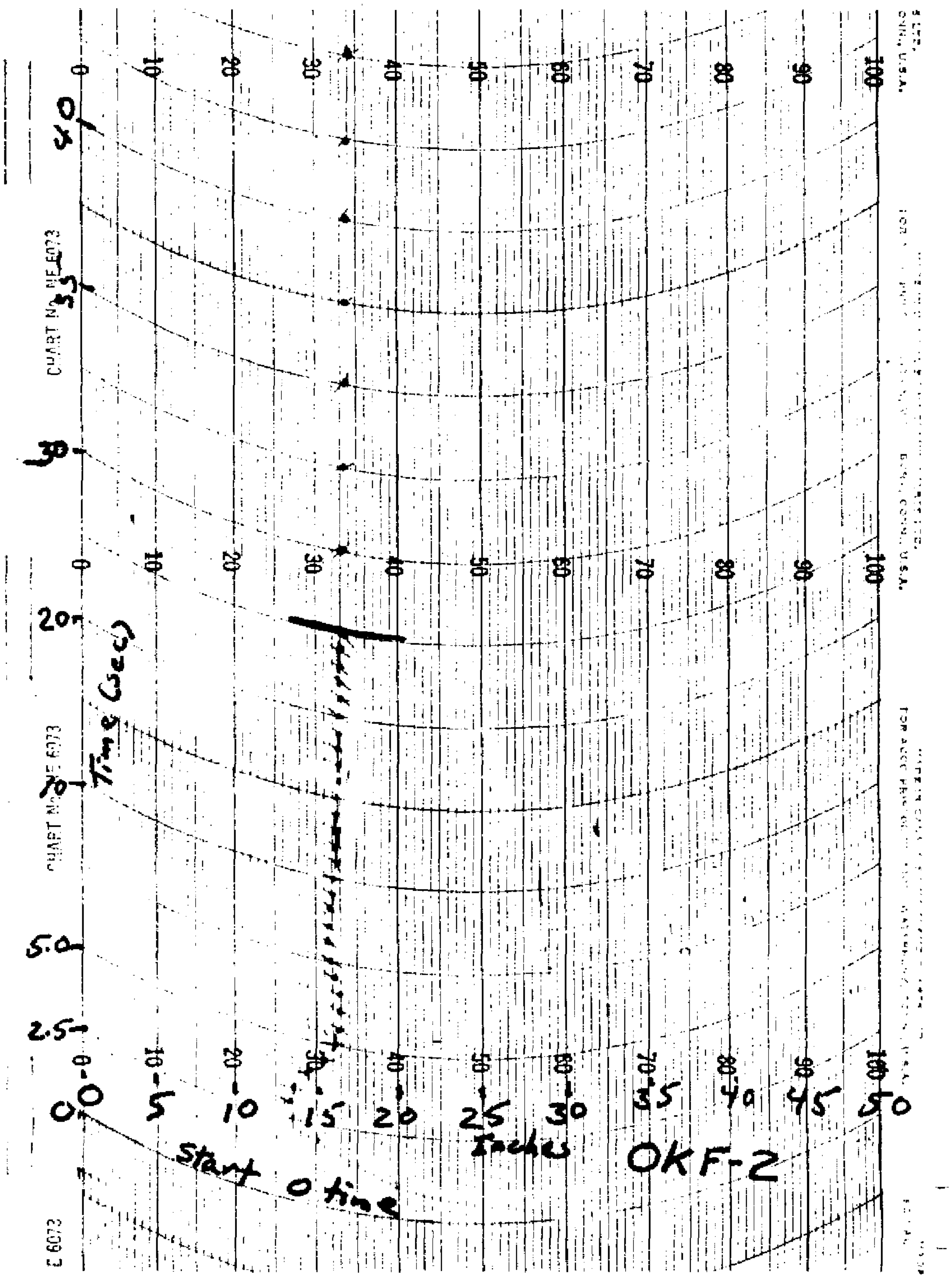


Figure 6 - Typical Strip Chart from Continuous Pressure Recorder

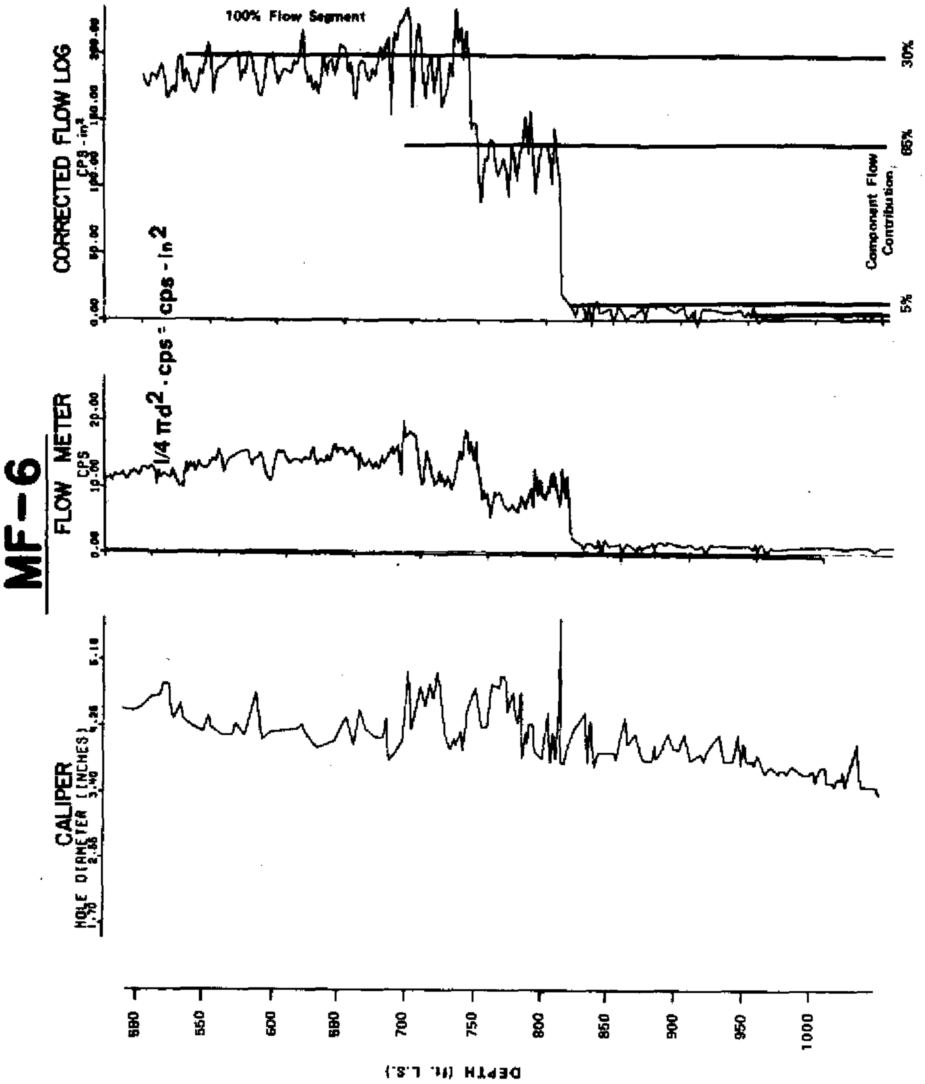


Figure 7 - Typical Well Showing the Use of Caliper and Flowmeter Surveys to Compute a Corrected Flow Log (Taken from Brown and Reece, 1979)

Where,

d = diameter (in.)

Diameter of the borehole is derived via use of the caliper survey and velocity is derived from the flowmeter survey. The corrected flow log in Figure 7 was computed at constant depth intervals of 2 ft. A best fit line is drawn showing constant flow along a given length of borehole. Where a producing zone contributes water, the flow increases reflecting a cumulative flow in relative units of all producing zones below that point of measurement.

Within the casing, as at the wellhead, 100 percent of the total flow is measured. Thus the contribution of any segment of the borehole can be computed as a function of total borehole flow as measured at the wellhead. These contributing changes in flow from the various producing zones can be examined on the corrected flow log as shifts in the straight line segments of the log which reflect the percent changes in contribution relative to the total discharge.

Flow contributions from producing zones penetrated were calculated from 10 of the 16 wells in which aquifer tests were performed. Results of these analyses are shown in Table 2.

TABLE 2

PRODUCING ZONE(S) FLOW IN PERCENT CONTRIBUTION

WELL NO.	PROD. ZONE 1	PROD. ZONE 2	PROD. ZONE 3	PROD. ZONE 4
OKF-2	70	0	15	15
SLF-17	60	5	25	10
MF-6	30	65	5	-
MF-23	0	55	30	15
SLF-28	40	60	-	-
SLF-21	20	80	-	-
SLF-9	40	0	0	60
SLF-20	60	20	10	10
SLF-4	30	40	20	10
MF-9	35	65	-	-

SUMMARY OF RESULTS

Transmissivity and Storage Coefficient

Tabulated, calculated composite transmissivity values for the Floridan aquifer system in the UECPA are shown in Table 3. Composite transmissivity values ranged from 24,600 gpd/ft. (excluding MF-4) to 956,700 gpd/ft. The large range of composite values in the area of study is probably due to differences in aquifer thickness penetrated by test wells and to anisotropy and heterogeneity of the system. Figure 8 shows the general trends of composite transmissivity values for the UECPA as ranges of composite transmissivity which vary from a high of 950,000 - 500,000 gpd/ft. to a low of 25,000 - 10,000 gpd/ft. A trend of relatively high composite transmissivity values is observed striking north-south with the largest range of values of 950,000 - 500,000 gpd/ft. in north central St. Lucie County. Composite transmissivity ranges drop to the east and west of the high, decreasing to a range of 25,000 - 10,000 gpd/ft. in east central St. Lucie and Martin Counties.

Storage coefficients, as determined from two aquifer tests in the area of investigation, are shown in Table 3 and range from 1.83×10^{-4} to 9.55×10^{-4}. On the basis of this study a storage coefficient on the order of 5.0×10^{-4} for the Floridan aquifer system in the UECPA is considered to be a good working estimate.

Comparison of this data with geologic data by Mooney, 1979, and water quality data by Brown and Reece, 1979, leads to some interesting correlations. Figure 9 shows concentrations of total dissolved solids (TDS) of composite water samples collected in September 1977 in the UECPA. A "ridge" of high TDS concentrations (2500 mg/l) trends northwest-southeast with concentrations decreasing to 1500 and 500 mg/l along the east and

TABLE 3

COMPOSITE AQUIFER TEST RESULTS

WELL NO.	TRANSMISSIVITY (GPD/FT.)	STORAGE COEFFICIENT
MF-9	104,300	
OKF-2	153,400	
SLF-4	461,700	
SLF-20	44,600	
MF-6	104,900	
MF-23	54,400	
SLF-17	166,600	
SLF-24 (prod. well, recovery)	208,500	
SLF-24A(ob. well, drawdown)	208,500	1.83×10^{-4}
SLF-24A(ob. well, recovery)	215,900	1.88×10^{-4}
SLF-13	775,300	
SLF-14	412,800	
SLF-9	956,700	
SLF-21	49,000	
SLF-28	24,600	
SLF-15 (ob. well, drawdown)	629,200	9.55×10^{-4}
SLF-15 (ob. well, recovery)	670,800	8.32×10^{-4}
SLF-23	106,700	
*MF-4 (ob. well)	12,700	5.00×10^{-4}

ob. well = observation well
prod. well = production well

* = Data Collected and analyzed by Gee & Jensen, 1977.

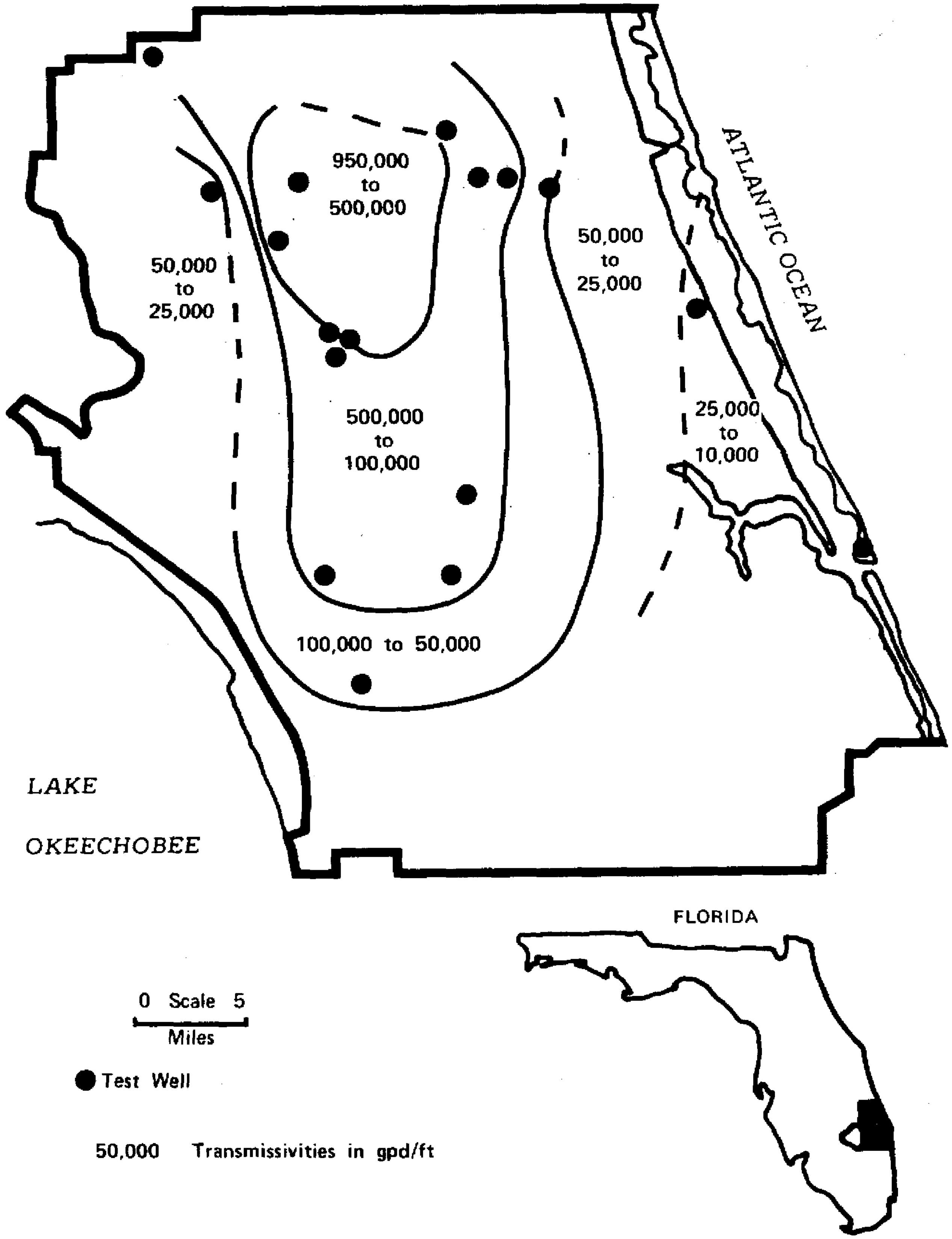


Figure 8 - General Composite Transmissivity Trends

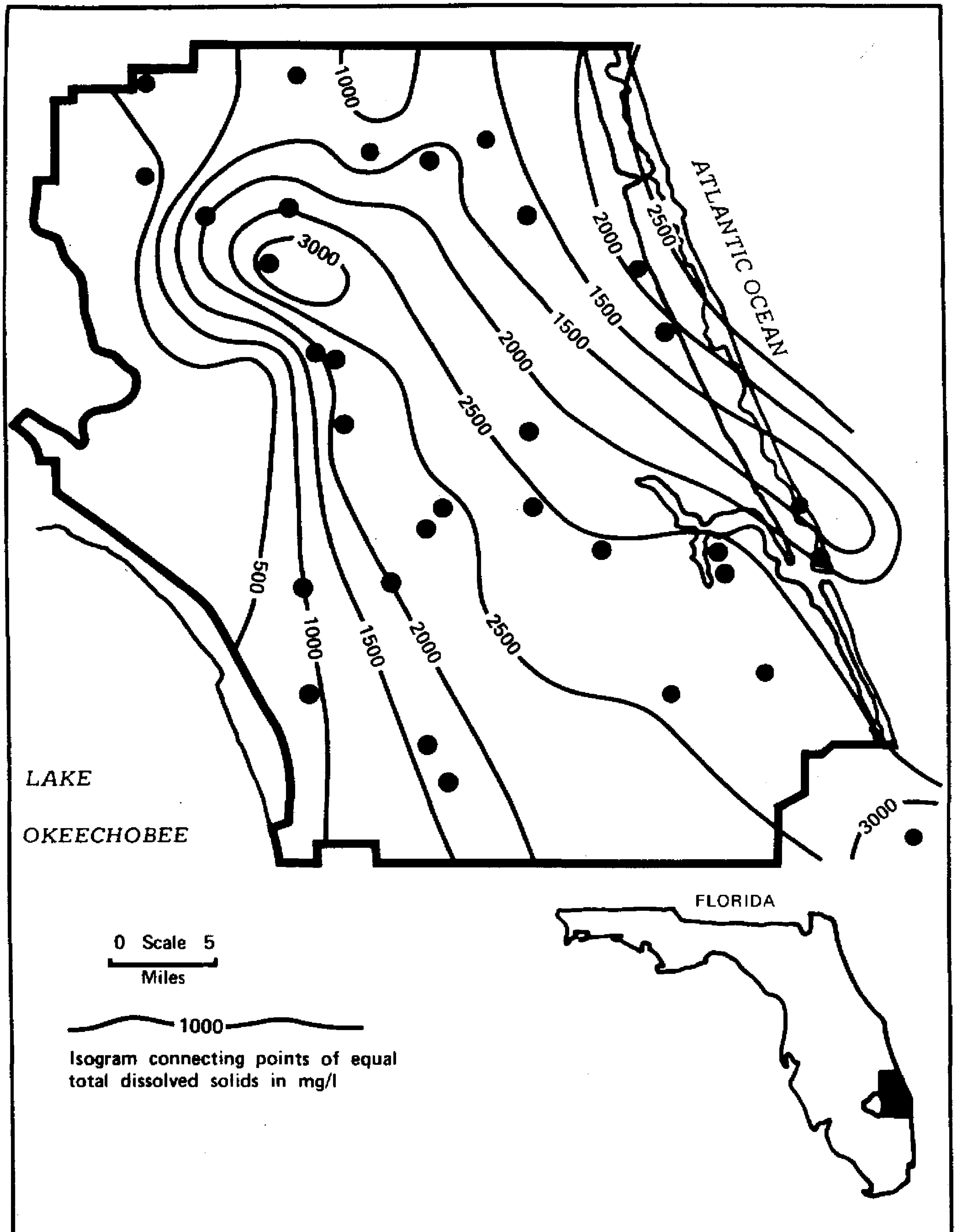


Figure 9 - Total Dissolved Solids of Floridan Aquifer System Waters for September, 1977 (replotted from Brown and Reece, 1979)

west flanks of this feature, respectively.

Figure 10 shows an isopach map of the Ocala limestone by Mooney, 1979. As can be observed, the thickest section of Ocala strikes northwest-southeast thinning to the east and west. This also follows the general transmissivity trends. The general north-south trend of high transmissivity values, although not precisely aligned with the axis of poor water quality and thick Ocala limestone, can possibly be associated with this feature considering the lack of data points in southeastern Martin County. This lack of data points possibly biassed contouring to cause the apparent north-south trend in high transmissivity values.

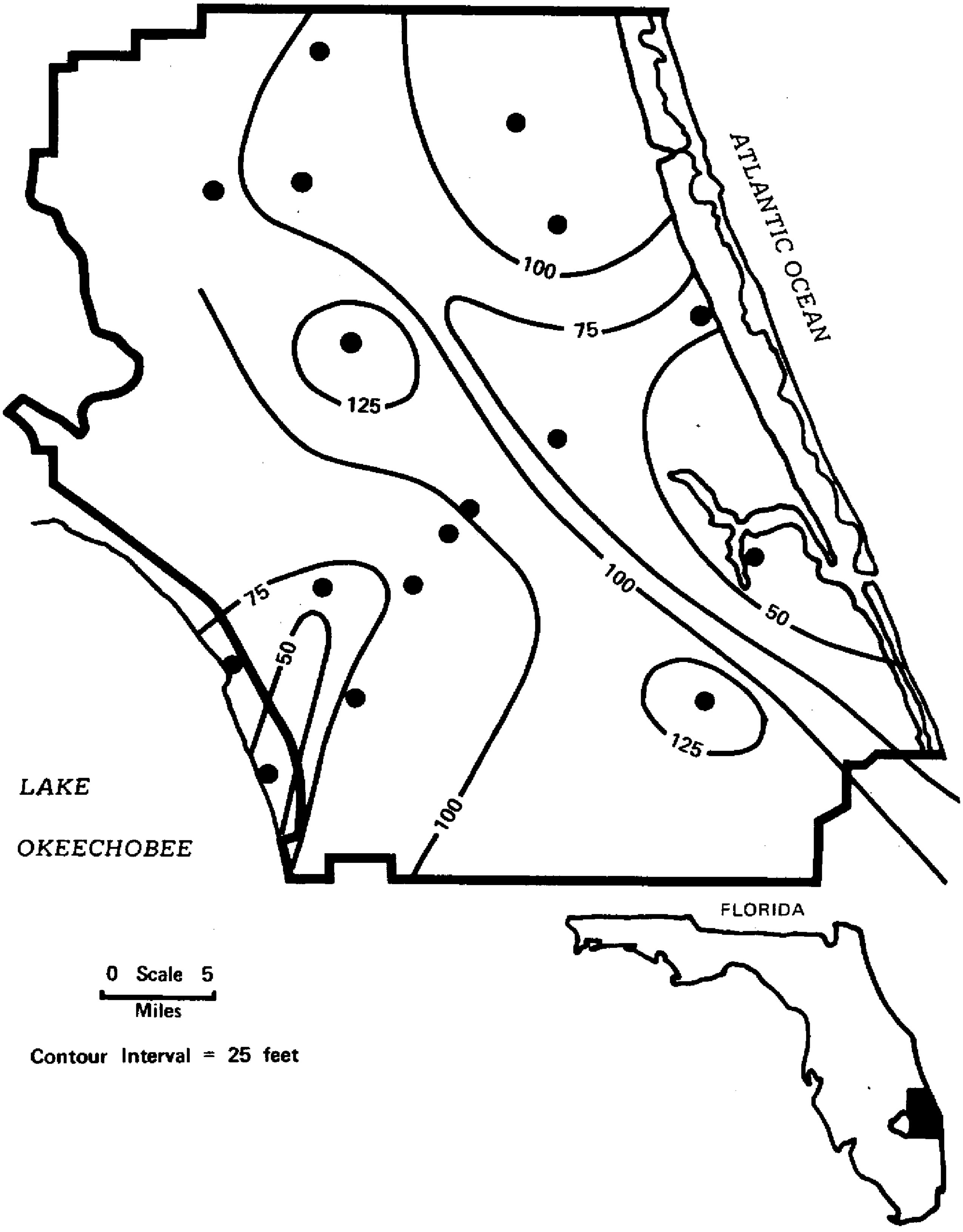


Figure 10 - Isopach Map of the Ocala Limestone (replotted from Mooney, 1979)

CONCLUSIONS

The large quantities of water withdrawn from the Floridan aquifer system in the UECPA need to be evaluated to properly manage this important resource for present and future use. Time recovery and drawdown data collected in the UECPA using a high speed, high resolution recording pressure gage and analyzed by the modified non-equilibrium equation are documented in this report for use as input data for a preliminary mathematical model. Composite transmissivity data can be used in a single layered model if the system is assumed to be a relatively homogeneous aquifer rather than a number of producing zones.

For any model beyond a preliminary type, further work is needed to determine differences in gradients between producing zones. The true transmissivity value for each producing zone can be calculated by packer testing, drawing water levels down in each producing zone. Also, leakance from the semi-permeable zones needs to be examined along with that section below producing zone 4 to evaluate upward leakance from zones of potential poorer quality water.

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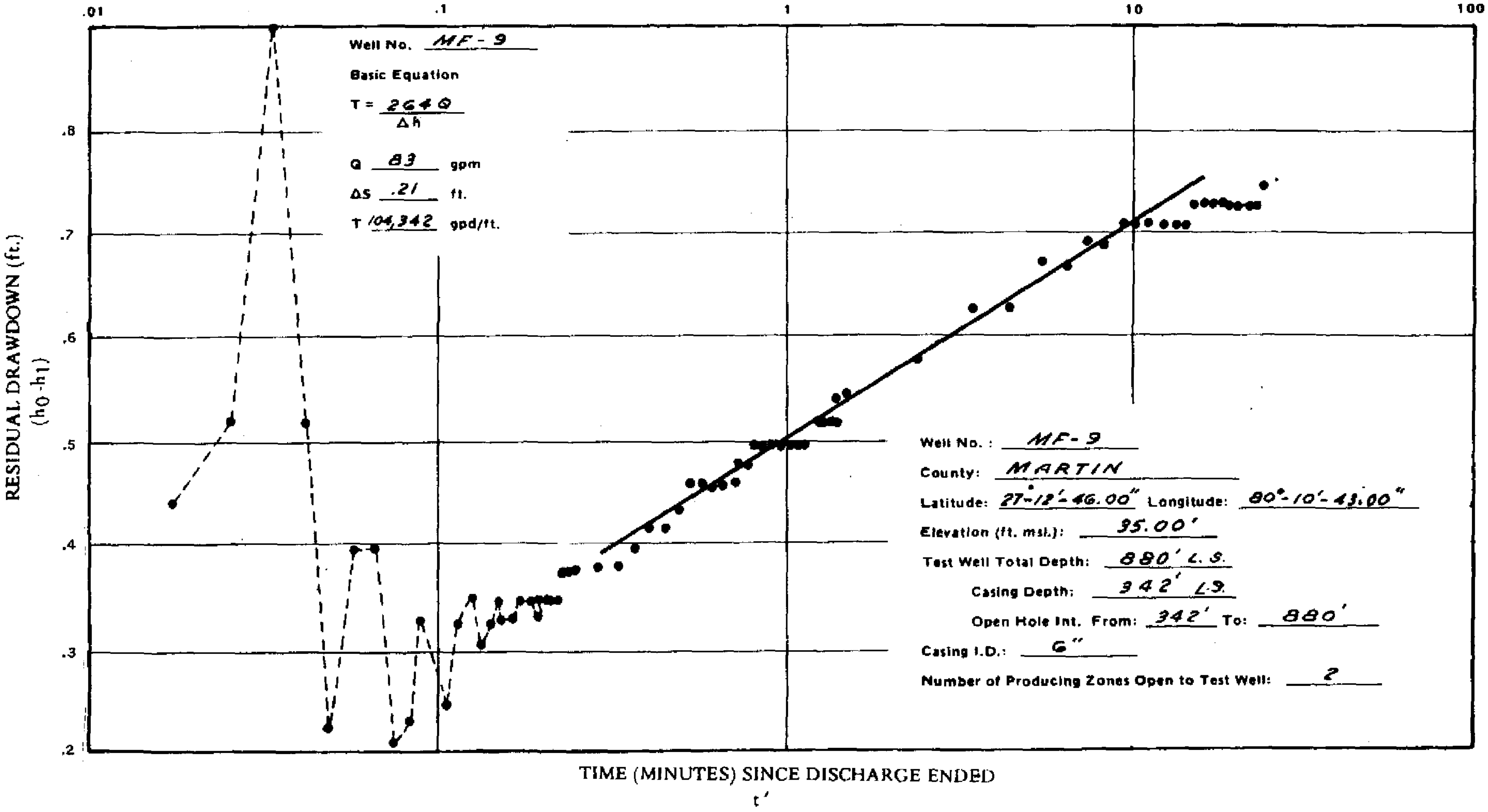
APPENDIX

Graphs showing recovery and drawdown test analyses and site data.

*Observation well some distance from the production well.



Well No. MF - 9

Basic Equation

$T = \frac{264 Q}{\Delta h}$

Q 83 gpm

ΔS .21 ft.

T 104,342 gpd/ft.

Well No. : MF - 9

County: MARTIN

Latitude: 27°-12'-46.00" Longitude: 80°-10'-43.00"

Elevation (ft. msl.): 35.00'

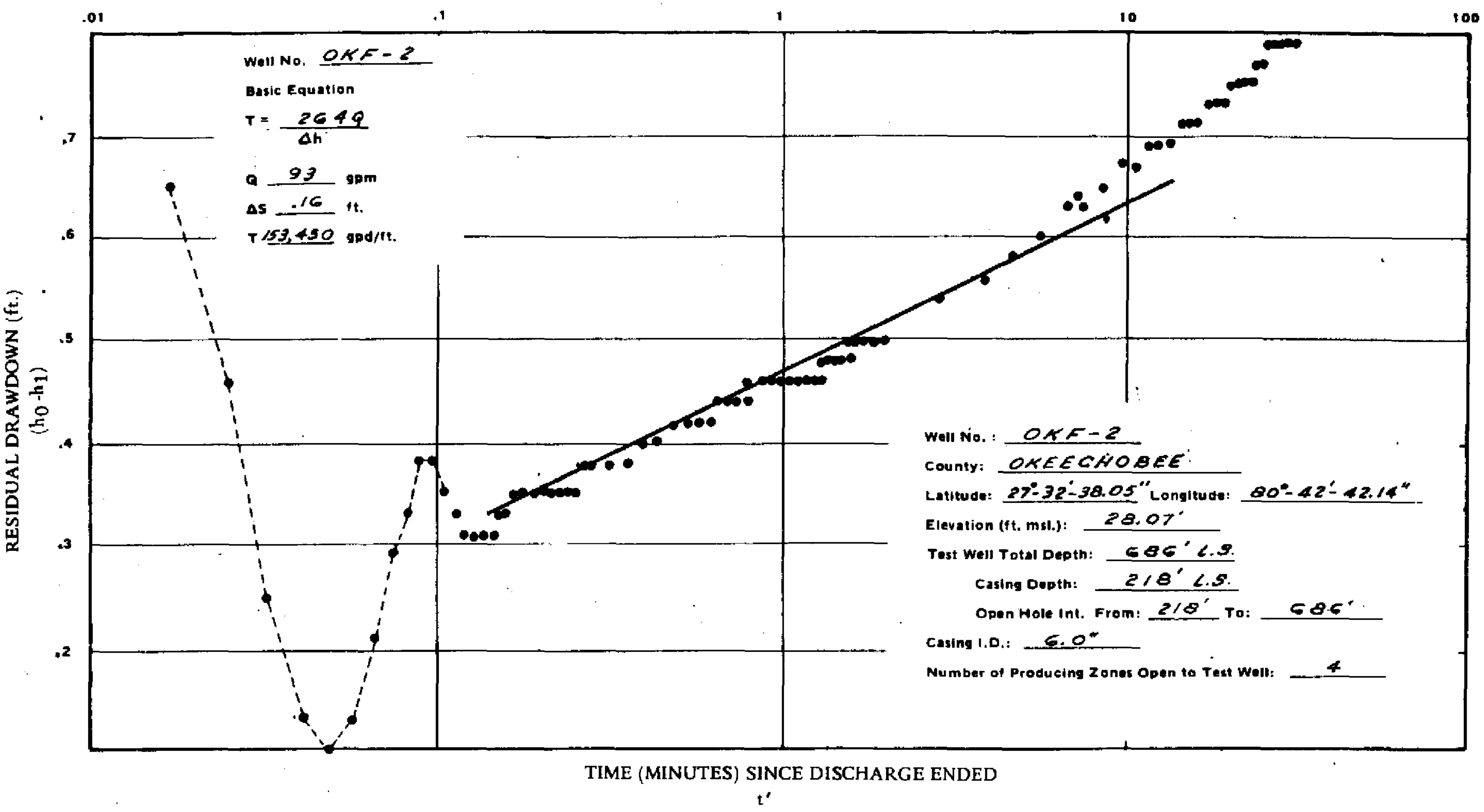
Test Well Total Depth: 880' L.S.

Casing Depth: 342' L.S.

Open Hole Int. From: 342' To: 880'

Casing I.D.: 6"

Number of Producing Zones Open to Test Well: 2



Well No. OKF-2

Basic Equation

$T = \frac{264Q}{\Delta h}$

Q 93 gpm

ΔS .16 ft.

T 153,450 gpd/ft.

Well No.: OKF-2

County: OKEECHOBEE

Latitude: 27°-32'-38.05" Longitude: 80°-42'-42.14"

Elevation (ft. msl.): 28.07'

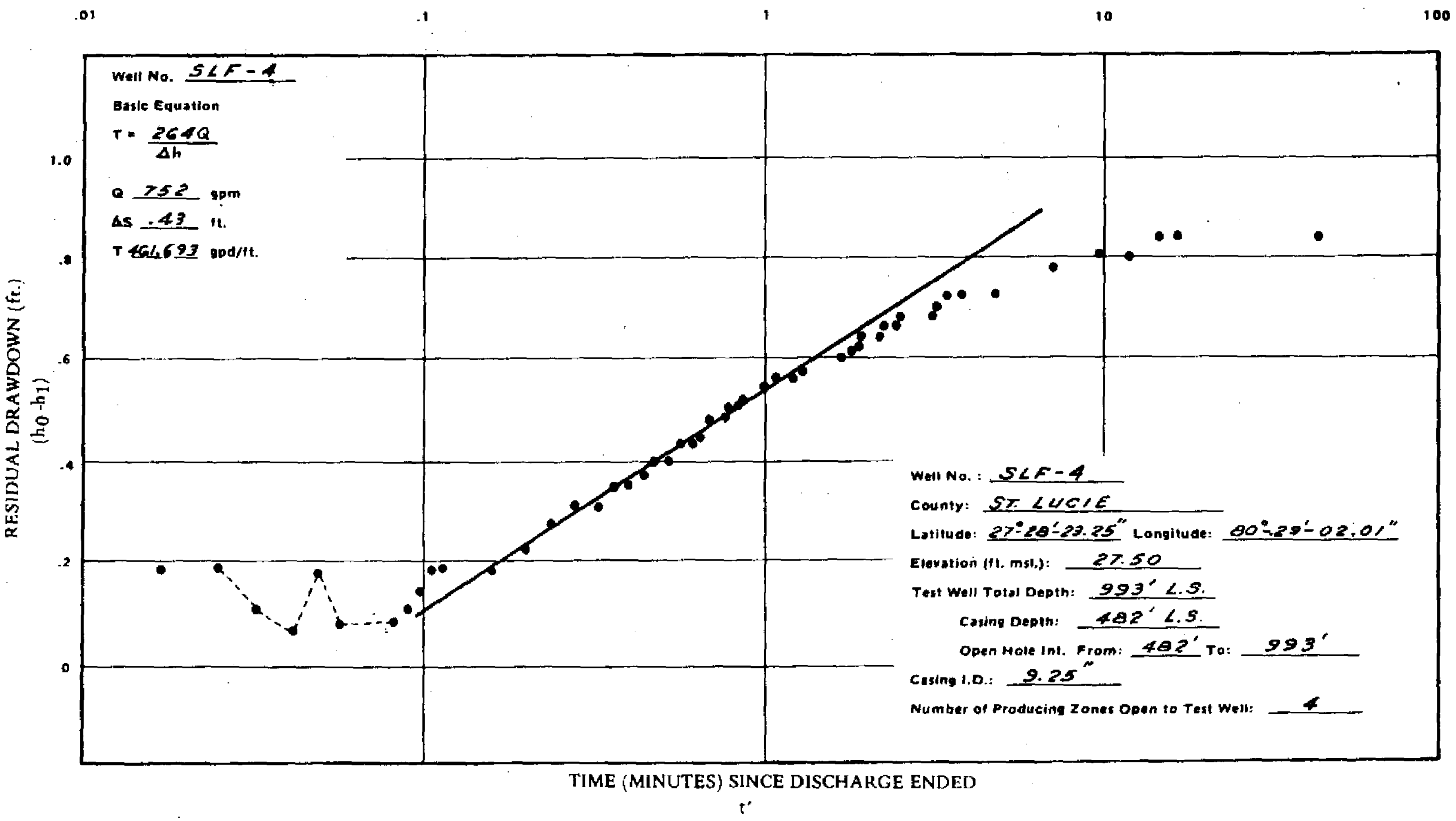
Test Well Total Depth: 686' L.S.

Casing Depth: 218' L.S.

Open Hole Int. From: 218' To: 686'

Casing I.D.: 6.0"

Number of Producing Zones Open to Test Well: 4



Well No. SLF-4

Basic Equation

$T = \frac{264Q}{\Delta h}$

Q 752 gpm

Δs .43 ft.

T 461,693 gpd/ft.

Well No.: SLF-4

County: ST. LUCIE

Latitude: 27°28'23.25" Longitude: 80°29'02.01"

Elevation (ft. msl.): 27.50

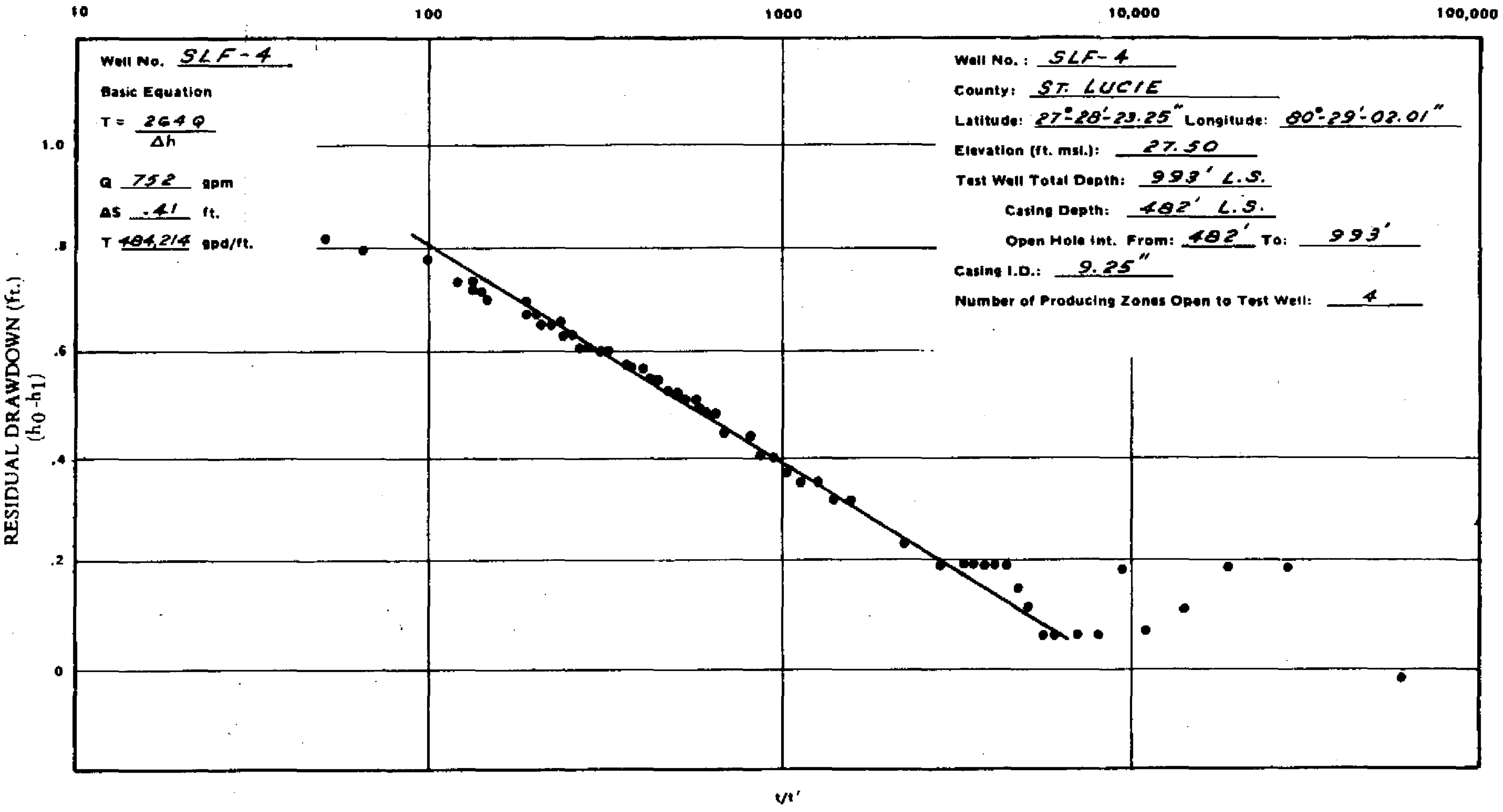
Test Well Total Depth: 993' L.S.

Casing Depth: 482' L.S.

Open Hole Int. From: 482' To: 993'

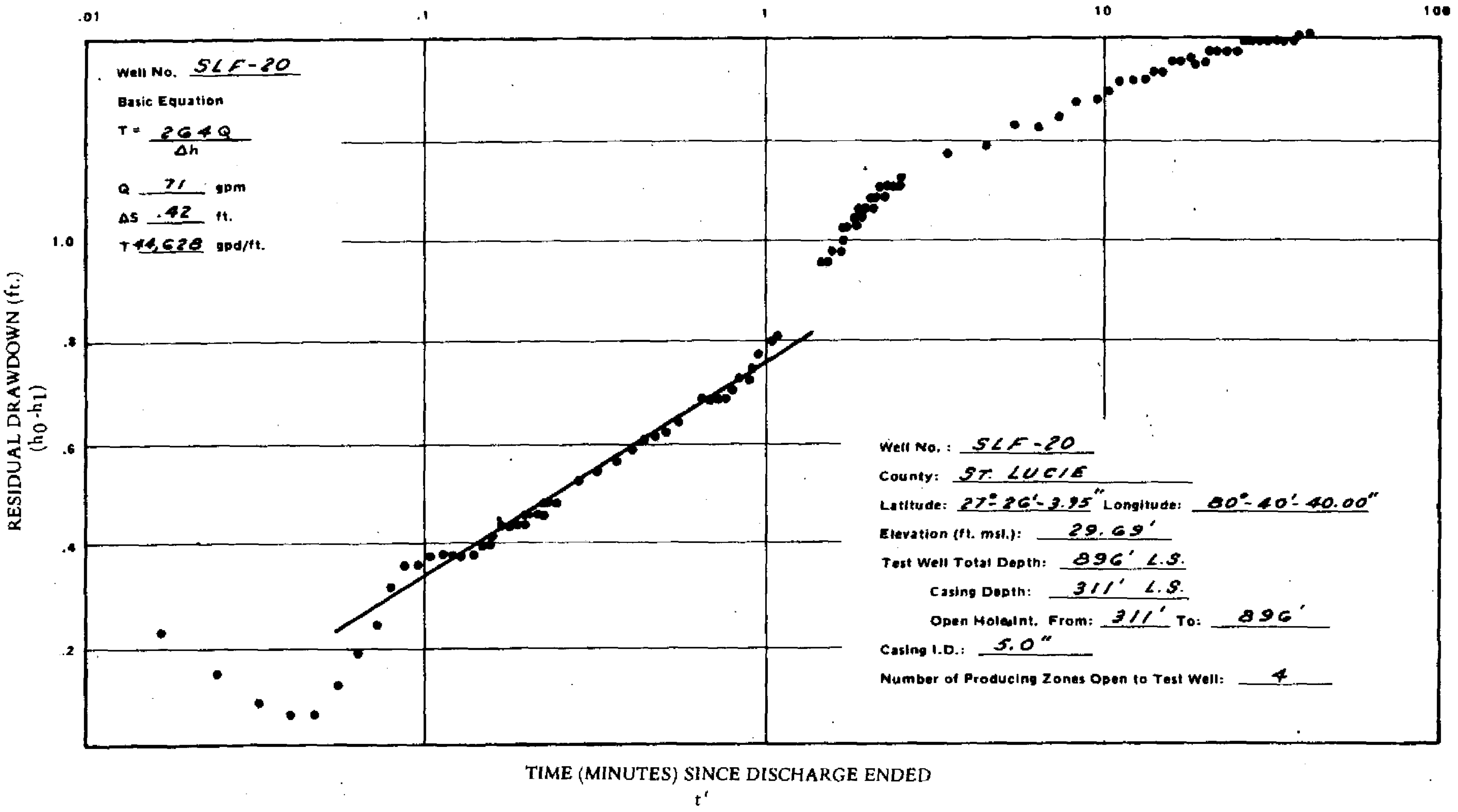
Casing I.D.: 9.25"

Number of Producing Zones Open to Test Well: 4



Well No. *SLF-4*
Basic Equation
T = $\frac{264Q}{\Delta h}$
Q *752* gpm
ΔS *.41* ft.
T *484,214* gpd/ft.

Well No.: *SLF-4*
County: *ST. LUCIE*
Latitude: *27°-28'-23.25"* Longitude: *80°-29'-02.01"*
Elevation (ft. msl.): *27.50*
Test Well Total Depth: *993' L.S.*
Casing Depth: *482' L.S.*
Open Hole Int. From: *482'* To: *993'*
Casing I.D.: *9.25"*
Number of Producing Zones Open to Test Well: *4*



Well No. SLF-20

Basic Equation

$T = \frac{264Q}{\Delta h}$

Q 71 gpm

ΔS .42 ft.

T 44,628 gpd/ft.

Well No.: SLF-20

County: ST. LUCIE

Latitude: 27°-26'-3.95" Longitude: 80°-40'-40.00"

Elevation (ft. msl.): 29.69'

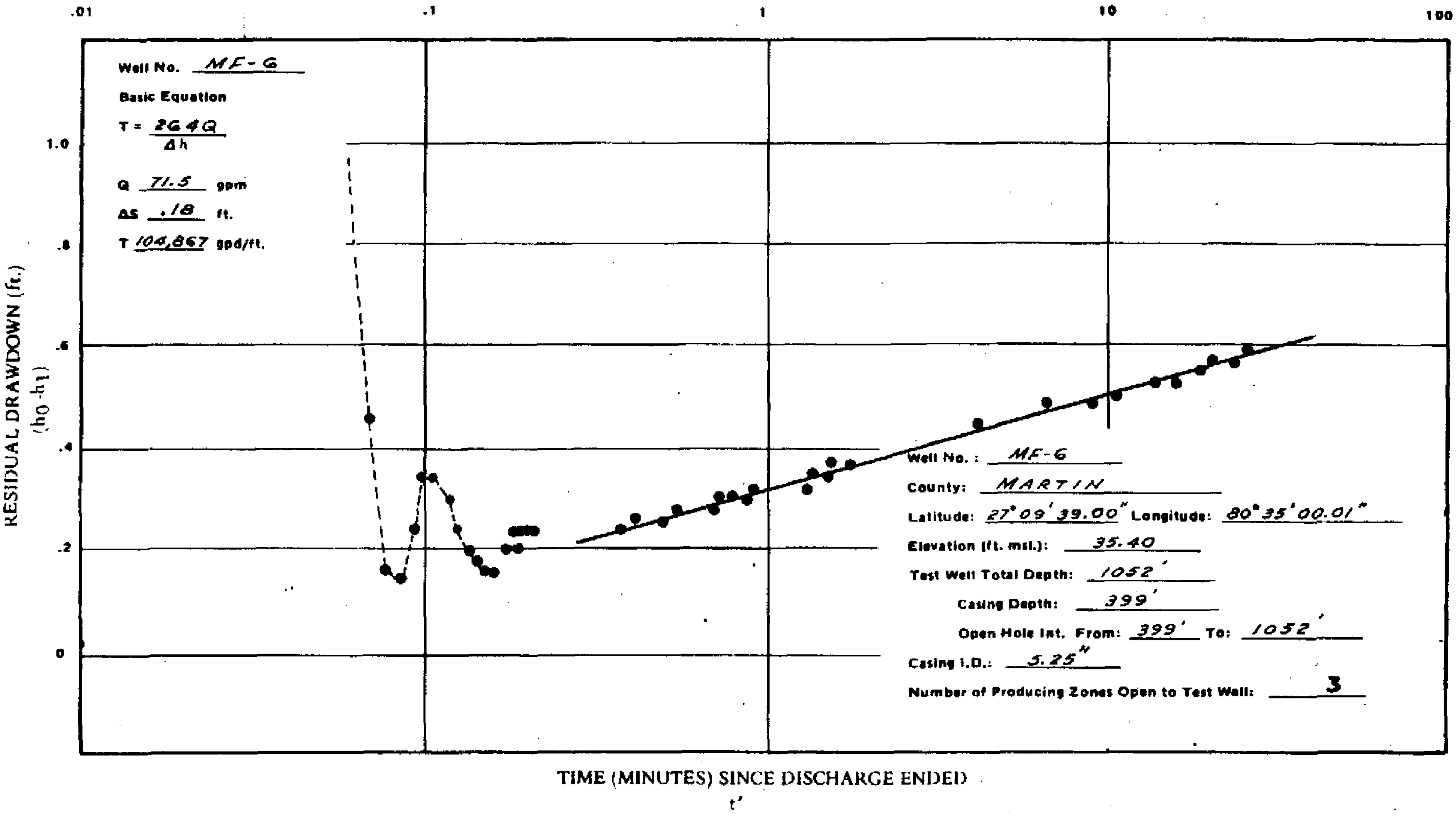
Test Well Total Depth: 896' L.S.

Casing Depth: 311' L.S.

Open Hole Int. From: 311' To: 896'

Casing I.D.: 5.0"

Number of Producing Zones Open to Test Well: 4



Well No. MF-6

Basic Equation

$T = \frac{264Q}{\Delta h}$

Q 71.5 gpm

ΔS .18 ft.

T 104,867 gpd/ft.

Well No.: MF-6

County: MARTIN

Latitude: 27°09'39.00" Longitude: 80°35'00.01"

Elevation (ft. msl.): 35.40

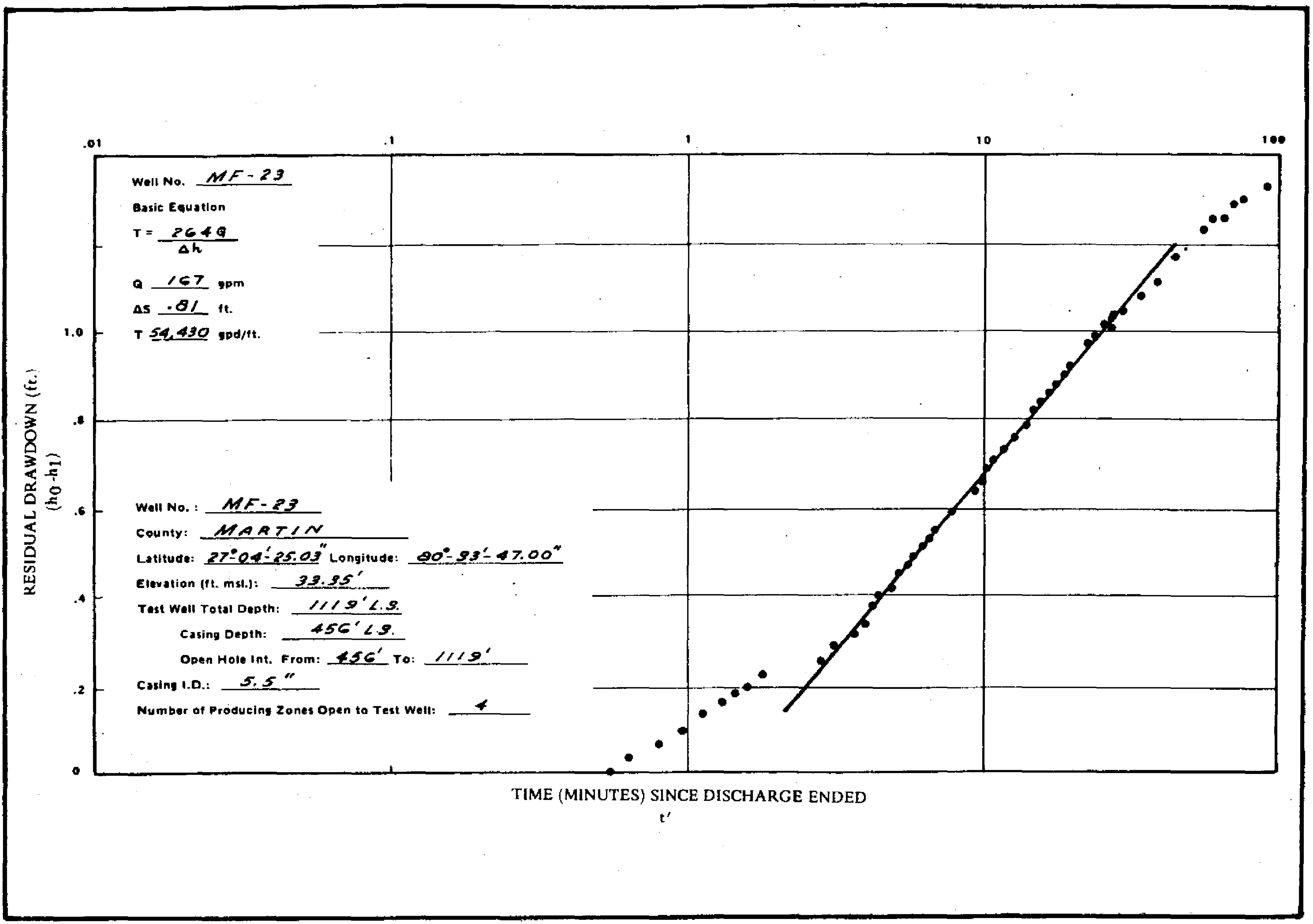
Test Well Total Depth: 1052'

Casing Depth: 399'

Open Hole Int. From: 399' To: 1052'

Casing I.D.: 5.25"

Number of Producing Zones Open to Test Well: 3



Well No. MF-23

Basic Equation

$T = \frac{264Q}{\Delta h}$

Q 167 gpm

ΔS .81 ft.

T 54,430 gpd/ft.

Well No.: MF-23

County: MARTIN

Latitude: 27°-04'-25.03" Longitude: 80°-33'-47.00"

Elevation (ft. msl.): 33.35'

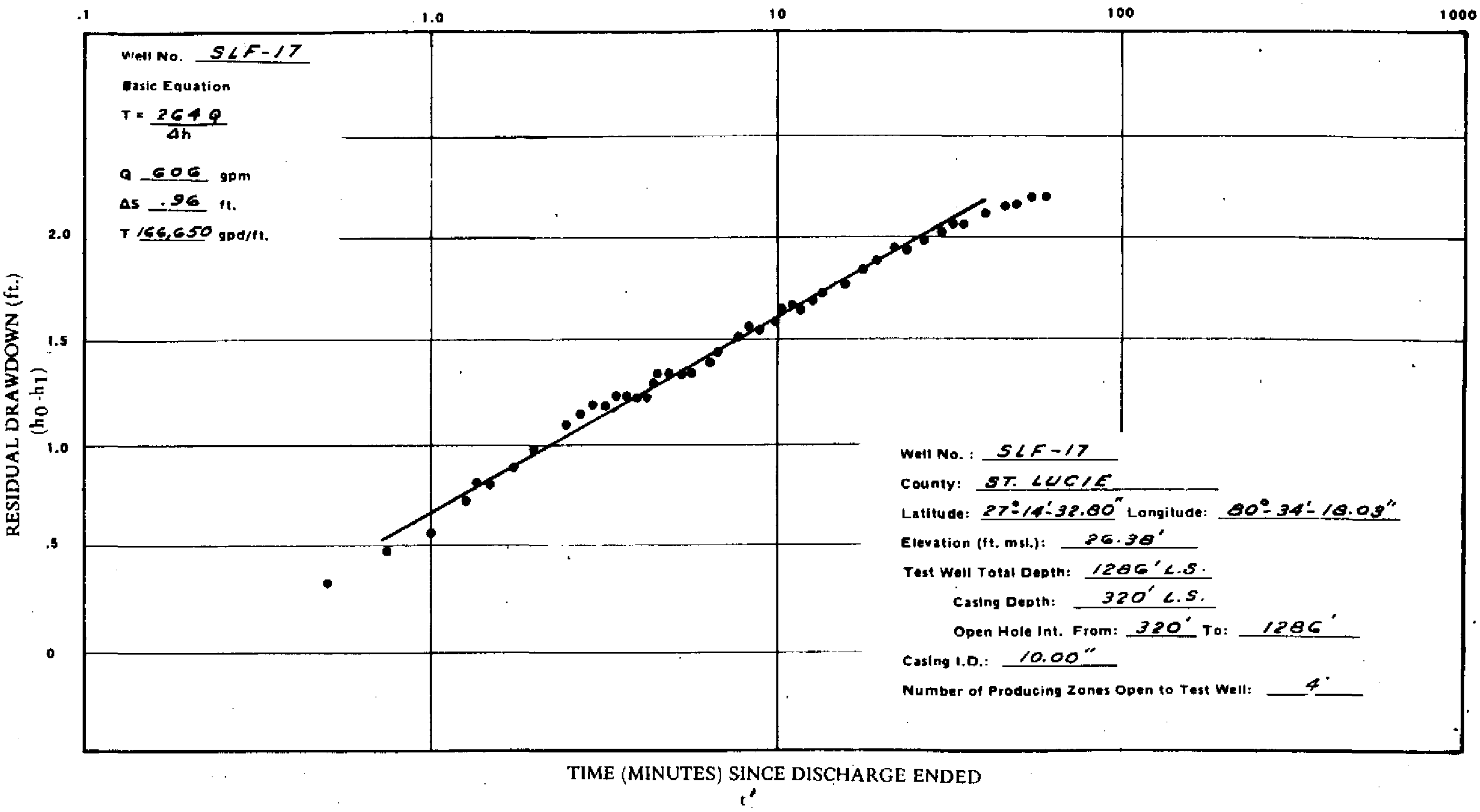
Test Well Total Depth: 1119' L.S.

Casing Depth: 456' L.S.

Open Hole Int. From: 456' To: 1119'

Casing I.D.: 5.5"

Number of Producing Zones Open to Test Well: 4



Well No. SLF-17

Basic Equation

$T = \frac{264Q}{\Delta h}$

Q 606 gpm

Δs .96 ft.

T 166,650 gpd/ft.

Well No. : SLF-17

County: ST. LUCIE

Latitude: 27°-14'-32.80" Longitude: 80°-34'-18.03"

Elevation (ft. msl.): 26.38'

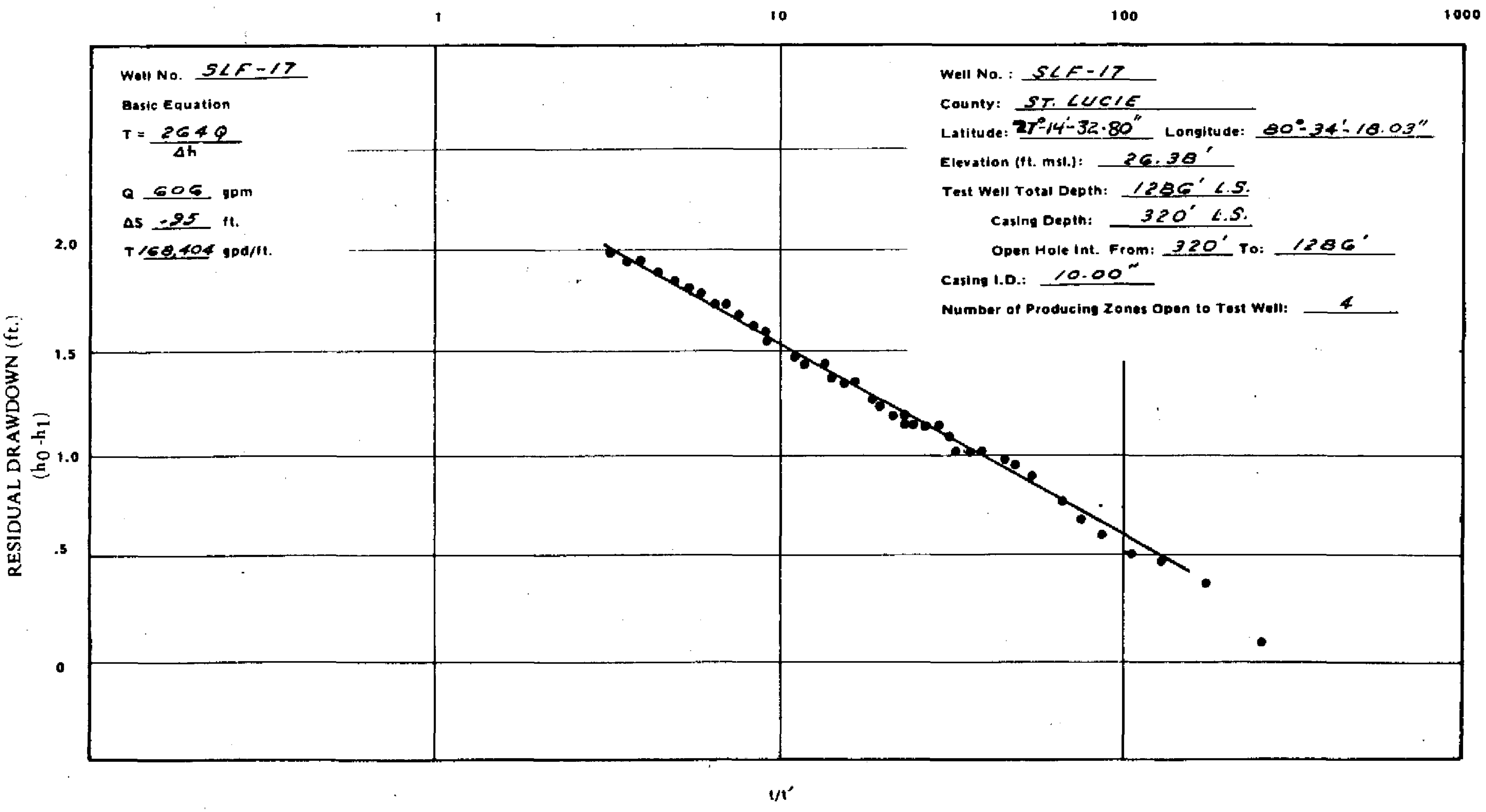
Test Well Total Depth: 1286' L.S.

Casing Depth: 320' L.S.

Open Hole Int. From: 320' To: 1286'

Casing I.D.: 10.00"

Number of Producing Zones Open to Test Well: 4'



Well No. *SLF-17*

Basic Equation

$T = \frac{264Q}{\Delta h}$

Q *606* gpm

ΔS *.95* ft.

T *168,404* gpd/ft.

Well No. : *SLF-17*

County: *ST. LUCIE*

Latitude: *27°-14'-32.80"* Longitude: *80°-34'-18.03"*

Elevation (ft. msl.): *26.38'*

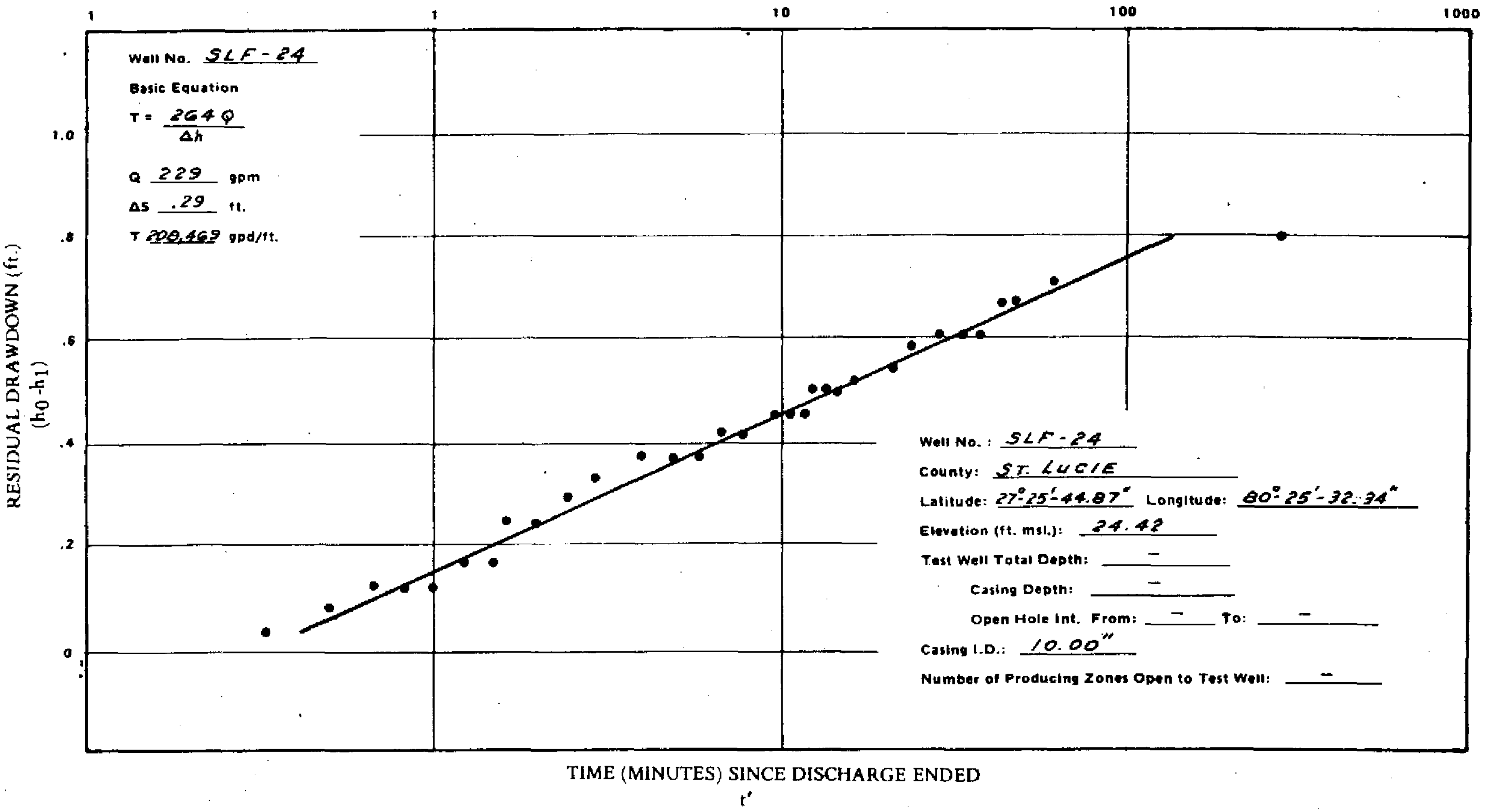
Test Well Total Depth: *1286' L.S.*

Casing Depth: *320' L.S.*

Open Hole Int. From: *320'* To: *1286'*

Casing I.D.: *10.00"*

Number of Producing Zones Open to Test Well: *4*



Well No. SLF-24

Basic Equation

$T = \frac{264Q}{\Delta h}$

Q 229 gpm

ΔS .29 ft.

T 208,469 gpd/ft.

Well No.: SLF-24

County: ST. LUCIE

Latitude: 27°25'-44.87" Longitude: 80°25'-32.34"

Elevation (ft. msl.): 24.42

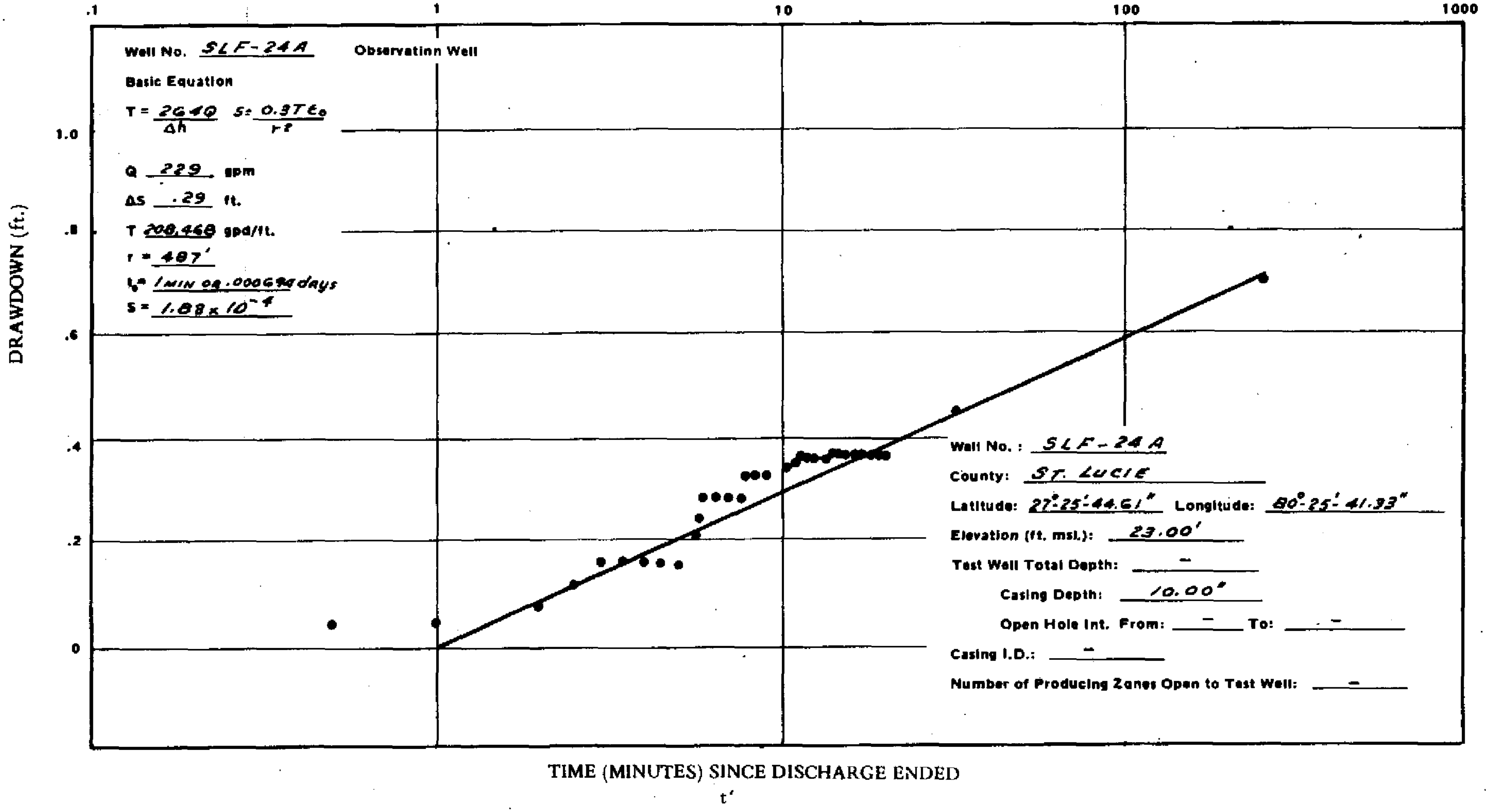
Test Well Total Depth: –

Casing Depth: –

Open Hole Int. From: – To: –

Casing I.D.: 10.00"

Number of Producing Zones Open to Test Well: –



Well No. SLF-24A **Observatinn Well**

Basic Equation

$T = \frac{264Q}{\Delta h}$ $S = \frac{0.3Tt_0}{r^2}$

Q 229 **gpm**

ΔS .29 **ft.**

T 208,468 **gpd/ft.**

r = 487′

t_0 **=** 1 MIN OR .000694 days

S = 1.88×10^{-4}

Well No. : SLF-24 A

County: ST. LUCIE

Latitude: 27°-25′-44.61″ **Longitude:** 80°-25′-41.33″

Elevation (ft. msl.): 23.00′

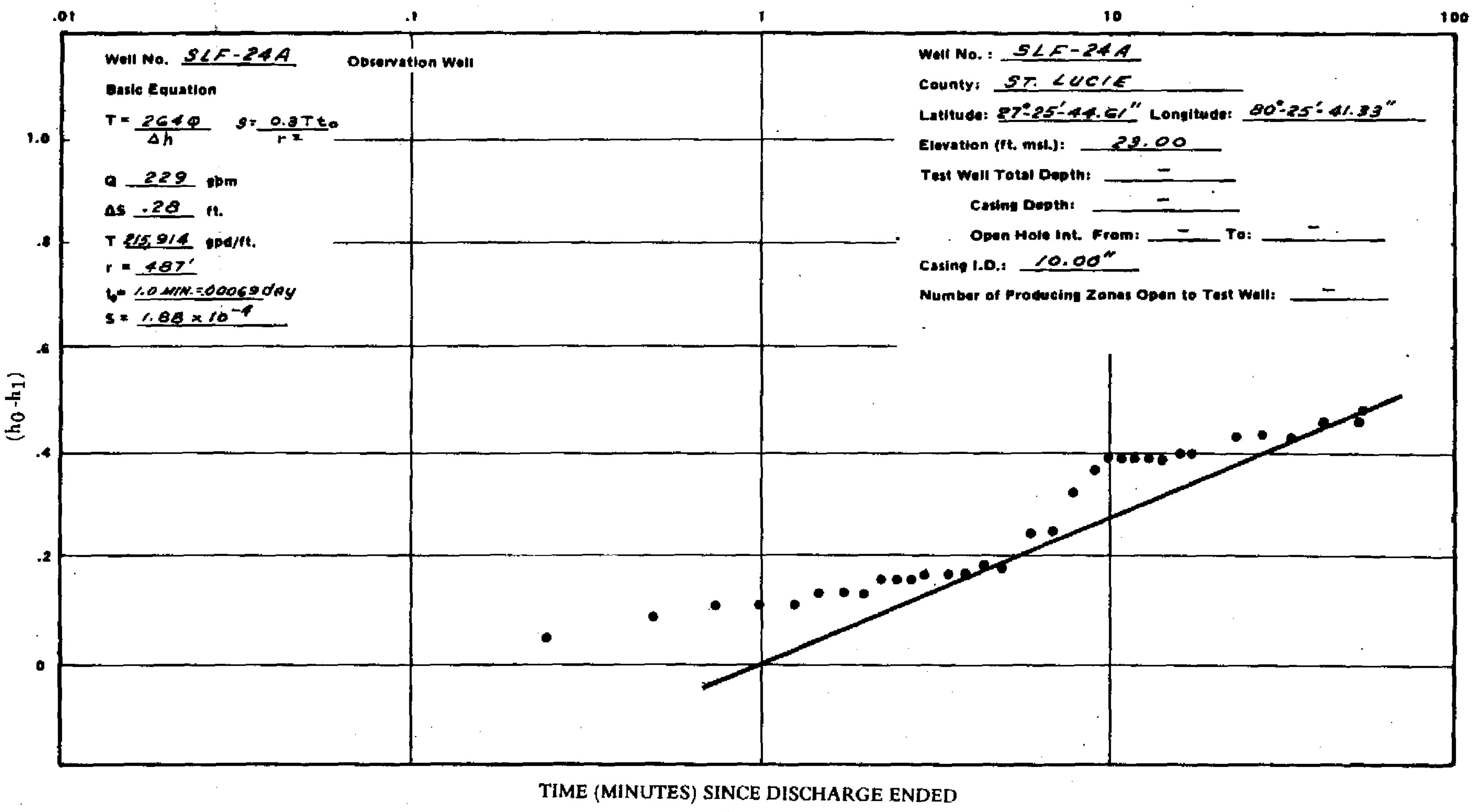
Test Well Total Depth: –

Casing Depth: 10.00″

Open Hole Int. From: – **To:** –

Casing I.D.: –

Number of Producing Zones Open to Test Well: –



Well No. SLF-24A Observation Well

Basic Equation

$T = \frac{264Q}{\Delta h}$ $S = \frac{0.3Tt_o}{r^2}$

Q 229 gpm

Δs .28 ft.

T 215,914 gpd/ft.

r = 487'

t_o = 1.0 MIN. = .00069 day

S = 1.88×10^{-4}

Well No.: SLF-24A

County: ST. LUCIE

Latitude: 27°-25'-44.61" Longitude: 80°-25'-41.33"

Elevation (ft. msl.): 23.00

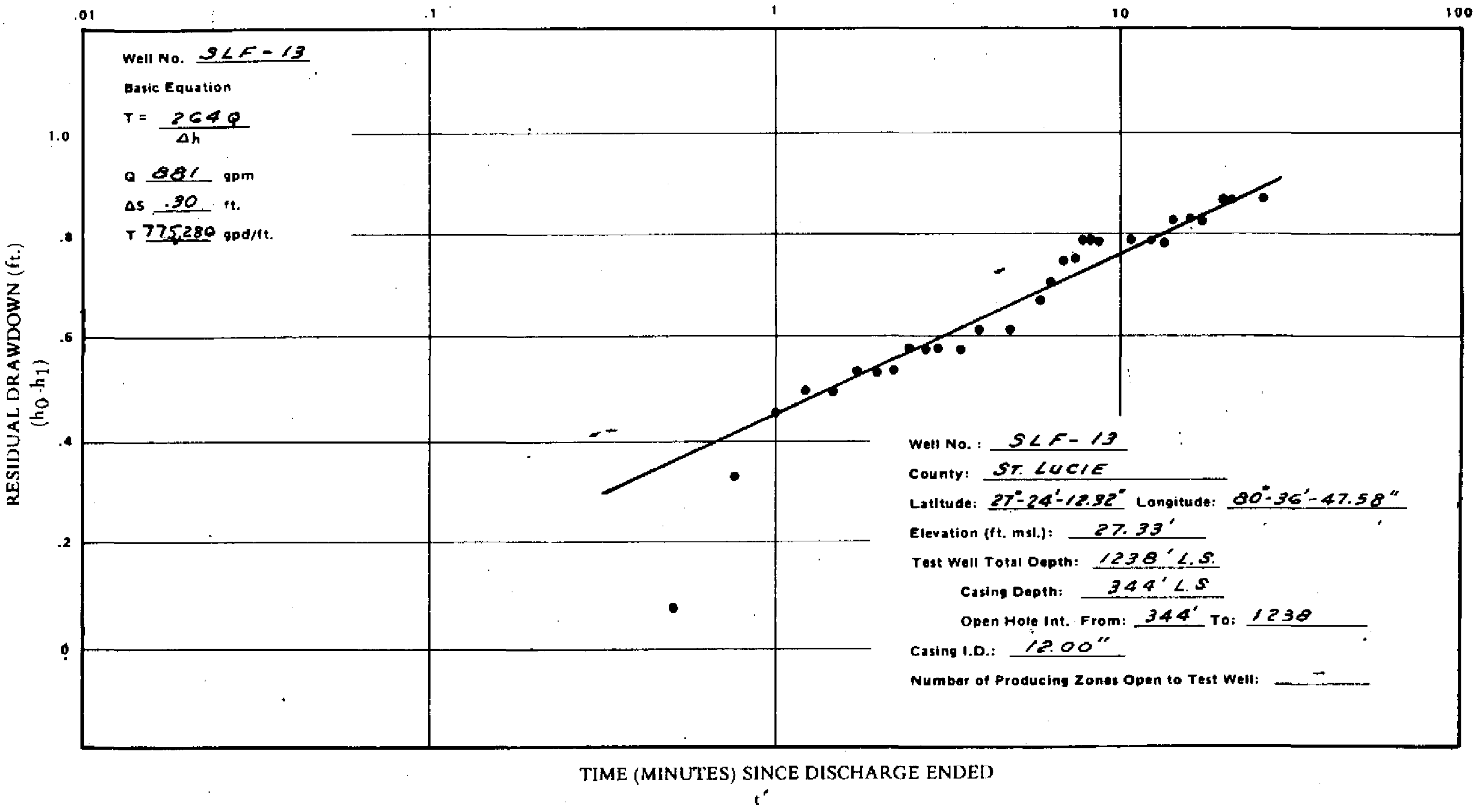
Test Well Total Depth: –

Casing Depth: –

Open Hole Int. From: – To: –

Casing I.D.: 10.00"

Number of Producing Zones Open to Test Well: –



Well No. SLF-13

Basic Equation

$T = \frac{264Q}{\Delta h}$

Q 881 gpm

ΔS .30 ft.

T 775,280 gpd/ft.

Well No.: SLF-13

County: ST. LUCIE

Latitude: 27°-24'-12.32" Longitude: 80°-36'-47.58"

Elevation (ft. msl.): 27.33'

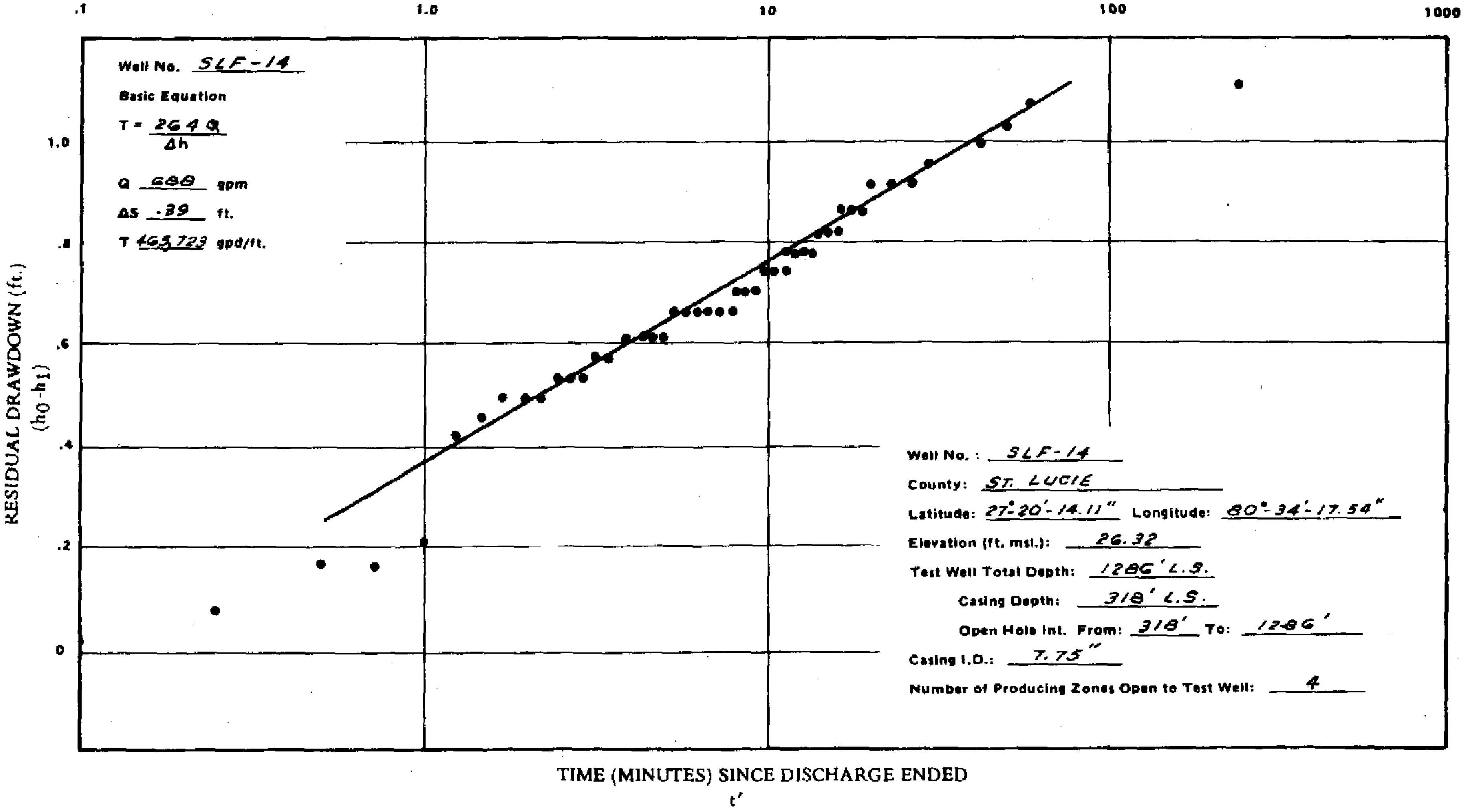
Test Well Total Depth: 1238' L.S.

Casing Depth: 344' L.S

Open Hole Int. From: 344' To: 1238

Casing I.D.: 12.00"

Number of Producing Zones Open to Test Well: -



Well No. SLF-14

Basic Equation

$$T = \frac{264\,Q}{\Delta h}$$

Q 688 **gpm**

ΔS .39 **ft.**

T 465,723 **gpd/ft.**

Well No.: SLF-14

County: ST. LUCIE

Latitude: 27°-20'-14.11" **Longitude:** 80°-34'-17.54"

Elevation (ft. msl.): 26.32

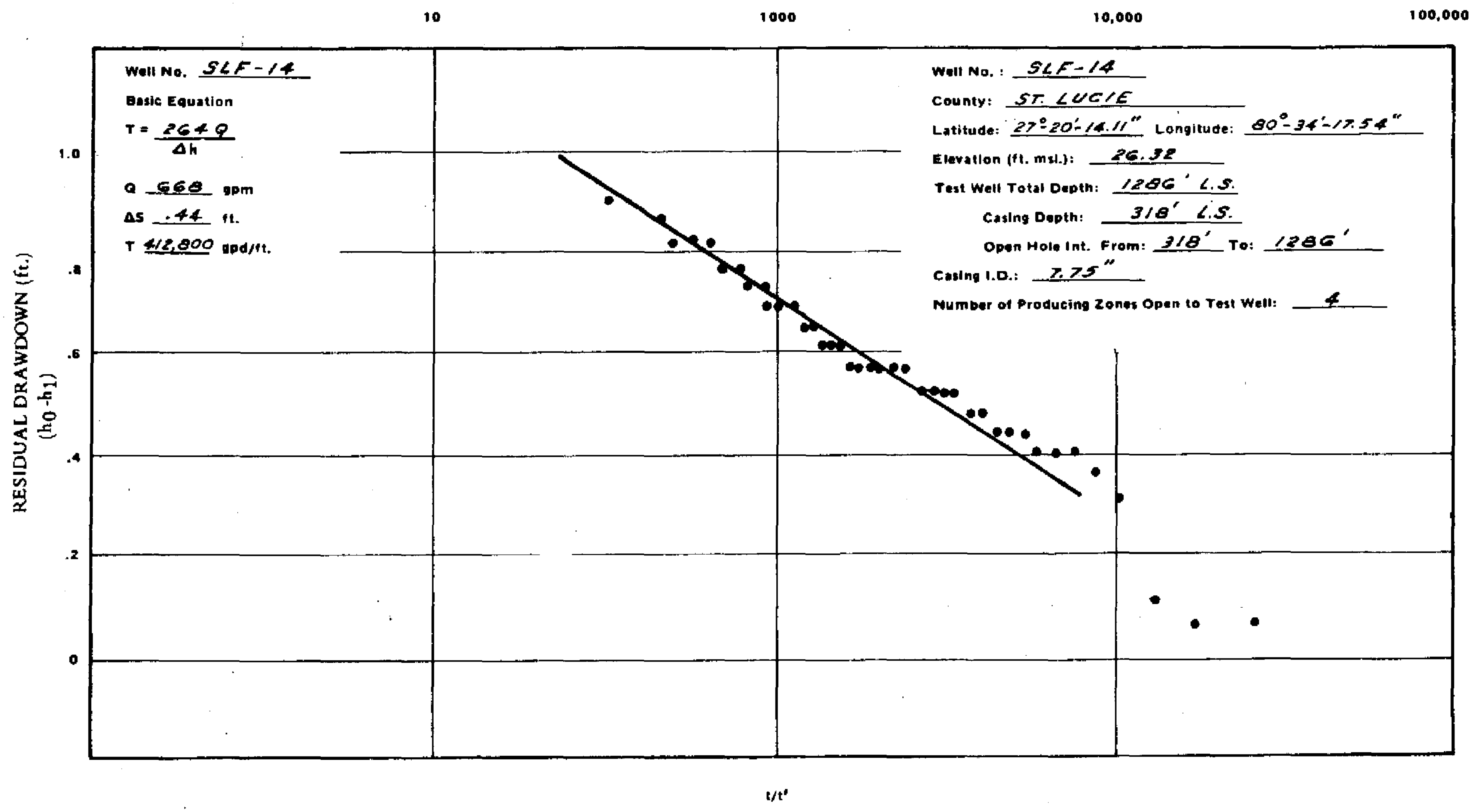
Test Well Total Depth: 1286' L.S.

Casing Depth: 318' L.S.

Open Hole Int. From: 318' **To:** 1286'

Casing I.D.: 7.75"

Number of Producing Zones Open to Test Well: 4



Well No. SLF-14

Basic Equation

$T = \frac{264Q}{\Delta h}$

Q 668 gpm

ΔS .44 ft.

T 412,800 gpd/ft.

Well No.: SLF-14

County: ST. LUCIE

Latitude: 27°20'-14.11" Longitude: 80°-34'-17.54"

Elevation (ft. msl.): 26.32

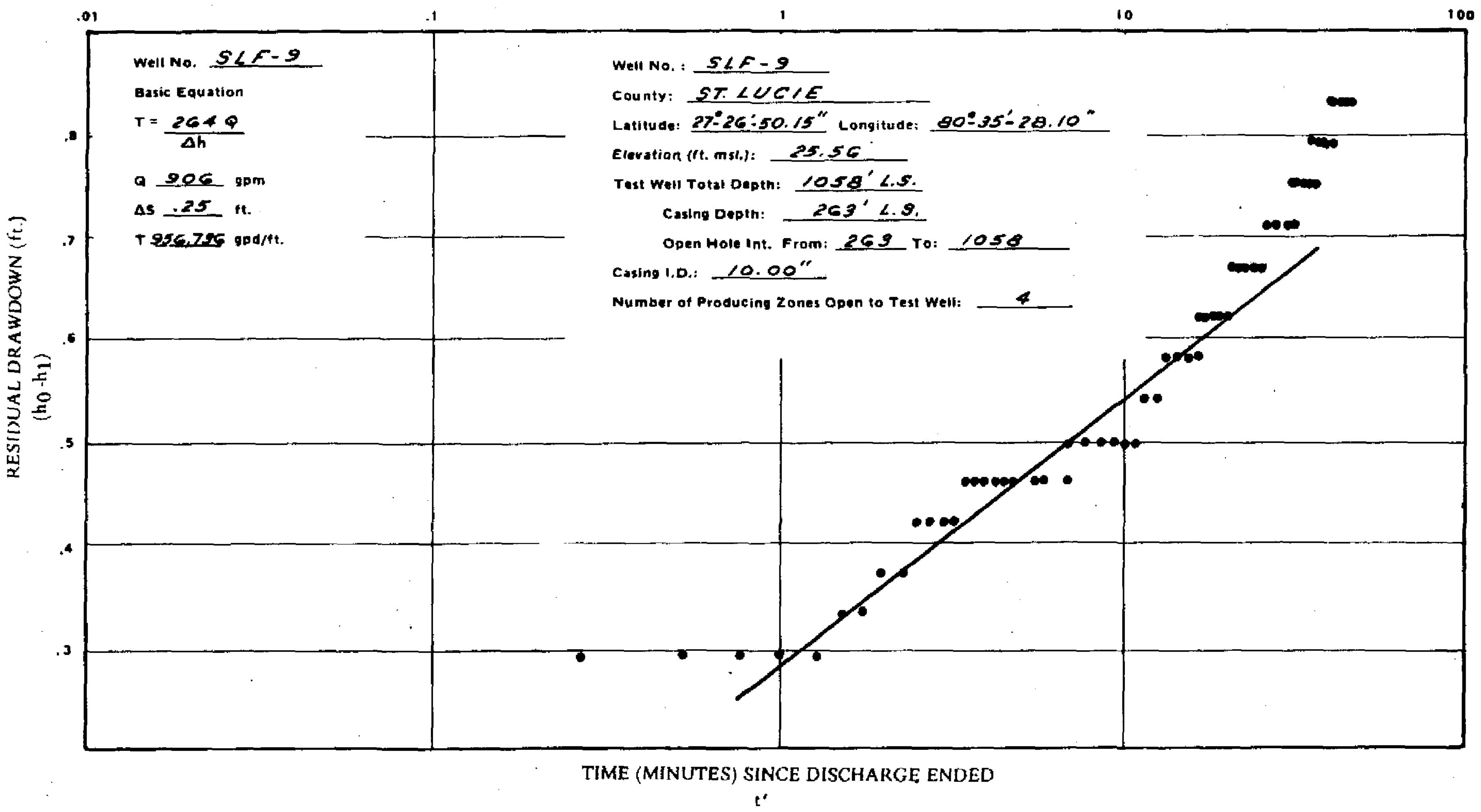
Test Well Total Depth: 1286' L.S.

Casing Depth: 318' L.S.

Open Hole Int. From: 318' To: 1286'

Casing I.D.: 7.75"

Number of Producing Zones Open to Test Well: 4



Well No. SLF-9

Basic Equation

$$T = \frac{264\,Q}{\Delta h}$$

Q 906 gpm

Δs .25 ft.

T 956,736 gpd/ft.

Well No.: SLF-9

County: ST. LUCIE

Latitude: 27°26'50.15" Longitude: 80°35'28.10"

Elevation (ft. msl.): 25.56

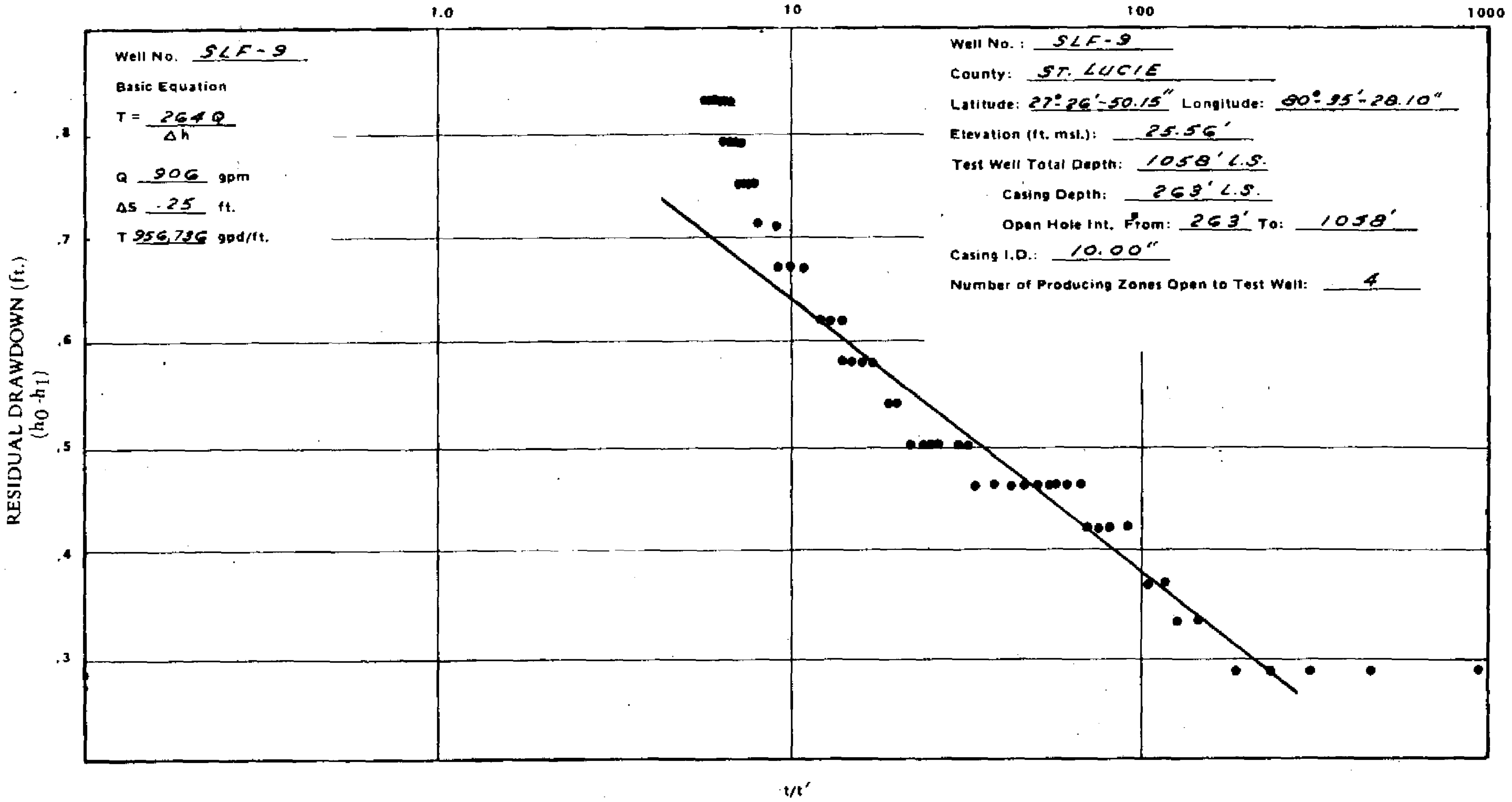
Test Well Total Depth: 1058' L.S.

Casing Depth: 263' L.S.

Open Hole Int. From: 263 To: 1058

Casing I.D.: 10.00"

Number of Producing Zones Open to Test Well: 4



Well No. SLF-9

Basic Equation

$T = \frac{264Q}{\Delta h}$

Q 906 gpm

ΔS .25 ft.

T 956,736 gpd/ft.

Well No.: SLF-9

County: ST. LUCIE

Latitude: 27°26′-50.15″ Longitude: 80°35′-28.10″

Elevation (ft. msl.): 25.56′

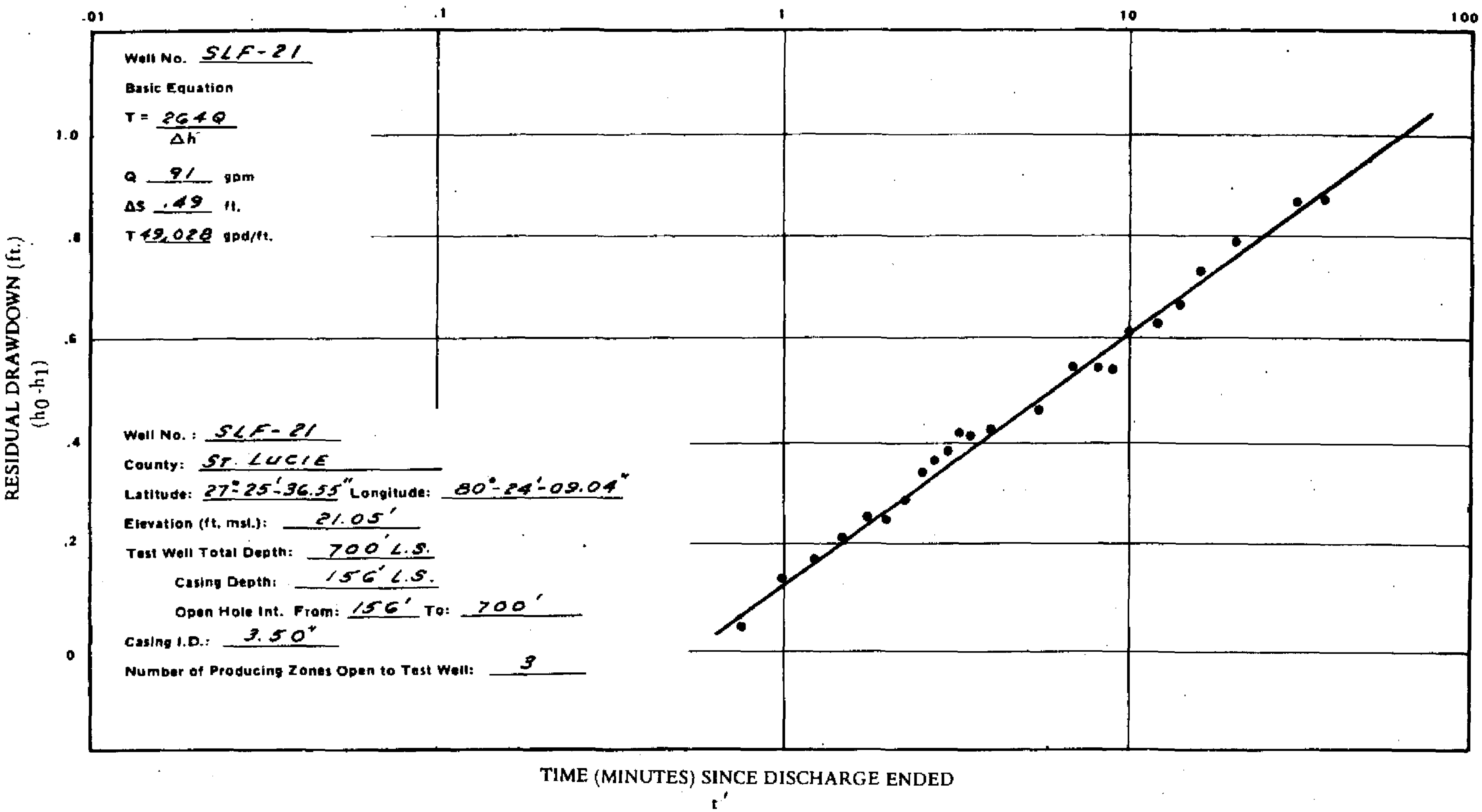
Test Well Total Depth: 1058′ L.S.

Casing Depth: 263′ L.S.

Open Hole Int. From: 263′ To: 1058′

Casing I.D.: 10.00″

Number of Producing Zones Open to Test Well: 4



Well No. SLF-21

Basic Equation

$T = \frac{264Q}{\Delta h}$

Q 91 gpm

ΔS .49 ft.

T 49,028 gpd/ft.

Well No. : SLF-21

County: ST. LUCIE

Latitude: 27°-25'-36.55" Longitude: 80°-24'-09.04"

Elevation (ft. msl.): 21.05'

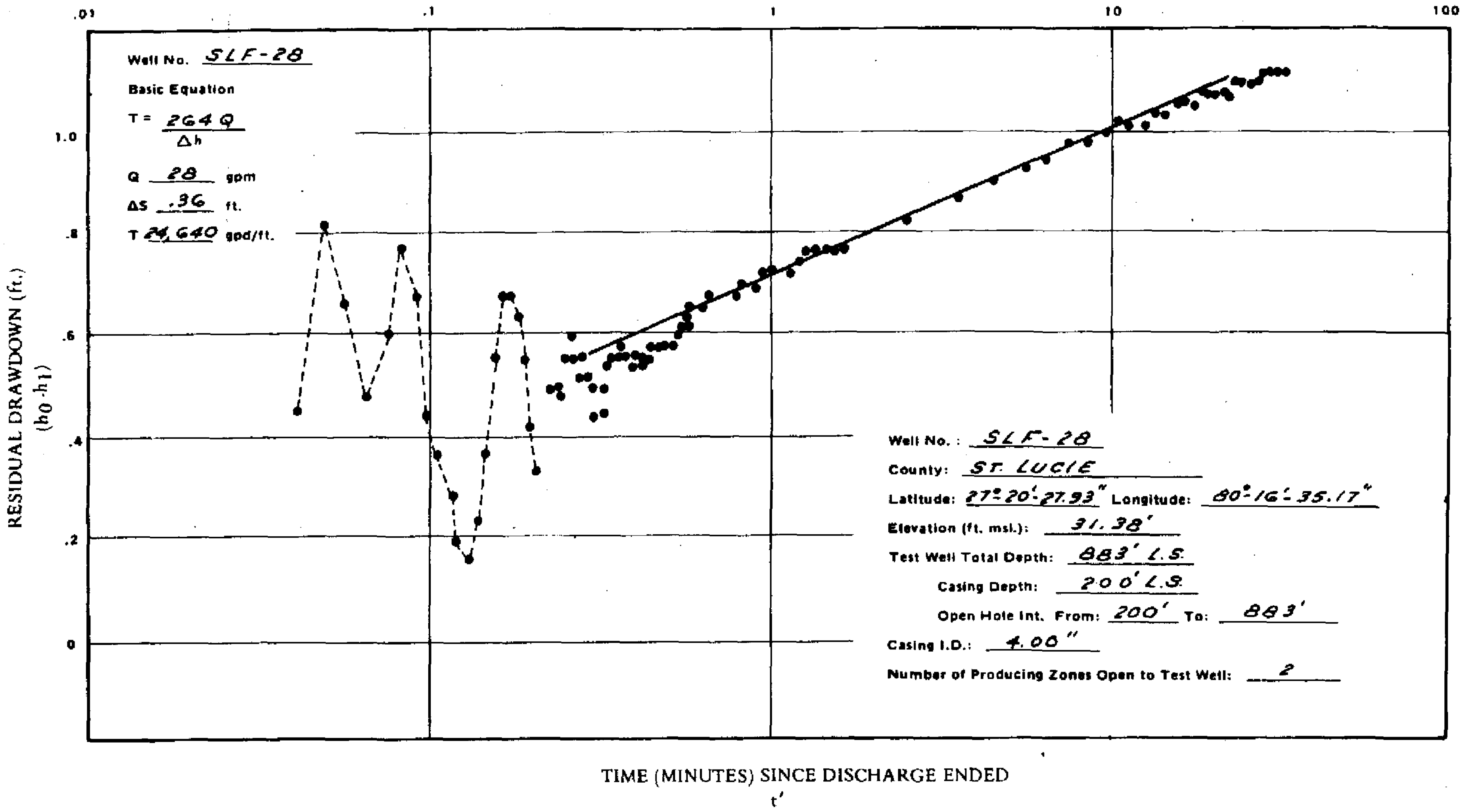
Test Well Total Depth: 700' L.S.

Casing Depth: 156' L.S.

Open Hole Int. From: 156' To: 700'

Casing I.D.: 3.50"

Number of Producing Zones Open to Test Well: 3



Well No. SLF-28

Basic Equation

$T = \frac{264\,Q}{\Delta h}$

Q 28 gpm

ΔS .36 ft.

T 24,640 gpd/ft.

Well No.: SLF-28

County: ST. LUCIE

Latitude: 27°20′27.93″ Longitude: 80°16′35.17″

Elevation (ft. msl.): 31.38′

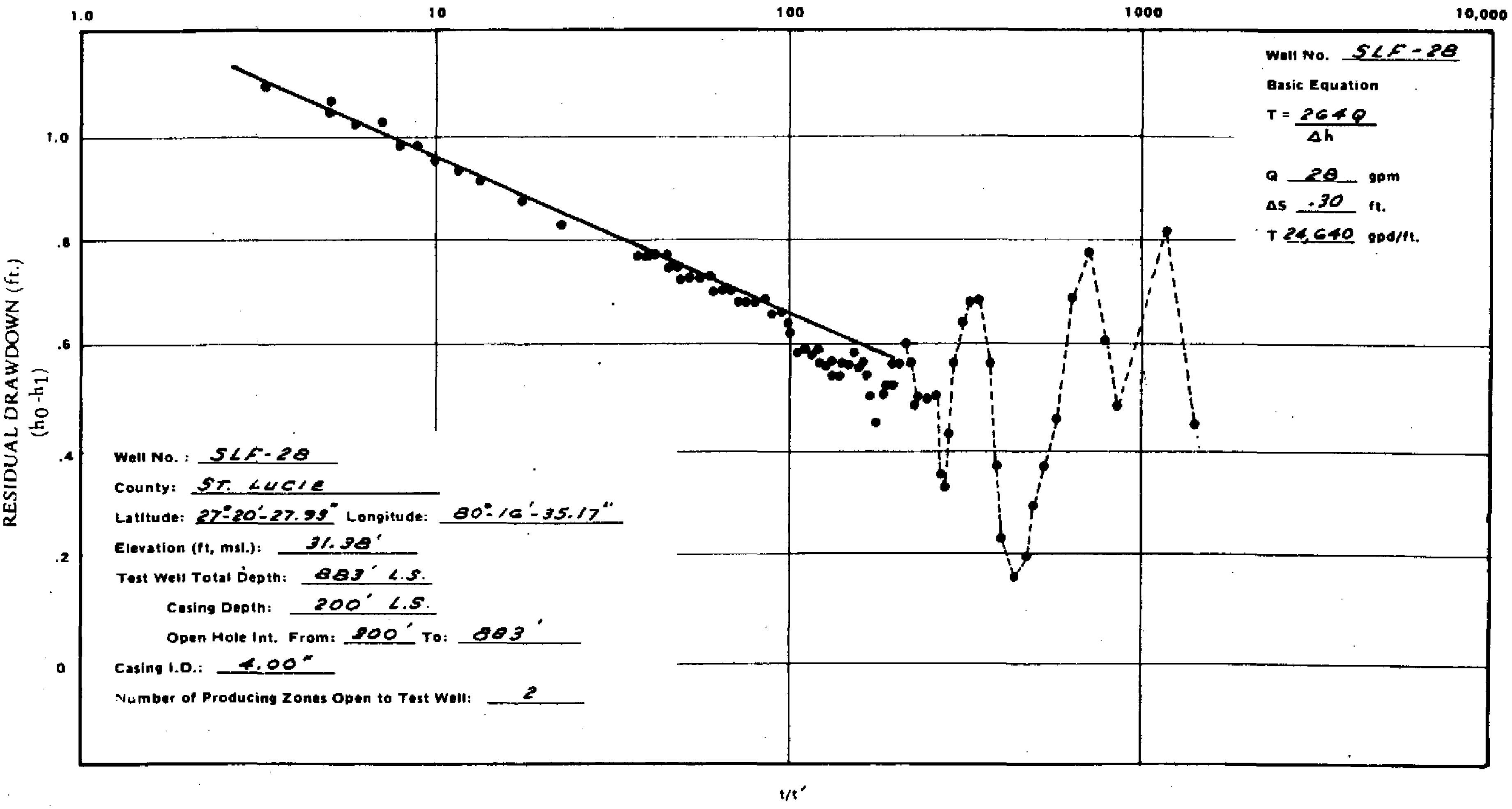
Test Well Total Depth: 883′ L.S.

Casing Depth: 200′ L.S.

Open Hole Int. From: 200′ To: 883′

Casing I.D.: 4.00″

Number of Producing Zones Open to Test Well: 2



Well No. SLF-28

Basic Equation

$$T = \frac{264Q}{\Delta h}$$

Q 28 gpm

ΔS .30 ft.

T 24,640 gpd/ft.

Well No. : SLF-28

County: ST. LUCIE

Latitude: 27°-20′-27.93″ Longitude: 80°-16′-35.17″

Elevation (ft, msl.): 31.38′

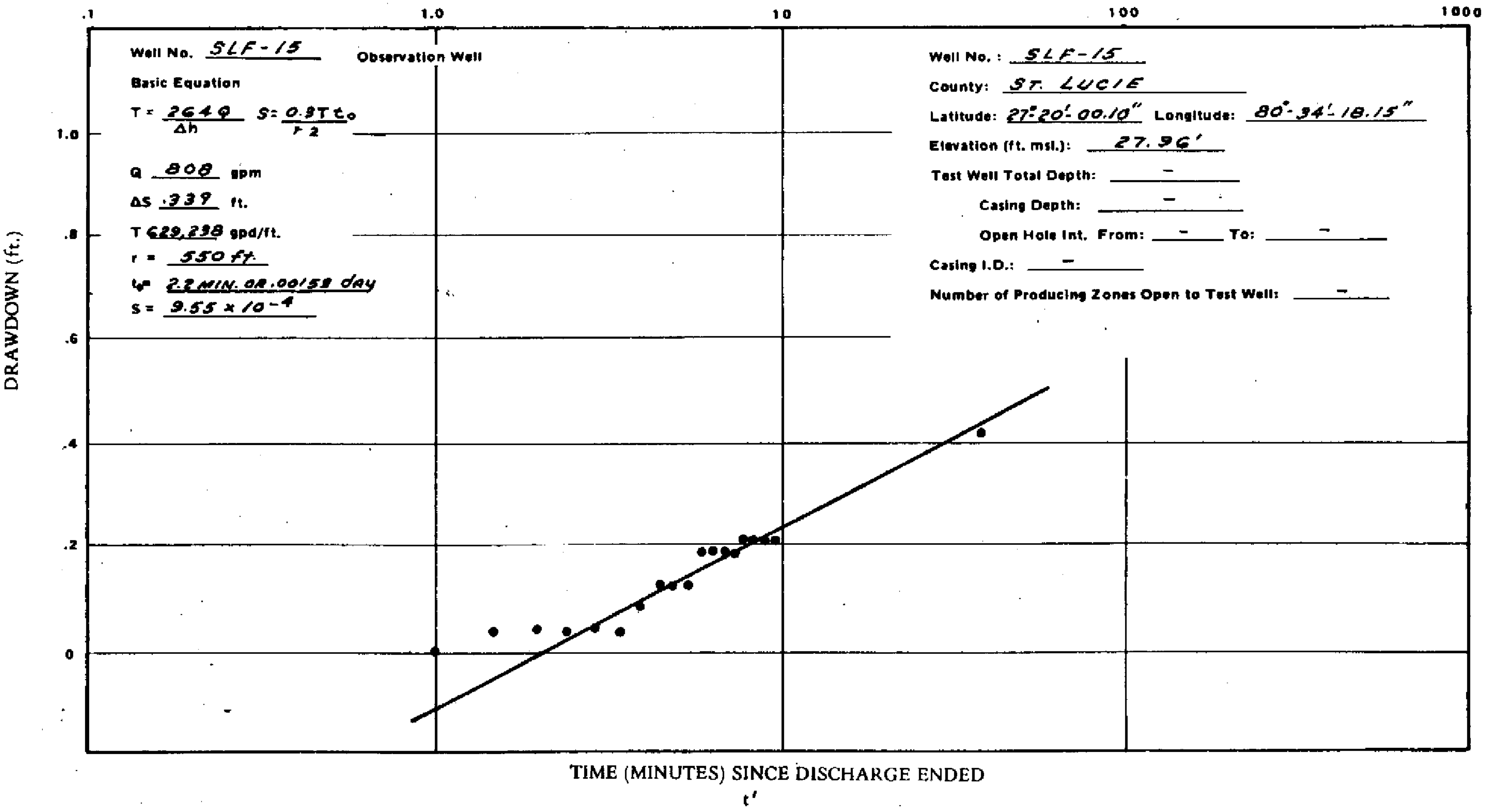
Test Well Total Depth: 883′ L.S.

Casing Depth: 200′ L.S.

Open Hole Int. From: 800′ To: 883′

Casing I.D.: 4.00″

Number of Producing Zones Open to Test Well: 2



Well No. SLF-15 **Observation Well**

Basic Equation

T = $\frac{264Q}{\Delta h}$ S = $\frac{0.3Tt_0}{r^2}$

Q 808 gpm

ΔS .339 ft.

T 629,238 gpd/ft.

r = 550 ft.

t_0 = 2.2 MIN. OR .00153 day

S = 9.55×10^{-4}

Well No.: SLF-15

County: ST. LUCIE

Latitude: 27°20'00.10" **Longitude:** 80°34'18.15"

Elevation (ft. msl.): 27.96'

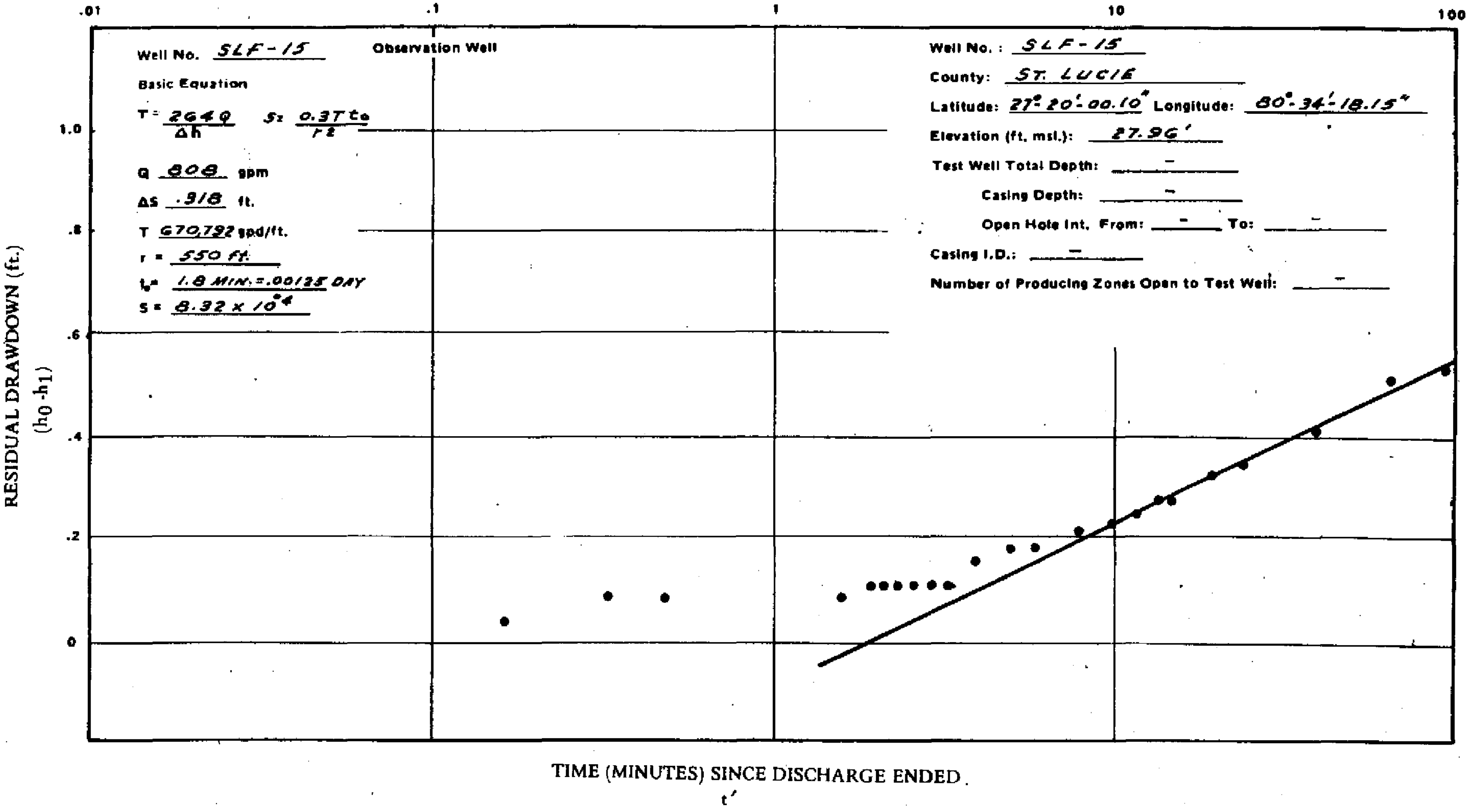
Test Well Total Depth: –

Casing Depth: –

Open Hole Int. From: – **To:** –

Casing I.D.: –

Number of Producing Zones Open to Test Well: –



Well No. SLF-15 Observation Well

Basic Equation

$T = \frac{264Q}{\Delta h}$ $S = \frac{0.3 T t_0}{r^2}$

Q 808 gpm

ΔS .918 ft.

T 670,792 gpd/ft.

r = 550 ft.

t_0 = 1.8 MIN. = .00125 DAY

S = 8.32×10^{-4}

Well No.: SLF-15

County: ST. LUCIE

Latitude: 27°-20′-00.10″ Longitude: 80°-34′-18.15″

Elevation (ft. msl.): 27.96′

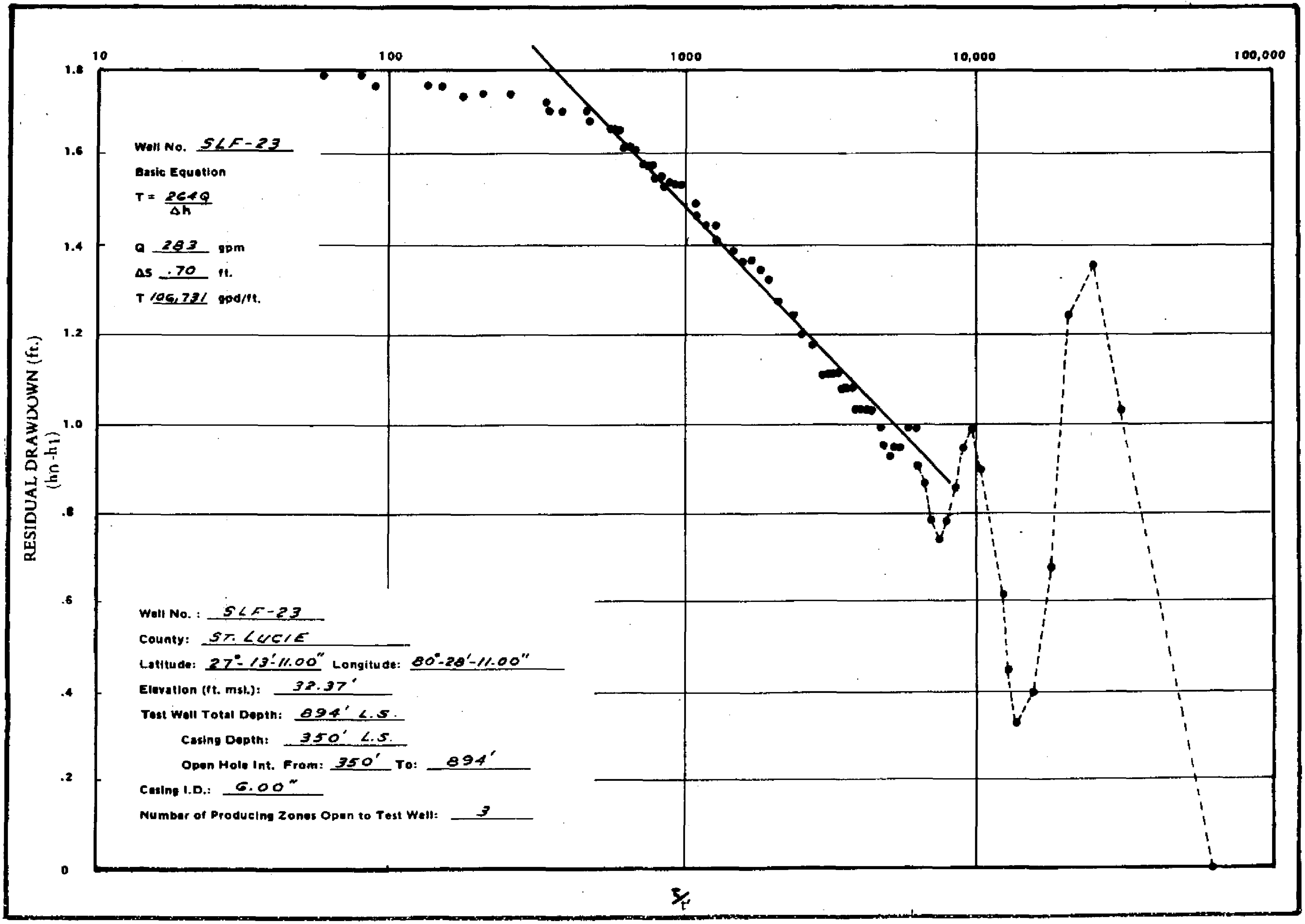
Test Well Total Depth: –

Casing Depth: –

Open Hole Int. From: – To: –

Casing I.D.: –

Number of Producing Zones Open to Test Well: –



Well No. SLF-23

Basic Equation

$T = \frac{264Q}{\Delta h}$

Q 283 **gpm**

ΔS .70 **ft.**

T 106,731 **gpd/ft.**

Well No. : SLF-23

County: ST. LUCIE

Latitude: 27°-13'-11.00" **Longitude:** 80°-28'-11.00"

Elevation (ft. msl.): 32.37'

Test Well Total Depth: 894' L.S.

Casing Depth: 350' L.S.

Open Hole Int. From: 350' **To:** 894'

Casing I.D.: 6.00"

Number of Producing Zones Open to Test Well: 3