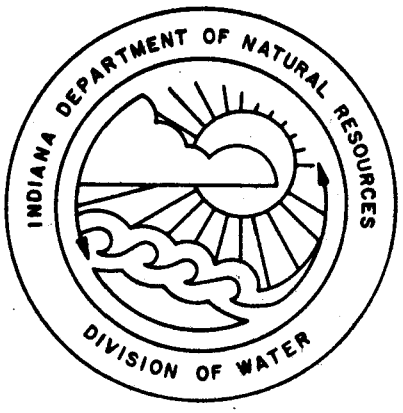
DIVISION OF WATER

INDIANA DEPARTMENT OF NATURAL RESOURCES

HYDROGEOLOGIC EVALUATION OF PROPOSED NORTH (TEAYS VALLEY) WELL FIELD: MARION, INDIANA



JANUARY 1985

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Hydrogeologic Evaluation of Proposed North (Teays Valley) Well Field: Marion, Indiana

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January, 1985

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Table

HYDROGEOLOGY OF THE PROPOSED NORTH WELL FIELD, MARION, INDIANA

INTRODUCTION

The City of Marion, Indiana has been confronted by various types of water supply problems over the last 20 years. Four separate well fields have supplied water to the city at one time or another. The four well fields have had a general history of lowering static water and pumping levels and have been straining to keep up with the needs of Marion's expanding population and industrial base.

At present, the Northeast Well Field and the "downtown" well fields are being used to supply the city with water. Unfortunately, these respective fields have a limited combined sustained pumping capacity. It was originally thought that these well fields combined would be able to safely yield 9.0 MGD without mining water from the sources of supply. However, there are strong indications that water is at present being mined in the Northeast Well Field. Determination of a new "safe yield" is in progress with the Northeast Field currently supplying 5 MGD and the downtown fields contributing approximately 1.0 MGD.

Marion's current population is roughly 35,000 and by the year 2000, approximately 44,500 water customers are expected to be connected to the city water system (Howard, Needles, Tammen, and Bergendoff, 1981). This figure along with estimates of increasing future industrial water use has led to a projected pumpage of 12 MGD (based on 24 hours of pumping) in the year 2000. Consequently, the city has begun a search for a new water supply source to meet future daily needs and maximum or peak day demands. In 1981, a ground-water development program was undertaken by the firm of Stremmel and Hill, Inc., (LaFontaine, Indiana). A new prospective well field was defined north of the city. Surrounding landowners have expressed strong concerns over the location of the new prospective field, claiming that the field will result in a depletion of water supplies in the area. In the effort to better evaluate the geologic and hydrologic conditions of the area, the city of Marion and the Indiana Department of Natural Resources (Division of Water) has been monitoring the development of this prospective new well field.

Purpose and Scope

The purpose of this report is to:

(1) Outline the general ground-water hydrology of the area containing a new prospective well field for the city of Marion, Indiana.

(2) Present analyses of pumping test data obtained from the prospective field.

(3) Determine a safe yield for the new prospective field.

(4) Better define and understand the Teays buried channel and its associated sand and gravel deposits in the vicinity of the proposed well field.

Acknowledgements

The authors are grateful to Tom Kallio and Jerry Hill of Stremmel and Hill Inc., principal consultants for the project, for their gracious cooperation throughout the many aspects of this investigation. We would also like to thank Dr. James Howard and Marsha Taylor, hydrogeologists with the consulting firm of Howard Consultants, Inc. for their help. Thanks are also in order to Richard and Ned Ortman of Ortman Drilling, Inc. who contributed information and assistance during the drilling and sampling of the test and production wells. Finally, the authors would like to express sincere appreciation to geologists Judith Beaty and William J. Steen of the Department of Natural Resources Ground-Water Section for their assistance and collaboration during the collection, analysis, and processing of data for this report.

HISTORICAL INFORMATION

Existing Well Fields

The City of Marion has at one time or another obtained its water from four well fields which were located in and north of the city (Figure 1). The first field to be developed was located near the water works plant in the center of town. This particular field originally consisted of five wells, the first of which was drilled in 1941. Each of the wells was initially rated in excess of 1 million gallons/day (MGD). However, the wells have degenerated in yield over time to the point where present yields are far less than their original ratings. A new well has since been added west of this field.

The second well field is located on the west flood plain of the Mississinewa River south of 3rd Street. This field, indefinitely abandoned, consists of three wells, drilled in 1947, 1954, and 1957, respectively. These wells were also initially rated above 1 MGD, but gradually lost their productive capabilities due to well deterioration and lowered static water levels.

The third well field is located along Valley Avenue between 14th and 26th Street, near the Marion High School. The field originally consisted of four wells, the first of which was drilled in 1962. This well field had an initial rating of 3 MGD. Since its initial development, two wells have subsequently been added north of the well field, along Valley Avenue.

The fourth well field, the Northeast Well Field, is located two miles northeast of Marion along Bethlehem Road, next to Massey Creek. This field, developed in the mid-to-late 1960's, consists of four wells. The field was originally rated at 6-10 MGD; however, subsequent analysis over the past few years (following approximately 15 years of 5-7 MGD pumping) indicate a safe yield of less than that amount.

The first three well fields obtain water from the alluvial and outwash material associated with the Mississinewa River. The Northeast Well Field is located on the Tipton Till Plain near the Mississinewa Moraine complex and obtains its water from an inter-till sand and gravel deposit that fills a narrow buried valley located south of the main Teays Valley.

Northeast Well Field Problem

With the addition of subsequent pumping and static water level measurements it can be shown that the dominant factor affecting safe yield in the Northeast Well Field is the amount of recharge into the system and not the aquifer's hydraulic characteristics. Wells in the Northeast field are completed in 50 to 70 feet of gravel and are overlain by approximately 120 feet of glacial material. The only source of recharge into the well field is through the till cap, which has been estimated to have an infiltration rate of 1.5-2.0 inches/year. The well field has been pumping at greater than this recharge rate and has been experiencing substantial water level declines. At present, the piezometric surface has dropped below the till cap and the well field has gone from confined to unconfined conditions. Private water wells near the well field have also undergone water level declines. It now appears that water is being mined from the aquifer.

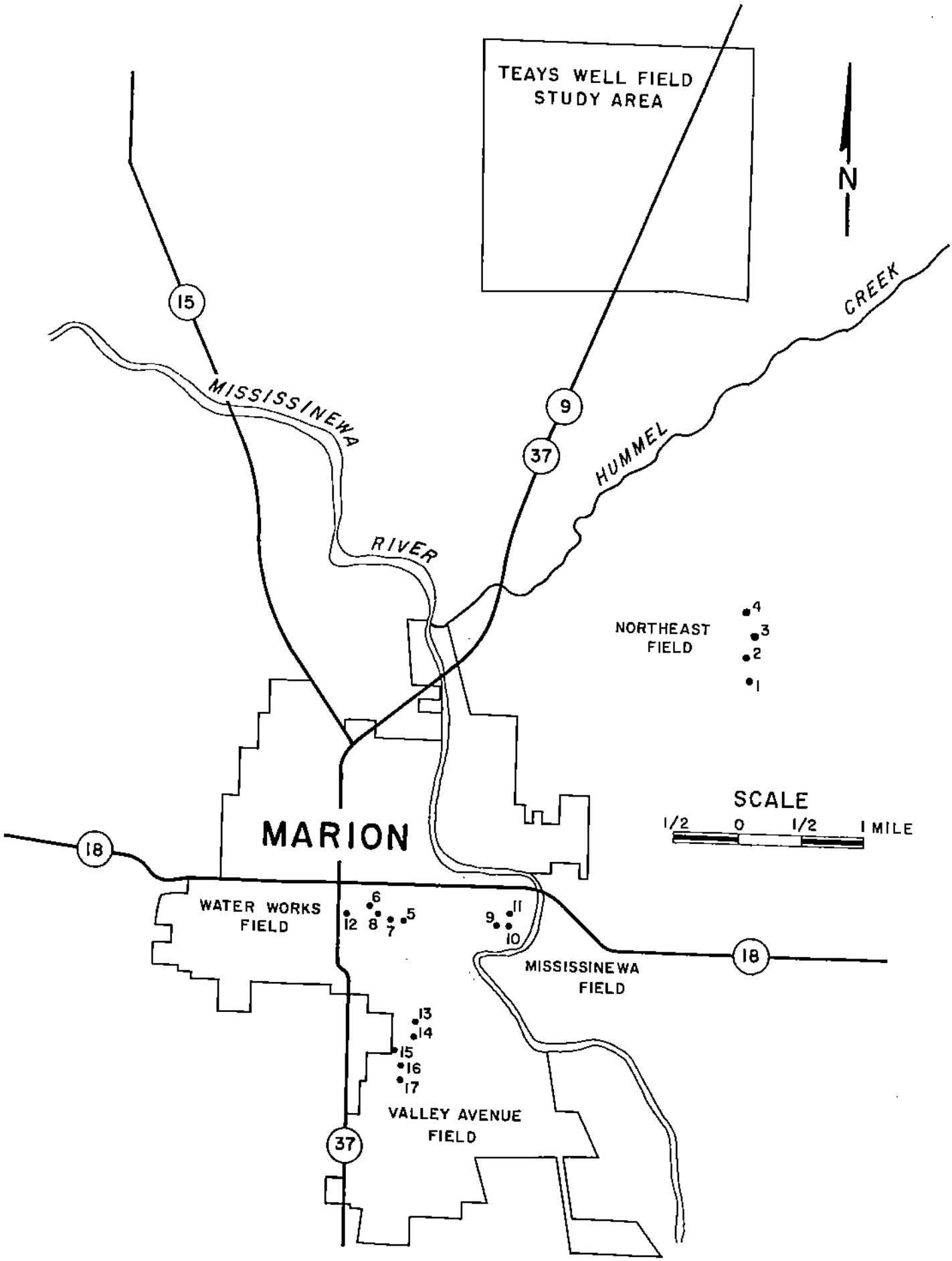


FIGURE 1. LOCATION MAP OF EXISTING WELL FIELDS

LOCATION AND DESCRIPTION OF THE STUDY AREA

Geographic Location

The new proposed Marion well field is located approximately 4 miles north of Marion near the Grant, Wabash, and Huntington County lines in Township 25 North, Range 8 East, Sections 4, 5, 8, and 9 (Figure 2). The bulk of the test drilling has occurred on property owned by Clyde and Leatha Cox of rural Marion. Test drilling encompassed an area of approximately 4 square miles.

Farming is the major use of the land in the study area with corn, wheat, and soybeans making up the dominant crops.

Drainage

Grant County lies within the Wabash River drainage basin. The new proposed well field is drained by two small unnamed intermittant streams which drain into Jocinah Creek. Jocinah Creek flows northwestward, eventually branching into Metocinah Creek, a tributary of the Mississinewa River. These creeks are shown in Figure 2. Many of the fields have had their drainage pattern altered somewhat due to the addition of several large drainage tile networks.

Climate and Precipitation

According to U.S. Weather Bureau Records, the average annual temperature at Marion, Indiana is 51.2° F and the average annual precipitation is 37.62 inches.

Surficial Geology

The study area is completely mantled by unconsolidated Pleistocene deposits that overlie the Silurian and Devonian bedrock. The Pleistocene deposits are part of the Mississinewa recessional moraine complex and are composed primarily of a clay-rich till. There are also several small isolated areas of ice contact stratified till and lacustrine sediments. These types of deposits are typically associated with this end moraine complex.

Bedrock Geology

The bedrock consists mainly of Silurian age limestone, dolomite, and shale of the Salina Formation. The buried bedrock channel of the Teays Valley has dissected the Salina Formation in the northern portion of the study area; consequently, shales and limestones of the Ordovician Richmond Group subcrop in the deeper portions of the Valley.

Teays Valley

The incised Teays bedrock buried channel was part of the major drainage trunk that drained much of the eastern United States during pre-Wisconsin time. In Grant County this valley is located approximately 5 miles north of Marion with an average width of 1 mile. The valley's nearly northwest-

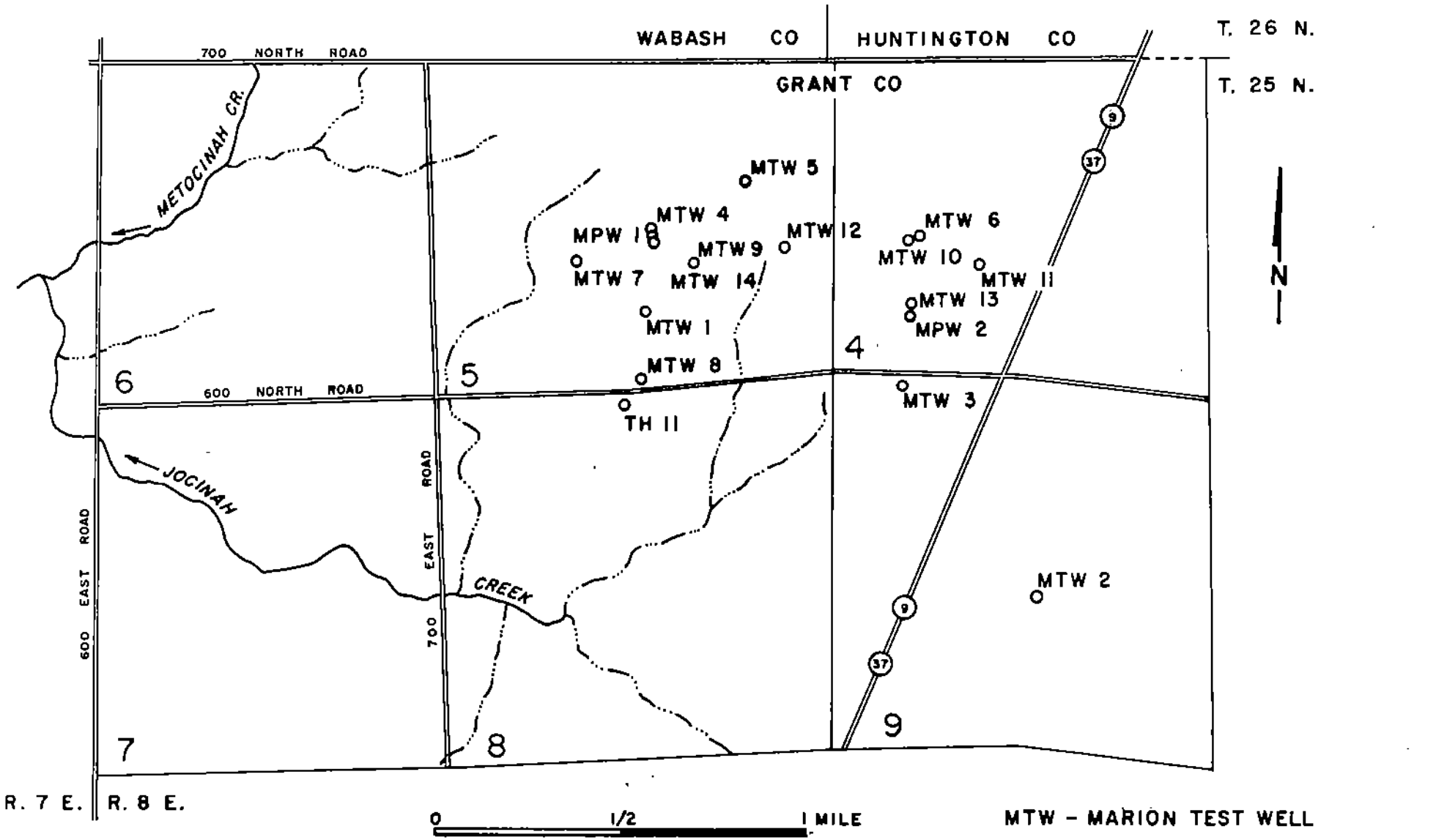


FIGURE 2. MAP SHOWING LOCATION OF TEST WELLS IN PROPOSED NORTH MARION WELL FIELD

southeast extension can be seen in the bedrock topography map shown in Figure 3. In the thalweg of the channel the depth to bedrock can be greater than 400 feet; however, subsequent Wisconsin Stage deposits have covered the channel to such an extent that no surficial expression of the valley can presently be seen.

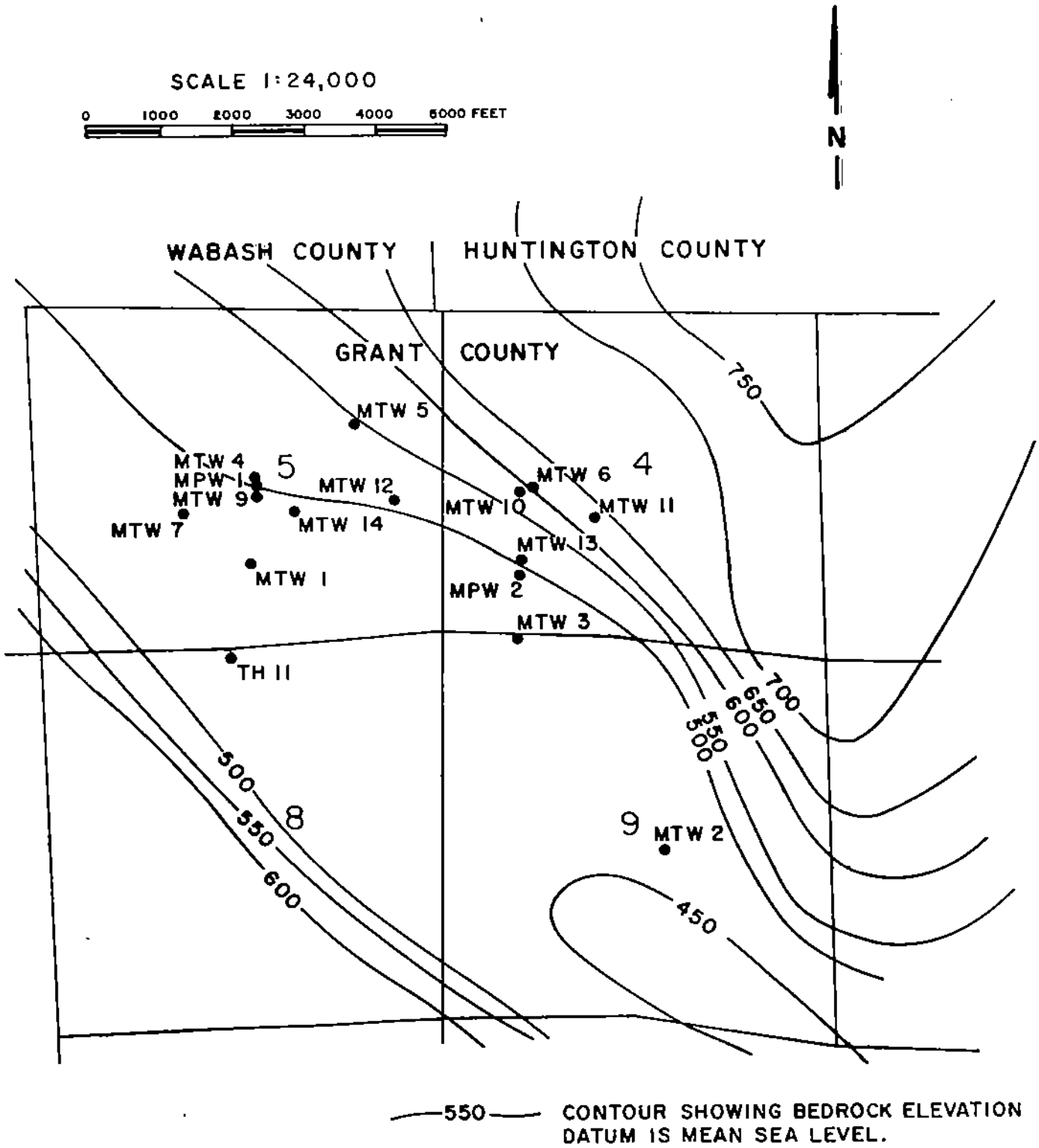


FIGURE 3. LOCATION OF OBSERVATION WELLS WITH RESPECT TO OVERALL BEDROCK TOPOGRAPHY

HYDROGEOLOGY

Aquifers

Bedrock aquifers in the Marion area have never been thought of as a viable source of water for the city's needs. The ground water potential of the Salina Formation is generally limited to only 10 to 50 gallons per minute (gpm). In addition, the Richmond Group is low yielding and typically too mineralized to be considered as a potable supply.

The search for water in the area of the new proposed well field concentrated on the glaciofluvial sand and gravel deposits, especially those associated with the buried Teays Valley.

The general stratigraphy of the Teays Valley north of Marion, in the proposed well field, consists of 120 to 140 feet of clayey till overlying 60 to 70 feet of coarse sand and gravel. Beneath the glaciofluvial deposits is a brown clayey unit, possibly lacustrine in origin, that continues to bedrock. A basal gravel horizon is present in the deeper parts of the channel in some areas; however, this unit is expected to be low yielding and hydrologically isolated. Due to the overlying clay unit, the aquifers within the proposed well field are under confined conditions with static water levels averaging 100 feet.

WATER QUALITY

Water quality samples from the Marion wells have been periodically analyzed by the Indiana State Board of Health. This data indicates that the ground water in the glacial aquifers is of acceptable quality for most uses; however, there have been some wells in the town well fields that have higher than average hardness and iron concentrations. The slight variations in water quality between the well fields is summarized in Table 1.

The overall water quality in the Northeast Well Field is generally better than the town well fields; consequently, the Northeast Field has been the most heavily pumped. The relative anion concentrations are nearly identical between the well fields and the cation concentrations (calcium, magnesium, sodium and potassium) are lower in the Northeast Well Field. Iron concentrations are also high in the town well fields, causing additional water treatment problems.

Preliminary water quality data from the proposed Teays Valley Well Field indicate that its water chemistry is comparable to the Northeast Well Field. Anion concentrations are slightly lower, primarily sulfates and chlorides, and cation concentrations are all relatively the same. The proposed Teays Well Field should not present a major treatment problem for the city of Marion.

Water treatment is a major concern for Marion and if at all possible the city would like to have a central treatment facility. Following preliminary analyses, a single, centrally located treatment plant does not seem practical. With the increasing demand for water there does not appear at this time to be a single well field or aquifer that can adequately meet the city's demands. A single treatment plant would require the construction of extensive pipelines to transport water from the various well fields.

Table 1. Chemical Characteristics of Marion Well Fields

	Water Works	Mississinewa Flood Plain	Valley Avenue	Northeast Well Field	Proposed Teays Well Field
Turbidity	27	28	18	8	-
pH	7.8	7.4	7.4	7.4	8.1
Hardness ($CaCO_3$)	545	577	543	441	380
Calcium (Ca)	137	178	150	97	85
Magnesium (Mg)	54	32	41	46	41
Sodium (Na)	31	14	16	37	37
Potassium (K)	4	3	3	2	2
Iron (Fe)	2.4	3.3	2.3	1.1	1.4
Manganese (Mn)	0.1	0.3	0.2	0.02	0.02
Alkalinity ($CaCO_3$)	376	367	363	331	357
Chlorides (C1)	24	20	17	7	8
Sulfates (SO_4)	215	204	208	167	93
Phosphates (PO_4)	-	-	0.3	<0.1	0.15
Fluorides (F)	06	0.1	0.4	1.1	1.7
Nitrates (NO_3)	0.06	0.05	0.2	<0.1	0.3
Dissolved Solids	694	675	670	-	530
Arsenic (As)	-	-	-	<0.01	-
Lead (Pb)	-	-	<0.5	<0.02	-

All units are miligrams per liter except pH and turbidity.

Turbidity is measured in Nephelometric Turbidity Units (NTU)

Hardness and alkalinity are expressed as $CaCO_3$

EVALUATION OF PROPOSED WELL FIELD

Investigation

Twelve five-inch diameter test wells and two twelve-inch diameter pumping wells were drilled in the proposed well field. The locations of these wells can be seen in Figure 2. Data regarding the physical characteristics of the wells are presented in Table 2. Thirteen of the wells were drilled to the depth at which the lower brown clay was encountered. One well was drilled to bedrock. Screened wells were set in the prime sand and gravel aquifer units. Well records are presented in Appendix A.

Based on information obtained from the test drilling, the two 12-inch pumping wells were constructed in what appeared to be the thickest and better producing portions of the sand and gravel. Pumping tests were performed on each of the pumping wells with the test wells being utilized for observation purposes. Ten test wells were monitored throughout the first test, conducted on pumping well number one (MPW-1). Six test wells were monitored throughout the second pumping test, conducted on pumping well number two (MPW-2). Measurements were recorded at given times over a pumping period of 72 hours and a recovery period of 12 hours. A type-F continuous recorder was installed at MPW-1 and was in operation throughout the pumping of MPW-2.

Hydrologic Properties

Analysis of the pumping test data indicates that the aquifer has a transmissivity of approximately 140,000 gal./day/foot and a storage coefficient of 0.00015. These values were determined by Theis and Jacob method calculations. Hydrologic properties of each of the test wells for both pumping tests are presented in Tables 3 and 4. Appendix B contains time/drawdown curves.

Ground-Water Production

Boundaries - An examination of the data revealed the existence of two impermeable boundaries. These boundaries, represented in semi-log plots of data from MTW-1 and MTW-10 (obtained during pumping of MPW-2) can be seen in Figures 4a and 4b. There is a possibility that the barriers are related to the flanks of the glaciofluvial sand and gravel deposits associated with the Teays buried channel. As can been seen in Table 1, the basal elevations of the aquifers are 180-225 feet above the bedrock floor of the buried valley. The location of the observation wells with respect to the overall bedrock topography is presented in Figure 3. The fact that the basal aquifer elevations are significantly higher than the bedrock elevation throws doubt into the possibility of a bedrock boundary. It seems more likely that the sand and gravel aquifer has simply pinched out and the cone of depression has encountered a relatively impermeable clay unit. The north-south and east-west cross sections shown in Figure 5 substantiate this possibility, especially since the boundaries were encountered in wells generally located in the northern portion of the field.

Initial analysis does not appear to indicate that the aquifer is severely anisotropic. When calculating the orientation and location of the impermeable barriers, isotrophy is assumed. If the aquifer is anistrophic the orientation and location of the barrier could significantly change. Further analysis

Table 2. Data Regarding the Physical Characteristics of Wells Drilled in New Proposed Well Field

Well #	Total Depth (ft.)	Casing Depth (ft.)	Screen Length	Static Water Level	*Aquifer Elev.	Piezo. Elev.	Formation Thickness
MTW-1	427	187	5	92	**474	803	45
MTW-4	200	185	5	96	698	804	81
MTW-5	220	-	-	-	692	-	8
MTW-6	232	195	5	120	690	802	51
MTW-7	200	171	5	86	682	798	37
MTW-8	195	167.5	2.5	87	683	789	62
MTW-9	195	166.5	2.5	97	700	822	70
MTW-10	260	234.5	3	121	670	809	83
MTW-11	240	191.5	5	113	685	812	16
MTW-13	260	240	3	112	660	808	67.5
MTW-14	200	140	5	100	705	803	54
MPW-1	192	160	20	92	708	822	72
MPW-2	262	222	21	111	658	809	71

*Elevation at the base of the aquifer

**Bedrock elevation

Table 3. Data Regarding Pumping of the #1 Well (MPW-1). May 22-25, 1984

Well Number	Transmissibility Gal/day/ft	Average Coefficient of Storage	Distance From Pumped Well (Feet)	Total Amount of Drawdown (Feet)	12 Hour Recovery (Feet)
MTW-1	157,600	1.5×10^{-4}	1125	E	4.54
MTW-4	140,000	3.3×10^{-3}	56.8	7.21	4.85
MTW-6	NA	NA	3750	2.27	-
MTW-7	144,750	1.0×10^{-4}	1300	5.14	2.76
MTW-8	166,600	1.9×10^{-4}	1920	4.08	3.11
MTW-9	141,800	4.0×10^{-3}	22.2	8.50	7.21
MTW-10	E	E	3700	2.23	-
MTW-12	180,200	7.4×10^{-5}	2000	3.70	1.79
MTW-13	333,430	2.3×10^{-4}	3600	2.02	E
MTW-14	133,100	1.2×10^{-4}	620	6.05	5.08
MPW-1	-	-	-	26.26	23.43

Avg. Pumping Rate - 921 gpm

E: Large degree of error in data. Accurate calculations not possible.

NA: No available data

Table 4. Data Regarding Pumping of the #2 Well (MPW-2). June 18-22, 1984

Well Number	Transmissibility Gal/day/ft	Average Coefficient of Storage	Distance From Pumped Well (Feet)	Total Amount of Drawdown (Feet)	12 Hour Recovery (Feet)
MPW-1	243,000	1.6×10^{-4}	3525	2.76	1.50
MTW-1	161,700	2.5×10^{-4}	3630	2.81	1.00
MTW-6	126,600	9.3×10^{-5}	1200	5.99	4.52
MTW-9	FD	FD	-	-	-
MTW-10	133,000	3.0×10^{-4}	1100	7.21	4.17
MTW-11	124,600	1.3×10^{-4}	1250	5.83	4.31
MTW-12	148,000	1.4×10^{-4}	1200	4.64	3.23
MTW-13	121,000	1.0×10^{-4}	10	13.25	12.02
MPW-2	-	-	-	23.48	19.35

Avg. Pumping Rate = 940 gpm

FD: Fluctuation in data prevented accurate analysis

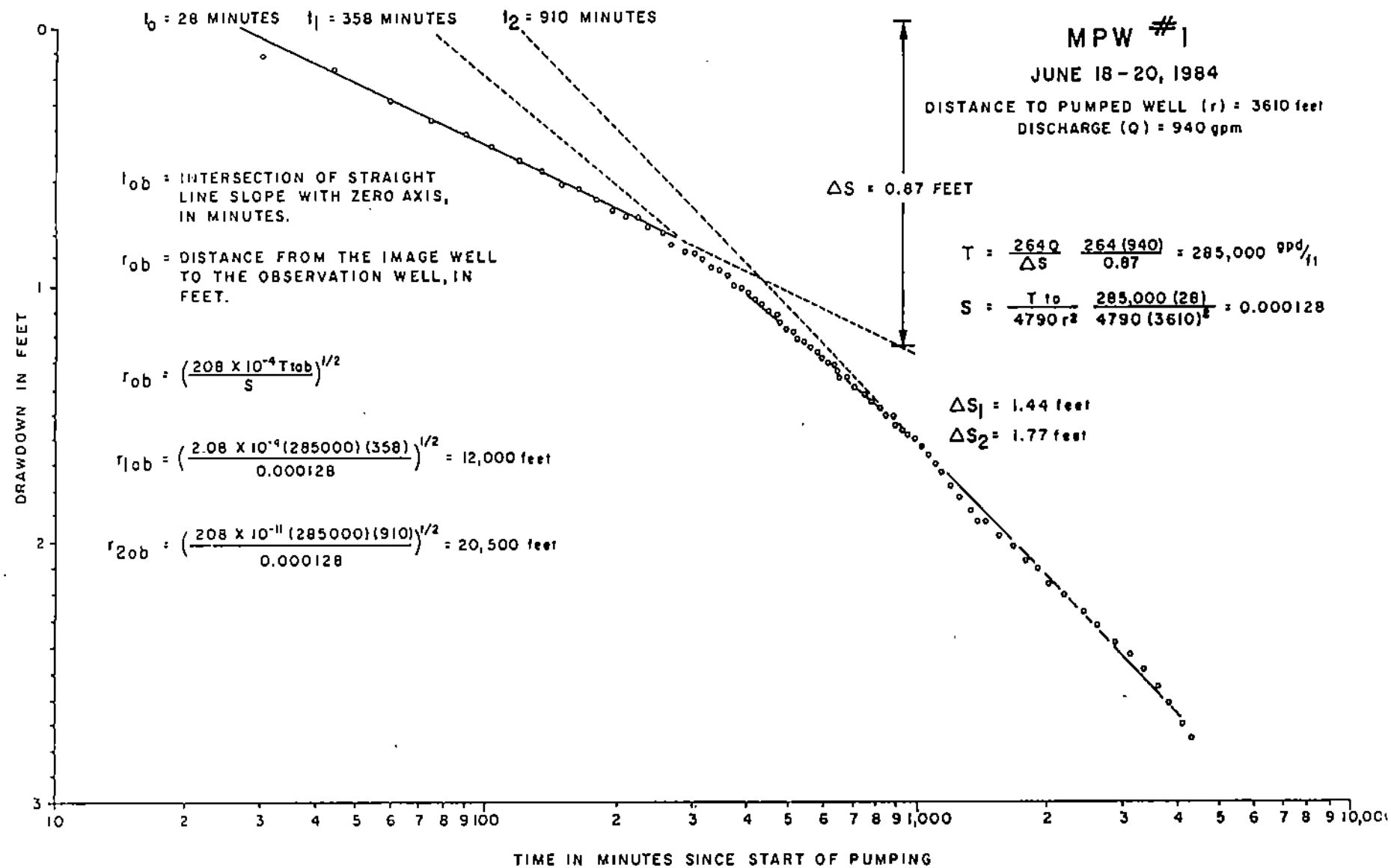


FIGURE 4A. TIME-DRAWDOWN GRAPH FOR MPW-1

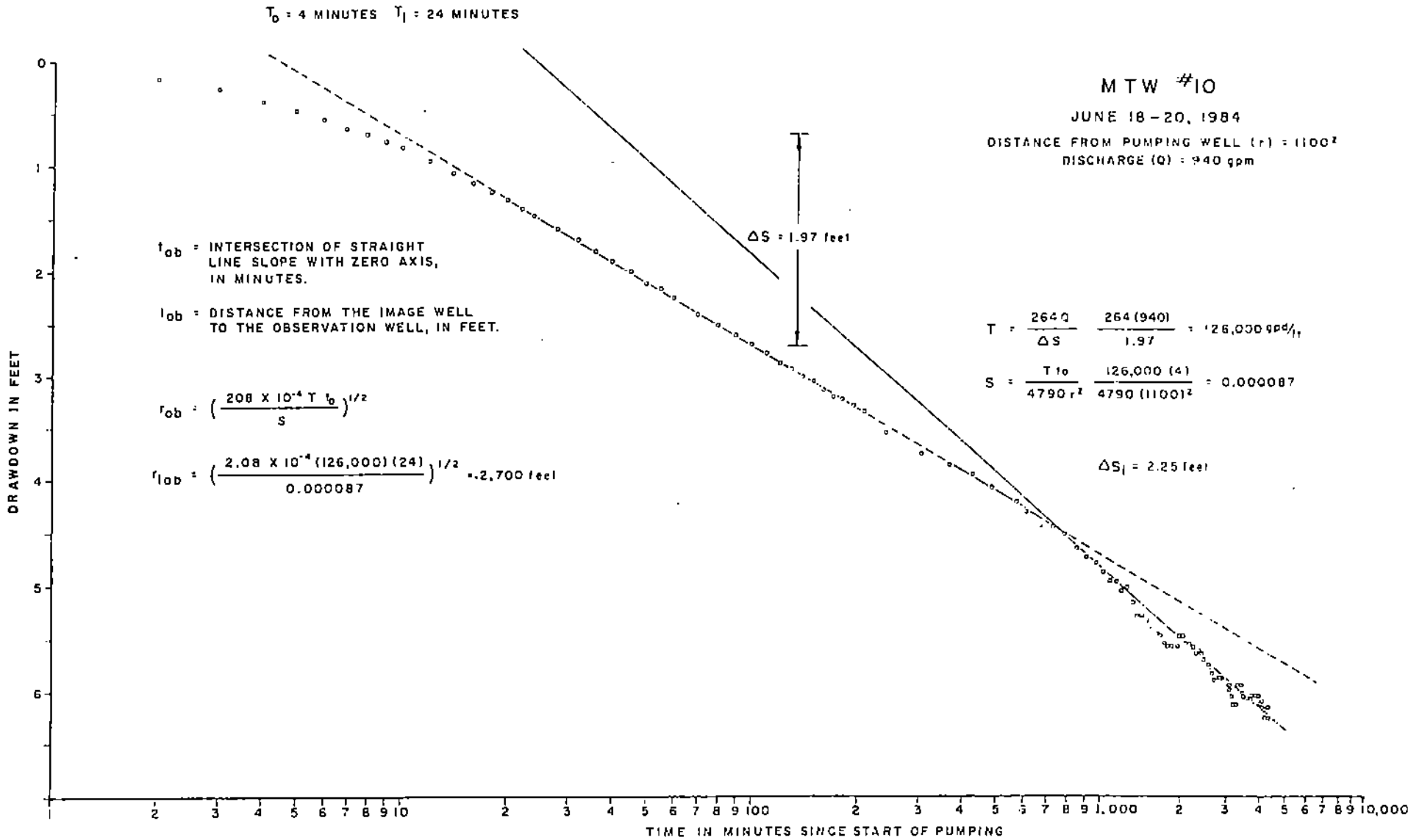


FIGURE 4B. TIME-DRAWDOWN GRAPH FOR MTW-10

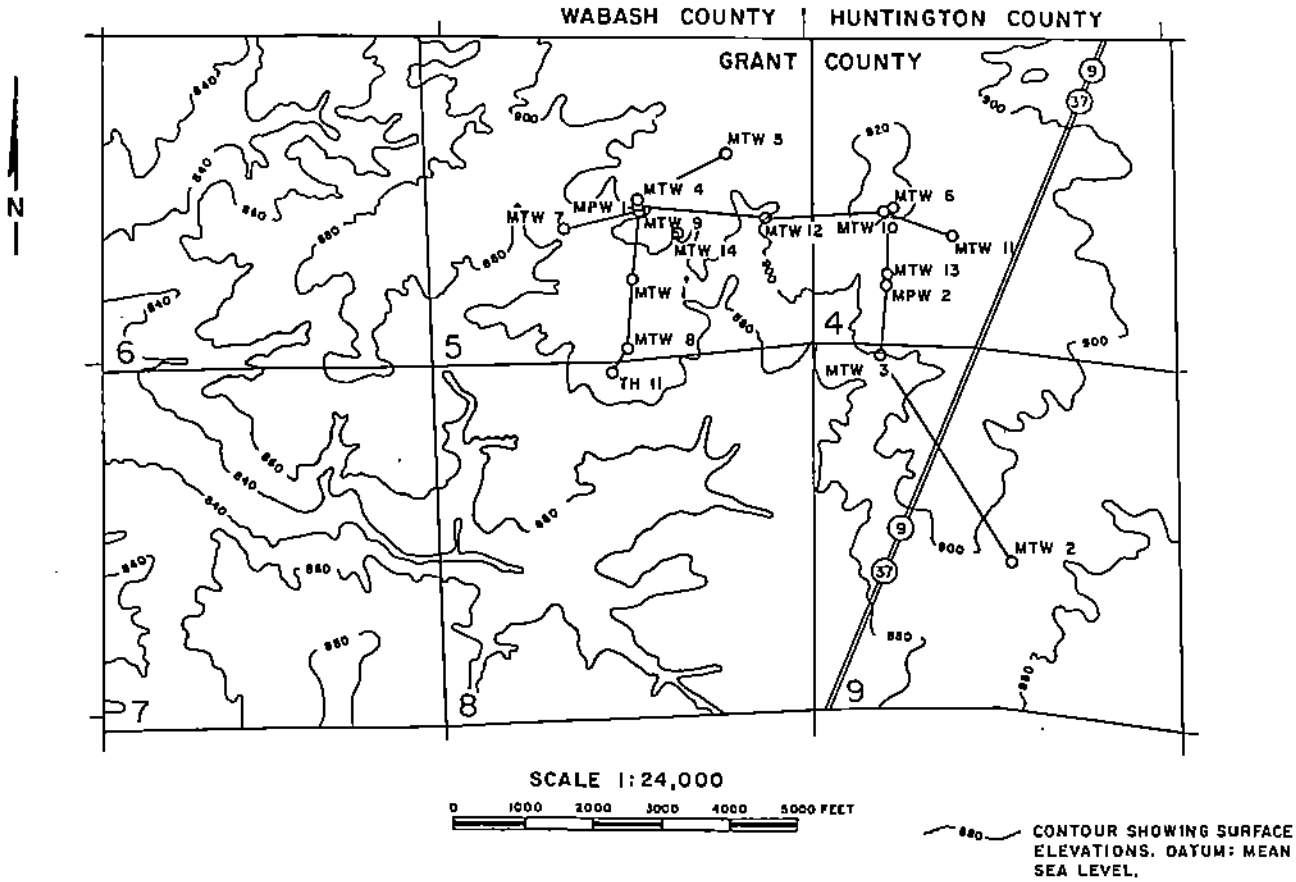


FIGURE 5A. MAP SHOWING LOCATIONS OF CROSS SECTIONS

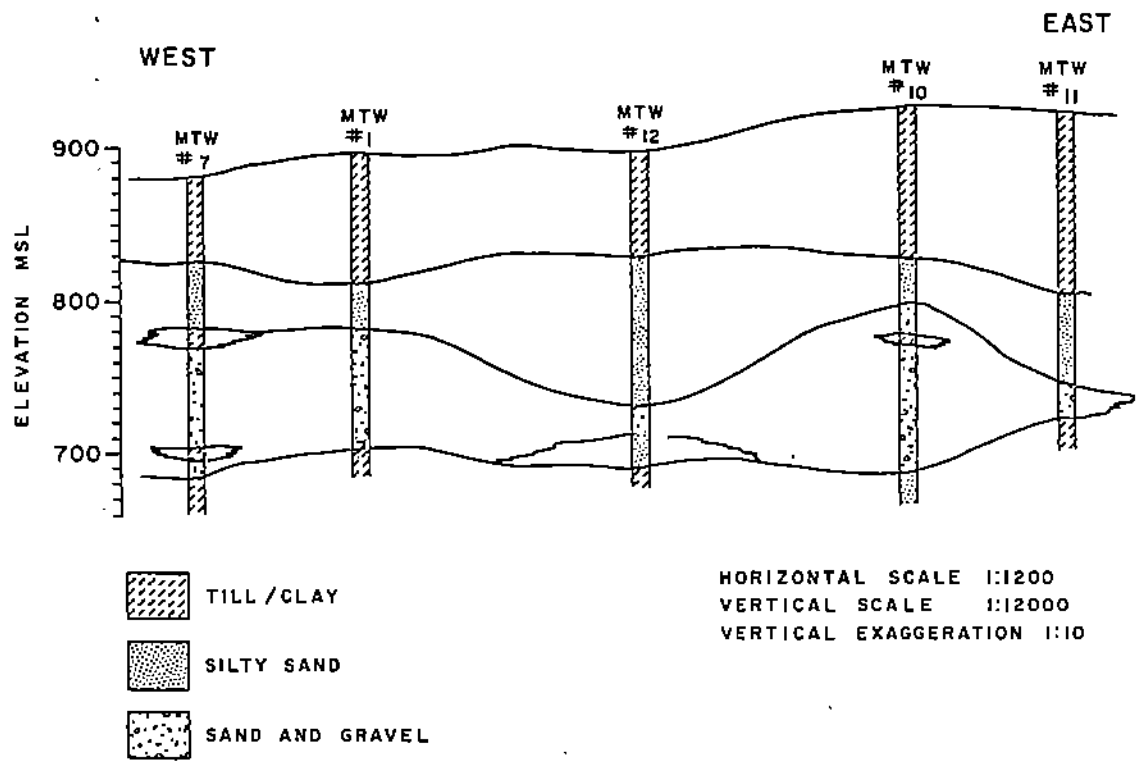


FIGURE 5B. EAST-WEST CROSS SECTION

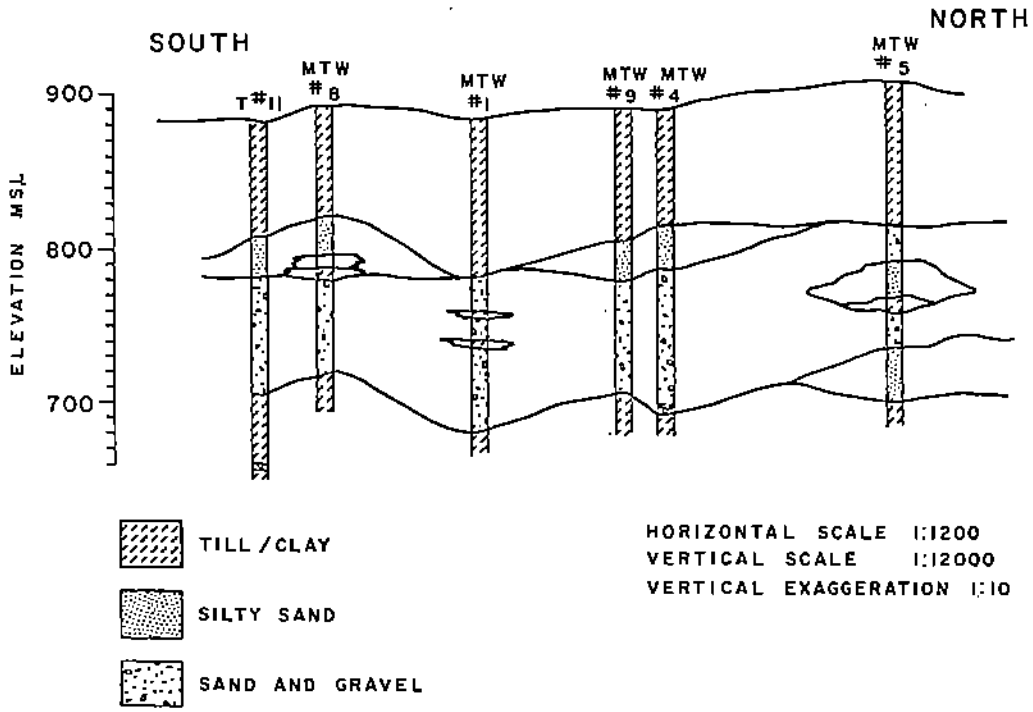


FIGURE 5C. NORTH-SOUTH CROSS-SECTION THROUGH SECTIONS 5 AND 8

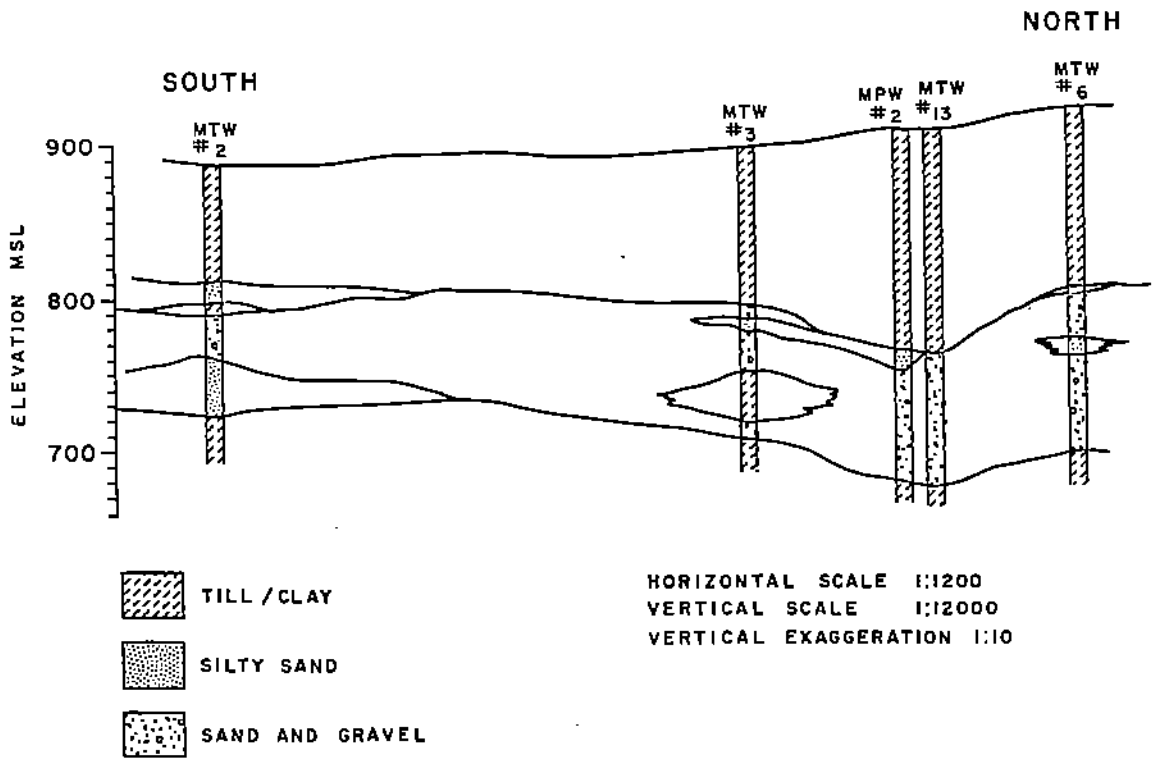


FIGURE 5D. NORTH-SOUTH CROSS SECTION, THROUGH SECTIONS 4 AND 9

is needed to determine if this situation exists.

Recharge - The only source of recharge to the aquifer appears to be infiltration through the till cap. Based on previous analyses of the Northeast Well Field and a review of the literature concerning the local till, an infiltration rate of 1.5 - 2.0 inches/year has been estimated. An infiltration rate of 2 inches/year results in approximately 95,000 gallons per day/square mile of accretion to the subsurface (Herring, 1967). It has already been ascertained that the transmissivity and storage values of the aquifer are high enough to support intensive pumping; consequently, a safe yield for the proposed field is more dependent on available recharge than any other factor.

Image Well Modeling - Image well modeling of the barriers was attempted with limited results. The calculated distances to the boundaries encountered by wells MTW-10 and MPW-1 were 2,700 feet and 12,000 feet, respectively. The technique also indicated that recharge in the proposed well field is greater than that in the Northeast Well Field. However, it must be kept in mind that current analyses regarding the new proposed field are based on only 72 hours of continuous pumping. Long term safe yields in the well field are somewhat difficult from a 72 hour test.

Yield Probabilities

The configuration of the aquifer in the proposed well field is quite complicated with several clay lenses interspersed within the sand and gravel. Substantial amounts of permeable formation of high transmissibility exist in the area and even in the lower transmissivity areas, encountered by wells MTW-10 and MPW-1, transmissivities greater than 100,000 gal/day/ft were calculated.

The total available artesian - equivalent drawdowns for pumping wells MPW-1 and MPW-2 are calculated below.

	Aquifer		
Well #	Top	Bottom	Static Level (ft.)
MPW-1	113	185	92
MPW-2	177	248	111

Artesian behavior for MPW-1: 92 to 113 = 21'
Artesian behavior for MPW-2: 111' to 177 = 66'
Water table conditions are assumed to exist below the 113' and 177' levels, respectively.

Screen length for MPW-1 = 20' Top of Screen at 160'
Screen length for MPW-2 = 21' Top of Screen at 222'

The Jacob (1944) method to adjust drawdown for the decrease in the coefficient of transmissibility when pumping in water table conditons can now be utilized.

$$S' = S - \frac{(S^2)}{(2m)}$$

Where S' = drawdown that would occur in an equivalent nonleaky artesian aquifer, in feet.

S = observed drawdown under water table conditions, in ft.

m = initial saturated thickness of aquifer, in ft.

MPW-1 artesian equivalence

$$S = 160 - 113 - 47'$$

$$S = 47 - \frac{(47)^2}{2(72)} = 31.66'$$

MPW-2 artesian equivalence

$$S = 222 - 177 = 45'$$

$$S = 45 - \frac{(45)^2}{2(71)} = 30.74'$$

Total Available Artesian-Equiv. Drawdown:

$$\text{MPW-1} = 31.66 + 21 = 52.66'$$

$$\text{MPW-2} = 30.74 + 66 = 96.74$$

Following 72 hours of pumping at rates of approx. 940 GPM and 921 GPM respectively, total drawdowns for the pumping wells are.

$$\text{MPW-1} = 26.26'$$

$$\text{MPW-2} = 23.48'$$

Consequently, the theoretical yield of these wells are:

$$\text{MPW-1: } \frac{52.66}{26.26} \times 940 = 1{,}885 \text{ GPM} \quad (2.7 \text{ MGD})$$

$$\text{MPW-2: } \frac{96.74}{23.48} \times 921 = 3{,}794 \text{ GPM} \quad (5.5 \text{ MGD})$$

It should be noted that the theoretical yields here-in represented are not necessarily the rate at which the field should be developed. Water levels in all of the monitoring wells as well as the pumping wells had not completely stabilized after the 72 hour test. There is little doubt that wells in the field would be hydraulically capable of yielding large quantities of water. As was previously mentioned, the problem with the new proposed well field lies in the fact that recharge to the aquifer is limited; however, it has been determined that the rate of recharge to the new proposed field is somewhat greater than the rate to the Northeast Well Field. Due to the depletion of the aquifer in the Northeast field, the rate has been adjusted from 9 MGD to 5 MGD. Consequently, a initial safe yield for the new proposed well field appears to be in the range of 3.5 MGD.

SUMMARY AND CONCLUSIONS

The new proposed well field for the City of Marion located approximately 5 miles north of the city limits lies within an area underlain by the buried Teays Valley bedrock incised channel.

The principal aquifer in the area consists of sand and gravel glaciofluvial deposits of Pleistocene age, occassionally interfingered with clay and silty sand. The sand and gravel aquifer is present below the Mississinewa recessional moraine complex and apparently overlies the main portion of the Teays River Valley, although the aquifer does not appear to be directly related to the Teays channel fill deposits.

Thicknesses of the sand and gravel deposits are variable, producing a somewhat complicated ground-water system. The average transmissibility is 140,000 gal/day/ft. with a storage coefficient of 0.00015. The potential yield of the well field has been estimated to be 6-8 MGD; although a safe yield appears to be more in the range of 3-4 MGD.

The expected major problem in the proposed well field is recharge to the aquifer. Rainfall infiltration, apparently the only source of recharge, is inhibited by over 100 feet of till overlying the aquifer. Infiltration has been estimated to be 1.5 to 2.0 inches per year with an estimated potential recharge of 95,000 gal/day/sq.mi.

Two barrier boundaries were encountered during a pumping test conducted on MPW-2. The boundaries are apparently a result of a change in permeability due to pinch-out of the aquifer. Neither of the boundaries appeared to seriously affect transmissivity values.

Water quality in the new proposed field is similar to that in the Northeast Well Field. Dominant cations in the Northeast Field are calcium and magnesium with bicarbonate being the dominant anion. Additional water samples from the proposed well field are currently in the process of analysis.

Following 72 hours of continuous pumping, water levels in the proposed field were still declining. In the event that the well field is developed, observation wells should be monitored until they reach equilibrium in order to more accurately determine a safe pumping rate.

APPENDIX A

Stratigraphic Information Regarding Test Wells in New Proposed Marion Well Field

TEST WELL RECORD

WELL NUMBER MTW-1

COUNTY Grant

TOPO MAP La Fontaine

DATE complete: 9-28-81

TWP. 25N RGE. 8E NW ¼ SW ¼ SE ¼ SEC 5

2600 Ft W of EL. Ground Elevation 893

1150 Ft N of SL. Depth to bedrock

_____ Ft E of WL. Bedrock elevation

_____ Ft S of NL. Aquifer elevation

WELL LOCATION:

600N, 180E, and 40 rods in field. Clyde Cox Farm

REMARKS

Casing: 2" PVC
Screen: .040 PVC WW

FORMATIONS (Color, type of material, hardness, etc.)	From	To
Brown clay	0 ft.	14 ft
Gray clay	14	99
Soft gray clay	99	105
Gray clay & sand stringers	105	117
Sand and med. gravel	117	123
Gray clay	123	133
Cemented sand and clay	133	143
Gray clay	143	148
Sand and gravel (medium)	148	158
Sand	158	160
Sand and med.-fine gravel	160	169
Sand	169	174
Sand and gravel (medium)	174	176
Sand	176	178
Sand and med. gravel	178	193
Gray clay	193	195
Sand and med. gravel	195	203
Clay (brown rock at 258')	203	288

TEST WELL RECORD

WELL NUMBER MTW-1 (Continued)

TWP._____ RGE._____ _____ ¼ ____ ¼ ____ SEC _____

COUNTY _____

TOPO MAP _____

DATE _____

_____ Ft W of EL. Ground Elevation _____

_____ Ft N of SL. Depth to bedrock _____

_____ Ft E of WL. Bedrock elevation _____

WELL LOCATION:

_____ Ft S of NL. Aquifer elevation _____

REMARKS

FORMATIONS (Color, type of material, hardness, etc.)	From	To
Sand & some wood	288	300
Sandy brown clay	300	353
Coarse sand	353	355
Gray clay	355	376
Med. sand & clay stringers	376	388
Gray clay	388	420
Broken limestone & gravel	420	427

TEST WELL RECORD

WELL NUMBER MTW-2

COUNTY Grant

TOPO MAP La Fontaine

DATE completed 9-30-81

TWP. 25N RGE. 8E NW ¼ NW¼ SE SEC 9

_____ Ft W of EL. Ground Elevation 885

2250 Ft N of SL. Depth to bedrock 220

3000 Ft E of WL. Bedrock elevation 665

_____ Ft S of NL. Aquifer elevation _____

WELL LOCATION:

550 N and 250 E
on South side

REMARKS

FORMATIONS (Color, type of material, hardness, etc.)	From	To
Brown clay	0 ft.	8 ft.
Gray clay (boulder at 71')	8	80
Sandy silt	80	83
Gray clay	83	94
Sand	94	95
Gray clay	95	100
Compacted sand	100	110
Sand & med. gravel	110	115
Gray clay	115	130
Sand	130	131
Gray sticky clay	131	157
Sandy gray clay	157	203
Sticky brown clay	203	220

TEST WELL RECORD

WELL NUMBER MTW-3

COUNTY Grant

TOPO MAP La Fontaine

DATE completed 9-30-81

TWP. 25N RGE. 8E NE ¼ NW ¼ NW SEC 9

_____ Ft W of EL. Ground Elevation 902

_____ Ft N of SL. Depth to bedrock 200

1000 Ft E of WL. Bedrock elevation _____

30 Ft S of NL. Aquifer elevation _____

WELL LOCATION:

600 N and 230 E on South side
Glenn Ross Farm

REMARKS

FORMATIONS (Color, type of material, hardness, etc.)	From	To
Brown clay	0 ft.	11 ft
Sticky gray clay	11	75
Sandy gray clay	75	106
Sand & gravel	106	112
Sand (took some water)	112	114
Sand & gravel	114	115
Gray clay	115	118
Sand & med gravel	118	133
Coarse sand	133	134
Sand & gravel	134	137
Sand & gray clay	137	141
Sand & gravel	141	145
Gray clay	145	147
Sand & silt	147	156
Sandy silt	156	165
Sandy silt & clay	165	183
Sand & gravel	183	189
Gray clay	189	196
Brown clay	196	200

TEST WELL RECORD

WELL NUMBER MTW-4

COUNTY Grant

TOPO MAP La Fontaine

DATE completed 10-1-81

WELL LOCATION:

TWP. 25N RGE. 8E NE ¼ NW ¼ SE ¼ SEC 5

2500 Ft W of EL. Ground Elevation 898

_____ Ft N of SL. Depth to bedrock _____

_____ Ft E of WL. Bedrock elevation _____

2300 Ft S of NL. Aquifer elevation _____

FORMATIONS (Color, type of material, hardness, etc.)	From	To
Yellow Clay	0 ft.	13 ft
Soft gray clay	13	75
Harder gray clay	75	105
Soft gray clay	105	110
Sand & gravel (coarse)	110	118
Gray clay	118	120
Sand & gravel (coarse)	120	133
Sand & fine gravel	133	135
Coarse gravel w/some sand	135	150
Sand & med. gravel	150	155
Sand & gravel, med. loose	155	160
Sand & fine gravel	160	165
Sand & coarse gravel	165	170
Coarse gravel (took water & mud)	170	175
Med gravel and sand	175	180
Fine gravel and sand	180	191
Gray clay	191	194
Sand and gravel	194	197
Brown clay	197	200

REMARKS

Casing: 2" PVC
Screen: .040
PVC WW

TEST WELL RECORD

WELL NUMBER MTW-5

COUNTY Grant

TOPO MAP La Fontaine

DATE completed 10-12-81

WELL LOCATION:

TWP. 25N RGE. 8E SW ¼ SE ¼ NE SEC 5

1200 Ft W of EL. Ground Elevation 910+

_____ Ft N of SL. Depth to bedrock _____

_____ Ft E of WL. Bedrock elevation _____

1600 Ft S of NL. Aquifer elevation _____

REMARKS

FORMATIONS (Color, type of material, hardness, etc.)	From	To
Yellow clay	0 ft.	10 ft.
Gray clay (soft)	10	73
Gray clay (harder)	73	94
Sandy gray clay	94	110
Sand & gravel	110	112
Gray clay	112	138
Sand & gravel	138	139
Gray clay	139	140
Gray clay & gravel (mixed)	140	155
Gray clay & silt	155	166
Sand & gravel	166	174
Brown clay	174	195
Brown & gray clay with sand streaks	195	210
Gray & brownish clay	210	220

TEST WELL RECORD

WELL NUMBER MTW-6

COUNTY Grant

TOPO MAP La Fontaine

DATE Complete 10-12-81

WELL LOCATION:

TWP. 25B RGE. 8E SE ¼ NW ¼ SW SEC 4

_____ Ft W of EL. Ground Elevation 920'

1900' Ft N of SL. Depth to bedrock _____

1150' Ft E of WL. Bedrock elevation _____

_____ Ft S of NL. Aquifer elevation 690'

REMARKS

FORMATIONS (Color, type of material, hardness, etc.)	From	To
Yellow clay	0 ft.	13 ft
Soft blue clay	13	48
Gray clay	48	64
Soft gray clay	64	100
Gritty gray clay	100	118
Sand and gravel	118	120
Gray clay	120	140
Sandy clay and fine gravel	140	145
Gray clay w/fine sand and silt	145	163
Sand and fine gravel (tight)	163	171
Sand and fine gravel w/clay stringers	171	175
Sand and coarse gravel (tight)	175	180
Sand and fine gravel	180	200
Sand and clay with fine gravel	200	214
Gray clay	214	232

TEST WELL RECORD

WELL NUMBER MTW-7

COUNTY Grant

TOPO MAP La Fontaine

DATE completed: 10-13-81

TWP. 25N. RGE. 8E. SW ¼ NE ¼ SW SEC 5

_____ Ft W of EL. Ground Elevation 882'

1900' Ft N of SL. Depth to bedrock _____

2000' Ft E of WL. Bedrock elevation _____

_____ Ft S of NL. Aquifer elevation 682'

WELL LOCATION:

Co. Rd. 600N and 180E on North side, 60 rods N. and 20 rods W.

REMARKS

Casing: 2" PVC

Screen: .040 PVC WW

FORMATIONS (Color, type of material, hardness, etc.)	From	To
Yellow clay	0 ft.	14 ft
Soft gray clay	14	75
Harder gray clay & stones	75	95
Sand	95	97
Soft gray clay	97	108
Sand & fine gravel	108	114
Clay & mixed gravel	114	116
Cemented sand & gravel	116	118
Med sand & gravel	118	125
Silty sand & clay	125	130
Sand & silt	130	134
Hard gray clay	134	139
Sand & coarse gravel	139	150
Sand & med gravel	150	155
Gray clay	155	156½
Sand & silt	156½	160
Coarse sand & gravel	160	163
Sand & med. gravel	163	166

TEST WELL RECORD

WELL NUMBER MTW-7 (continued)

COUNTY _____

TOPO MAP _____

DATE _____

TWP._____RGE._____ ____¼ ____¼ ____SEC____

_____ Ft W of EL. Ground Elevation _____

_____ Ft N of SL. Depth to bedrock _____

_____ Ft E of WL. Bedrock elevation _____

_____ Ft S of NL. Aquifer elevation _____

WELL LOCATION:

REMARKS

FORMATIONS (Color, type of material, hardness, etc.)	From	To
Sand & fine gravel w/clay	166	170
Gray clay	170	171
Sand & gravel	171	176
Gray clay	176	185
Sand & gravel	185	192
Gray clay	192	200

TEST WELL RECORD

WELL NUMBER MTW-8

COUNTY Grant

TOPO MAP La Fontaine

DATE complete 1/17/84

TWP. 25N RGE. 8E SW ¼ SW ¼ SE SEC 5

_____ Ft W of EL. Ground Elevation 878'

100' Ft N of SL. Depth to bedrock _____

2850' Ft E of WL. Bedrock elevation _____

_____ Ft S of NL. Aquifer elevation 683'

WELL LOCATION:

600 N approx. 5/8 mile West
of St. Rd. 9 & 37 on North side

REMARKS

FORMATIONS (Color, type of material, hardness, etc.)	From	To
Yellowish-brown clay (gritty)	0 ft.	14 ft
Yellowish-brown clay (smooth)	14	16
Gray clay	16	32
Brownish-gray gritty clay	32	35
Gray clay	35	46
Gritty gray clay	46	47
Gray clay	47	67
Gritty gray clay	67	69
Gray clay	69	77½
Gray clay w/stringers of gravel at 77½, 78, 80½, 81	77½	81
Gray clay	81	95
Gritty gray clay	95	99
Fine to med. gravel (took some water)	99	104½
Gritty brown clay	104'	111
Fine to coarse gravel	111	120
Fine to med. gravel w/med. to coarse sand	120	125
Fine to med. gravel w/fine to coarse sand	125	130
Fine to coarse sand w/fine to med. gravel	130	135

Casing: 5" PVC
Screen: .060

TEST WELL RECORD

WELL NUMBER MTW-8 (continued)

COUNTY _____

TOPO MAP _____

DATE _____

TWP._____RGE._____ ____¼ ____¼ ____SEC____

_____ Ft W of EL. Ground Elevation _____

_____ Ft N of SL. Depth to bedrock _____

_____ Ft E of WL. Bedrock elevation _____

_____ Ft S of NL. Aquifer elevation _____

WELL LOCATION:

REMARKS

FORMATIONS (Color, type of material, hardness, etc.)	From	To
Sandy silt	135	140
Fine to coarse sand w/fine to med. gravel	140	145
Silty fine to med. sand	145	150
Fine to med. sand	150	152
Med. to coarse sand & fine gravel	152	155
Med. gravel w/med. to coarse sand	155	160
Med. to coarse gravel w/coarse sand (tight)	160	173
Gray, gritty clay w/thin streaks of gravel	173	195

TEST WELL RECORD

WELL NUMBER MTW-9

COUNTY Grant

TOPO MAP La Fontaine

DATE completed 1-18-84

TWP. 25N. RGE. 8E. NW ¼ NW ¼ SE SEC 5

3100' Ft W of EL. Ground Elevation 895'

_____ Ft N of SL. Depth to bedrock _____

_____ Ft E of WL. Bedrock elevation _____

2550' Ft S of NL. Aquifer elevation 700'

WELL LOCATION:

600 N. & approx. 5/8 mile West
of St. Rd. 9 & 37 on North side.
Then North 1/4 mile.

REMARKS

Casing: 5" PVC

Screen: .060

FORMATIONS (Color, type of material, hardness, etc.)	From	To
Yellowish-brown clay	0 ft.	10 ft
Gritty brown clay	10	15
Gray clay	15	70
Brownish-gray clay	70	80
Gravely, brownish-gray clay	80	88
Gravely gray clay	88	111
Med. to coarse gravel (took alot of water & mud)	111	115
Med. to coarse gravel	115	130
Fine to med. gravel w/coarse sand	130	135
Fine to coarse sand w/fine gravel	135	140
Fine to med. gravel & med. to coarse sand	140	145
Med. to coarse sand w/fine to med. gravel	145	181
Gray clay	181	195

TEST WELL RECORD

WELL NUMBER MTW-10

COUNTY Grant

TOPO MAP La Fontaine

DATE completed 1/23/84

WELL LOCATION:

TWP. 25N RGE. 8E NE ¼ NW ¼ SW SEC 4

_____ Ft W of EL. Ground Elevation 930'

_____ Ft N of SL. Depth to bedrock _____

1100' Ft E of WL. Bedrock elevation _____

2600' Ft S of NL. Aquifer elevation 670'

REMARKS

Casing: 5" PVC

Screen: 040 RB WW

FORMATIONS (Color, type of material, hardness, etc.)	From	To
Yellowish-brown clay	0 ft.	12 ft
Gray clay	12	100
Gritty gray clay	100	107
Silty sand & fine to med. gravel	107	109
Gritty brownish-gray clay	109	113
Fine to med. gravel w/some clay stringers	113	119
Gray clay	119	121
Alternating 6" layer of gravel & clay	121	123
Gray clay	123	136
Fine to med. gravel	136	138
Gravely gray clay	138	141
Fine to med. sand w/some coarse sand & fine gravel	141	149
Coarse sand fine to med. gravel w/fine-med. sand	149	157
Fine to coarse gravel w/fine to med. sand	157	159
Coarse sand and fine to med gravel w/fine-med sand	159	165
Fine to coarse gravel w/fine to med sand	165	179
(Clay Stringer)	176	177½
Boulder	179	180

TEST WELL RECORD

WELL NUMBER MTW-10 (continued)

TWP._____ RGE._____ ____¼ ____¼ SEC_____

COUNTY _____

TOPO MAP _____

DATE _____

_____ Ft W of EL. Ground Elevation _____

_____ Ft N of SL. Depth to bedrock _____

_____ Ft E of WL. Bedrock elevation _____

WELL LOCATION:

_____ Ft S of NL. Aquifer elevation _____

REMARKS

FORMATIONS (Color, type of material, hardness, etc.)	From	To
Med to coarse gravel w/fine to med sand	180	182
Clay	182	182½
Fine to coarse gravel w/fine to med sand & Boulders	182½	191
Limestone boulder laying in gray clay	191	192½
Fine to med sand w/coarse sand & fine gravel	192½	200
Silty sand	200	213
Fine to med gravel w/med sand	213	220
Fine to med gravel w/med to coarse sand	220	240
(Clay stringers)	237	238½
Gravely brown clay	240	260

TEST WELL RECORD

WELL NUMBER MTW-11

COUNTY Grant

TOPO MAP La Fontaine

DATE completed 1-24-84

TWP. 25N RGE. 8E NE ¼ NE ¼ SW SEC 4

_____ Ft W of EL. Ground Elevation 925'

_____ Ft N of SL. Depth to bedrock _____

2100' Ft E of WL. Bedrock elevation _____

2900' Ft S of NL. Aquifer elevation 685'

WELL LOCATION:

600 N and about 1/8 mile West, then 1/4 mile North in field

REMARKS

Casing: 2" PVC
Screen: .040 PVC WW

FORMATIONS (Color, type of material, hardness, etc.)	From	To
Brown clay	0 ft	3 ft
Yellowish-brown clay	3	8
Gray clay	8	57
Silty fine sand	57	60
Gray clay	60	72
Silty fine to med. sand & gray clay	72	80
Gray clay	80	90
Brownish-gray clay	90	95
Gravely gray clay	95	100
Gravely grayish-brown clay	100	117
Sand and gravel	117	118
Gray clay w/streaks of sand & fine gravel	118	140
Silty sand w/gray clay	140	170
Fine to coarse sand w/fine gravel and gray clay	170	178
Limestone boulder	178	179
Med to coarse sand w/fine to med. gravel	179	185
Fine to med gravel & coarse sand w/some med. sand	185	190
Fine to med. gravel & coarse sand w/less med. sand	190	195

TEST WELL RECORD

WELL NUMBER MTW-11 (continued)

COUNTY _____

TOPO MAP _____

DATE _____

TWP._____RGE._____ ¼ ¼ SEC_____

_____ Ft W of EL. Ground Elevation _____

_____ Ft N of SL. Depth to bedrock _____

_____ Ft E of WL. Bedrock elevation _____

_____ Ft S of NL. Aquifer elevation _____

WELL LOCATION:

REMARKS

FORMATIONS (Color, type of material, hardness, etc.)	From	To
Cemented fine to med. gravel & broken stone w/gray		
clay & white putty stone (tight)	195	200
Gravely gray clay	200	207
Gritty brown clay	207	240

TEST WELL RECORD

WELL NUMBER MTW-12

COUNTY Grant

TOPO MAP La Fontaine

DATE complete 1/25/84

TWP. 25N RGE. 8E NE ¼ NE ¼ SE SEC 5

650' Ft W of EL. Ground Elevation 900'

_____ Ft N of SL. Depth to bedrock _____

_____ Ft E of WL. Bedrock elevation _____

2700' Ft S of NL. Aquifer elevation 680'

WELL LOCATION:

600 N & approx. 3/8 mile West of St. Rd. 9 & 37, then North about 1/4 mile in field

REMARKS

Casing: 2" PVC
Screen: .040 PVC WW

FORMATIONS (Color, type of material, hardness, etc.)	From	To
Yellowish-brown clay	0 ft.	12 ft.
Gray clay	12	50
Gritty gray clay	50	52
Gray clay	52	60
Gradual color change from gray to brownish-gray clay	60	70
Grayish-brown clay	70	80
Brownish-gray clay	80	85
Gravely grayish-brown clay	85	90
Gravely grayish-brown clay	90	95
Gray clay	95	115
Silty sand w/clay streaks	115	132
Sand & fine gravel w/ clay	132	140
Sandy gray clay	140	148
Fine to med. gravel w/med to coarse sand	148	155
Fine sand & clay	155	165
Med. to coarse sand & fine gravel	165	180
Fine to coarse sand w/small amount of fine gravel & clay stringers (tight)	180	202

TEST WELL RECORD

WELL NUMBER MTW-12 (continued)

TWP._____ RGE._____ _____ ¼ _____ ¼ _____ SEC _____

COUNTY _____

TOPO MAP _____

DATE _____

_____ Ft W of EL. Ground Elevation _____

_____ Ft N of SL. Depth to bedrock _____

_____ Ft E of WL. Bedrock elevation _____

WELL LOCATION:

_____ Ft S of NL. Aquifer elevation _____

REMARKS

FORMATIONS (Color, type of material, hardness, etc.)	From	To
Reddish-brown clay w/alt. layers of sand and fine gravel	202	213
Brown clay	213	220

TEST WELL RECORD

WELL NUMBER MTW-13

COUNTY Grant

TOPO MAP La Fontaine

DATE complete 1-26-84

TWP. 25N RGE. 8E NE ¼ SW ¼ SW SEC 4

_____ Ft W of EL. Ground Elevation 920

900 Ft N of SL. Depth to bedrock _____

1000 Ft E of WL. Bedrock elevation _____

_____ Ft S of NL. Aquifer elevation 660

WELL LOCATION:

600 N. approx. 1/4 mile West and slightly less than 1/4 mile North in field.

REMARKS

Casing: 5" PVC
Screen: .030
RB WW

FORMATIONS (Color, type of material, hardness, etc.)	From	To
Yellowish-brown clay	0 ft.	10 ft
Gray clay	10	99
Grayish-brown clay w/gravel	99	110
Gray clay	110	120
Silty sand and clay	120	126
Gray clay	126	135
Gritty gray clay	135	150
Silty sand and clay	150	165
Silty fine to med. sand w/some clay	165	177½
Fine to med. gravel & coarse sand w/clay stringers	177½	185
Fine to coarse gravel & coarse sand w/clay stringers	185	195
Fine to med. gravel & fine to med. sand w/clay	195	200
Fine to coarse gravel w/med. to coarse sand	200	205
Fine to med. gravel w/med. to coarse sand	205	215
Fine to coarse gravel w/med. to coarse sand	215	220
Fine to med. gravel w/fine to coarse sand	220	225
Fine to coarse sand w/fine to med. gravel	225	230
Fine to med. gravel w/fine to med. gravel	230	245

TEST WELL RECORD

WELL NUMBER MTW-13 (continued)

TWP._____ RGE._____ _____¼ _____¼ _____ SEC _____

COUNTY _____

TOPO MAP _____ _____ Ft W of EL. Ground Elevation _____

DATE _____ _____ Ft N of SL. Depth to bedrock _____

_____ Ft E of WL. Bedrock elevation _____

WELL LOCATION: _____ Ft S of NL. Aquifer elevation _____

REMARKS

FORMATIONS (Color, type of material, hardness, etc.)	From	To
Gravely gray clay	245	249
Smooth gray clay	249	252
Silty clay	252	257
Smooth gray clay	257	260

TEST WELL RECORD

WELL NUMBER MTW-14

COUNTY Grant

TOPO MAP La Fontaine

DATE completed 1-27-84

TWP. 25N RGE. 8E SE ¼ NW ¼ SE SEC 5

2000' Ft W of EL. Ground Elevation 905'

_____ Ft N of SL. Depth to bedrock _____

_____ Ft E of WL. Bedrock elevation _____

2850' Ft S of NL. Aquifer elevation 705'

WELL LOCATION:

600N and about 1/2 mile West of St. Rd. 9 & 37, then North of road about 1/4 mile.

REMARKS

FORMATIONS (Color, type of material, hardness, etc.)	From	To
Yellowish-brown clay	0 ft.	13 ft.
Gray clay	13	81
Greenish-gray gritty clay	81	85
Silty fine sand & clay	85	90
Grayish-brown gritty clay	90	95
Gritty gray clay	95	115
Silty fine sand & clay	115	119
Fine to coarse gravel & coarse sand w/stringers and some fine sand	119	124
Fine to med. gravel & fine to coarse sand w/clay stringers (much more sand)	124	131½
Brown clay	131½	134
Fine to med. sand w/some coarse sand	134	145
Fine to med. sand	145	155
Fine to med. sand w/some cementing material	155	160
Silty sand w/thin clay stringers	160	173
Gray clay	173	200

Casing: 2" PVC
Screen: .040 PVC WW

TEST WELL RECORD

WELL NUMBER MPW-1

COUNTY Grant

TOPO MAP La Fontaine

DATE complete 2-8-84

TWP. 25N RGE. 8E NW ¼ NW ¼ SE SEC 5

3010' Ft W of EL. Ground Elevation 900'

_____ Ft N of SL. Depth to bedrock _____

_____ Ft E of WL. Bedrock elevation _____

2500' Ft S of NL. Aquifer elevation 708'

WELL LOCATION:

600 N & Approx. 5/8 mile
West of St. Rd. 9 & 37 on
North side then N about 1/4 mile

REMARKS

Casing: 12"

Screen: .110

FORMATIONS (Color, type of material, hardness, etc.)	From	To
Yellowish-brown clay	0 ft	12 ft
Brownish-gray clay	12	82
Gravely grayish-brown clay	82	87
Gravely brownish-gray clay	87	107
Grayish-brown clay w/sand & gravel streaks	107	113
Fine to coarse sand w/fine to med. gravel	113	118
Med. to coarse sand w/fine to med. gravel & clay stringer	118	122
Med. to coarse sand & fine to med. gravel	122	180
Fine to med. sand	180	182
Boulders & sand w/cemented white clay material	182	185
Grayish-brown, sandy clay (slightly gravely)	185	192

TEST WELL RECORD

WELL NUMBER MPW-2

COUNTY Grant

TOPO MAP La Fontaine

DATE complete 2-14-84

TWP. 25N RGE. 8E NE ¼ SW ¼ SEC 4

_____ Ft W of EL. Ground Elevation 920

800' Ft N of SL. Depth to bedrock _____

1000' Ft E of WL. Bedrock elevation _____

_____ Ft S of NL. Aquifer elevation 658

WELL LOCATION:

600 N. approx. 1/4 mile
west of St. Rd. 9 & 37
then 1/4 North in field

FORMATIONS (Color, type of material, hardness, etc.)	From	To
Yellowish-brown clay	0 ft.	10 ft
Gray clay	10	99
Grayish-brown clay w/gravel	99	110
Gray clay	110	120
Silty sand and clay	120	126
Gray clay	126	135
Gritty gray clay	135	150
Silty sand and clay	150	165
Silty fine to med. sand w/some clay	165	177
Fine to med. gravel & coarse sand w/clay stringers	177	185
Fine to coarse gravel & coarse sand w/clay stringers	185	195
Fine to med. gravel & sand w/gray clay	195	200
Fine to coarse gravel & med. to coarse sand	200	205
Fine to med. gravel w/med. to coarse sand	205	215
Fine to coarse gravel w/med. to coarse sand	215	220
Fine to med. gravel & fine to coarse sand	220	243
Fine to med. gravel w/clay stringers	243	248
Very gravely gray clay	248	255

REMARKS

Casing: 12"
Screen: .060
SS WW (8')
222 - 230'
.090
SS WW (12')
230-242'
Test Rate: 400 gpm

TEST WELL RECORD

WELL NUMBER MPW-2 (continued)

COUNTY _____

TOPO MAP _____

DATE _____

WELL LOCATION:

TWP._____RGE._____ ____¼ ____¼ ____SEC____

_____ Ft W of EL. Ground Elevation _____

_____ Ft N of SL. Depth to bedrock _____

_____ Ft E of WL. Bedrock elevation _____

_____ Ft S of NL. Aquifer elevation _____

REMARKS

FORMATIONS (Color, type of material, hardness, etc.)	From	To
Smooth gray clay	255	257
Slightly silty gray clay	257	262

TEST WELL RECORD

WELL NUMBER TH-11

COUNTY Grant

TOPO MAP La Fontaine

DATE completed 10-13-78

TWP. 25N RGE. 8E NE ¼ NE ¼ NW SEC 8

2900 Ft W of EL. Ground Elevation 885

109 Ft N of SL. Depth to bedrock 413

____ Ft E of WL. Bedrock elevation 470

____ Ft S of NL. Aquifer elevation ____

WELL LOCATION:

600N, 145E on S. side of road
about 100 ft. S. of road and
20 ft. W. of lane fence

REMARKS

FORMATIONS (Color, type of material, hardness, etc.)	From	To
Brown clay	0 ft.	15 ft
Gray clay	15	60
Brownish-gray clay	60	67
Gray clay	67	69
Brownish-gray clay	69	75
Sandy gray clay	75	90
Sandy silty brown gravel	90	101
Sandy brown clay	101	104
Broken stone & gravel w/clay stringers	104	110
Sandy brown fine to med. gravel	110	144
Gray clay	144	145
Gray sandy gravel & broken stone	145	157
Soft gray clay w/layers of gravel	157	168
Sticky gray clay	168	170
Very fine sand	170	179
Sticky smooth gray clay	179	195
Gray clay	195	223
Gravel	223	227

TEST WELL RECORD

WELL NUMBER TH-11 (continued)

TWP._____RGE._____ ____¼ ____¼ ____SEC_____

COUNTY _____

TOPO MAP _____

DATE _____

_____ Ft W of EL. Ground Elevation _____

_____ Ft N of SL. Depth to bedrock _____

_____ Ft E of WL. Bedrock elevation _____

WELL LOCATION:

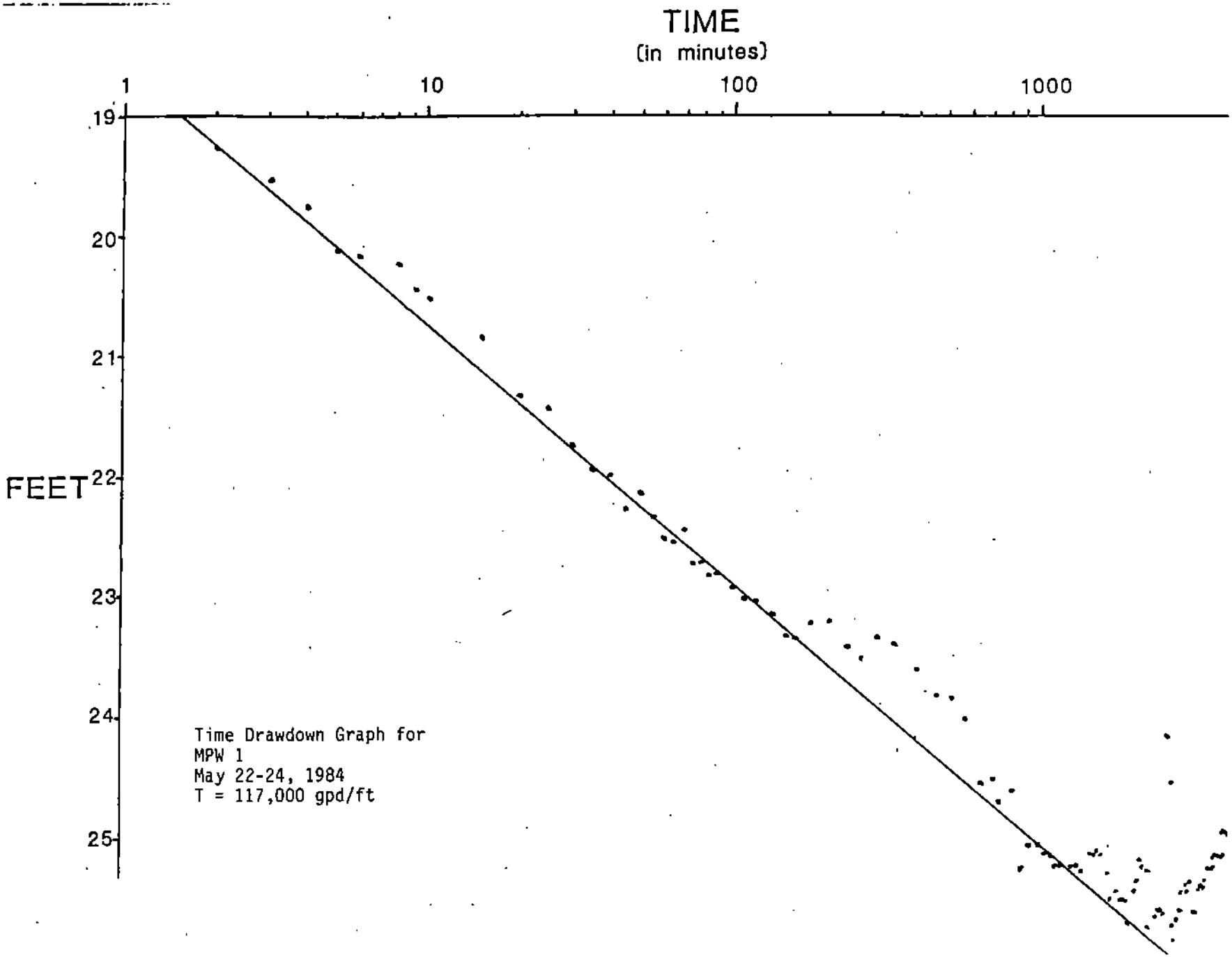
_____ Ft S of NL. Aquifer elevation _____

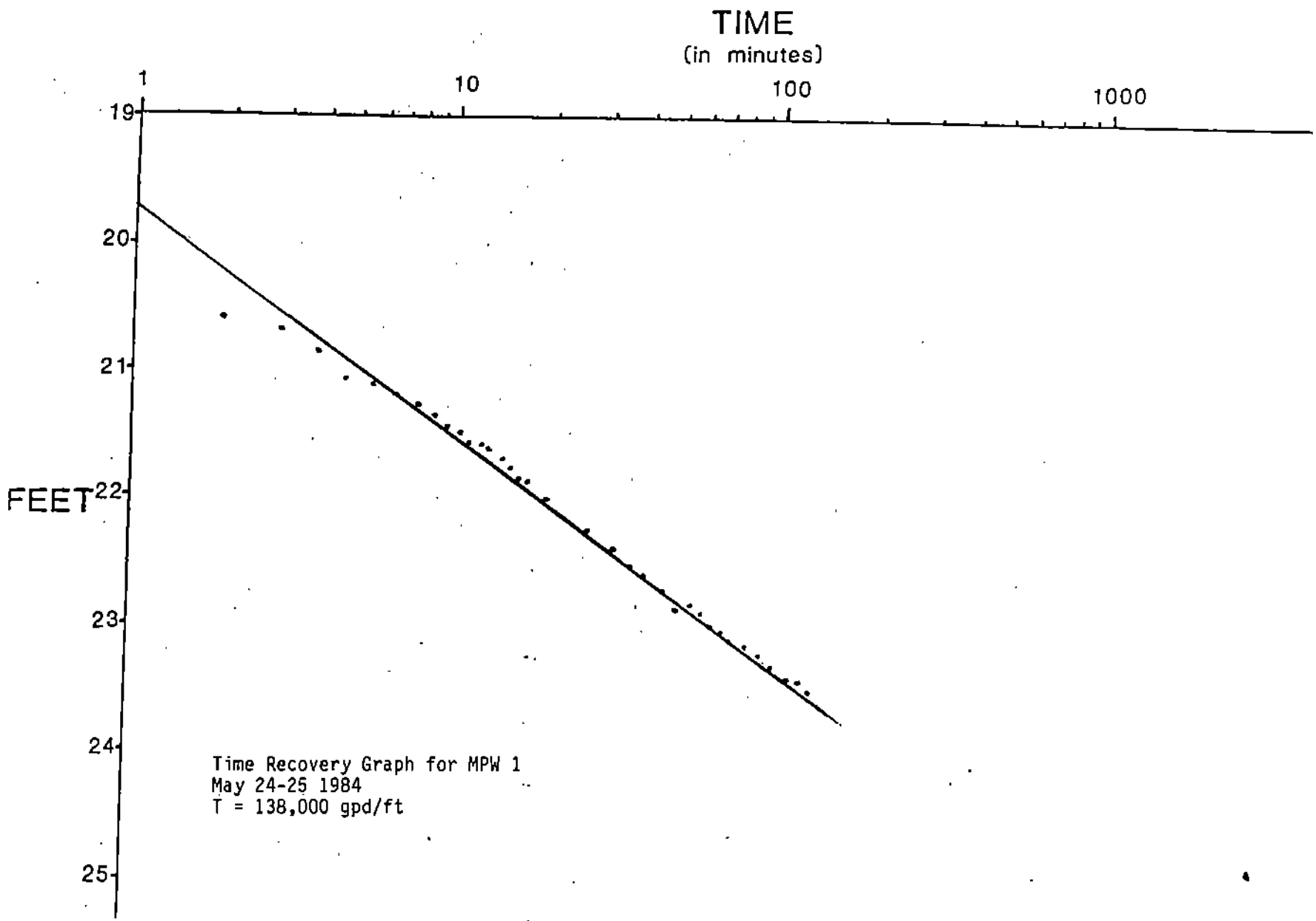
REMARKS

FORMATIONS (Color, type of material, hardness, etc.)	From	To
Gray silty clay	227	241
Gray clay	241	262
Sandy fine to med. gravel	262	269
Brown clay	269	269½
Tight gravel & broken stone	269½	277
Loose fine to med sand and gravel	277	290
Soft red-brown smooth clay	290	353
Brown clay and sand	353	365
Brown clay w/occasional streaks of sand	365	395
Fine sand & gravel	395	410
CLay	410	410½
Sand & gravel	410½	413
Blue shale	413	415
Gray shale	415	418
Gray limestone	418	426

APPENDIX B

Time/Drawdown and Time/Recovery Graphs of
Observation Wells in New Proposed
Marion Well Field
(Pumping of MPW-1)


TIME
(in minutes)
1
10
100
1000
19
20
21
22
23
24
25
FEET
Time Drawdown Graph for
MPW 1
May 22-24, 1984
T = 117,000 gpd/ft


TIME
(in minutes)
1
10
100
1000
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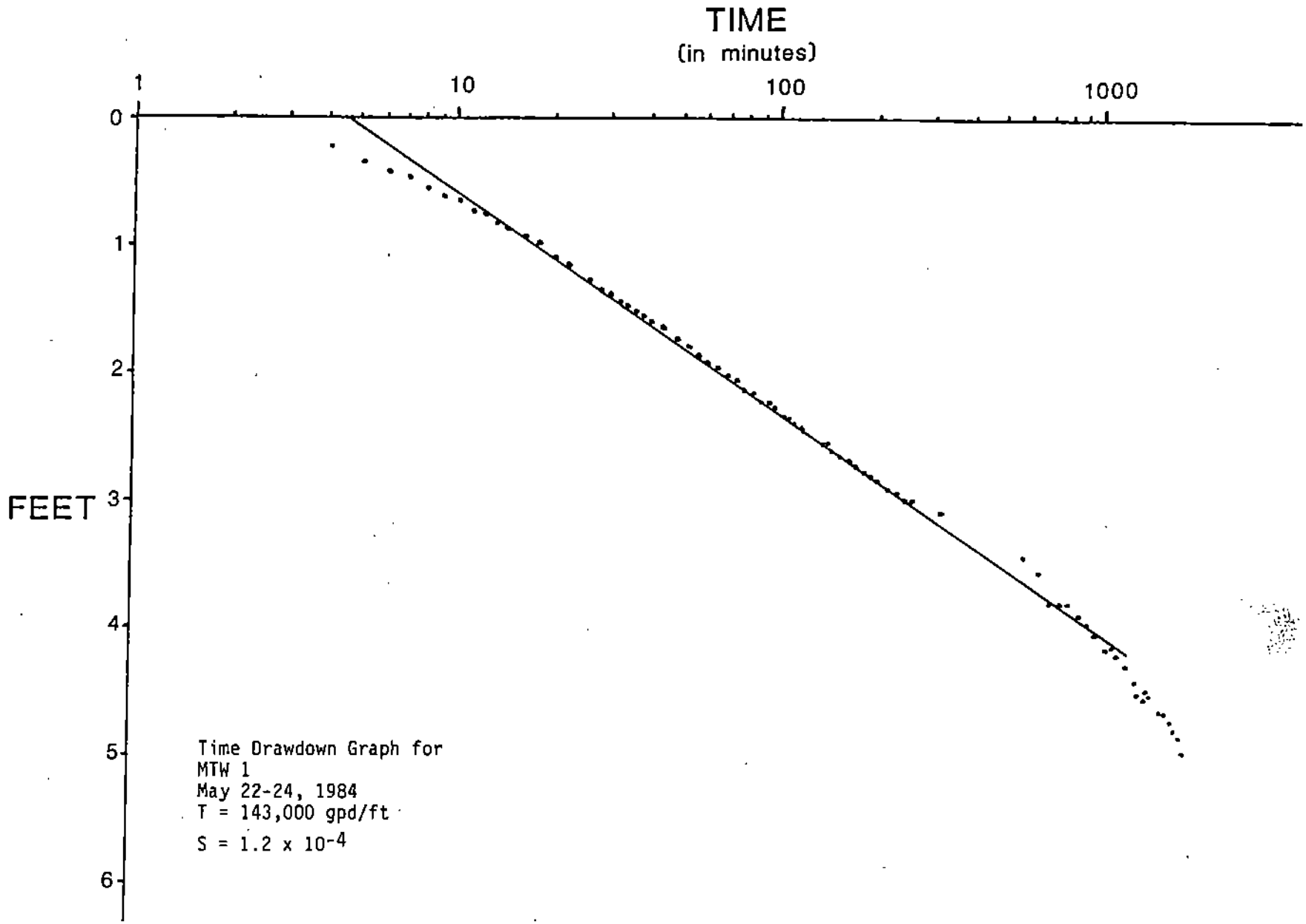
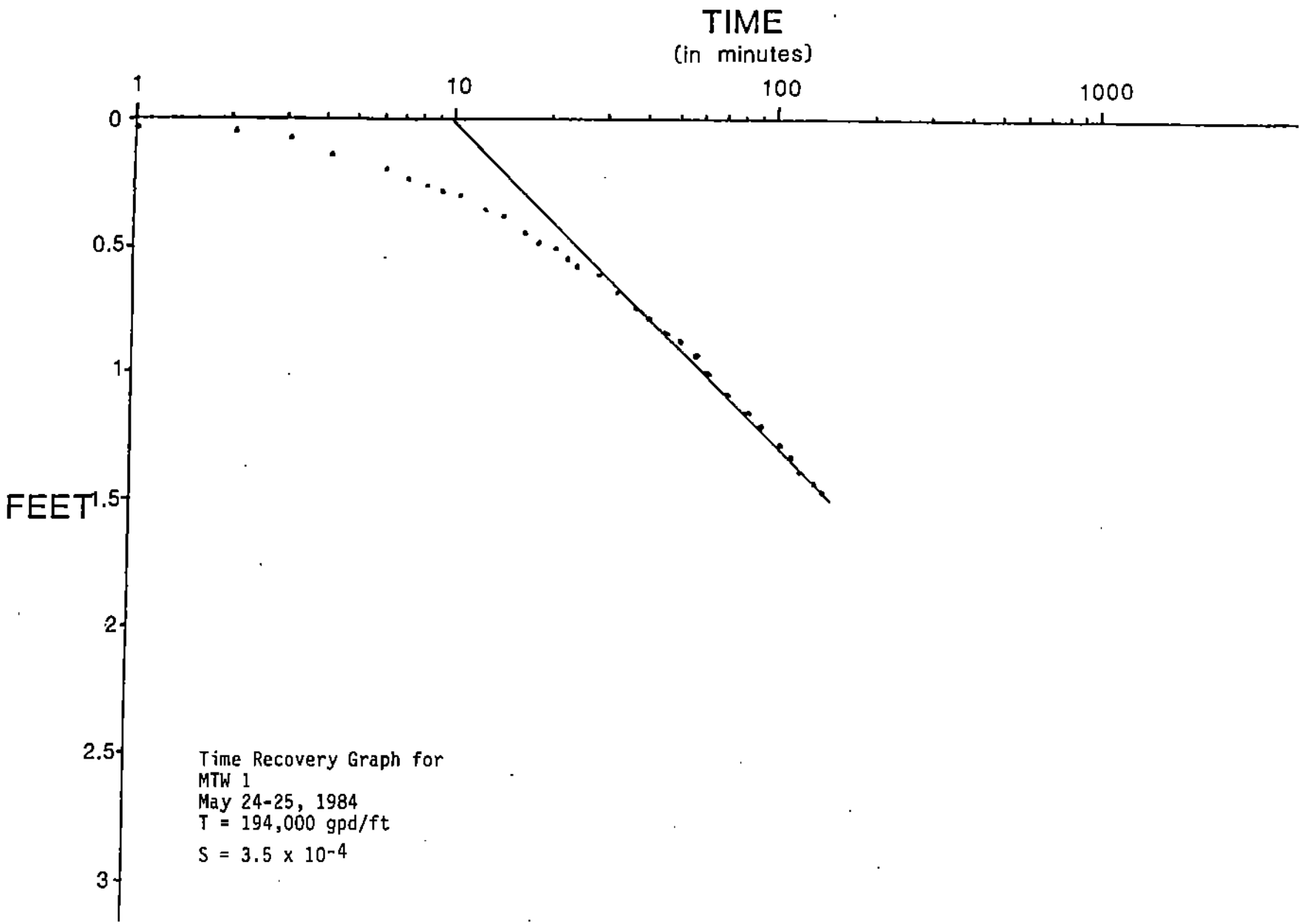
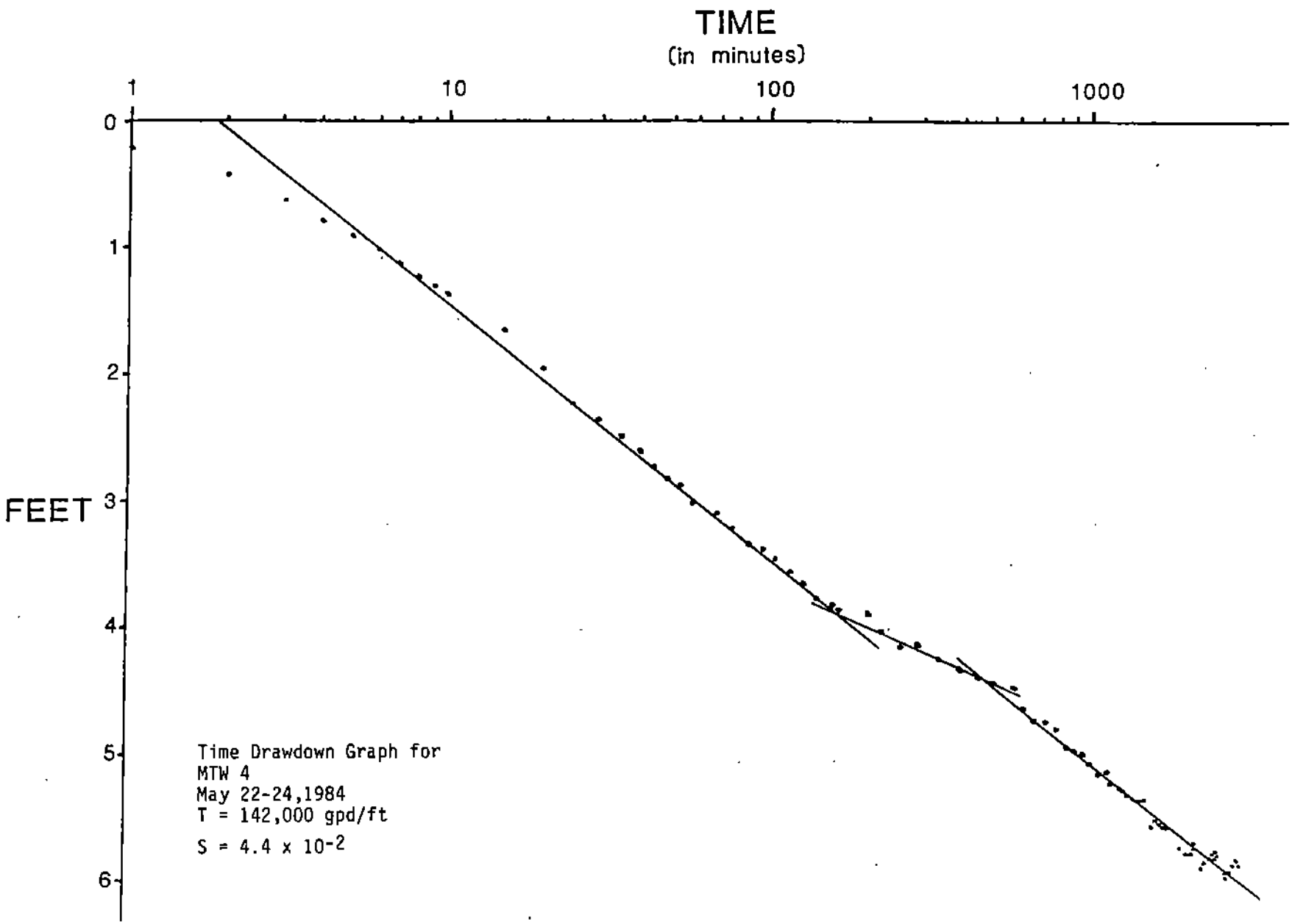
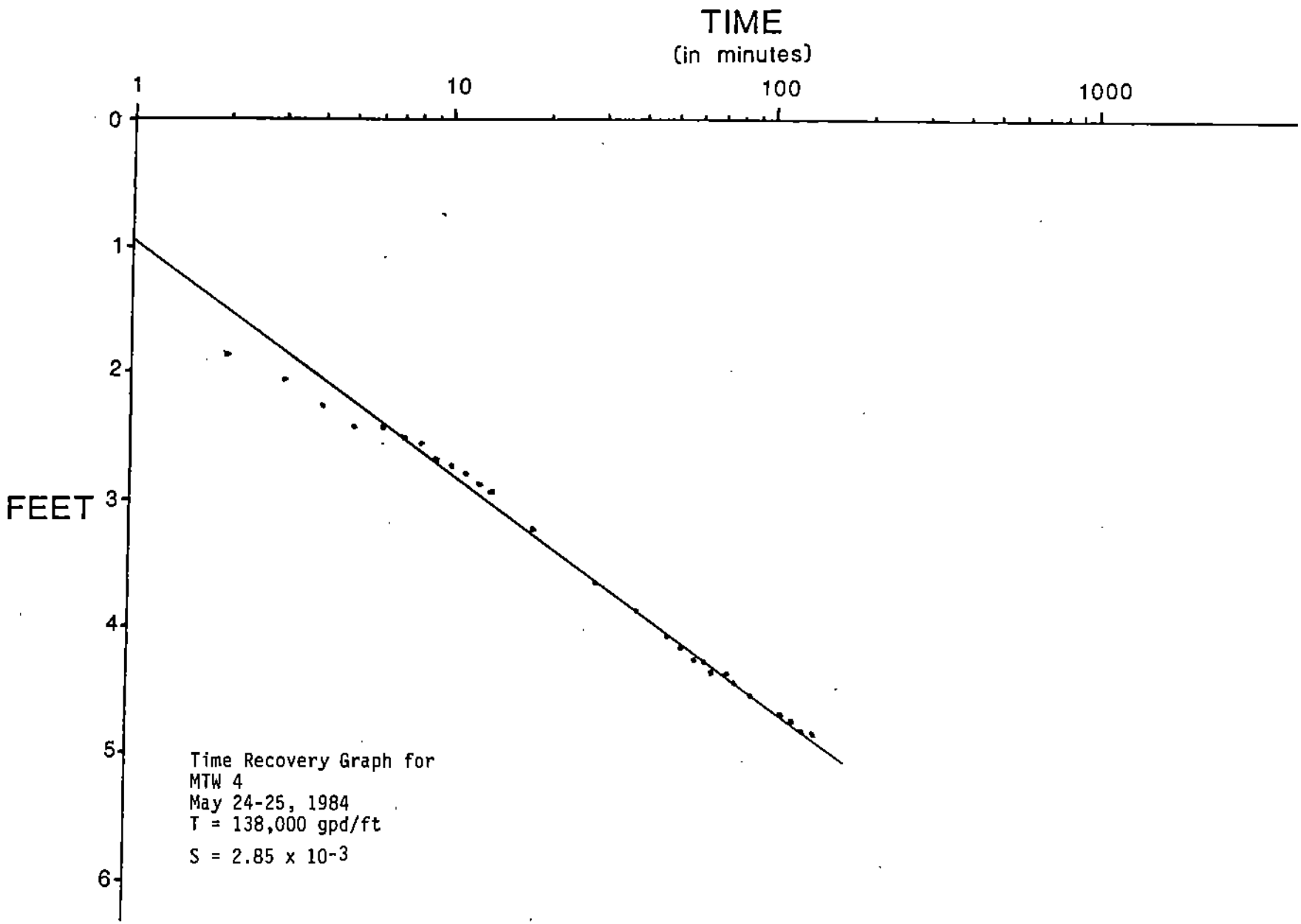
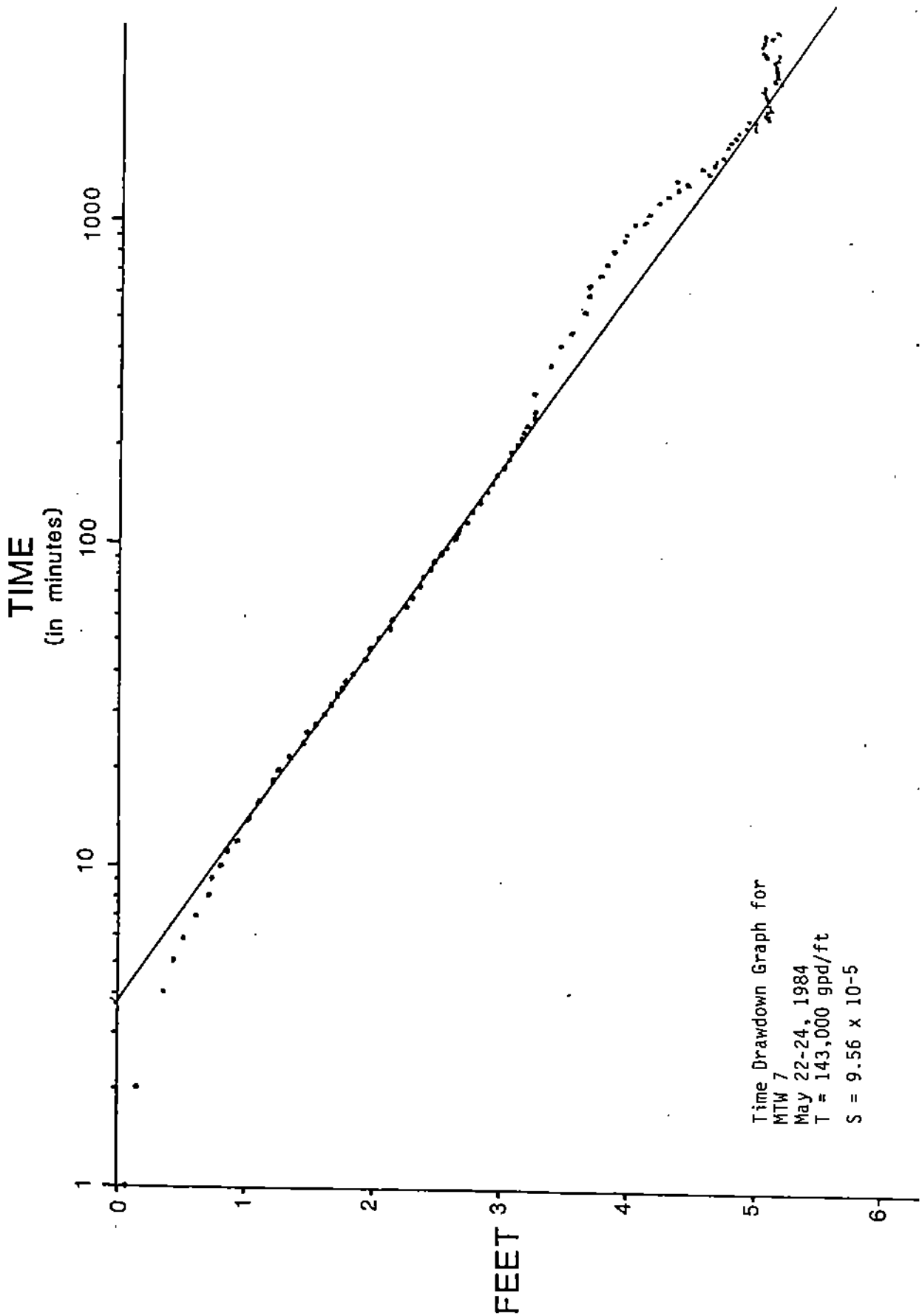
20
21
22
23
24
25
FEET
Time Recovery Graph for MPW 1
May 24-25 1984
T = 138,000 gpd/ft

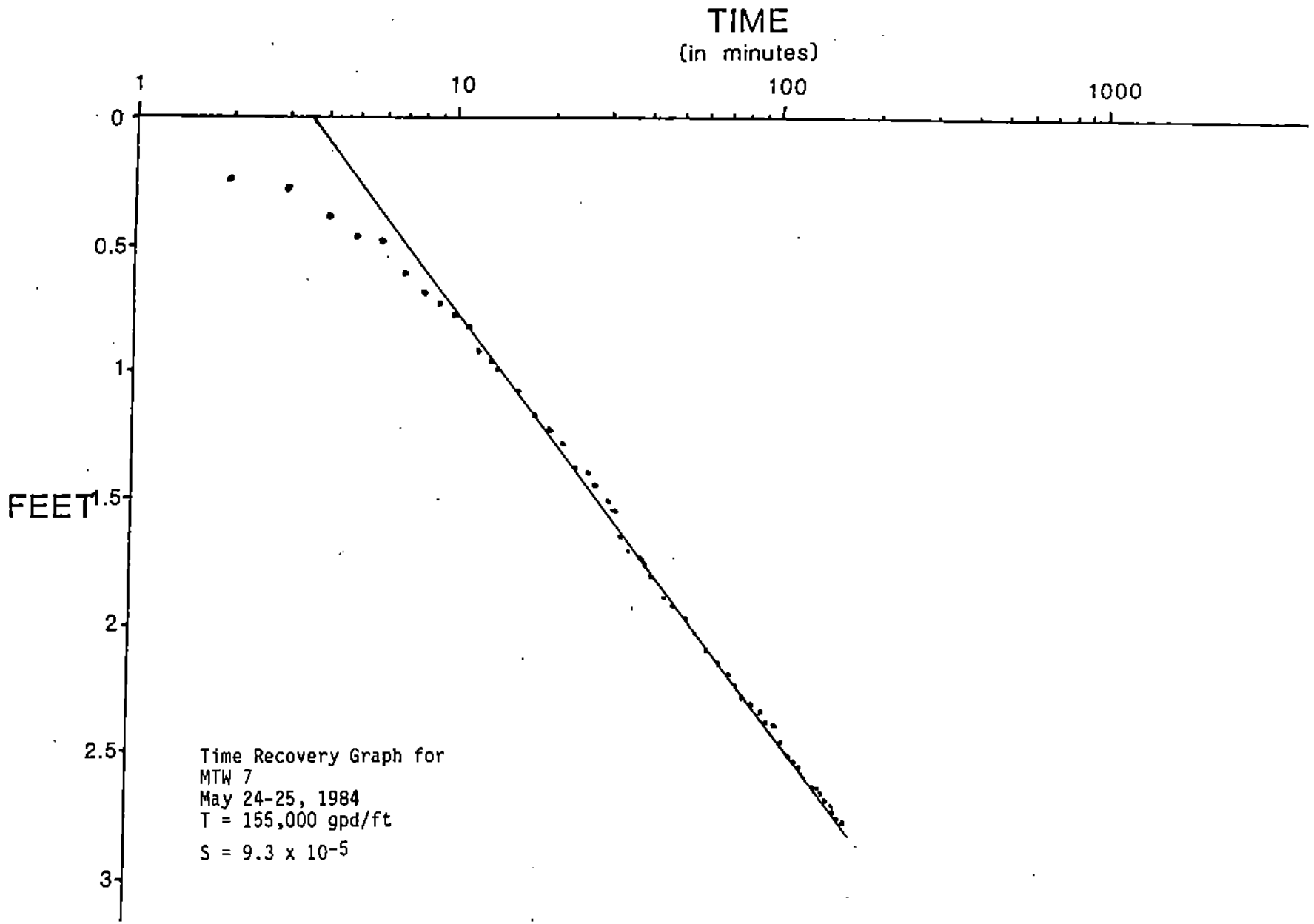

TIME
(in minutes)
1
10
100
1000
0
1
2
3
4
5
6
FEET
Time Drawdown Graph for
MTW 1
May 22-24, 1984
T = 143,000 gpd/ft
S = 1.2 x 10-4


TIME
(in minutes)
1
10
100
1000
0
0.5
1
1.5
2
2.5
3
FEET
Time Recovery Graph for
MTW 1
May 24-25, 1984
T = 194,000 gpd/ft
S = 3.5 x 10-4


TIME
(in minutes)
1
10
100
1000
0
1
2
3
4
5
6
FEET
Time Drawdown Graph for
MTW 4
May 22-24,1984
T = 142,000 gpd/ft
S = 4.4 x 10-2


TIME
(in minutes)
1
10
100
1000
0
1
2
3
4
5
6
FEET
Time Recovery Graph for
MTW 4
May 24-25, 1984
T = 138,000 gpd/ft
S = 2.85 x 10-3


TIME
(in minutes)
1
10
100
1000
0
1
2
3
4
5
6
FEET
Time Drawdown Graph for
MTW 7
May 22-24, 1984
T = 143,000 gpd/ft
S = 9.56 x 10-5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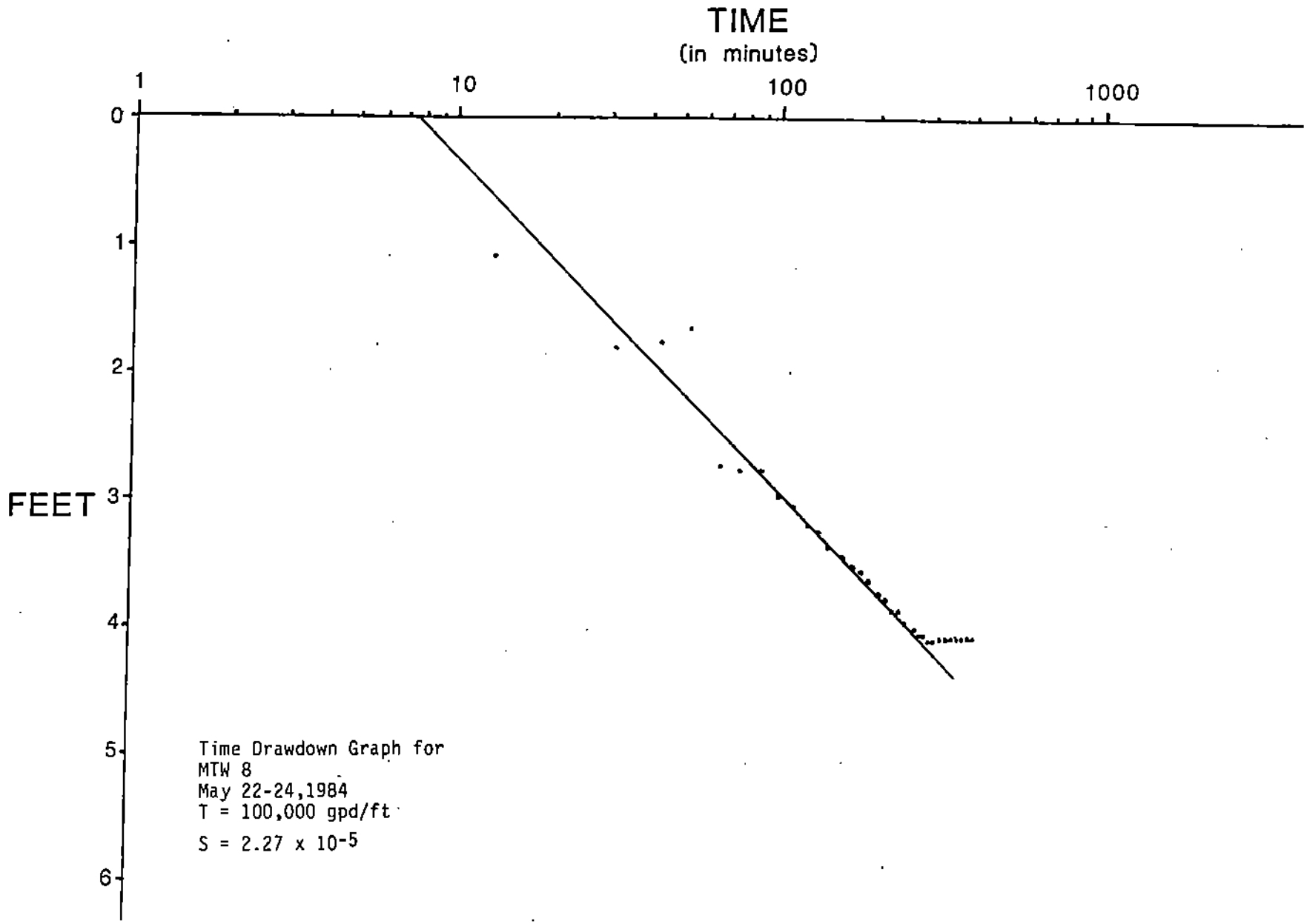
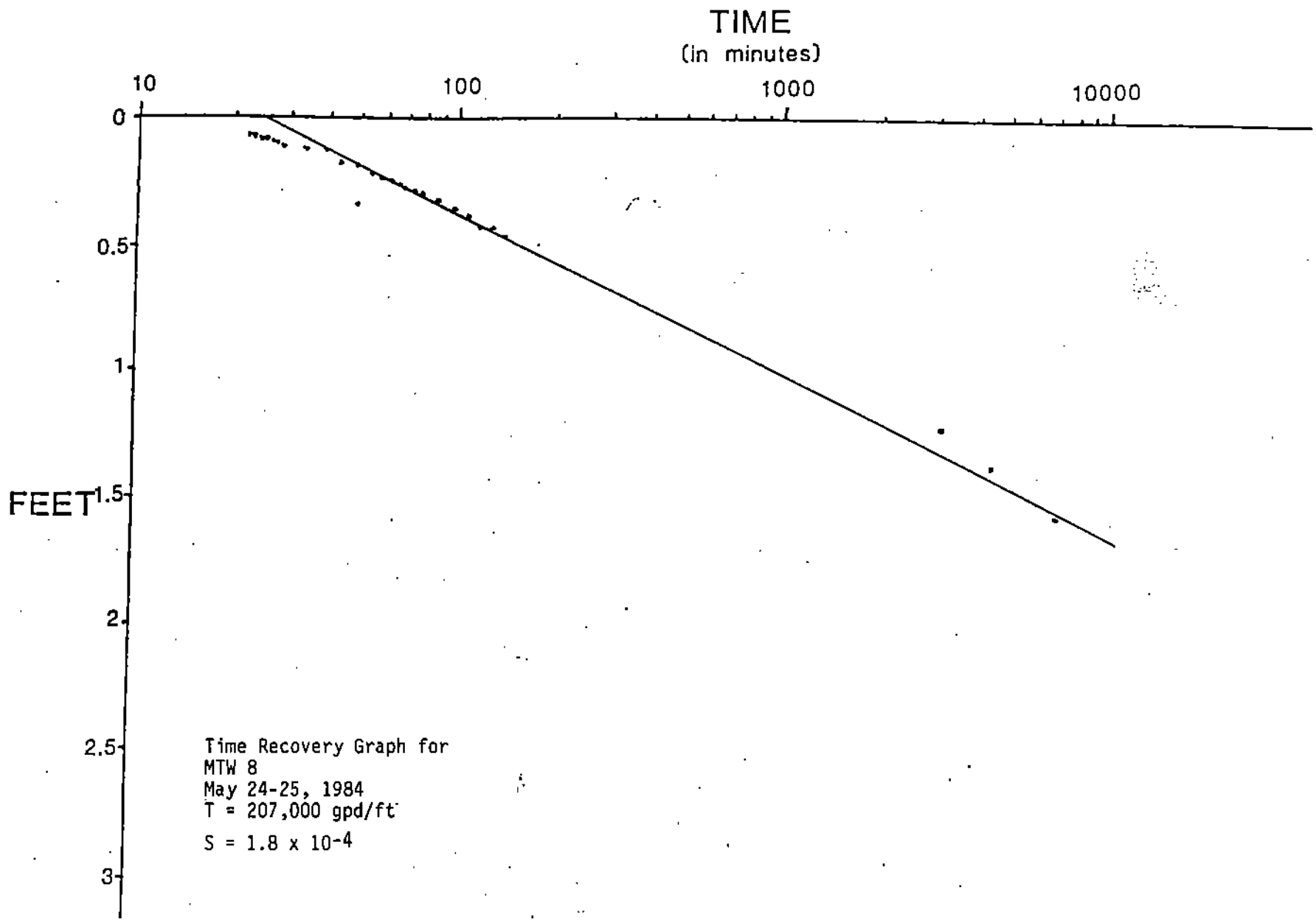
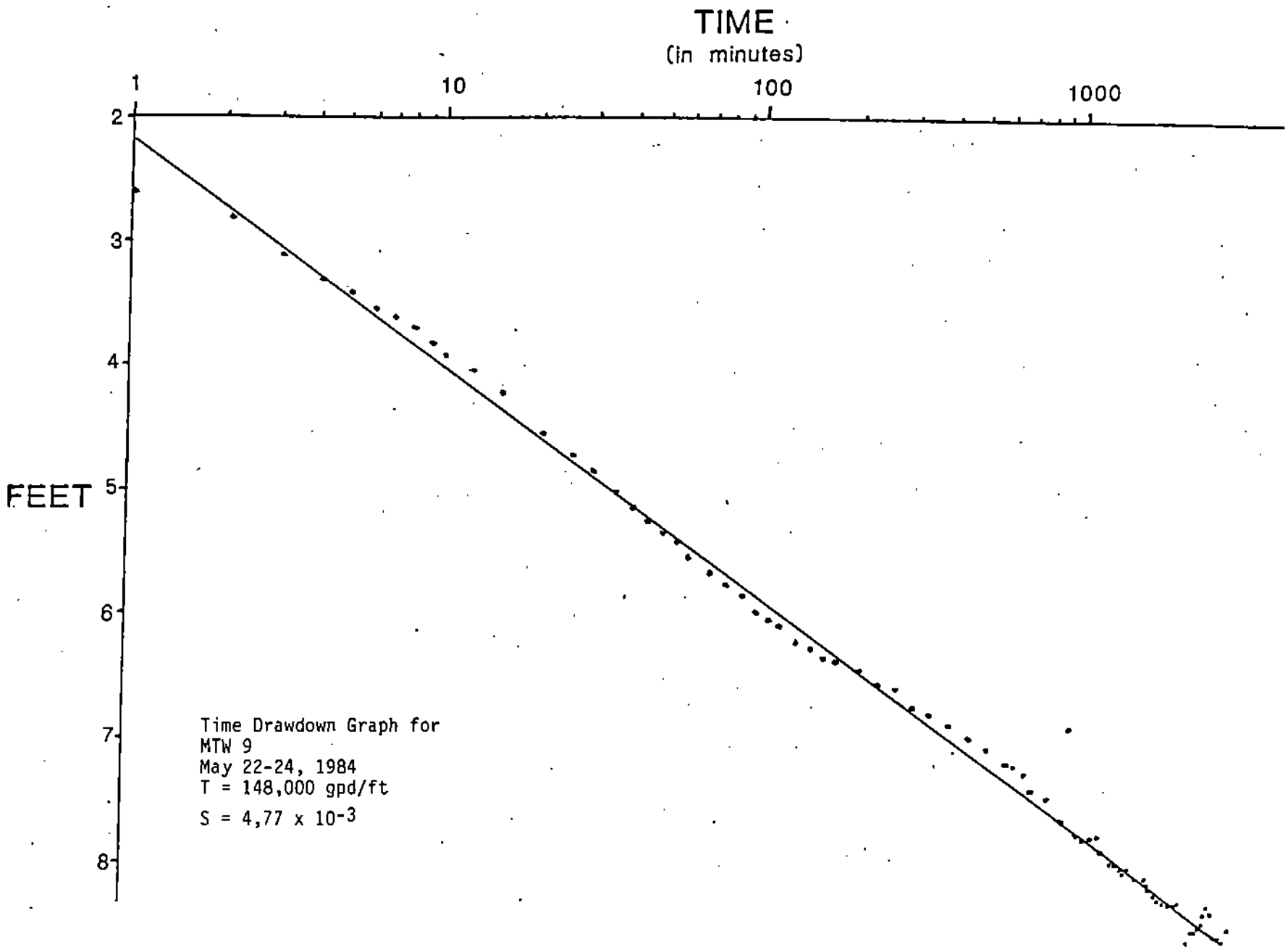
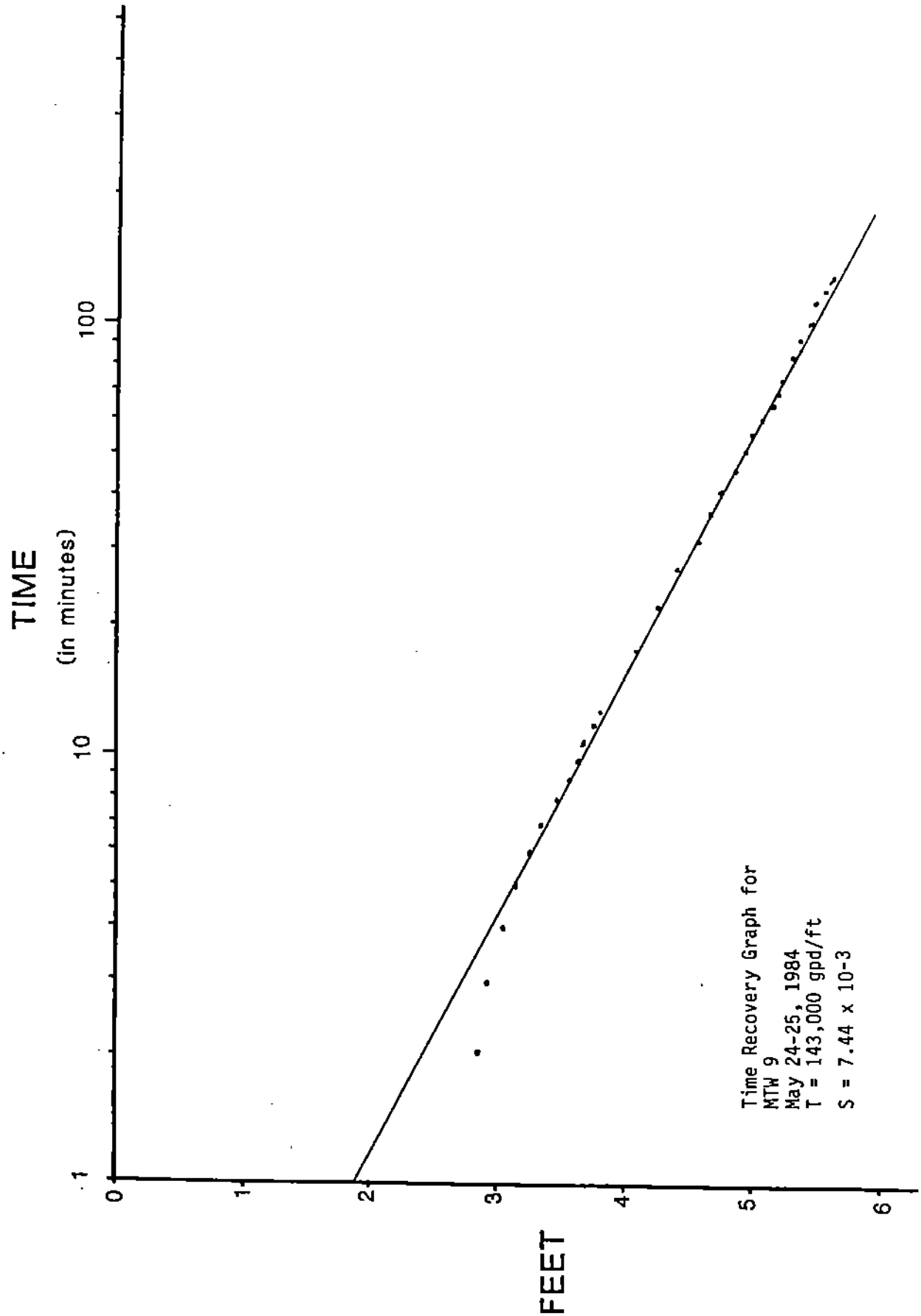
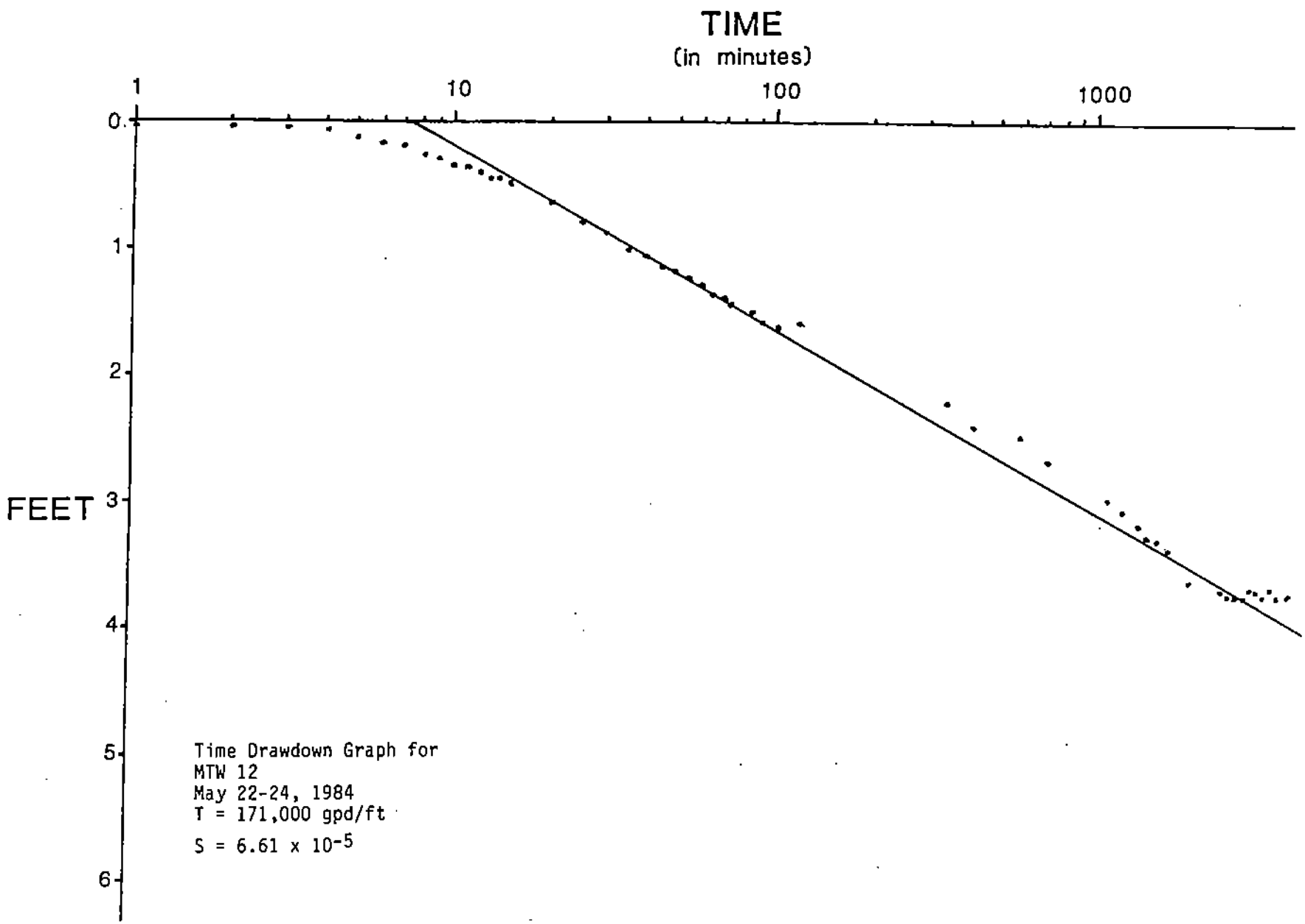
(in minutes)
1
10
100
1000
0
0.5
1
1.5
2
2.5
3
FEET
Time Recovery Graph for
MTW 7
May 24-25, 1984
T = 155,000 gpd/ft
S = 9.3 x 10-5

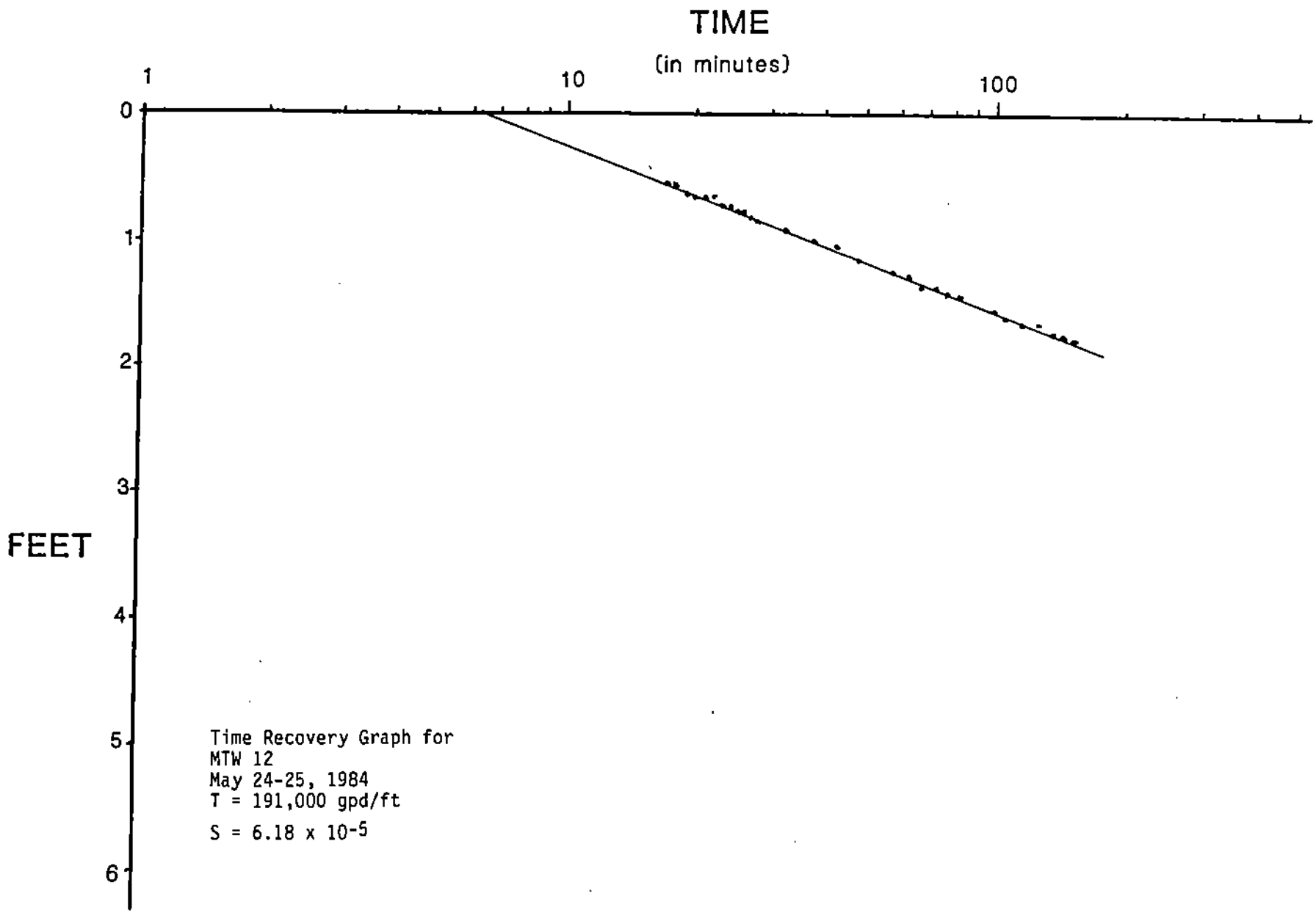

TIME
(in minutes)
1
10
100
1000
0
1
2
3
4
5
6
FEET
Time Drawdown Graph for
MTW 8
May 22-24,1984
T = 100,000 gpd/ft
S = 2.27 x 10-5

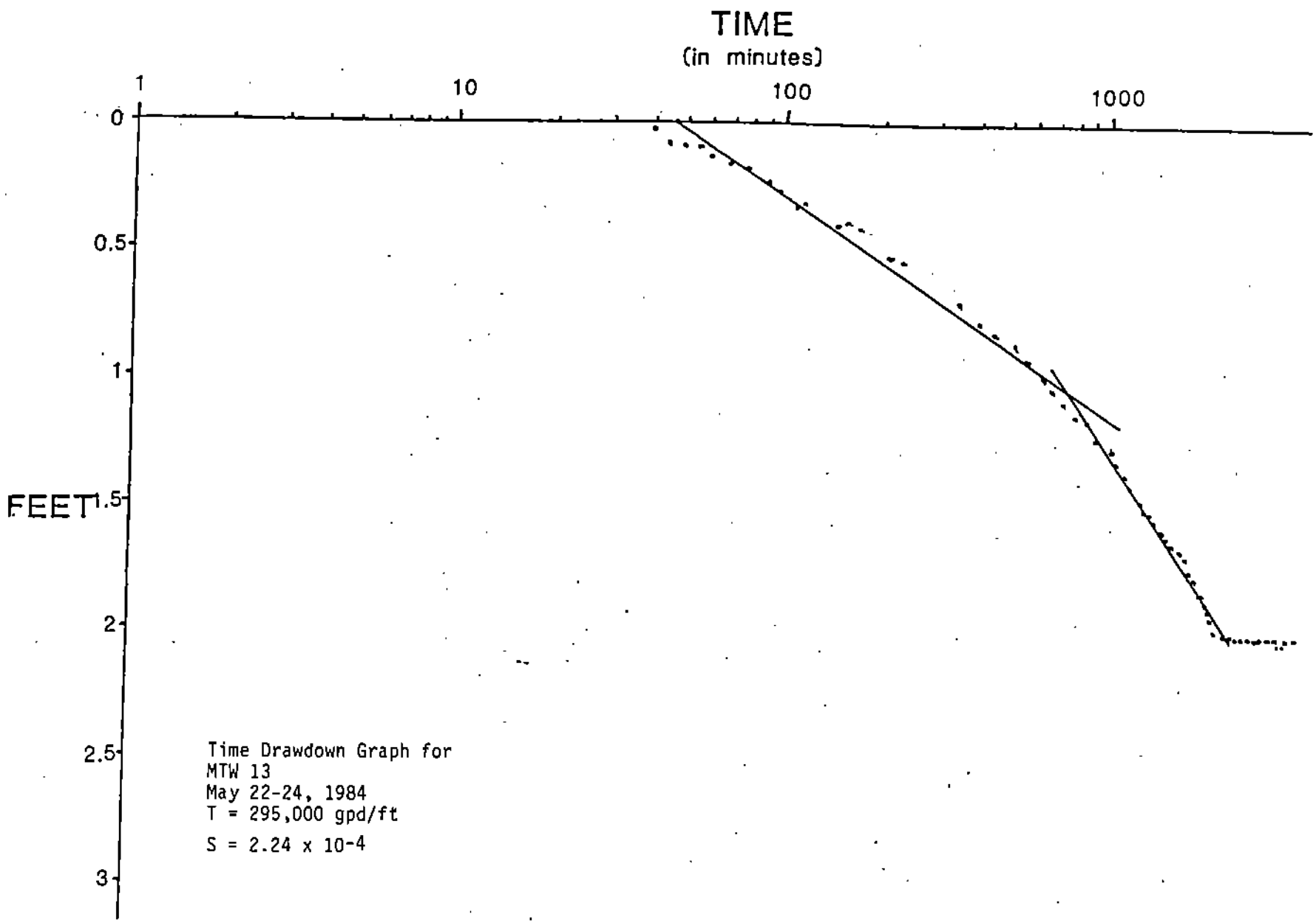

TIME
(in minutes)
10
100
1000
10000
0
0.5
1
1.5
2
2.5
3
FEET
Time Recovery Graph for
MTW 8
May 24-25, 1984
T = 207,000 gpd/ft
S = 1.8 x 10-4

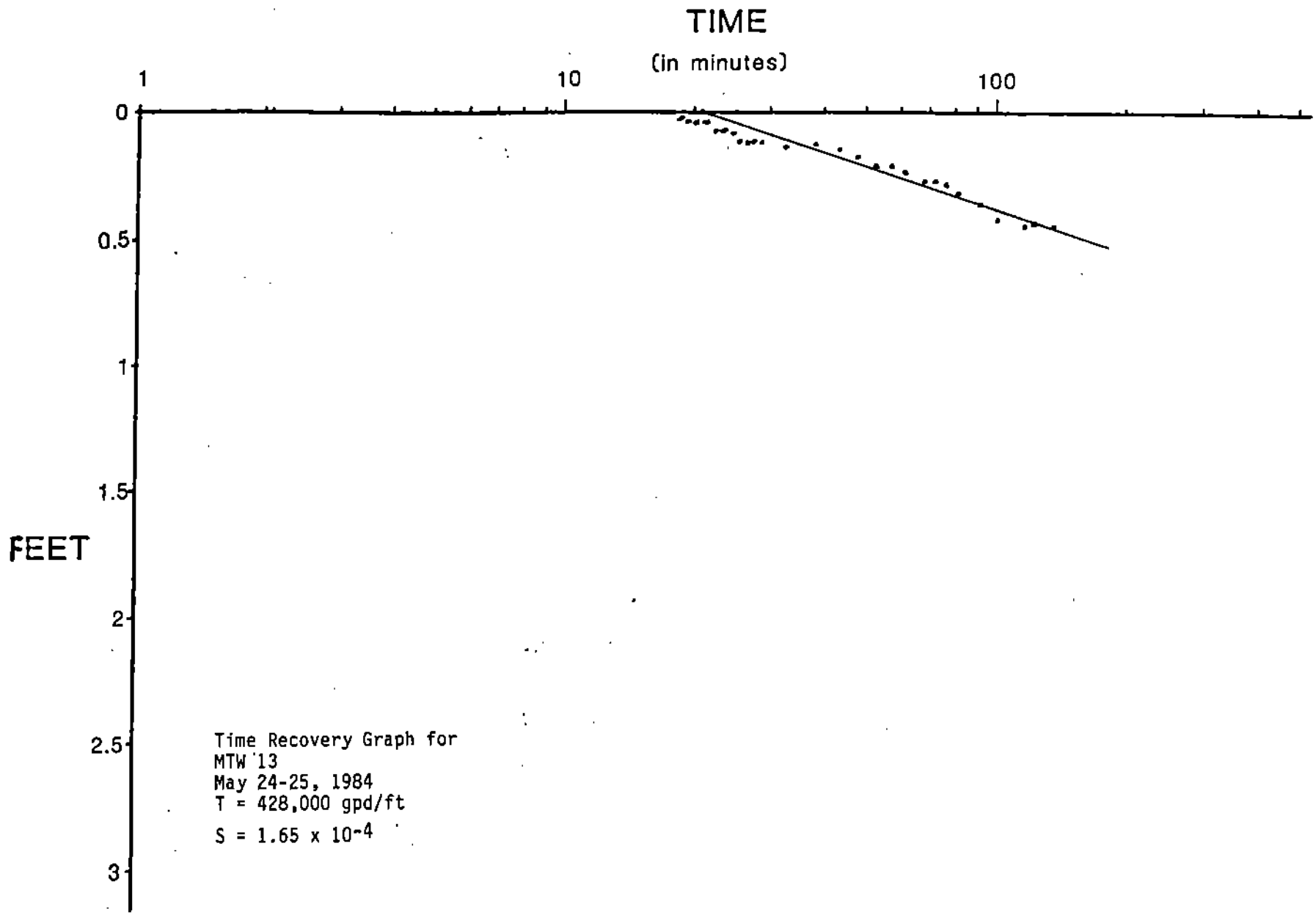

TIME
(in minutes)
1
10
100
1000
2
3
4
5
6
7
8
FEET
Time Drawdown Graph for
MTW 9
May 22-24, 1984
T = 148,000 gpd/ft
S = 4,77 x 10-3

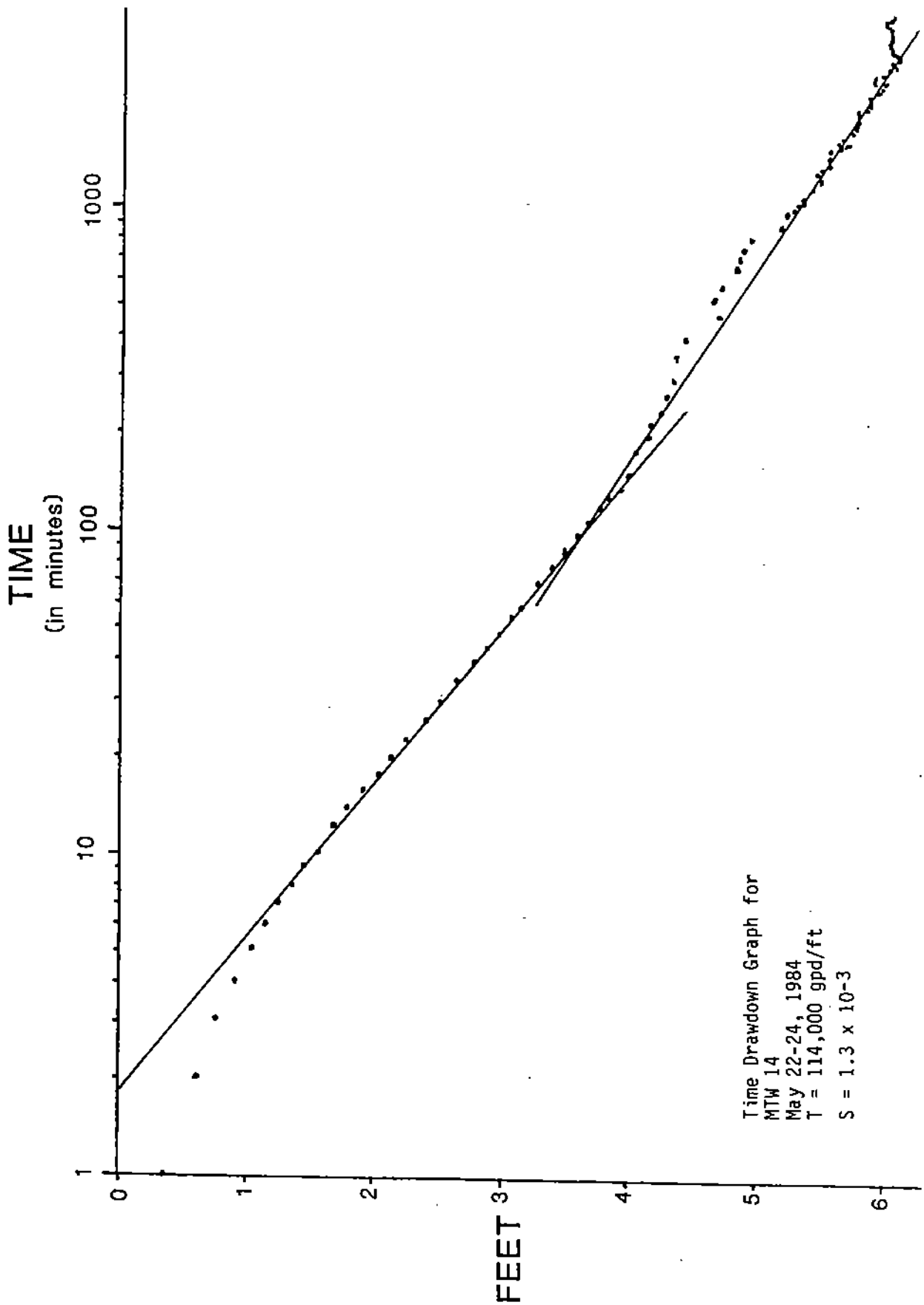

TIME
(in minutes)
.1
10
100
0
1
2
3
4
5
6
FEET
Time Recovery Graph for
MTW 9
May 24-25, 1984
T = 143,000 gpd/ft
S = 7.44 x 10-3

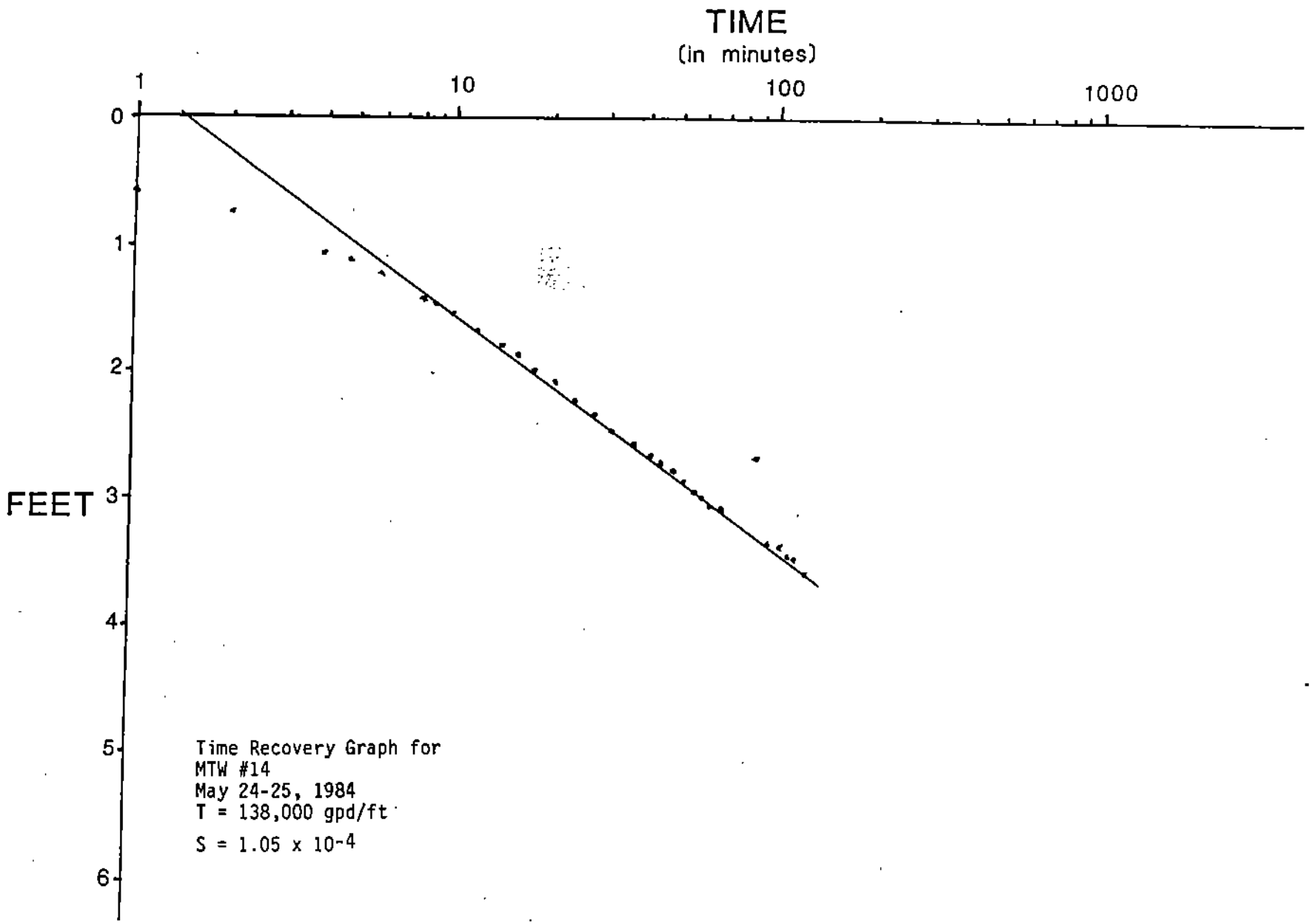

TIME
(in minutes)
1
10
100
1000
0
1
2
3
4
5
6
FEET
Time Drawdown Graph for
MTW 12
May 22-24, 1984
T = 171,000 gpd/ft
S = 6.61 x 10-5


TIME
(in minutes)
1
10
100
0
1
2
3
4
5
6
FEET
Time Recovery Graph for
MTW 12
May 24-25, 1984
T = 191,000 gpd/ft
S = 6.18 x 10-5


TIME
(in minutes)
1
10
100
1000
0
0.5
1
1.5
2
2.5
3
FEET
Time Drawdown Graph for
MTW 13
May 22-24, 1984
T = 295,000 gpd/ft
S = 2.24 x 10-4


TIME
(in minutes)
1
10
100
0
0.5
1
1.5
2
2.5
3
FEET
Time Recovery Graph for
MTW 13
May 24-25, 1984
T = 428,000 gpd/ft
S = 1.65 x 10-4


TIME
(in minutes)
1
10
100
1000
0
1
2
3
4
5
6
FEET
Time Drawdown Graph for
MTW 14
May 22-24, 1984
T = 114,000 gpd/ft
S = 1.3 x 10-3


TIME
(in minutes)
1
10
100
1000
0
1
2
3
4
5
6
FEET
Time Recovery Graph for
MTW #14
May 24-25, 1984
T = 138,000 gpd/ft
S = 1.05 x 10-4

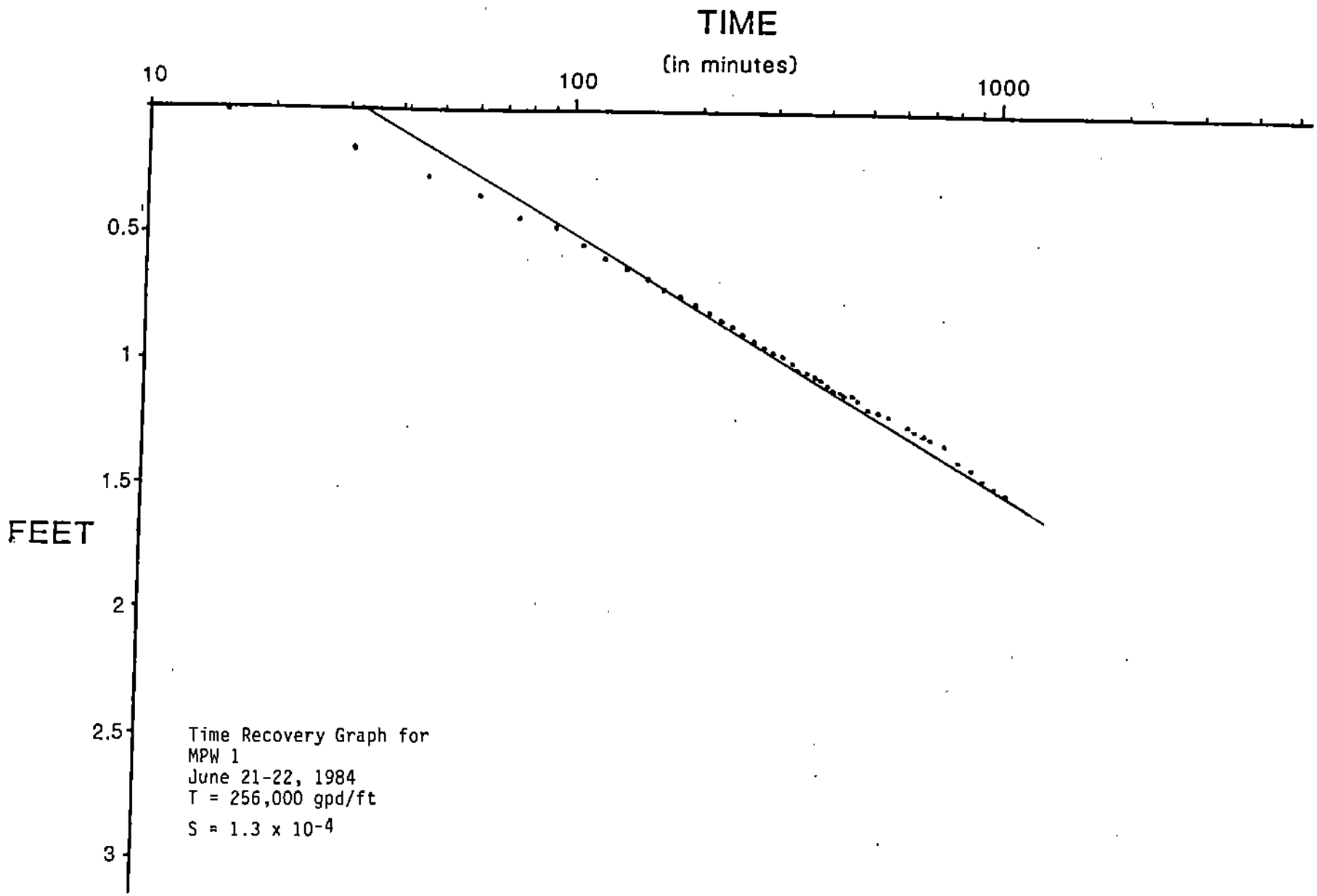
APPENDIX B

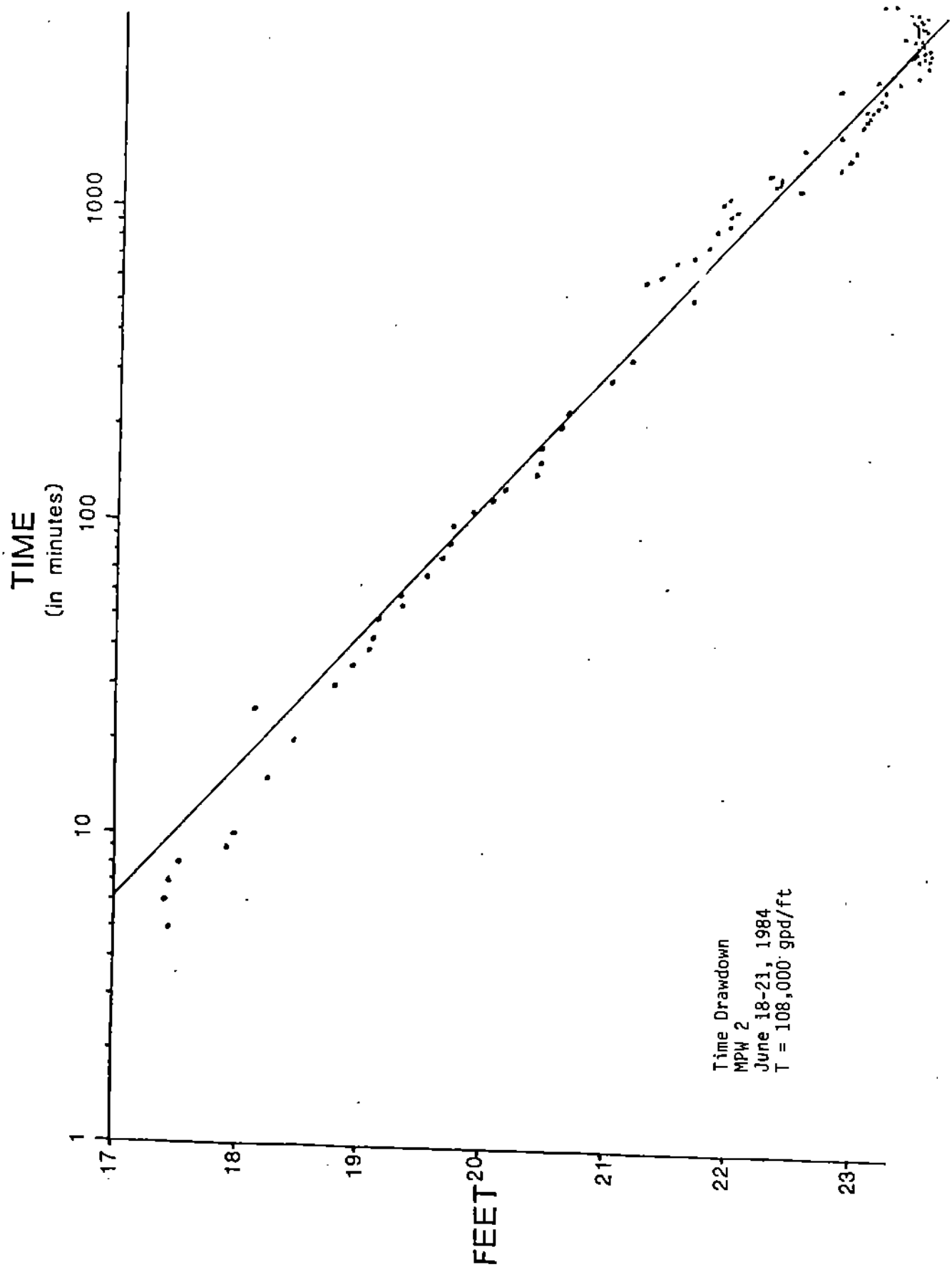
Time/Drawdown and Time/Recovery Graphs of

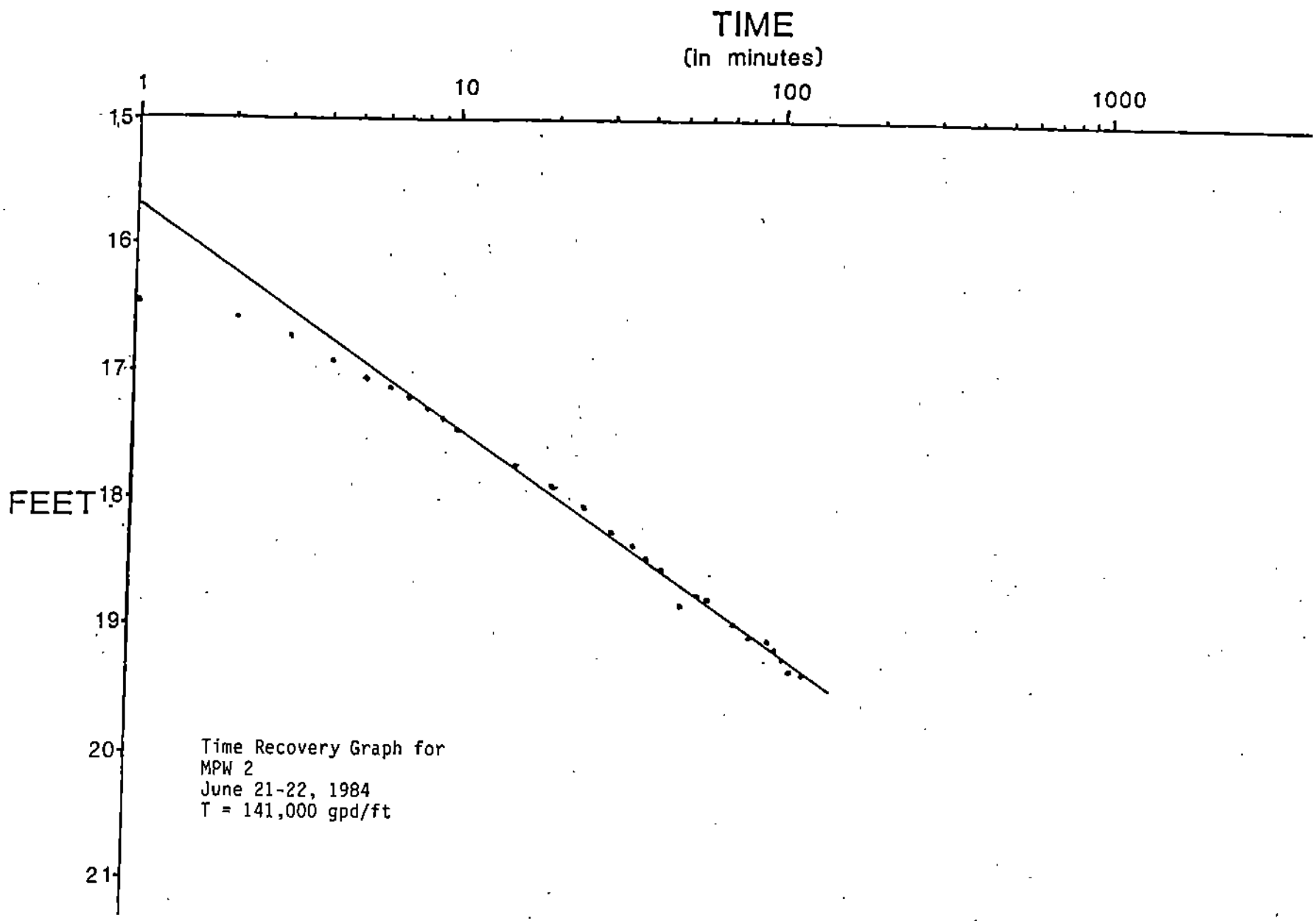
Observation Wells in New Proposed

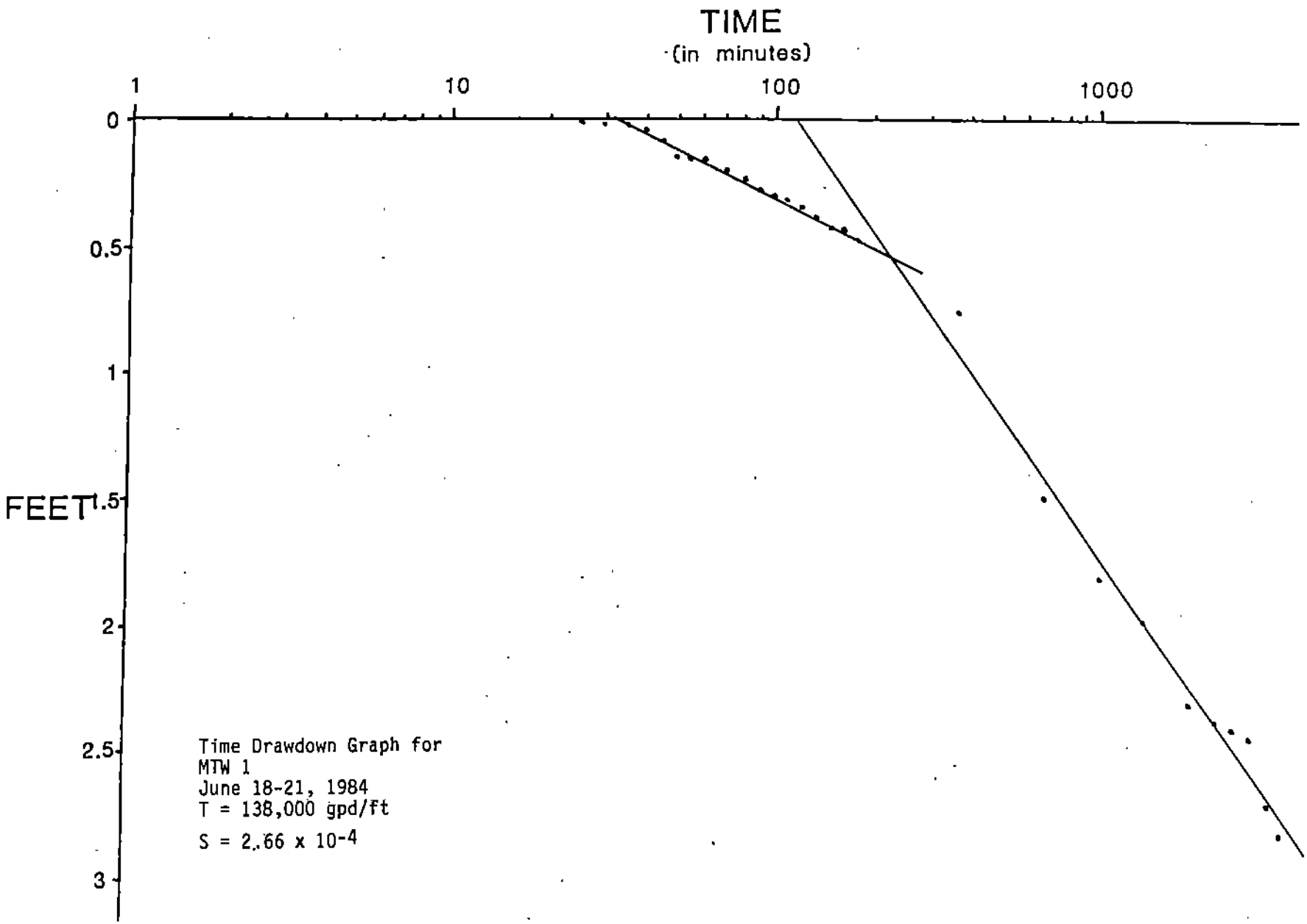
Marion Well Field

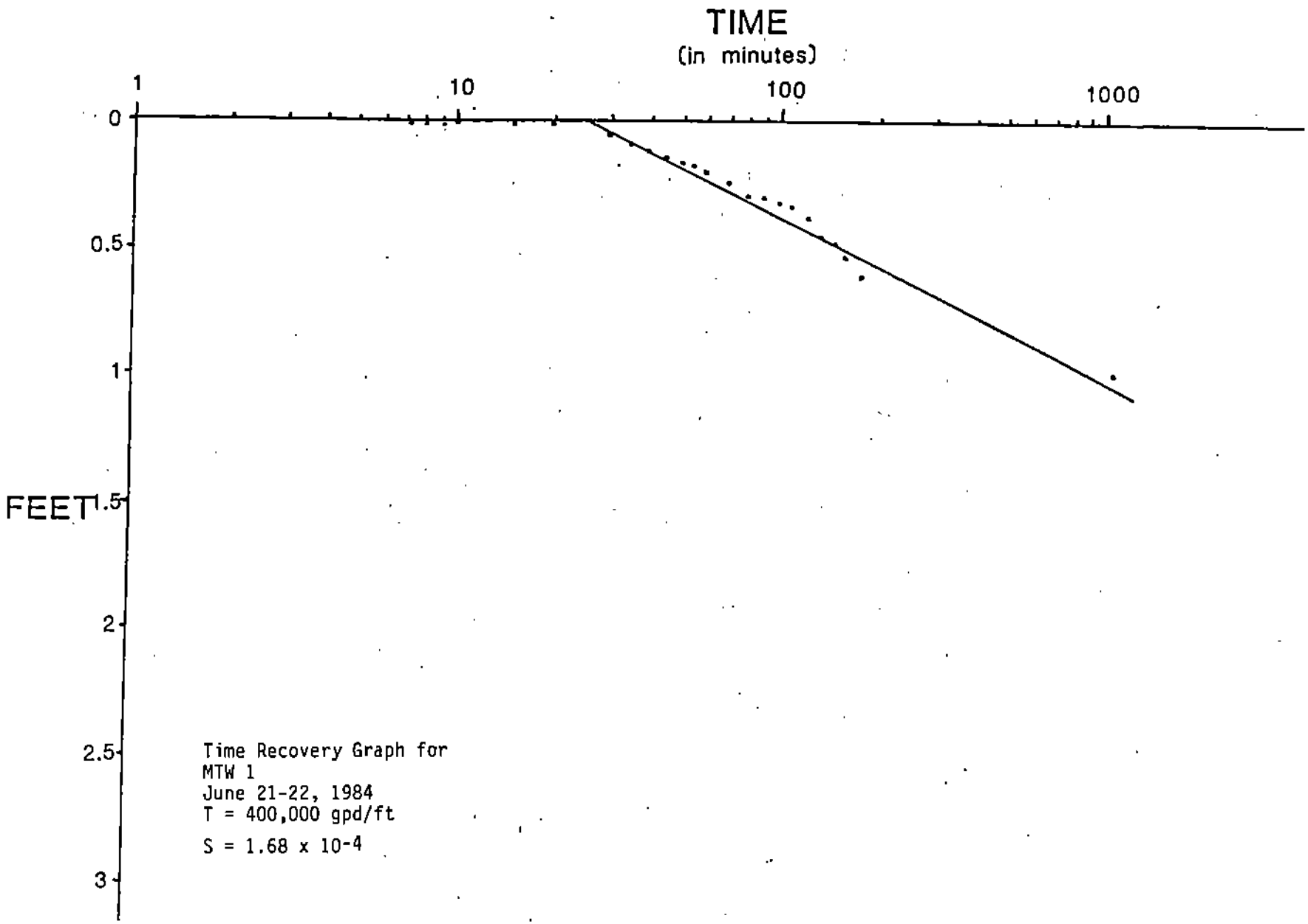
(Pumping of MPW-2)

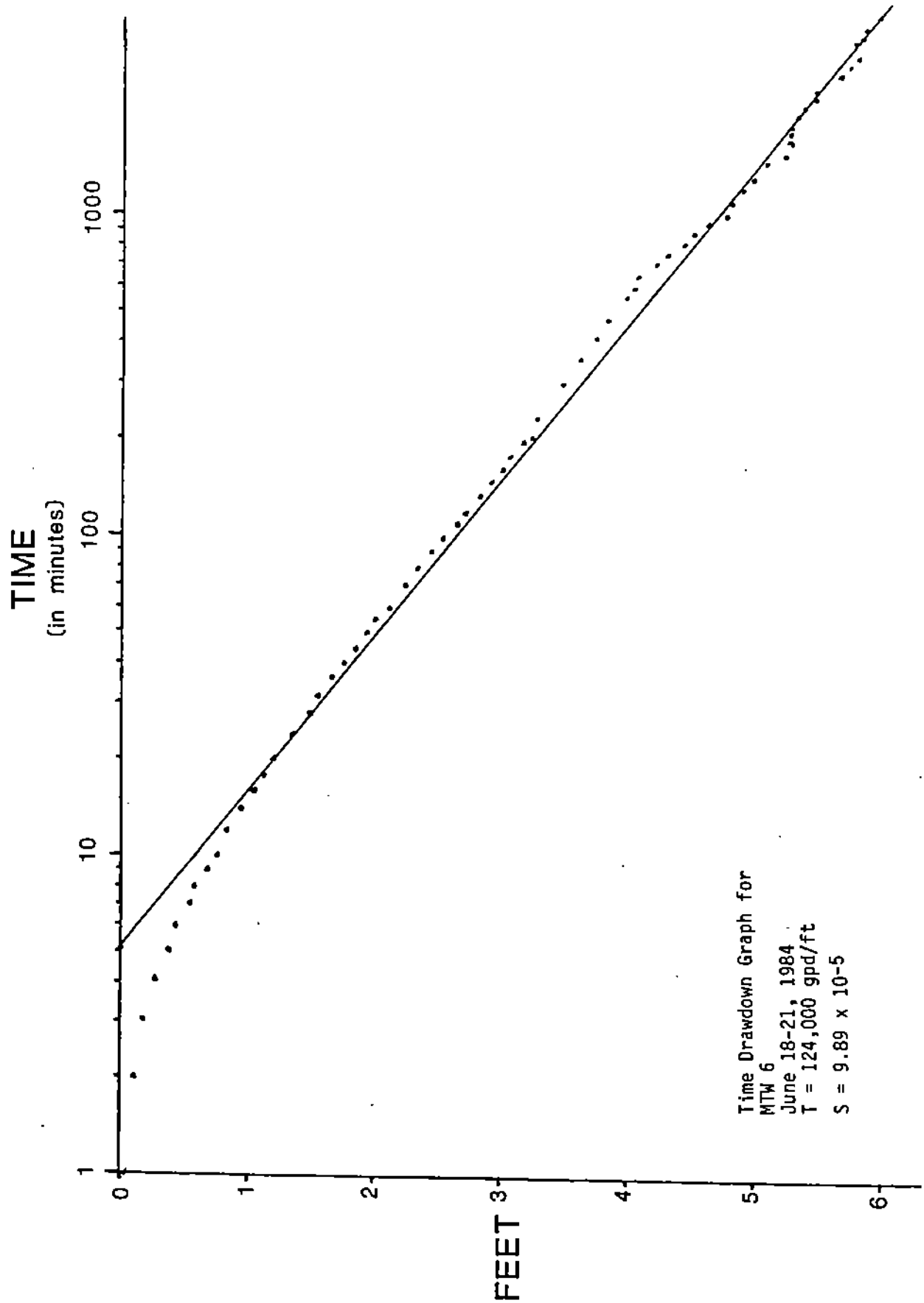

TIME
(in minutes)
10
100
1000
0.5
1
1.5
2
2.5
3
FEET
Time Recovery Graph for
MPW 1
June 21-22, 1984
T = 256,000 gpd/ft
S = 1.3 x 10-4


TIME
(in minutes)
1
10
100
1000
17
18
19
20
21
22
23
FEET
Time Drawdown
MPW 2
June 18-21, 1984
T = 108,000 gpd/ft


TIME
(In minutes)
1
10
100
1000
FEET
15
16
17
18
19
20
21
Time Recovery Graph for
MPW 2
June 21-22, 1984
T = 141,000 gpd/ft


TIME
(in minutes)
1
10
100
1000
0
0.5
1
1.5
2
2.5
3
FEET
Time Drawdown Graph for
MTW 1
June 18-21, 1984
T = 138,000 gpd/ft
S = 2.66 x 10-4


TIME
(in minutes)
1
10
100
1000
0
0.5
1
1.5
2
2.5
3
FEET
Time Recovery Graph for
MTW 1
June 21-22, 1984
T = 400,000 gpd/ft
S = 1.68 x 10-4


TIME
(in minutes)
1
10
100
1000
0
1
2
3
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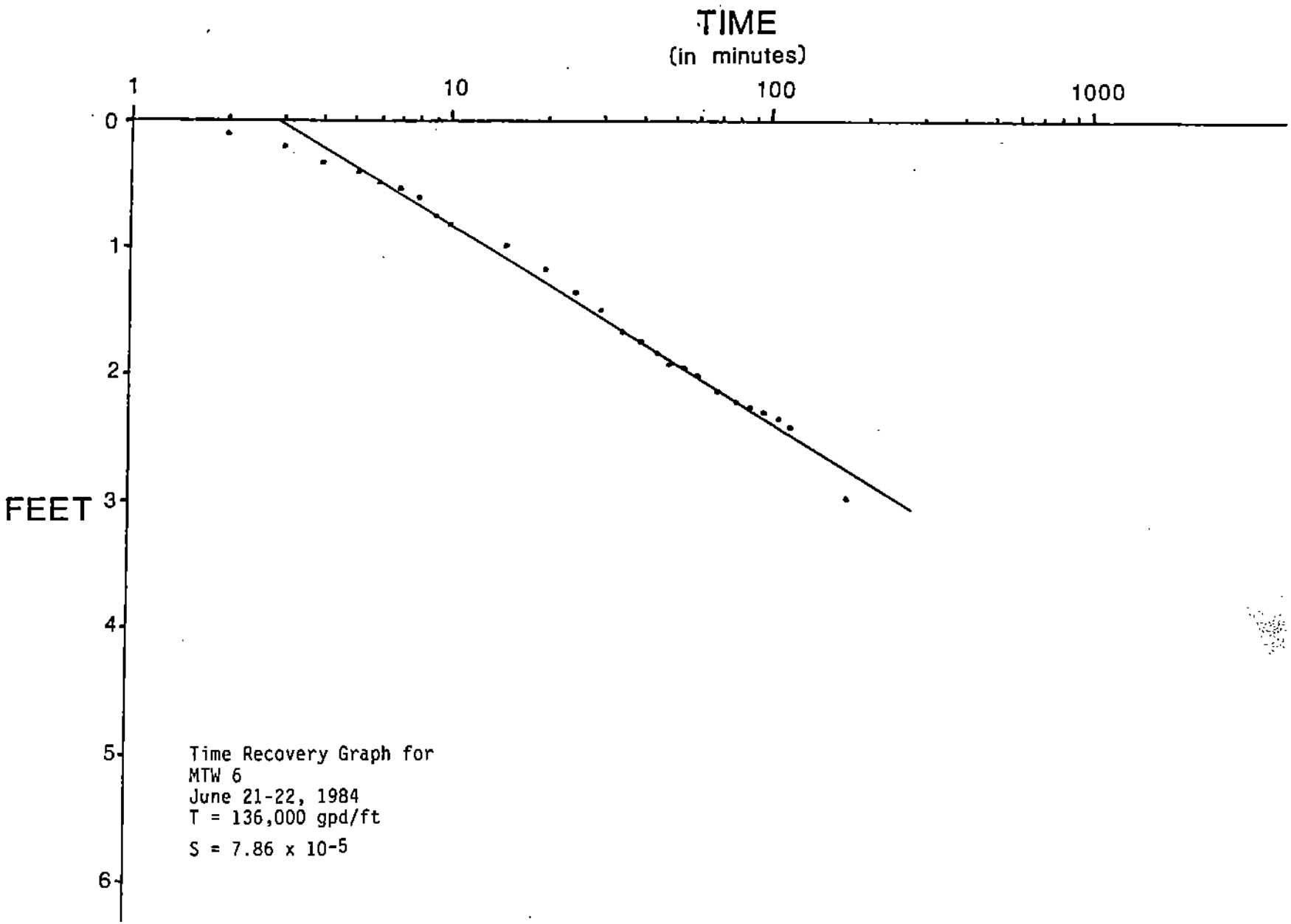
6
FEET
Time Drawdown Graph for
MTW 6
June 18-21, 1984
T = 124,000 gpd/ft
S = 9.89 x 10-5


TIME
(in minutes)
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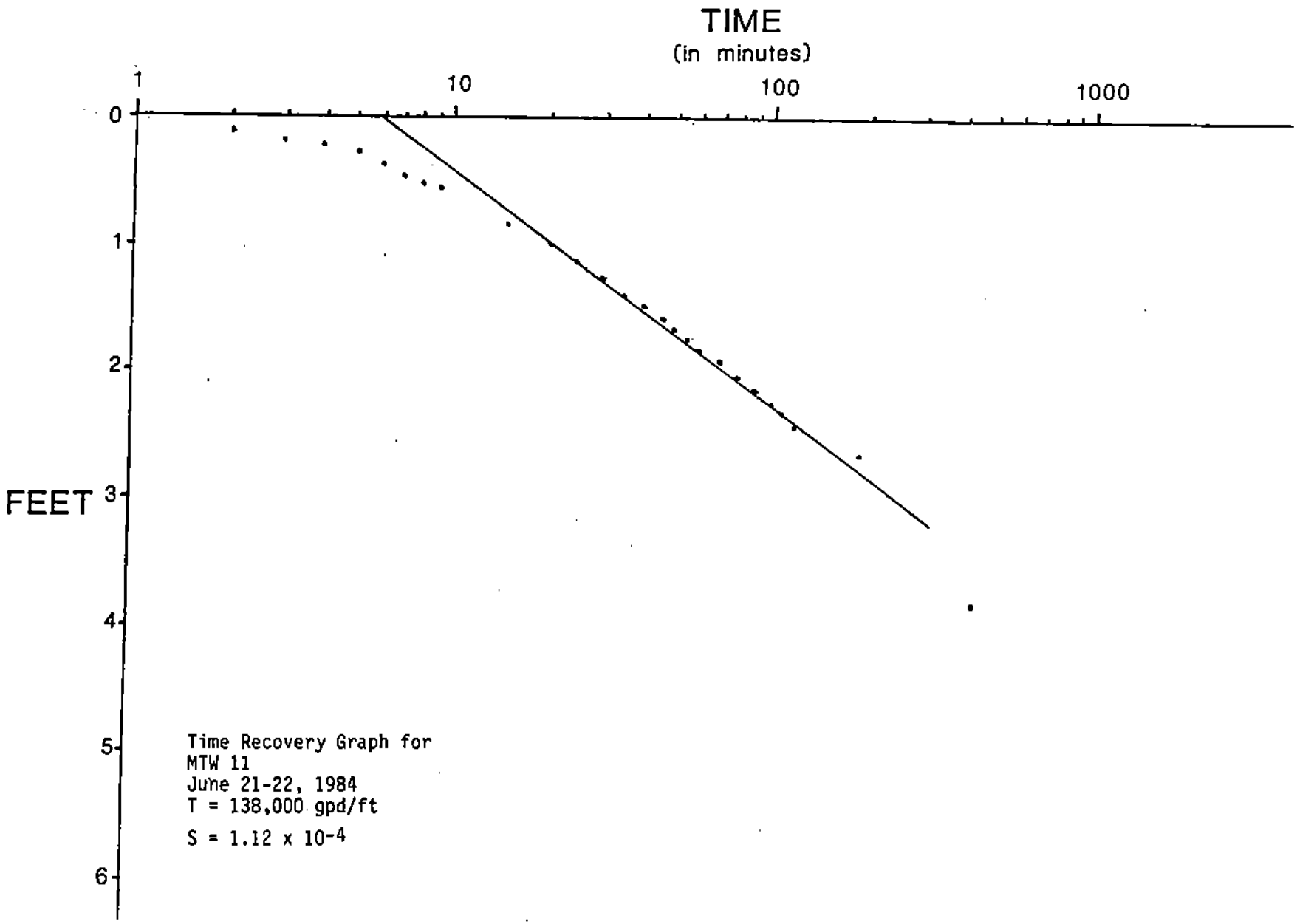
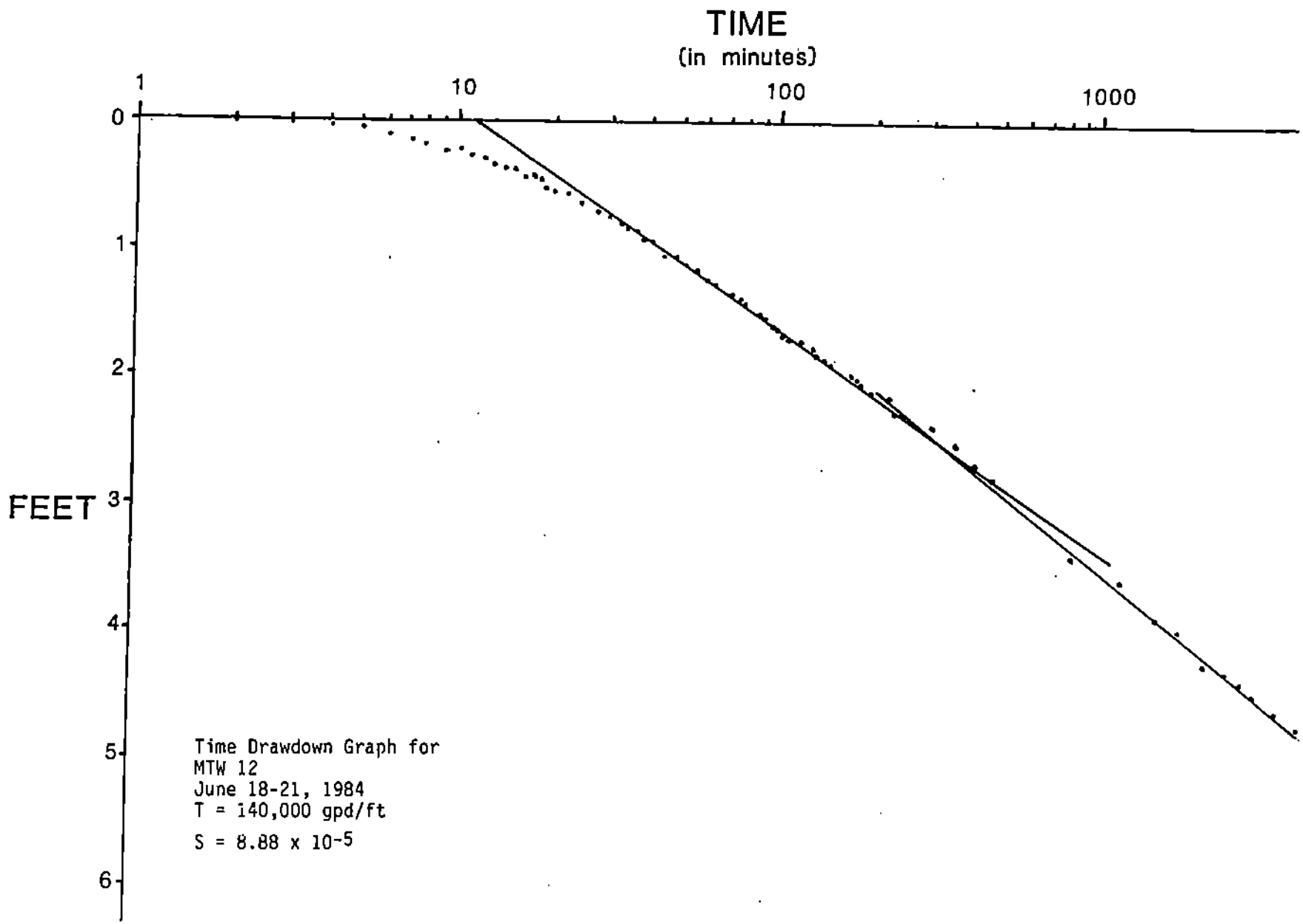
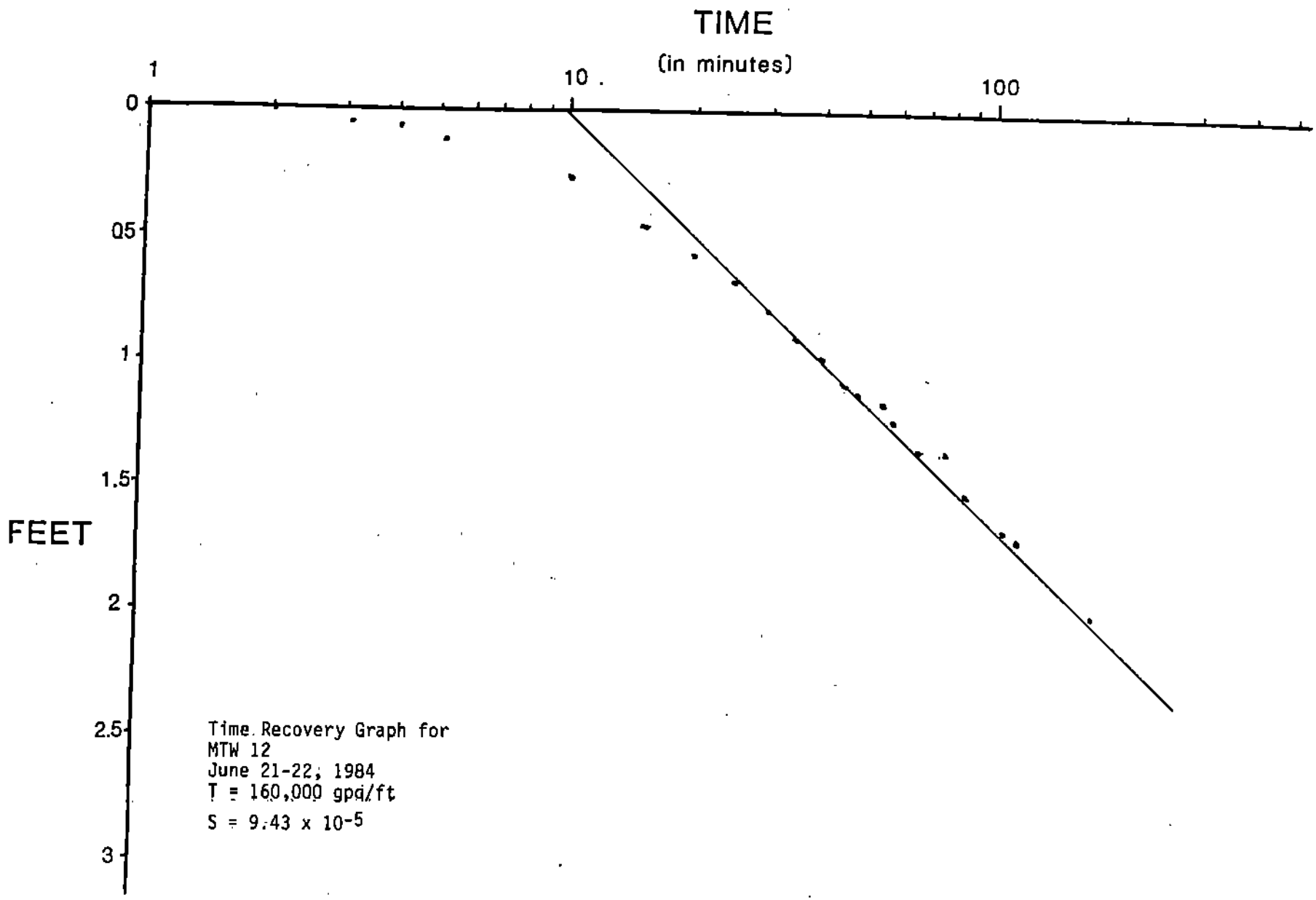
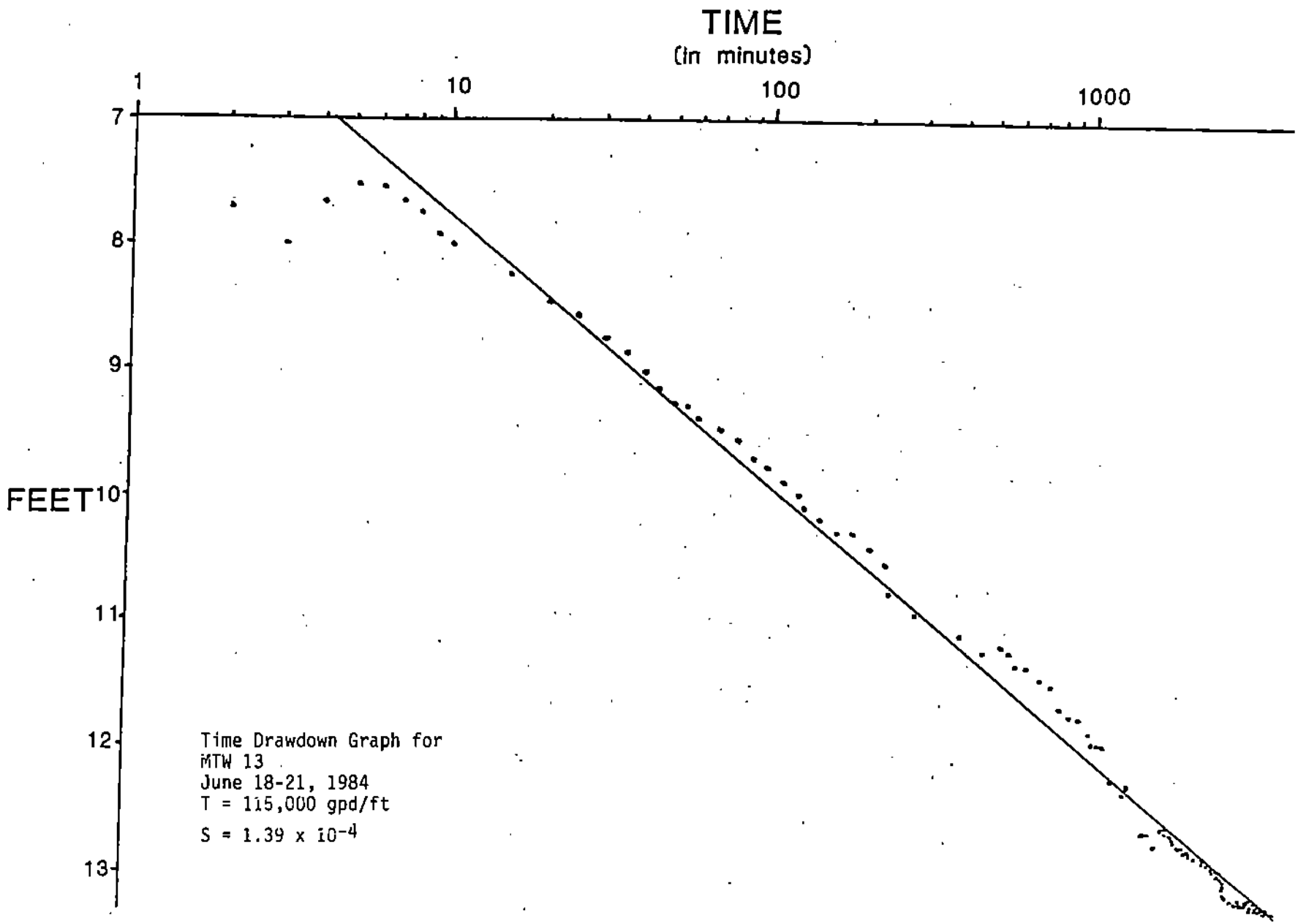
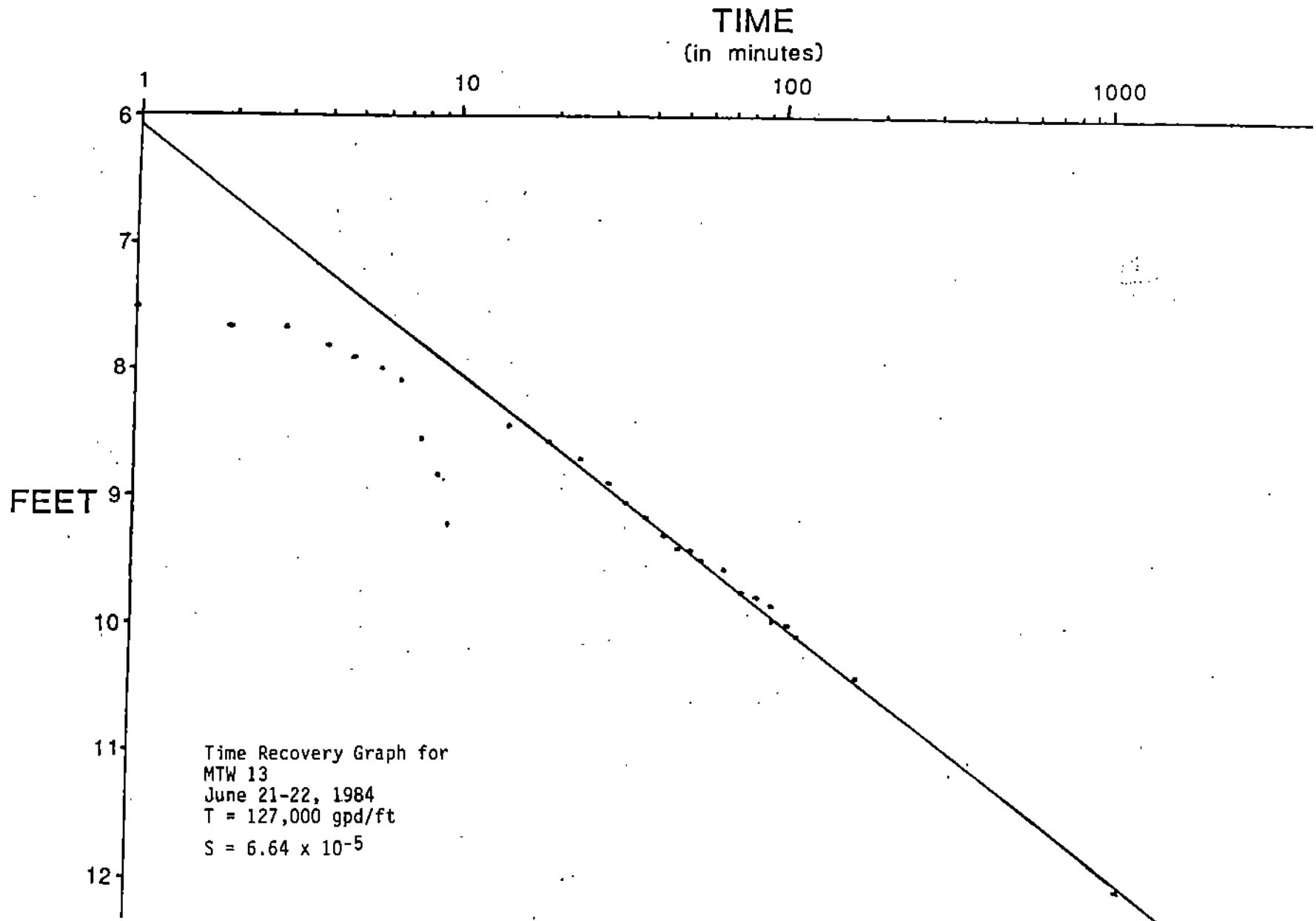
1
2
FEET 3
4
5
6
Time Recovery Graph for
MTW 6
June 21-22, 1984
T = 136,000 gpd/ft
S = 7.86 x 10-5


TIME
(in minutes)
1
10
100
1000
0
1
2
3
4
5
6
FEET
Time Recovery Graph for
MTW 11
June 21-22, 1984
T = 138,000 gpd/ft
S = 1.12 x 10-4


TIME
(in minutes)
1
10
100
1000
0
1
2
3
4
5
6
FEET
Time Drawdown Graph for
MTW 12
June 18-21, 1984
T = 140,000 gpd/ft
S = 8.88 x 10-5


TIME
(in minutes)
1
10
100
0
05
1
1.5
2
2.5
3
FEET
Time Recovery Graph for
MTW 12
June 21-22, 1984
T = 160,000 gpd/ft
S = 9.43 x 10-5


TIME
(in minutes)
1
10
100
1000
7
8
9
10
11
12
13
FEET
Time Drawdown Graph for
MTW 13
June 18-21, 1984
T = 115,000 gpd/ft
S = 1.39 x 10-4


TIME
(in minutes)
1
10
100
1000
6
7
8
9
10
11
12
FEET
Time Recovery Graph for
MTW 13
June 21-22, 1984
T = 127,000 gpd/ft
S = 6.64 x 10-5