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ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MISS F/G 13/2
INSTRUMENTATION OBSERVATIONS FROM THE U-FRAME LOCK OF THE ARKAN--ETC(U)
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INSTRUMENTATION OBSERVATIONS FROM THE U-FRAME LOCK OF THE ARKANSAS RIVER LOCK AND DAM 5.

by

10 Roy E. Leach

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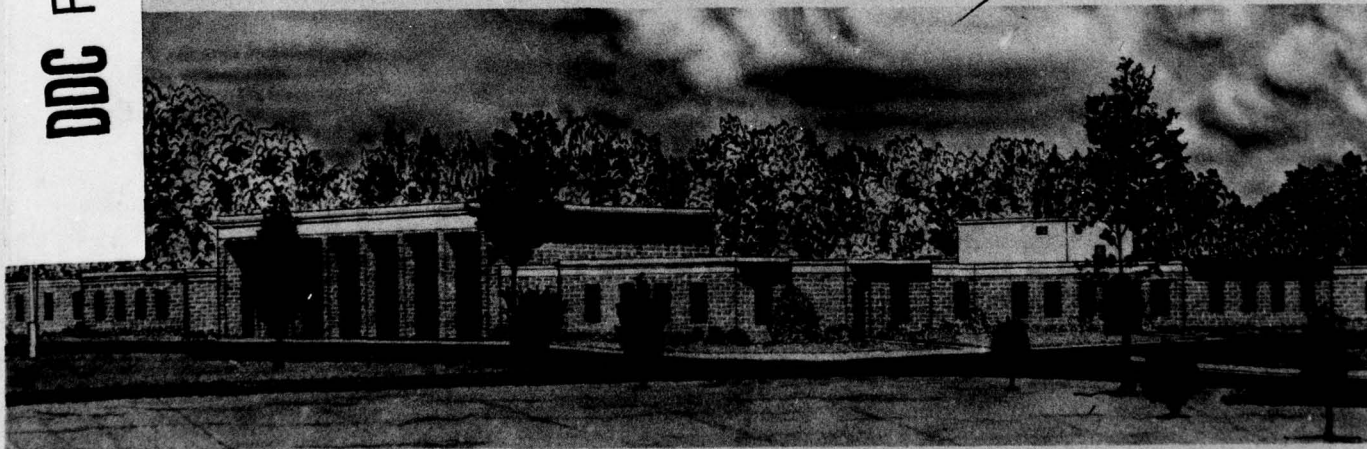
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20. ABSTRACT (Continued).

CONT

→ The instrumentation was provided to determine the validity of design assumptions and to use in design of similar structures. From the data, earth and hydrostatic pressures were calculated beneath the base slab and along the walls, while the stresses and strains within the slab and walls were also obtained.

Overall, it appears the instruments were operating satisfactorily until September 1969 at which point a reduction in personnel precluded acceptable engineering measurements. Considerable judgment must be exercised when interpreting data collected after this point in time. A set of conditions, as specified in the design cases, had occurred before the September 1969 date, and only the dewatered case and possibly a more accurate normal operating case require data for analysis.

Based on the soil stresses under the lock, it appears that the stress curves are similar in shape to the ones plotted for Old River and Port Allen with large stresses under the lock walls and much less under the lock floor. Concrete strains and stresses are shown for the design cases chosen for the soil stress cases. No attempt is made in this report to analyze the structural response.

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Preface

The investigation reported herein was one phase of a project entitled "Analysis of Structure and Foundation Interaction," sponsored by the Office, Chief of Engineers (OCE), U. S. Army, under CWIS 31203. The investigation was conducted by the U. S. Army Engineer Waterways Experiment Station (WES) during the period FY 74-FY 76.

This report was prepared under the general supervision of Messrs. J. P. Sale, Chief, Geotechnical Laboratory; C. L. McAnear, Chief, Soil Mechanics Division; and G. B. Mitchell, Chief, Engineering Studies Branch (ESB). Mr. Lucian G. Guthrie was the OCE Technical Monitor. Preparation of the data was made by Mr. W. L. Hanks (ESB). Mr. Roy E. Leach (ESB) prepared this report.

Directors of the WES during the investigation and preparation of this report were COL G. H. Hilt, CE, and COL J. L. Cannon, CE. Technical Director was Mr. F. R. Brown.

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Conversion Factors, U. S. Customary to Metric (SI)
Units of Measurement

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>
cubic feet	0.02831685	cubic metres
cubic yards	0.7645549	cubic metres
degrees (angle)	0.01745329	radians
feet	0.3048	metres
inches	25.4	millimetres
microinches per inch	0.001	microns per millimetre
miles (U. S. statute)	1.609344	kilometres
pounds (force) per square inch	6.894757	kilopascals
pounds (mass)	0.4535924	kilograms
seconds (angle)	0.000004848137	radians

INSTRUMENTATION OBSERVATIONS FROM THE U-FRAME LOCK
OF THE ARKANSAS RIVER LOCK AND DAM 5

Introduction

Background

1. Arkansas River Lock and Dam (L&D) 5 is one of 13 in an overall plan to develop the Arkansas River basin from Catoosa, Oklahoma, to the Mississippi River as authorized by the River and Harbor Act of 24 July 1946. Each lock has a 110- by 600-ft* chamber with normal lifts ranging from 14 to 54 ft and each is connected to a nonnavigable dam. For the purpose of checking design values or operational status, each lock was instrumented to some degree with L&D 5 being the most heavily instrumented.

Purpose

2. The purpose of this study is to take 8 years of instrumentation data from Lock No. 5 and report it in such a manner that it can be used later in other studies, such as a finite element analysis. Included is a discussion of the quality of the data and a brief comparison of measured values with design cases for several soil-structure interaction cases.

Location and description of the structure

3. Lock No. 5 is located between Pine Bluff and Little Rock, Arkansas, at river mile 128. It is a 110- by 600-ft reinforced concrete U-frame lock with a design normal lift of 17 ft. Design upper pool, el 213,** is controlled with a gated dam connecting the river-side wall of the lock and the opposite riverbank. The 600-ft semigravity-type guide walls and the lock chamber are founded on Tertiary-age clay.

* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 4.

** All elevations (el) cited herein are in feet referred to mean sea level (msl).

Description and Location of Electrical
Measuring Devices

4. Experience obtained at two other U-frame locks, Old River and Port Allen, helped in determining the type and location of the needed instrumentation. The task was to measure soil-structure interaction and to determine load transfers, stresses, and strains in the concrete. All 95 electrical devices, including concrete strain and stress meters, joint meters, pore pressure cells, and soil stress meters, were installed in two monoliths.

5. The special structural safety instrumentation devices are installed across monolith 11, a gate bay monolith, and monolith 18 in the central portion of the lock chamber. Location of the devices are as shown in Plates 1 and 2 and include:

- a. Carlson concrete strain meters (SM-1 to SM-23) to determine strain across and through the center of the lock floor slab and walls.
- b. Carlson concrete stress meters (CS-1 to CS-16) to determine the magnitude and distribution of stress in the floor and walls at points where compressive stress can be reasonably predicted.
- c. Carlson soil stress meters (SS-1 to SS-30) to determine, in conjunction with applicable piezometer data, effective earth pressures beneath the lock and against the walls.
- d. Carlson pore pressure cells (PP-1 to PP-18) to determine pore pressure gradients in the lock floor horizontal lift joints.
- e. Joint meters (JM-1 to JM-8) to determine the load transfer in the closure section of the lock.
- f. Piezometers, as shown on Plate 2, to determine the hydrostatic pressure in the vicinity of the soil stress meters.

Observations

General

6. Normal observational procedures were followed for each device. A reading was taken immediately before and after concrete was placed around each meter, and a third was taken one day later to establish a

zero reading. After the zero reading was established, a time schedule for recording data was to be followed. This schedule was flexible in that milestones or problems in construction were incorporated, such as completion of a concrete pour, completion of a stage of construction, or development of some anomaly that warranted investigation.

7. Starting in February 1966 or the date of installation, most of the gages were read 30 to 50 times the first year and only an additional 70 to 100 times through August 1974. Due to personnel reductions from June 1967 forward, no rigid data collection schedule was followed, and some large gaps exist in the information recorded. Instrumentation readings were made only two times between June 1967 and July 1968 and only five times from October 1969 to February 1972. Although the initial conditions through June 1967 appear to be adequately defined, engineering experience and judgment must be relied upon when interpreting the data collected beyond that point. These factors also preclude obtaining adequate histories of the site and instrument conditions needed for interpretation.

Concrete strain meters

8. The observed strains and the stresses computed from the strains are shown in Plates 3-30. After the strains caused by the initial lifts of concrete have stabilized, it appears from the data that long-term strain is temperature dependent with the largest values of tension occurring in the winter and lesser values in the summer. This agrees with the conclusions for two other locks with which the U. S. Army Engineer Waterways Experiment Station has been involved. Other than these seasonal changes, a variation is apparent during the cutoff of the dewatering system and flooding of Cofferdam II surrounding the dam and gates. Construction history is not complete enough to explain the sharp changes.

9. Maximum allowable tensile stress for concrete was determined from the following equation:

$$\tau = 7.5 \sqrt{f'_c} \quad (1)$$

where

τ = tensile stress, F/L^2

f'_c = compressive strength of concrete, F/L^2

By substituting 3000 psi for f'_c , τ is calculated to be ~ 400 psi. Values of strain corresponding to 400-psi stress on the "Observed Strain" (Plates 3-30) average 100 $\mu\text{in./in.}$ With these values as rough approximations for cracking of the concrete, Plates 7 and 11 show that cracking would be indicated. However, these particular strain meters are installed in a spider arrangement, and further study might negate this conclusion. Several other gages show brief periods where the strain was higher than 100 $\mu\text{in./in.}$, but the allowable tensile strain of the concrete might have been larger than these temporary strains and the 100 $\mu\text{in./in.}$ value is only an approximation.

Concrete stress meters

10. The observed concrete stresses are shown in Plates 31-41. In general, the data range from 0 to 200 psi (compression) up until late 1969. The main exceptions are:

- a. CS 9 - data shift to tension noted in 1968.
- b. CS 12 - very large tension values occur after early 1967.
- c. CS 13 - data plot shows tension through 1967 and then a sudden shift to > 700-psi compression.
- d. CS 15 - in late 1968, values shift to > 4000-psi compression.

The continuation sheets for each concrete stress meter start with data plotted for December 1971 after a discontinuation of readings in September 1969. In most cases, values computed to be in tension were > 50 percent of the total number of data points, while approximately 50 percent of all the gages had sudden large shifts or fluctuations in values.

Soil stress meters

11. Effective stresses (total stress minus hydrostatic pressure) for the soil stress meters are shown in Plates 42-65. Since effective stress is shown, a plot of hydrostatic pressure for the piezometer nearest the soil stress meter is also presented for comparison purposes. Data coverage for the soil stress meters is fair for the period up

through September 1969; most of the changes, i.e. peaks and slopes, can be related to some phase of construction, but thereafter the data are questionable. The measured soil stress under the floor and the walls increased as the additional lifts of concrete were added. But then, after the dewatering system was discontinued and the hydrostatic head was allowed to rise, the stresses were relieved somewhat by the uplift pressure on the base of the slab. Soil stresses against the land-side wall increased as the fill was brought up and then decreased slightly as the hydrostatic head was allowed to rise.

Pore pressure cells

12. The pore pressure cell data for gages PP-1 through PP-18 are shown in Plates 66-75. Data from 14 of the 18 gages are essentially zero or negative for the period up through 1968. The mechanics of the gage itself (water pressure deflecting a diaphragm attached to a strain gage) indicate that only very small negative readings are possible, and therefore the negative readings are somewhat questionable. One explanation put forth by the manufacturer is that for the earlier instruments, aggregate in the concrete could possibly deform the part of the meter containing the strain gage and thereby create an electrical reading that would convert into negative pressures.

13. By accepting this explanation and assuming the gages are reliable, a definite rise in hydrostatic pressure in the concrete is evident starting in late 1968 with three gages (1, 4, and 16) showing as much as 30 ft of head by mid 1969. The project, both lock and dam, was completed in late 1968. The dewatering system shut-down, the breaching of the last cofferdam, and the differential head on the lock are believed to be the factors causing the rise in hydrostatic pressure in the concrete. All data past 1969 are questionable; therefore, no trends can be established, and no verification of the high pressures can be made without reliable, up-to-date data.

Joint meters

14. Data collected from joint meters 1-8 are shown in Plates 76-79. The joint meters (Plate 2) were installed to determine load transfer by rotation or sliding. To determine movement in the vertical plane,

meters 2 and 7 were installed 45 deg from the horizontal with the downstream end being up, while meters 3 and 6 were installed 45 deg from the horizontal with the downstream end being down. A comparison of the data (Plates 76-79) shows that there is movement but that meters 3 and 6 have twice as much movement as 2 and 7. This indicates that the space between the joint has widened. That an outward rotation of the bottom of the joint has also occurred is evidenced by the differential movement. To determine movement in the horizontal plane, meters 1 and 8 were installed horizontally and 45 deg from the center line of the lock with the downstream end being to the right, while meters 4 and 5 were installed in the same manner with the downstream end being to the left. The magnitude of the data for these meters indicates outward movement (expansion of the joint) but no differential movement or rotation in the horizontal plane.

Piezometers

15. Data collected from each piezometer are not presented but are incorporated as uplift pressures on the soil stress meter plots.

Discussion

Soil stresses under the lock

16. It is not the purpose of this report to present a thorough analysis of the lock, but an effort was made to determine the acceptability of the present data. For comparison, measured values for the conditions that most nearly match design conditions are plotted versus the design values.

17. Plate 80 shows conditions as specified for the design cases, which are referred to as the construction, normal operating, and extreme maintenance cases. Other design conditions were checked, but only these will be considered. Each case incorporates a set of soil and water conditions from which pressures exerted on the lock can be calculated. Up to the present, two of the design cases have occurred, i.e. construction and normal operating. Comparisons of the measured and design pressures beneath the lock for selected cases are shown in Plates 81-84 for monoliths 11 and 18. The design data were computed using

a "Beam on Elastic Foundation" analysis based on an IBM 650 Computer analysis furnished to the Fort Worth District by the Buffalo District.

18. Design conditions during construction (lock complete and dewatered) for monolith 18 were most nearly duplicated on 27 May 1967, and a comparison with measured values is shown in Plate 81. The stress data for the curve labeled "computed (Σ FORCES)" were obtained by taking the total weight for each section (two walls and the lock floor), dividing by the area of each to obtain total pressure, then subtracting the uplift pressure to obtain effective stress. This curve is presented for use in determining a range for the actual measured forces. For the construction case shown (27 May 1967), there is good agreement for all three curves under the land-side wall and the lock floor. Under the river-side wall, there is some difference in the curves, but this might have been smaller had there been more data points for the measured and computed curves (beam). It should be noted that for the construction case, the soil properties and existing forces should be more nearly known, thus the close agreement between design and measured stresses. As mentioned earlier, the Port Allen and Old River designs were considered during the Lock No. 5 design, for the general shape of the measured stress curves for the three locks is similar under the land-side wall and the lock floor. Since there is no overburden other than water outside the river-side lock wall, the measured stress under that wall is less than the stress under the land-side wall.

19. For the normal operating case with the lower pool in the lock at el 196 (case I-A monolith 18, Plate 80), design conditions were most nearly met on 23 December 1968. A comparison of design and measured values is shown in Plate 82. Again, there is agreement for the distribution of stresses under the land-side wall and the floor slab, but the data are scattered under the river-side wall. The same observations apply to the normal operating case where the upper pool is in the lock (case I-A, Plate 80) as indicated in Plate 83.

20. The data for the construction case for monolith 11 are shown in Plate 84. Again, the same type curve for the measured stresses is apparent with large stresses under the walls and lesser stresses under

the slab. The design curve (beam on an elastic foundation) is much flatter and does not show the high stresses under the lock walls.

Stress and strains
in the lock floor slab

21. Stresses in the concrete were measured directly with concrete stress meters and were also calculated from strain meters located at the same points. These data (Plates 85-87) are presented for the same three cases shown previously in Plates 81-84. The stresses at the center line of the lock are within a range of 400 psi, while the gages located near the construction joint measured stresses within a range of 800 psi. Data collected from SM 13 and SM 15 indicate tensile stresses for all three cases near the construction joint located to the river-side of the center line. This cannot be verified by the concrete stress meters since they only measure compressive stress. A high compressive stress is indicated by data from gage CS 12 (top of the slab) near the construction joint land-side of the center line. This stress is not verified by the strain meter SM 19. The stresses in the lock floor slab are complicated near the joint; therefore, a thorough analysis would need to be performed before any conclusions could be drawn from the data.

22. Strains calculated from data collected near the same construction joints mentioned above are shown in Plates 88-90. These data indicate mostly tensile strains in the lock floor slab for all three cases. After the construction case (Plate 88), the strains in the top of the slab became more tensile, while the strains in the bottom of the slab became less tensile to the extent of even becoming compressive for case I-A (Plate 89). If the strains are tensile, then this is an explanation for the erratic behavior of the concrete stress meters mentioned above since they cannot measure tensile forces.

23. For monolith 18, Plate 91 presents the observed rebound due to the excavation of the foundation. Heave points (HP) 4 and 5 were located beneath the land-side and river-side walls, respectively, while HP 6 was located on the center line of the lock. The subsequent settlements are listed in Table 1. The construction settlement plug is located on the outside toe of the walls, but the settlement reference

points are on the top of the wall. If it is assumed that there is no rotation of the walls, the settlements can be added for a maximum of 0.963 and 0.856 in. for the land-side and river-side walls, respectively. This compares with measured rebound of 0.9 and 0.75 in. for the land-side and river-side walls, respectively.

Conclusions

24. Based on the limited analysis and observations of the instrumentation devices, it is concluded that most of the devices were operating satisfactorily at least until September 1969, but after this time much engineering judgment must be exercised in data interpretation. If current data are needed for future studies, a thorough instrument check would have to be performed and new data collected.

25. Furthermore, based mainly on the measured soil stresses under the lock, the subgrade reaction curves have the general shape of these measured at Old River and Port Allen Locks, i.e., larger stresses under the lock walls with much less under the lock floor. The less compressible foundation at L&D 5 appears to cause much larger subgrade reactions beneath the land-side face of the land-side wall than at either of the other locks, where the foundations are much more compressible. Although it is beyond the scope of this report to analyze the structural stresses, after the lock was flooded and the uplift pressure and the downward force of the pool in the lock were stabilized, the slab itself flexed upward in the middle. This situation produced more tensile strain in the top of the slab and less near the bottom.

Table 1
Construction Settlement Data

No.	1966						1967		
	<u>3 Jun</u>	<u>26 Jun</u>	<u>10 Jul</u>	<u>13 Sep</u>	<u>13 Oct</u>	<u>10 Nov</u>	<u>7 Feb</u>	<u>3 Mar</u>	<u>25 May</u>
	<u>Settlement Plug Readings*</u>								
R-18	0.0	-0.8	-0.06	0.0	-0.05	0.0	0.1**	-0.22	--
L-18	--	--	0.0	-0.19	-0.16	-0.2	-0.13	-0.12	-0.52

Reference Point Readings

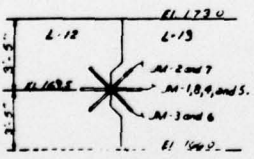
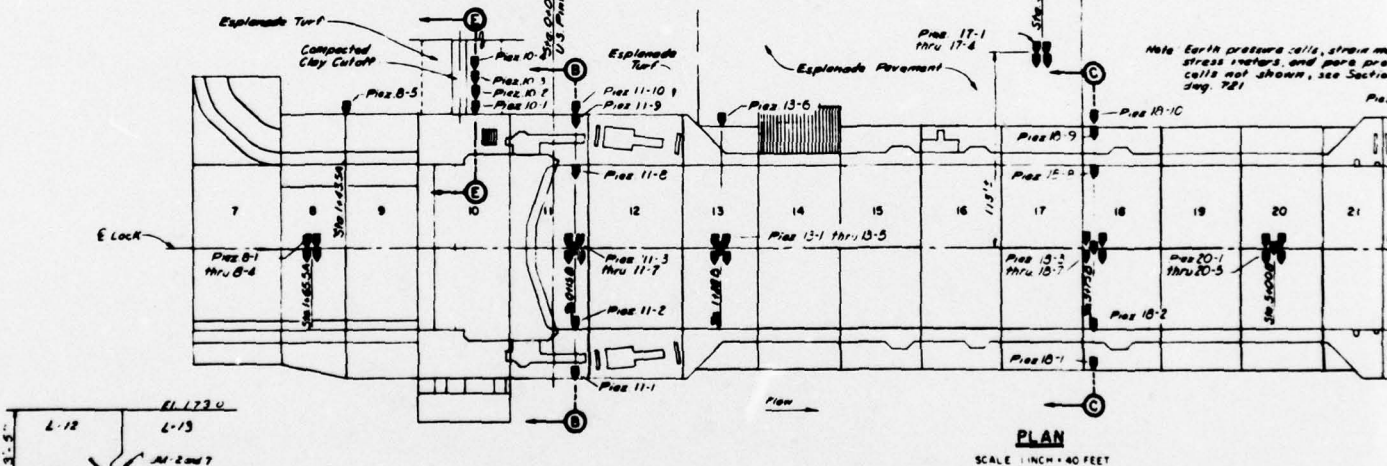
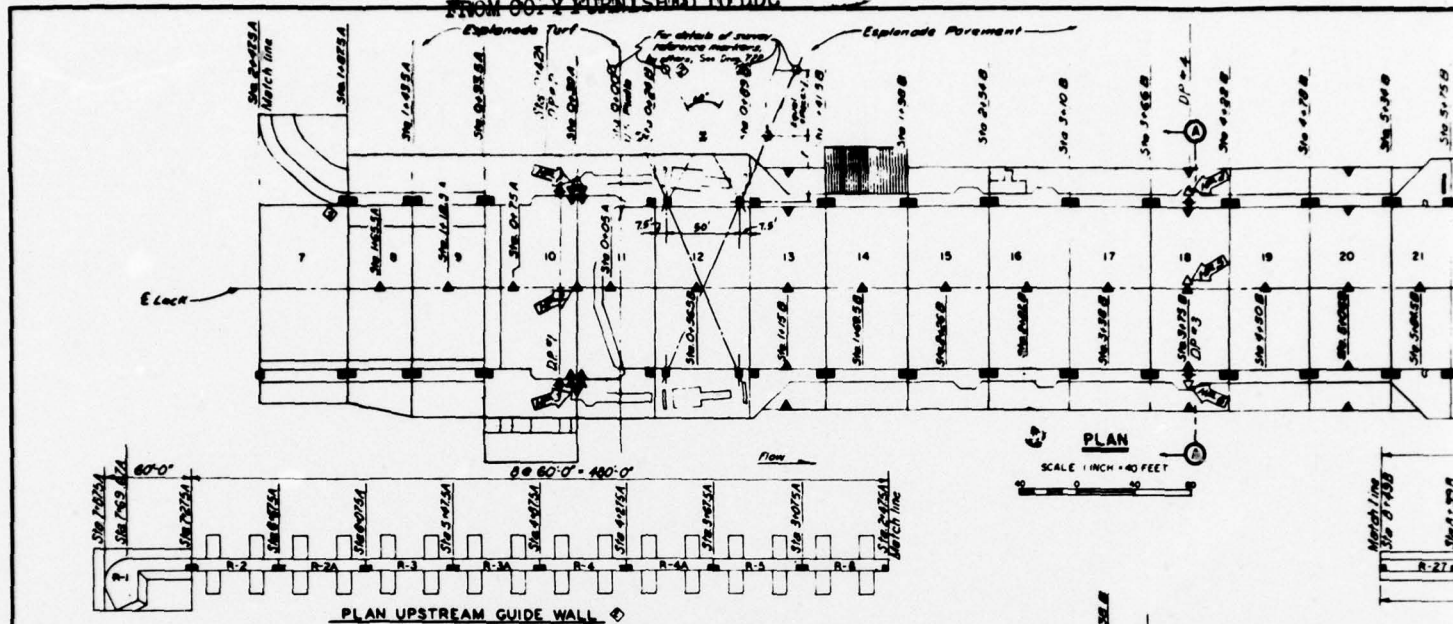
	<u>12 Jun 1967</u>	<u>14 Jun 1968</u>	<u>25 Feb 1969</u>	<u>6 Jun 1969</u>
L18U	0.0	-0.540	--	-0.768
L18D	0.0	-0.480	-0.768	-0.720
R18U	0.0	-0.468	-0.660	-0.600
R18D	0.0	-0.456	-0.636	-0.600

Note: Data taken from draft of: CWI Item No. 039, Arkansas River Lock and Dam Structural Studies, Arkansas River and Tributaries, Arkansas and Oklahoma, Report No. 3, Vertical Displacement of Foundation Soils (Unloading and Loading Conditions), June 1971.

* Points picked off curve.

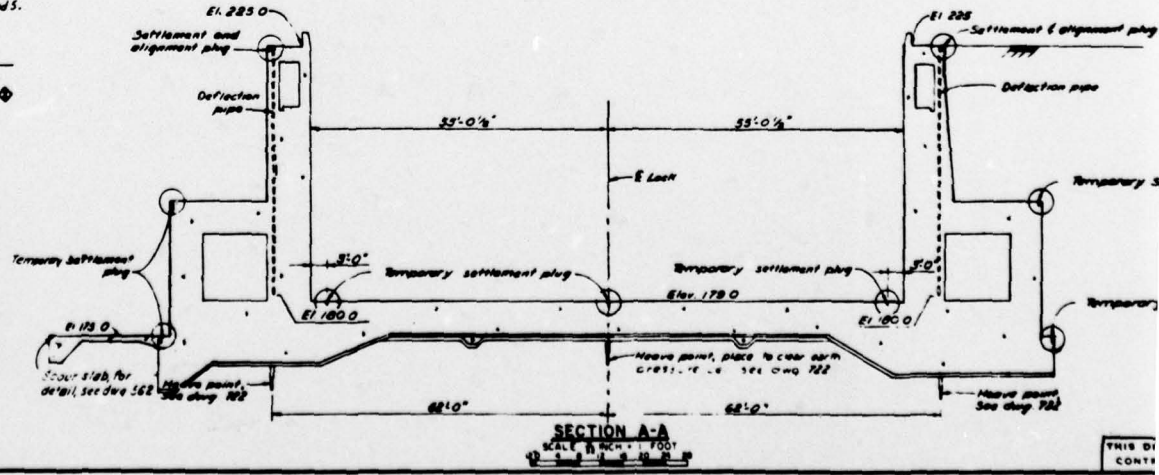
** Heave upward.

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Note: For location of joint meters see day 721.

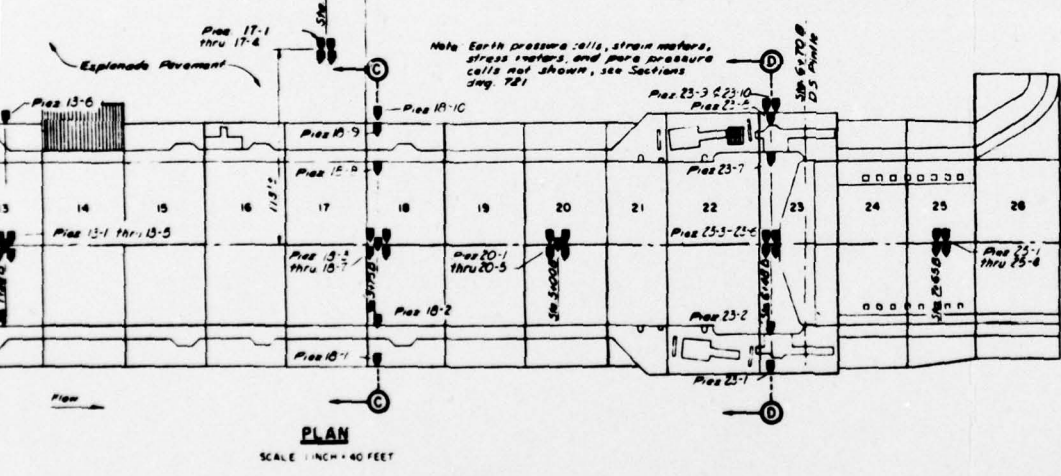
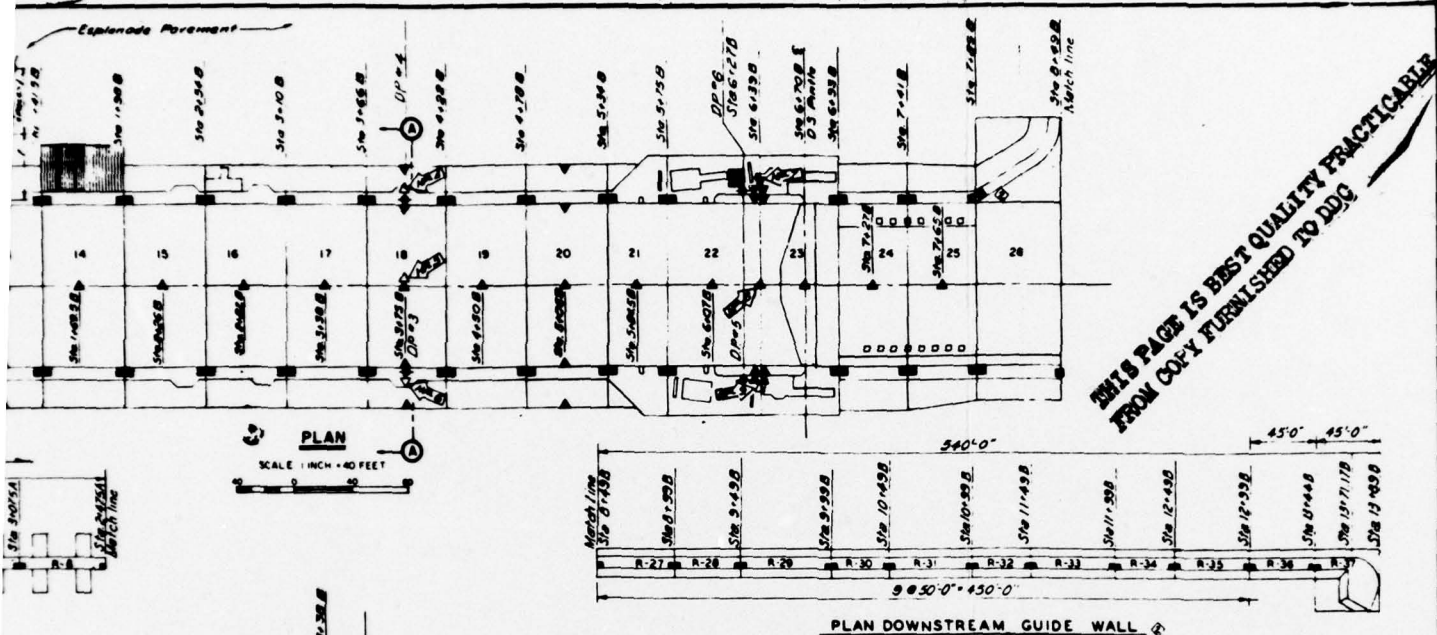
METER NO.	JOINT METER PLACEMENT SCHEDULE
1 and 8	Horizontal and 45° from E of lock (downstream-right)
2 and 7	Parallel to E of lock and 45° from horizontal (downstream-up)
3 and 6	Parallel to E of lock and 45° from horizontal (upstream-up)
4 and 5	Horizontal and 45° from E of lock (downstream-left)



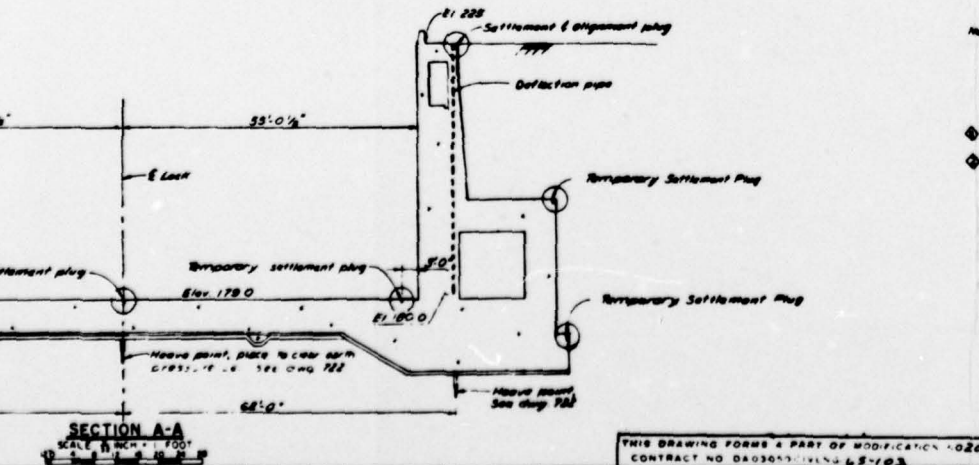
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- LEGEND**
- ⊙ Temporary Settlement Plug
 - ⊙ Permanent Settlement and Alignment Plug
 - ⊙ Move Measurement Point
 - ⊙ Deflection Pipe
 - ⊙ Piezometer
 - ⊙ Survey Reference Marker (By Others) Joint meter



CONTRACT NO. 63-103
RECORD DRAWING AS CONSTRUCTED
18 Feb 66

- Notes**
- 1 For Sections "B-B", "C-C", "D-D", and "E-E", see dng "21"
 - 2 For details of deflection pipes, see Dam drawings
 - 3 For details of temporary settlement plugs and alignment plugs, see Dam drawings
 - 4 For Piezometer details, see Dwg. 722
 - 5 Permanently set each Piezometer, and settlement and alignment plug
 - 6 Survey reference markers to be visible by others after lock construction is completed
 - 7 All piezometer riser pipes must be plumb

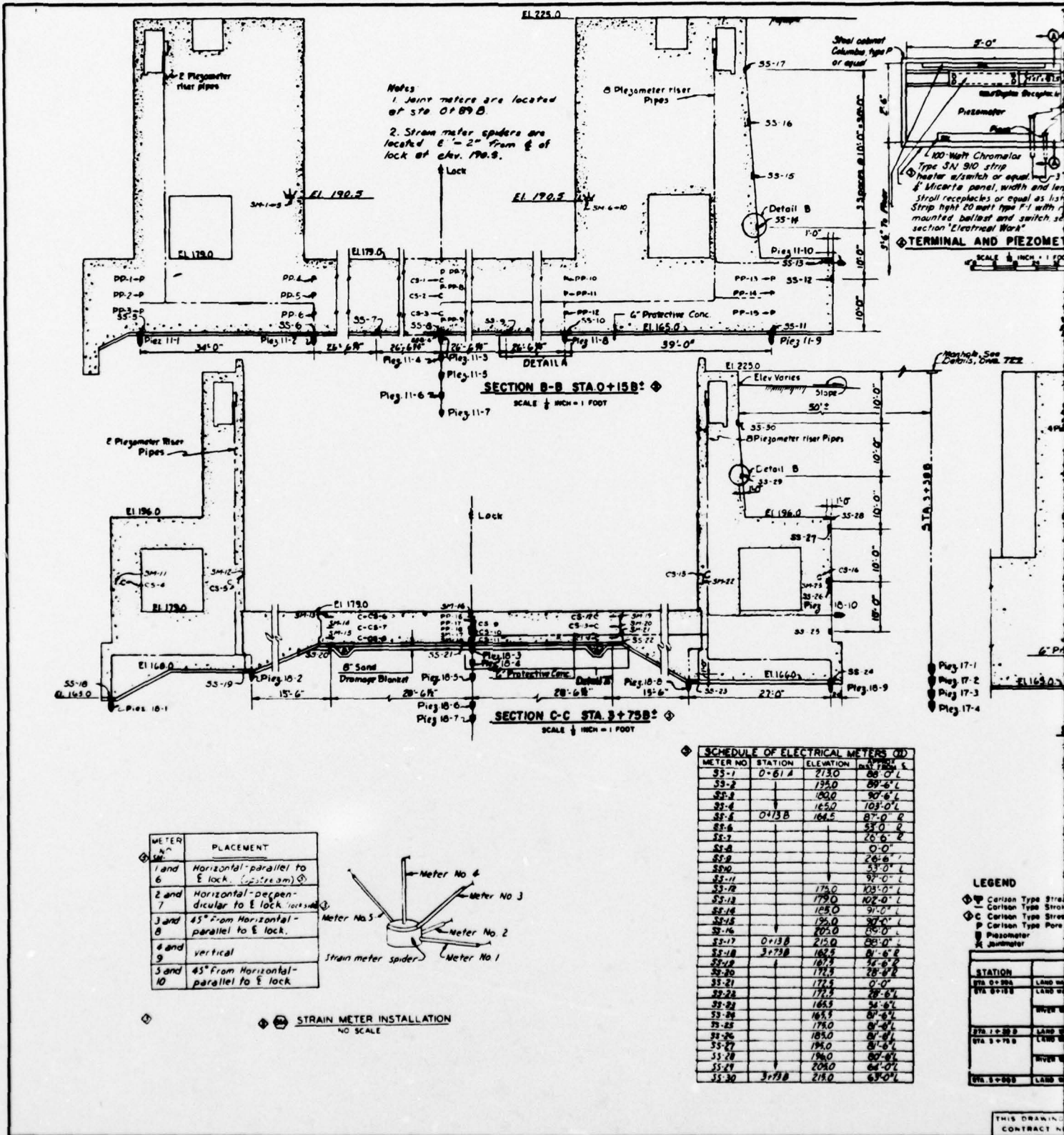
1-12-66 added settlement and align plugs on U.S. (D.S.) guide walls and joint meter detail and placement schedule. Mod No. 2-20-66
2-21-66 Revised piezometer numbers. Amend. 2

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DESIGNED BY E. J. R. J.	CHECKED BY E. J. R. J.	APPROVED BY E. J. R. J.	DATE NOVEMBER 1964
LOCK AND DAM NO. 5 NAVIGATION LOCK			
ENGINEERING MEASUREMENT DEVICES DETAILS I			
DRAWN UNDER THE DIRECTION OF CHARLES S. HOFFMAN, COL., C.E., DISTRICT ENGINEER		PROJECT NUMBER 6258-56/720	

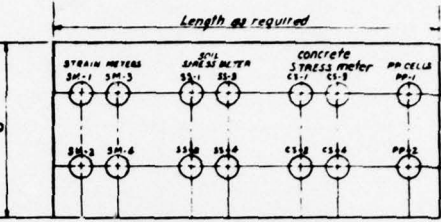
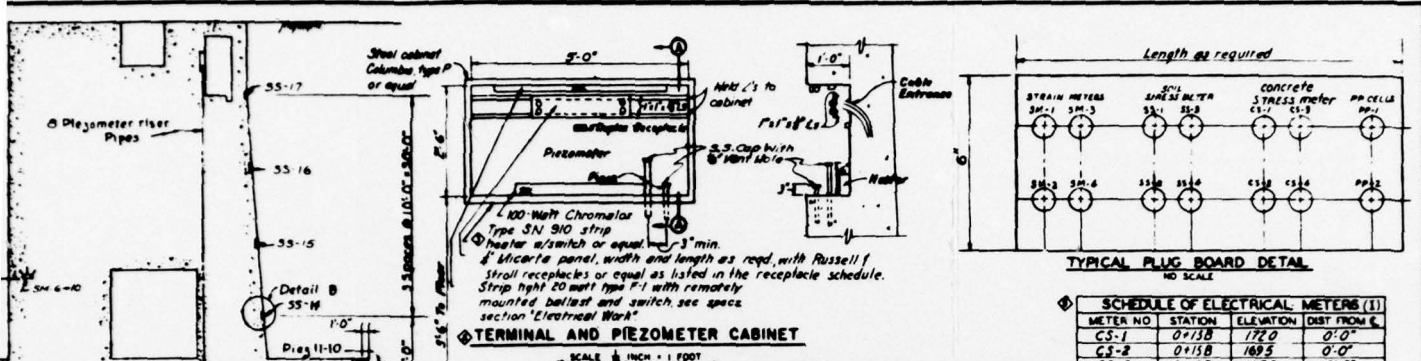
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CONTRACT NO. DA03037-1-1-63-103

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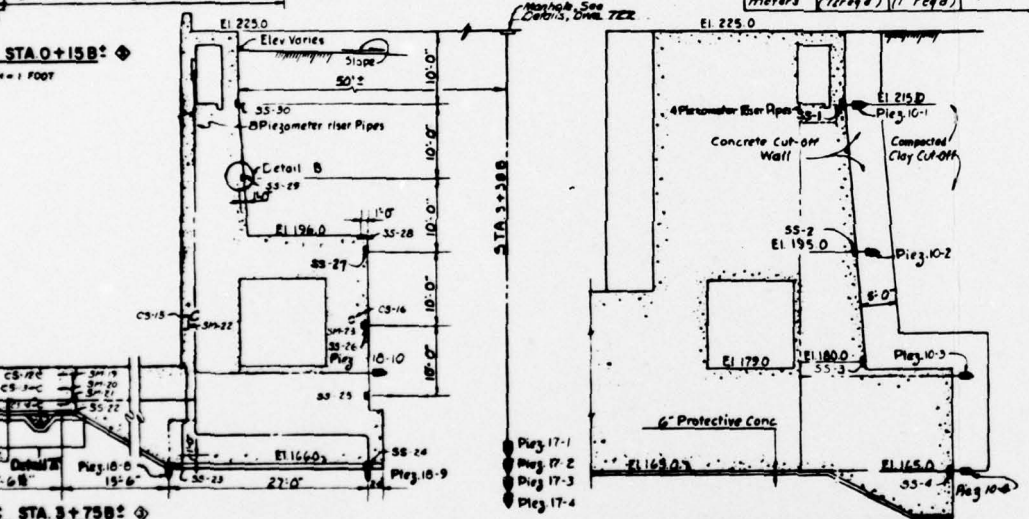
TYPICAL PLUG BOARD DETAIL
NO SCALE

SCHEDULE OF ELECTRICAL METERS (11)

METER NO	STATION	ELEVATION	DIST FROM E
CS-1	0+13B	1720	0'-0"
CS-2	0+15B	1695	0'-0"
CS-3	0+15B	1670	0'-0"
CS-4	3+75B	1650	79'-0" R
CS-5		1650	57'-0" R
CS-6		1760	25'-0" R
CS-7		1760	25'-0" R
CS-8		1760	25'-0" R
CS-9		1760	0'-0"
CS-10		1760	0'-0"
CS-11		1760	0'-0"
CS-12		1760	25'-0" L
CS-13		1760	25'-0" L
CS-14		1740	25'-0" L
CS-15		1690	57'-0" L
CS-16	3+75B	1650	79'-0" L
SM-1-5	0+13B	1905	61'-2" R
SM-6-10	0+13B	1905	61'-2" R
SM-11	3+75B	1690	80'-0" R
SM-12		1690	26'-0" R
SM-13		1760	26'-0" R
SM-14		1760	26'-0" R
SM-15		1760	0'-0"
SM-16		1760	0'-0"
SM-17		1760	0'-0"
SM-18		1760	0'-0"
SM-19		1760	26'-0" L
SM-20		1760	26'-0" L
SM-21		1760	26'-0" L
SM-22		1650	26'-0" L
SM-23	3+75B	1650	80'-0" L
PP-1	0+15B	1790	87'-0" R
PP-2		1720	87'-0" R
PP-3		1720	87'-0" R
PP-4		1720	87'-0" R
PP-5		1720	53'-0" R
PP-6		1690	53'-0" R
PP-7		1730	0'-0"
PP-8		1705	0'-0"
PP-9		1680	0'-0"
PP-10		1750	53'-0" L
PP-11		1720	53'-0" L
PP-12		1690	53'-0" L
PP-13		1790	91'-0" L
PP-14		1720	91'-0" L
PP-15	0+15B	1690	53'-0" L
PP-16	3+75B	1760	0'-0"
PP-17	3+75B	1760	0'-0"
PP-18	3+75B	1760	0'-0"
JM-1	0+89B	1725	83'-0" R
JM-2		1725	71'-0" R
JM-3		1725	71'-0" R
JM-4		1725	60'-0" R
JM-5		1695	71'-0" R
JM-6		1695	71'-0" R
JM-7		1695	71'-0" R
JM-8	0+89B	1695	64'-3" L

RECEPTACLE SCHEDULE

METER	PANEL RECEPTACLE	MATCHING PLUG	CABLE
Strain meter	AFS 20MMR PLS 2779R	(1 reqd)	4k #16
Other meters	AFS 20MMR PLS 2779R	(1 reqd)	3k #16



SECTION E-E STA 0+39A
SCALE 1/4" = 1 FOOT

SCHEDULE OF ELECTRICAL METERS (10)

METER NO	STATION	ELEVATION	DIST FROM E
SS-1	0+81A	2130	86'-0" L
SS-2		1750	89'-6" L
SS-3		1600	90'-6" L
SS-4		1650	103'-0" L
SS-5	0+75B	1645	67'-0" R
SS-6		1645	53'-0" R
SS-7			26'-6" R
SS-8		0'-0"	
SS-9		26'-6"	
SS-10		53'-0"	L
SS-11		97'-0"	L
SS-12		1750	103'-0" L
SS-13		1790	102'-0" L
SS-14		1650	91'-0" L
SS-15		1750	30'-0" L
SS-16		202'-0"	85'-0" L
SS-17	0+13B	2250	25'-0" L
SS-18	3+75B	1695	81'-6" R
SS-19		1695	54'-6" R
SS-20		1725	28'-6" R
SS-21		1725	0'-0"
SS-22		1725	28'-6" R
SS-23		1695	54'-6" R
SS-24		1695	81'-6" R
SS-25		1760	81'-6" R
SS-26		1650	81'-6" R
SS-27		1960	81'-6" R
SS-28		1960	81'-6" R
SS-29		2050	64'-0" L
SS-30	3+75B	2180	63'-0" L

LEGEND

- Carson Type Stress Meter for Soils (CS)
- Carson Type Strain Meter (SM)
- Carson Type Stress Meter for Concrete (C)
- Carson Type Pore Pressure Cell (PP)
- Piezometer
- Jaumeter

STATION	LAND HILL	INSTRUMENTS	DEPTH
STA 0+39A	LAND HILL	RES 0+13B, 0+15B, 0+15B	5'
STA 0+75B	LAND HILL	RES 0+75B, 0+75B, 0+75B	5'
STA 1+03B	LAND HILL	RES 1+03B, 1+03B, 1+03B	5'
STA 3+75B	LAND HILL	RES 3+75B, 3+75B, 3+75B	5'
STA 3+00B	LAND HILL	RES 3+00B, 3+00B, 3+00B	5'

CONTRACT NO. 65-131
RECORD DRAWING AS CONSTRUCTED
187136

Note: Elevations shown in schedule are approx. actual elevations to be determined by lift elevations.

- NOTES:
- FOR LOCATION OF SECTIONS SEE DIVISION TWO
 - FOR DETAILS SEE DIVISION TWO
 - FOR TAIL SEE DIVISION TWO
 - FOR DETAIL OF DETAILS SEE DIVISION TWO
 - PIEZOMETERS SHALL BE PLUGGED TO CLEAR ALL INSTRUMENTATION AND BENCHMARKS

Add joint meters; delete and revise location of strain/stress meters; added meter schedule and general revisions. Not No. 20

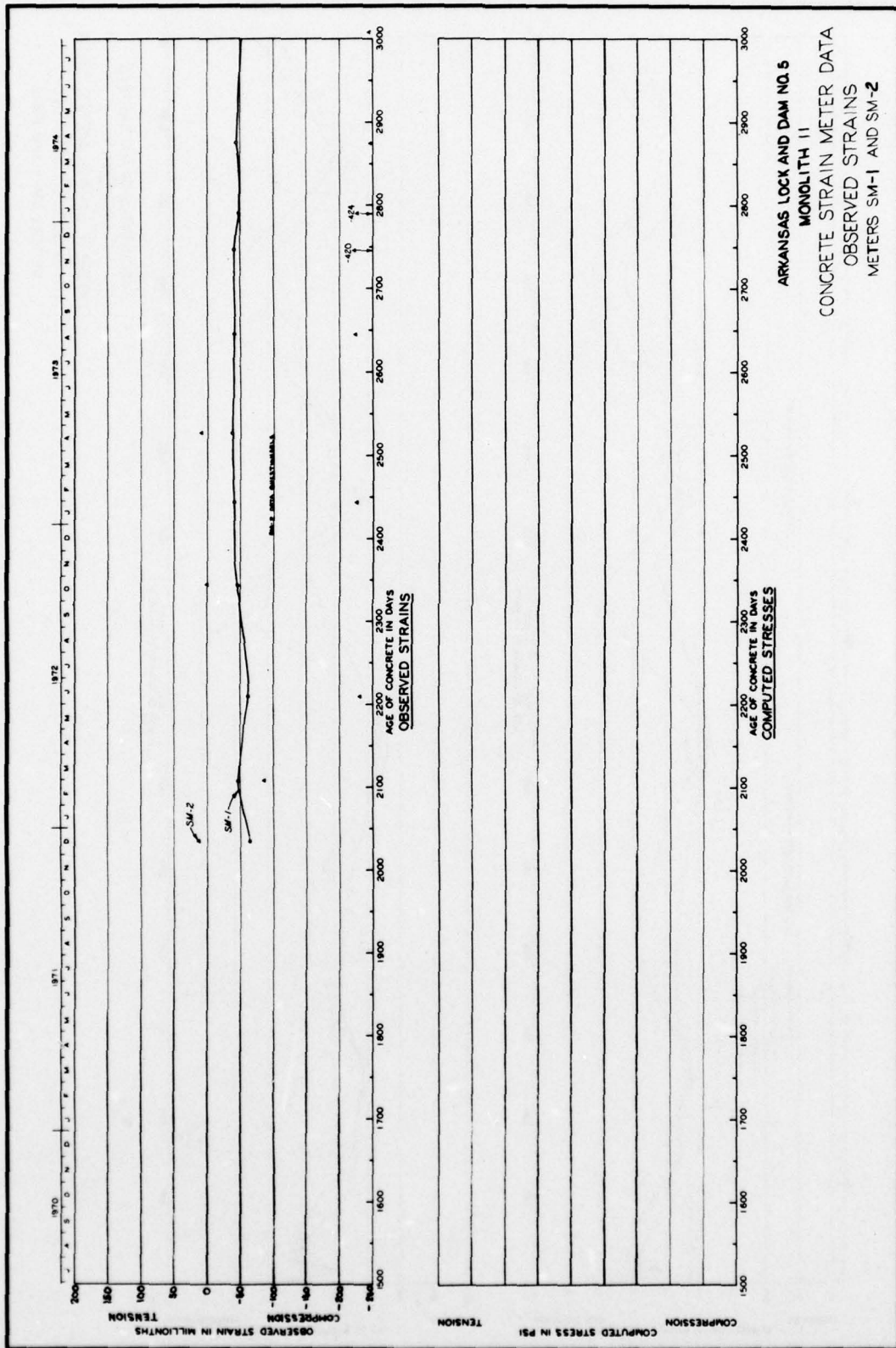
Revised instrument numbers, adding plug board detail, Annex 3

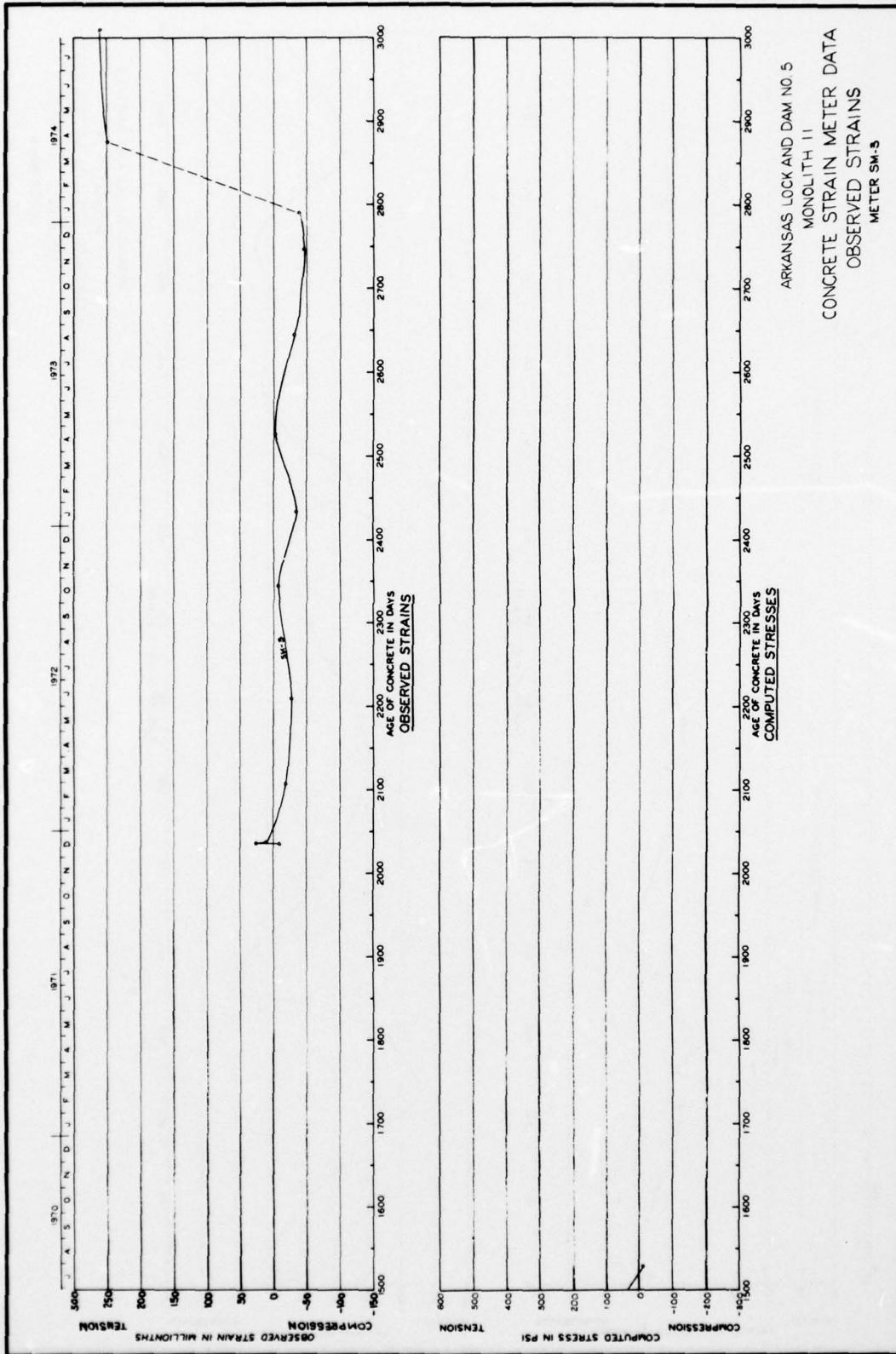
US ARMY ENGINEER DISTRICT, LITTLE ROCK, ARK. OFFICE OF THE DISTRICT ENGINEER

LOCK AND DAM NO. 5
NAVIGATION LOCK
ENGINEERING MEASUREMENT DEVICES
DETAILS 12

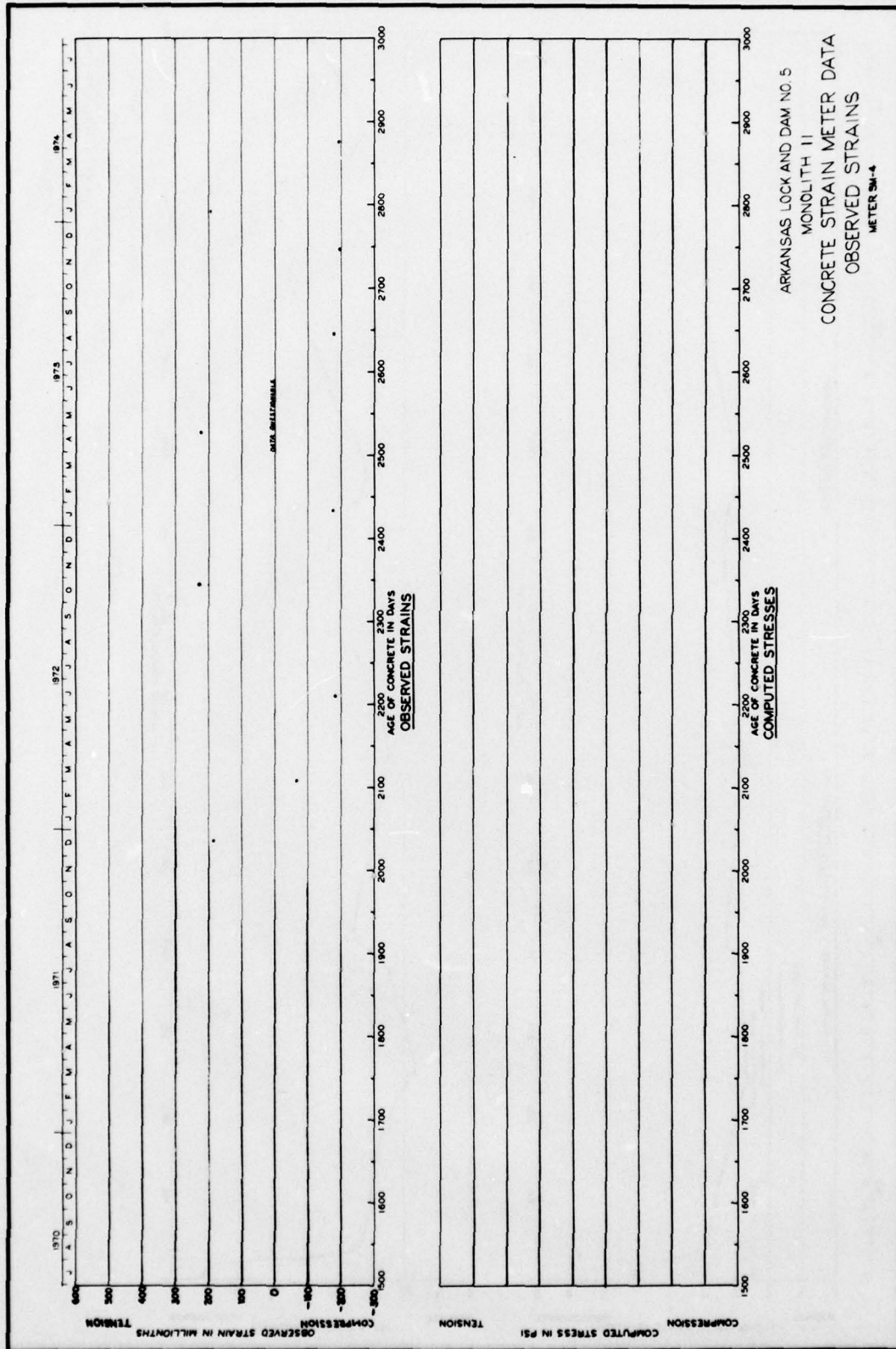
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SCALE: AS SHOWN
PROJECT NO: 6256-56/721

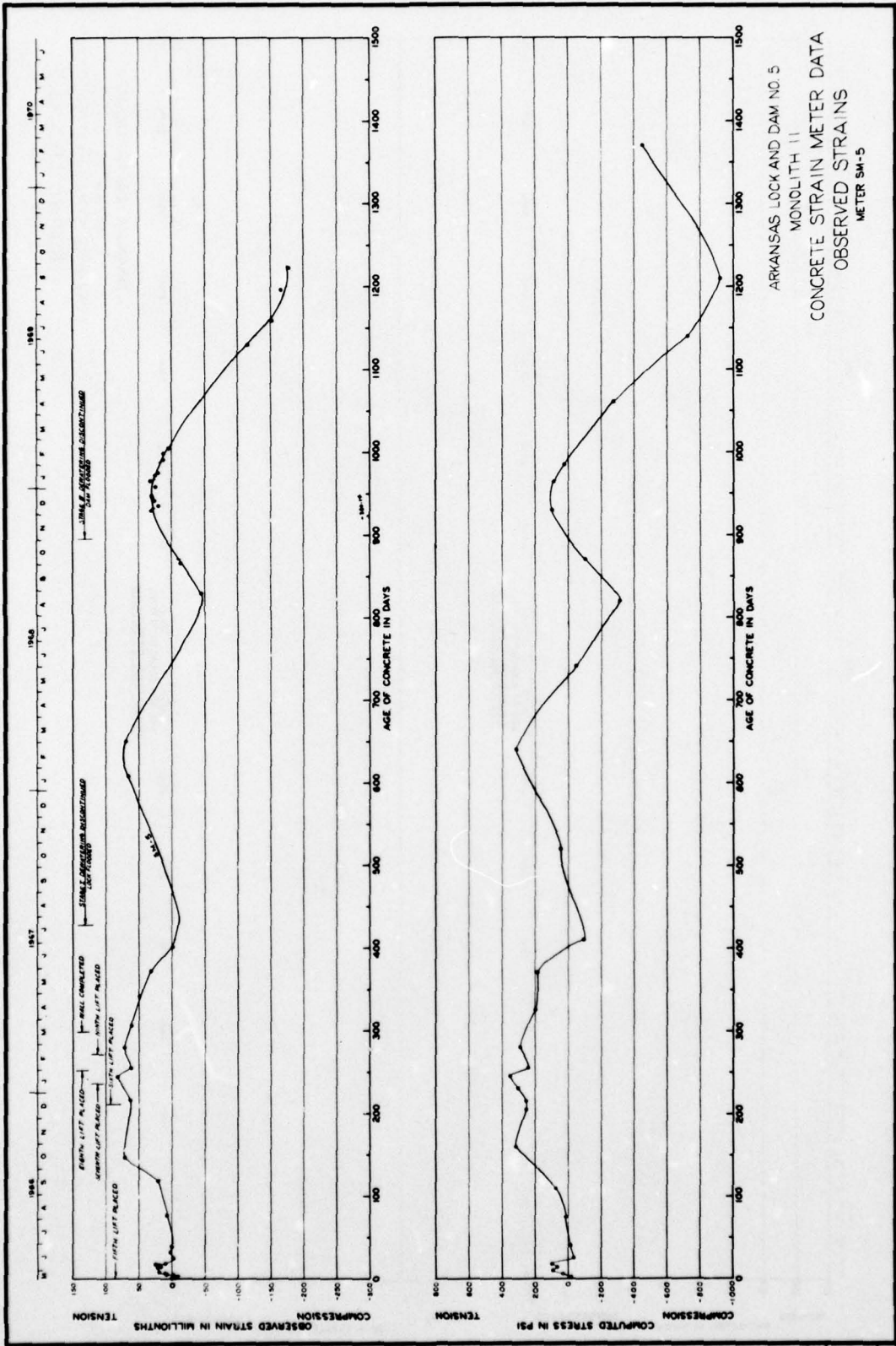
THIS DRAWING FORMS A PART OF MODIFICATION NO. 22
CONTRACT NO. DAB030CIVENG-65-103



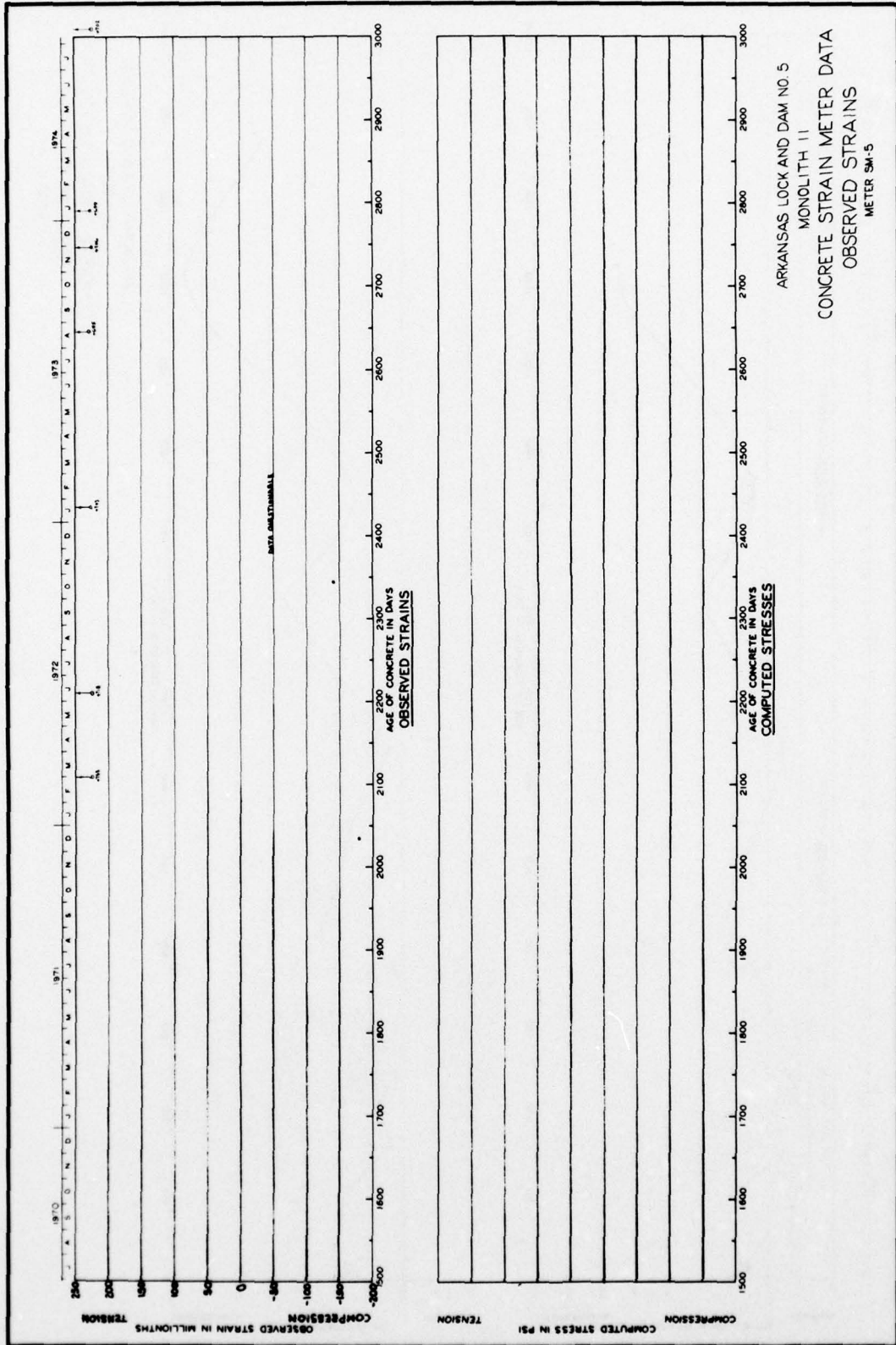


ARKANSAS LOCK AND DAM NO. 5
 MONOLITH 11
 CONCRETE STRAIN METER DATA
 OBSERVED STRAINS
 METER SM-3

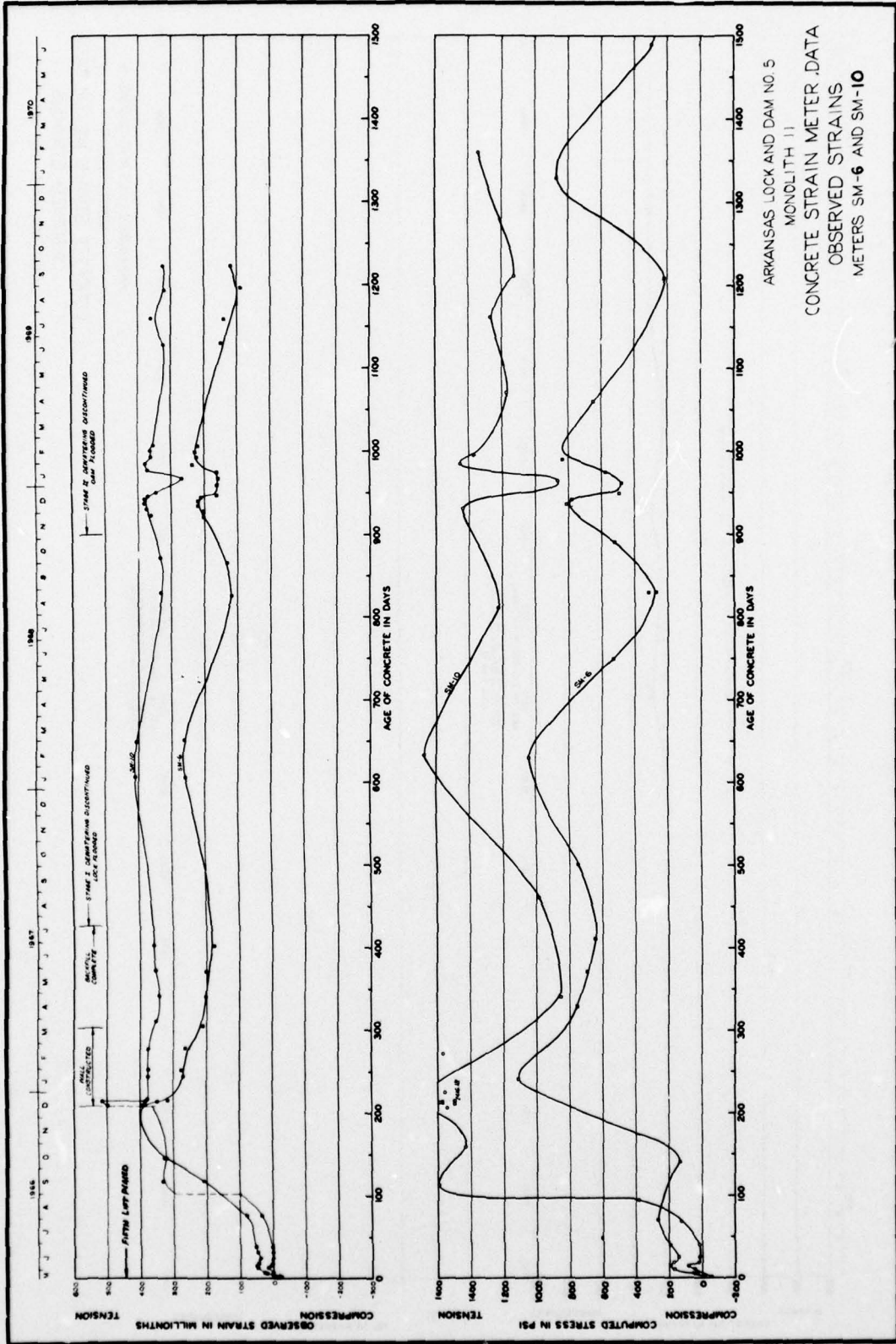




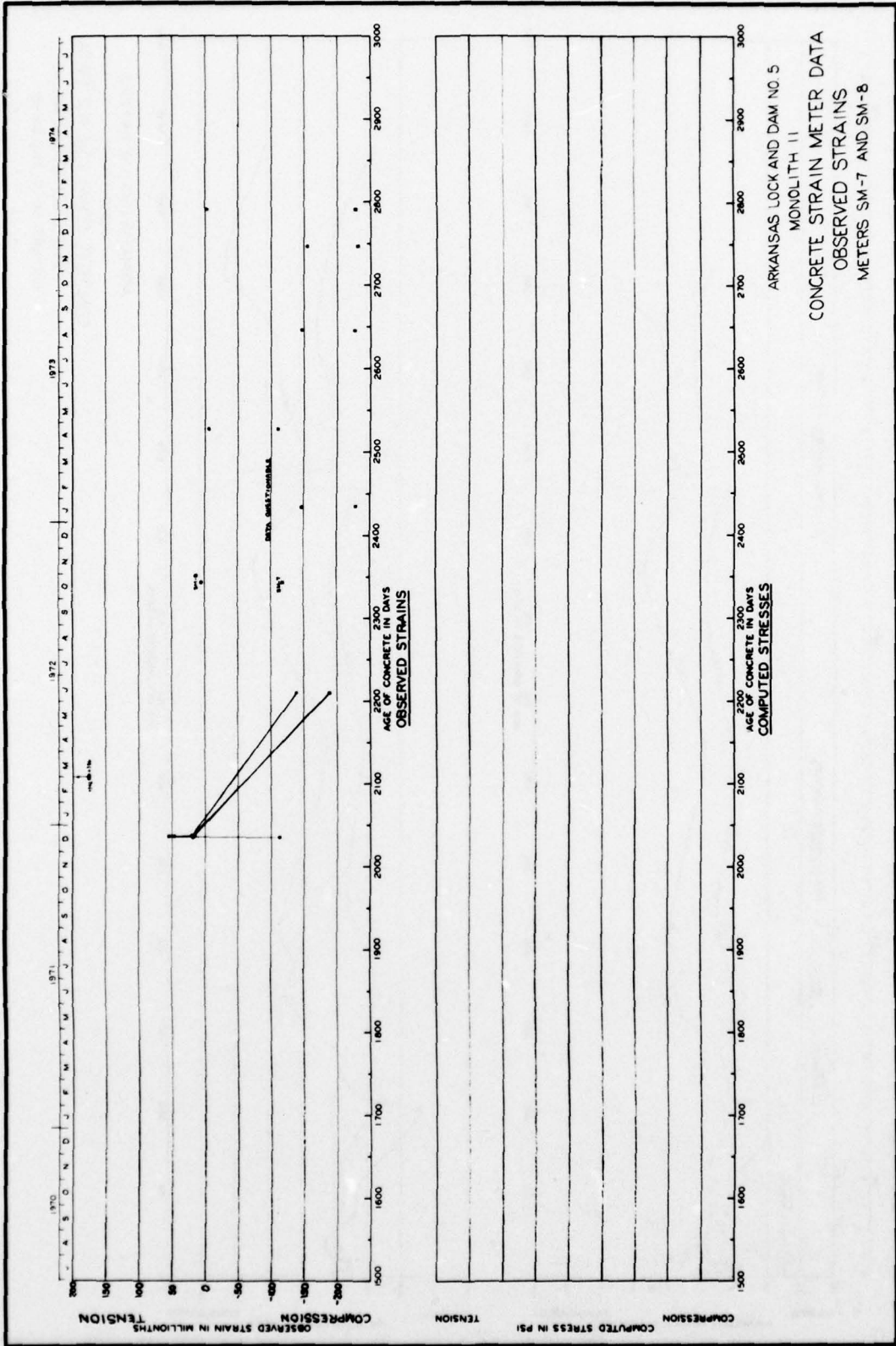
ARKANSAS LOCK AND DAM NO. 5
 MONOLITH II
 CONCRETE STRAIN METER DATA
 OBSERVED STRAINS
 METER SM-5

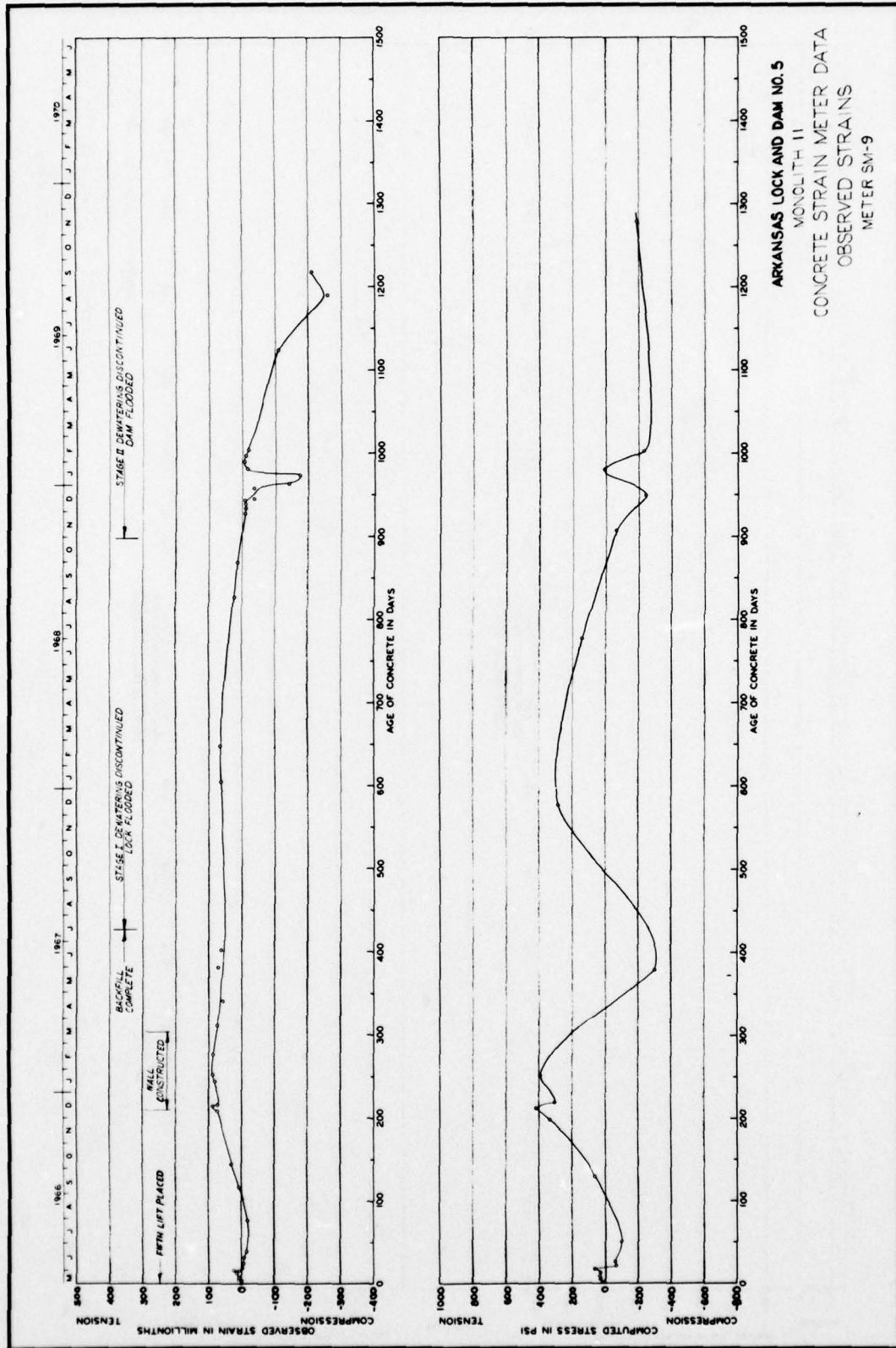


ARKANSAS LOCK AND DAM NO. 5
 MONOLITH II
 CONCRETE STRAIN METER DATA
 OBSERVED STRAINS
 METER SM-5



ARKANSAS LOCK AND DAM NO. 5
 MONOLITH 11
 CONCRETE STRAIN METER DATA
 OBSERVED STRAINS
 METERS SM-6 AND SM-10





ARKANSAS LOCK AND DAM NO. 5
 MONOLITH II
 CONCRETE STRAIN METER DATA
 OBSERVED STRAINS
 METER SM-9

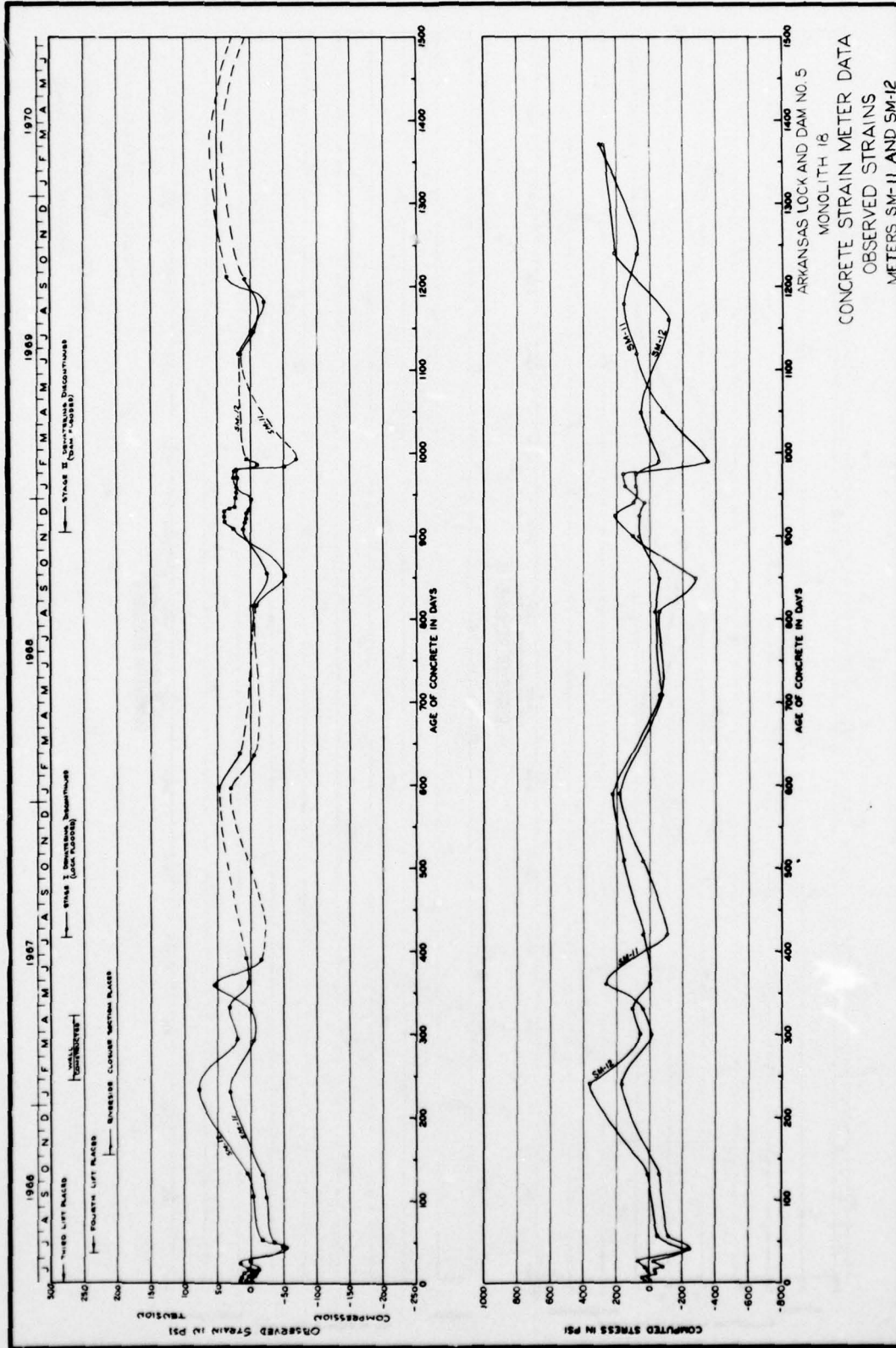
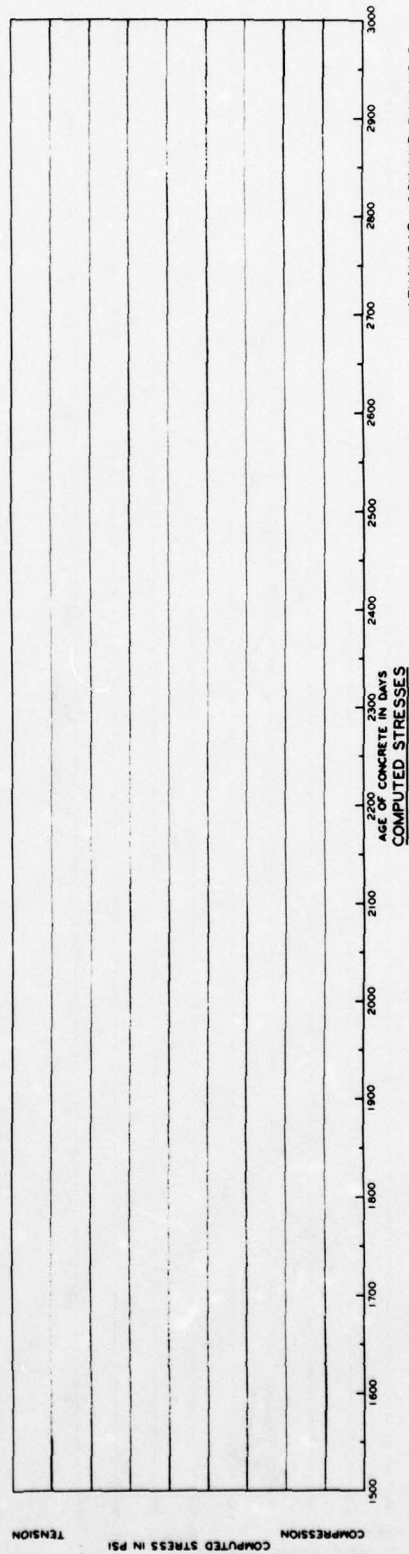
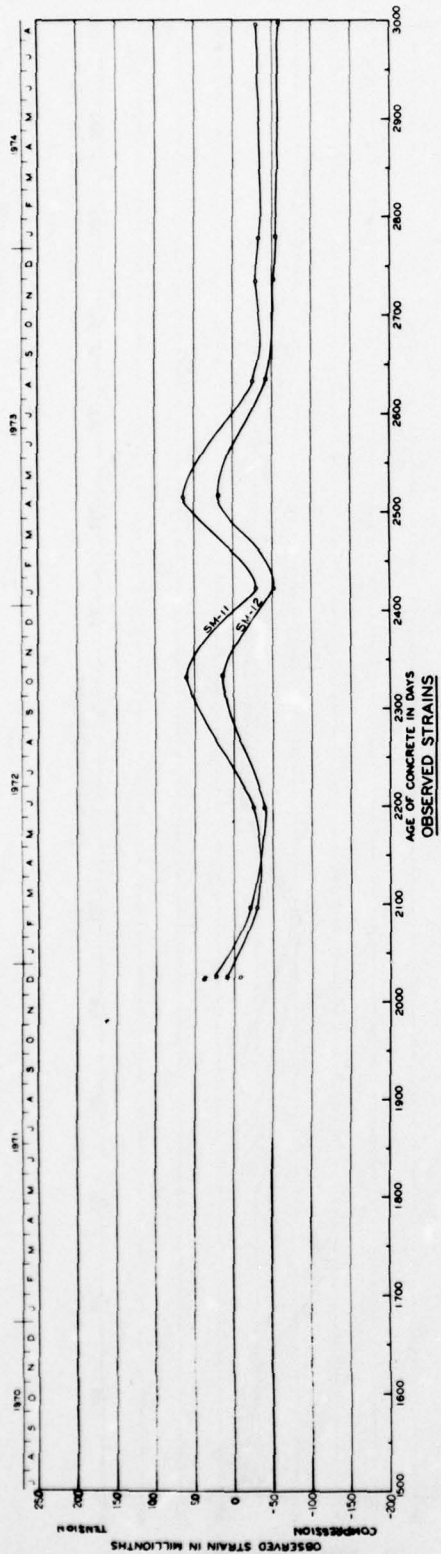
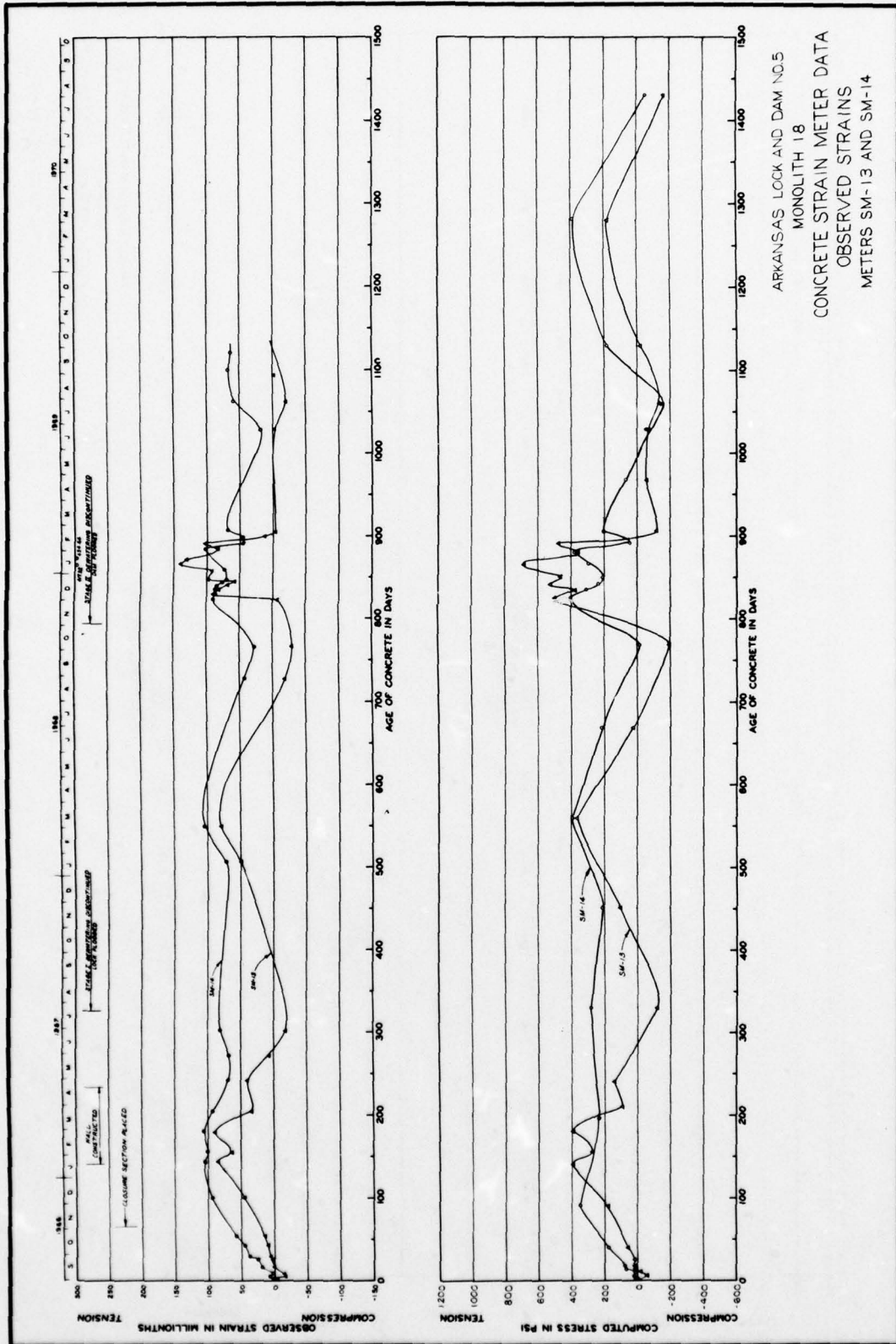


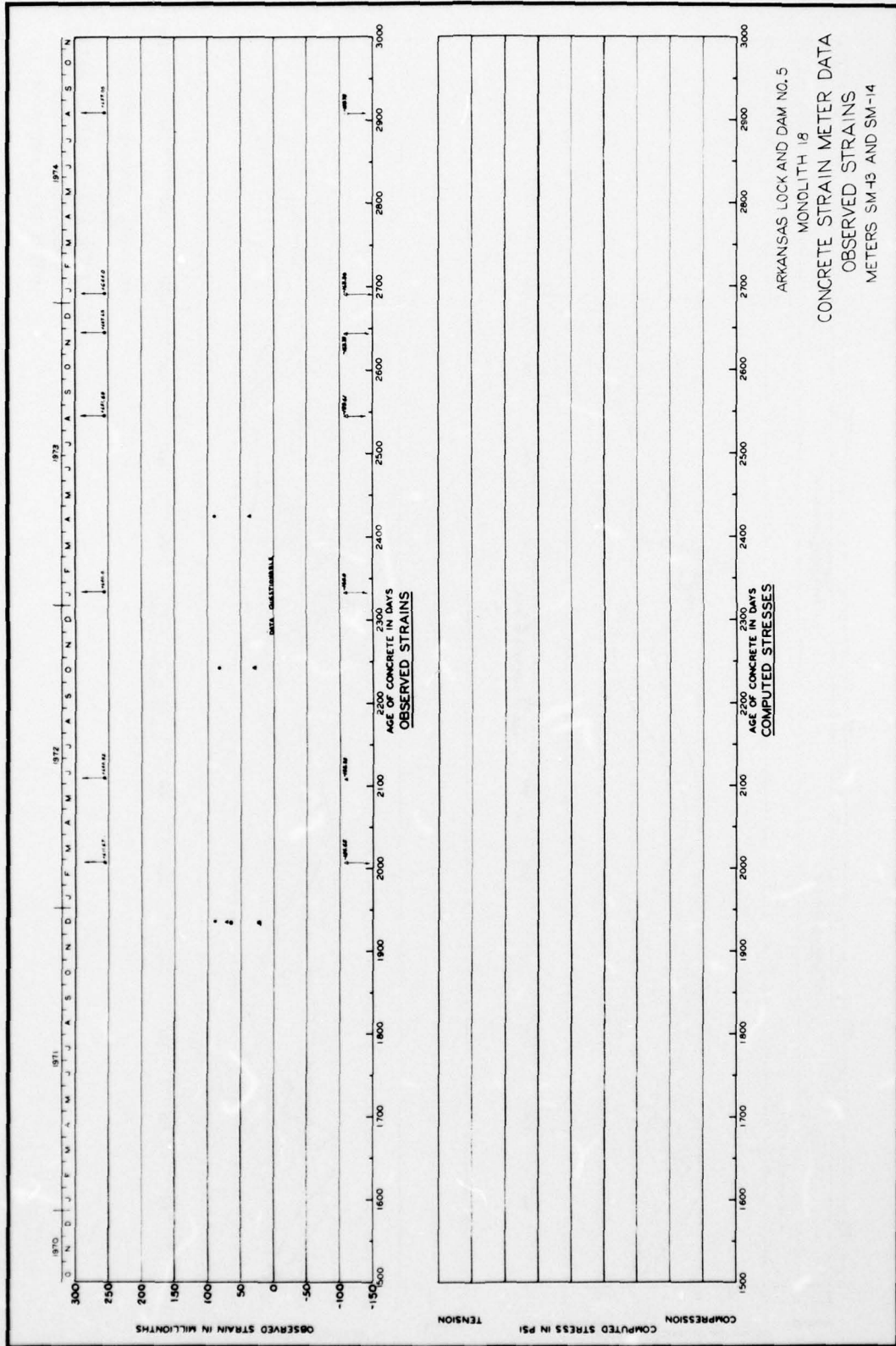
PLATE 18

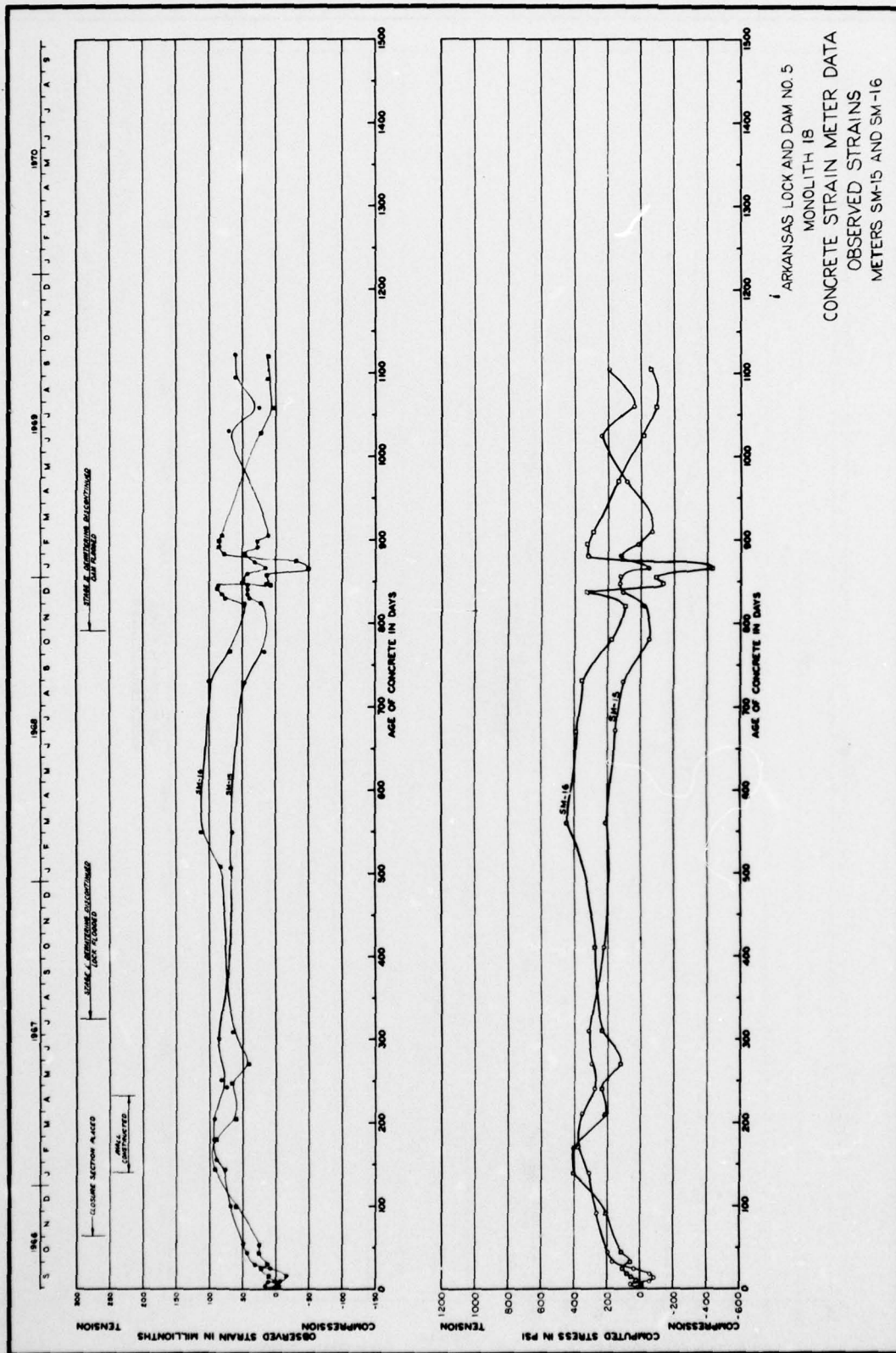


ARKANSAS LOCK AND DAM NO. 5
MONOLITH 18
CONCRETE STRAIN METER DATA
OBSERVED STRAINS
METERS SM-11 AND SM-12

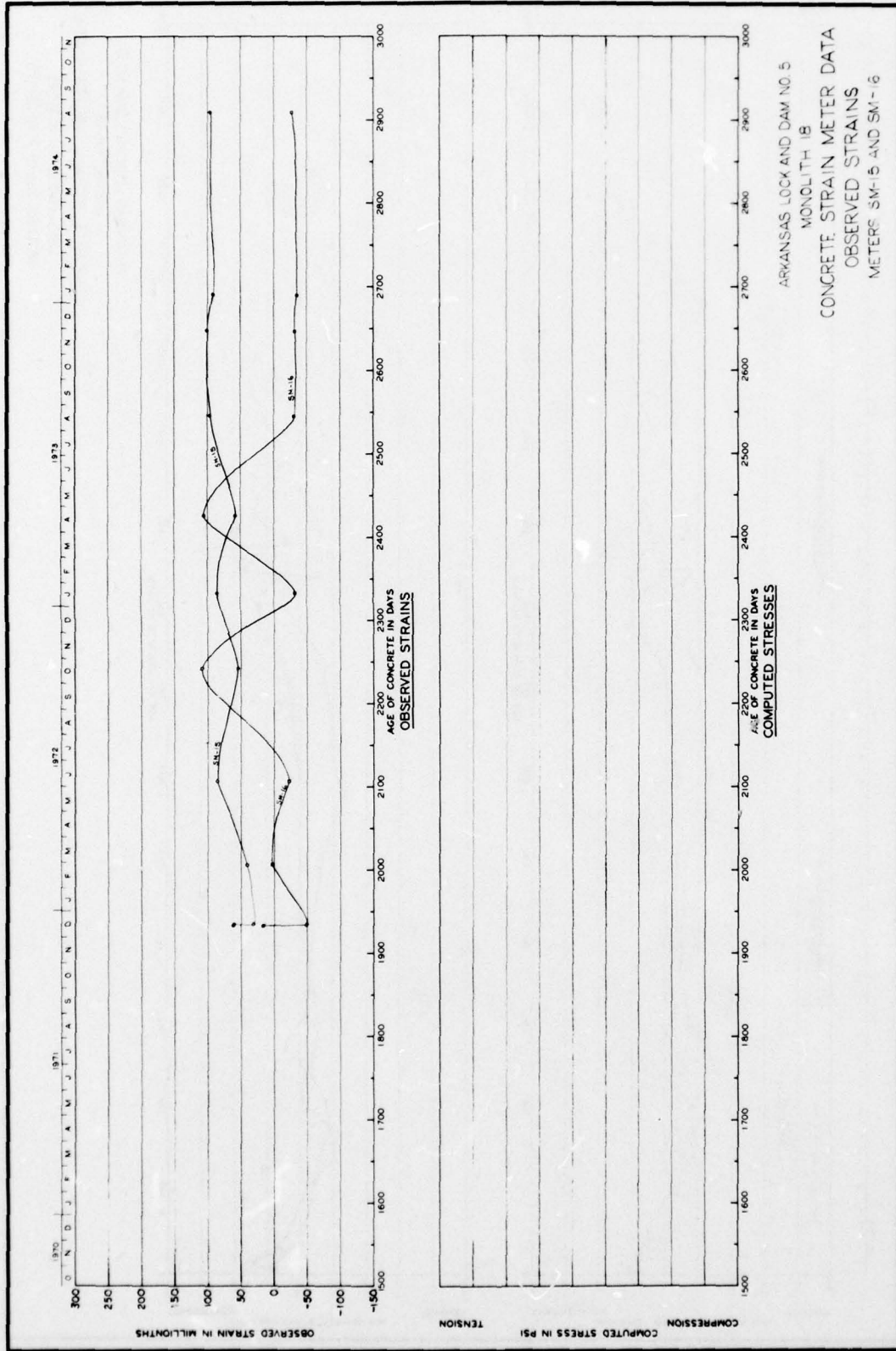


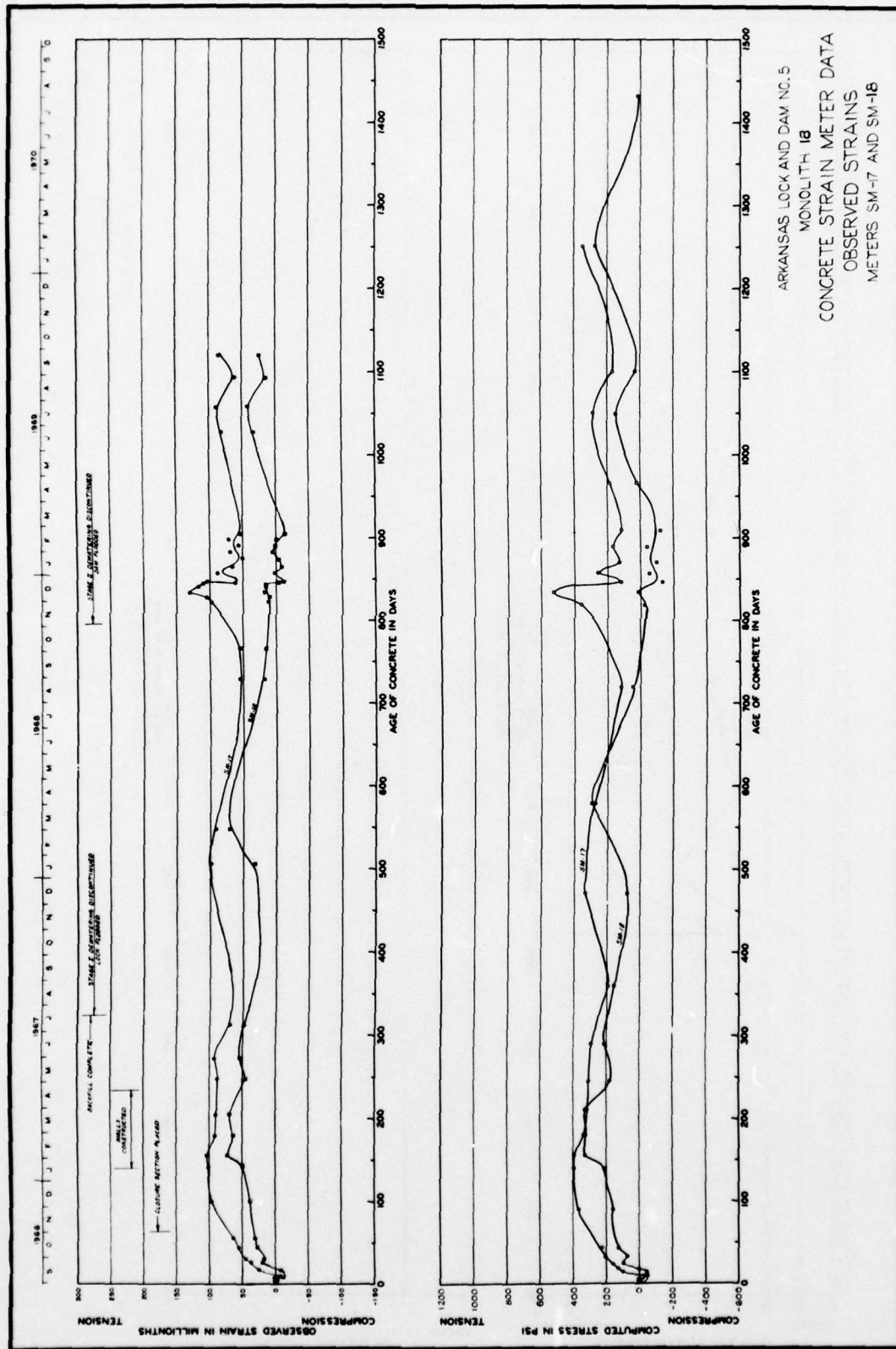
ARKANSAS LOCK AND DAM NO.5
 MONOLITH 18
 CONCRETE STRAIN METER DATA
 OBSERVED STRAINS
 METERS SM-13 AND SM-14



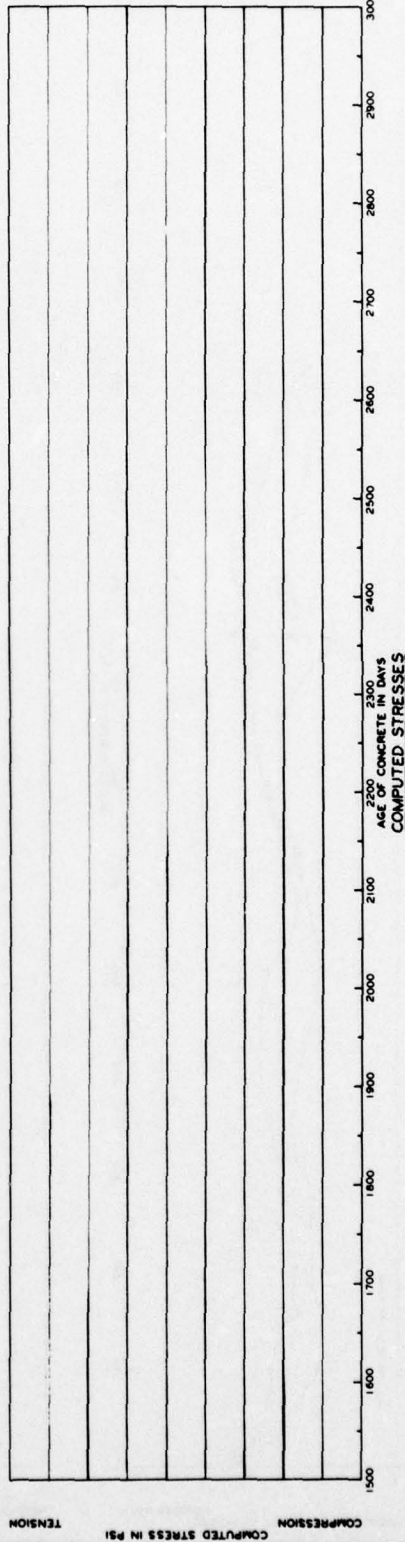
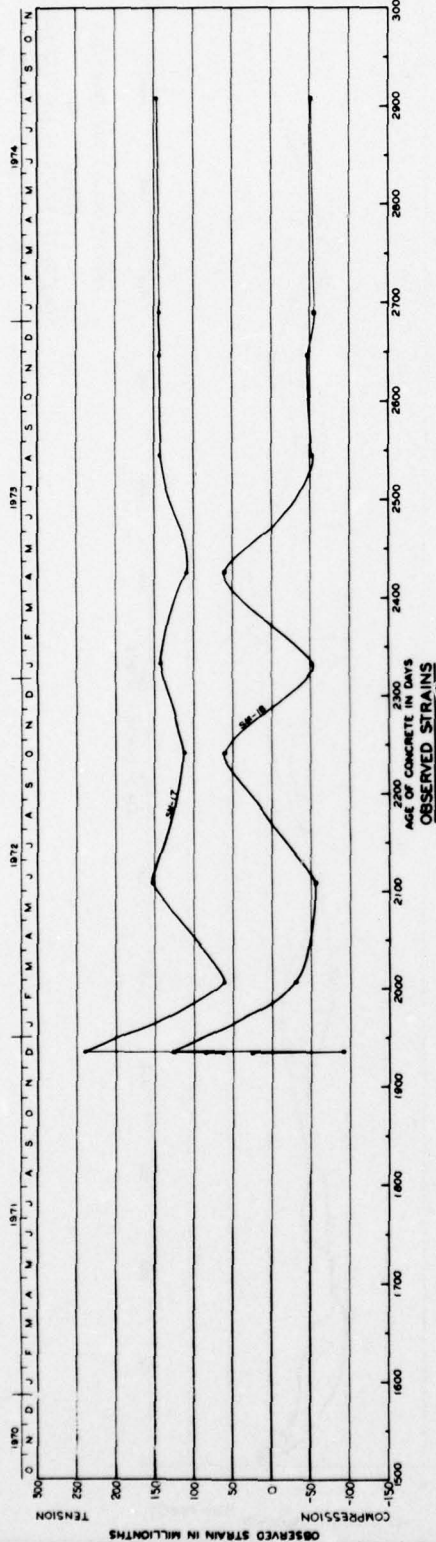


ARKANSAS LOCK AND DAM NO. 5
 MONOLITH 1B
 CONCRETE STRAIN METER DATA
 OBSERVED STRAINS
 METERS SM-15 AND SM-16

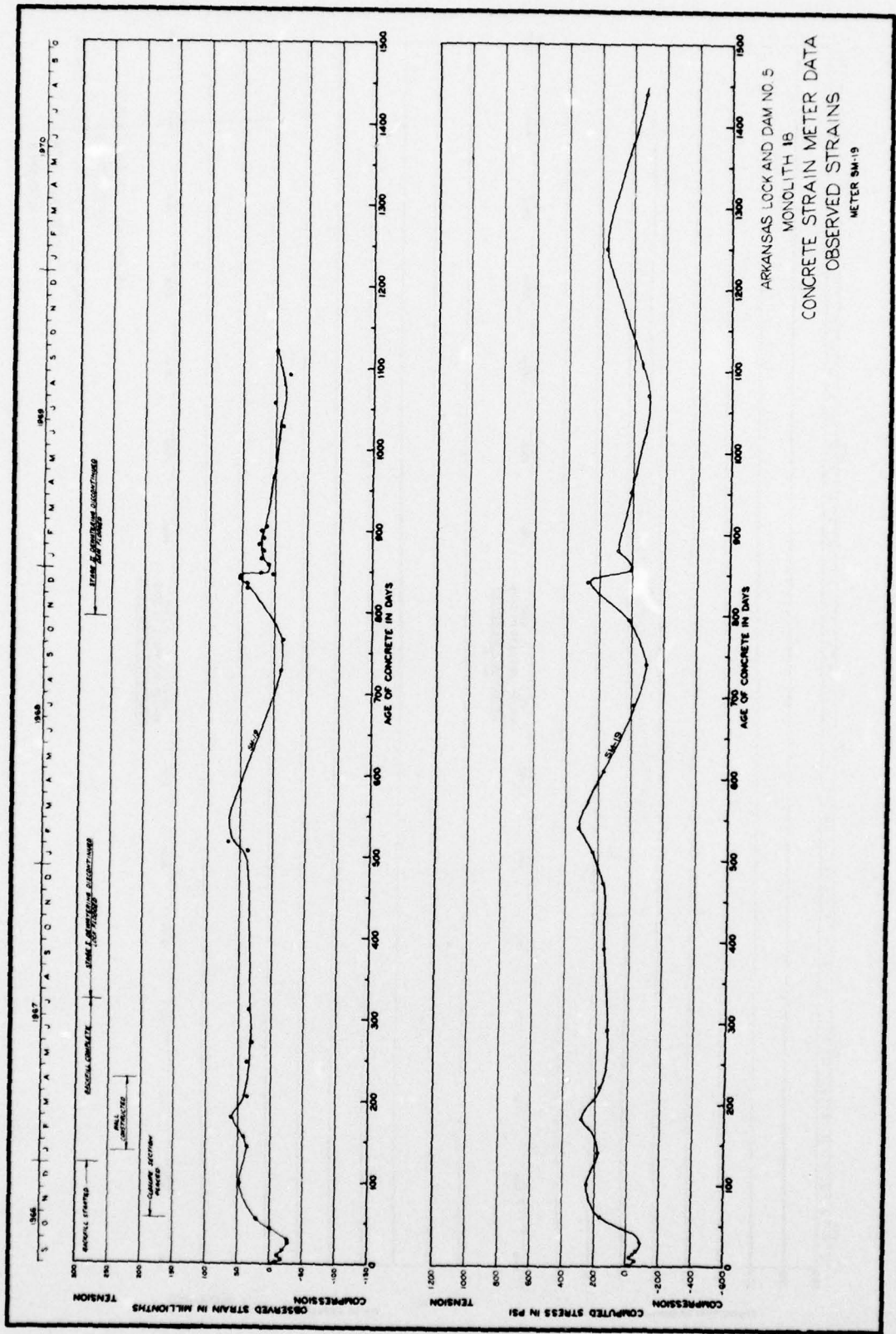




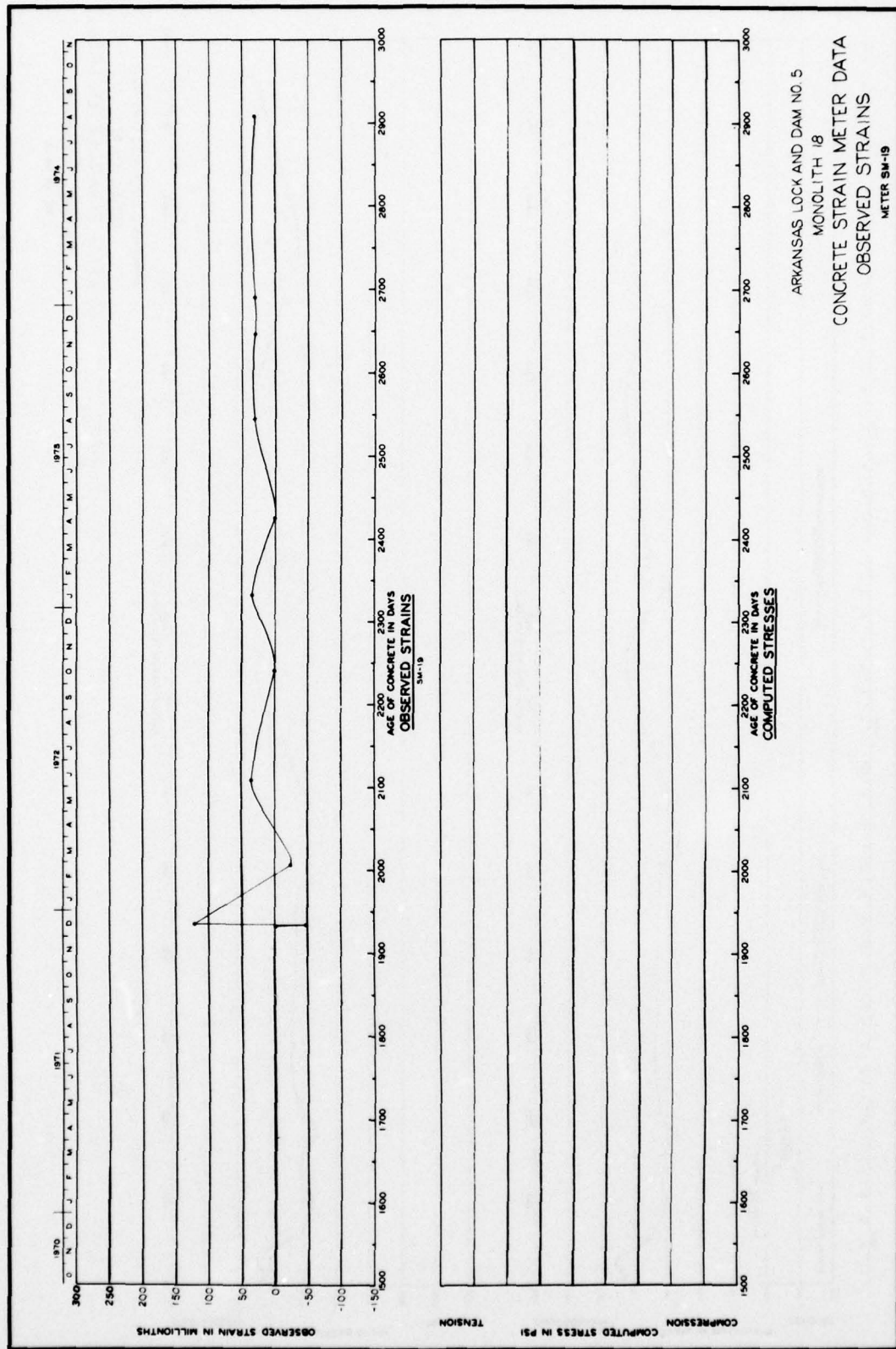
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 MONOLITH 1B
 CONCRETE STRAIN METER DATA
 OBSERVED STRAINS
 METERS SM-7 AND SM-1B



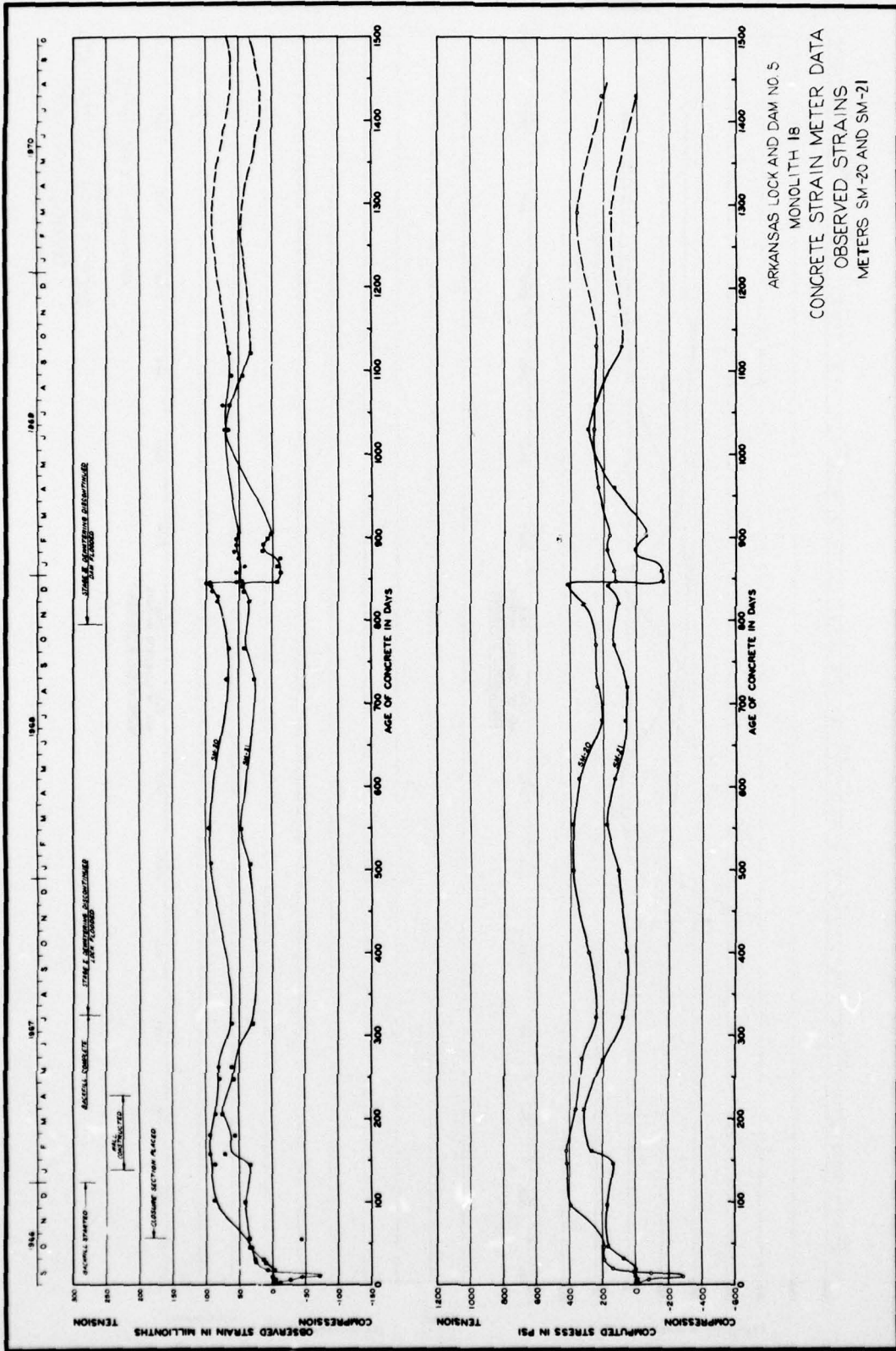
ARKANSAS LOCK AND DAM NO 5
 MONOLITH 18
 CONCRETE STRAIN METER DATA
 OBSERVED STRAINS
 METERS SM-17 AND SM-18



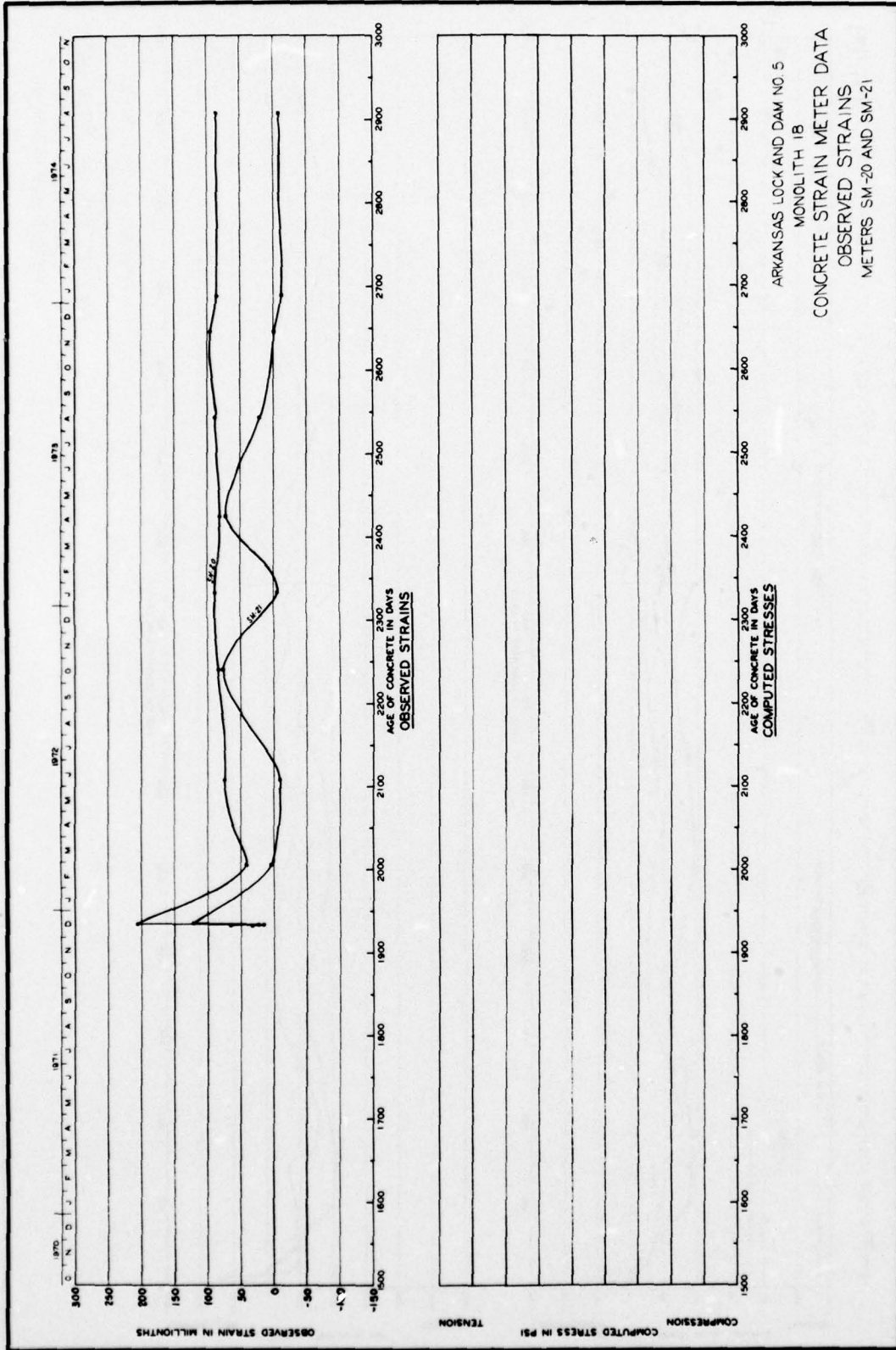
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 MONOLITH 1B
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 OBSERVED STRAINS
 METER SM-19

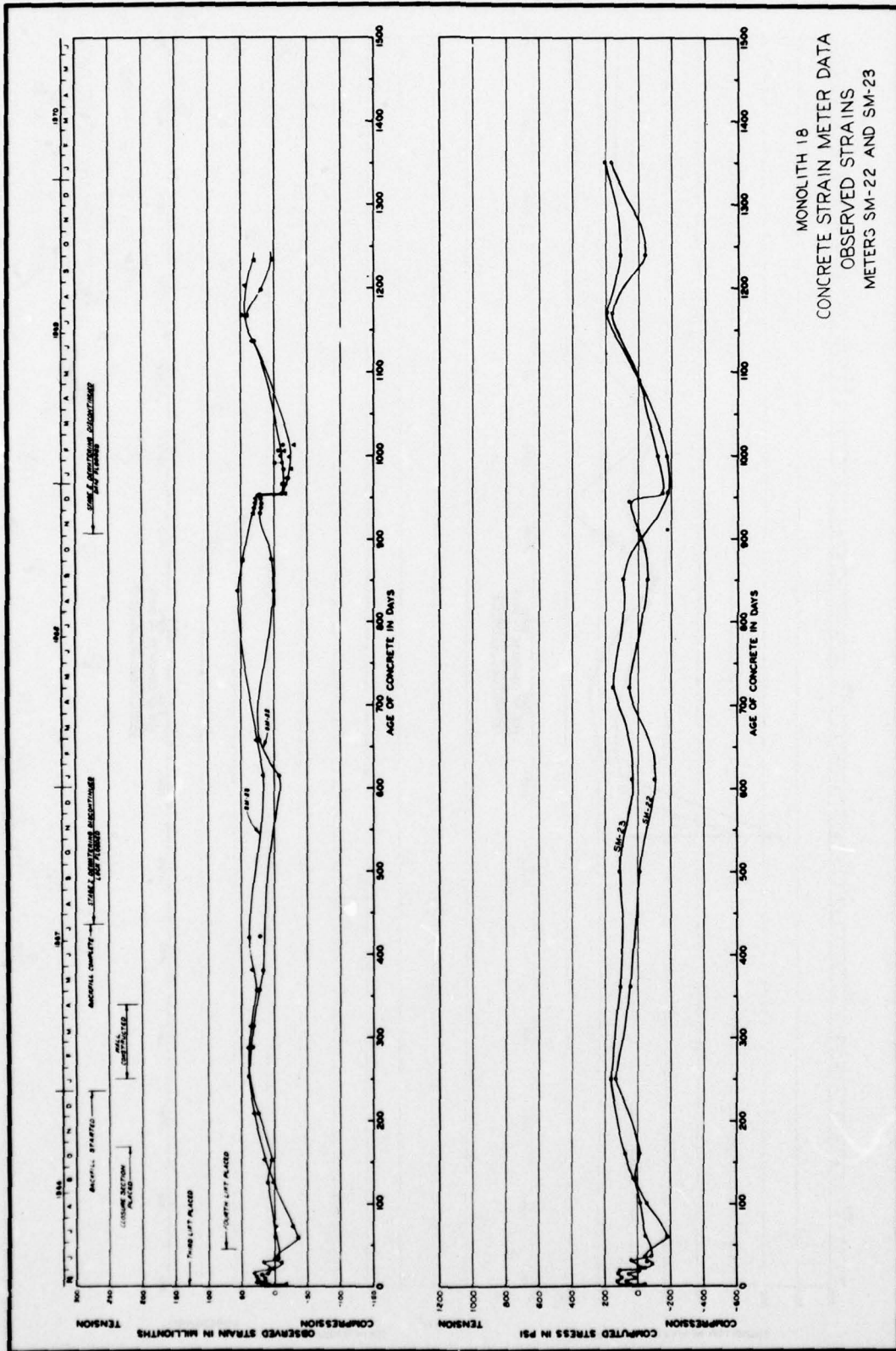


ARKANSAS LOCK AND DAM NO. 5
 MONOLITH 18
 CONCRETE STRAIN METER DATA
 OBSERVED STRAINS
 METER SM-19

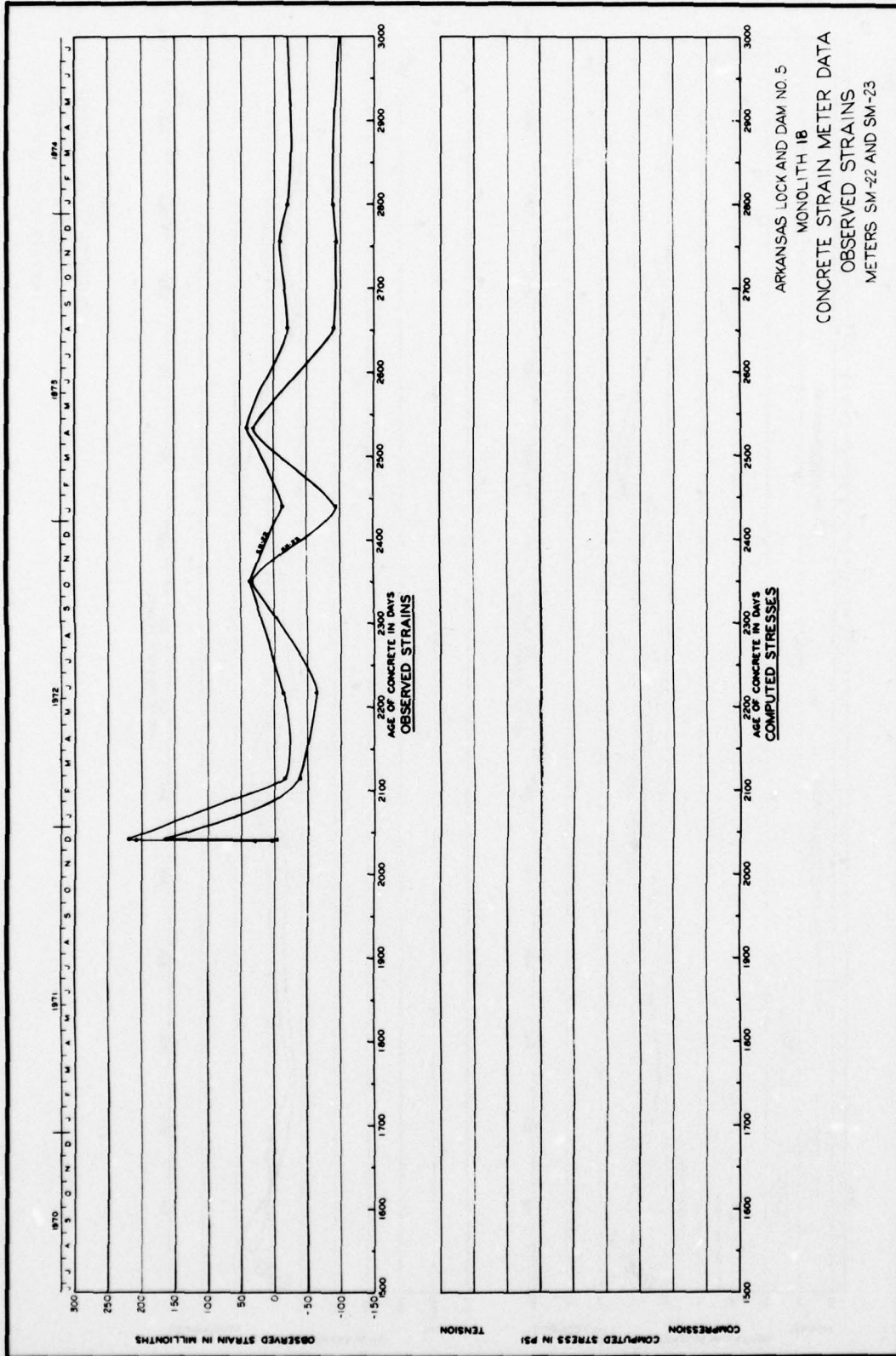


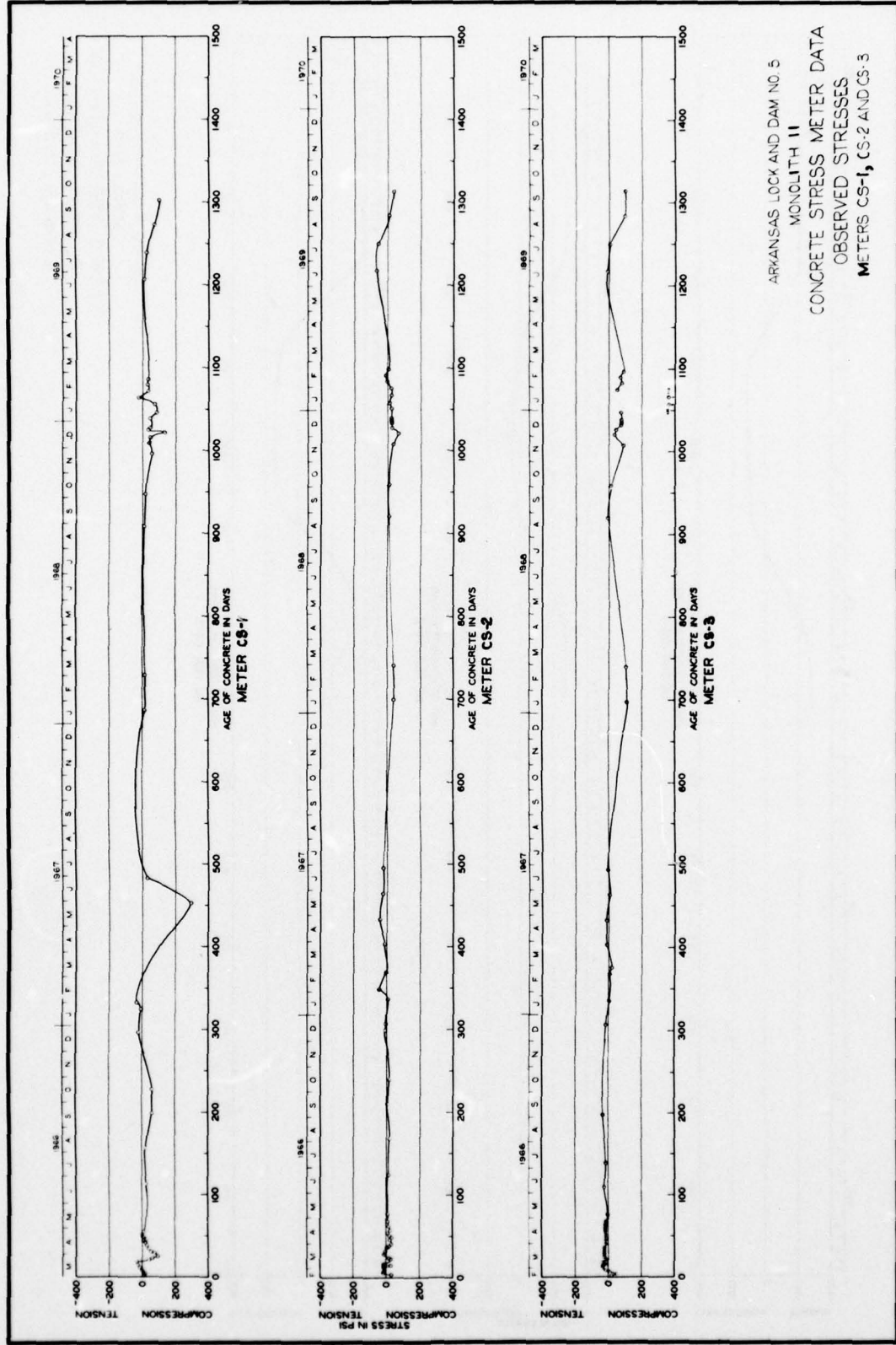
ARKANSAS LOCK AND DAM NO. 5
 MONOLITH 1B
 CONCRETE STRAIN METER DATA
 OBSERVED STRAINS
 METERS SM-20 AND SM-21



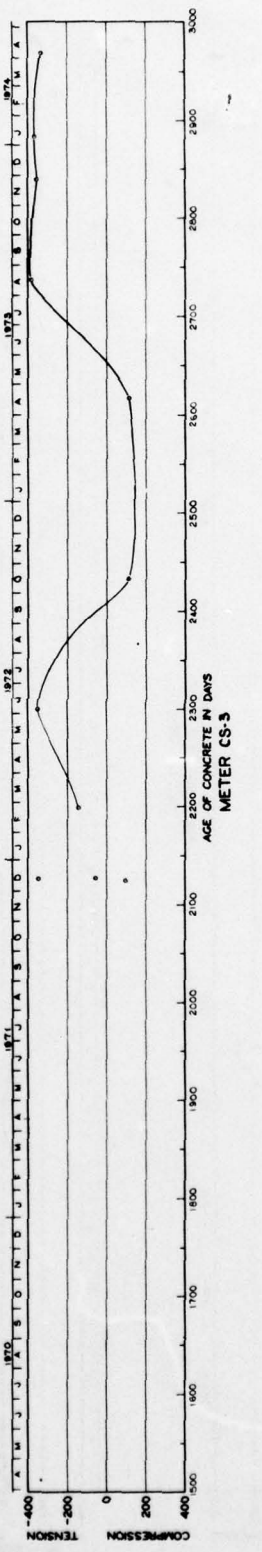
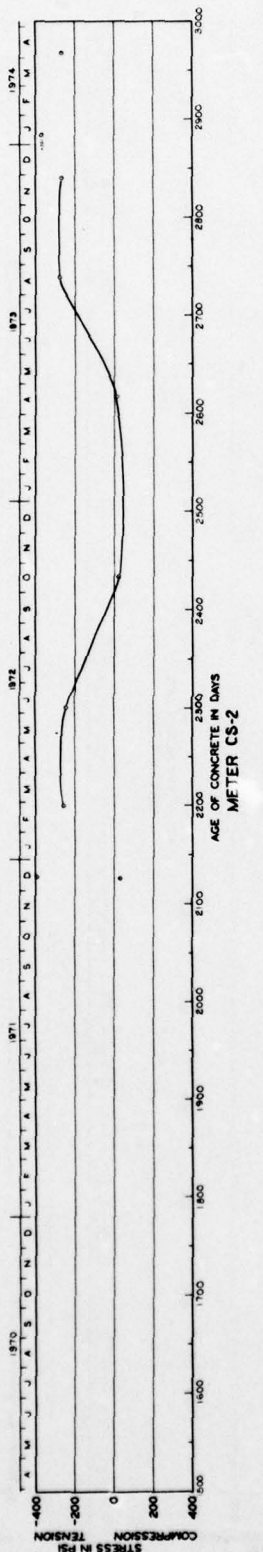
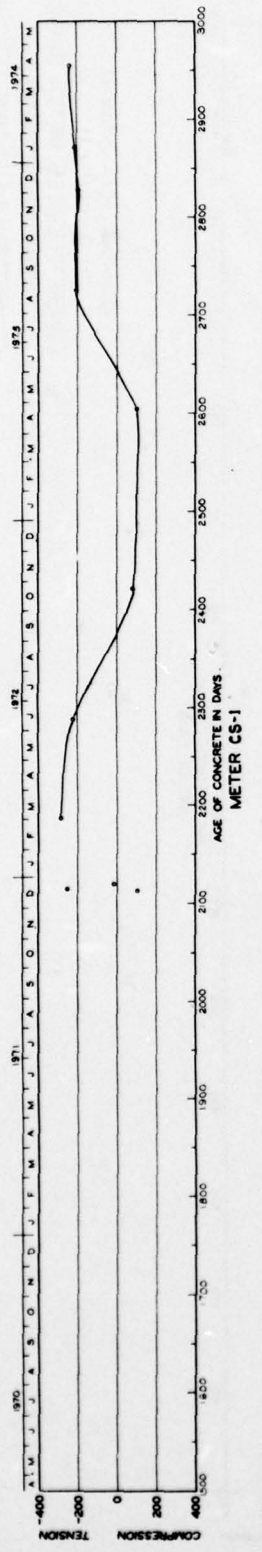


MONOLITH 18
 CONCRETE STRAIN METER DATA
 OBSERVED STRAINS
 METERS SM-22 AND SM-23

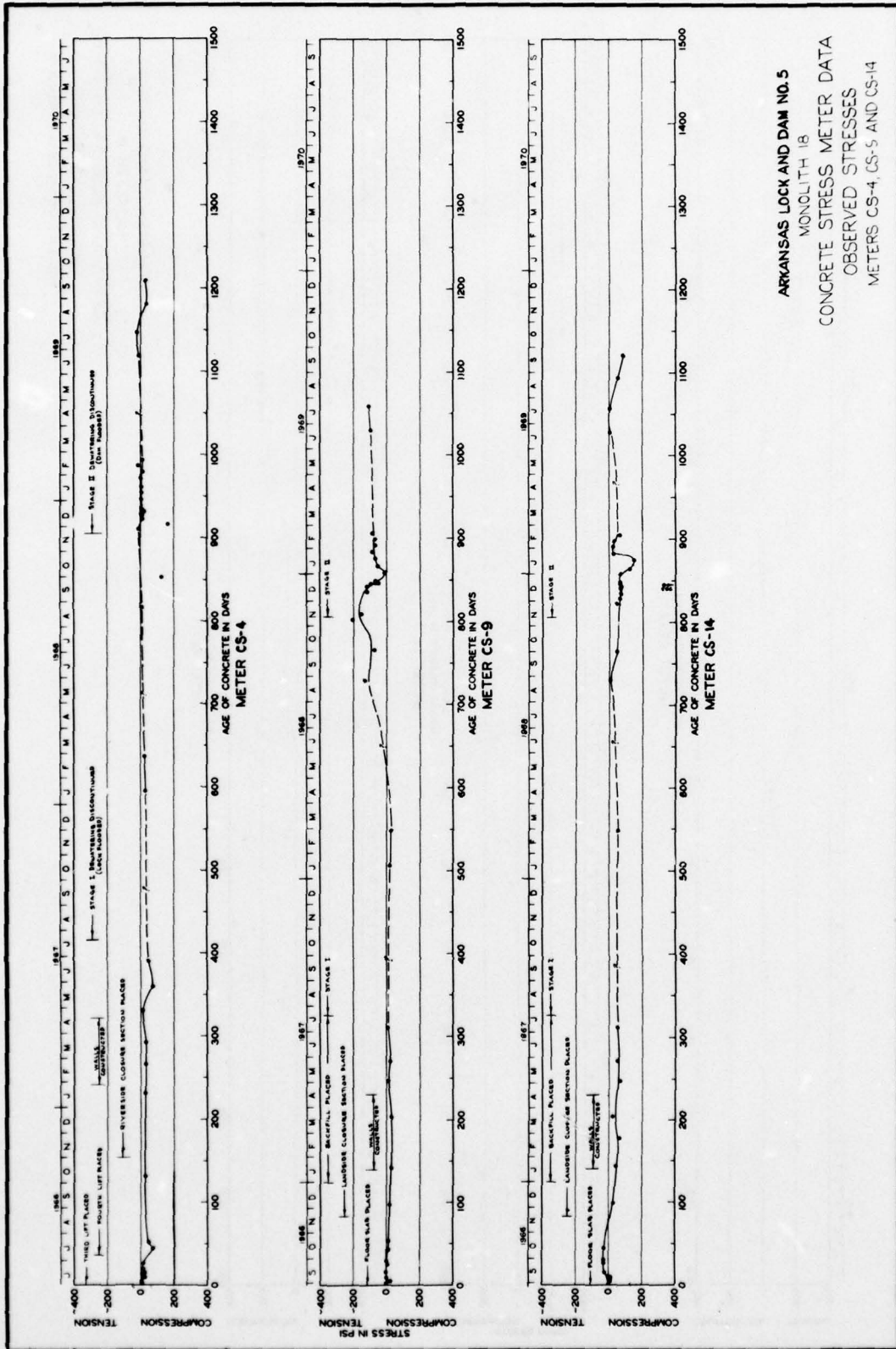




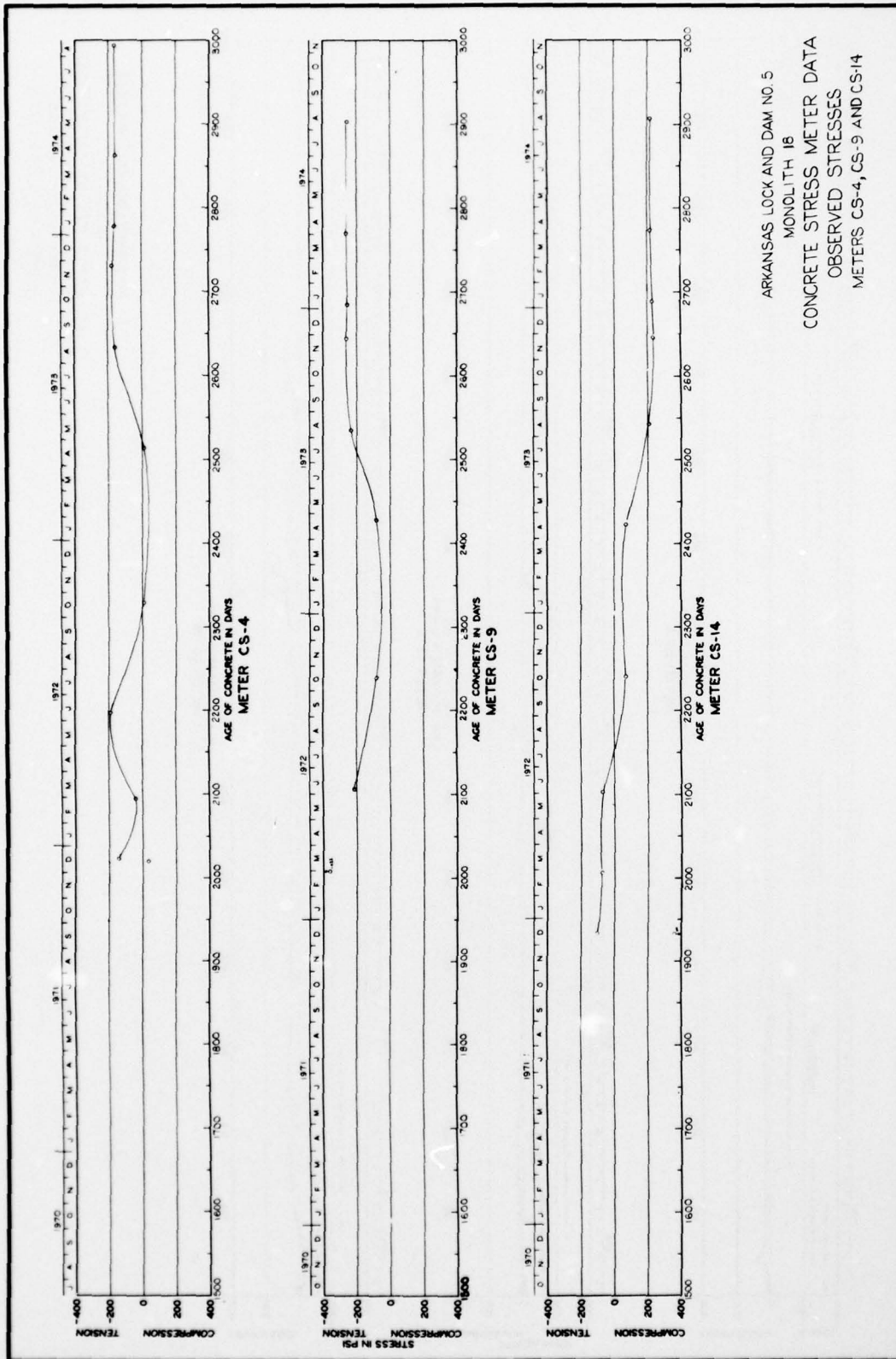
ARKANSAS LOCK AND DAM NO. 5
 MONOLITH II
 CONCRETE STRESS METER DATA
 OBSERVED STRESSES
 METERS CS-1, CS-2 AND CS-3

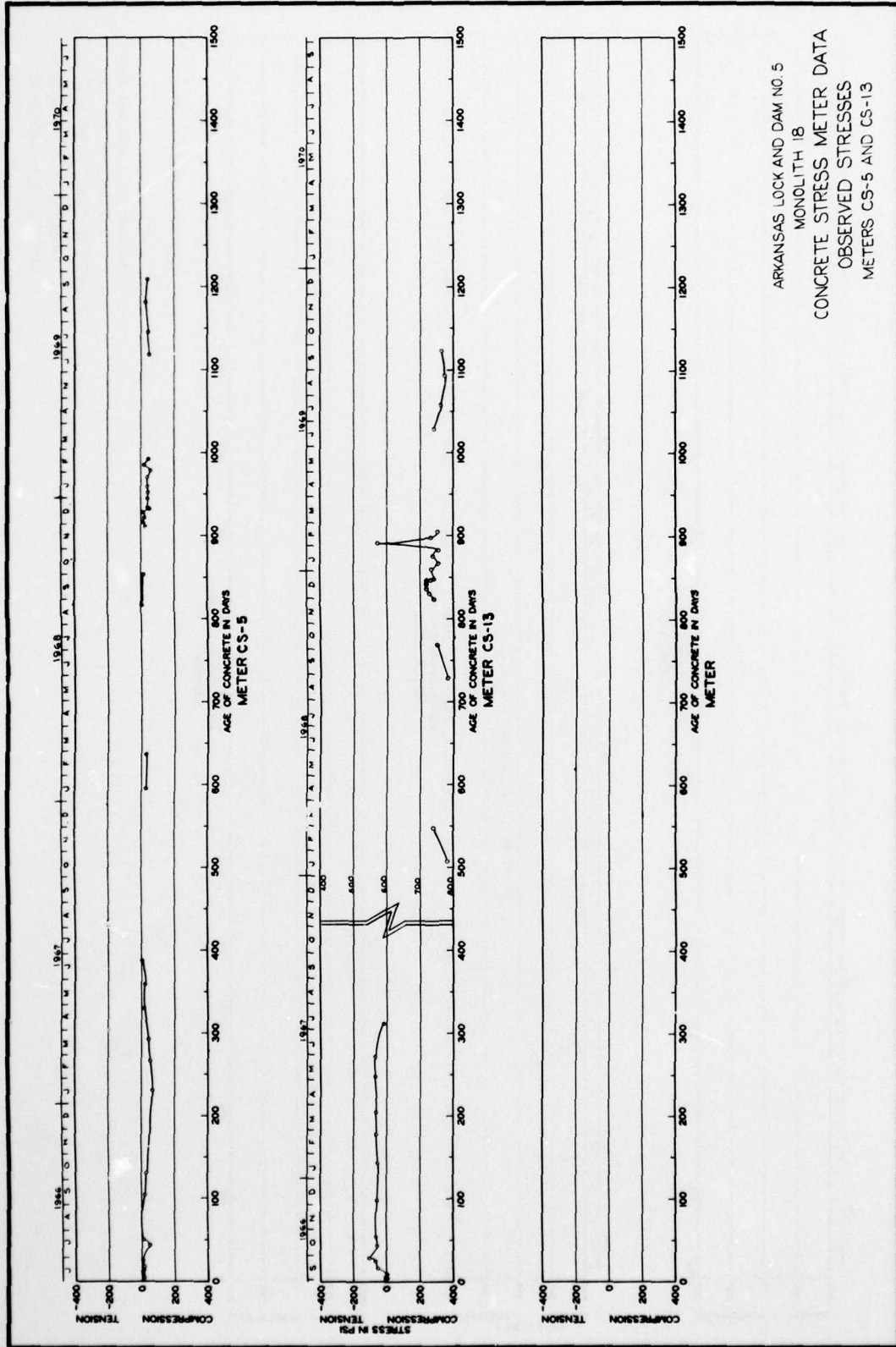


ARKANSAS LOCK AND DAM NO. 5
MONOLITH II
CONCRETE STRESS METER DATA
OBSERVED STRESSES
METERS CS-1, CS-2 AND CS-3

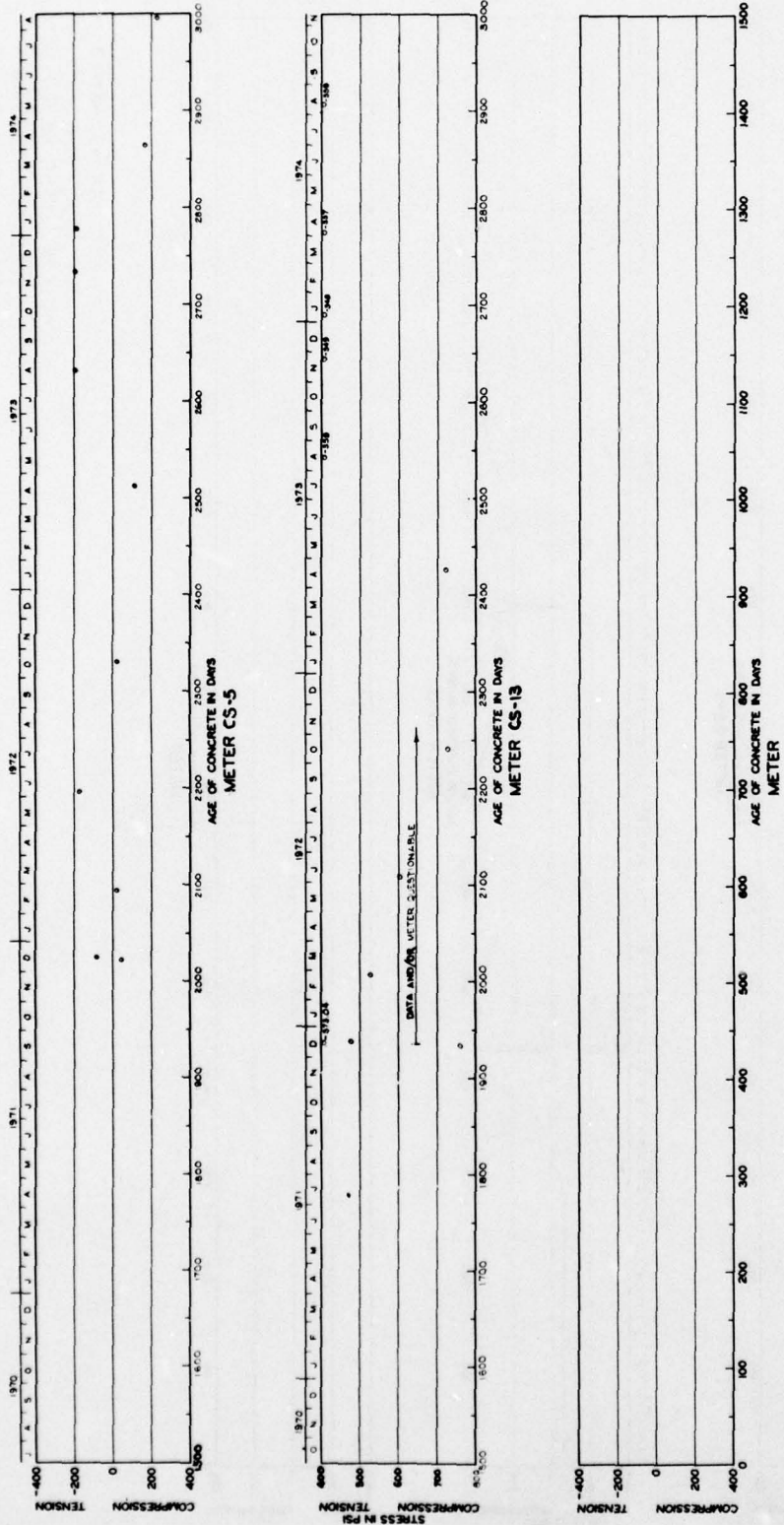


ARKANSAS LOCK AND DAM NO. 5
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 CONCRETE STRESS METER DATA
 OBSERVED STRESSES
 METERS CS-4, CS-5 AND CS-14

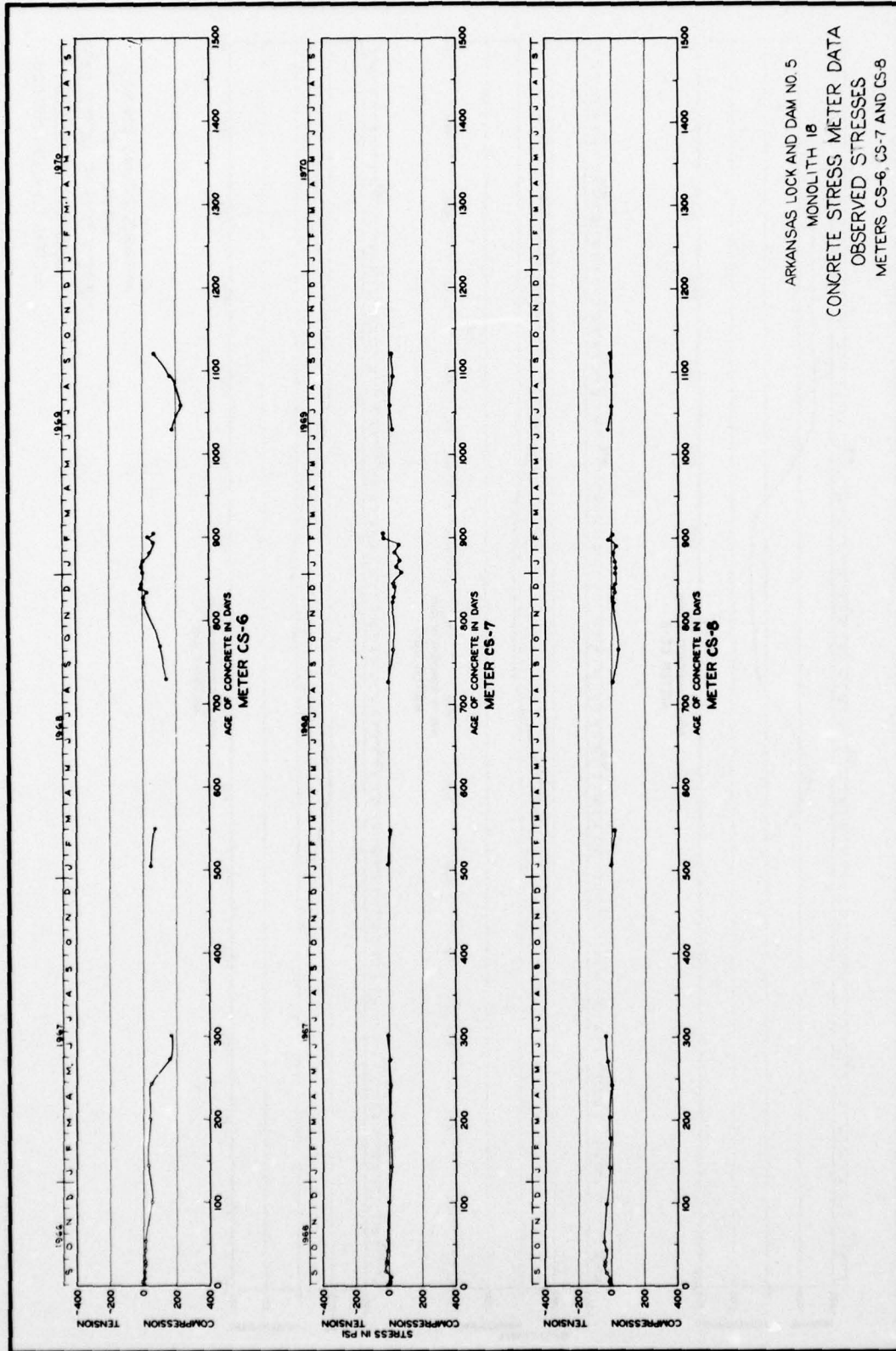




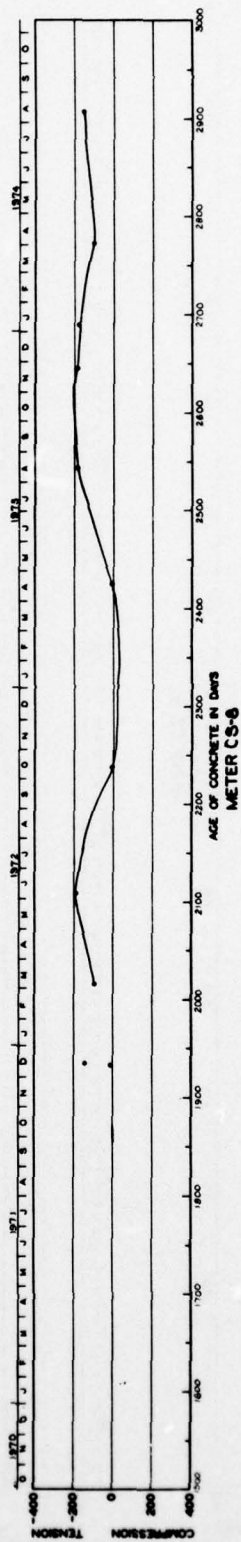
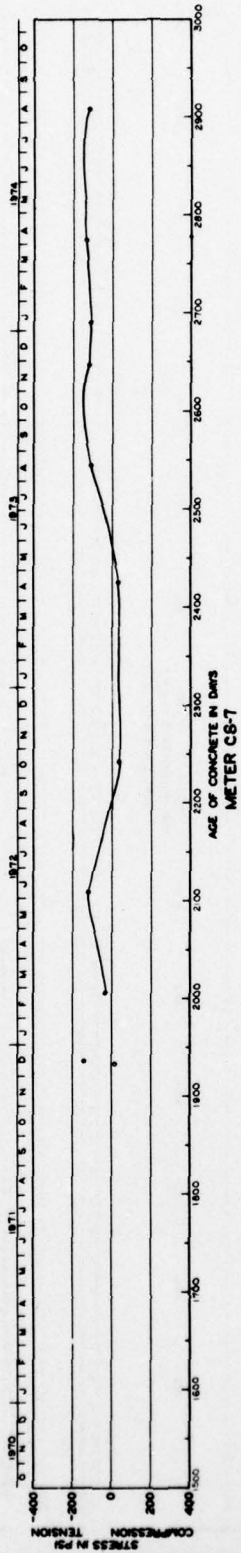
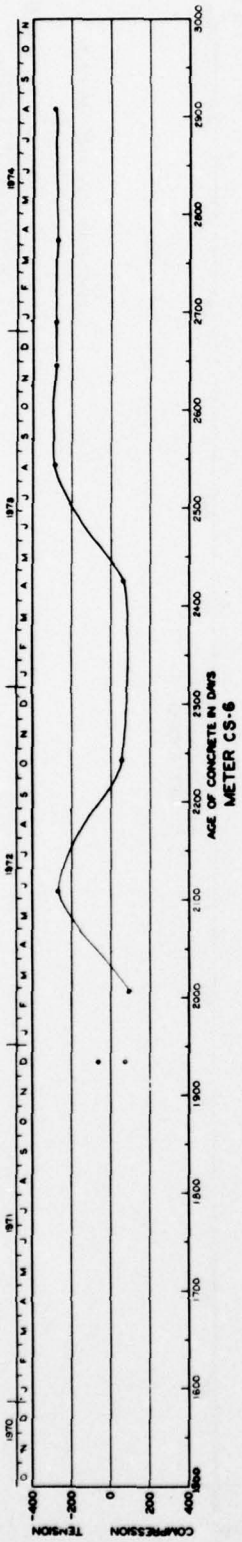
ARKANSAS LOCK AND DAM NO. 5
 MONOLITH 18
 CONCRETE STRESS METER DATA
 OBSERVED STRESSES
 METERS CS-5 AND CS-13



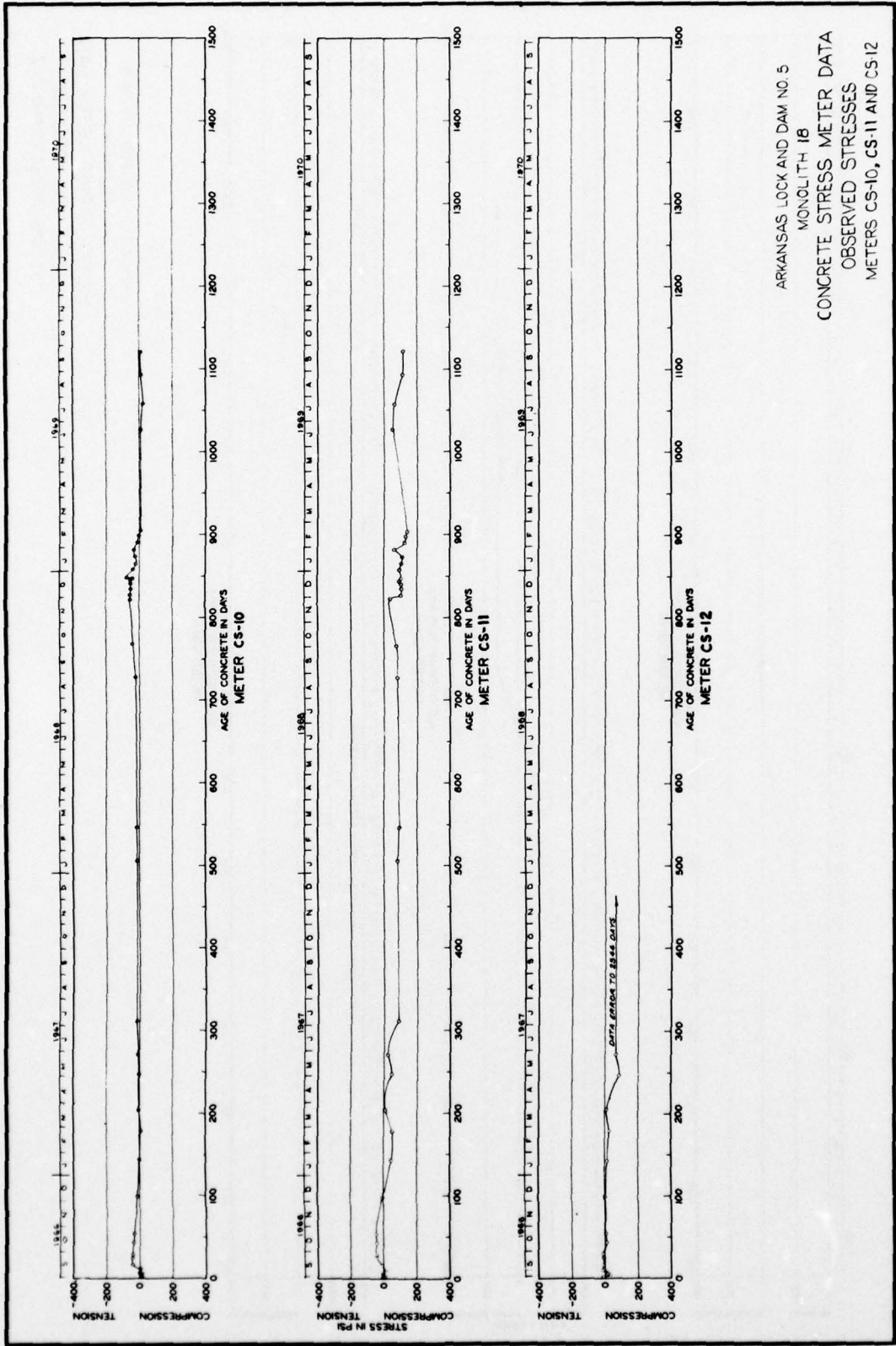
ARKANSAS LOCK AND DAM NO. 5
 MONOLITH 1B
 CONCRETE STRESS METER DATA
 OBSERVED STRESSES
 METERS CS-5 AND CS-13

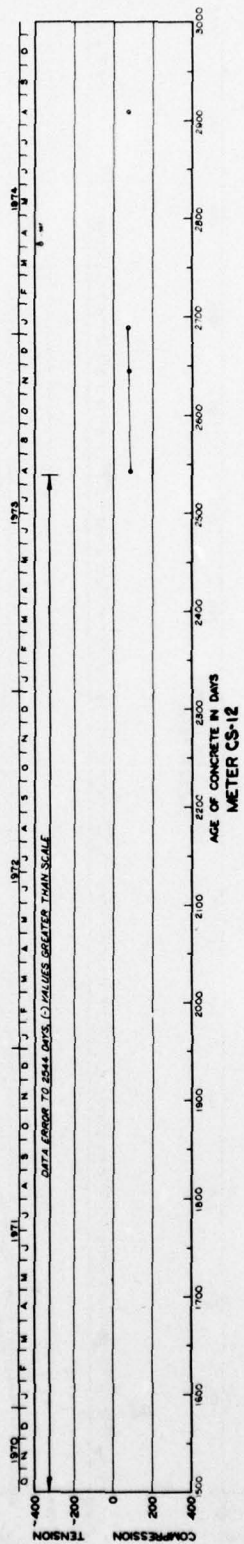
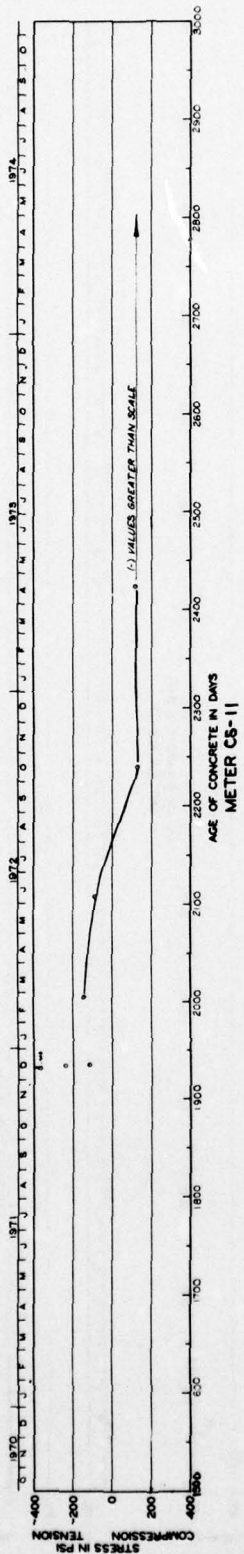
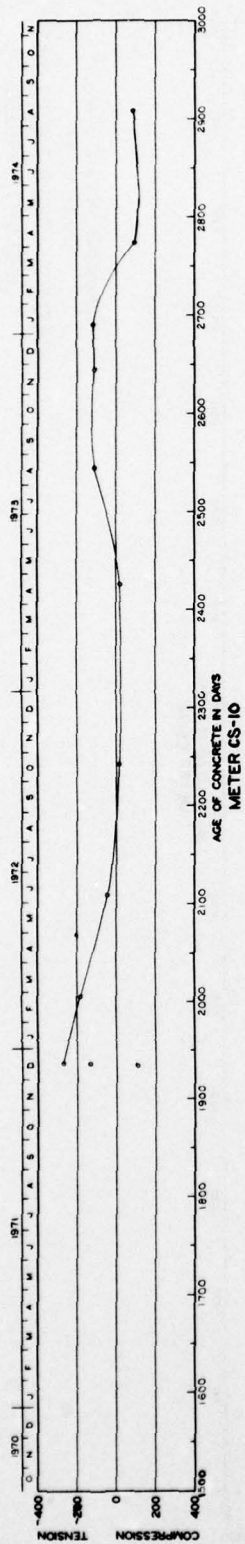


ARKANSAS LOCK AND DAM NO. 5
 MONOLITH 18
 CONCRETE STRESS METER DATA
 OBSERVED STRESSES
 METERS CS-6, CS-7 AND CS-8

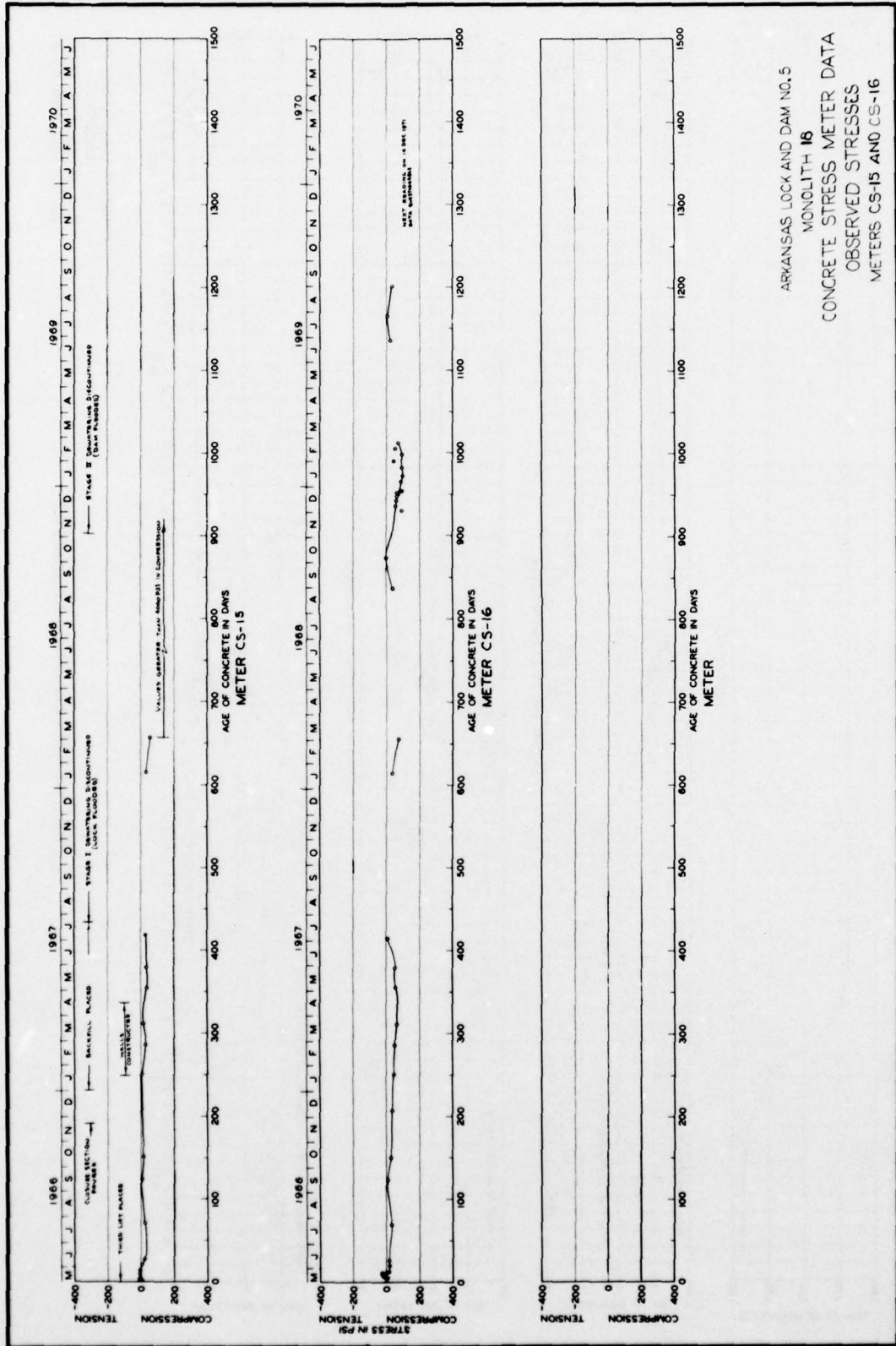


ARKANSAS LOCK AND DAM NO. 5
MONOLITH 18
CONCRETE STRESS METER DATA
OBSERVED STRESSES
METERS CS-6, CS-7 AND CS-8

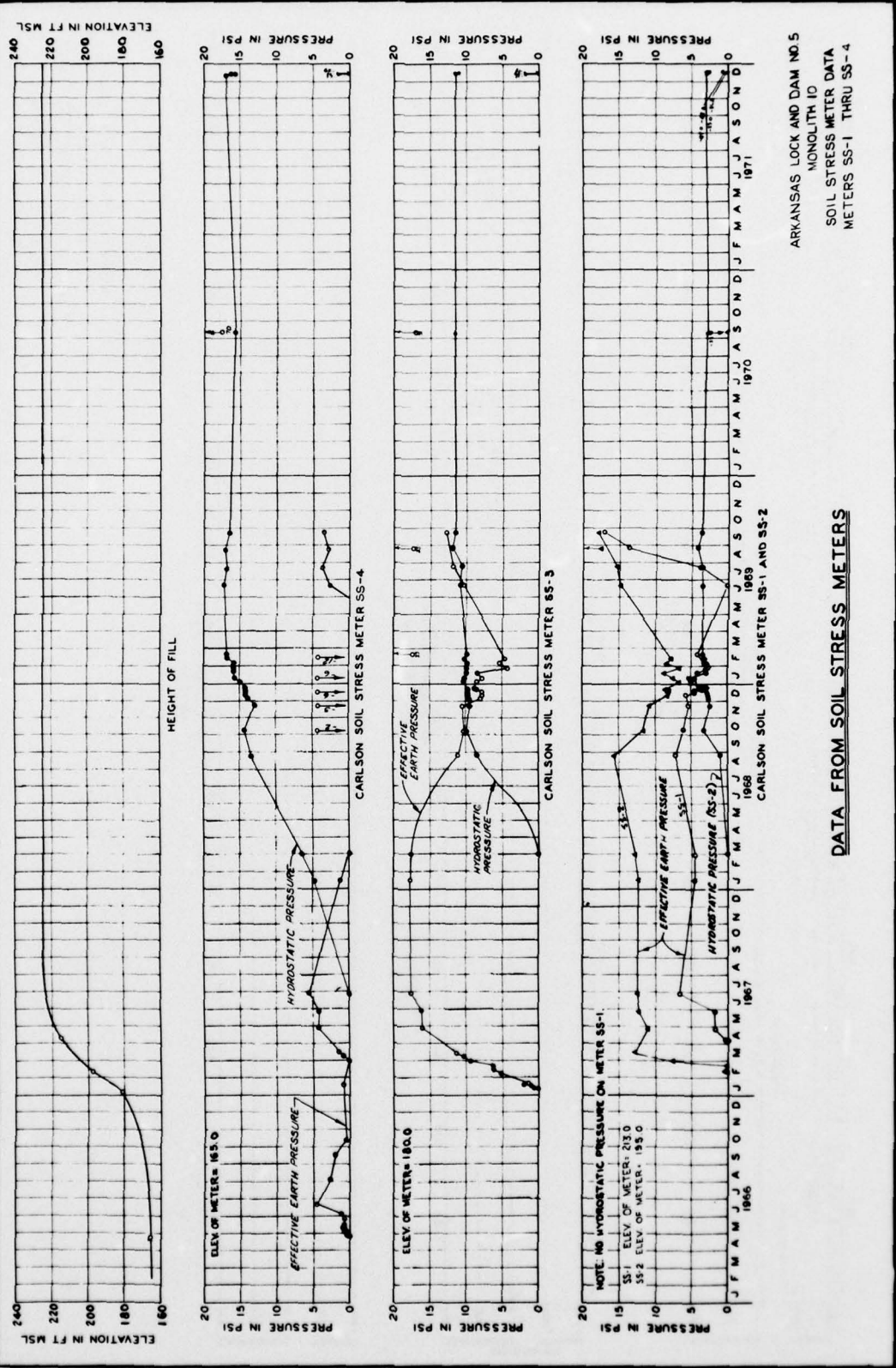




ARKANSAS LOCK AND DAM NO. 5
 MONOLITH 3
 CONCRETE STRESS METER DATA
 OBSERVED STRESSES
 METERS CS-10, CS-11 AND CS-12

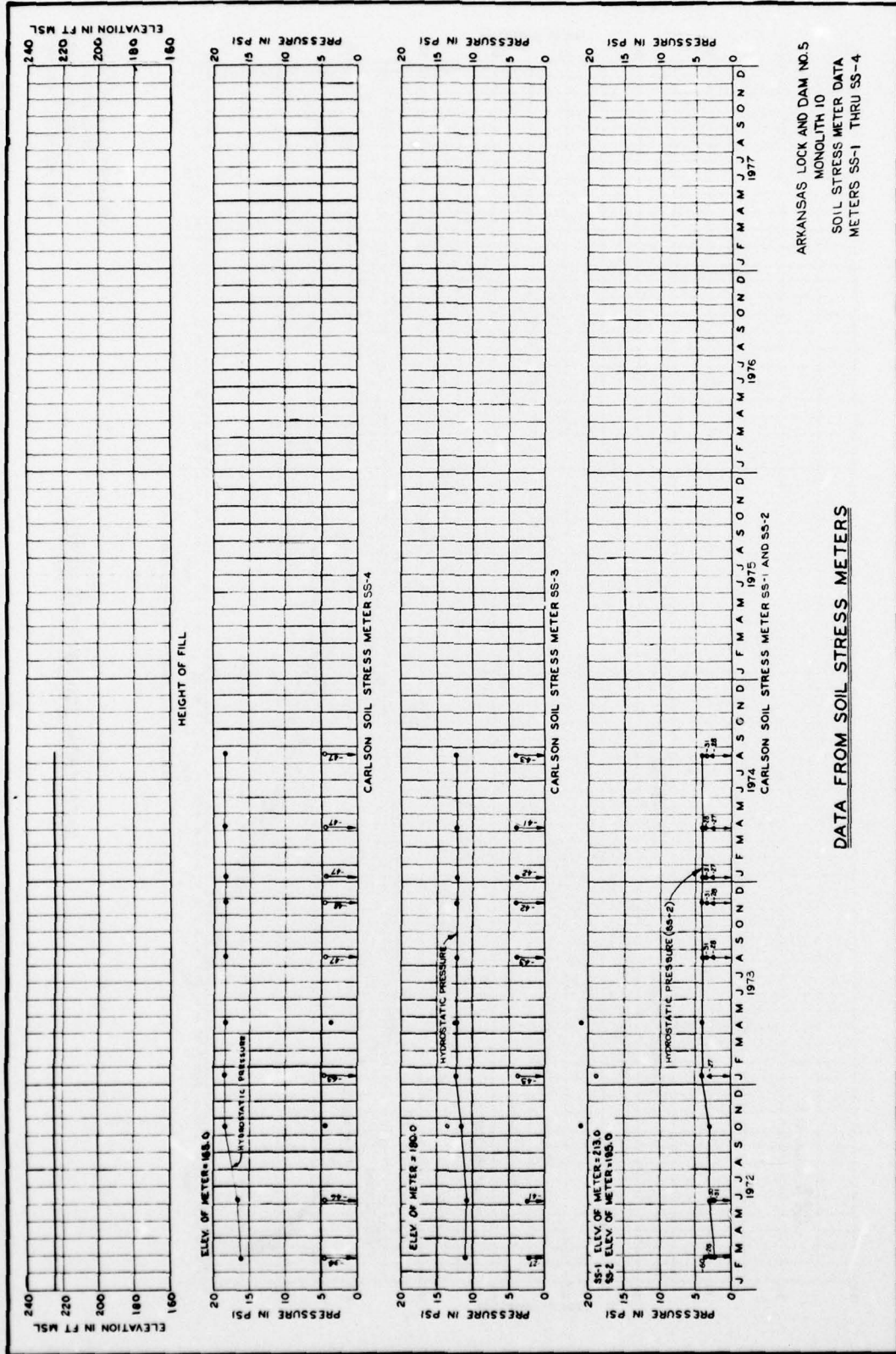


ARKANSAS LOCK AND DAM NO. 5
 MONOLITH 16
 CONCRETE STRESS METER DATA
 OBSERVED STRESSES
 METERS CS-15 AND CS-16



ARKANSAS LOCK AND DAM NO. 5
MONOLITH ID
SOIL STRESS METER DATA
METERS SS-1 THRU SS-4

DATA FROM SOIL STRESS METERS



ARKANSAS LOCK AND DAM NO.5
 MONOLITH 10
 SOIL STRESS METER DATA
 METERS SS-1 THRU SS-4

DATA FROM SOIL STRESS METERS

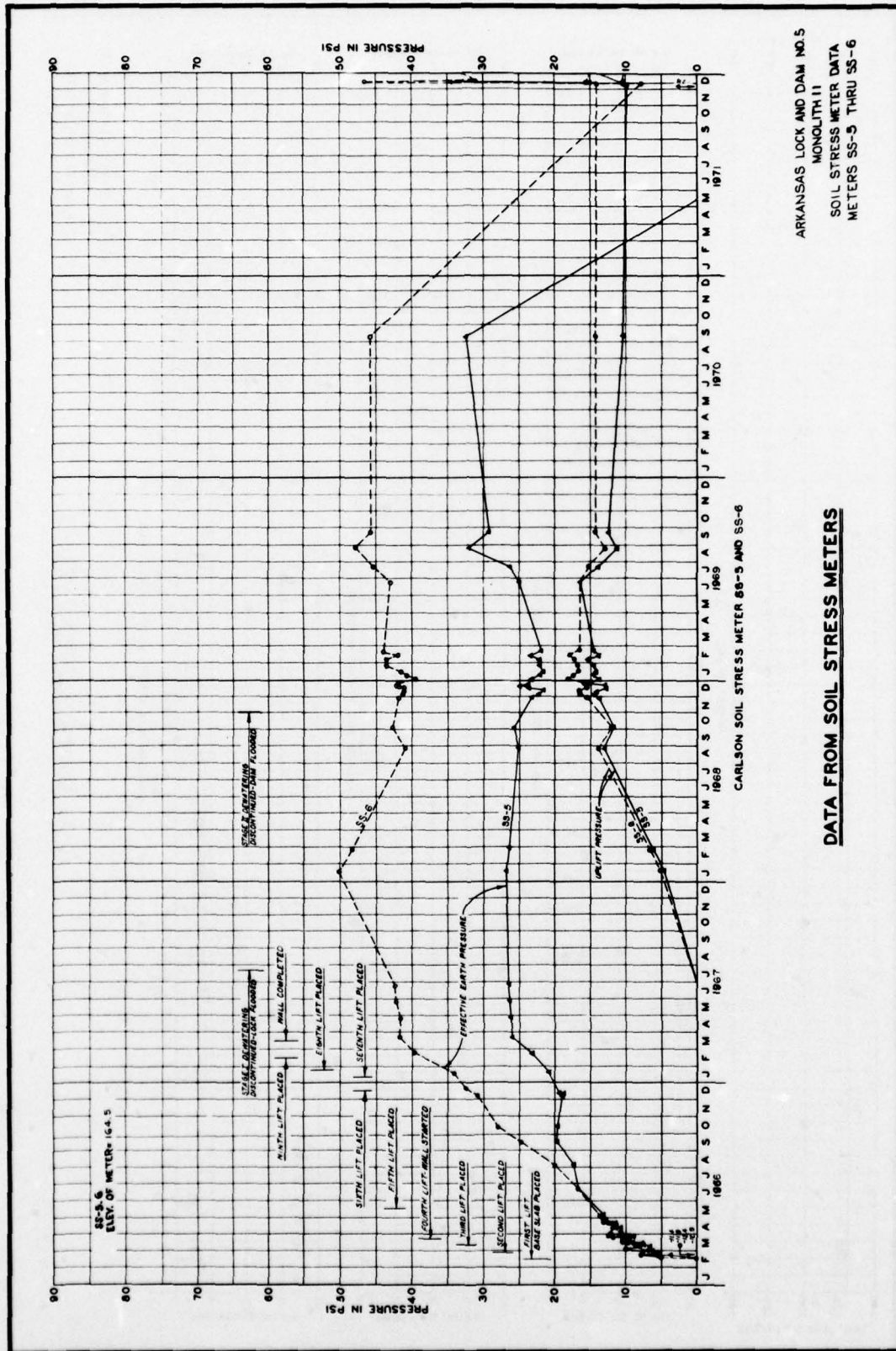
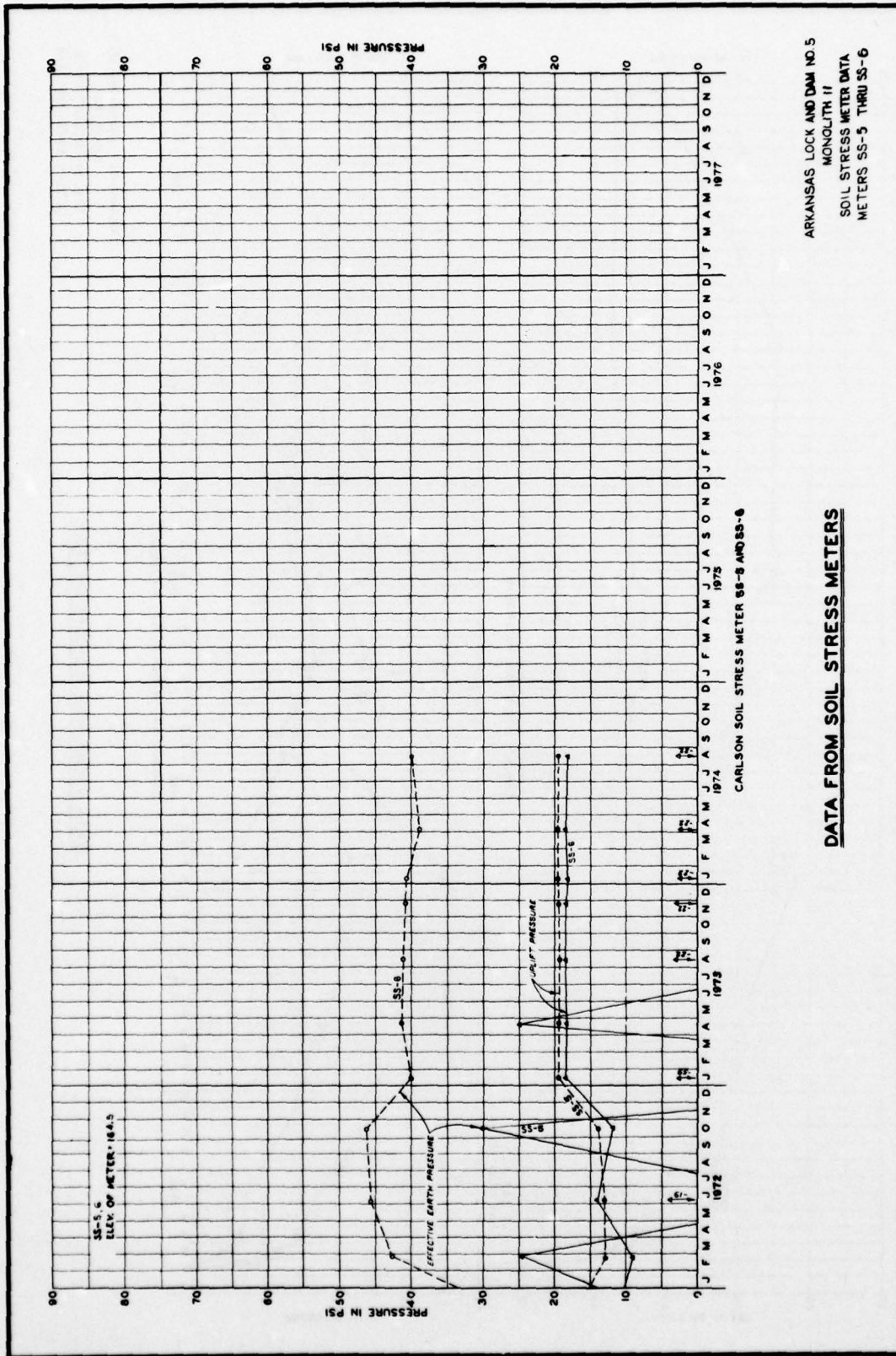


PLATE 44

ARKANSAS LOCK AND DAM NO. 5
MONOLITH II
SOIL STRESS METER DATA
METERS SS-5 THRU SS-6

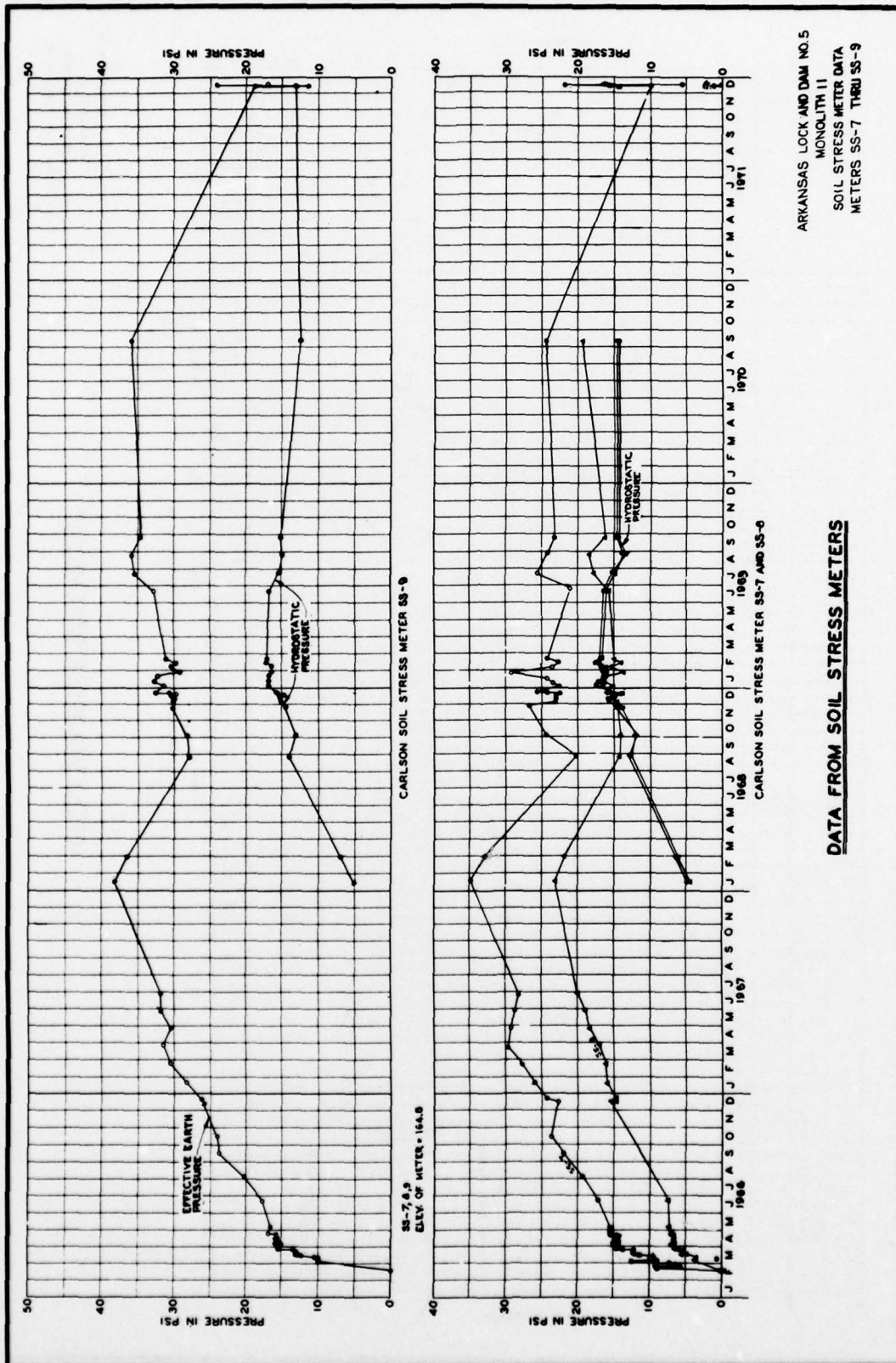
DATA FROM SOIL STRESS METERS

CARLSON SOIL STRESS METER 88-5 AND 88-6



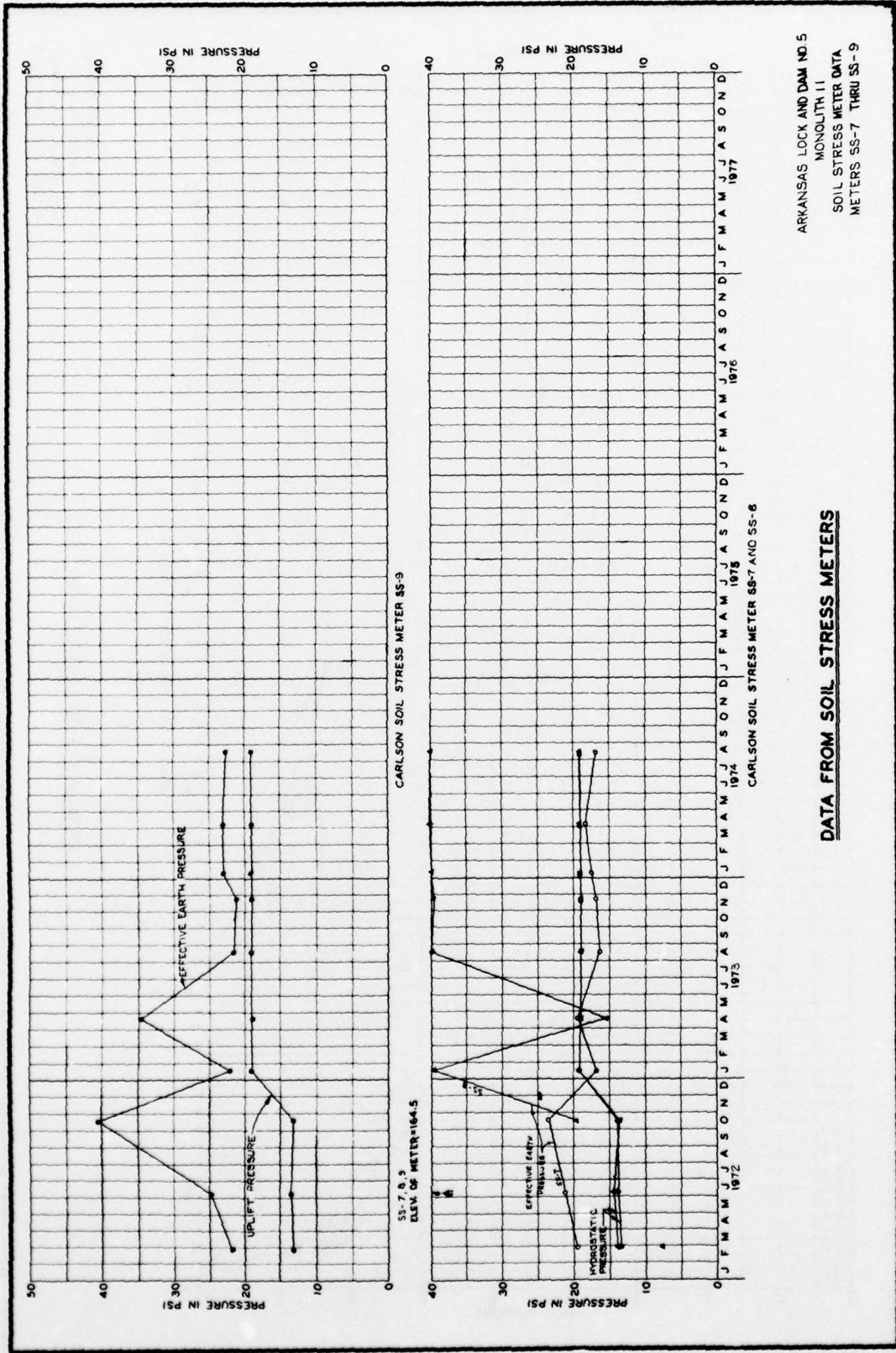
ARKANSAS LOCK AND DAM NO. 5
MONOLITH II
SOIL STRESS METER DATA
METERS SS-5 THRU SS-6

DATA FROM SOIL STRESS METERS



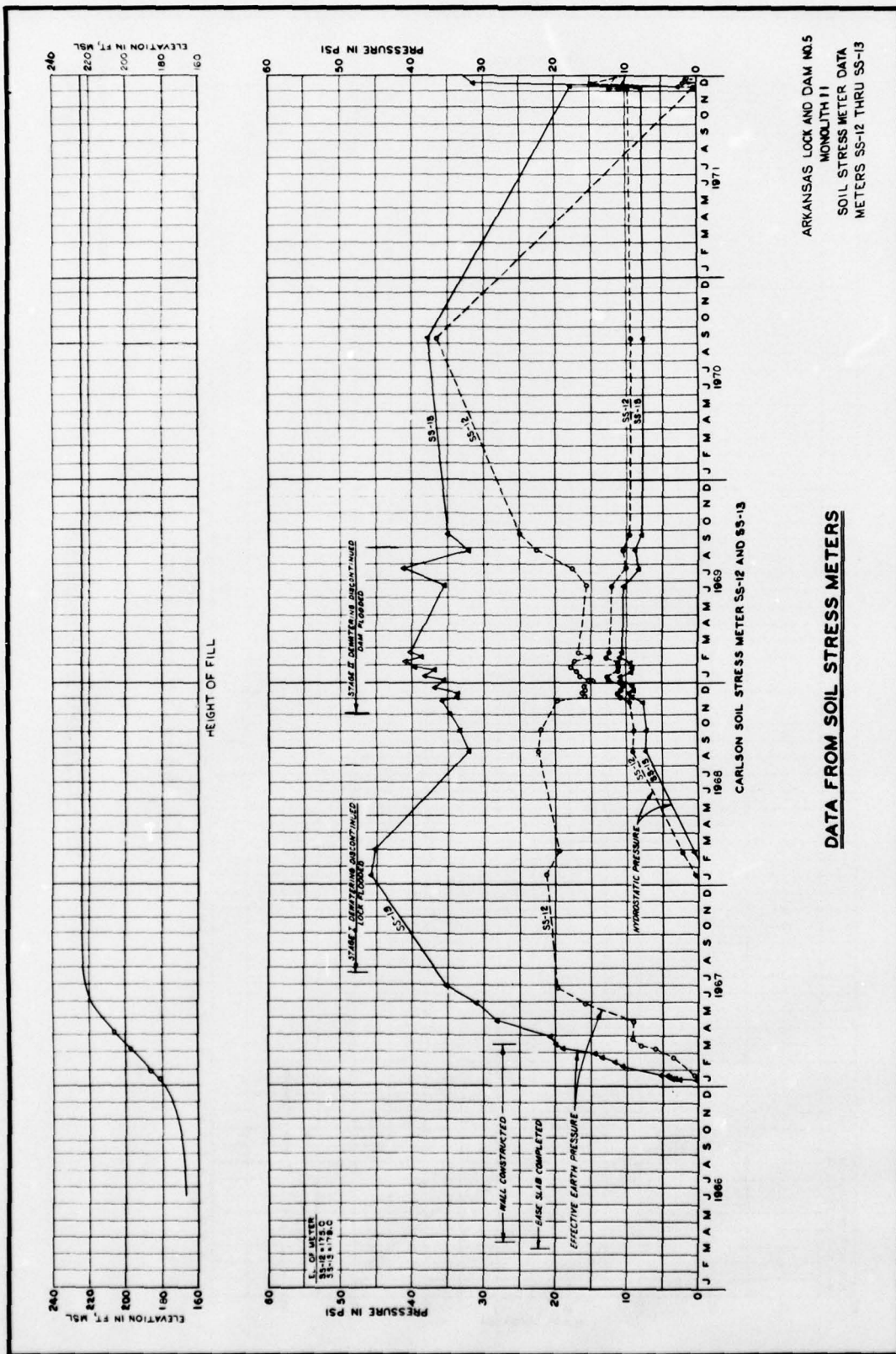
ARKANSAS LOCK AND DAM NO. 5
 MONOLITH 11
 SOIL STRESS METER DATA
 METERS SS-7 THRU SS-9

DATA FROM SOIL STRESS METERS



ARKANSAS LOCK AND DAM NO. 5
 MONOLITH 11
 SOIL STRESS METER DATA
 METERS SS-7 THRU SS-9

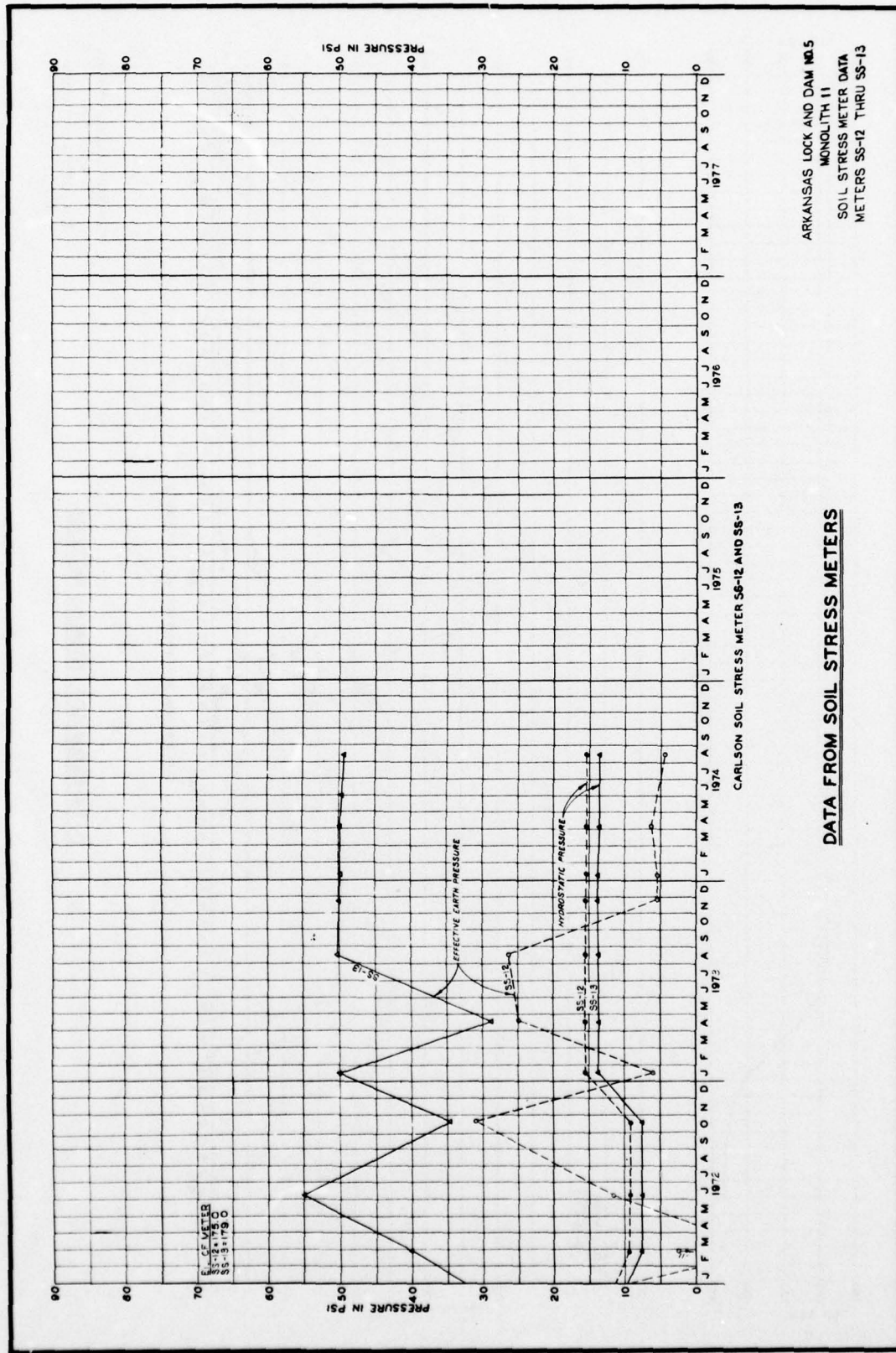
DATA FROM SOIL STRESS METERS

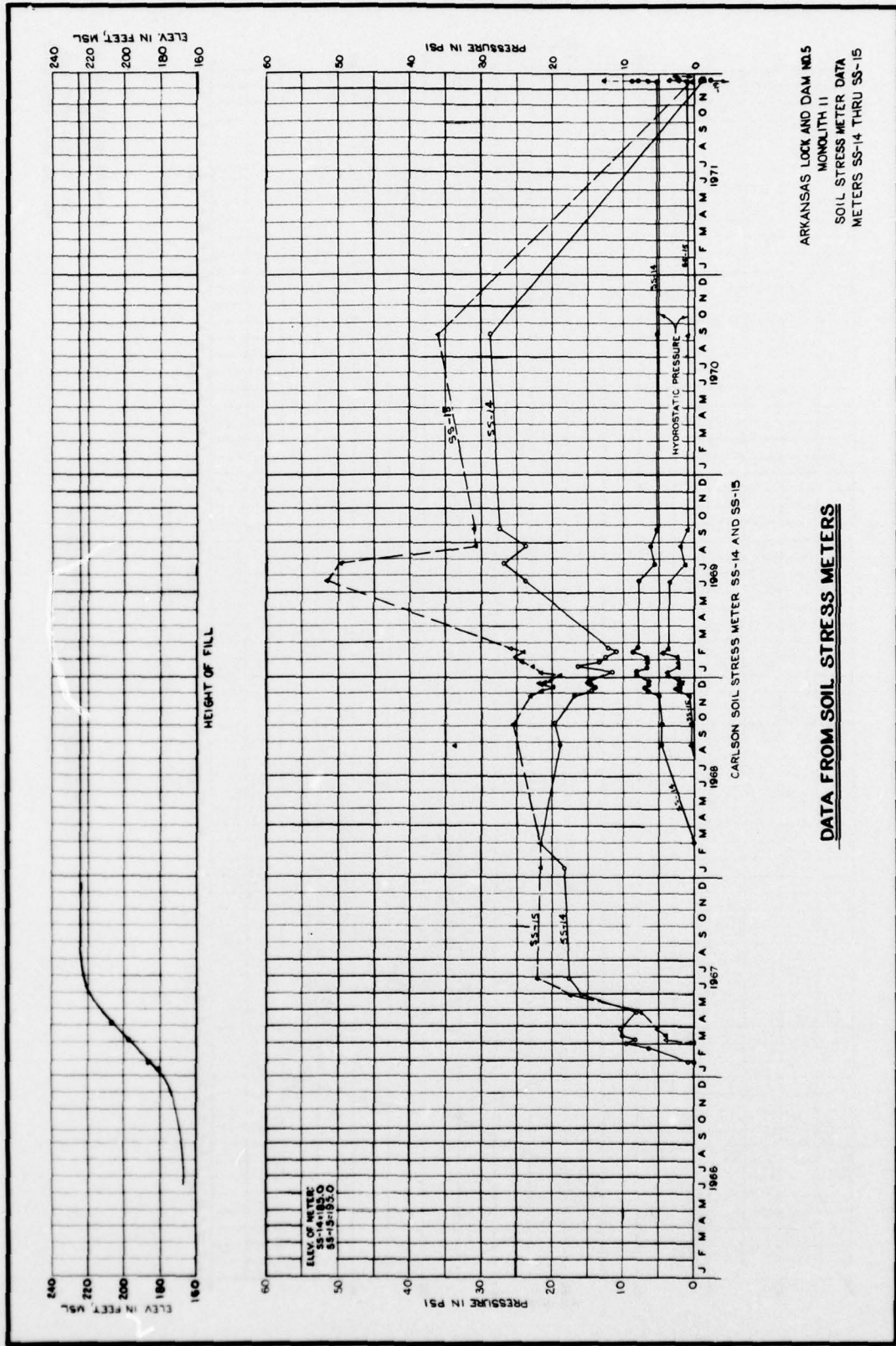


ARKANSAS LOCK AND DAM NO.5
MONOLITH II
SOIL STRESS METER DATA
METERS SS-12 THRU SS-13

DATA FROM SOIL STRESS METERS

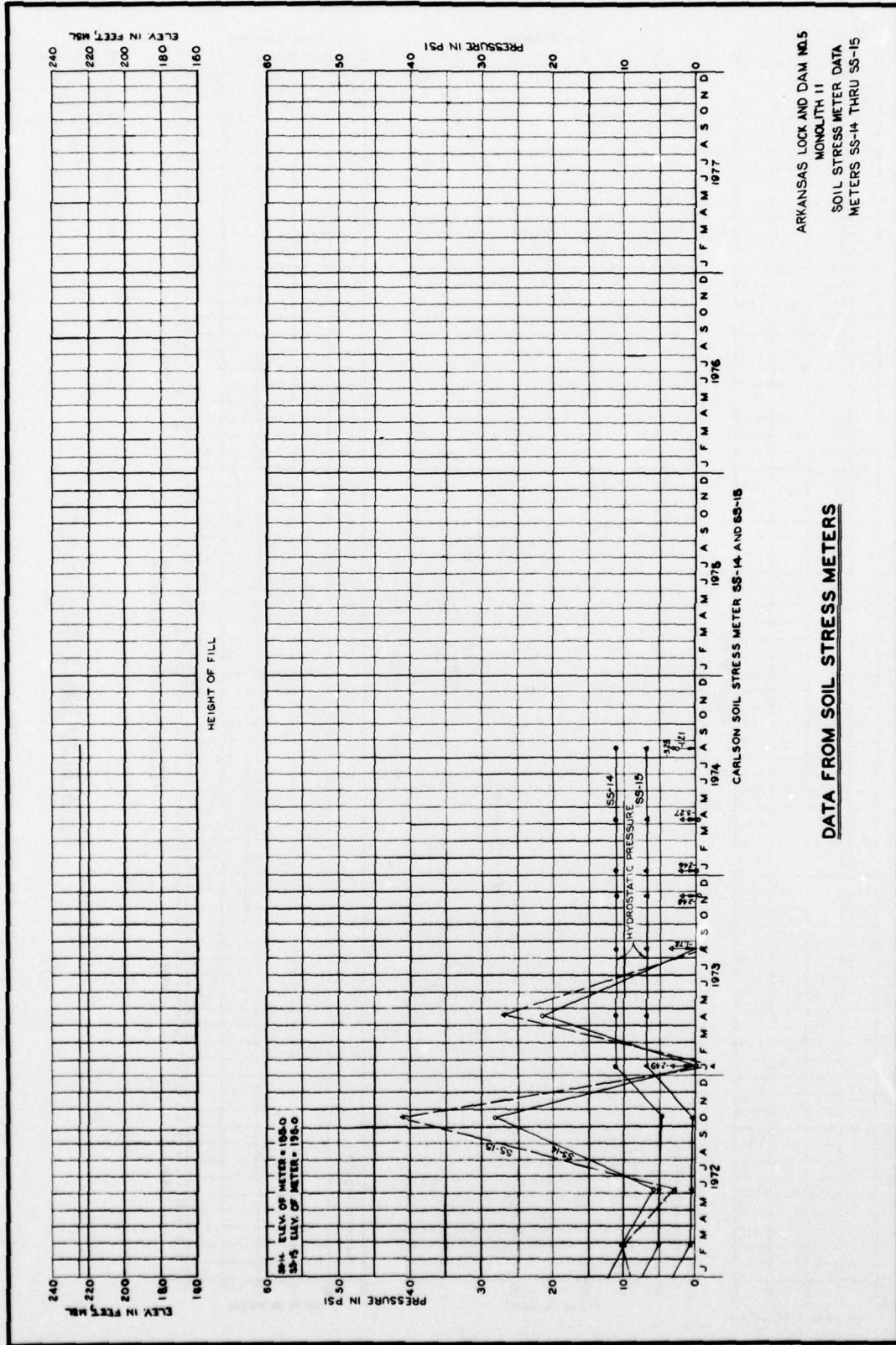
CARLSON SOIL STRESS METER SS-12 AND SS-13

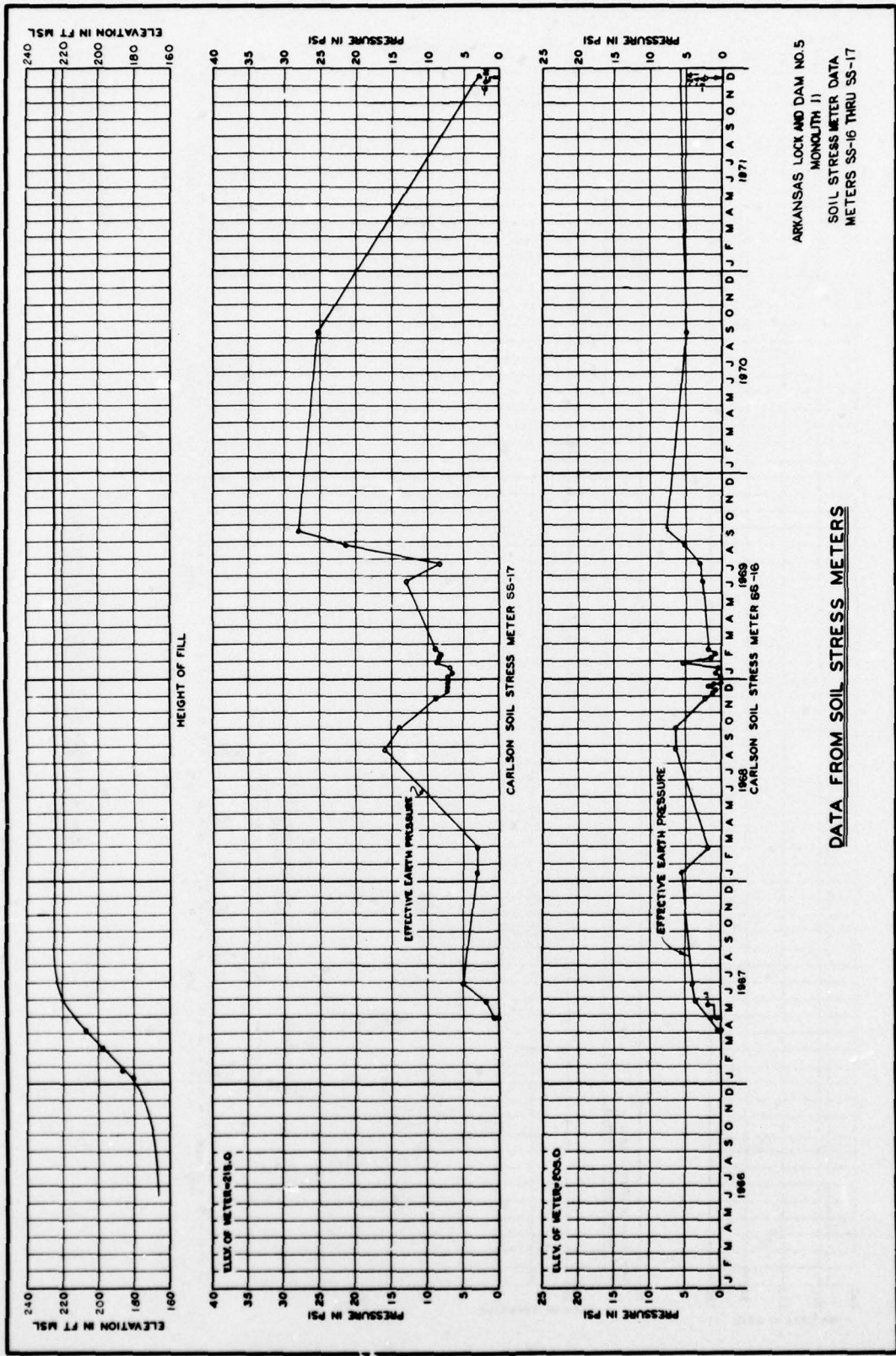




ARKANSAS LOCK AND DAM NO. 5
 MONOLITH II
 SOIL STRESS METER DATA
 METERS SS-14 THRU SS-15

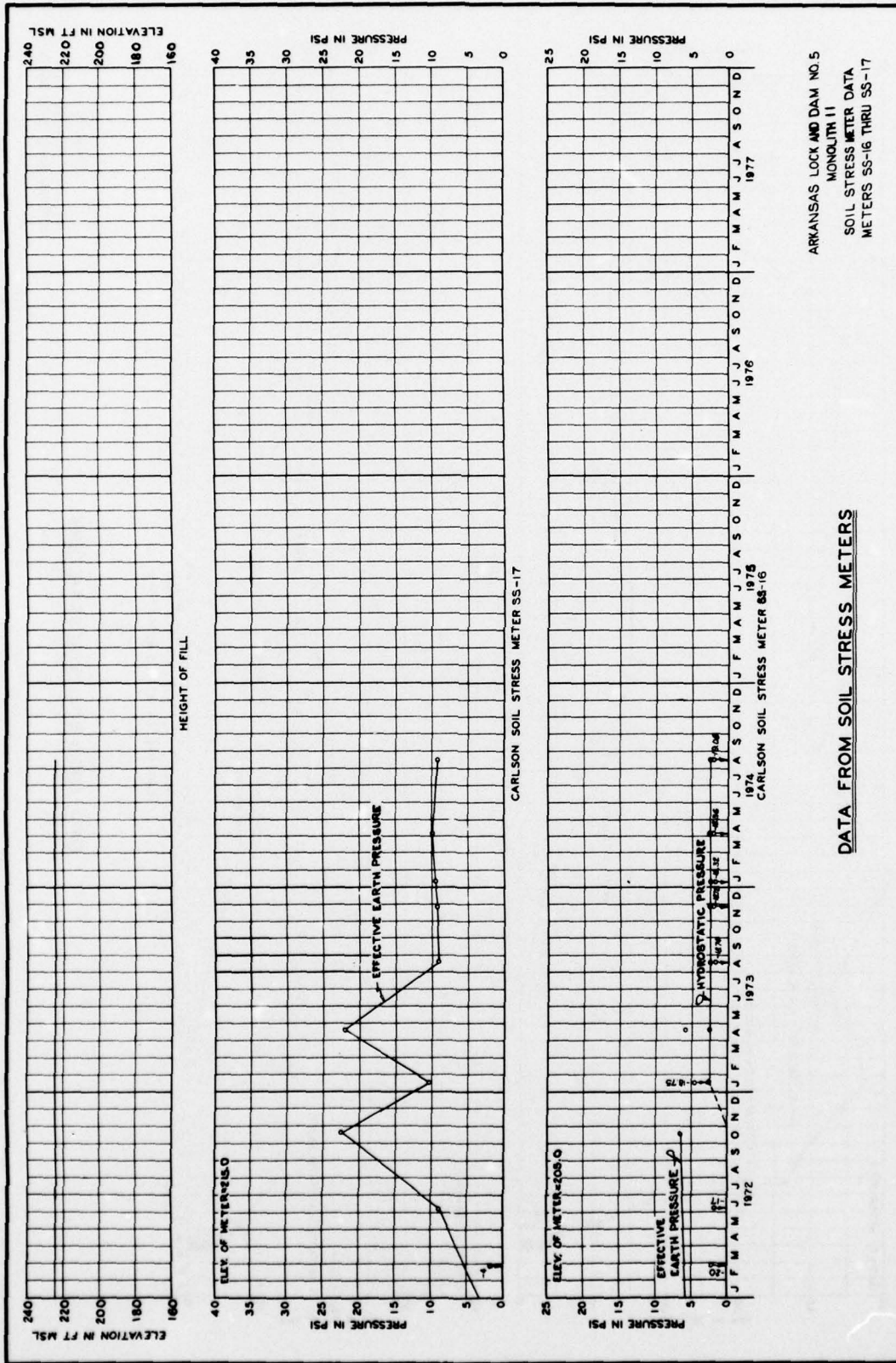
DATA FROM SOIL STRESS METERS

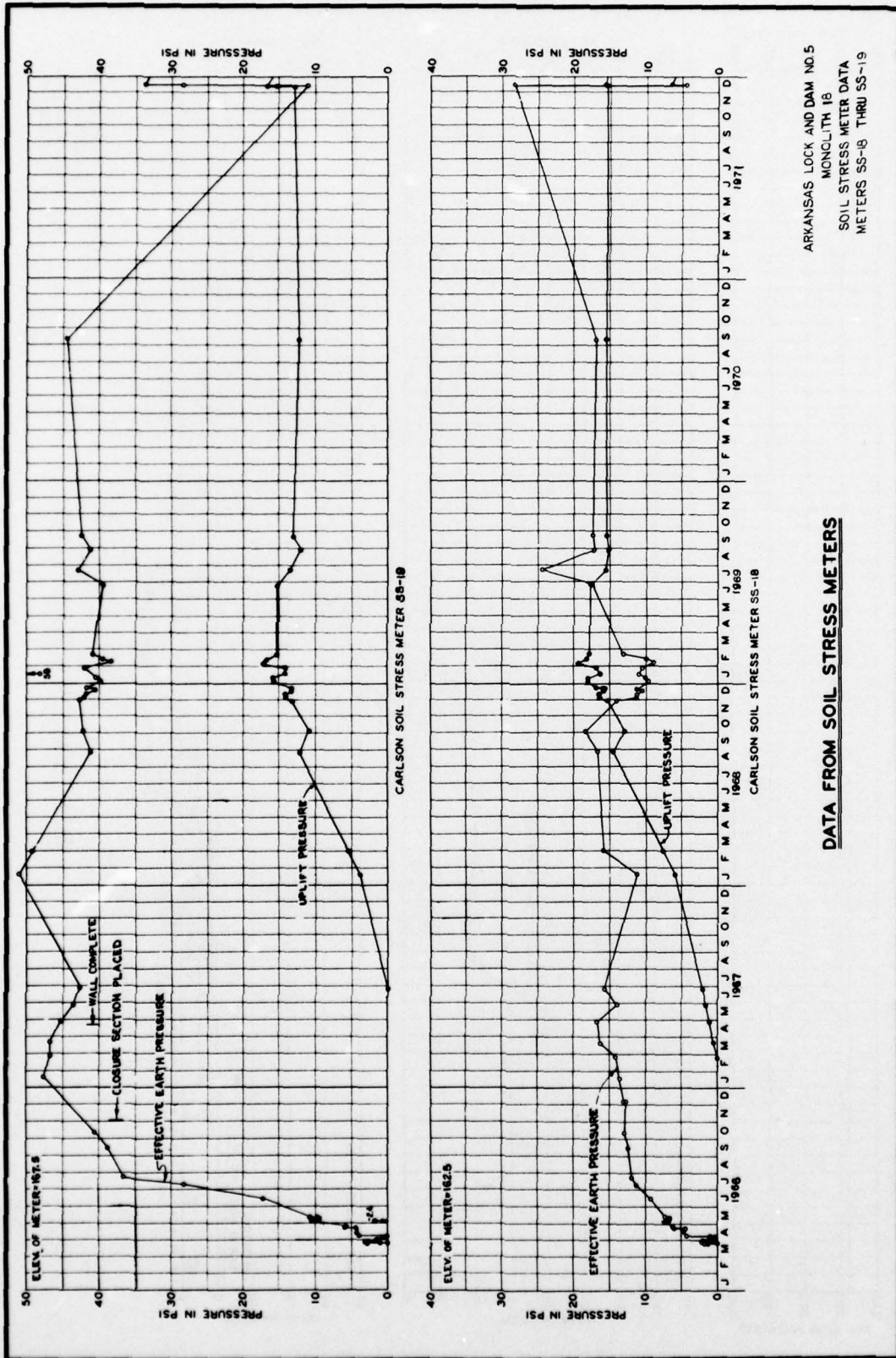




ARKANSAS LOCK AND DAM NO. 5
 MONMOUTH 1)
 SOIL STRESS METER DATA
 METERS SS-16 THRU SS-17

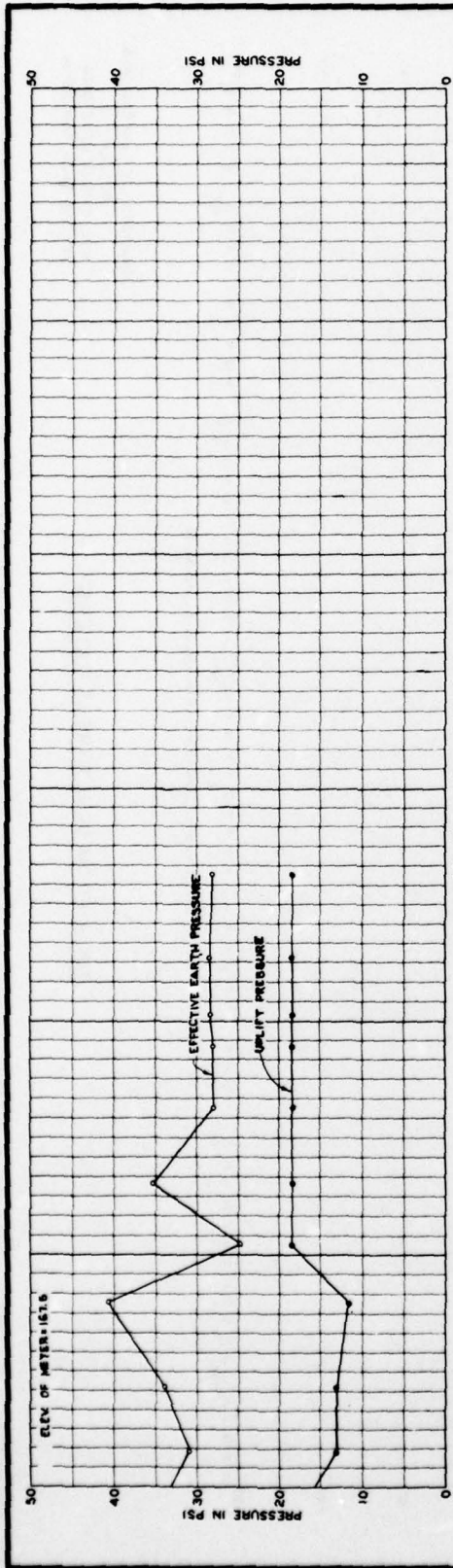
DATA FROM SOIL STRESS METERS



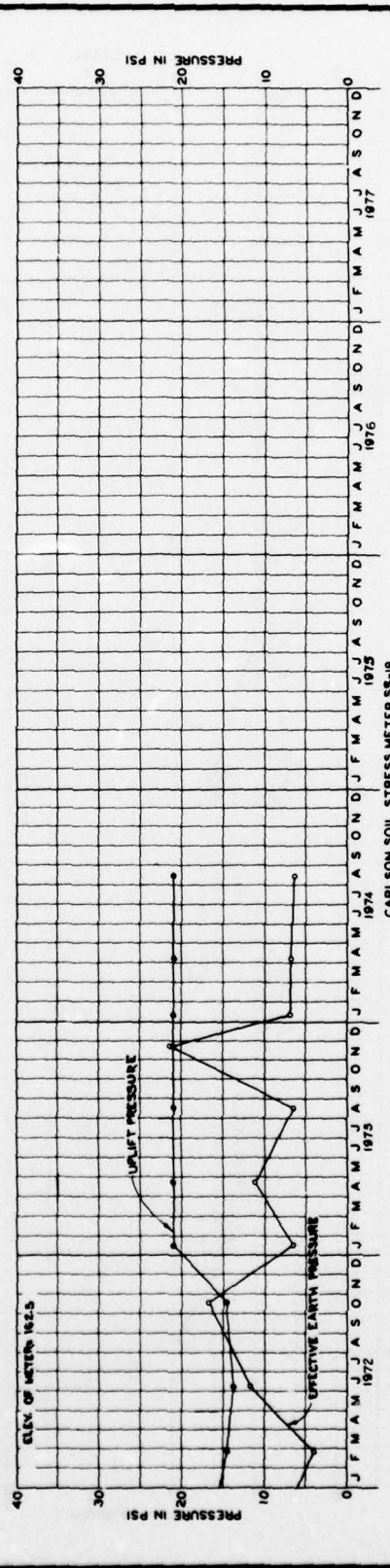


ARKANSAS LOCK AND DAM NO.5
 MONCLITH 18
 SOIL STRESS METER DATA
 METERS SS-18 THRU SS-19

DATA FROM SOIL STRESS METERS



CARLSON SOIL STRESS METER SS-19



CARLSON SOIL STRESS METER SS-16

ARKANSAS LOCK AND DAM NO. 5
 MONOLITH 18
 SOIL STRESS METER DATA
 METERS SS-16 THRU SS-19

DATA FROM SOIL STRESS METERS

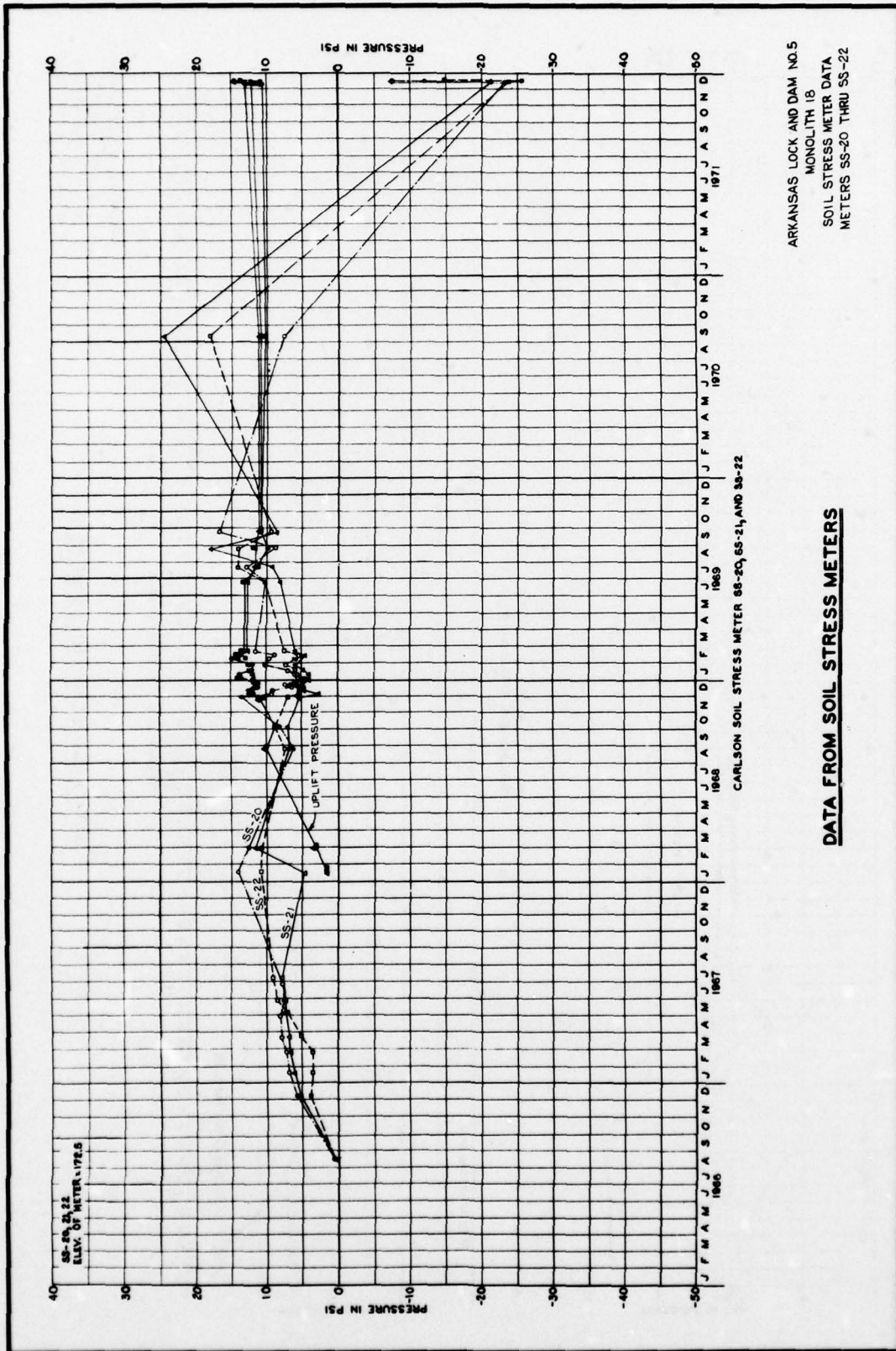
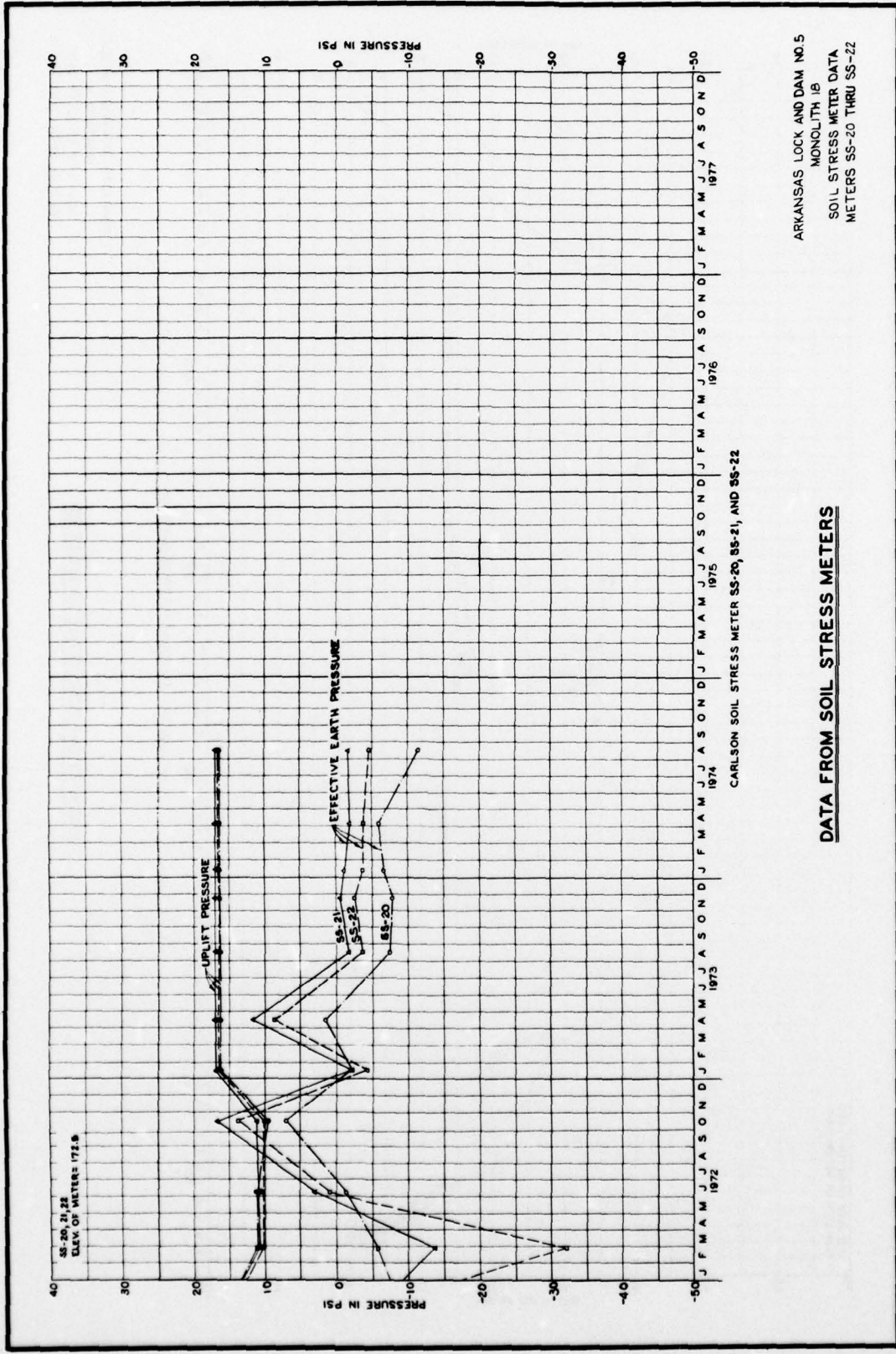


PLATE 58



ARKANSAS LOCK AND DAM NO. 5
MONOLITH 1B
SOIL STRESS METER DATA
METERS SS-20 THRU SS-22

CARLSON SOIL STRESS METER SS-20, SS-21, AND SS-22

DATA FROM SOIL STRESS METERS

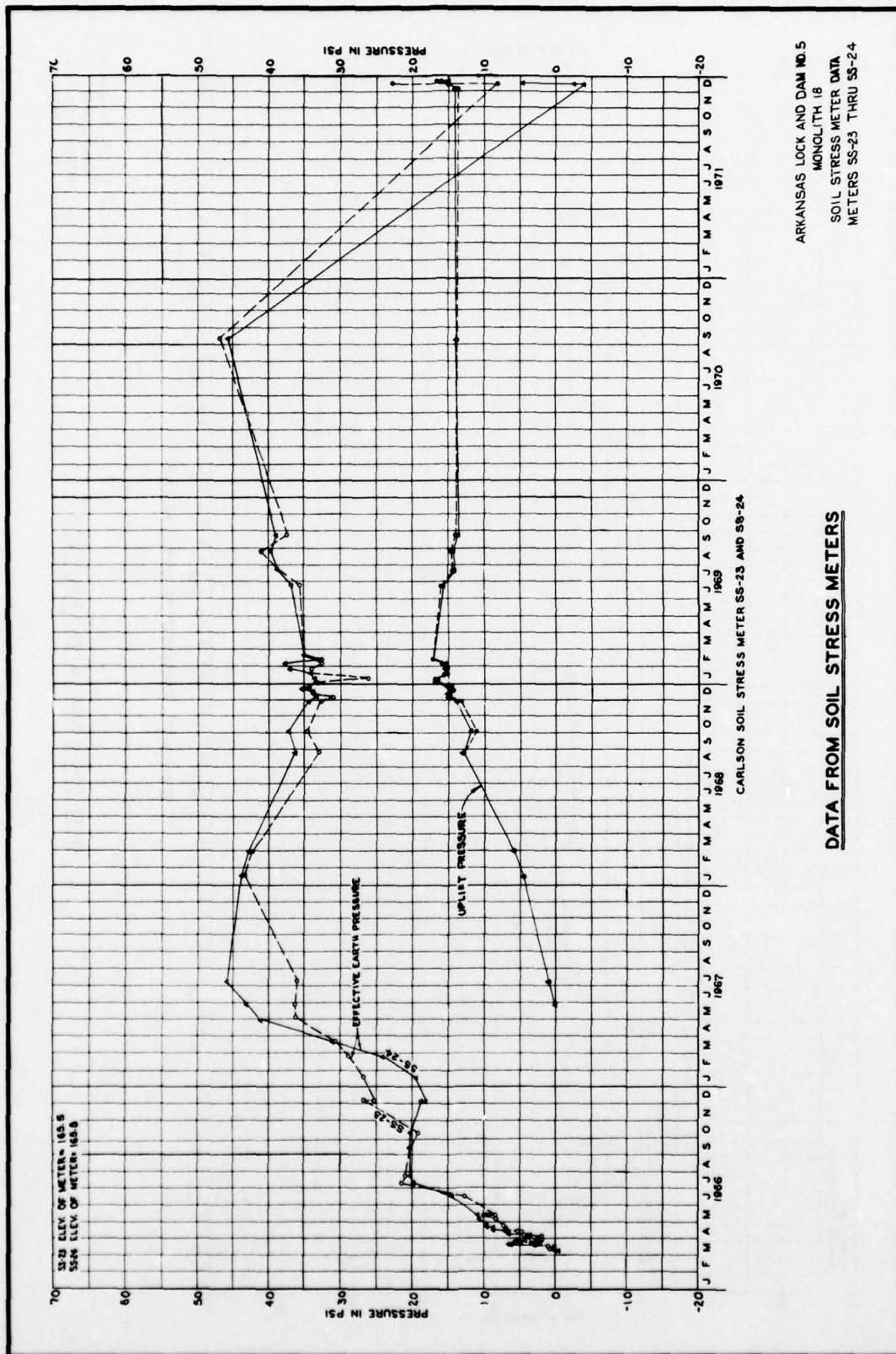
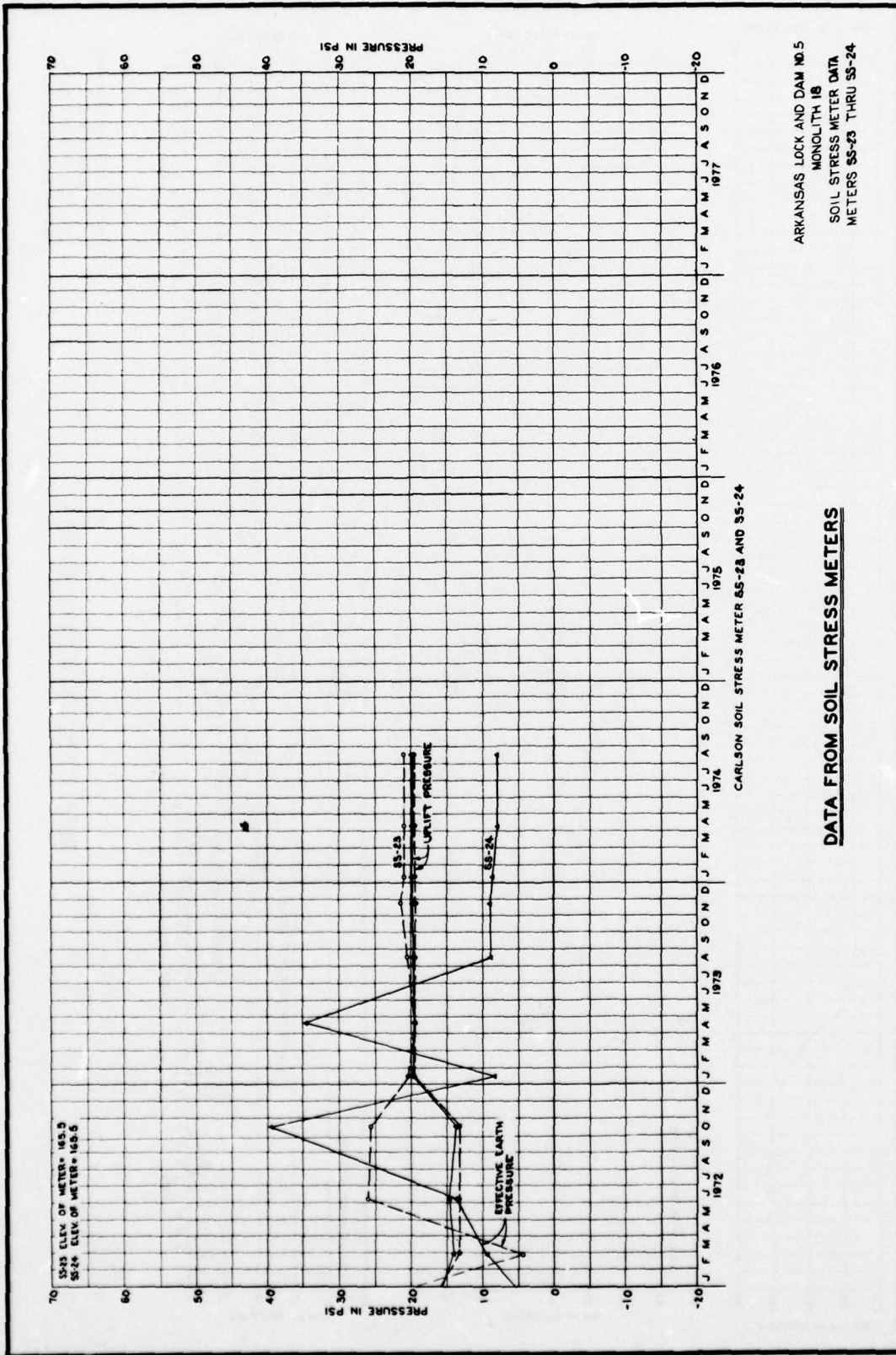
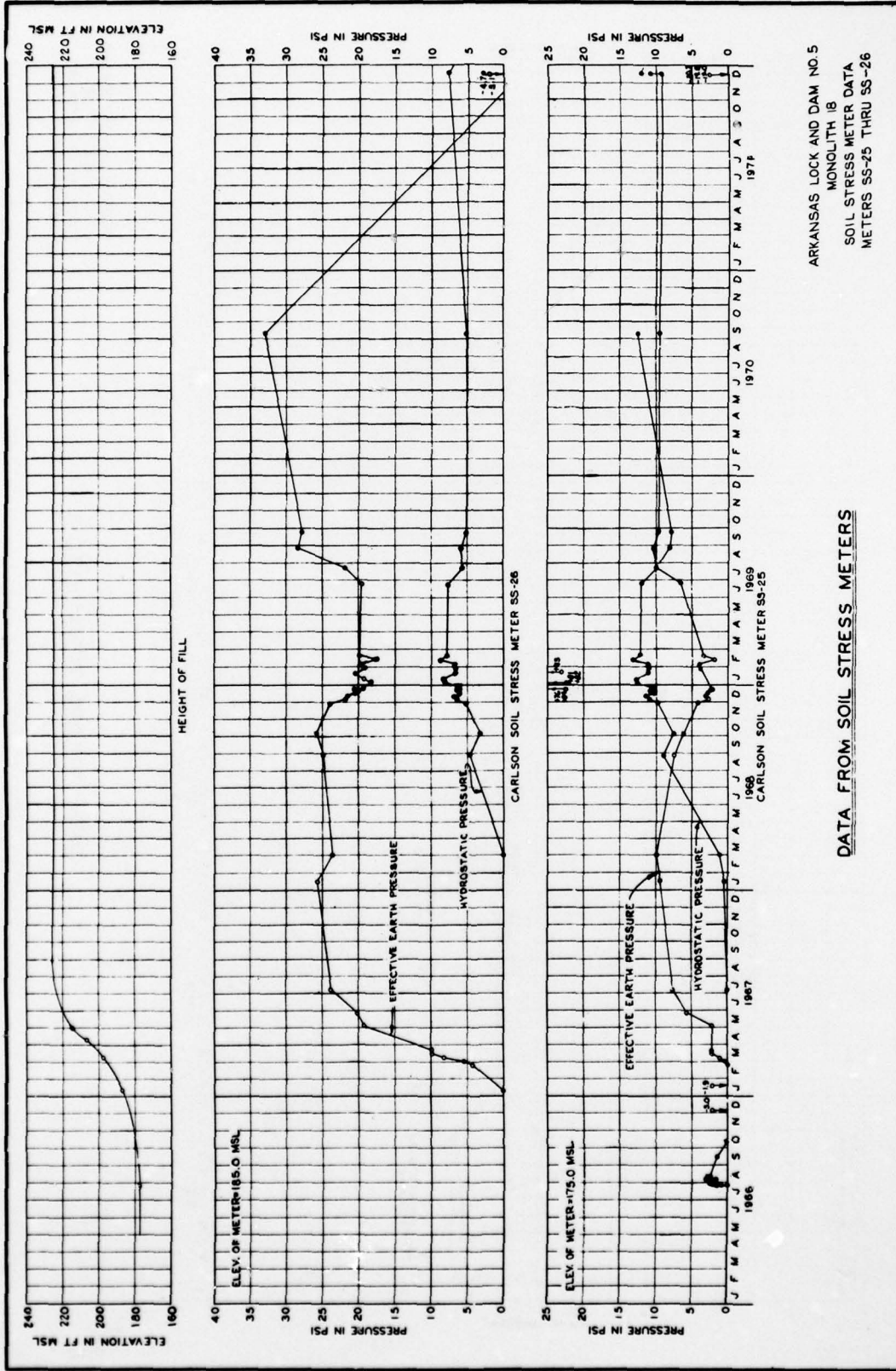


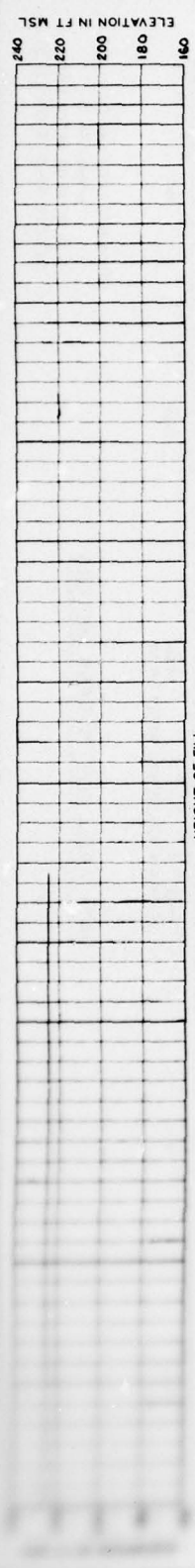
PLATE 60



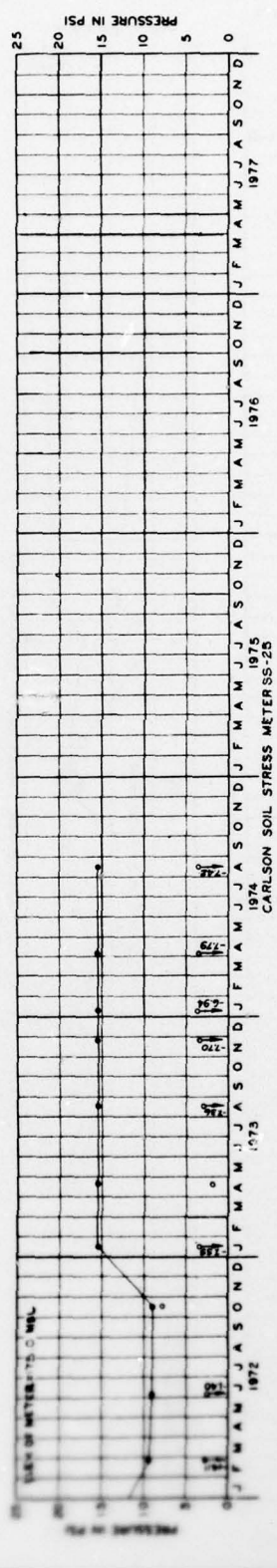
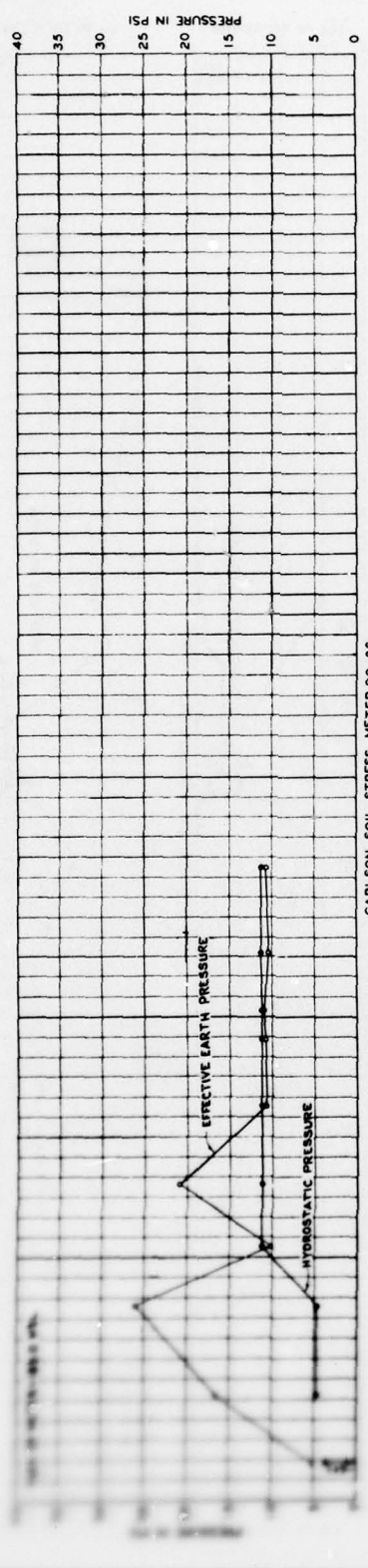


ARKANSAS LOCK AND DAM NO. 5
 MONOLITH 18
 SOIL STRESS METER DATA
 METERS SS-25 THRU SS-26

DATA FROM SOIL STRESS METERS

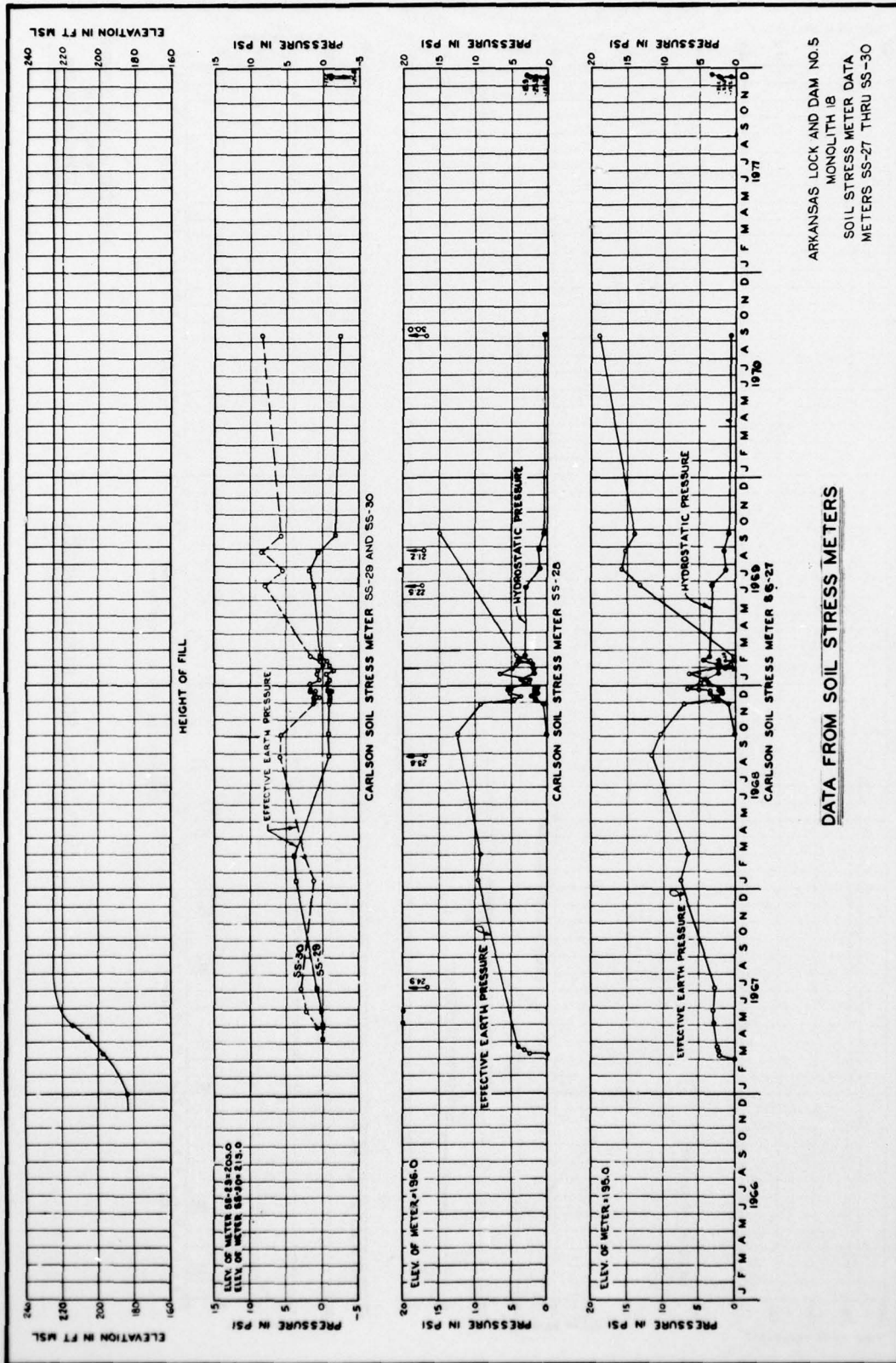


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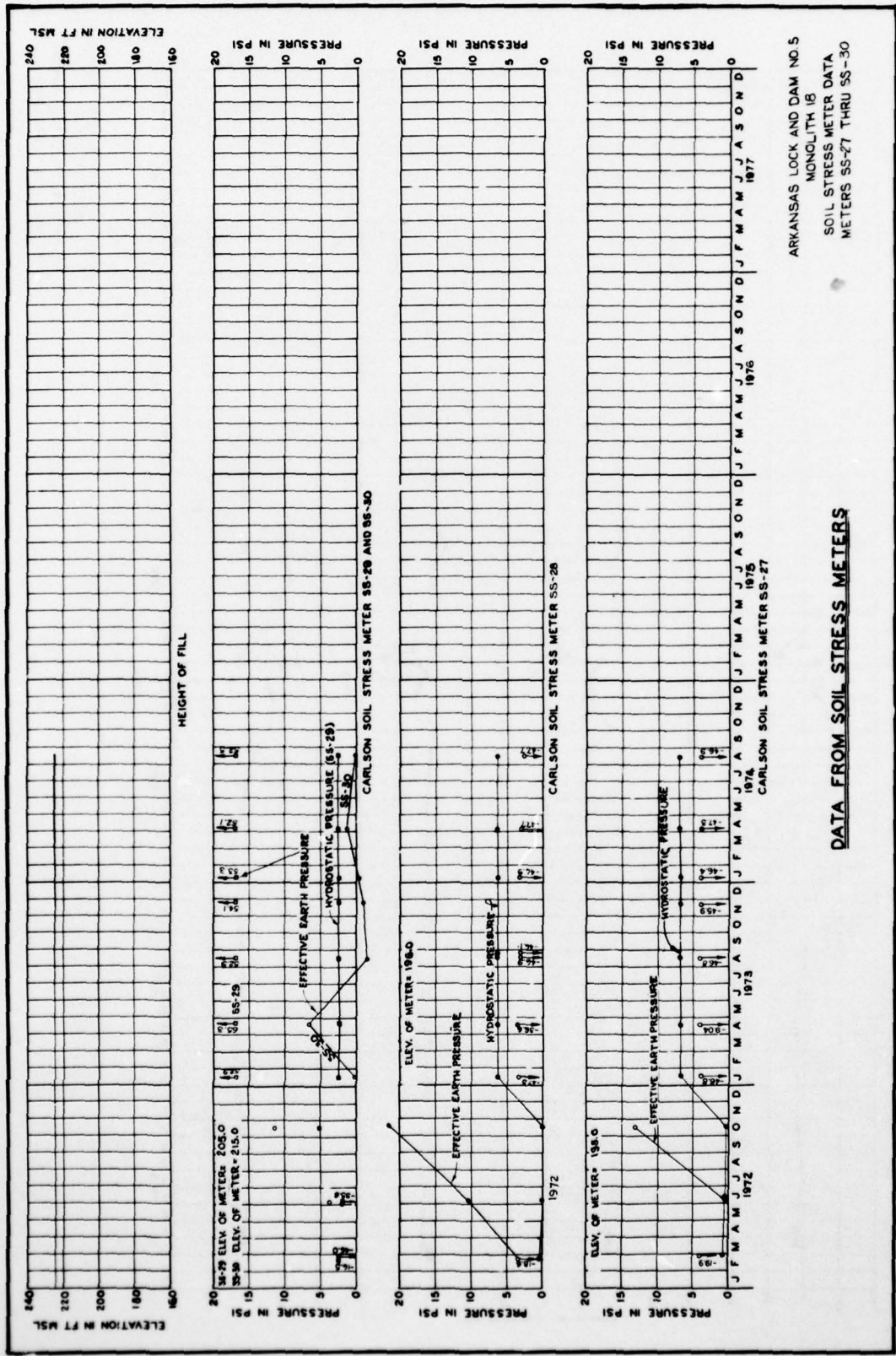
ARKANSAS LOCK AND DAM NO. 5
MONOLITH 18
SOIL STRESS METER DATA
METERS SS-25 THRU SS-26

DATA FROM SOIL STRESS METERS

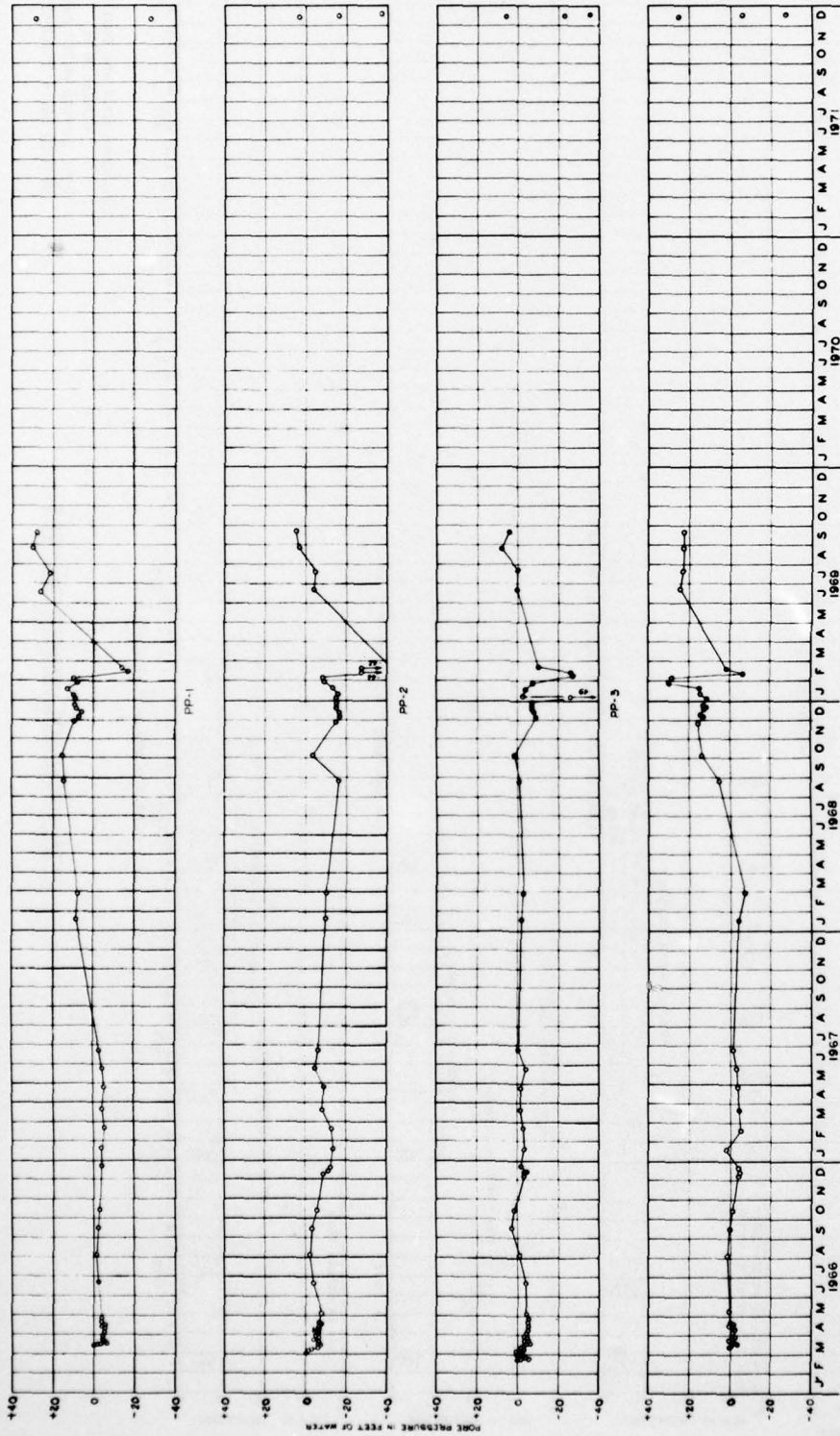


ARKANSAS LOCK AND DAM NO. 5
 MONOLITH 18
 SOIL STRESS METER DATA
 METERS SS-27 THRU SS-30

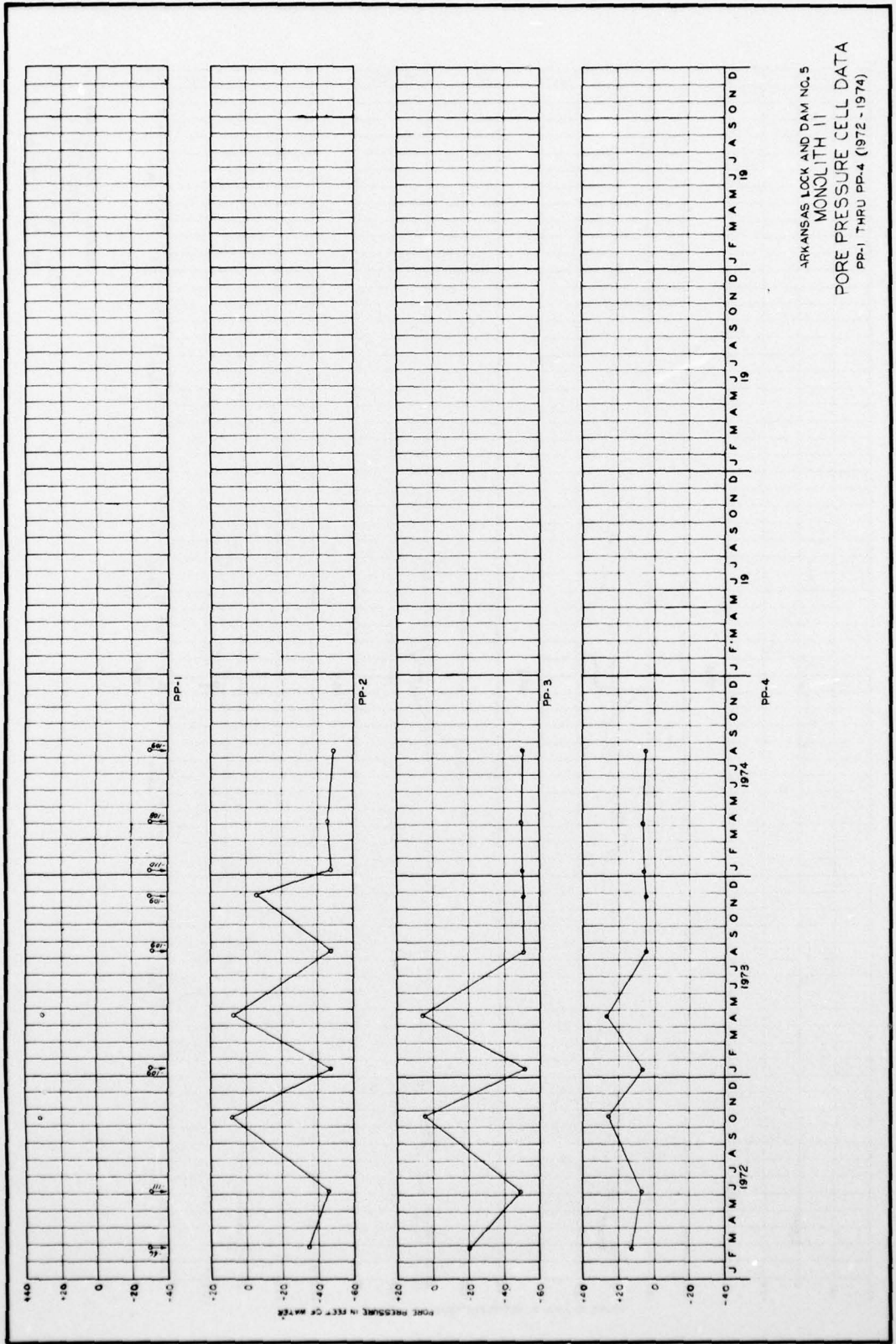
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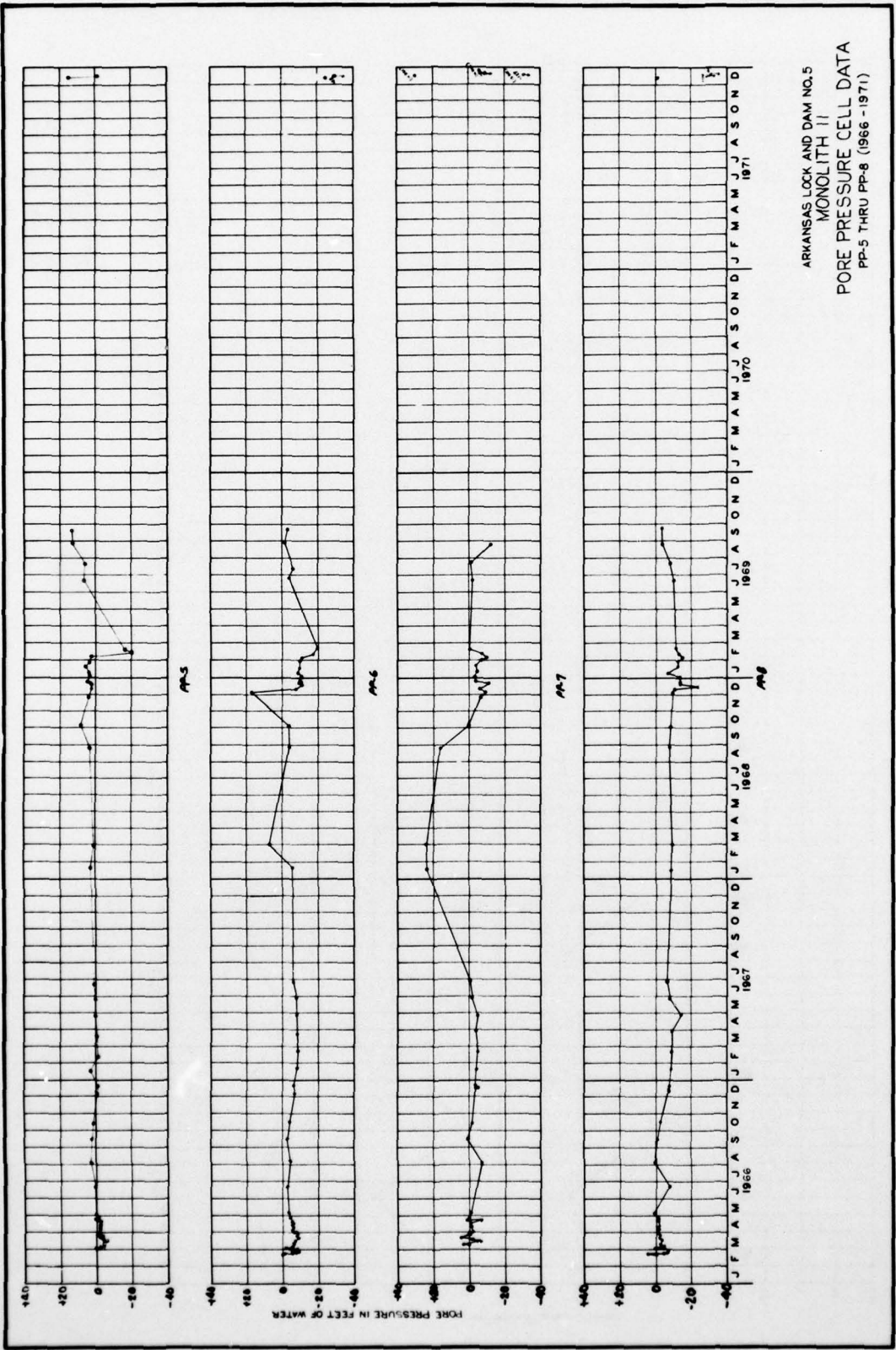


DATA FROM SOIL STRESS METERS

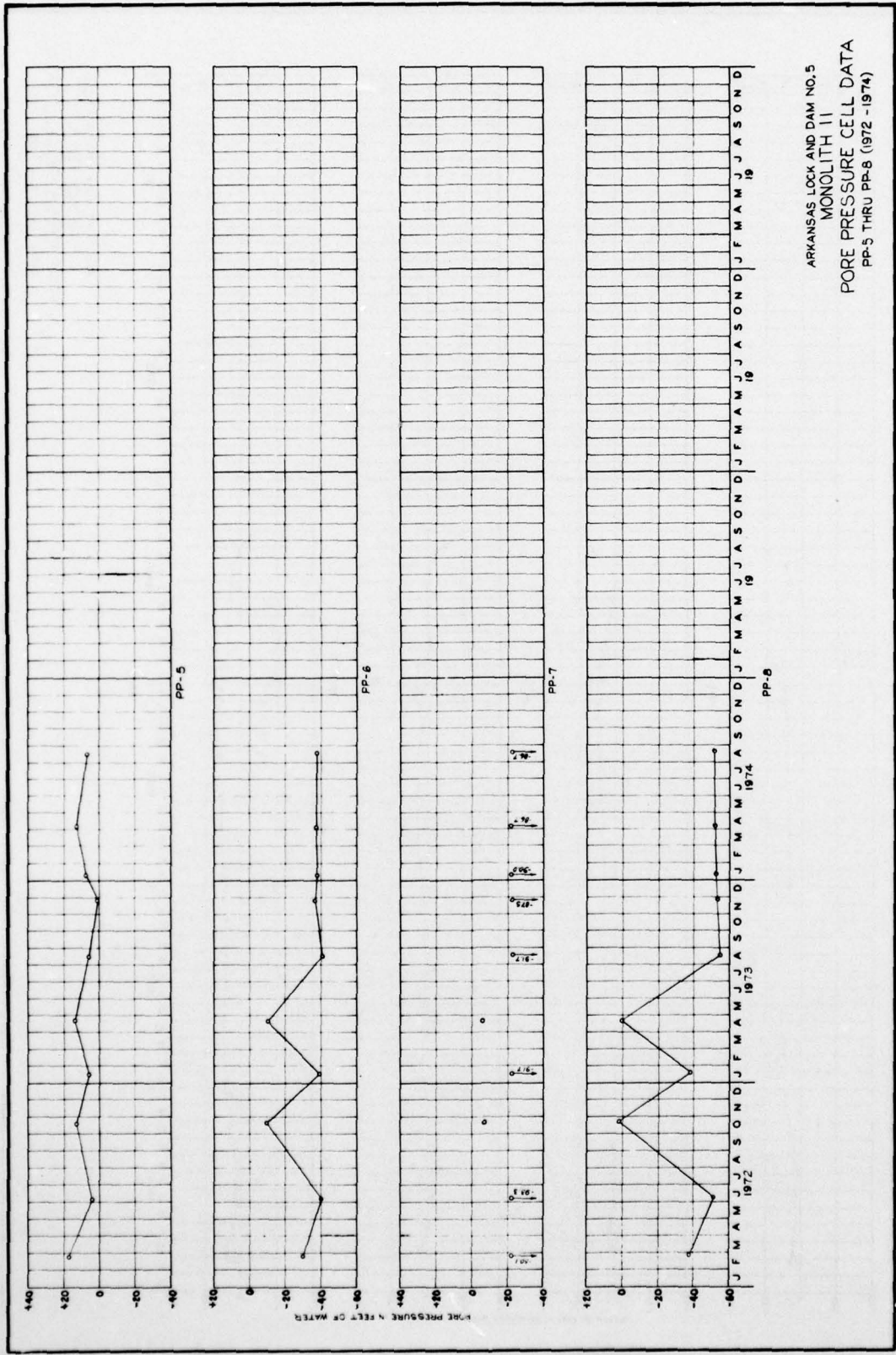


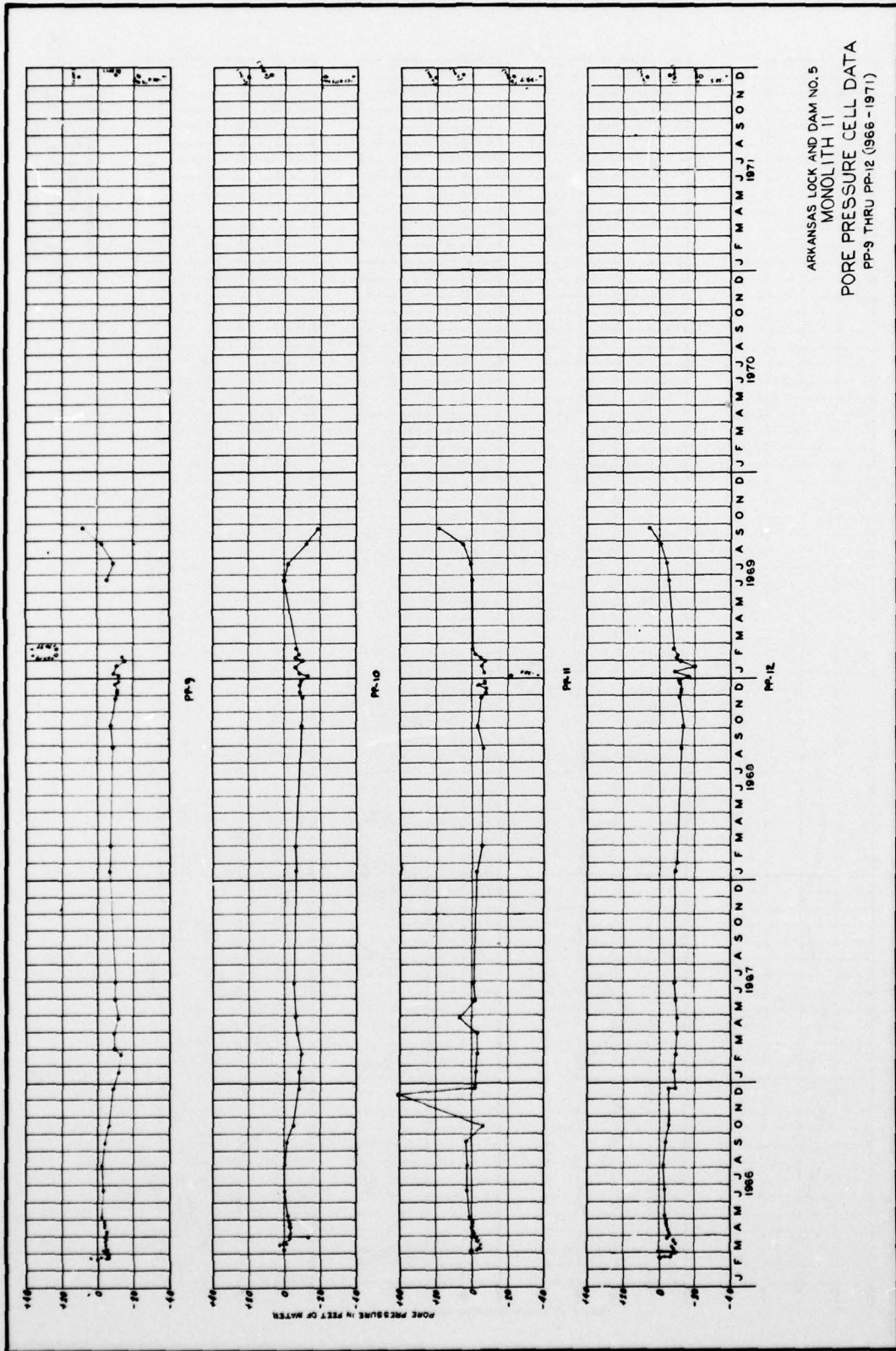
ARKANSAS LOCK AND DAM NO. 5
MONOLITH II
PORE PRESSURE CELL DATA
PP-1 THRU PP-4 (1966 - 1971)



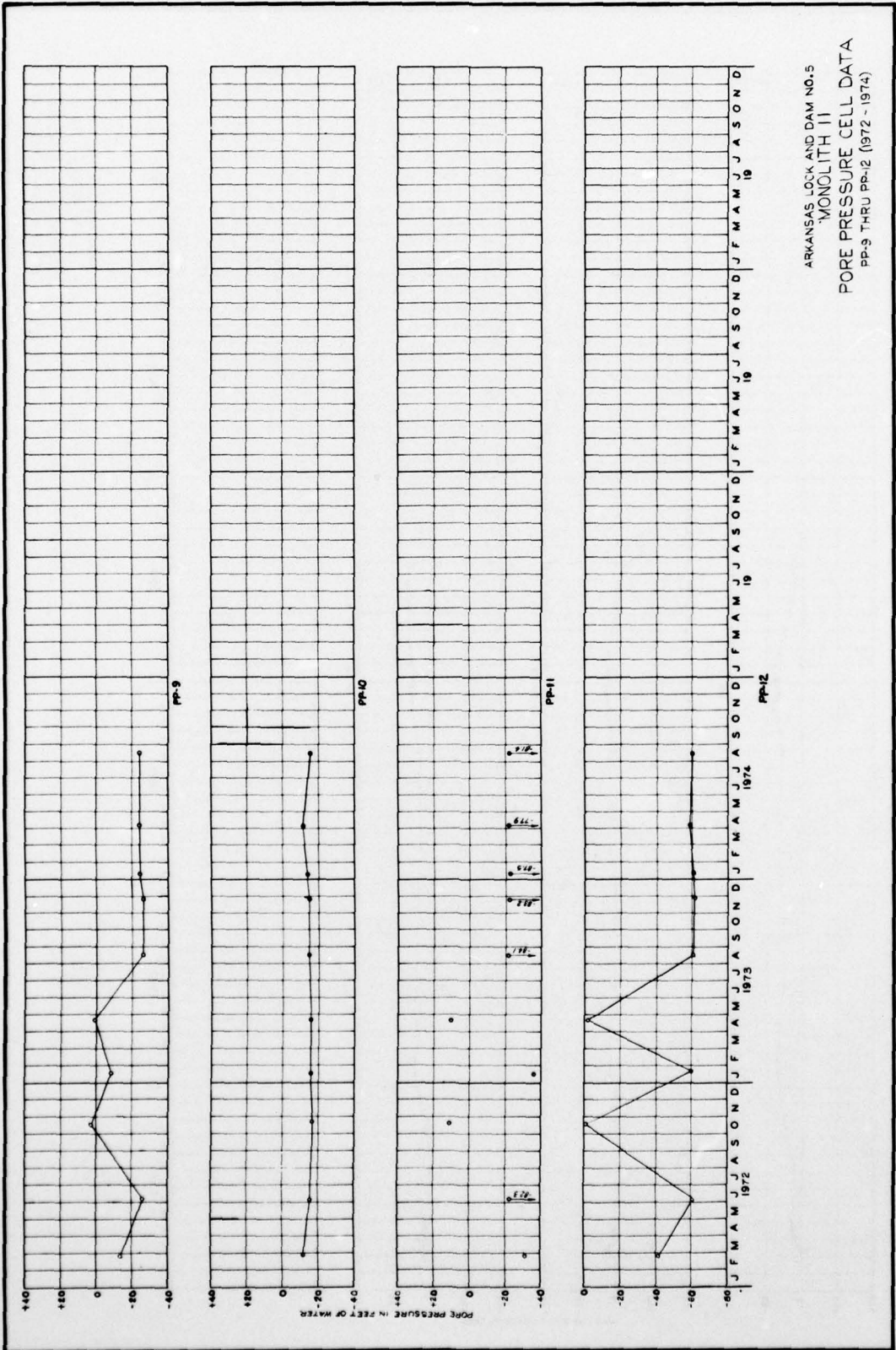


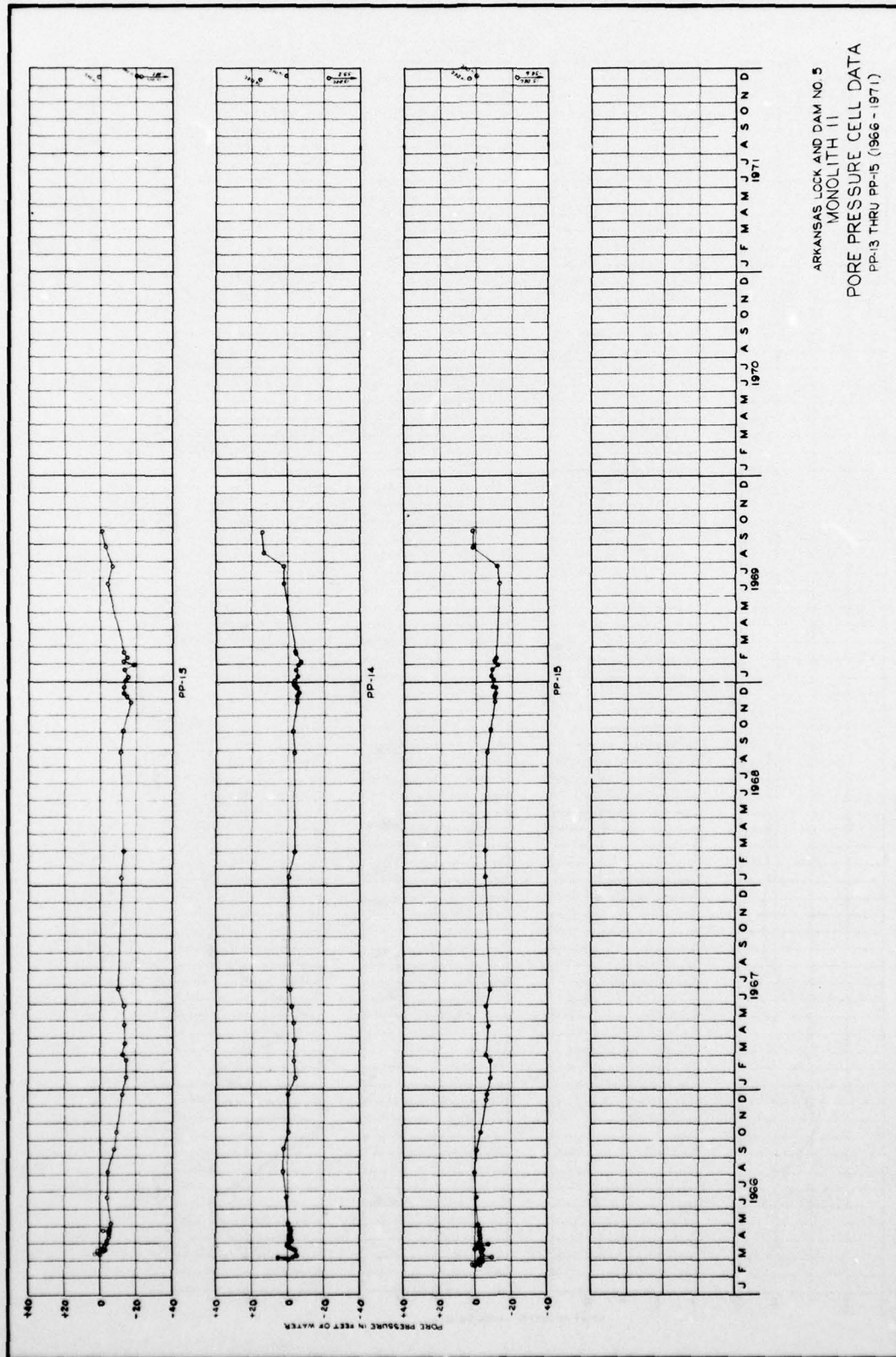
ARKANSAS LOCK AND DAM NO. 5
 MONOLITH II
 PORE PRESSURE CELL DATA
 PP-5 THRU PP-8 (1966 - 1971)



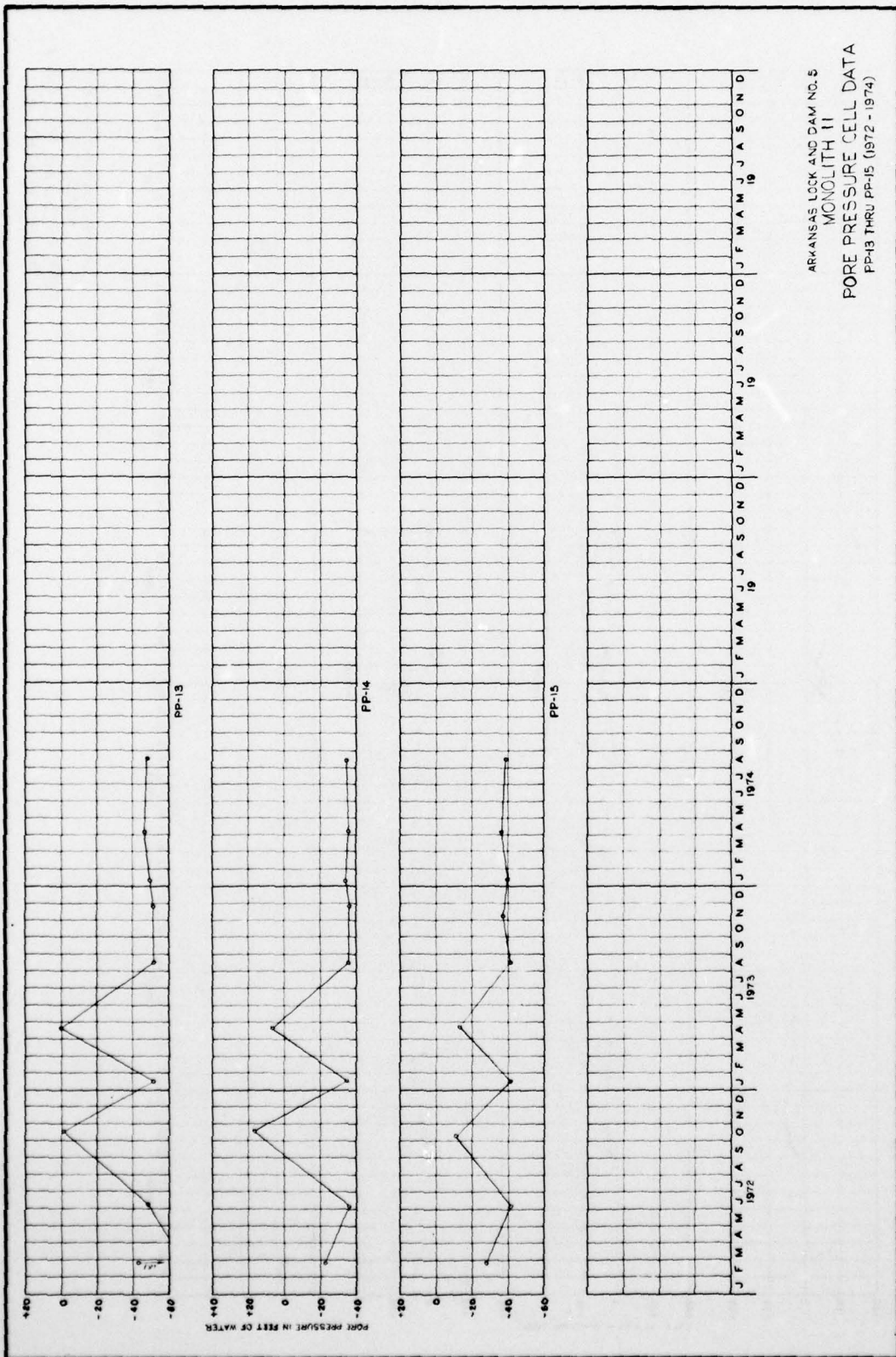


ARKANSAS LOCK AND DAM NO. 5
 MONOLITH II
 PORE PRESSURE CELL DATA
 PP-9 THRU PP-12 (1966 - 1971)

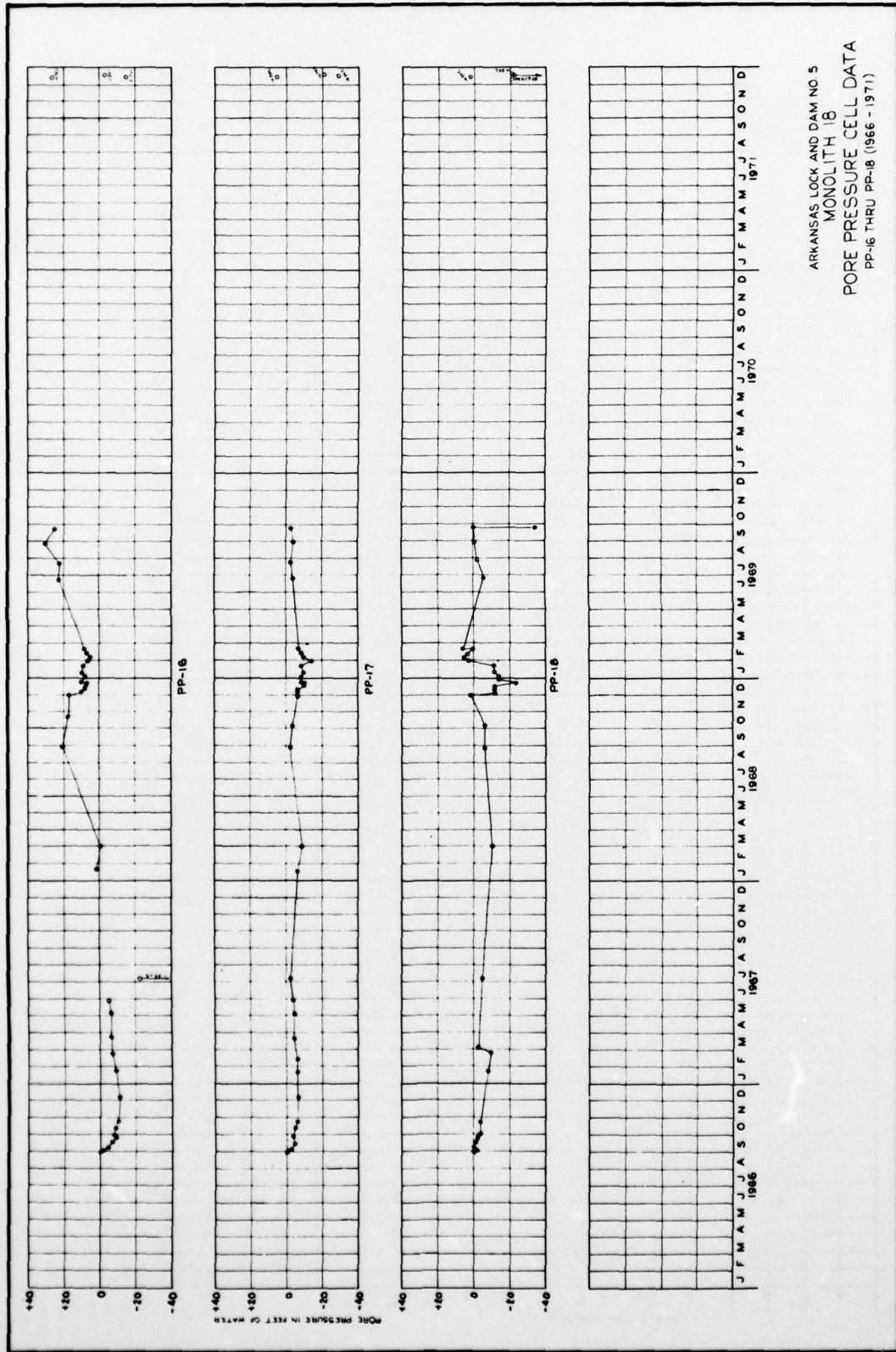




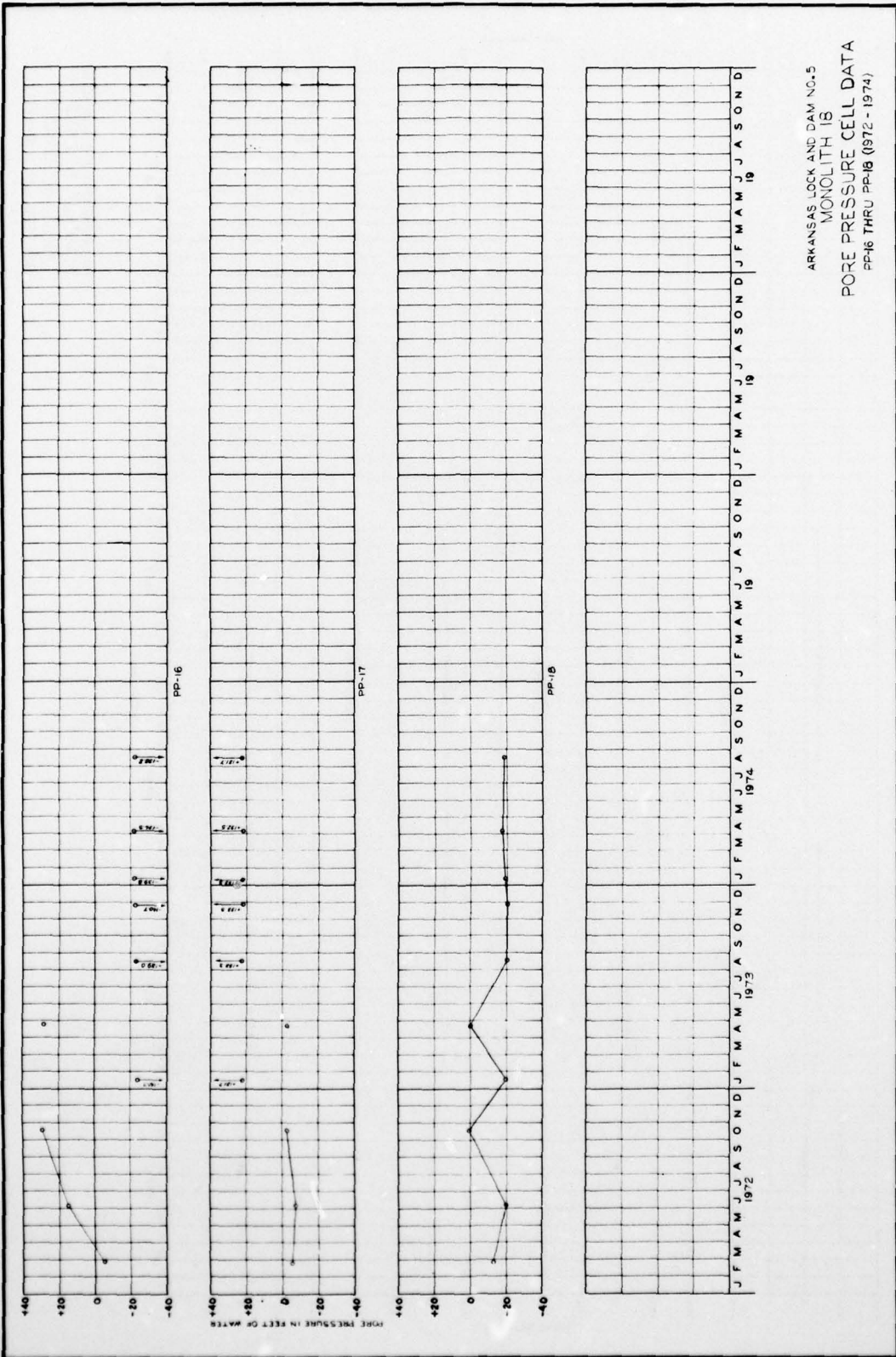
ARKANSAS LOCK AND DAM NO. 5
 MONOLITH II
 PORE PRESSURE CELL DATA
 PP-13 THRU PP-15 (1966 - 1971)

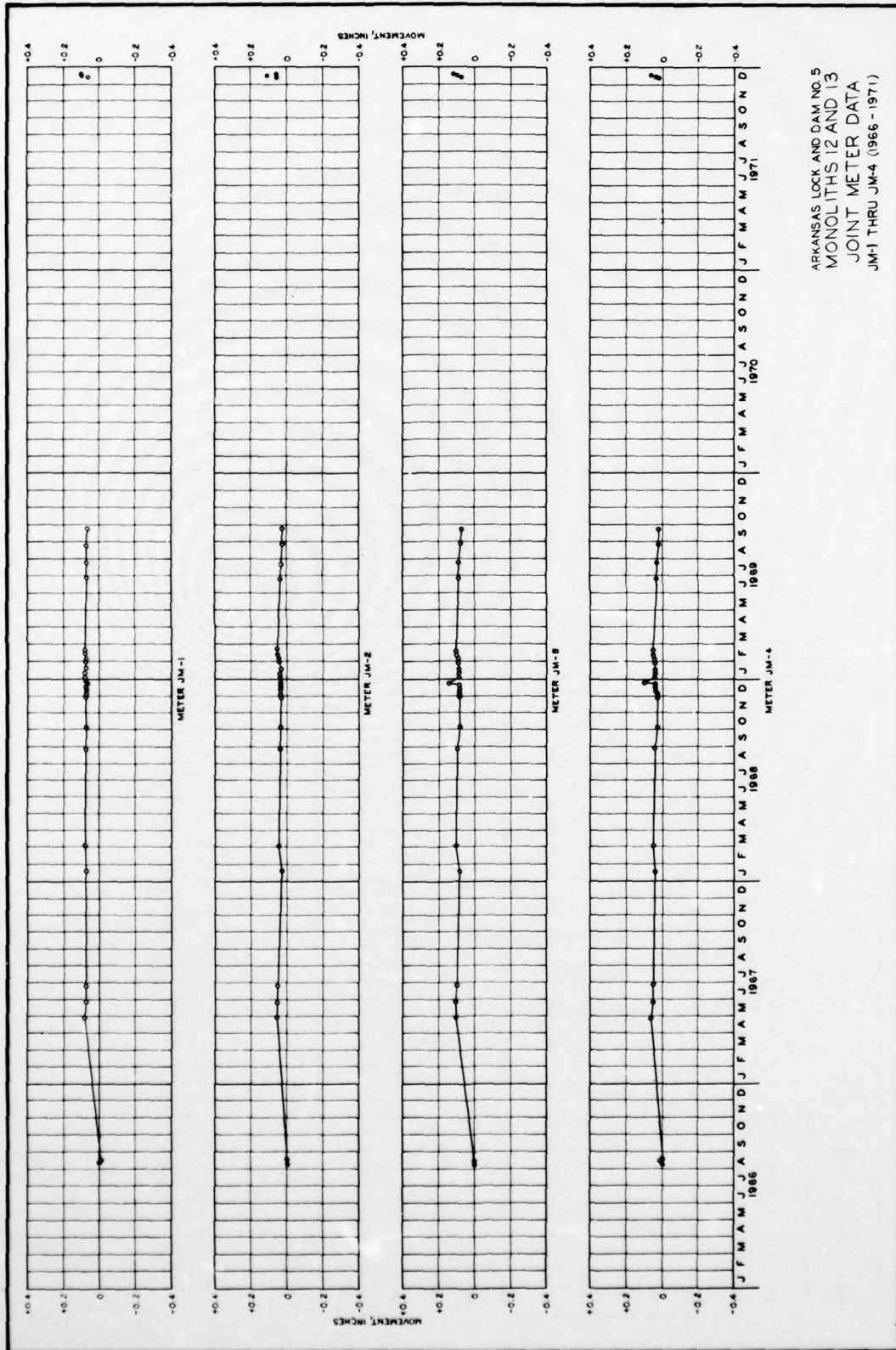


ARKANSAS LOCK AND DAM NO. 5
 MONOLITH 11
 PORE PRESSURE CELL DATA
 PP-13 THRU PP-15 (1972 - 1974)



ARKANSAS LOCK AND DAM NO. 5
 MONOLITH 18
 PORE PRESSURE CELL DATA
 PP-16 THRU PP-18 (1966 - 1971)





ARKANSAS LOCK AND DAM NO. 5
 MONOLITHS 12 AND 13
 JOINT METER DATA
 JM-1 THRU JM-4 (1966-1971)

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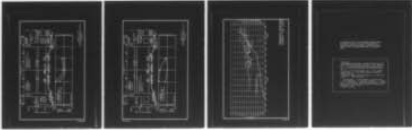
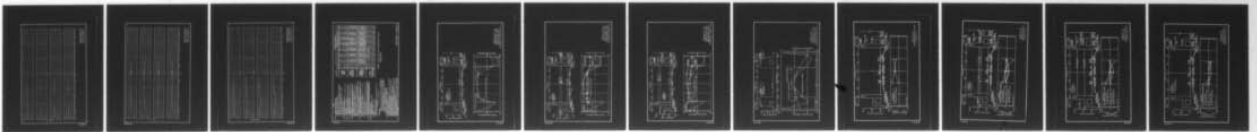
ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MISS F/G 13/2
INSTRUMENTATION OBSERVATIONS FROM THE U-FRAME LOCK OF THE ARKAN--ETC(U)

UNCLASSIFIED

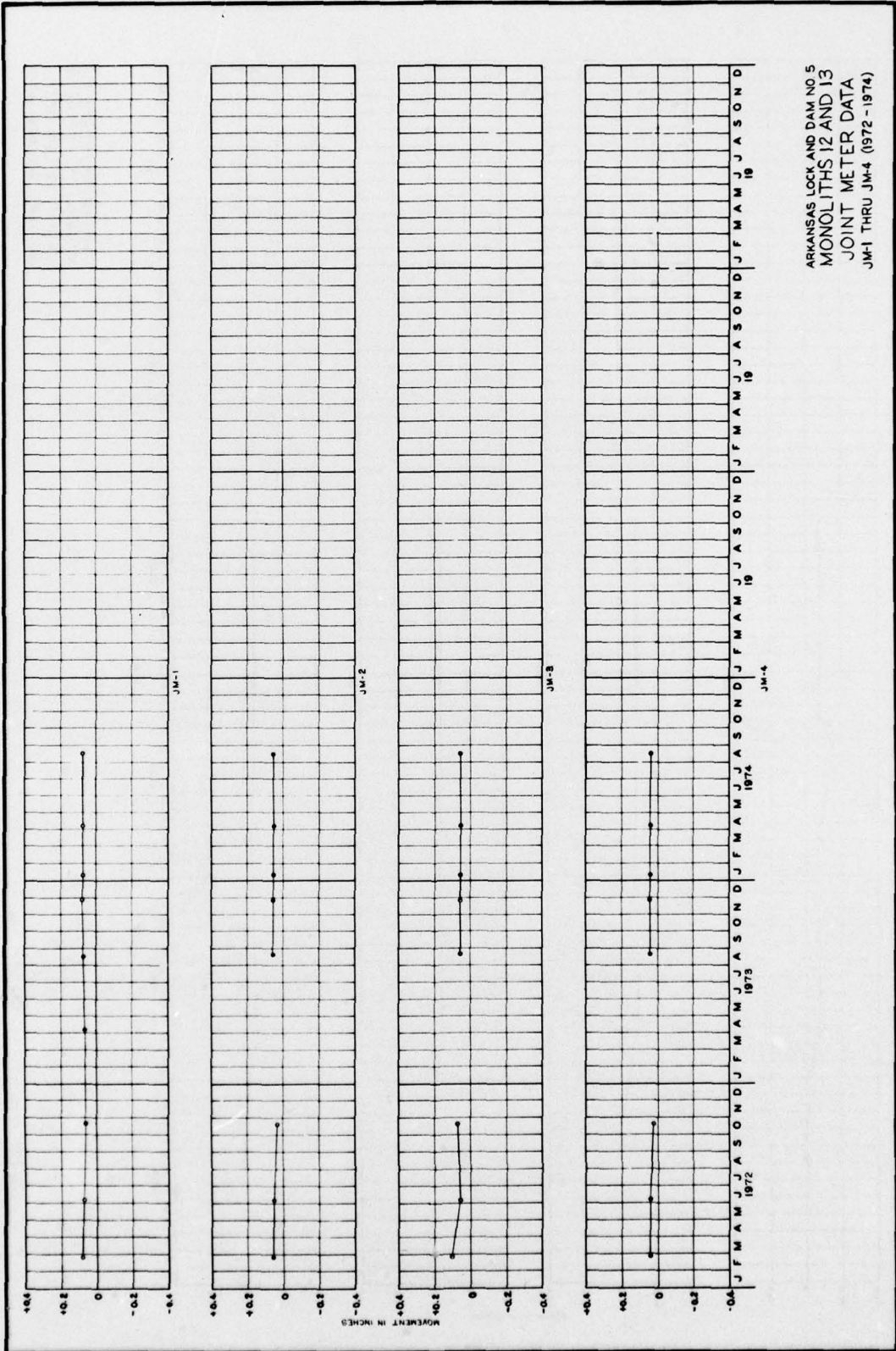
AUG 78 R E LEACH
WES-MP-S-78-11

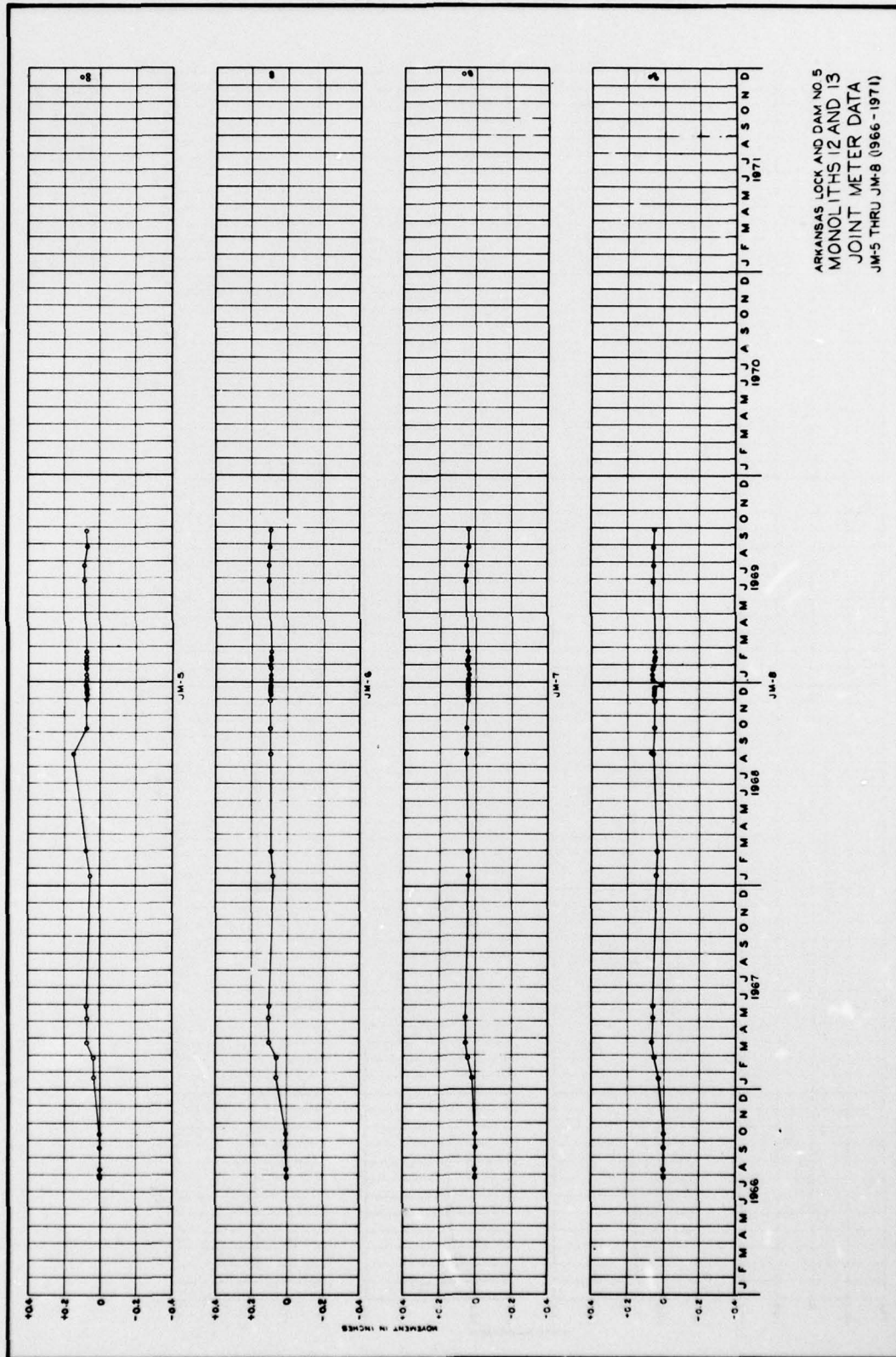
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2 OF 2
AD
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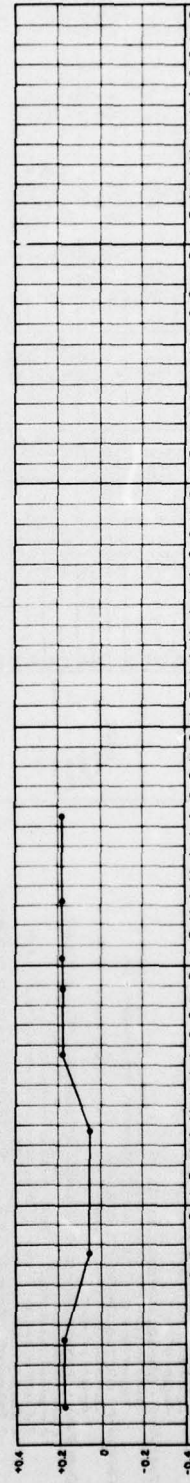
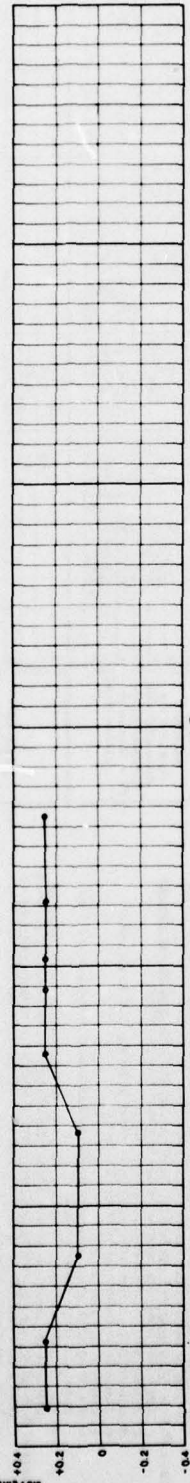
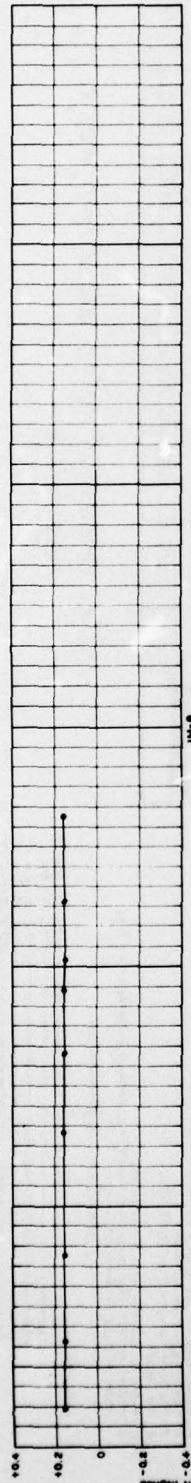
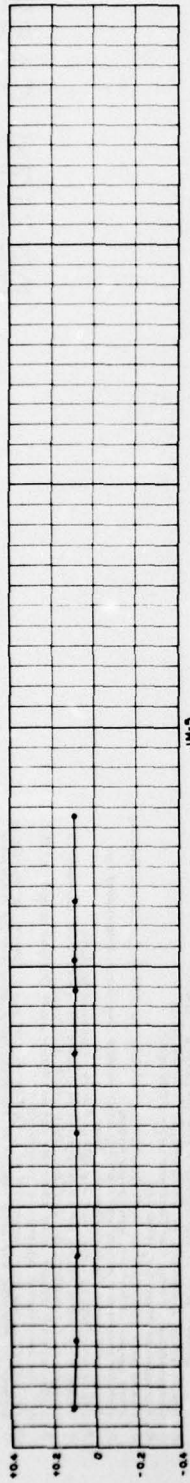


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ARKANSAS LOCK AND DAM NO 5
MONOLITHS 12 AND 13
JOINT METER DATA
JM-5 THRU JM-8 (1966-1971)



ARKANSAS LOCK AND DAM NO. 5
 MONOLITHS 12 AND 13
 JOINT METER DATA
 JM-5 THRU JM-8 (1972 - 1974)

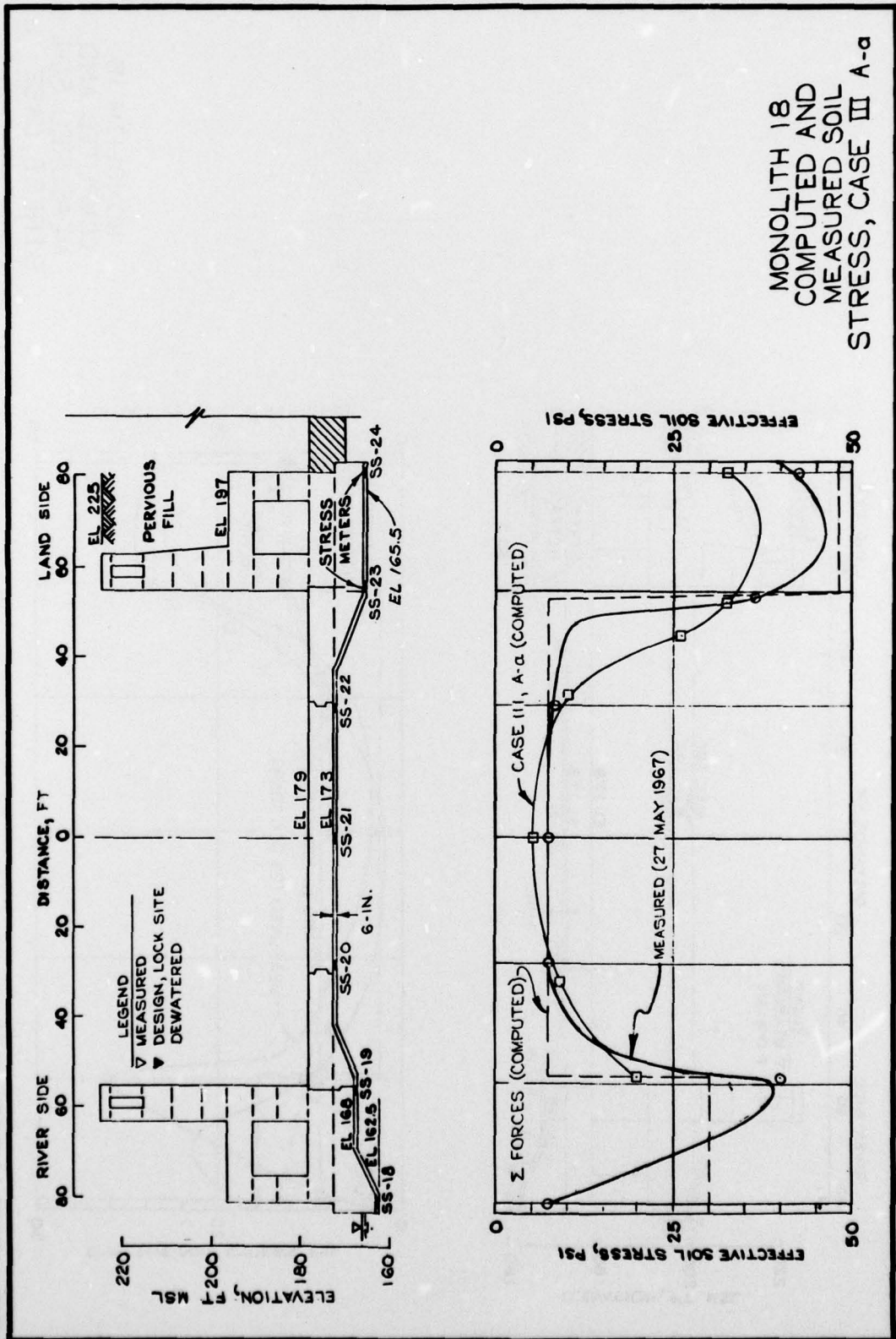
TABLE OF CASE RESULTS

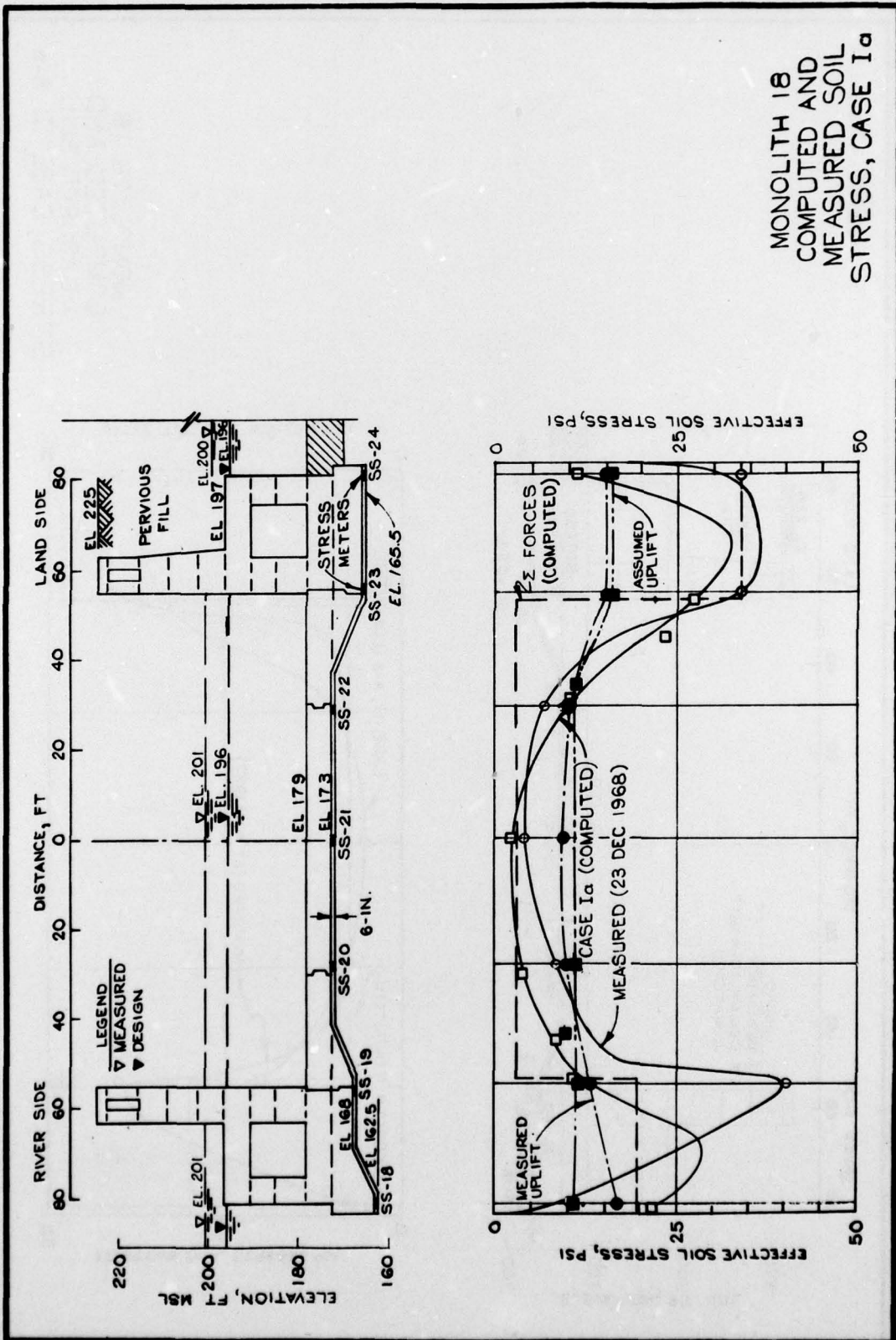
Member	CASES					
	X (ft)	Case I-a	Case I-a-b	Case II-a	Case II-b	Case III-a
UNIFORMITY MAYING BASE PRESSURE (KSF)	1a	1.05	1.87	1.74	1.82	1.07
	1b	1.24	2.02	1.94	1.45	1.26
	1c	1.31	2.07	2.01	1.53	1.32
	1d	1.41	2.15	2.11	1.65	1.42
	1e	1.61	2.31	2.32	1.90	1.62
	1f	1.81	2.47	2.53	2.15	1.82
	1g	1.91	2.55	2.63	2.27	1.92
	1h	1.98	2.60	2.70	2.35	1.98
	1i	2.17	2.76	2.80	2.48	2.17
	1j	1.771	1.957	1.972	1.54	2.29
	1k	1.226	1.423	1.428	1.02	1.946
	BASE PRESSURE Computed by Beam on Elastic Foundation Method (KSF)	2a	0.556	1.261	1.261	0.930
2b		0.221	1.241	1.241	0.687	0.27
2c		1.140	1.159	1.159	1.600	1.295
2d		2.429	2.428	2.424	3.271	3.083
2e		3.345	3.274	3.288	3.908	3.732
2f		9.075	11.747	10.043	163.327	301.316
2g		16.650	23.529	20.636	11.282	46.943
2h		37.496	44.04	41.538	3.9268	29.218
2i		58.06	65.3	63.3	1.333	10.861
2j		87.160	98.19	95.65	0.460	3.744
2k		113.5	135.04	132.2	0.2504	2.074
2l		135.271	174.033	172.480	0.16488	1.2104
AREA OF REINFORCING (in ²)	3a	0.44	0.57			
	3b	0.47	0.69			
	3c					
	3d					
	3e					
	3f					
	3g					
	3h					
	3i					
	3j	1.15	1.25	0.44	1.50	1.60
	3k					0.80
	3l					1.50

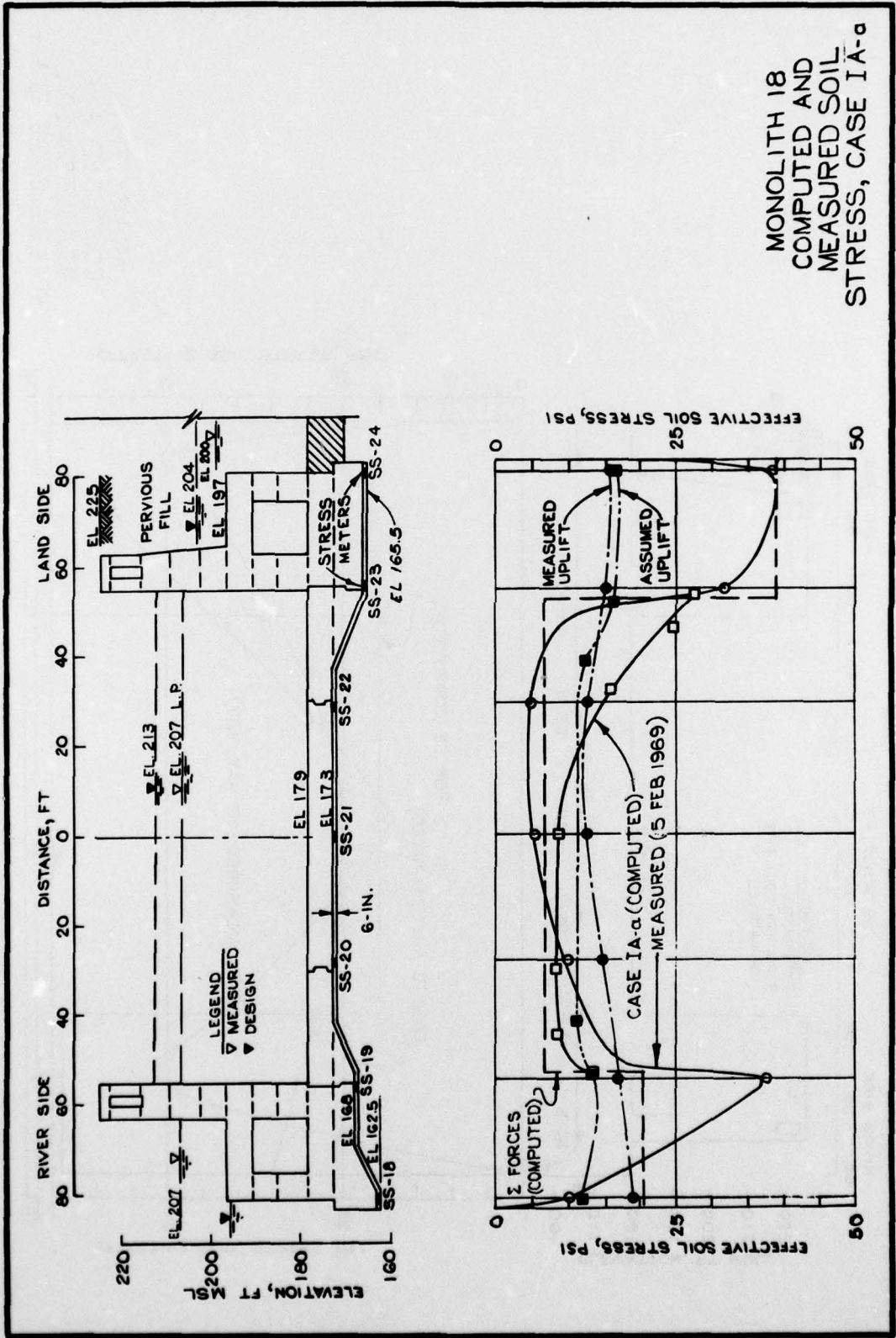
NOTE: Areas of reinf. steel not were negligible.

DESIGN CASES

- CASES**
- Case I-a - Normal Operating Condition**
1. Lower pool El. 196.0 in lock chamber
 2. Backfill to El. 225.0 behind riverwall
 3. Backfill to El. 225.0 behind landwall
 4. Solution line at El. 204.5 4'-10" to 10'-0", then constant earth pressure to depth where earth pressure equivalent to $K=0.35$, then constant earth pressure to base of wall.
 5. Uniform horizontal earth pressure equivalent to $K=0.35$, then constant earth pressure to base of wall.
 6. Uniform horizontal earth pressure equivalent to $K=0.35$, then constant earth pressure to base of wall.
 7. Horizontal earth pressure equivalent to $K=0.35$, then constant earth pressure to base of wall.
 8. Horizontal earth pressure equivalent to $K=0.35$, then constant earth pressure to base of wall.
 9. Horizontal earth pressure equivalent to $K=0.35$, then constant earth pressure to base of wall.
 10. Horizontal earth pressure equivalent to $K=0.35$, then constant earth pressure to base of wall.
- Case I-a-b - Normal Operating Condition**
1. Same as Case I-a, except upper pool El. 218.0 in lock chamber
 2. Same as Case I-a, except upper pool El. 218.0 in lock chamber
 3. Same as Case I-a, except upper pool El. 218.0 in lock chamber
 4. Same as Case I-a, except upper pool El. 218.0 in lock chamber
 5. Same as Case I-a, except upper pool El. 218.0 in lock chamber
 6. Same as Case I-a, except upper pool El. 218.0 in lock chamber
 7. Same as Case I-a, except upper pool El. 218.0 in lock chamber
 8. Same as Case I-a, except upper pool El. 218.0 in lock chamber
 9. Same as Case I-a, except upper pool El. 218.0 in lock chamber
 10. Same as Case I-a, except upper pool El. 218.0 in lock chamber
- Case II-a - Extreme Maintenance Condition - Normal Design Stresses**
1. Lock chamber lowered to top of floor slab El. 178.0
 2. Backfill behind riverwall to El. 188.0 behind riverwall
 3. Backfill behind riverwall to El. 188.0 behind riverwall
 4. Backfill behind riverwall to El. 188.0 behind riverwall
 5. Backfill behind riverwall to El. 188.0 behind riverwall
 6. Backfill behind riverwall to El. 188.0 behind riverwall
 7. Backfill behind riverwall to El. 188.0 behind riverwall
 8. Backfill behind riverwall to El. 188.0 behind riverwall
 9. Backfill behind riverwall to El. 188.0 behind riverwall
 10. Backfill behind riverwall to El. 188.0 behind riverwall
- Case II-b - Extreme Maintenance Condition - Out-Of-Phase Design Stresses**
1. Lock chamber lowered to top of floor slab El. 178.0
 2. Backfill behind riverwall to El. 188.0 behind riverwall
 3. Backfill behind riverwall to El. 188.0 behind riverwall
 4. Backfill behind riverwall to El. 188.0 behind riverwall
 5. Backfill behind riverwall to El. 188.0 behind riverwall
 6. Backfill behind riverwall to El. 188.0 behind riverwall
 7. Backfill behind riverwall to El. 188.0 behind riverwall
 8. Backfill behind riverwall to El. 188.0 behind riverwall
 9. Backfill behind riverwall to El. 188.0 behind riverwall
 10. Backfill behind riverwall to El. 188.0 behind riverwall
- Case III-a - Construction Condition**
1. Backfill to El. 225.0 behind riverwall
 2. Construction complete
 3. Riverwall excavation to El. 168.0
 4. Backfill to El. 225.0 behind riverwall
 5. Backfill to El. 225.0 behind riverwall
 6. Backfill to El. 225.0 behind riverwall
 7. Backfill to El. 225.0 behind riverwall
 8. Backfill to El. 225.0 behind riverwall
 9. Backfill to El. 225.0 behind riverwall
 10. Backfill to El. 225.0 behind riverwall
- REPERTINE INFORMATION**
1. Unit Weight of Material
 - Concrete 150 lb/cu ft
 - Backfill 120 lb/cu ft
 - Submerged sand backfill 120 lb/cu ft
 - Submerged sand backfill 120 lb/cu ft
 - Submerged sand backfill 120 lb/cu ft
 - Submerged sand backfill 120 lb/cu ft
 - Submerged sand backfill 120 lb/cu ft
 - Submerged sand backfill 120 lb/cu ft
 - Submerged sand backfill 120 lb/cu ft
 - Submerged sand backfill 120 lb/cu ft
 2. Moment arm of horizontal earth pressure = 0.4H
 3. Moment arm of horizontal earth pressure = 0.5H
 4. Moment arm of horizontal earth pressure = 0.5H
 5. Moment arm of horizontal earth pressure = 0.5H
 6. Moment arm of horizontal earth pressure = 0.5H
 7. Moment arm of horizontal earth pressure = 0.5H
 8. Moment arm of horizontal earth pressure = 0.5H
 9. Moment arm of horizontal earth pressure = 0.5H
 10. Moment arm of horizontal earth pressure = 0.5H







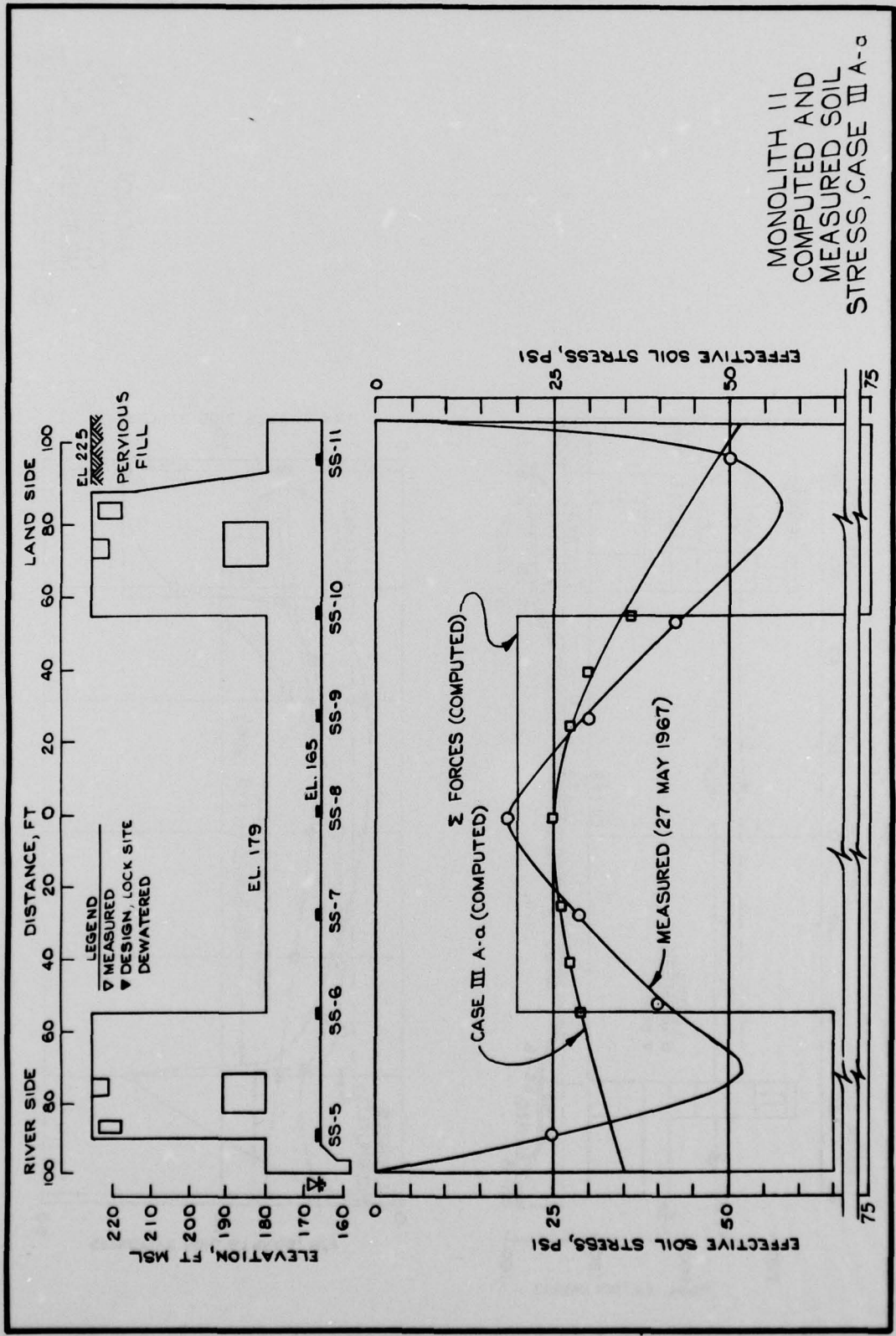
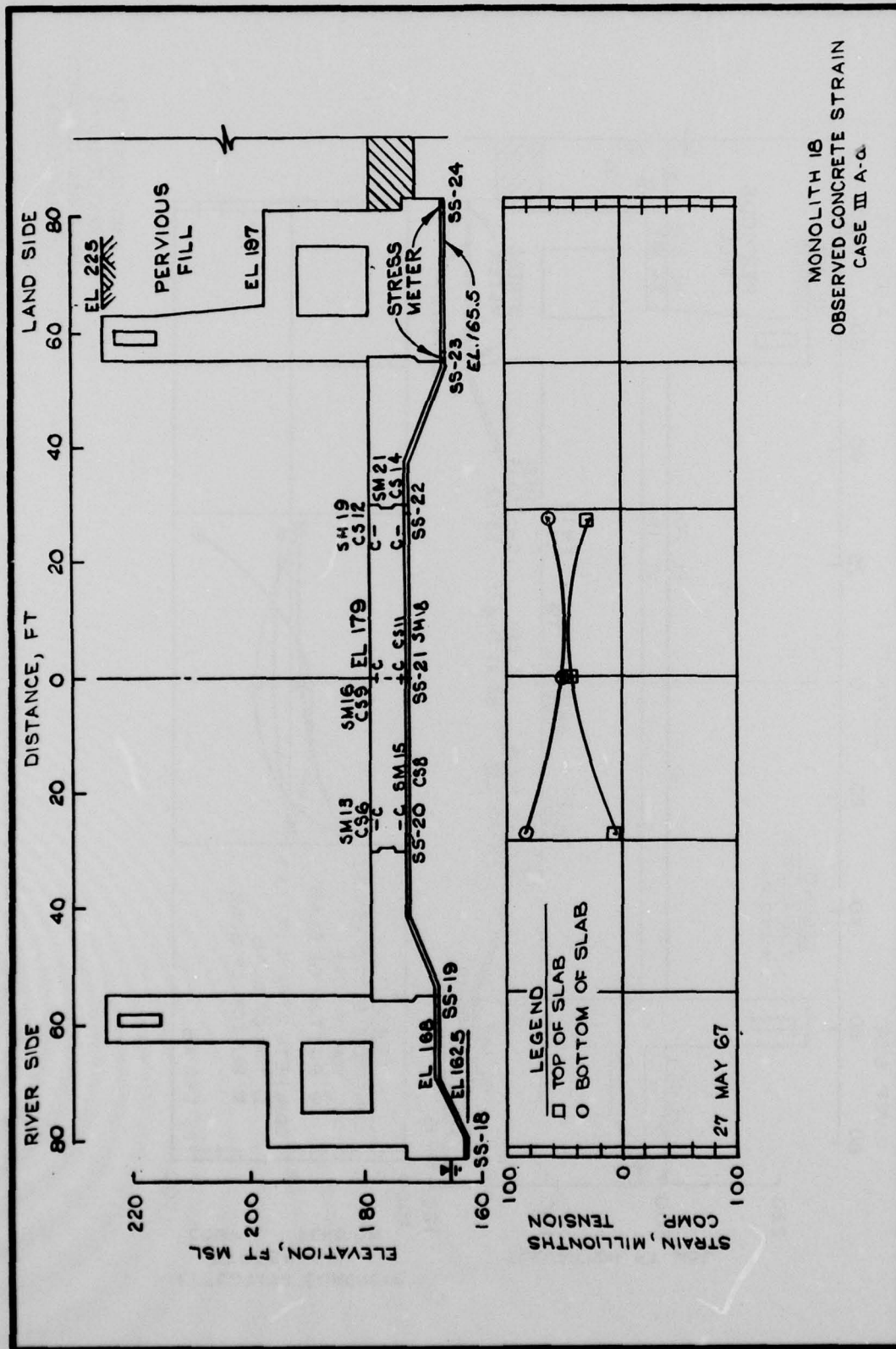
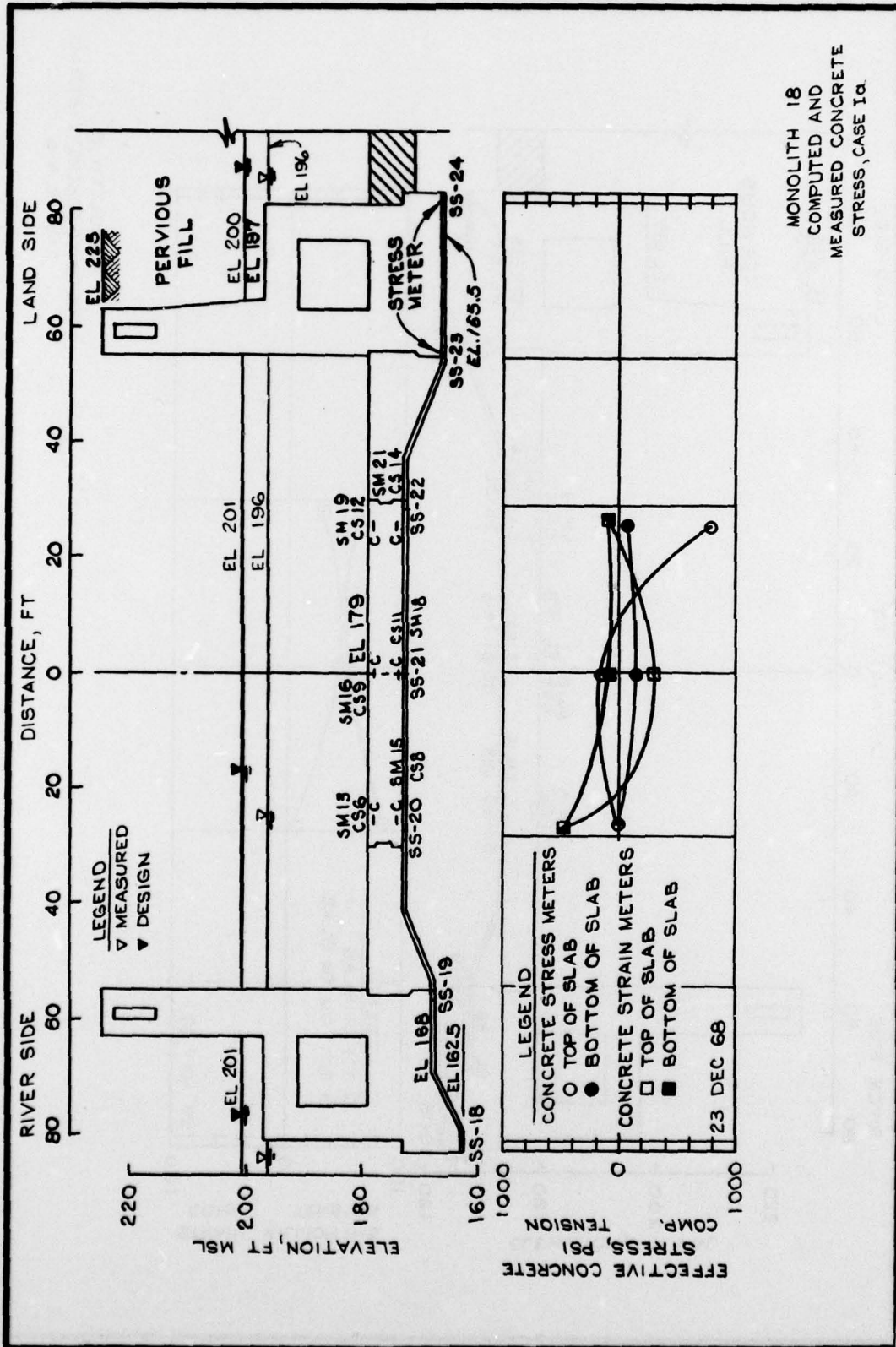
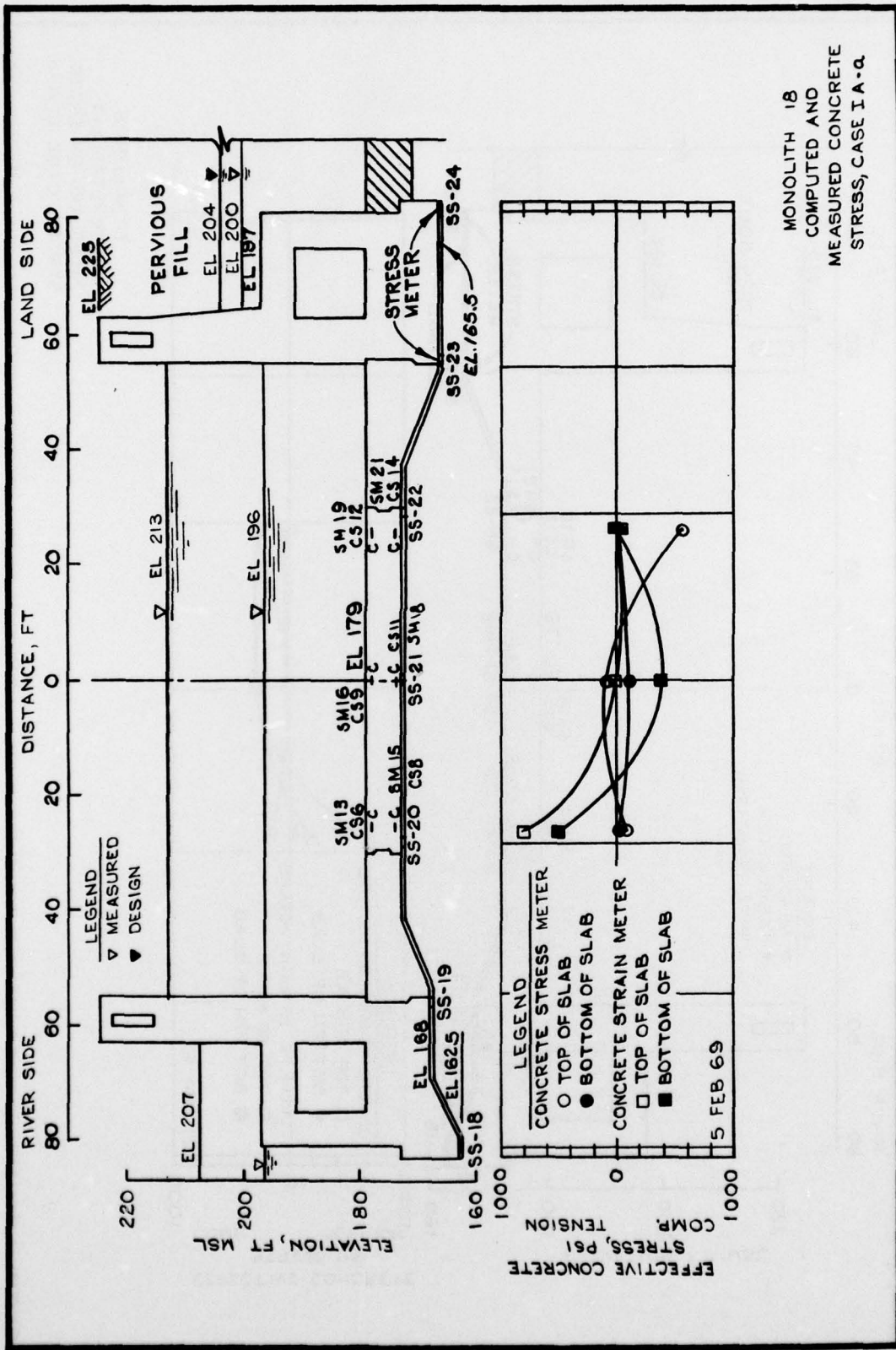
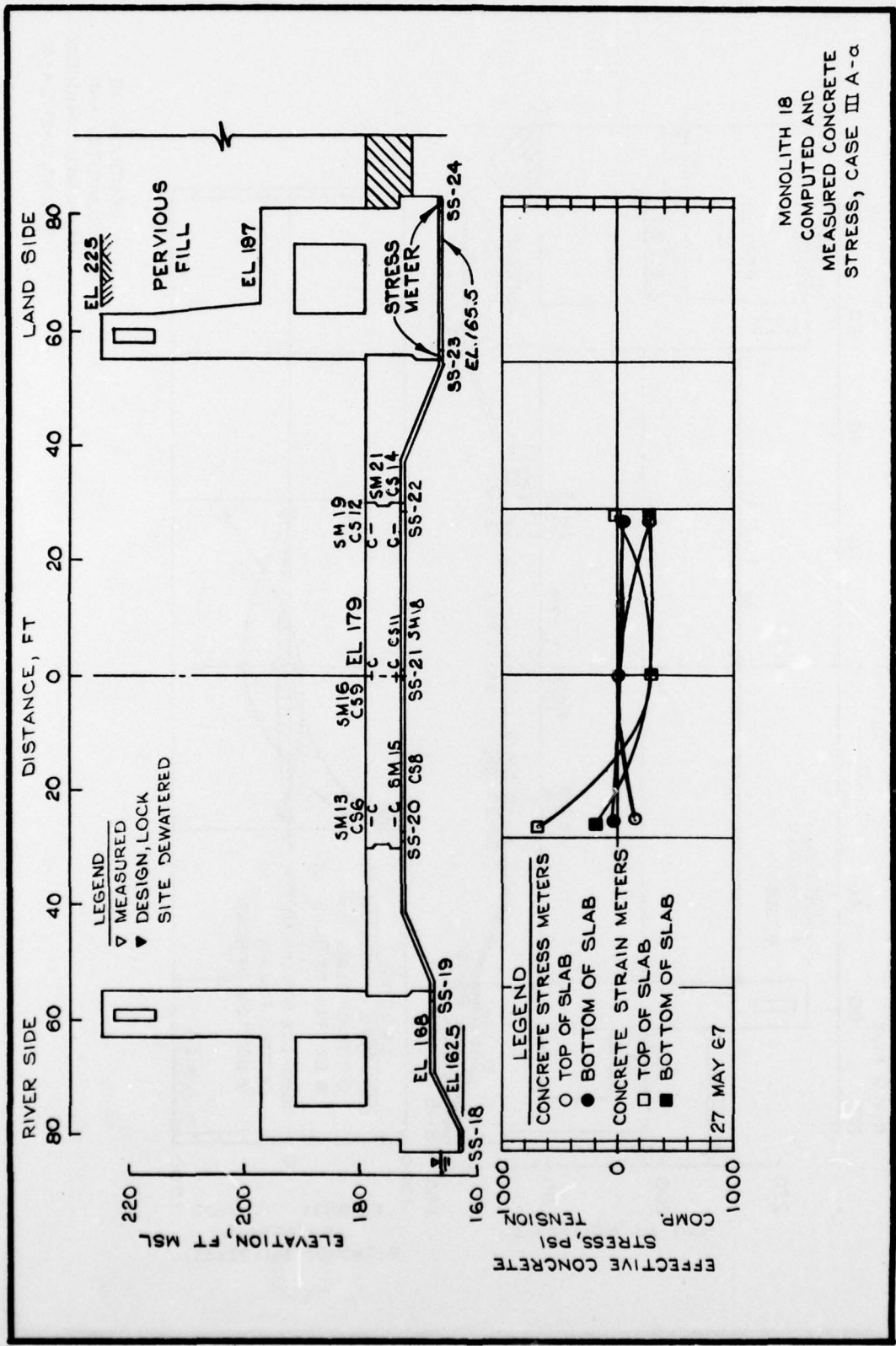


PLATE 84

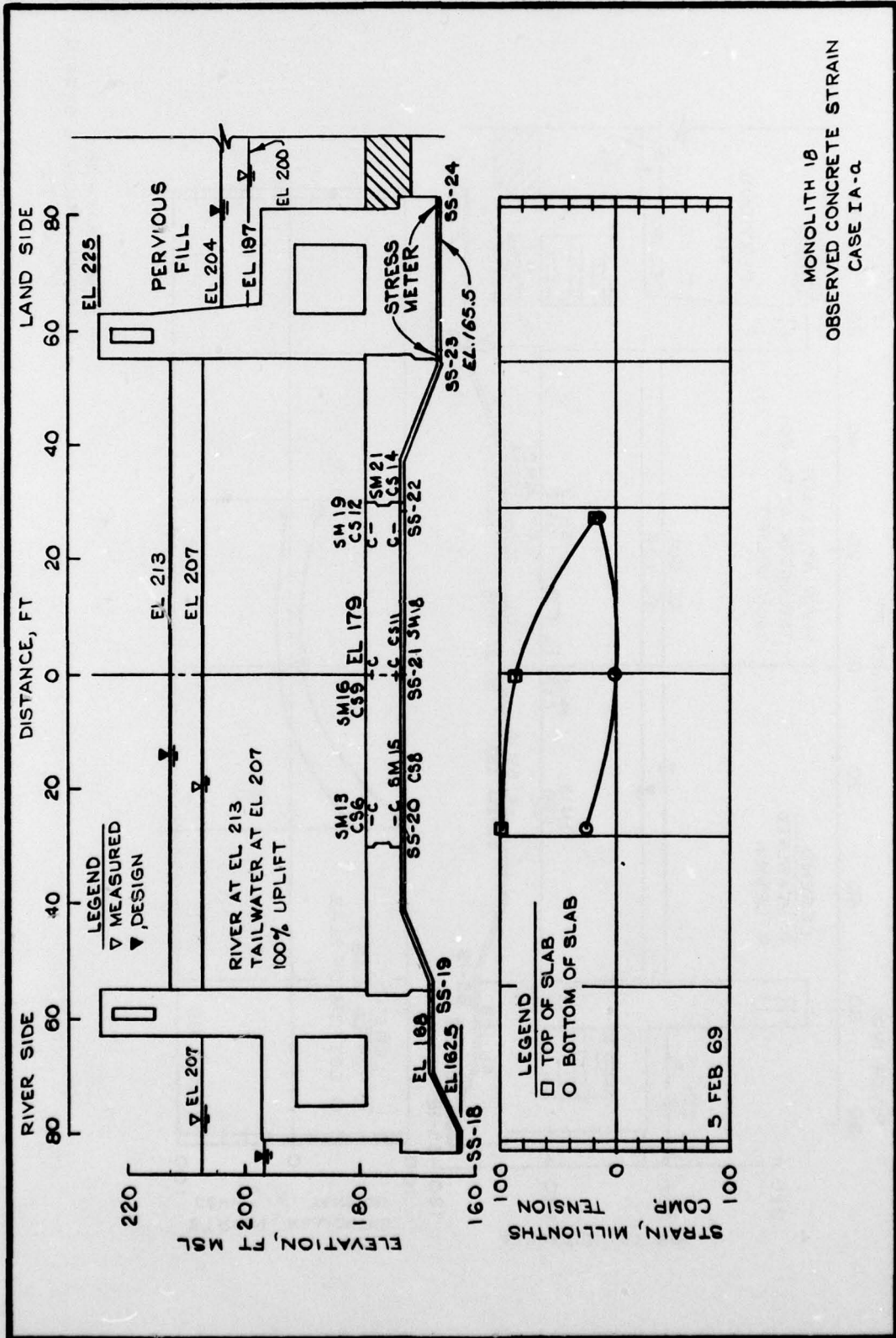


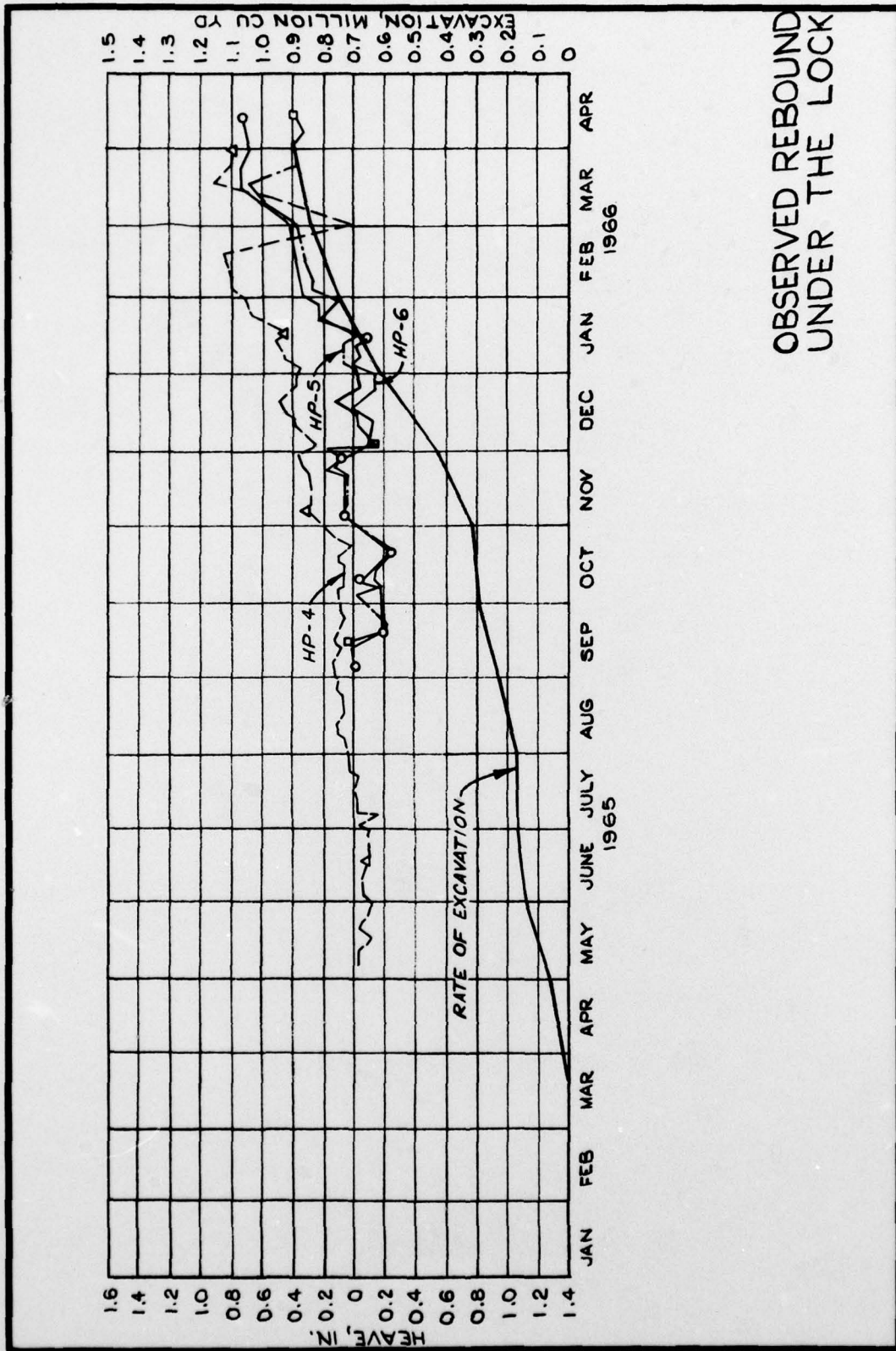






MONOLITH 18
 COMPUTED AND
 MEASURED CONCRETE
 STRESS, CASE III A-a





OBSERVED REBOUND
UNDER THE LOCK

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Leach, Roy E

Instrumentation observations from the U-frame lock of the Arkansas River Lock and Dam.5 / by Roy E. Leach. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1978.

13, [1] p., 91 leaves of plates : ill. ; 27 cm. (Miscellaneous paper - U. S. Army Engineer Waterways Experiment Station ; S-78-11)

Prepared for Office, Chief of Engineers, U. S. Army, Washington, D. C., under CWIS 31203.

1. Instrumentation. 2. Lock and Dam No. 5, Arkansas River. 3. Locks (Waterways). 4. Measuring instruments. 5. U-frame locks. I. United States. Army. Corps of Engineers. II. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Miscellaneous paper ; S-78-11.
TA7.W34m no.S-78-11