

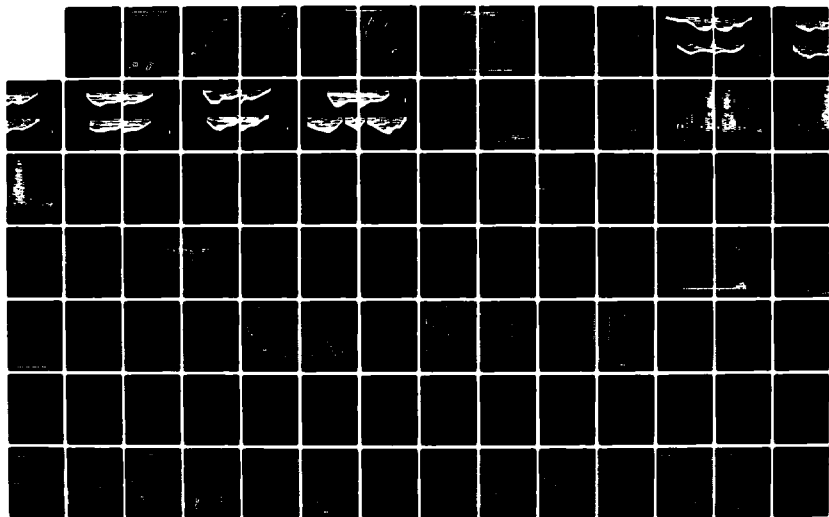
AD-A123 608

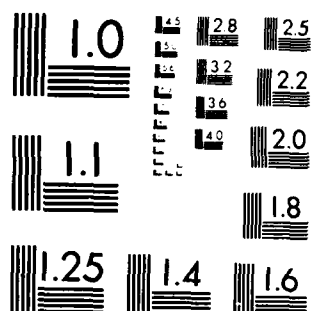
EMBANKMENT CRITERIA AND PERFORMANCE REPORT MISSOURI
RIVER FORT PECK LAKE MONTANA VOLUME II DRAWINGS(U) ARMY
ENGINEER DISTRICT OMAHA NEBR SEP 82

1/2

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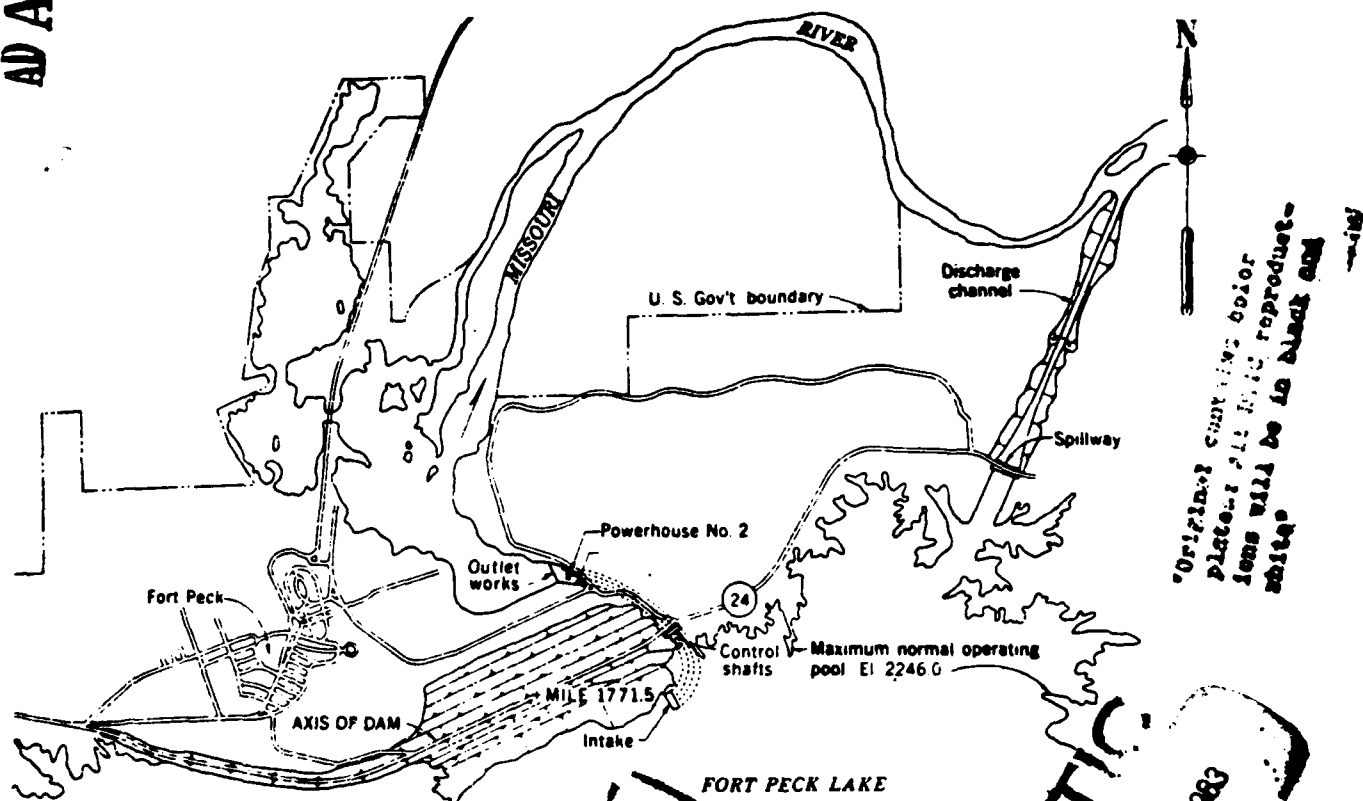
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

EMBANKMENT CRITERIA AND PERFORMANCE REPORT

SEPTEMBER 1982

ADA 123608

MISSOURI RIVER FORT PECK LAKE, MONTANA



US Army Corps
of Engineers
Omaha District

VOLUME II.
DRAWINGS

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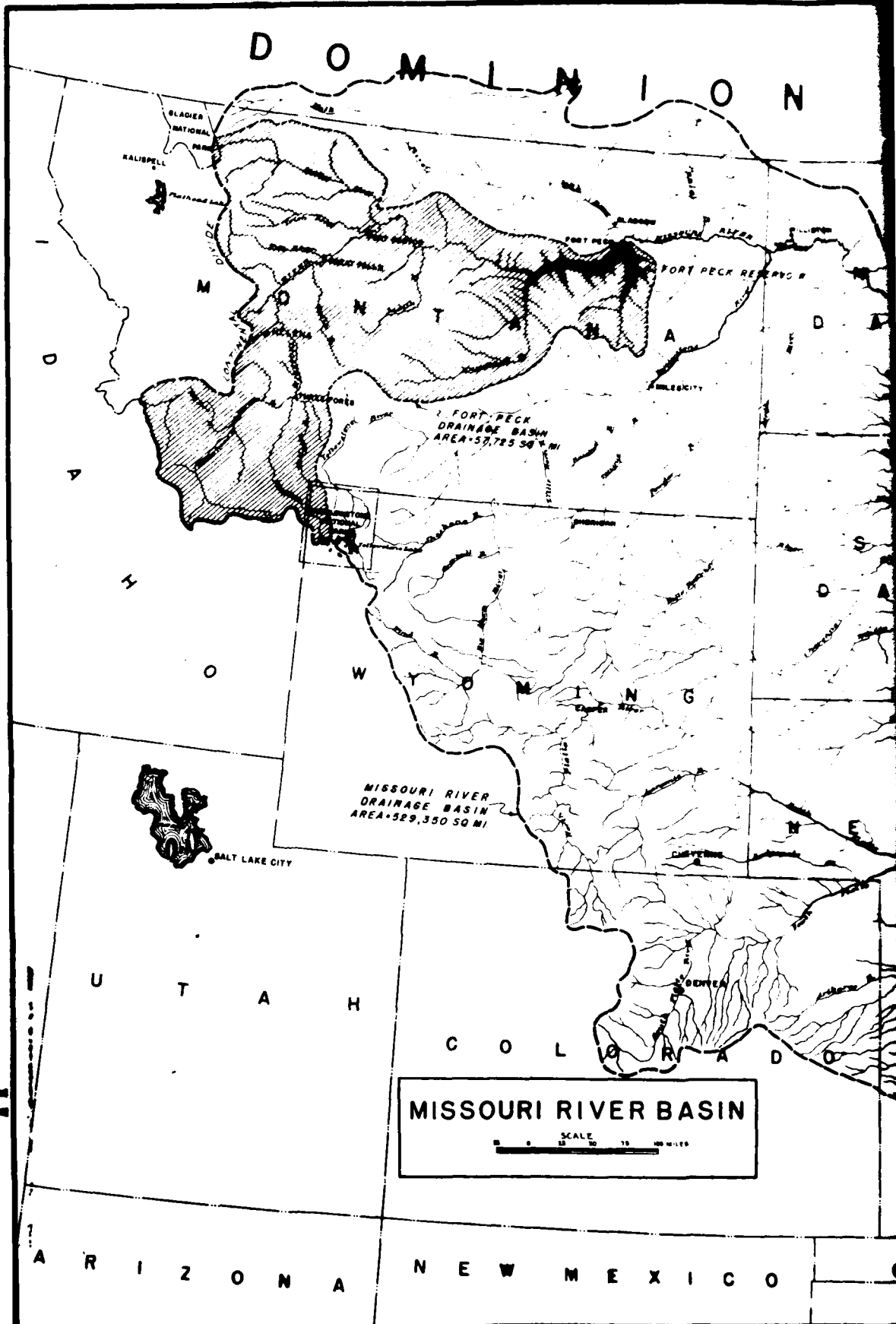


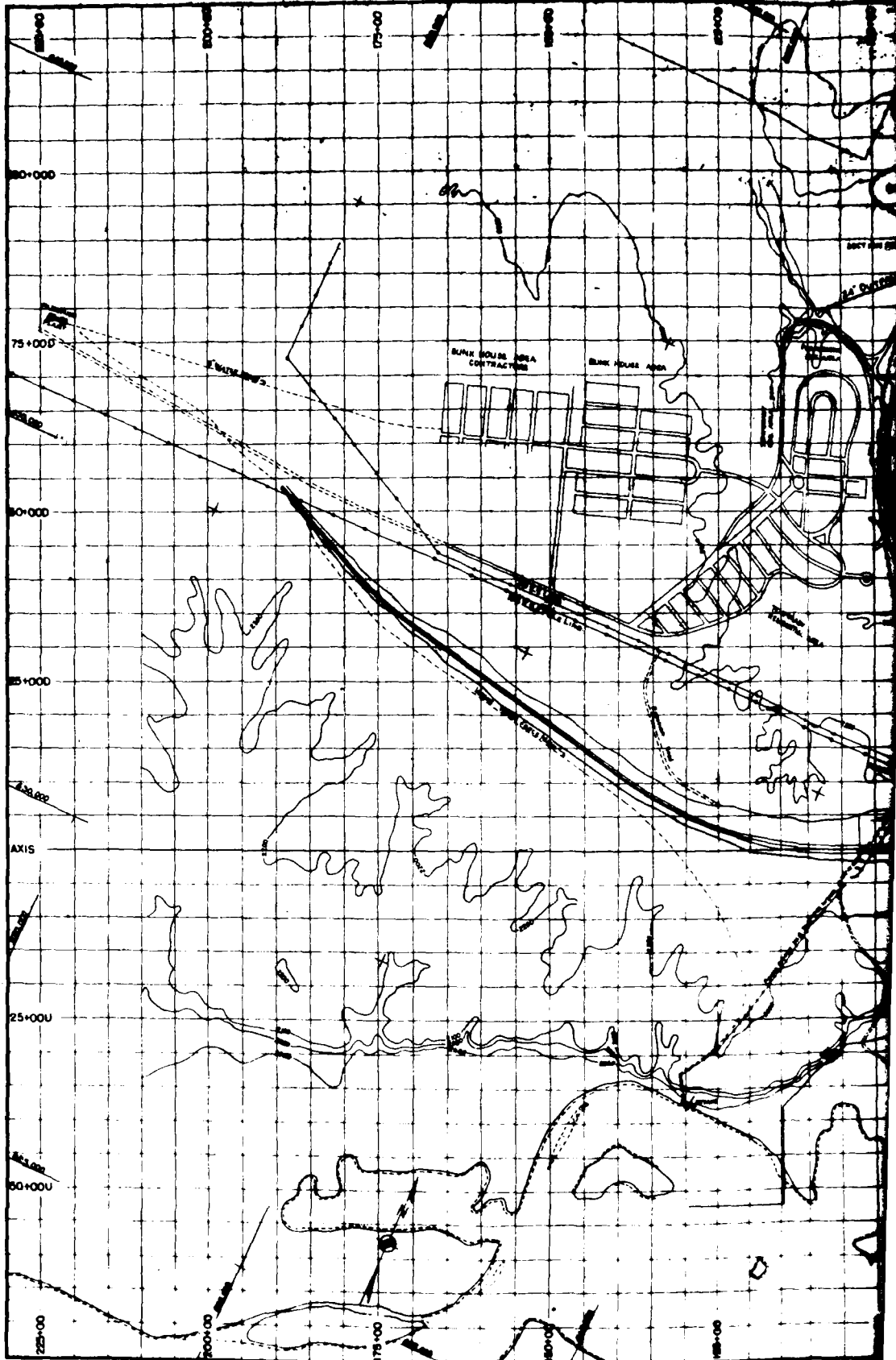


FIGURE 2

FORT PECK DAM AND RESERVOIR EMBANKMENT CRITERIA AND PERFORMANCE REPORT PLATE 1-1

2

WAR DEPARTMENT

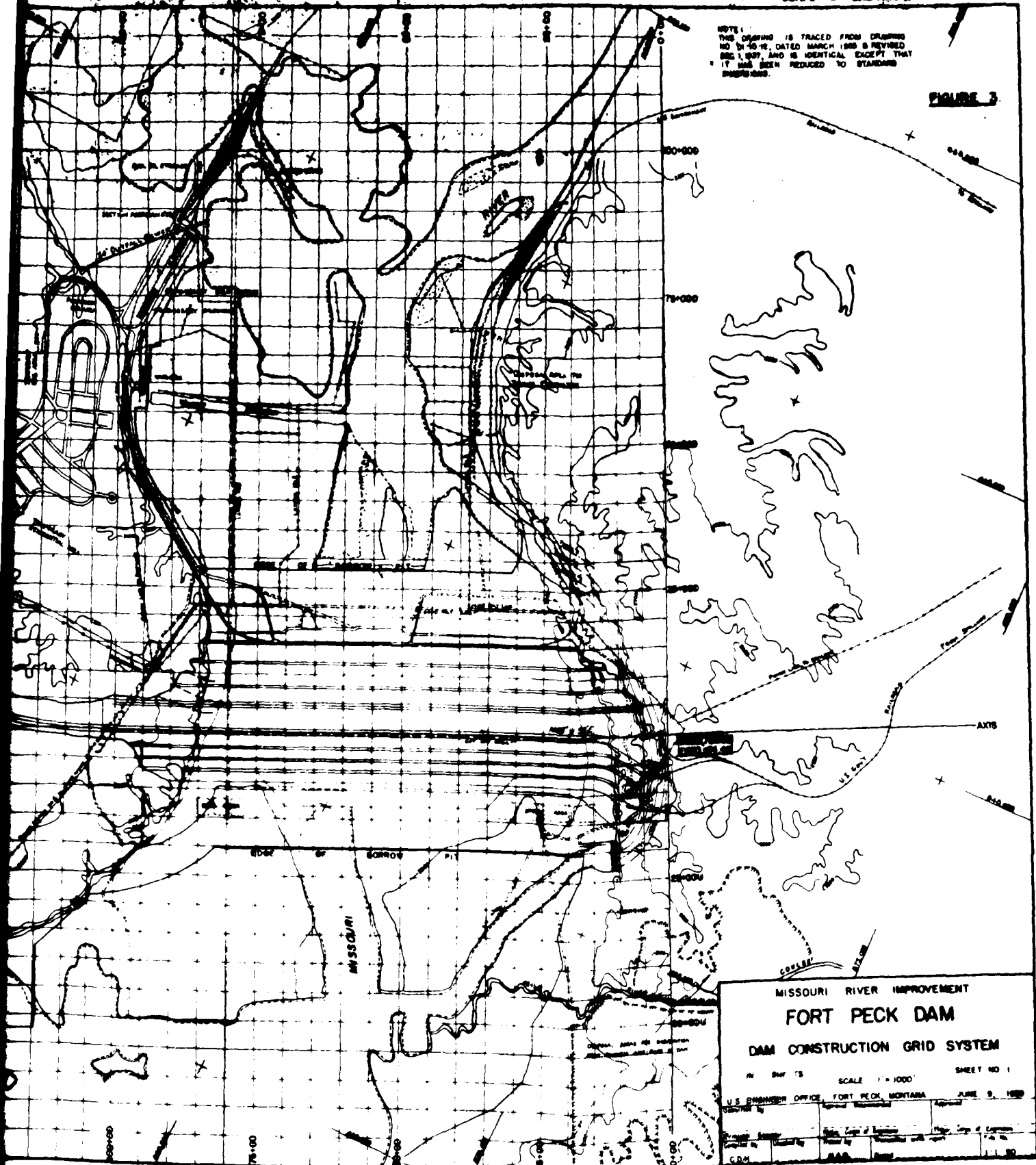


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INSPECTION
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By	
Availability	
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NOTE:
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NO. D-10-15, DATED MARCH 1958 & REVISED
D-10-15, AND IS IDENTICAL EXCEPT THAT
IT HAS BEEN REDUCED TO STANDARD
DIMENSIONS.

FIGURE 3



MISSOURI RIVER IMPROVEMENT

FORT PECK DAM

DAM CONSTRUCTION GRID SYSTEM

IN SHEETS

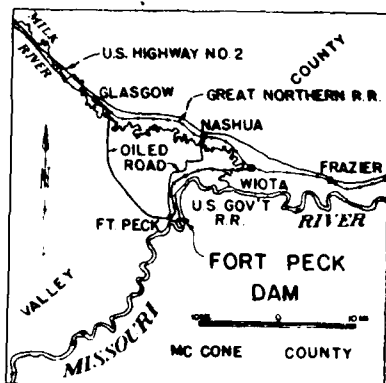
SCALE 1" = 1000'

SHEET NO. 1

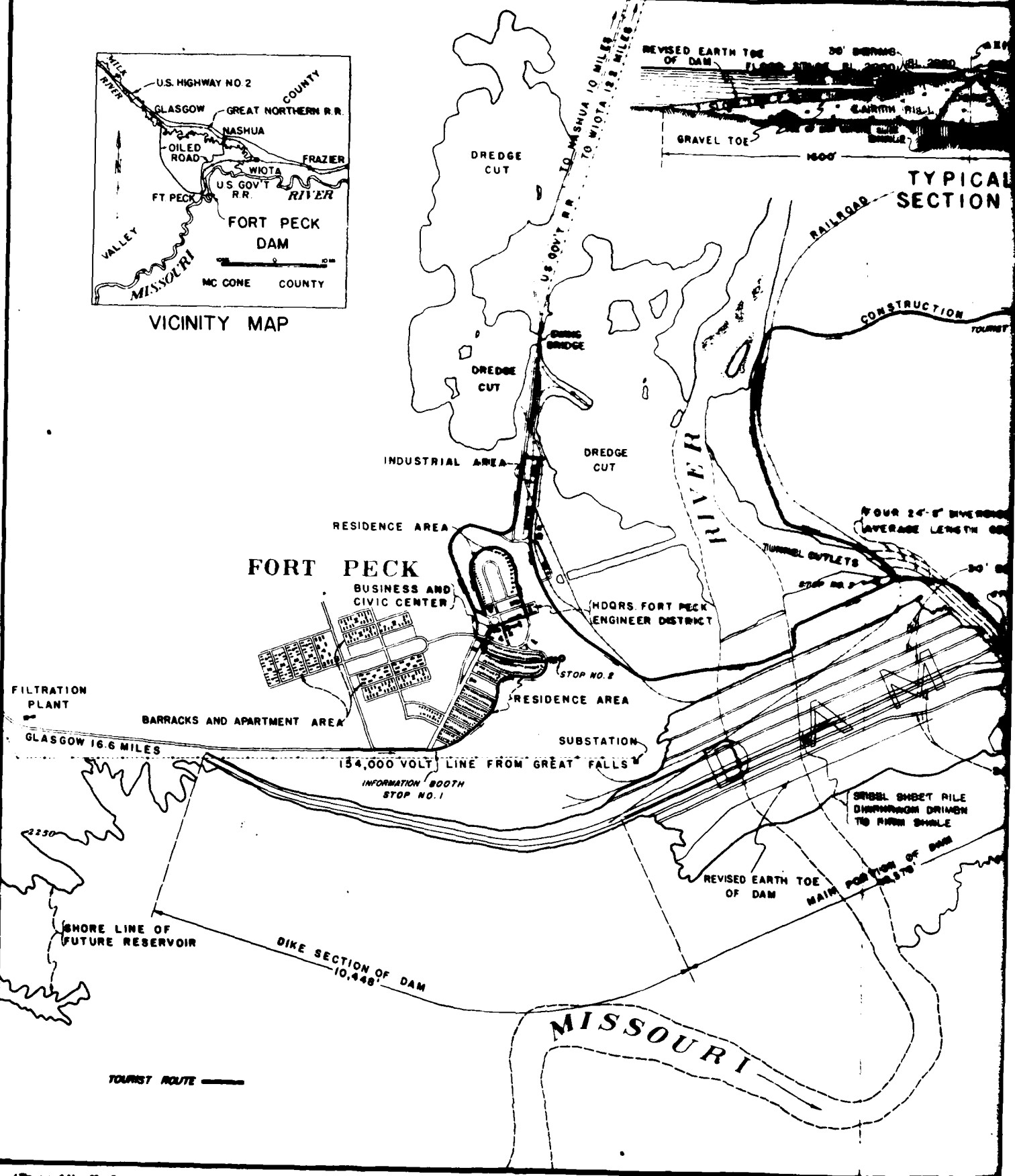
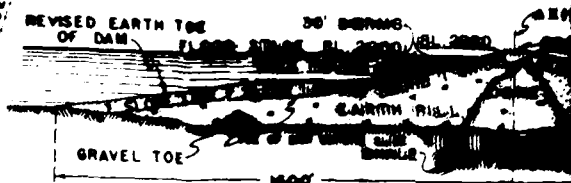
U.S. ENGINEER OFFICE, FORT PECK, MONTANA

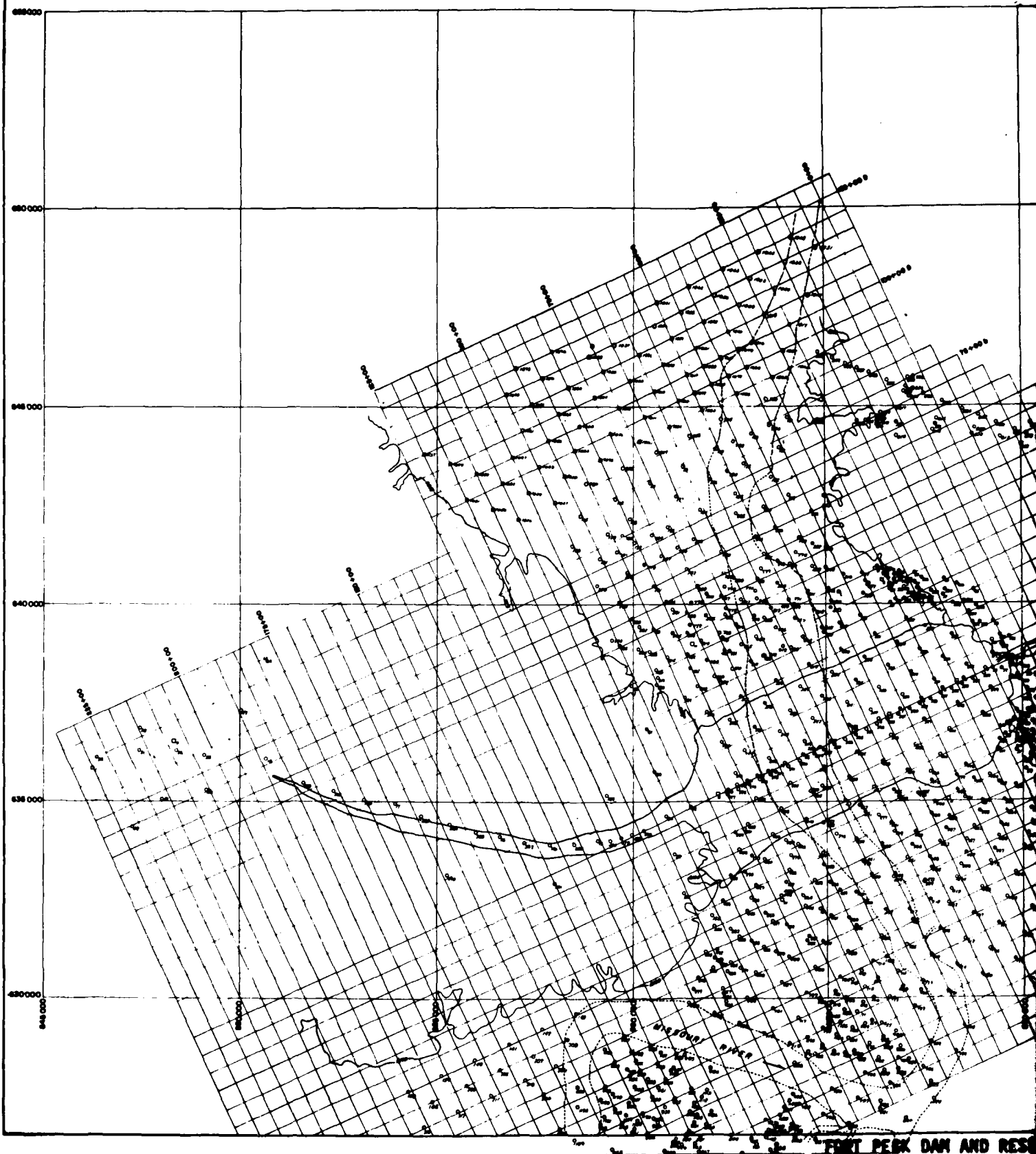
JUNE 9, 1959

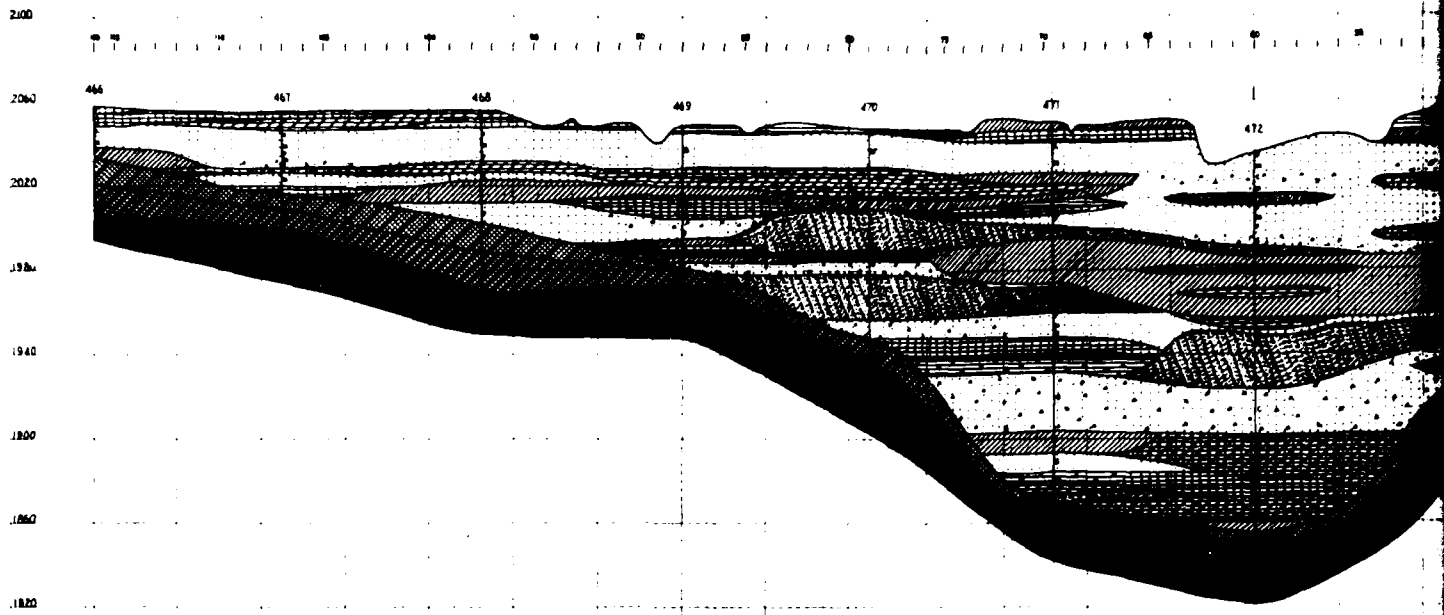
DESIGNED BY	C.D.N.	CHECKED BY	W.A.B.	APPROVED BY	
DATE		DATE		DATE	



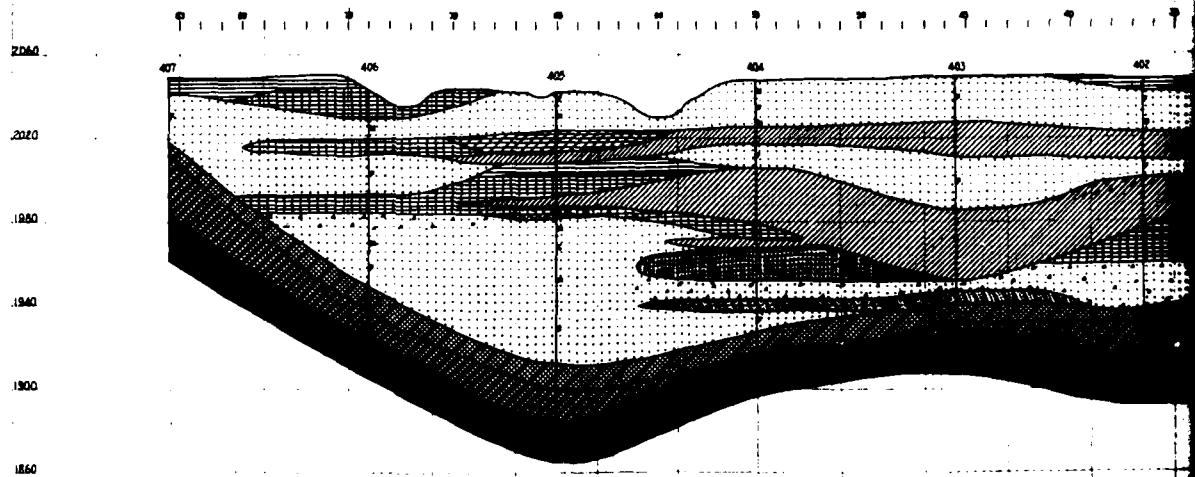
VICINITY MAP





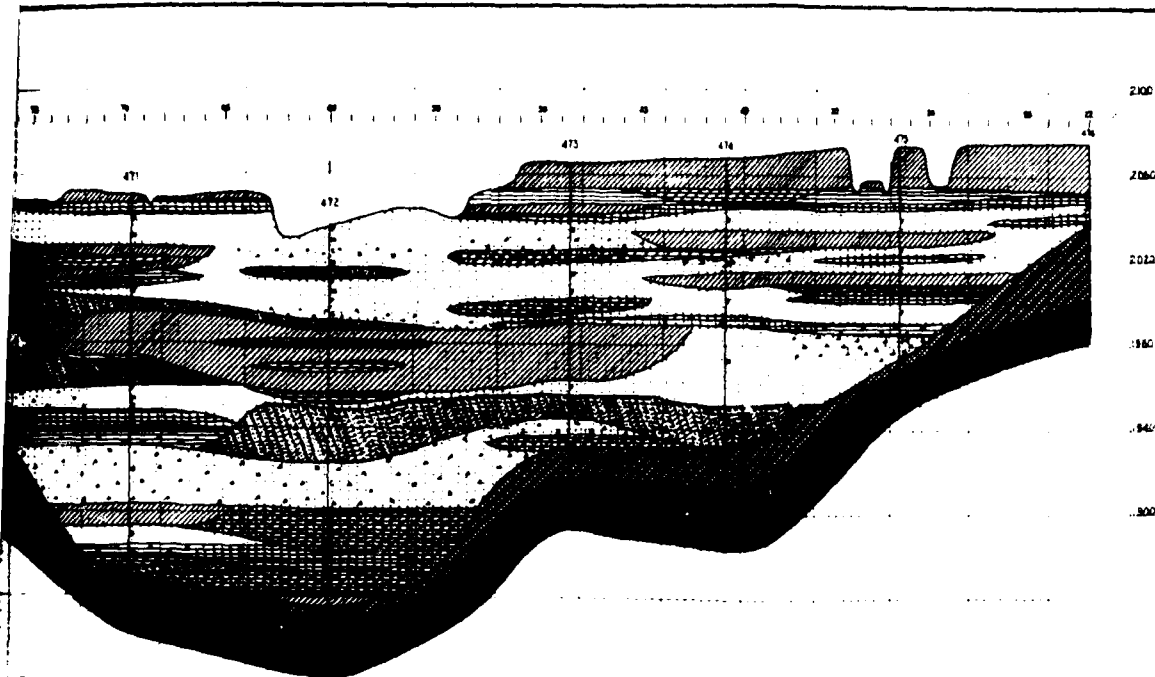


LINE 44+00-U

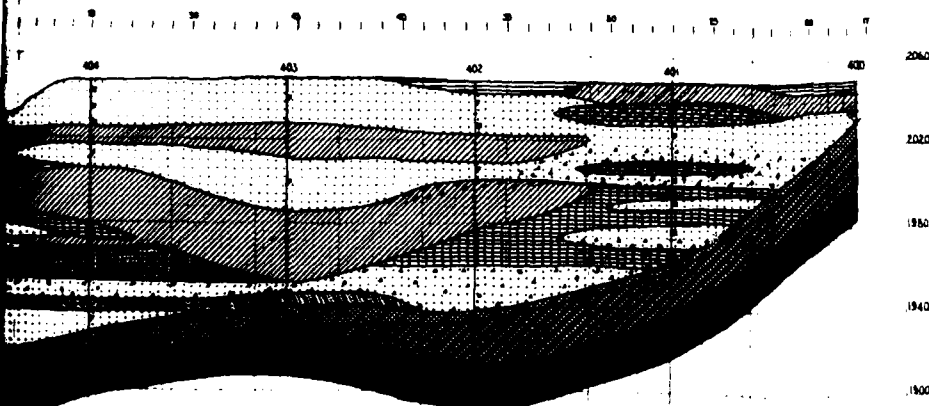


LINE 9+40-U

FORT PECK DAM AND RES



LINE 44+00-U



LINE 9+40-U

LEGEND
RANGE OF SOIL CLASSIFICATION

SAND	
GRAVELLY SAND	
LOAM	
BANDY LOAM	
GRAVELLY LOAM	
BANDY GRAVELLY LOAM	
CLAY	
GRAVELLY CLAY	
CLAY LOAM	
BANDY CLAY LOAM	
GRAVELLY CLAY LOAM	
BANDY GRAVELLY CLAY LOAM	
GRAVEL	
BANDY GRAVEL	
SOFT SHALE	
MID-FIRM SHALE	
FIRM SHALE	

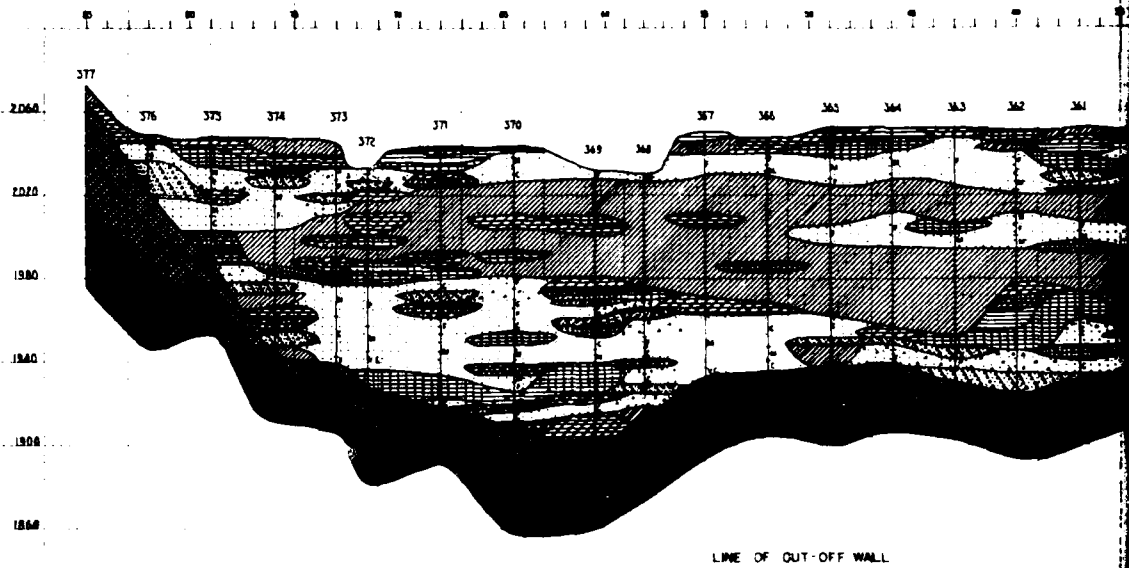
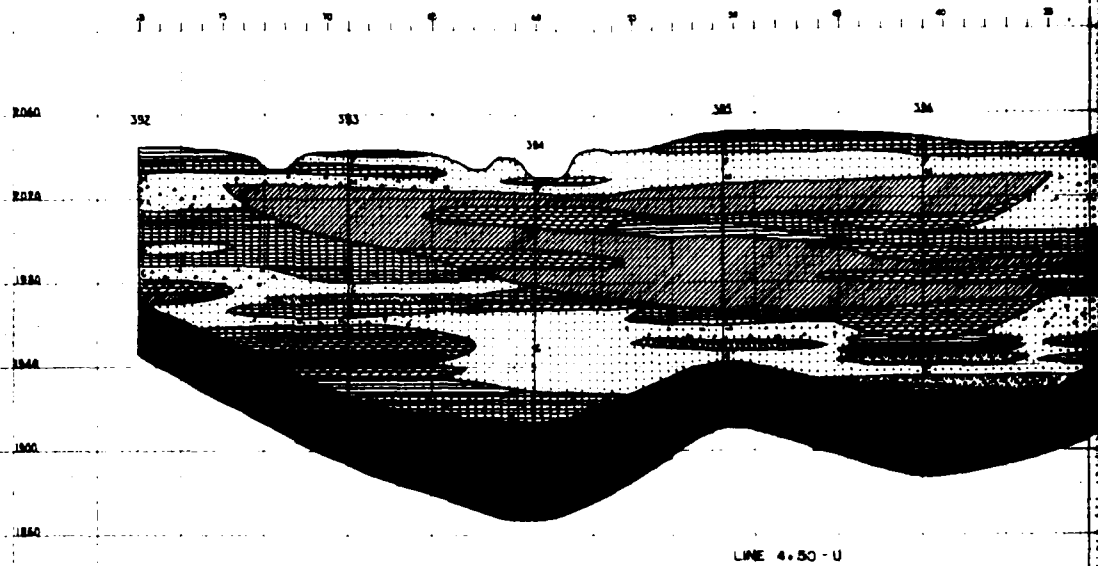
MISSOURI RIVER IMPROVEMENT
FORT PECK DAM
FOUNDATION
SOIL PROFILES

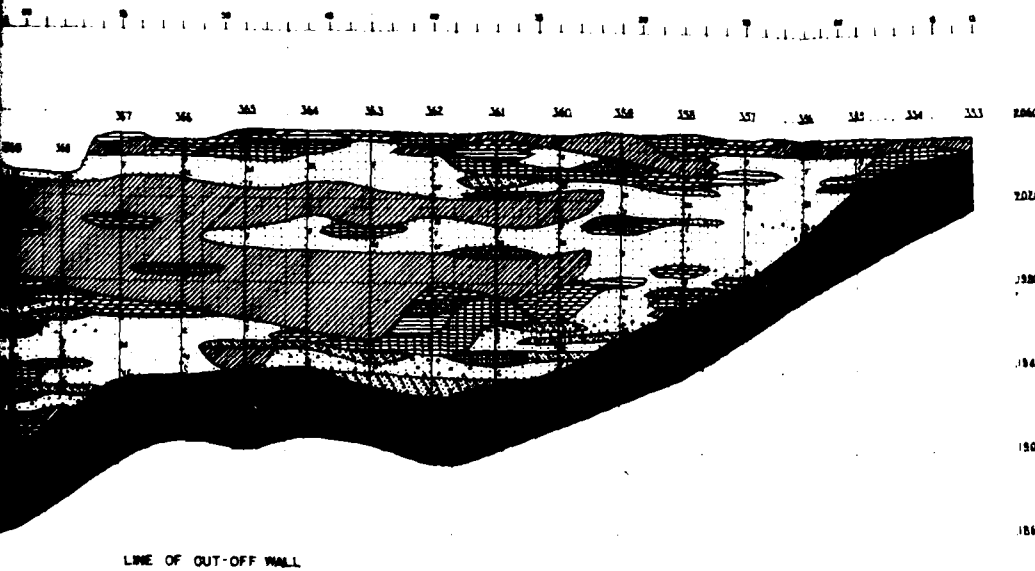
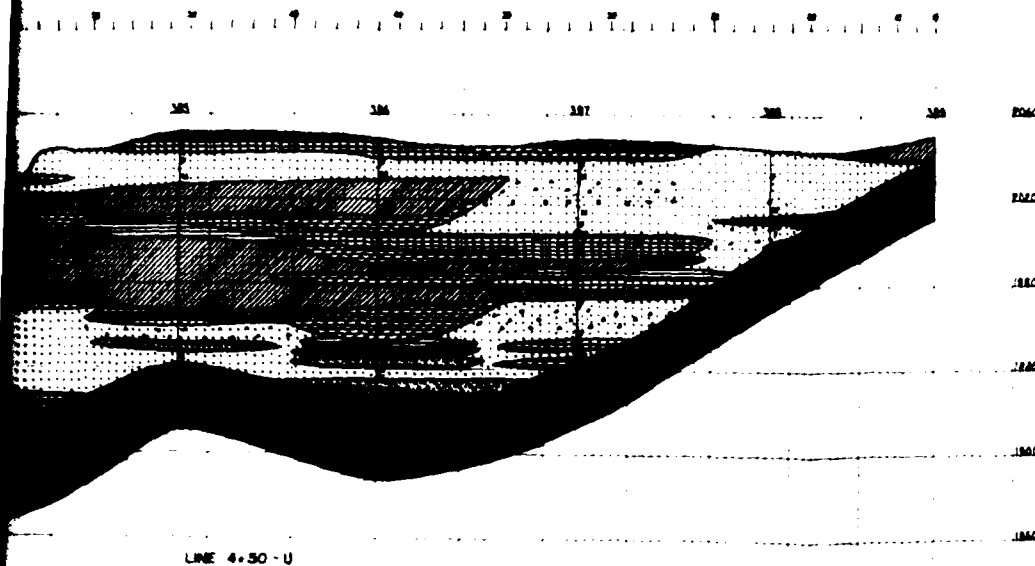
IN SHEETS		SCALE	1" = 40'	SHEET NO. 1
U.S. ENGINEER OFFICE		MISSOURI RIVER DIVISION		
FORT PECK, MONTANA		FEB. 1938		
Submitted	Recommended	Approved		
Associate Engineer	Special Engineer	Major Corps of Engineers		
Drawn	Traced	Checked	Transmitted	File
cas	cas			33-11-2

FORT PECK DAM AND RESERVOIR

EMBANKMENT CRITERIA AND PERFORMANCE REPORT

PLATE 3-2



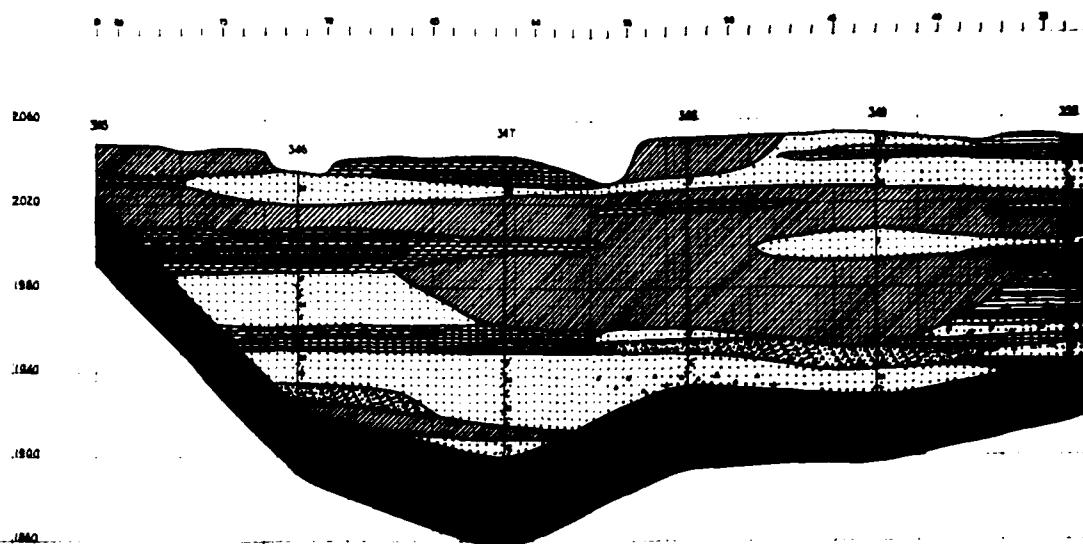


LEGEND
BUREAU OF SOIL CLASSIFICATION

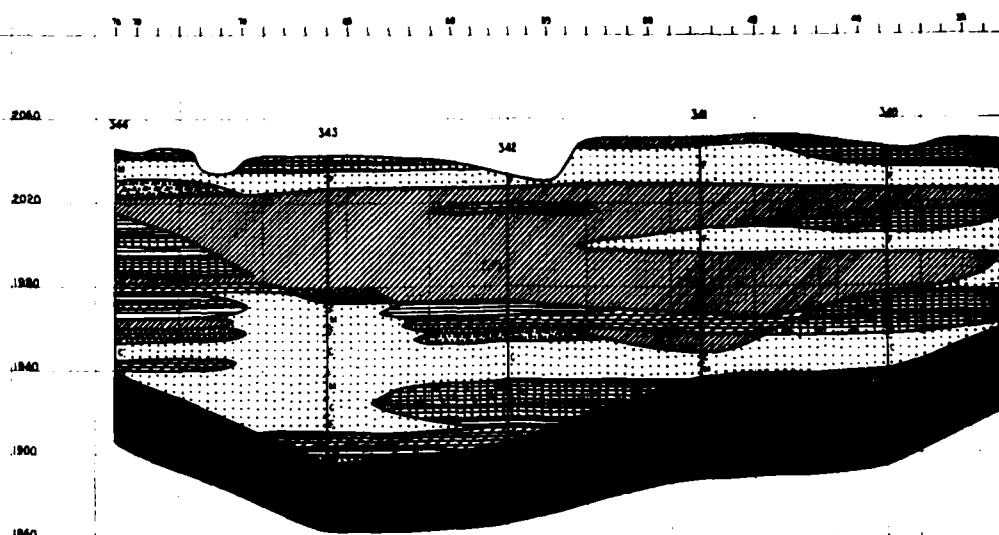
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	GRAVELLY SAND	[Pattern]
2020	LOAM	[Pattern]
	SANDY LOAM	[Pattern]
	GRAVELLY LOAM	[Pattern]
1980	SANDY GRAVELLY LOAM	[Pattern]
	CLAY	[Pattern]
	SANDY CLAY	[Pattern]
1840	CLAY LOAM	[Pattern]
	GRAVELLY CLAY LOAM	[Pattern]
	SANDY CLAY LOAM	[Pattern]
1800	SANDY GRAVELLY CLAY LOAM	[Pattern]
	GRAVEL	[Pattern]
	SANDY GRAVEL	[Pattern]
1660	WEATHERED SHALE	[Pattern]
	SOFT SHALE	[Pattern]
	SUB-FIRM SHALE	[Pattern]
	FIRM SHALE	[Pattern]

MISSOURI RIVER IMPROVEMENT
FORT PECK DAM
FOUNDATION
SOIL PROFILES

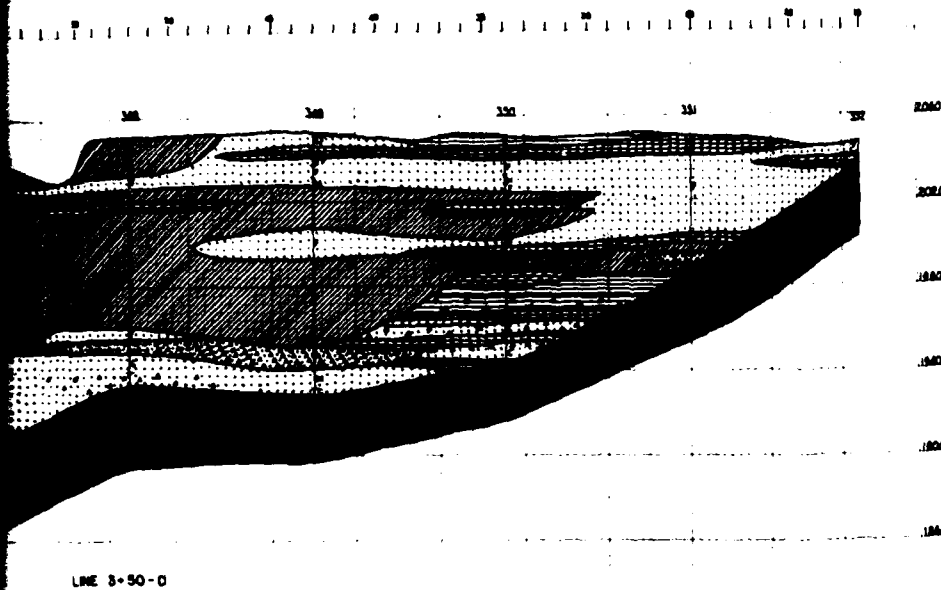
IN SHEETS				SCALE: 1" = 100'		SHEET NO. 2	
U.S. ENGINEER OFFICE, FORT PECK, MONTANA				MISSOURI RIVER DIVISION, FEB 1935			
Submitted		Recommended		Approved			
Assisted Engineer		Senior Engineer		Type of Soil		File	
Drawn	Traced	Checked	Transmitted			33112	



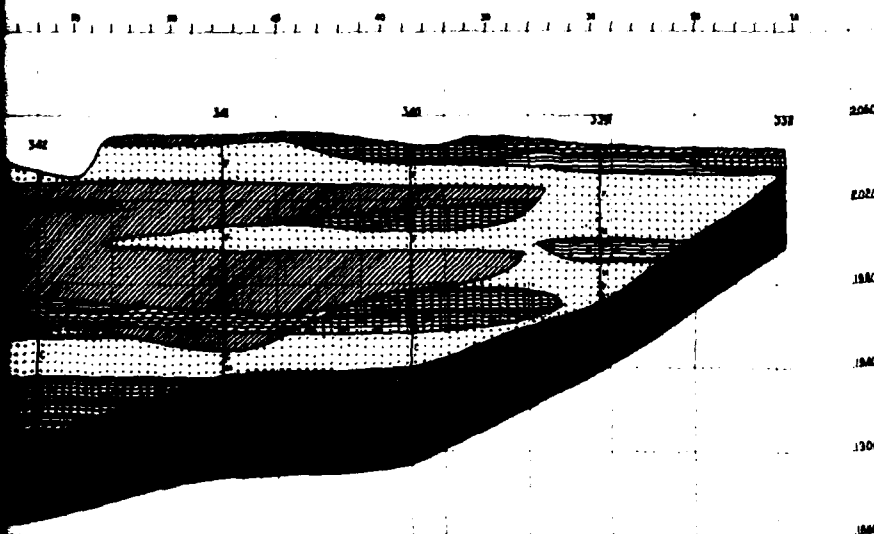
LINE 3+50-D



LINE 7+80-D



LINE 3+50-0



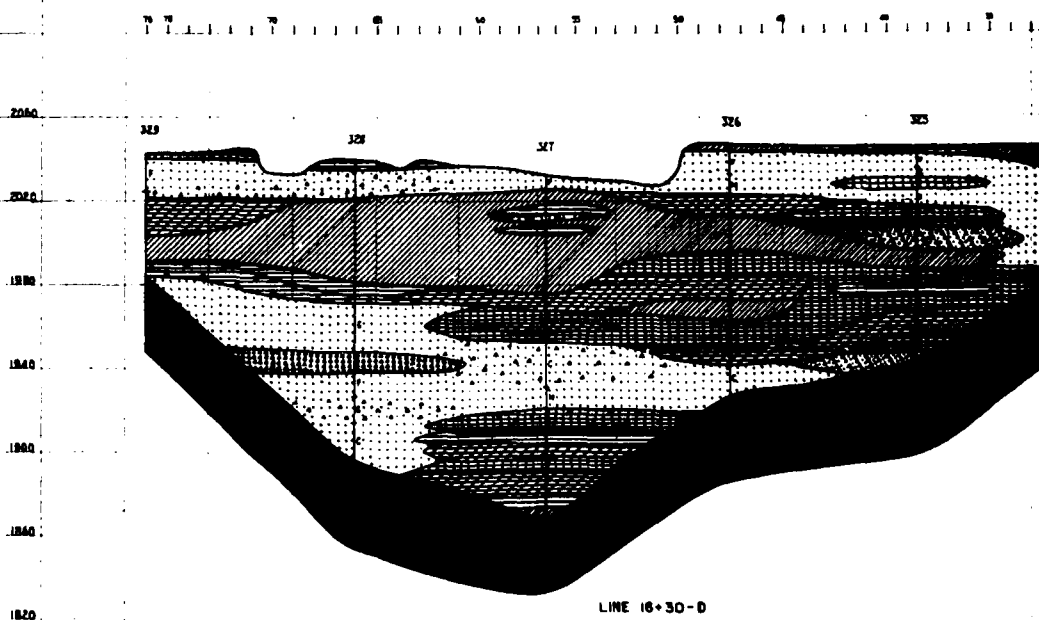
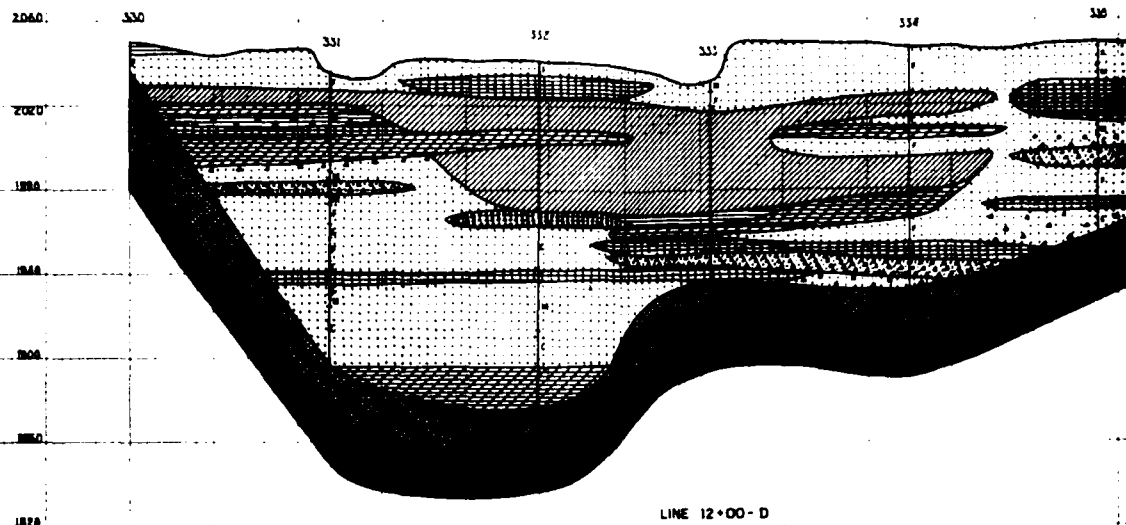
LINE 7+80-0

LEGEND
BUREAU OF SOIL CLASSIFICATION

SAND	
GRAVELLY SAND	
LOAM	
SANDY LOAM	
GRAVELLY LOAM	
SANDY GRAVELLY LOAM	
CLAY	
SANDY CLAY	
CLAY LOAM	
SANDY CLAY LOAM	
GRAVELLY CLAY LOAM	
SANDY GRAVELLY CLAY LOAM	
SANDY GRAVEL	
WEATHERED SHALE	
SOFT SHALE	
SUB-FIRM SHALE	
FIRM SHALE	

MISSOURI RIVER IMPROVEMENT
FORT PECK DAM
FOUNDATION
SOIL PROFILES

10 SHEETS	SCALE 1" = 40'	SHEET NO. 3
U.S. ENGINEER OFFICE, FORT PECK, MONTANA		MISSOURI RIVER DIVISION, FEB 1939
Submitted	Recommended	Approved
Designed	Checked	Tracked
Drawn	Tracked	Checked
Scale	Scale	Scale
3.3-11-2		



LINE 12+00-D

LINE 16+30-D

LEGEND
BUREAU OF SOIL CLASSIFICATION

SAND	
GRAVELLY SAND	
LOAM	
BANDY LOAM	
GRAVELLY LOAM	
BANDY GRAVELLY LOAM	
CLAY	
CLAY LOAM	
GRAVEL	
BANDY GRAVEL	
WEATHERED SHALE	
SOFT SHALE	
SUB-FIRM SHALE	
FIRM SHALE	

MISSOURI RIVER IMPROVEMENT
FORT PECK DAM
FOUNDATION
SOIL PROFILES

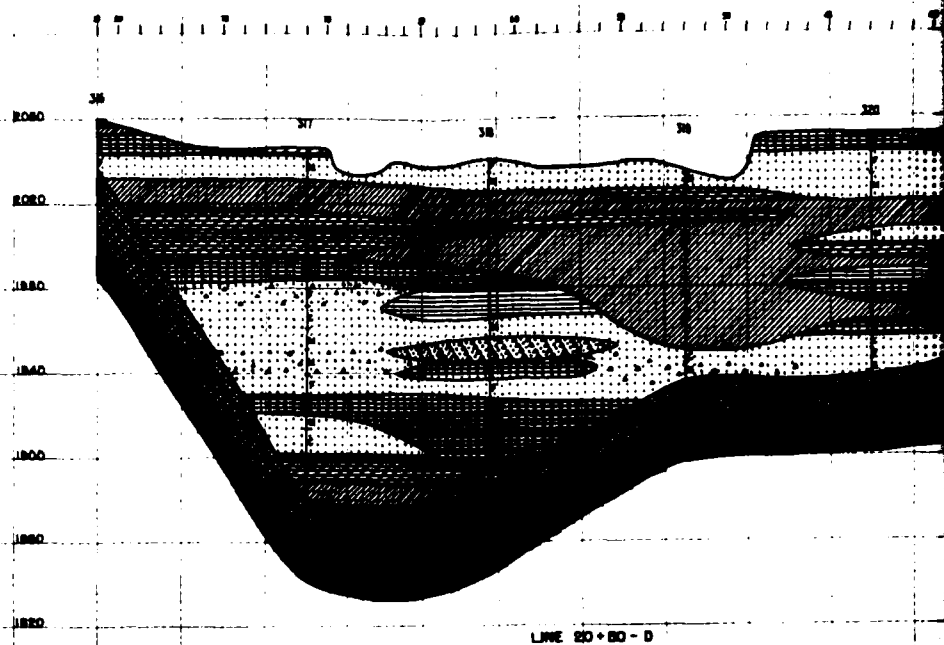
IN SHEETS		SCALE 1"=40'	SHEET NO. 4
U.S. ENGINEER OFFICE, FORT PECK, MONTANA		MISSOURI RIVER DIVISION MARCH 1936	
Submitted	Recommended	Approved	
Associate Engineer	Senior Engineer	Major Corps of Engineers	
Drawn	Traced	Checked	Transmitted
FILE			
33-11-Z			

FORT PECK DAM AND RESERVOIR

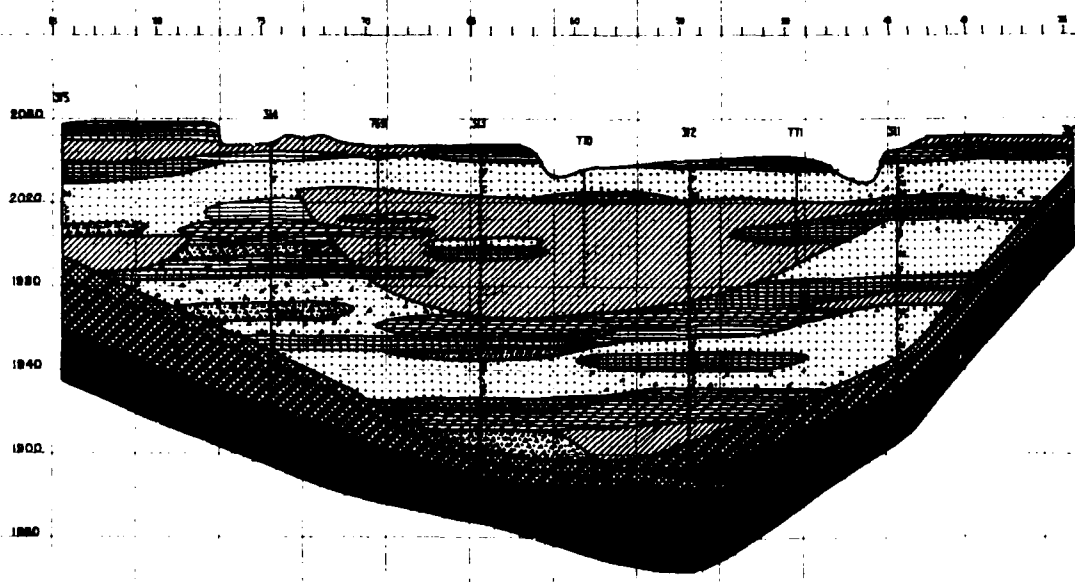
EMBANKMENT CRITERIA AND PERFORMANCE REPORT

PLATE 3-5

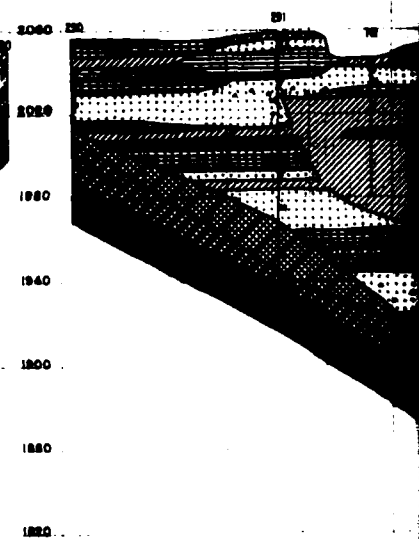
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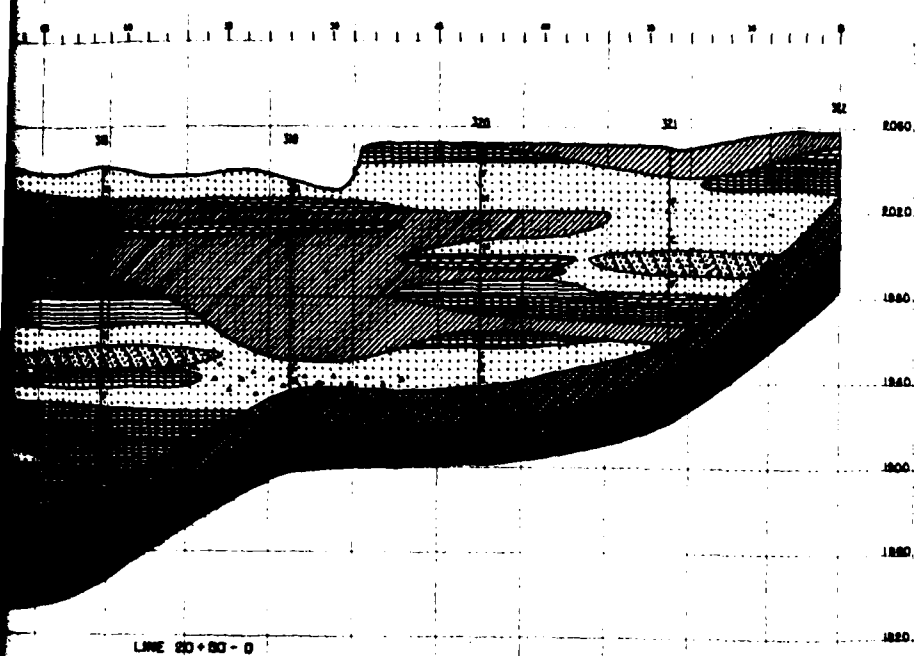


LINE 20+50-D

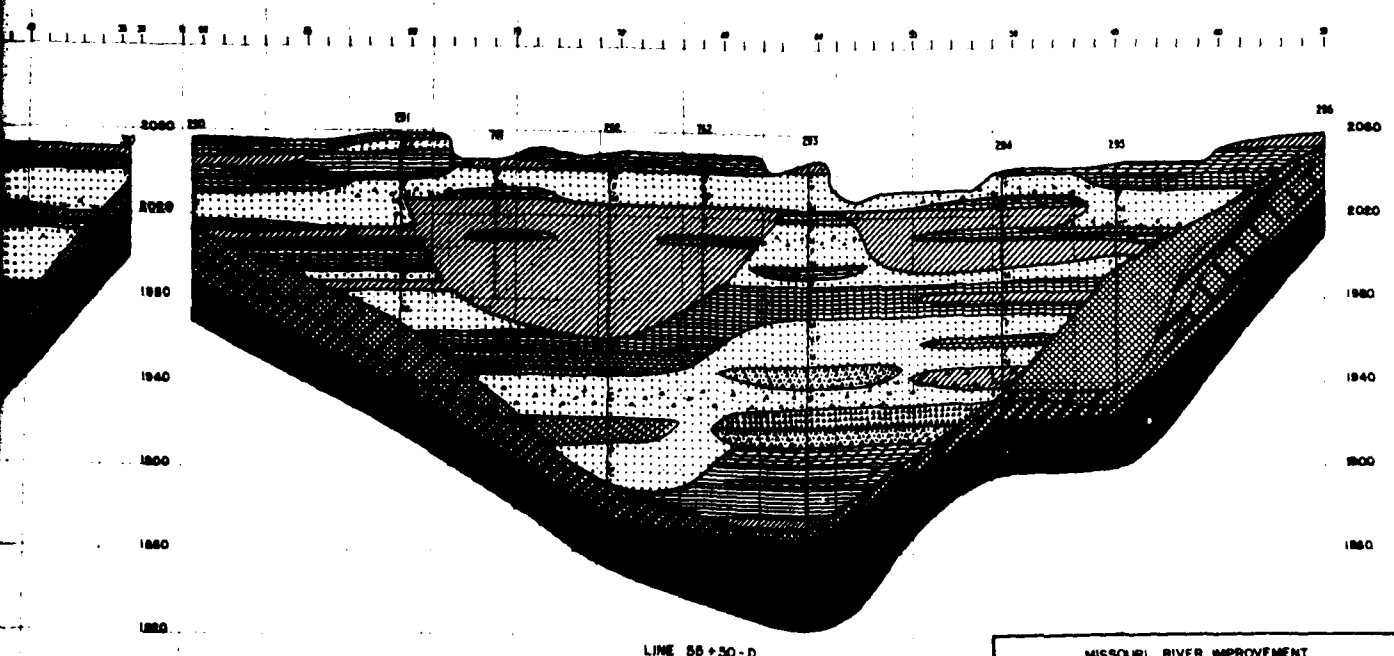


LINE 37+50-D



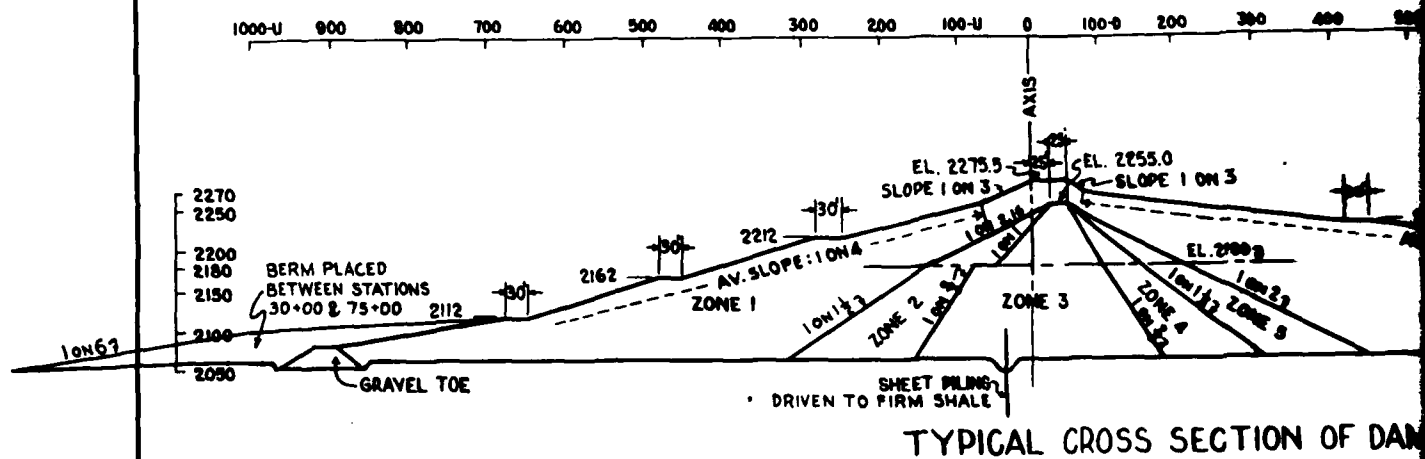


- LEGEND
- BUREAU OF SOIL CLASSIFICATION
- SAND
 - GRAVELLY SAND
 - LOAM
 - SANDY LOAM
 - GRAVELLY LOAM
 - SANDY GRAVELLY LOAM
 - CLAY
 - SANDY CLAY
 - GRAVELLY CLAY
 - CLAY LOAM
 - SANDY CLAY LOAM
 - GRAVEL
 - SANDY GRAVEL
 - DISINTEGRATED SHALE
 - WEATHERED SHALE
 - SOFT SHALE
 - SUB-FIRM SHALE
 - FIRM SHALE



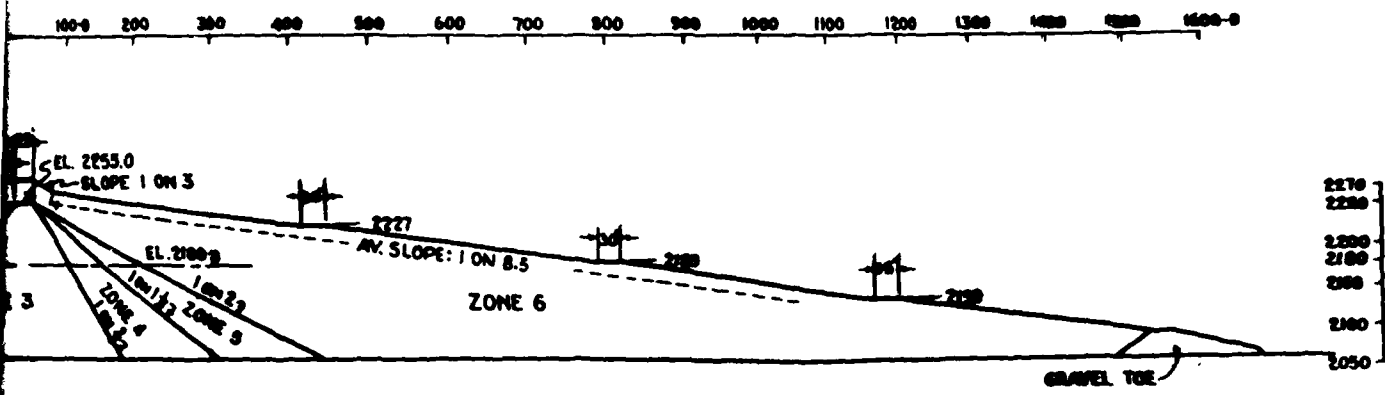
MISSOURI RIVER IMPROVEMENT			
FORT PECK DAM			
FOUNDATION			
SOIL PROFILES			
34 SHEETS		SCALE 1"=400'	SHEET NO. 5
U.S. ENGINEER OFFICE,		MISSOURI RIVER DIVISION,	MARCH 1935
FORT PECK, MONTANA			
Submitted	Recommended	Approved	
Checked	Traced	Checked	Traced
33-11-2			

WAR DEPARTMENT



TYPICAL CROSS SECTION OF DAM

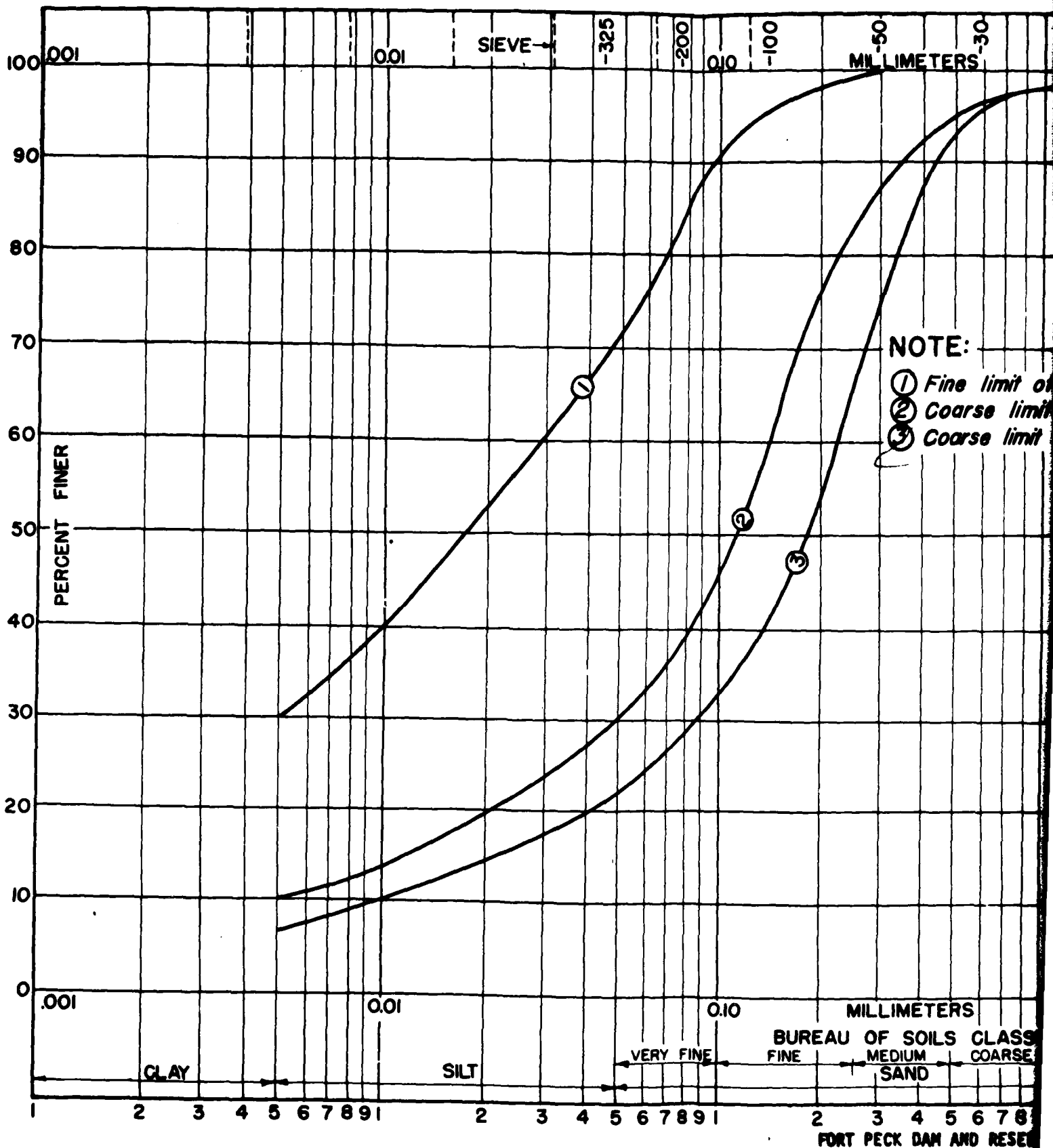
ZONE	ELEVATION	AVERAGE EFFECTIVE SIZE IN MILLIMETERS	AVERAGE CLAY CONTENT PER CENT
1 and 6	Below 2100	>0.1	<3.0
1 and 6	2100-2180	>0.1	<5.0
1 and 6	Above 2180	>0.05	<8.0
2 and 5	Below 2255	>0.005	<10.0
3	Below 2200	<0.005	>10.0 & <30.0
3	Above 2200	<0.01	<30.0
4	Below 2255	Same as Zone 3 or Zone 5	
Sand Plugs	Below 2180	<0.10	<20.0
Above Sand Plugs	2180-2255	<0.01	<30.0

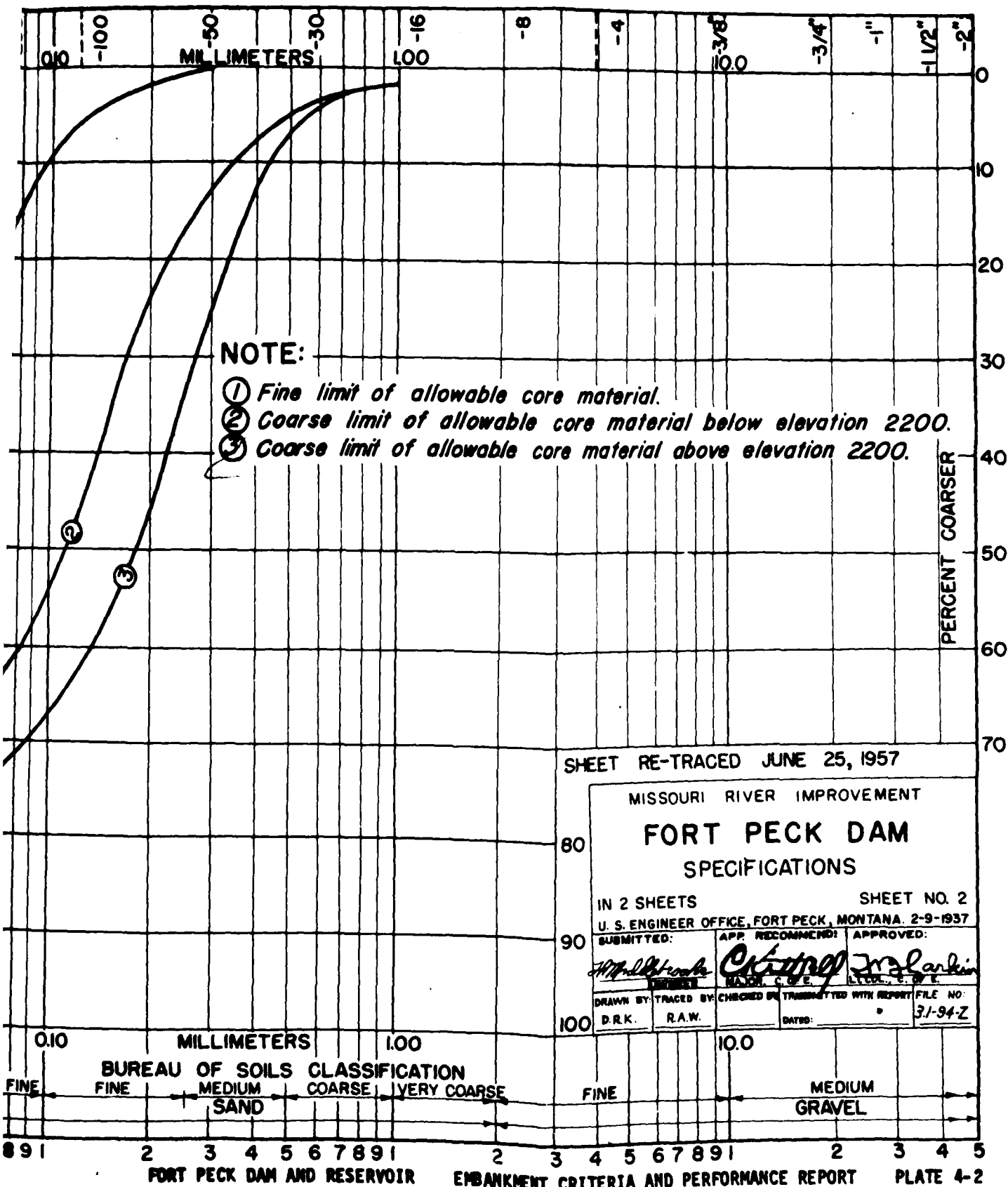


CROSS SECTION OF DAM

REVISED 3-31-38. F.K.M.		REVISED 8-31-38. R.A.W.	
MISSOURI RIVER IMPROVEMENT			
FORT PECK DAM			
SPECIFICATIONS			
* IN 2 SHEETS		SHEET NO. 1	
SCALE AS SHOWN			
U.S. ENGINEER OFFICE, FORT PECK, MONT. 2-3-1937			
Submitted:	Approved:	Recommended:	Approved:
<i>[Signature]</i>			
Checked by:	Reviewed by:	Presented with report:	File No.:
CHM.	CHM.		

Figure 6





SHEET RE-TRACED JUNE 25, 1957

MISSOURI RIVER IMPROVEMENT

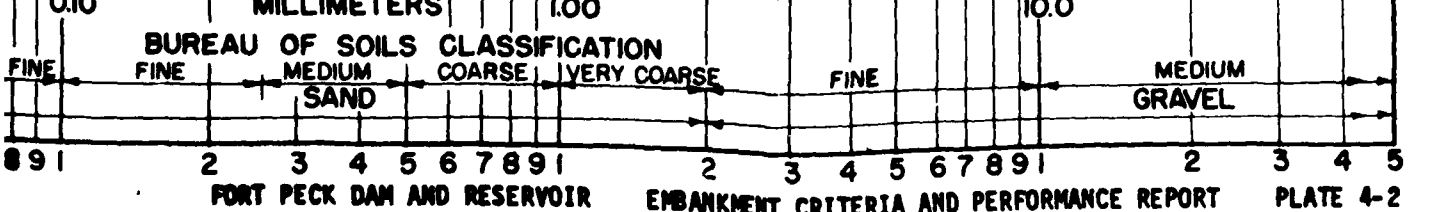
FORT PECK DAM

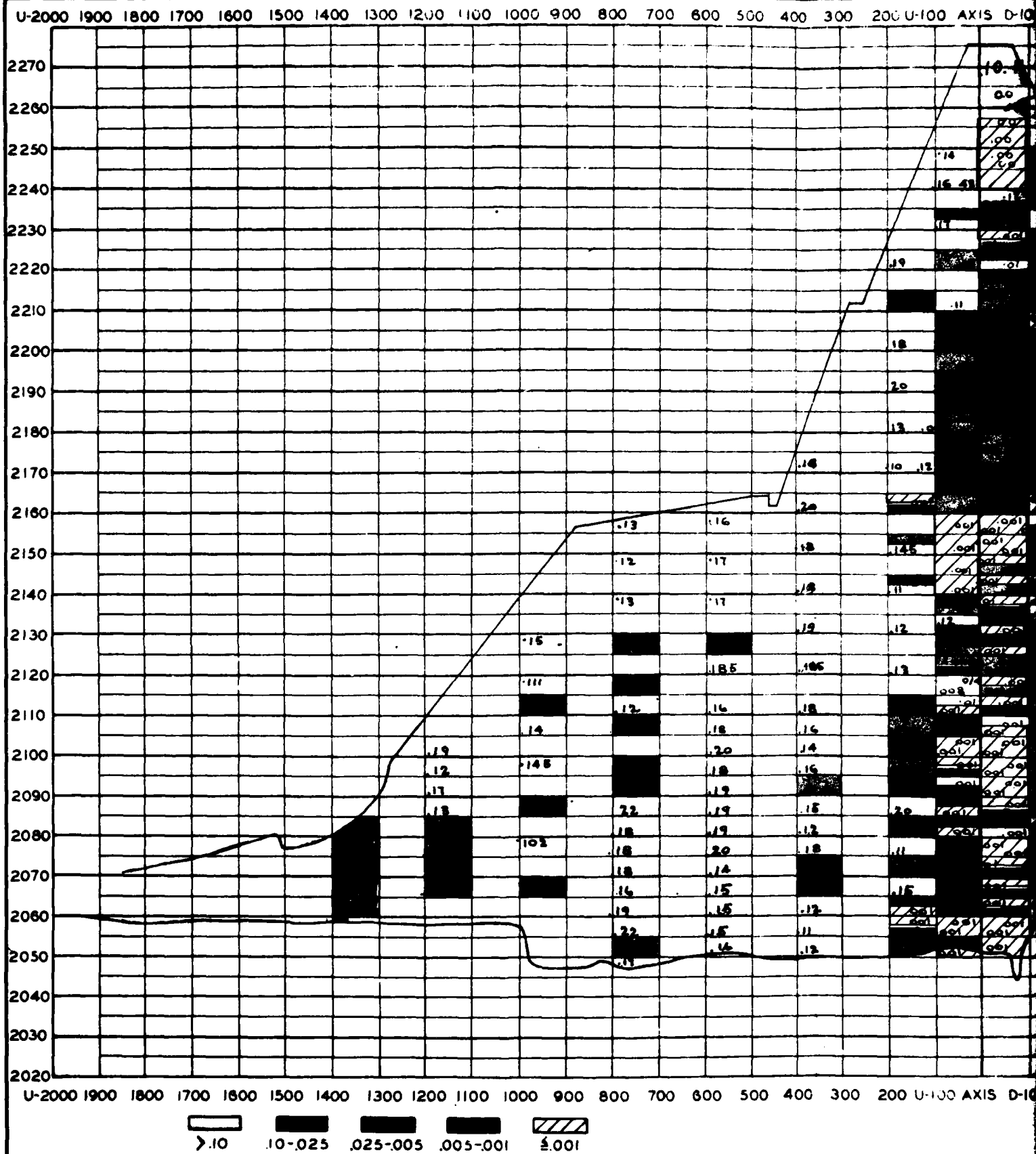
SPECIFICATIONS

IN 2 SHEETS SHEET NO. 2

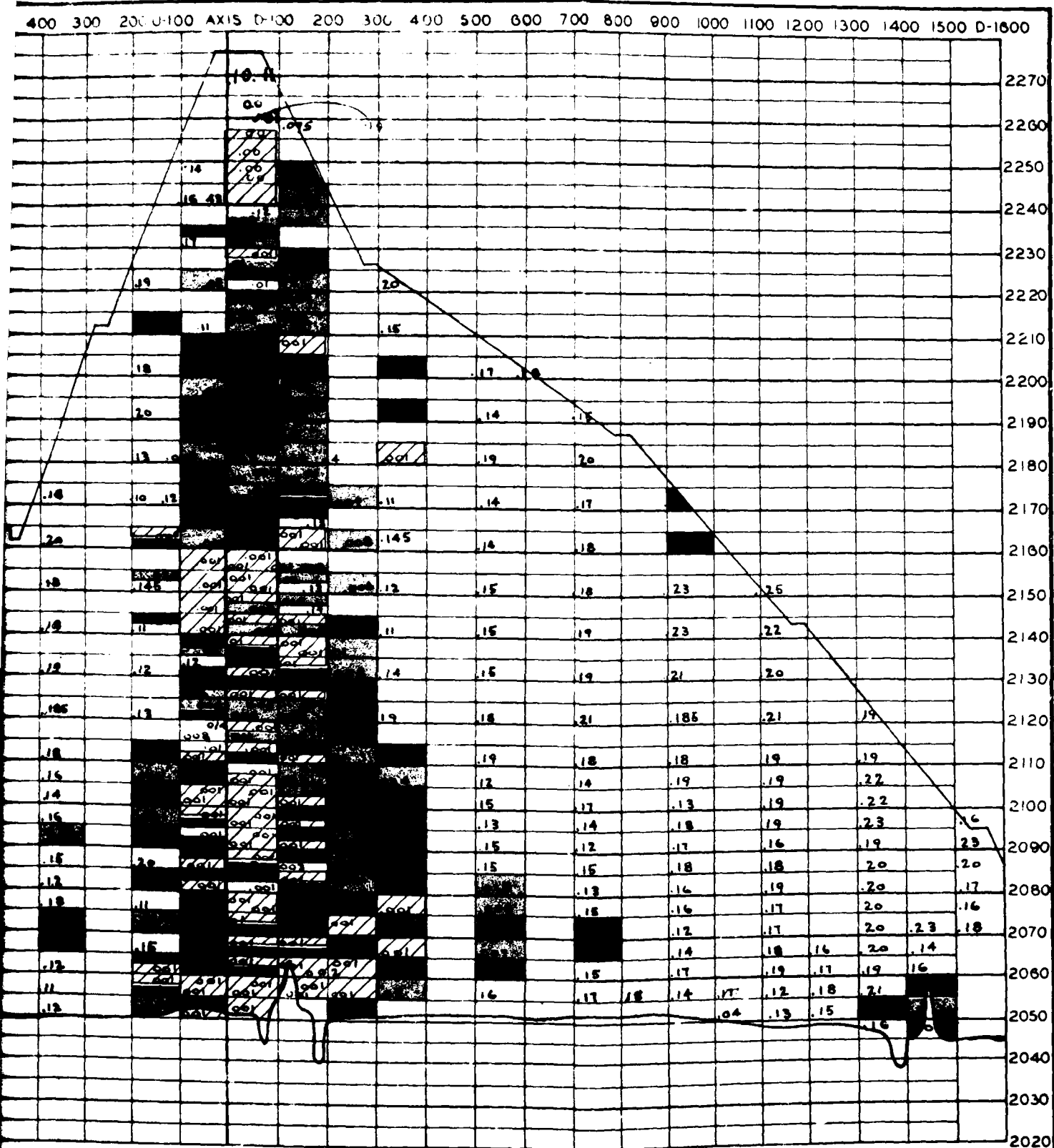
U. S. ENGINEER OFFICE, FORT PECK, MONTANA. 2-9-1937

SUBMITTED:	APP. RECOMMEND:	APPROVED:
<i>[Signature]</i>	<i>[Signature]</i>	<i>[Signature]</i>
DRAWN BY:	TRACED BY:	CHECKED BY:
D.R.K.	R.A.W.	
TRANSMITTED WITH REPORT		FILE NO:
		31-94-Z

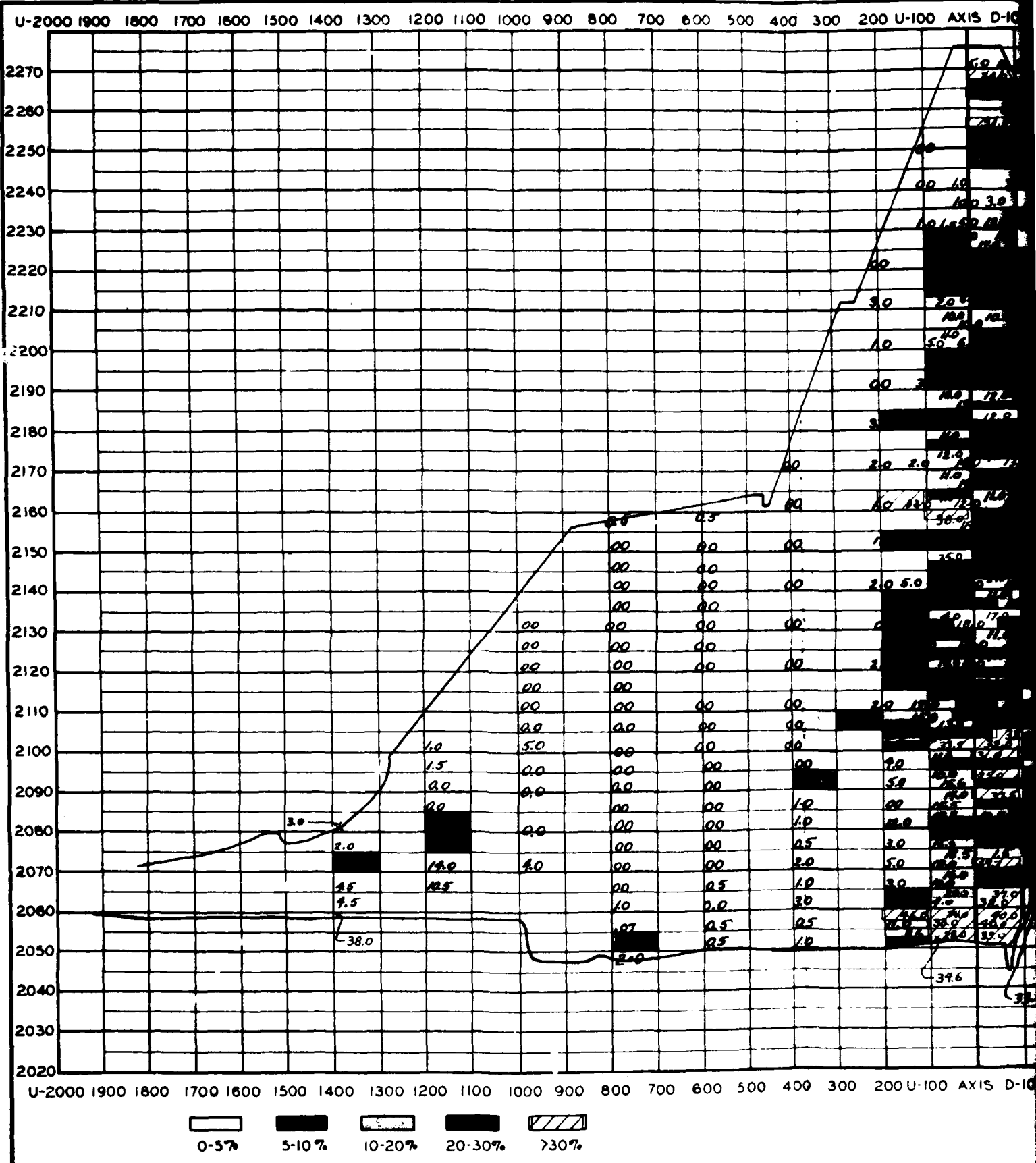




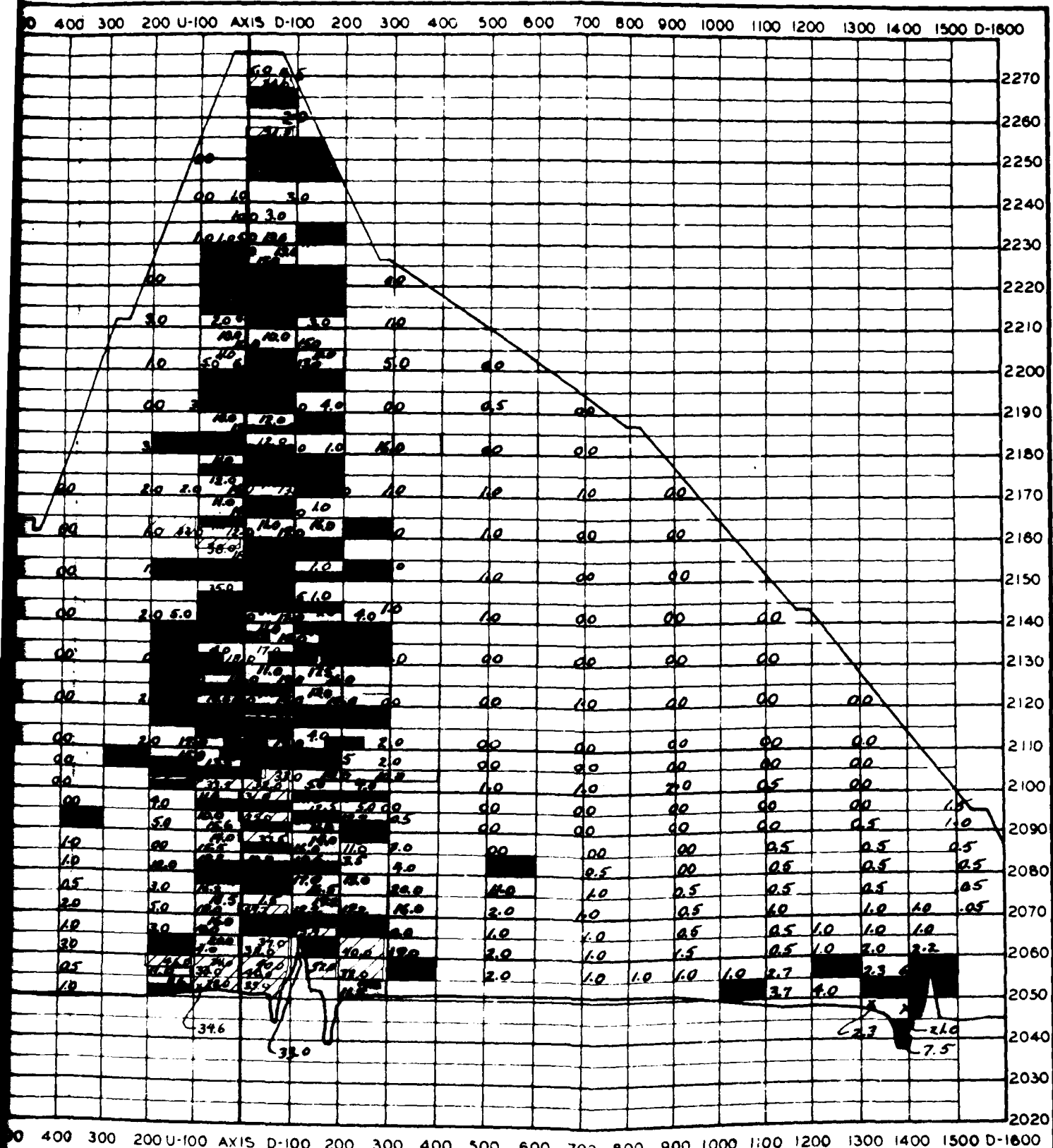
FORT PECK DAM

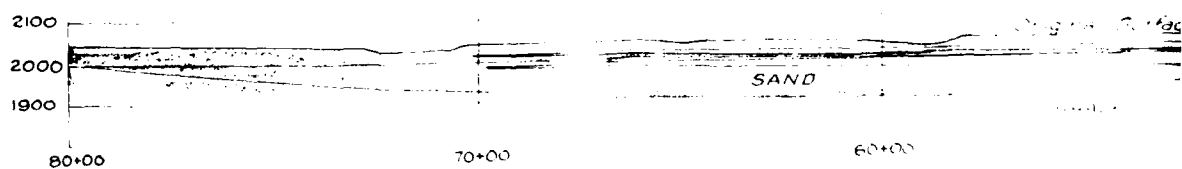
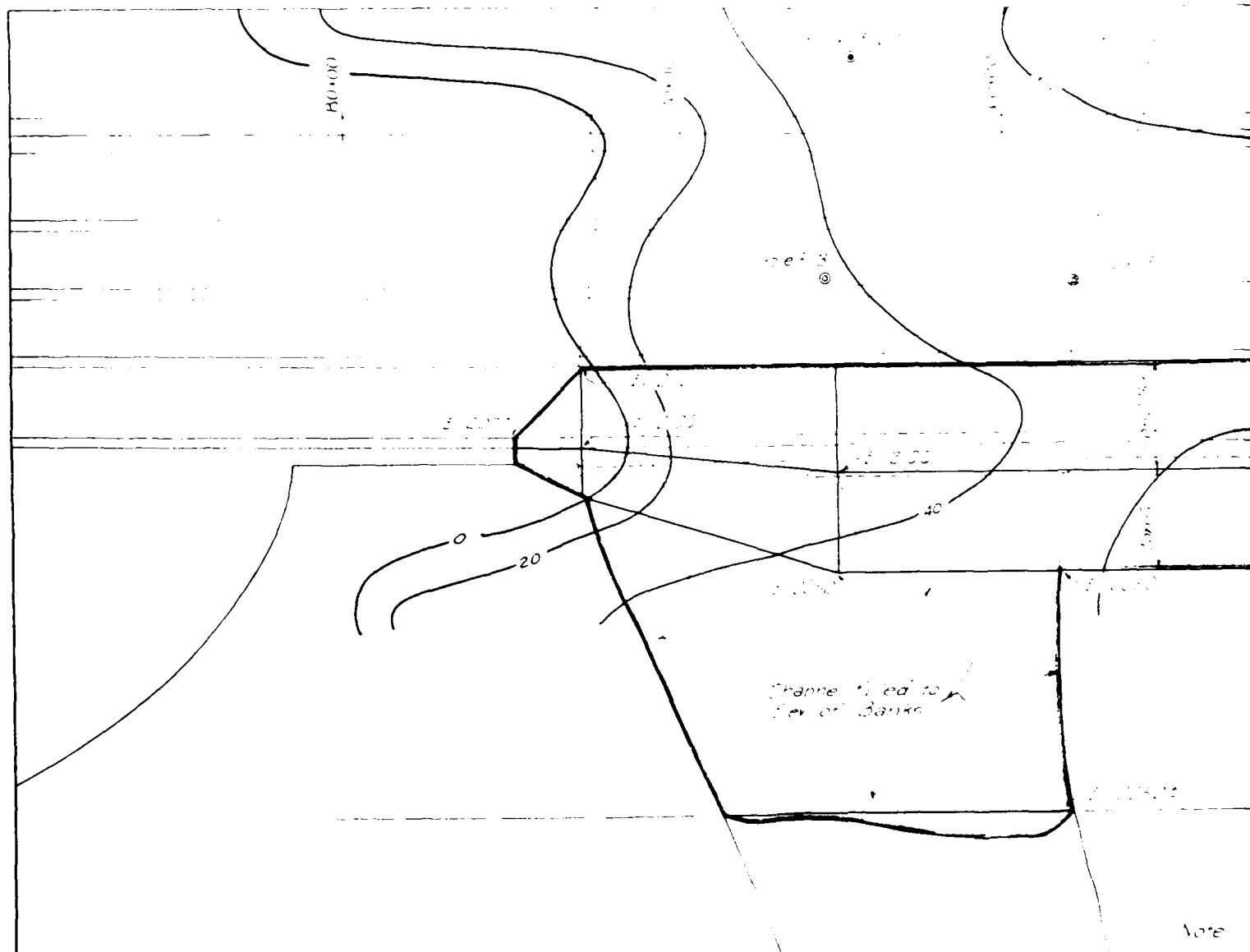


FORT PECK DAM
EFFECTIVE SIZE OF FILL SAMPLES, STA. 40+00
GROSS SECTION



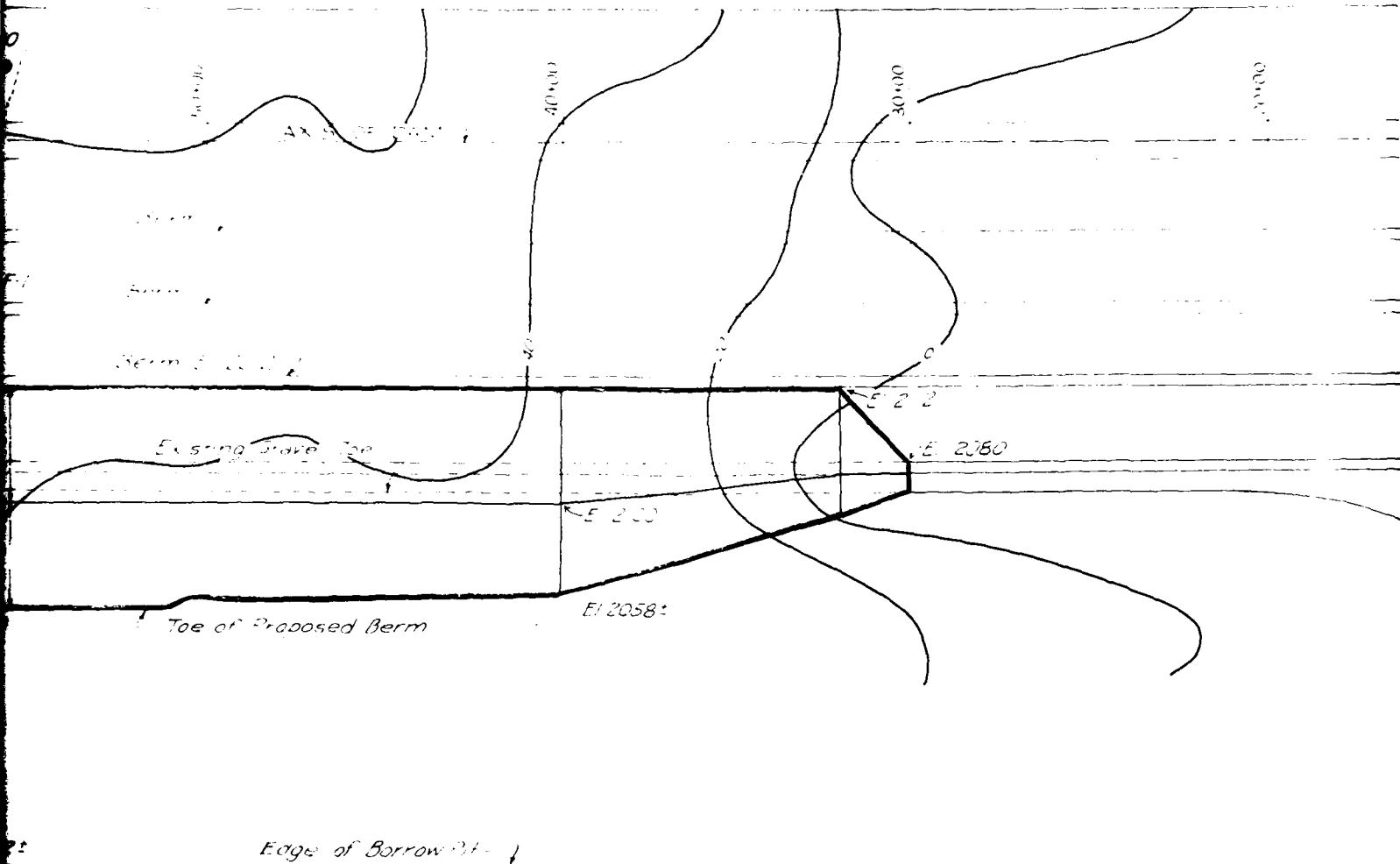
FORT PECK DA





FOUNDATION PROFILE
Scale

1



PLAN

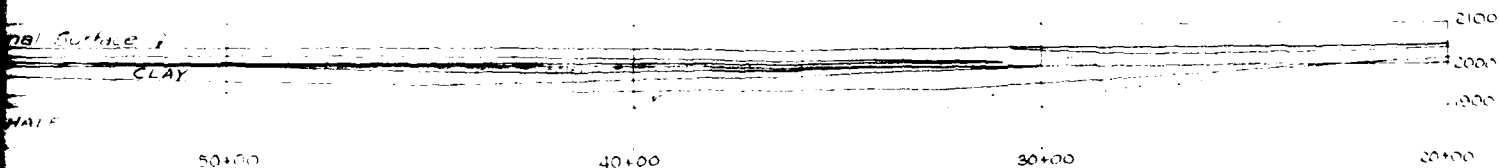
Scale 1" = 300'

Note: Contours indicate approximate total thickness of clay strata in foundation

FORT PECK DAM STABILITY ANALYSIS-UPSTREAM

PLAN OF PROPOSED

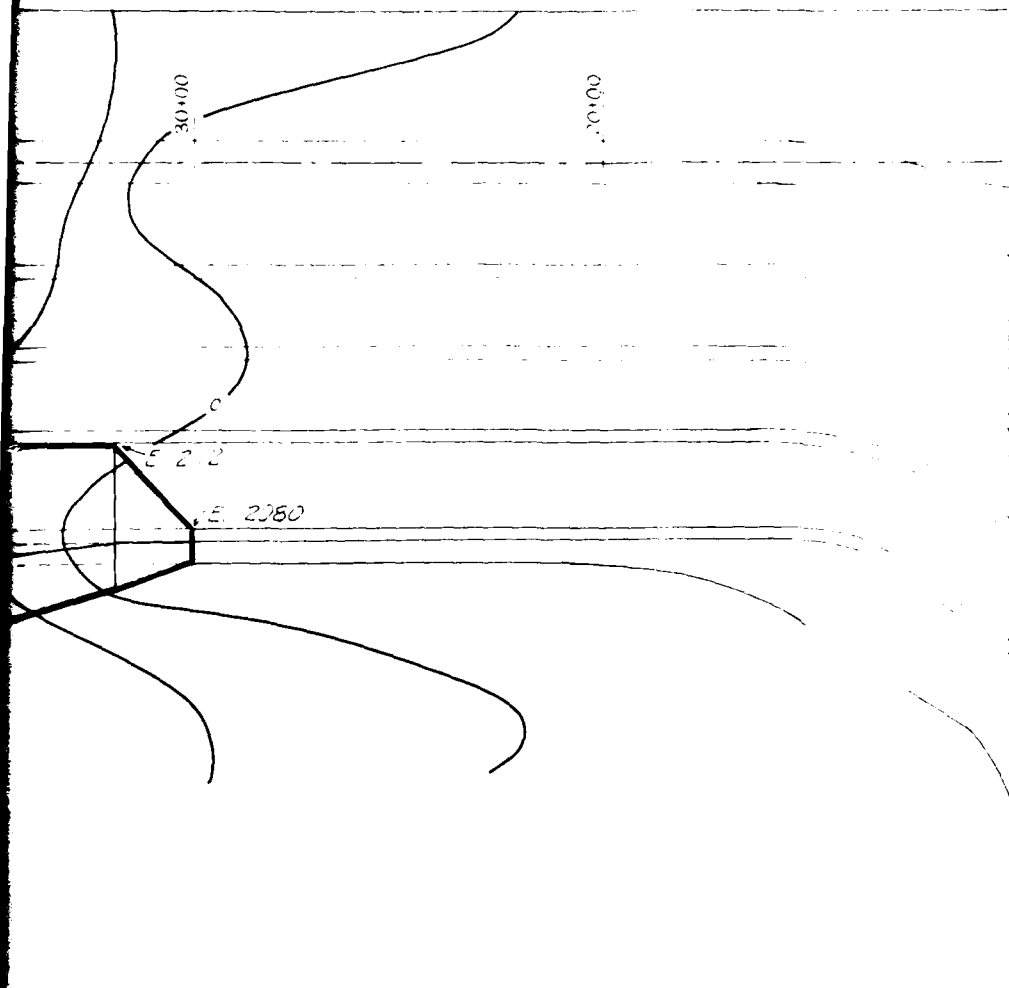
Prepared in Office of Division
Missouri River Division



PROFILE 940' UPSTREAM FROM AXIS

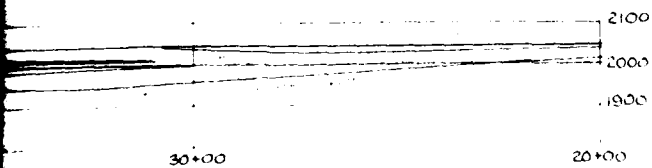
Scale 1" = 300'

7

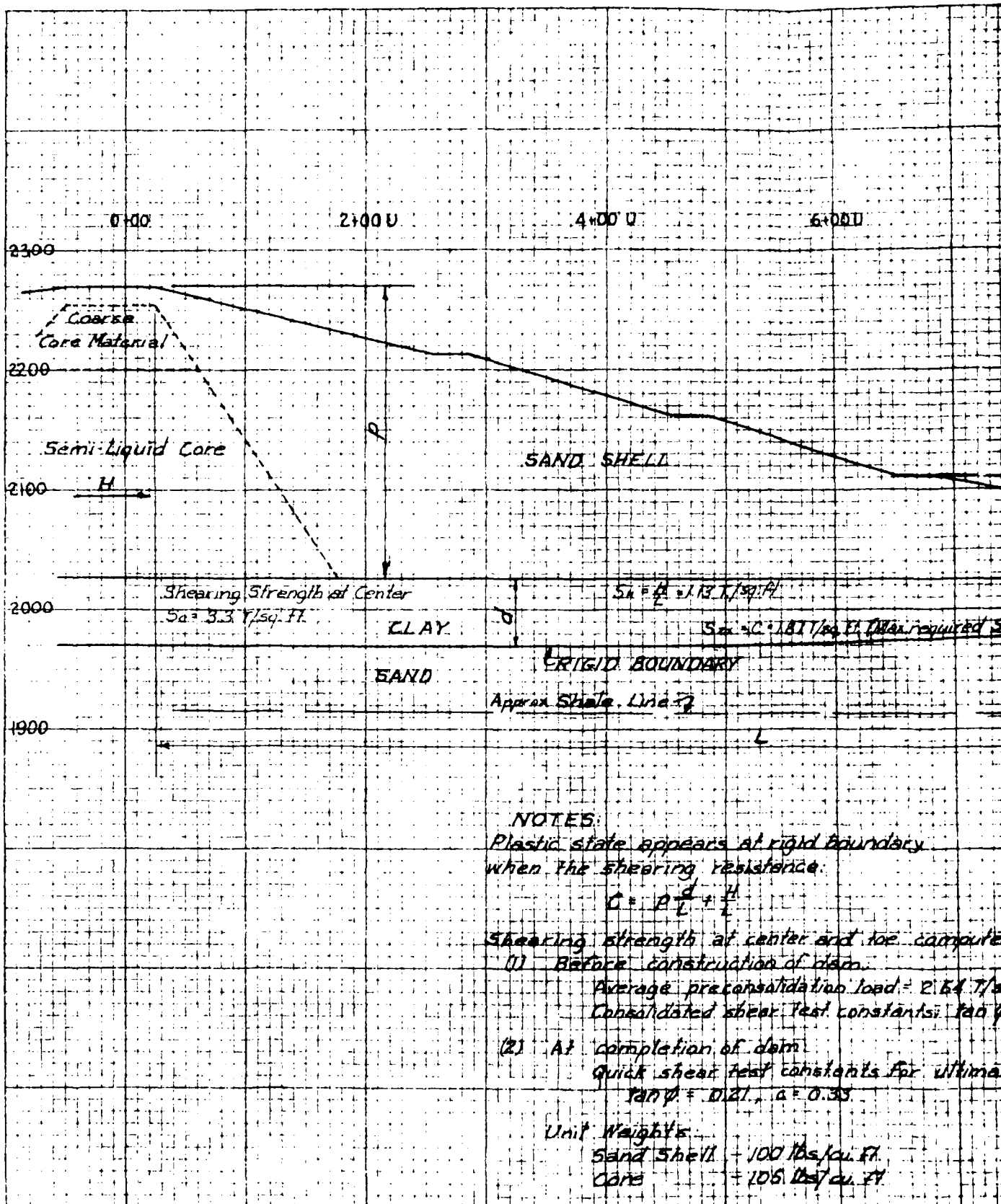


FORT PECK DAM
STABILITY ANALYSIS-UPSTREAM FOUNDATION

PLAN OF PROPOSED BERM
Prepared in Office of Division Engineer
Missouri River Division



3



6+00 U

8+00 U

10+00 U

12+00 U

Upstream Berm

(Would raise S_r to 1.37 T/sq ft and reduce C to 1.31 T/sq ft)

Gravel

CLAY

Shearing Strength at toe
 $S_r = 1.14 \text{ T/sq ft}$

1.81 T/sq ft (Max required Shearing Strength)

SAND

Rigid boundary
force:Water and toe computed:
at 10 ft dam

Validation load = 21.64 T/sq ft

at foot constants: $\tan \phi = 0.25$, $c = 0.40$

form

at constants for ultimate failure

at 0.33

at 10 ft cu ft

at 10 ft cu ft

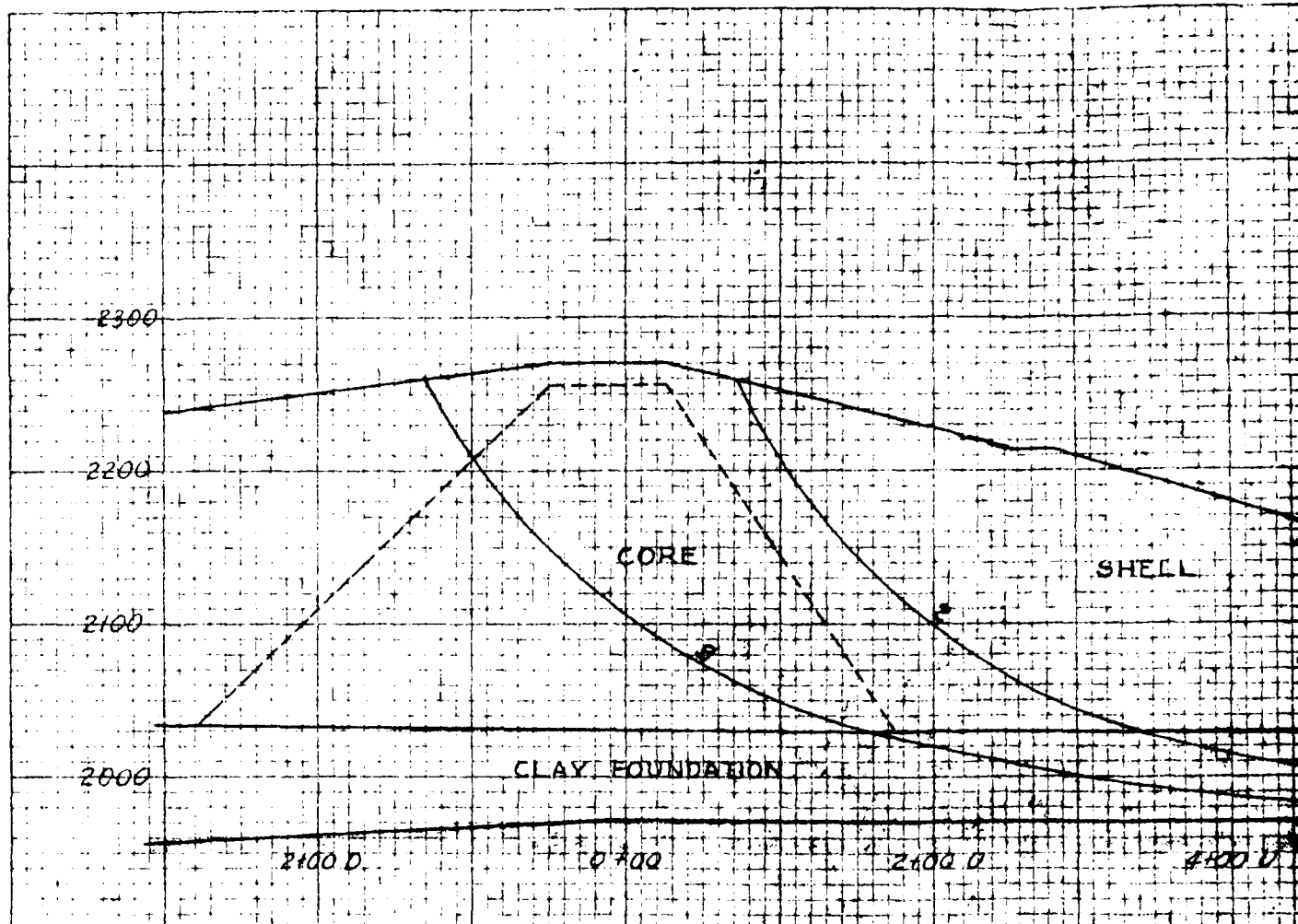
FORT PECK DAM

STABILITY ANALYSIS-UPSTREAM FOUNDATION

JURGENSON'S METHOD

STATION 58+00

Prepared in Office of Division Engineer - Mo. River Div.



CONSTANTS ADOPTED FOR ANALYSIS

SHELL Unit Wt. 100 lb/cu ft $\tan \phi = 0.65$ $c = 0$
(Saturated to elev. 2040)

CORE Unit Wt. 105 lb/cu ft $\tan \phi = 0.20$ $c = 0$
(Saturated to elev. 2200)

CLAY FOUNDATION Unit Wt. 120 lb/cu ft
(See Note for values of $\tan \phi$ and c)

Case I

Case II

Case III

Samples for

CURVE No.	FACTOR OF SAFETY		
	Case I	Case II	Case III
1	1.7	1.9	1.8
2	1.5	1.7	1.7
3	0.9	1.1	1.1

SHELL

400 U

500 U

800 U

1000 U

NOTE

Case I: $\tan \phi = 0.18$, $c = 0.5$ T/sq. ft. - Constants determined by average of quick shear tests using load applied to sample at time of apparent yield point.

Case II: $\tan \phi = 0.21$, $c = 0.33$ T/sq. ft. - Constants determined by average of quick shear tests using load applied to sample at time of ultimate failure.

Case III: $\tan \phi = 0.24$, $c = 0.12$ T/sq. ft. - Constants determined by weighted average according to thickness of soil strata, using yield point test data for sampled strata and estimating $\tan \phi$ and c for non-sampled strata.

Samples for testing were obtained from holes F-1, F-3, F-10 and F-20.

FORT PECK DAM

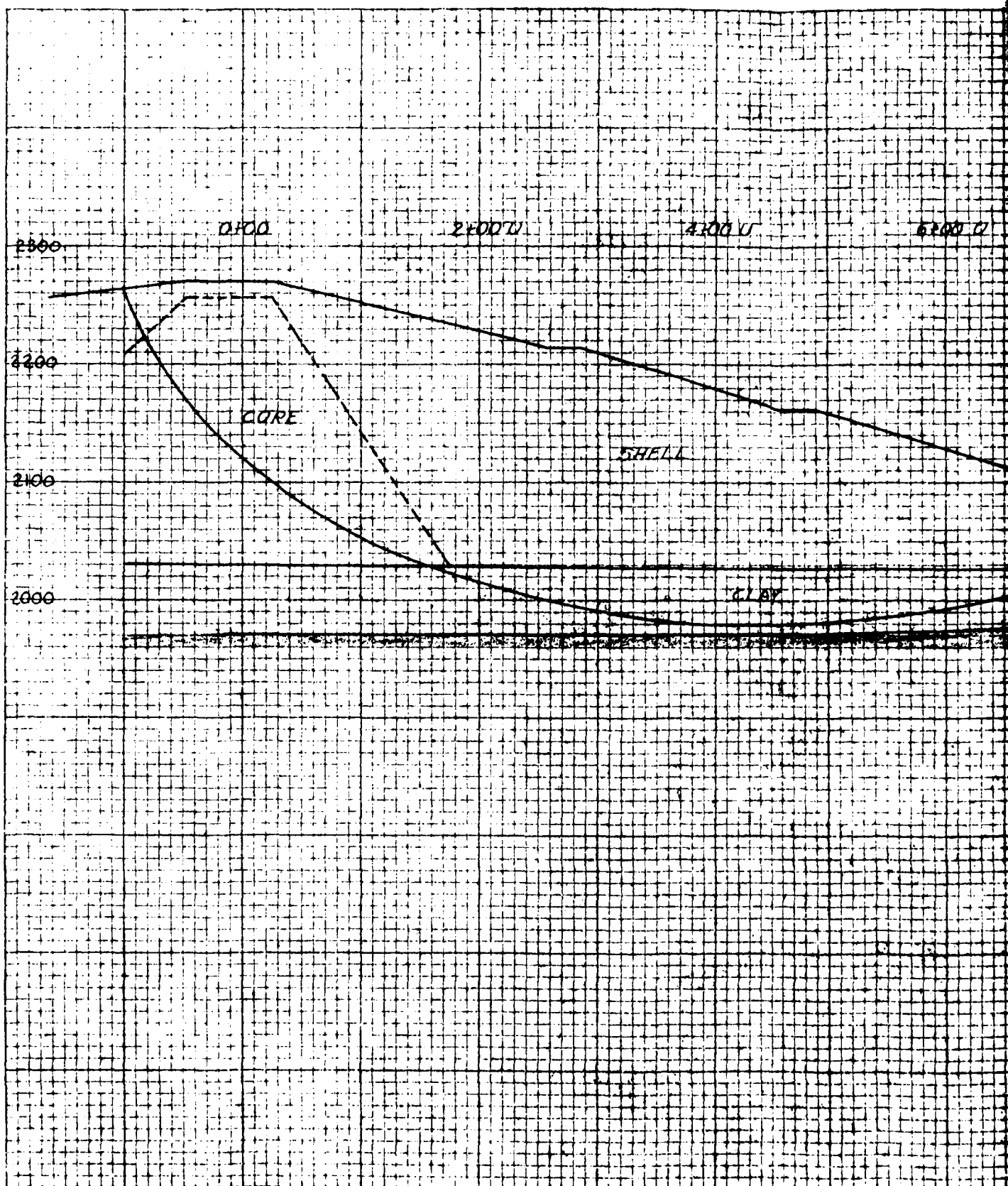
STABILITY ANALYSIS - UPSTREAM FOUNDATION

CRITICAL SLIDING PLANE

SWEDISH METHOD - CIRCLE ANALYSIS

STATION 58+00

Prepared in Office of Division Engineer - Mo. River Div.



NEUTEL & SONS, INC. N.Y. NO. 358-1

FORT PECK

6200 U

8400 U

10400 U

12400 U

2200

2400

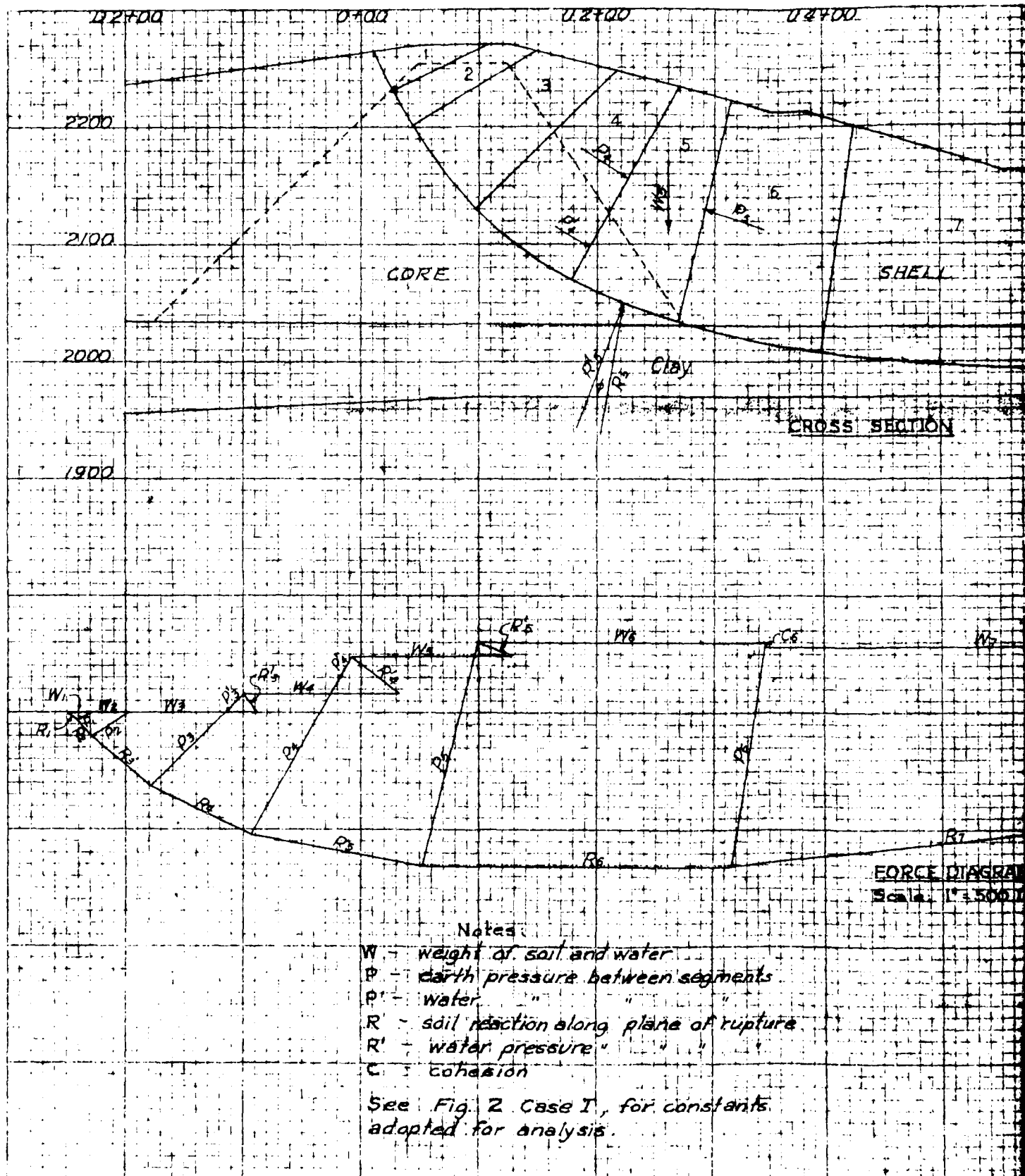
2600

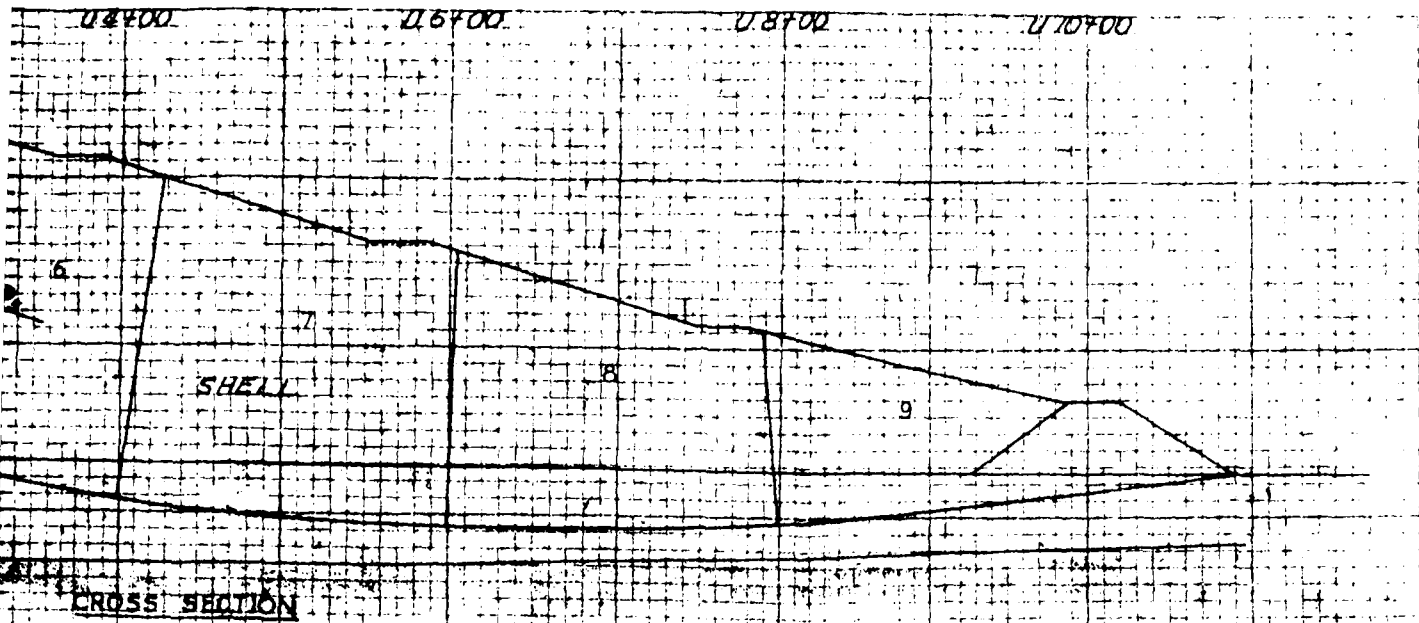
Berm 1

FACTOR OF SAFETY		
Case I	Case II	Case III
1.2	1.4	1.4

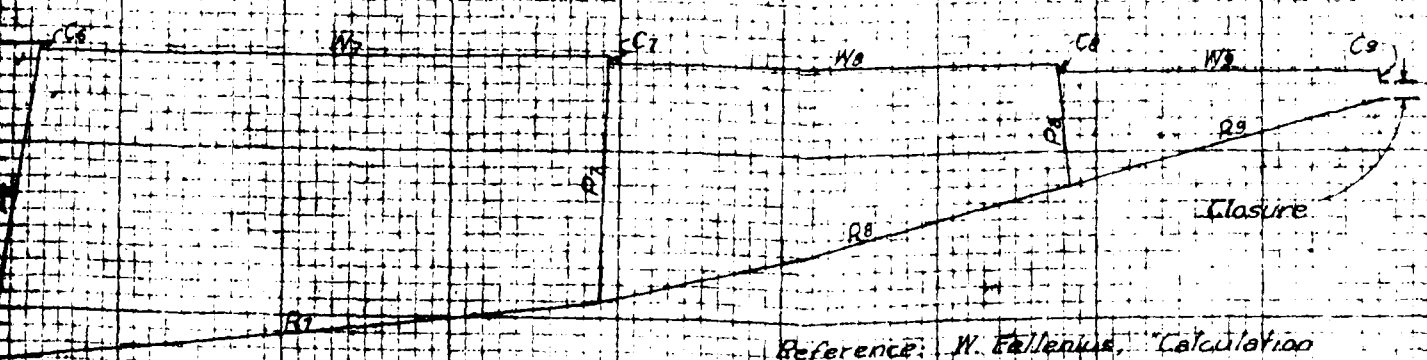
See Fig. 2 For constants used
in analysis.

FORT PECK DAM
STABILITY ANALYSIS - UPSTREAM FOUNDATION
 SWEDISH METHOD - CIRCLE ANALYSIS
 STA. 58+00 - WITH UPSTREAM BERM
 Prepared in Office of Division Engineer: Mo. River Div.





Factor of Safety, 1.0 -
 (Slight increase in ϕ or
 "Jan. 4" would close force diagram)

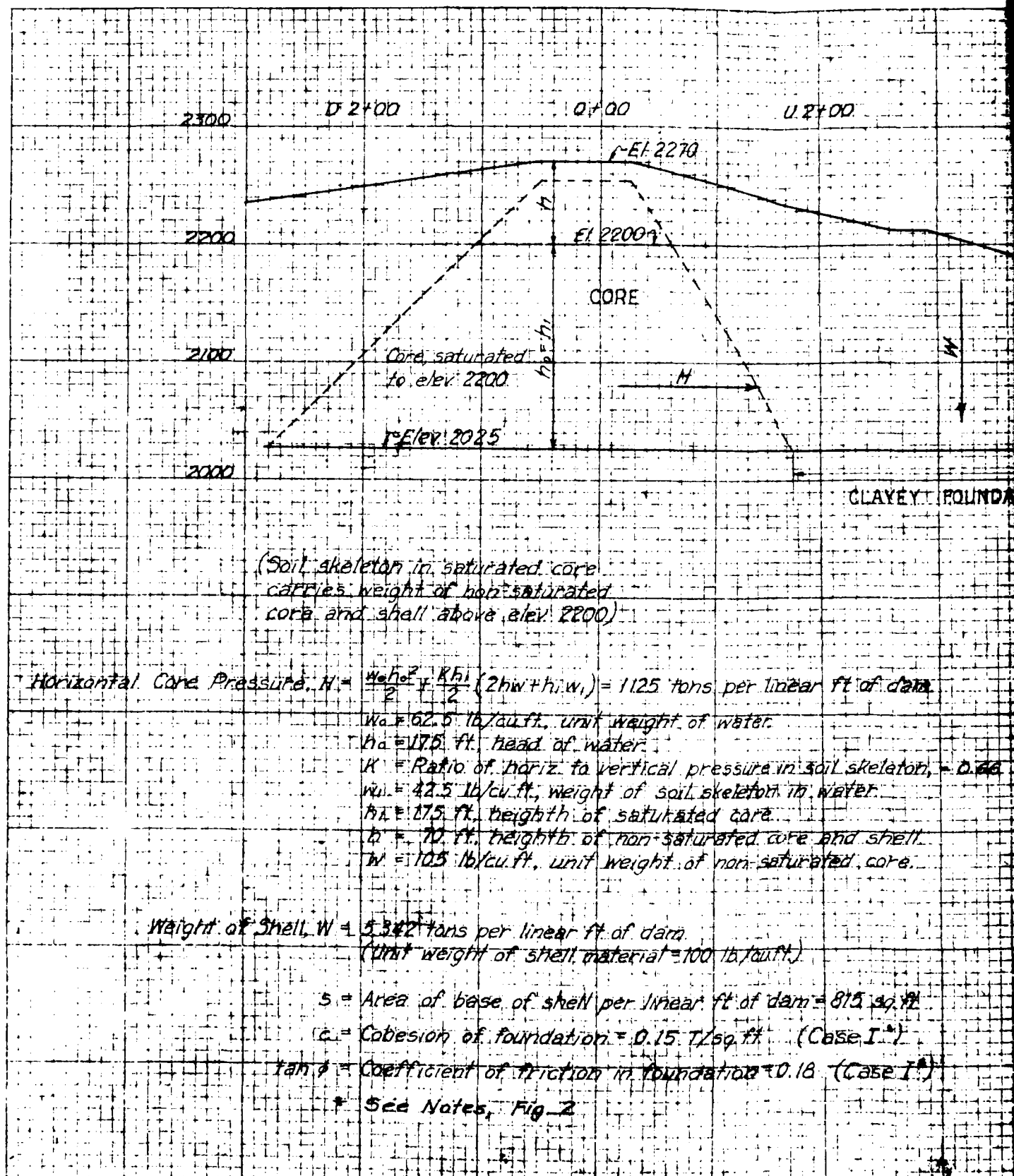


FORCE DIAGRAM
 Scale: 1" = 500 Tons

Reference: W. Fellenius, "Calculation
 of the Stability of Earth Dams."
 Second Congress on Large Dams - 1936

FORT PECK DAM **STABILITY ANALYSIS - UPSTREAM FOUNDATION** **GRAPHICAL ANALYSIS** **STATION 58+00**

Prepared in Office of Division Engineer - Mo. River Div.



02+00

04+00

06+00

08+00

H

SHELL

CLAYEY FOUNDATION

Under ft of data

Factor of Safety against sliding along base =

$$\frac{W \tan \phi + c}{H} = \frac{5342 \times .18 + 815 \times .15}{1125} = 0.96 \text{ Case I}^*$$

W in soil skeleton, = 0.66
 both in water

core and shell
 saturated, core

$$= \frac{5342 \times .21 + 815 \times .33}{1125} = 1.24 \text{ Case II}^*$$

$$= \frac{5342 \times .24 + 815 \times .12}{1125} = 1.23 \text{ Case III}^*$$

dam = 815 sq ft

(Case I*)

0.18 (Case I*)

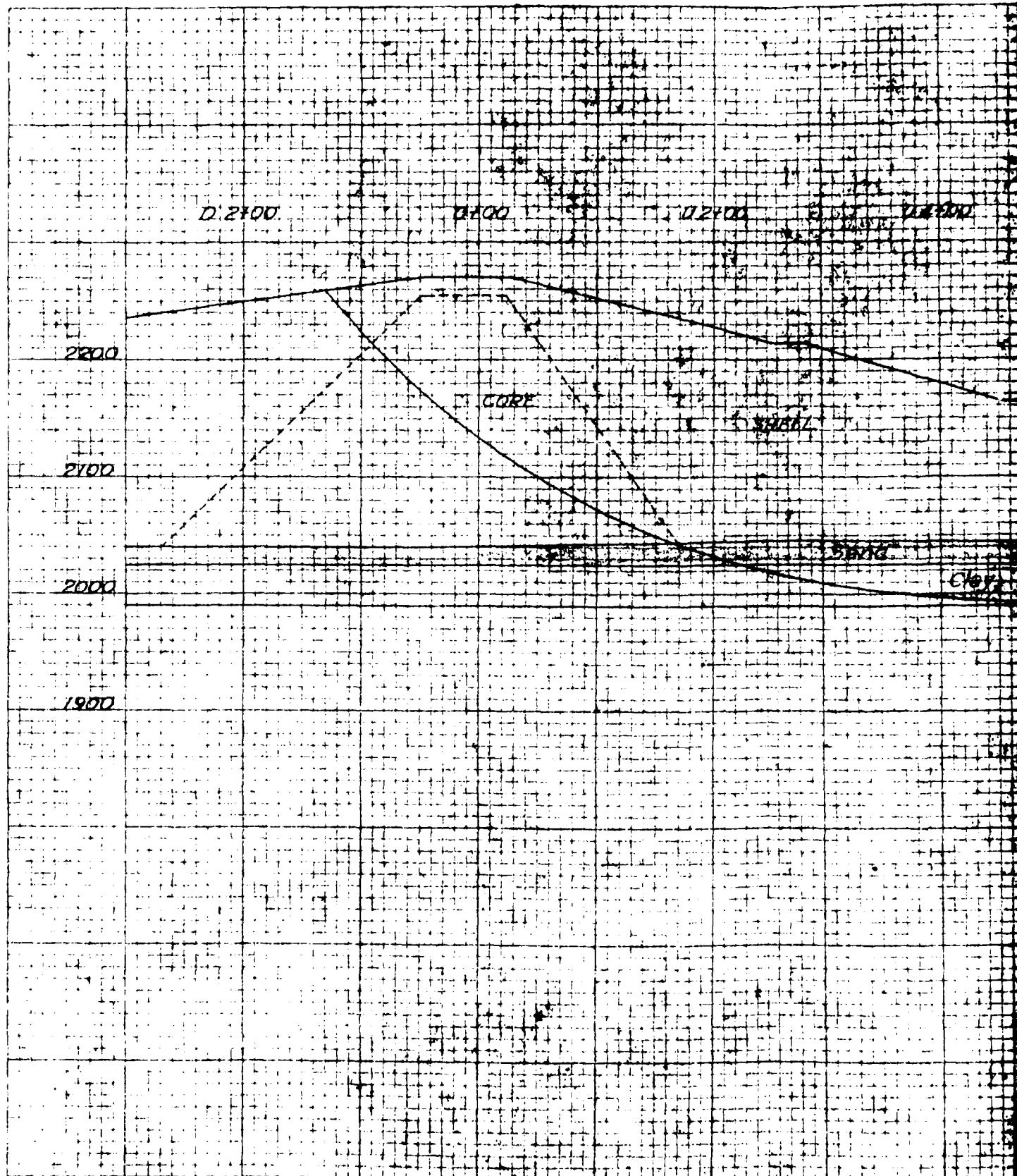
FORT PECK DAM

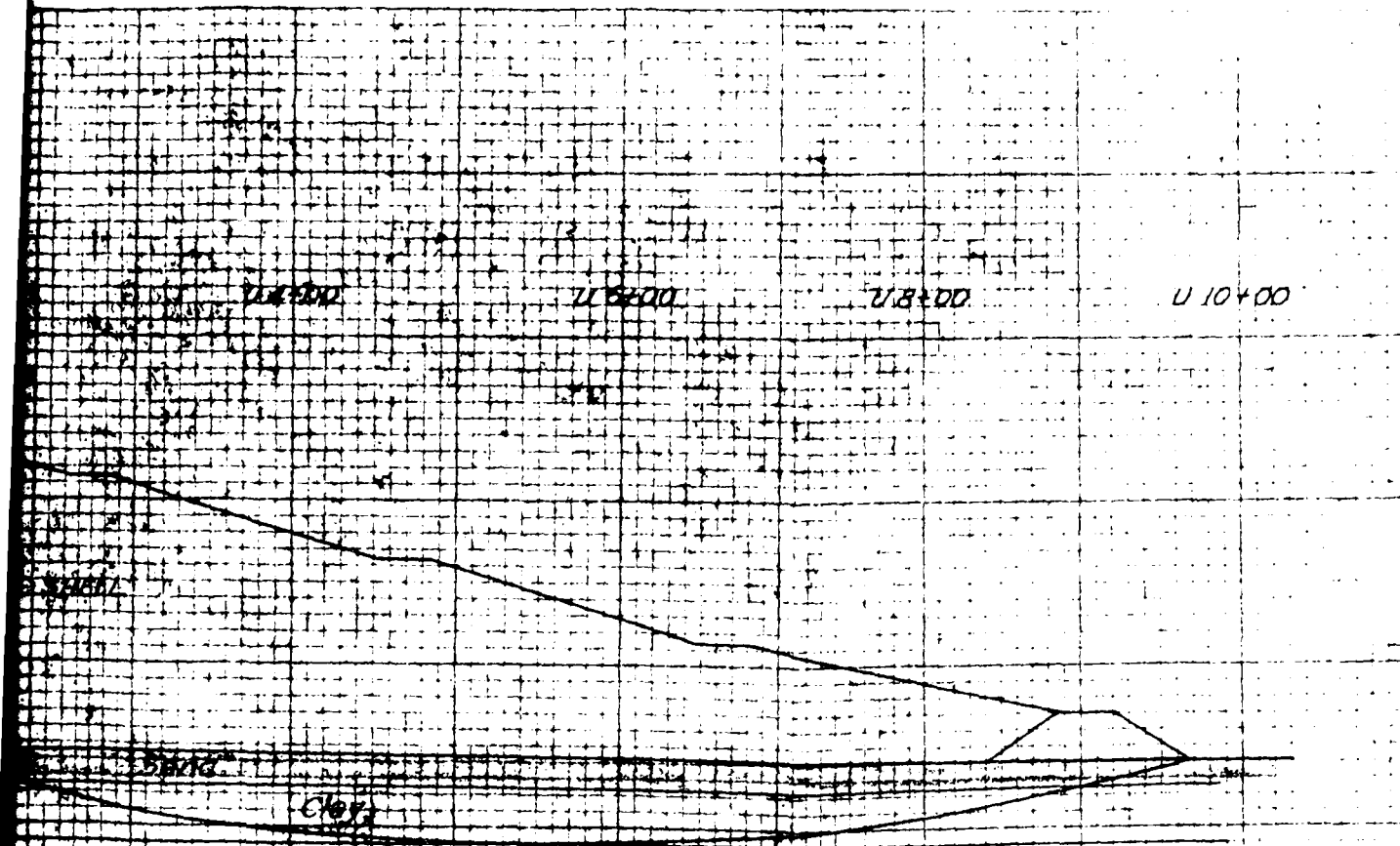
STABILITY ANALYSIS - UPSTREAM FOUNDATION

SLIDE ALONG CLAY FOUNDATION
 DUE TO CORE PRESSURE

STATION 58+00

Prepared in Office of Division Engineer - Mo River Div.



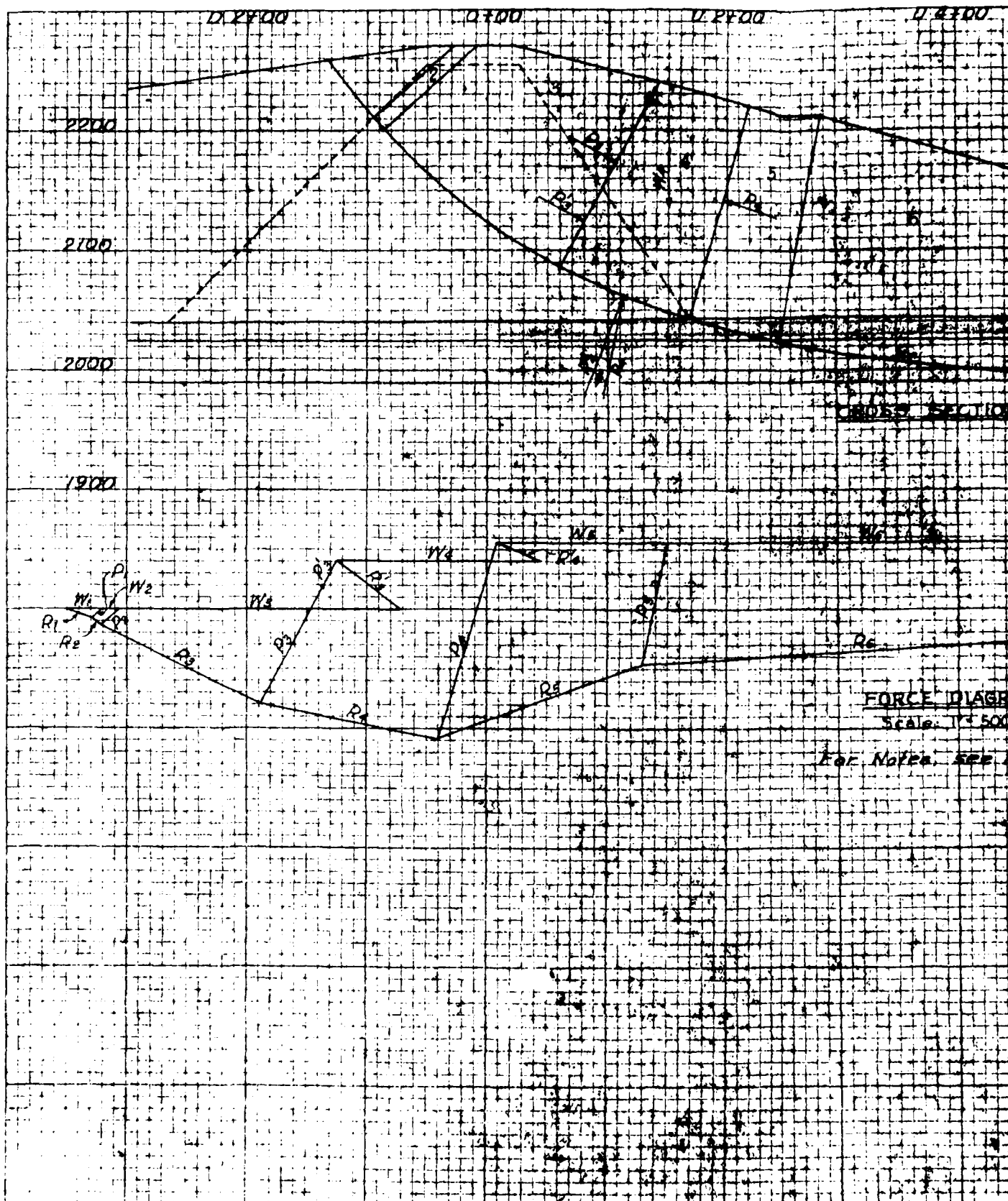


FACTOR OF SAFETY		
Case I	Case II	Case III
1.3	1.4	1.4

Sand Foundation, $\tan \phi = 0.65$, $c = 0$
 See Fig. 2 for other constants
 used in analysis

FORT PECK DAM
STABILITY ANALYSIS - UPSTREAM FOUNDATION
 SWEDISH METHOD - CIRCLE ANALYSIS
 STATION 65+00

Prepared in Office of Division Engineer - Mo. River Div.



CROSS SECTION

FORCE DIAGRAM

Scale: 1" = 500'

For Notes, SEE 1

REDFIELD & TOWNSEND, INC. NEW YORK, N.Y.

18 X 24 IN. (11)

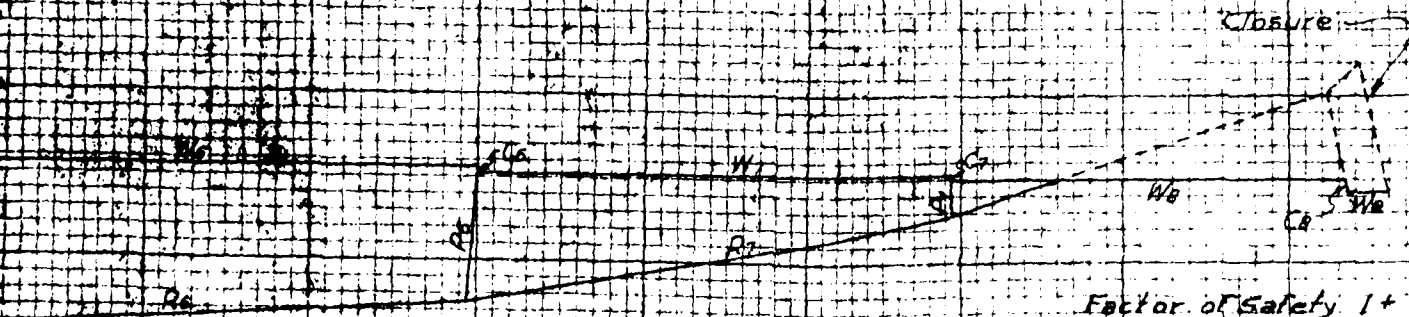
PORT PECK

0.00 0.2500 0.5000 0.7500 1.0000



CROSS SECTION

Closure



Factor of Safety 1+

FORCE DIAGRAM

Scale: 1" = 500 Tons

For Notes See Fig. 4

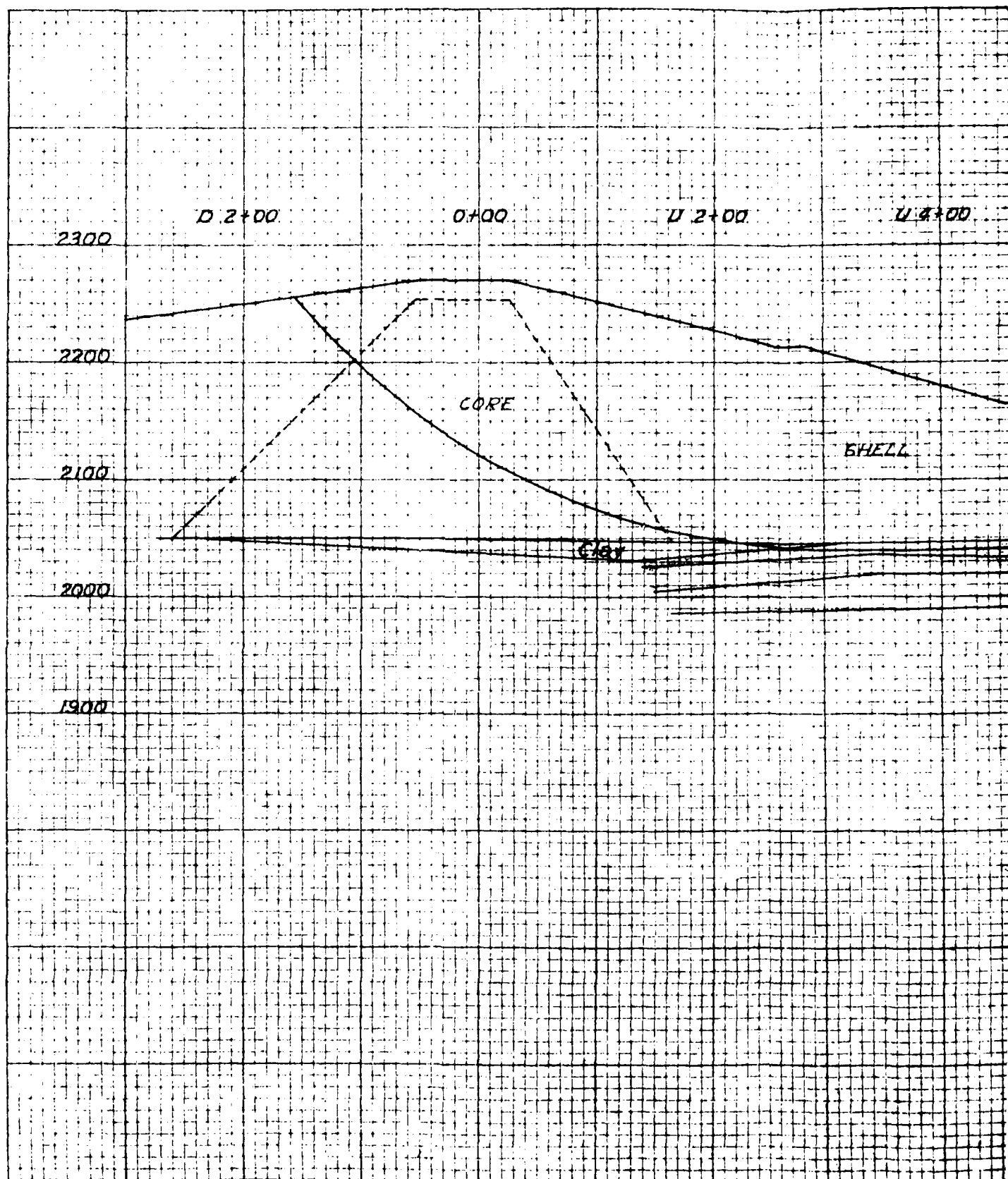
FORT PECK DAM

STABILITY ANALYSIS-UPSTREAM FOUNDATION

GRAPHICAL ANALYSIS

STATION: 65+00

Prepared in Office of Division Engineer, Mo. River Div.



FORT PECK

00 U 4+00 U 6+00 U 8+00 U 10+00

SHELL

Loam
Sand
Loam

FACTOR OF SAFETY = 1.9 (All Cases)

Loam Foundation $\tan \phi = .50, c = 0$

Sand $\tan \phi = .65, c = 0$

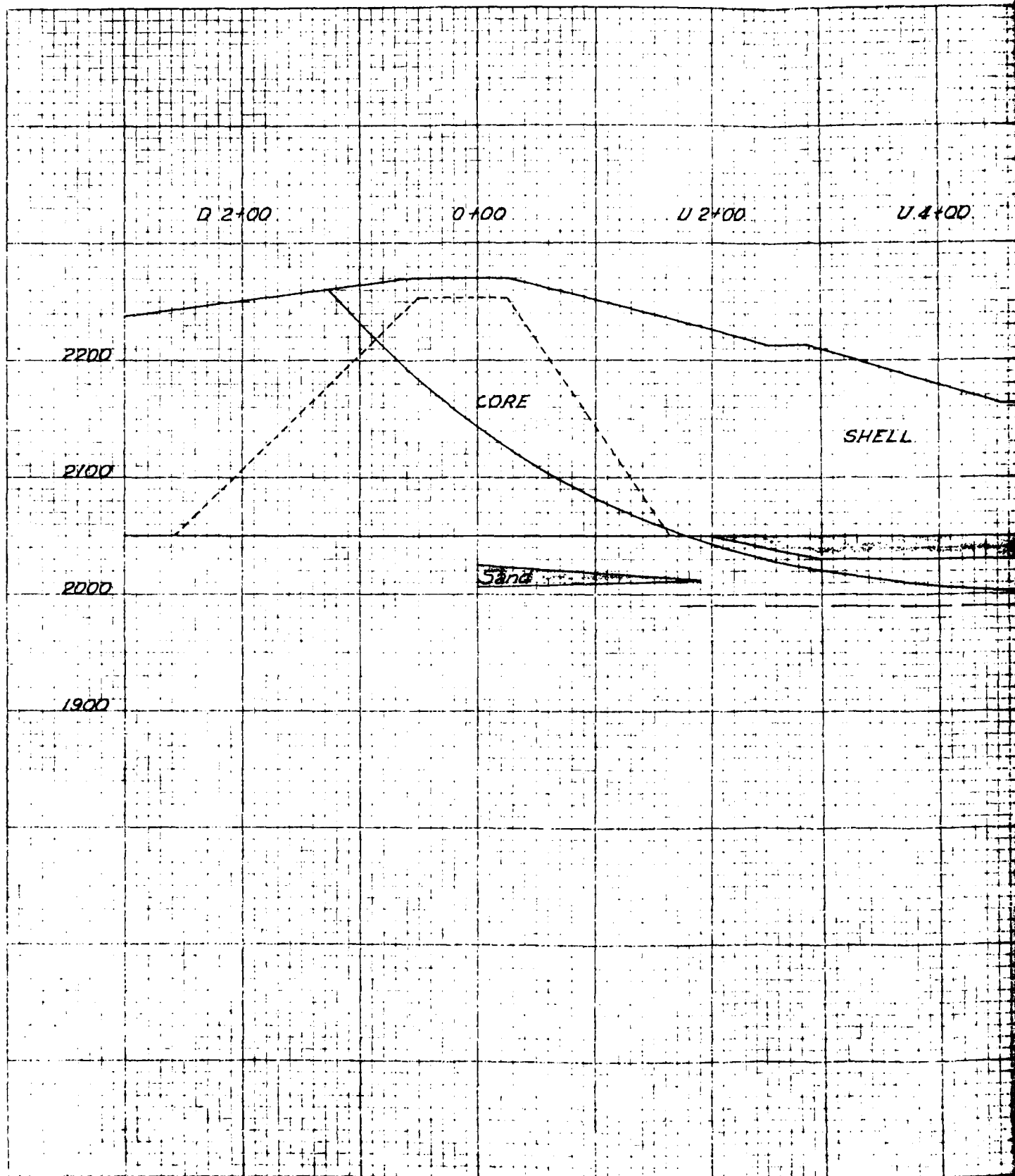
For other constants used in analysis, see Fig. 2

FORT PECK DAM
STABILITY ANALYSIS-UPSTREAM FOUNDATION
SWEDISH METHOD-CIRCLE ANALYSIS
STATION 75+00
Prepared in Office of Division Engineer, Mo. River Div.

FORT PECK DAM AND RESERVOIR

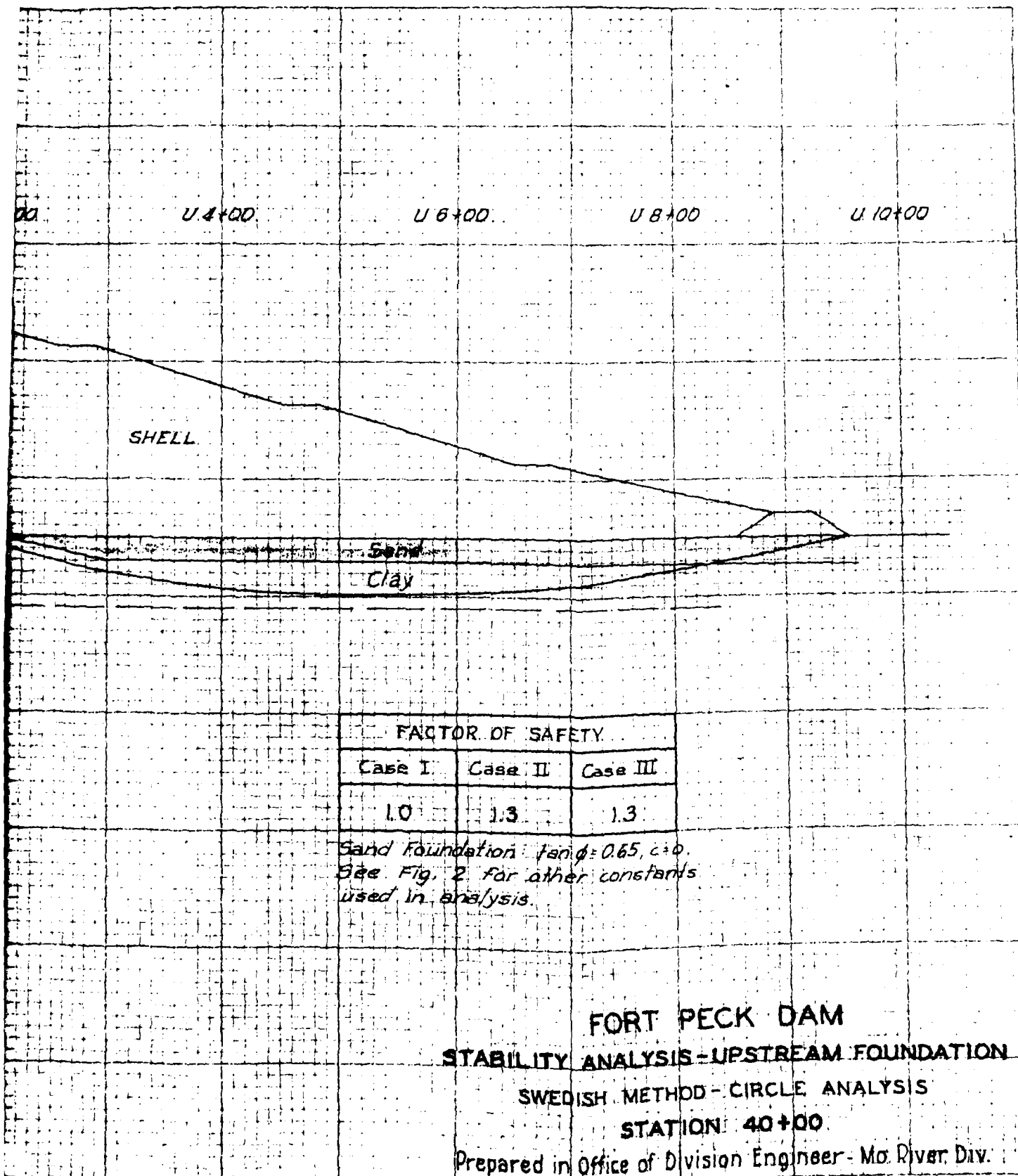
EMBANKMENT CRITERIA AND PERFORMANCE REPORT

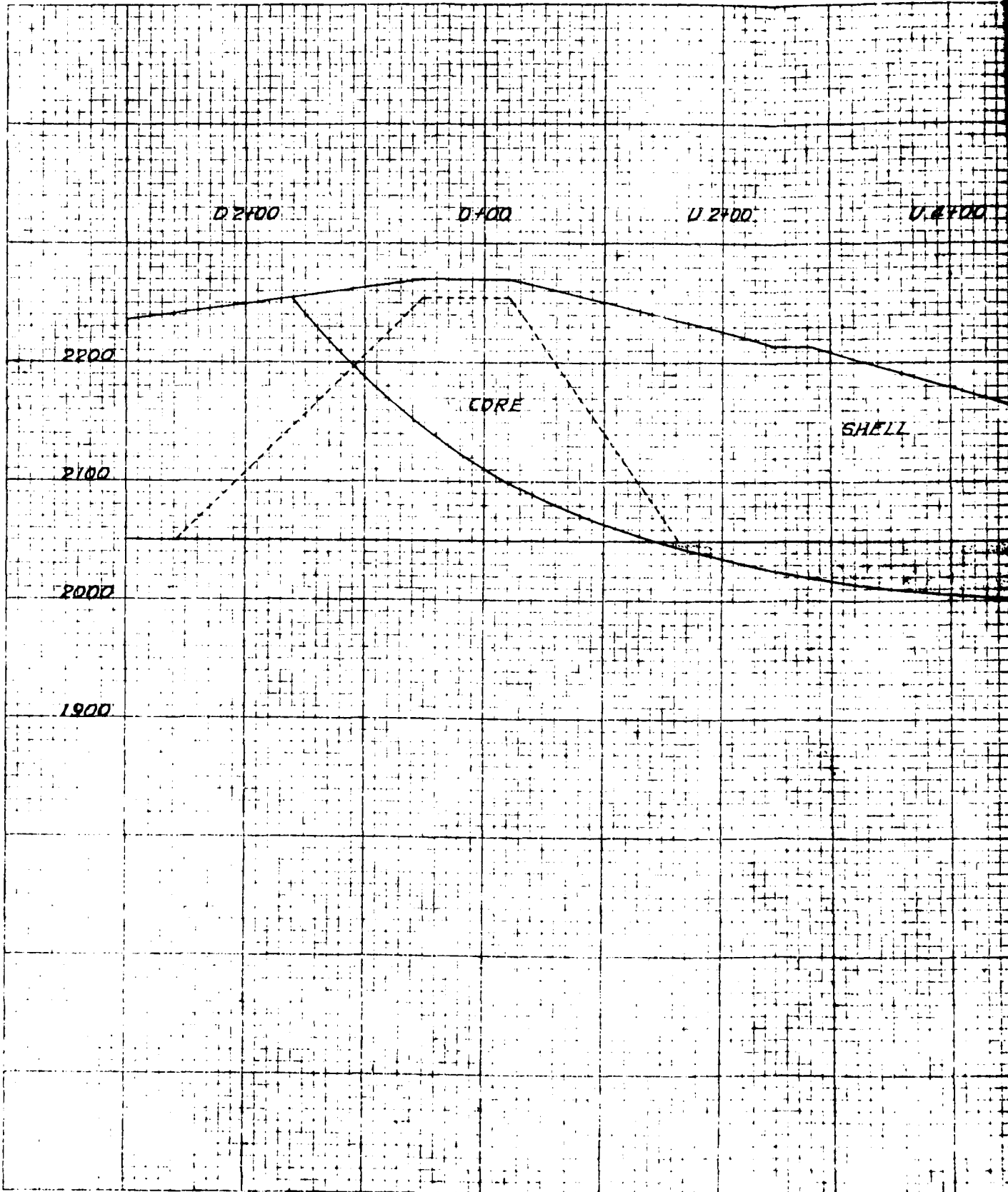
PLATE 4-13

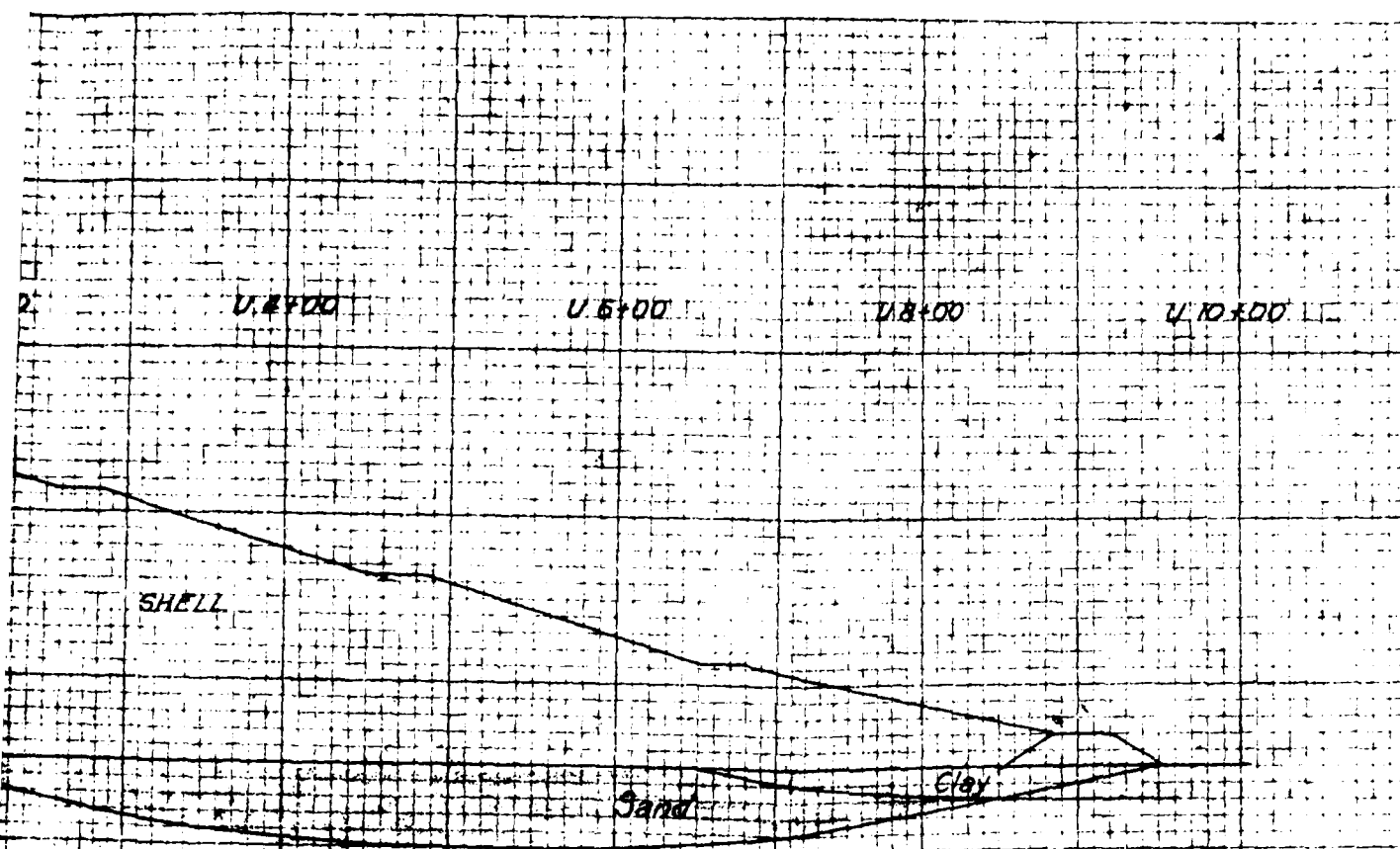


1
SECTION & ELEVATION
10' HORIZONTAL SCALE

FORT PECK D







FACTOR OF SAFETY = 2.9 (All Cases)
 Sand Foundation for $\phi = 0.65$, $c = 0$
 See Fig. 2 for other constants used in analysis

FORT PECK DAM
STABILITY ANALYSIS-UPSTREAM FOUNDATION
 SWEDISH METHOD-CIRCLE ANALYSIS
 STATION 25+00

Prepared in Office of Division Engineer-Mo. River Div.

STA
0+00

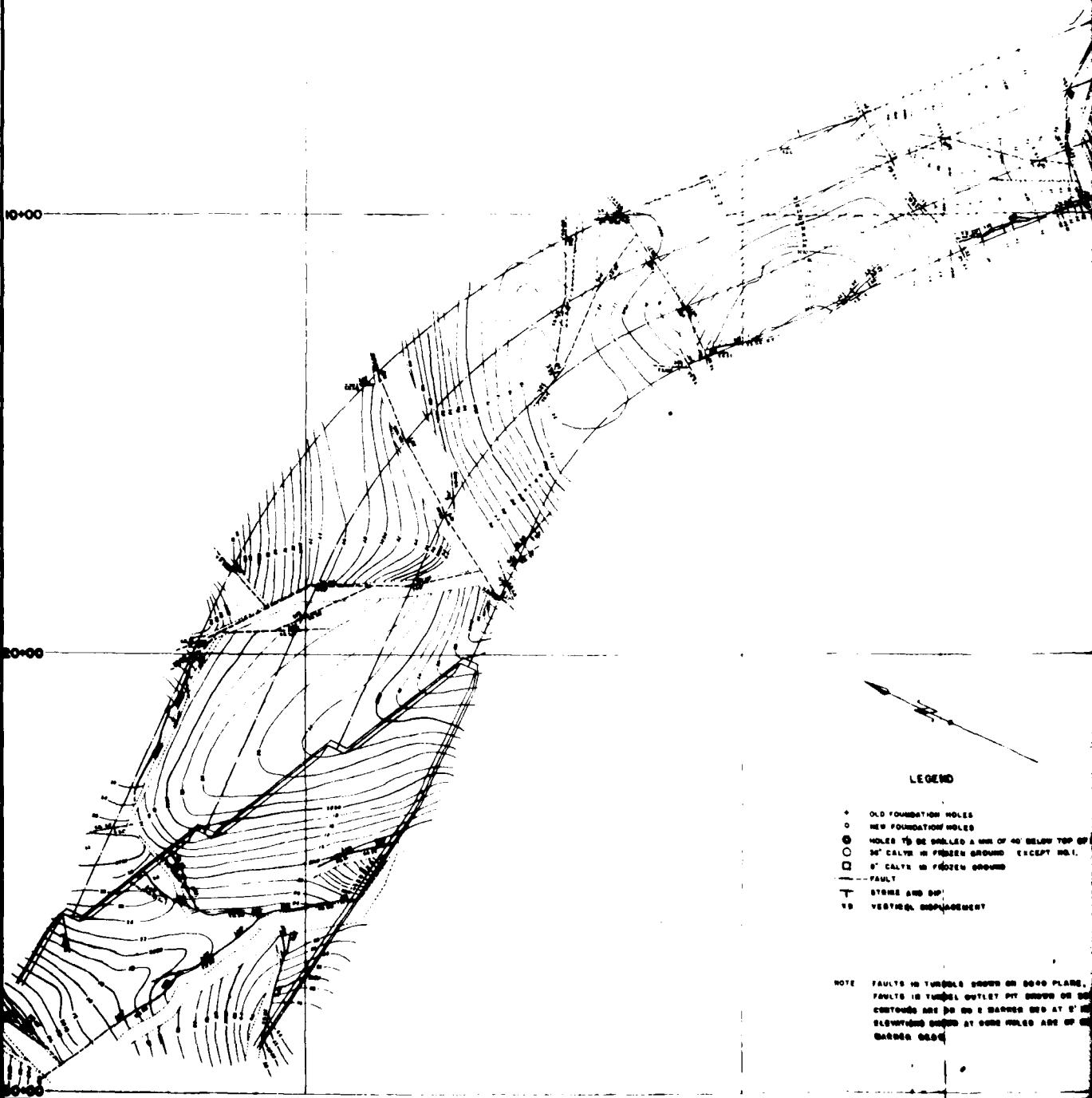
R300

R200

10+00

20+00

30+00



LEGEND

- OLD FOUNDATION HOLES
- NEW FOUNDATION HOLES
- ⊙ HOLES TO BE DRILLED A MIN OF 40' BELOW TOP OF
- 36" CALVE IN FROZEN GROUND EXCEPT NO. 1
- 5' CALVE IN FROZEN GROUND
- FAULT
- STREAM BED
- VERTICAL DISPLACEMENT

NOTE: FAULTS IN TUNNEL SHOWN ON CROSS PLANS.
FAULTS IN TUNNEL OUTLET PIT SHOWN ON SP
CONTIGUOUS ARE DO NOT HAVE BEEN AT 5' IN
ELEVATIONS SHOWN AT SOME HOLES ARE OF
GARDEN CREEK

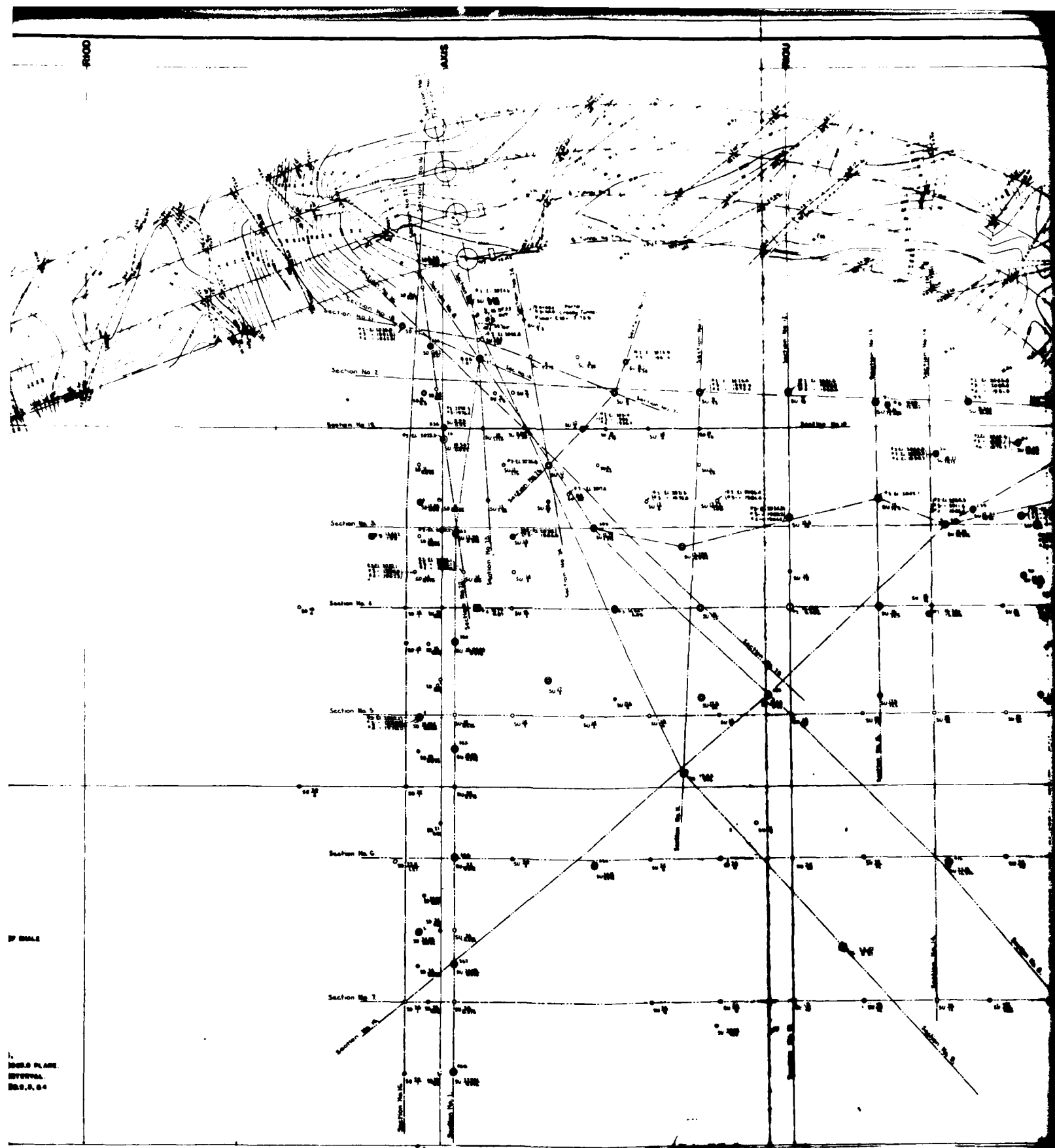
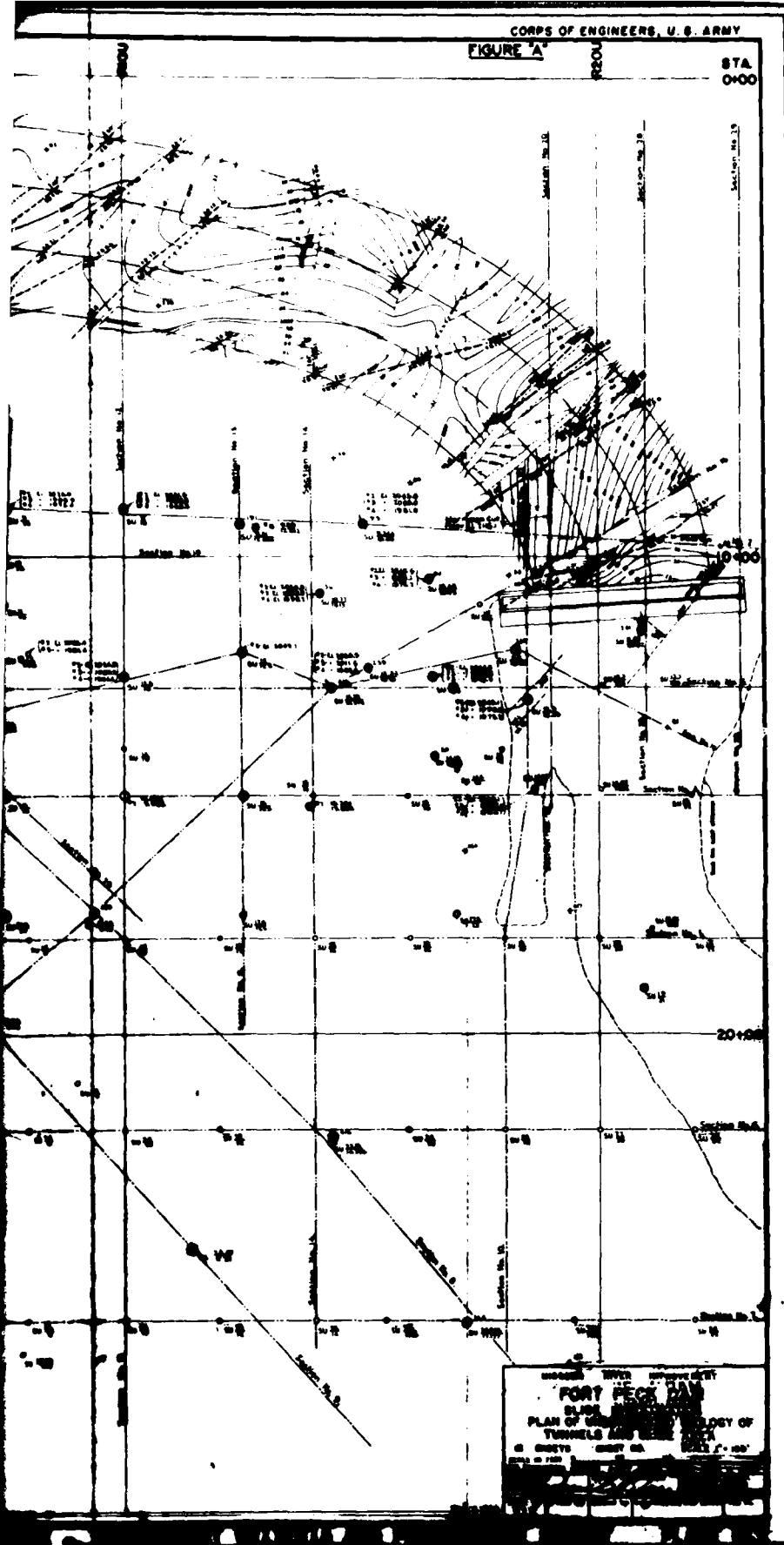


FIGURE "A"

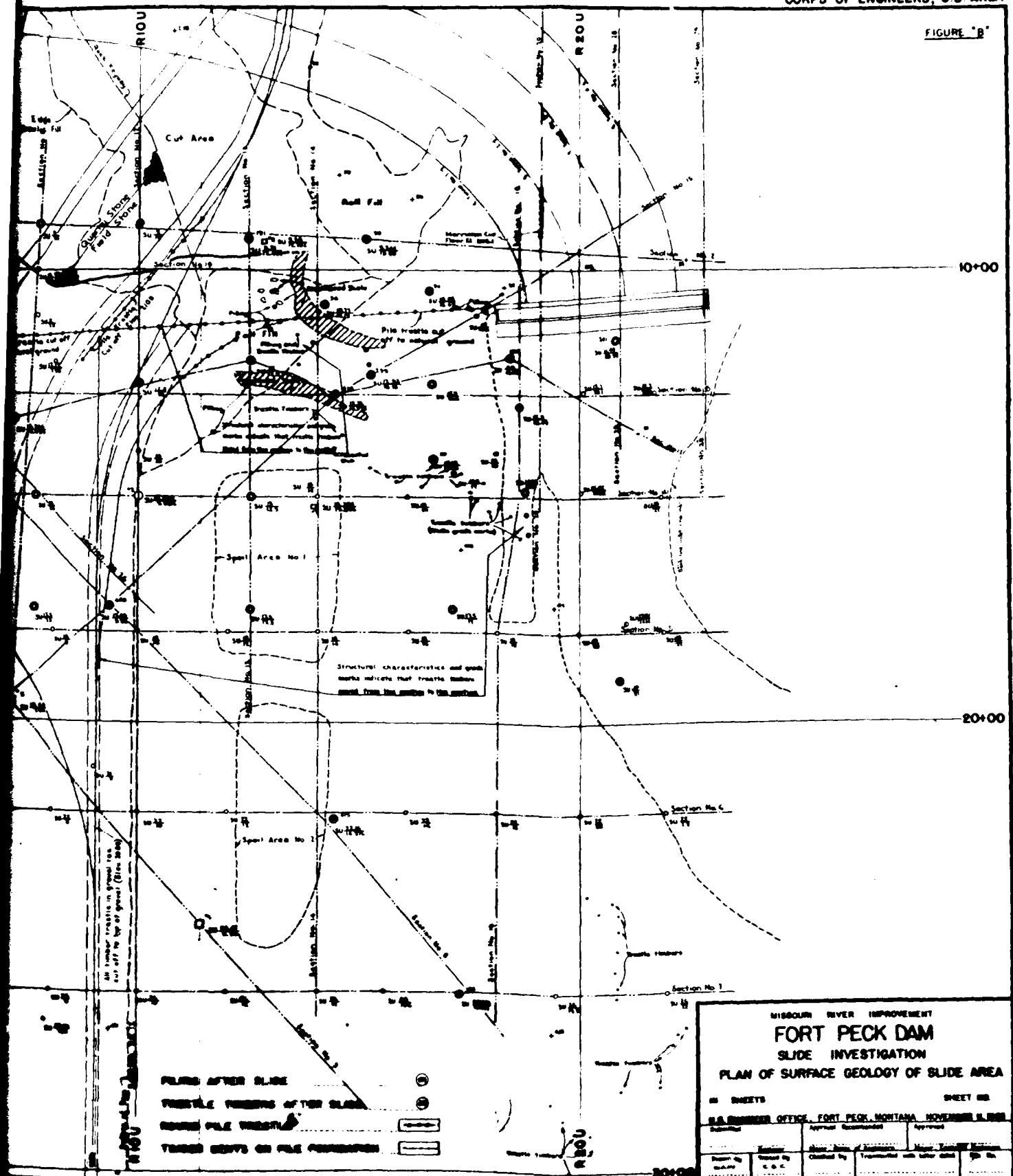
STA.
0+00



[illegible]

PLANE AFTER SLIDE
WRESTLE TURNING AFTER S
GROUND FILE WRESTLE
TURNER MOVES ON FILE COM

FIGURE "B"



A. GENERAL.

A comprehensive program of laboratory and field tests was made to determine the structural properties of the different types of materials in the damaged area, as well as in unaffected portions of the dam. These tests are grouped as follows:

Tests on overburden materials in the damaged area.

Tests on shell and transition zone material in unaffected portions of the dam.

Tests on typical foundation sands and clays.

Tests on core materials.

Tests on shale and bentonite.

These investigations are each discussed briefly.

1. Overburden materials in damaged area. The overburden in the damaged area included both shell and foundation sands, as well as alluvial clays and masses of core material that became intermixed during the movement.

Mechanical analyses for classification purposes were performed on overburden samples from the churn-drill holes. Overburden cores from the Calyx holes were split and photographed, and then samples for laboratory tests were cut from one of the halves. These samples, consisting of 4-inch (102 mm) cubes, were carefully selected and cut to represent typical material from each core. Tests on these included mechanical analyses, specific gravity, moisture content, and determination of the natural voids in the material. The samples were prepared in a cold-storage room, packed with dry ice to keep them frozen, and transported to the laboratory for testing.

Two series of shear tests were made on samples of overburden from Calyx hole No. 4. Plates 5-4 and 5-5 give typical results of tests on overburden materials.

2. Shell and transition-zone materials in unaffected portions of dam. Samples of typical shell materials were secured from undisturbed portions of the shell immediately west of the damaged area and from three test pits, located along the 2212 upstream berm, driven down to the saturation line.

A continuous photographic record was kept of the stratification of the material in the deepest test pit. On all samples, the tests included mechanical analyses, specific gravity, relative density (both wet and dry), and determination of natural voids. In addition, triaxial tests were made on disturbed and on several undisturbed samples of typical shell material from one of the test pits.

In order to check the results of critical-density tests performed on the triaxial shear machines, several series of direct-shear tests were also performed and critical density determined by the Taylor method.

Disturbed samples of material from the upstream edge of the core and the upstream edge of the slide were taken from the east transition section. On these samples, mechanical analyses, specific gravity tests, density tests, relative density tests, critical-density tests, and shear tests were performed. In the typical tests, a complete mineral analysis was made of a typical sample of shell. Plates 5-6 through 5-13 give results on these materials.

An experimental section of hydraulic fill structure was constructed to investigate the feasibility of this type of material by means of tractors. This fill was placed in 6-in (152 mm), 18-in (457 mm), and 30-in (762 mm) layers to a depth of from 5 feet (1.5 m) to 10 feet (3.0 m). Each layer was compacted by three, six, or nine passes of a 95-horsepower roller operating at half and full speed.

Continuous undisturbed samples were taken from test pits in each sampling area, and mechanical analyses, specific gravity, void determination, relative density tests were made on each. Results on these samples are shown on Plates 5-14 through 5-17.

3. Foundation sands and clays. A test pit was driven into the flood plane downstream of the dam in order to secure undisturbed samples of materials similar to the foundation materials in the section of the dam affected by the movement. A continuous photographic record of the natural strata in this pit, and mechanical analyses, specific gravity, void determination, relative density and critical-density tests were made on this material.

Undisturbed samples of the surface of the dam were taken at the upstream edge of the damaged area. Mechanical analyses, consolidation tests, and direct-shear tests were performed on them. Plates 5-18 to 5-21 show the results of tests on foundation sands and clays.

4. Core materials. At a selected location in the closure section, the undamaged core of the dam, and in the center of the slide (152 mm) drive samples were taken down the core. Mechanical analyses, moisture content, consolidation tests, and consolidation tests were performed on samples from 10-foot intervals in elevation. In addition, triaxial tests, consolidation tests, and direct-shear tests were made on samples from elevation 2080. The results of typical tests on these samples are given on Plates 5-22 to 5-24.

5. Shale and bentonite. Samples of

TESTS OF MATERIALS

in the transition zone, from the upstream shell, from the transition zone, from the Merriman drift above the inlet portals, and from several points in the damaged area, as well as from five holes, and a test pit driven into the weathered shale downstream from the damaged section. Samples of fault-zone material were also secured from the Crosby drift near the shafts. Mechanical analyses, consolidation tests, and both consolidated and quick-shear tests were performed on these samples.

Samples of bentonite were secured from Calyx holes, the Merriman drift, the Crosby drift, and from exposed seams at other points on the right abutment. Both quick and consolidated-shear tests were performed on these samples. The coefficient of friction of bentonite on shale was also determined for some samples. The results of these tests are given on Plates 5-25 to 5-30.

In addition to the laboratory tests on the bentonite, a series of shear tests was made in the field on the two bentonite seams in the Merriman drift. These seams were lying approximately horizontal and were separated by 3 inches (203 mm) of shale. Both the normal loads and shearing loads were applied by means of hydraulic jacks. The center section of shale was confined by a steel jacket, to prevent its being crushed by the vertical load and to properly distribute the shearing forces.

B. EQUIPMENT AND PROCEDURE FOR LABORATORY TESTS.

1. Mechanical analyses. All mechanical analyses were made by the sieve and hydrometer method and were usually run wet. Samples composed of distinctly different types of material, such as sand with quantities of shale fragments or clay balls and clay samples mixed with gravel, were segregated and the percentage of each kind of material determined separately. These samples were run dry.

2. Specific-gravity determinations. Specific-gravity determinations were made on material from every sample, so that void determinations could be made more accurately. Specific-gravity determinations were made by the vacuum method on 200-gram samples.

3. Void determinations. For the purpose of determining the natural void ratio in undisturbed samples of materials from the shells, transition zones, foundation sands, and the experimental rolled hydraulic fill, 6-inch-diameter (152 mm) samples were taken in accurately calibrated cylinders 6 inches (152 mm) in length.

Void determinations of material from the frozen Calyx cores were made on the 4-inch (102 mm) cubes. The volume of the cubes was accurately determined by submerging them in a pan filled to the overflow with mercury and weighing the mercury displaced.

4. Relative-density tests. Relative-density tests

were performed on all undisturbed samples of shell material, transition-zone material, and sandy material from the test pit in the flood plane below the dam, as well as on all samples from the experimental rolled hydraulic fill. The large number of relative-density tests made it necessary to construct a special device for compacting the samples to maximum density. This apparatus consisted of several pedestals, on which the tubes containing the samples were placed, the pedestals and samples being jarred up and down by cams on a motor-driven shaft. For determining the lowest possible degree of compaction, the materials were carefully deposited in glass cylinders through specially designed funnels. Relative-density tests were made on each sample in both dry and saturated condition.

5. Critical-density tests. Critical-density tests on shell materials were performed in the soils laboratory of the Graduate School of Engineering of Harvard University, at the Waterways Experiment Station, Vicksburg, Miss., and at the Fort Peck District laboratory. Tests on undisturbed samples of cohesionless materials were made at the Fort Peck laboratory.

6. Consolidation tests. All consolidation tests were made according to standard procedure in the Fort Peck type of consolidation equipment. Samples were all 5-5/8 inches (143 mm) in diameter. Samples of transition-zone material and the more pervious samples of core material were 2-1/2 inches (64 mm) in thickness, while samples of very impervious materials, such as clays and weathered shale, were 1.0 inch (25 mm) or 1-1/4 inches (32 mm) thick.

Consolidation of core and a few weathered-shale samples prior to making shear tests was accomplished in consolidation devices, although most of the bentonite and weather-shale samples were preconsolidated directly in the shear boxes.

7. Shear tests. Consolidated-shear tests on transition-zone material, weathered shale and bentonite were made in the M.I.T. shear machine, while the direct-shear tests on shell material and tests on core material were made in the Zanesville-type shear machine. All quick-shear tests were made in the Zanesville-type shear machine. The shear test samples were 4 inches (102 mm) square and 3/4-inch (10 mm) thick.

Consolidated shear tests were made by first consolidating the sample to the desired load and then adding the shearing loads in increments and waiting until movement ceased before adding additional load increments. Quick-shear tests were made with constant strain loading, the load being applied continuously, so that failure occurred within a few minutes after start of the test.

undisturbed samples of shell material, and sandy material in the flood plane below the samples from the experimental. The large number of relative necessary to construct a specting the samples to maximum consisted of several pedestals containing the samples were and samples being jarred up motor-driven shaft. For determinable degree of compaction, the samples deposited in glass cylinder designed funnels. Relative on each sample in both dry

Tests. Critical-density tests performed in the soils laboratory School of Engineering of the Waterways Experiment Station, and at the Fort Peck Districts on undisturbed samples of were made at the Fort Peck

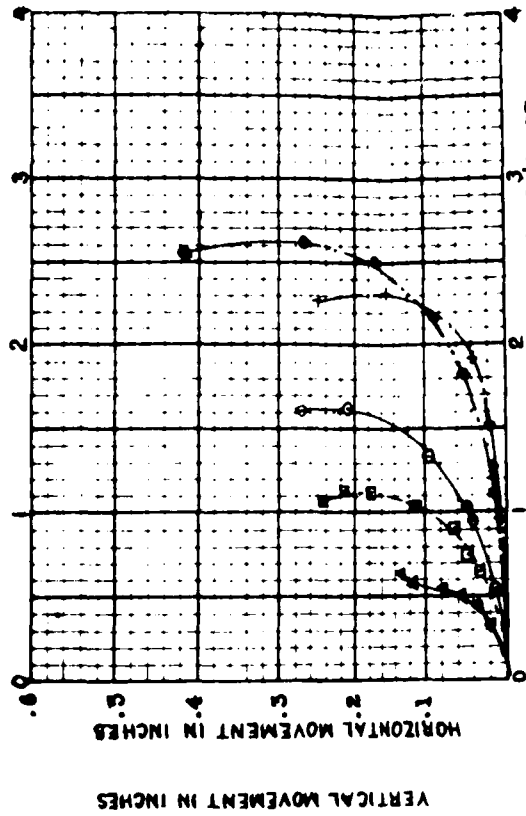
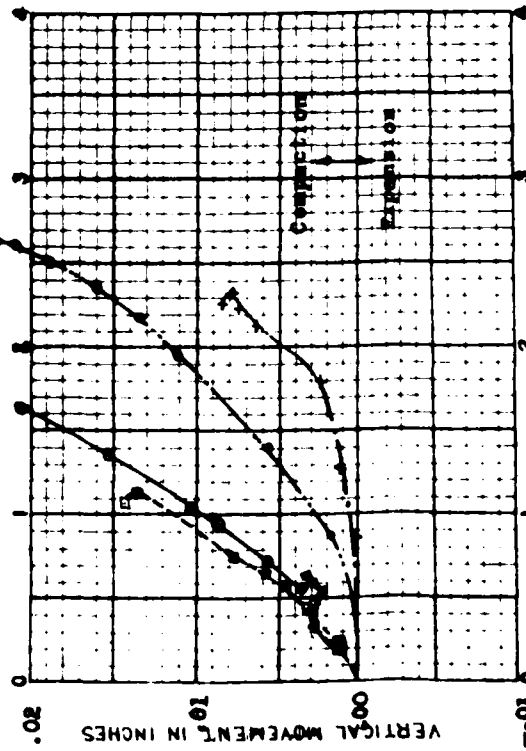
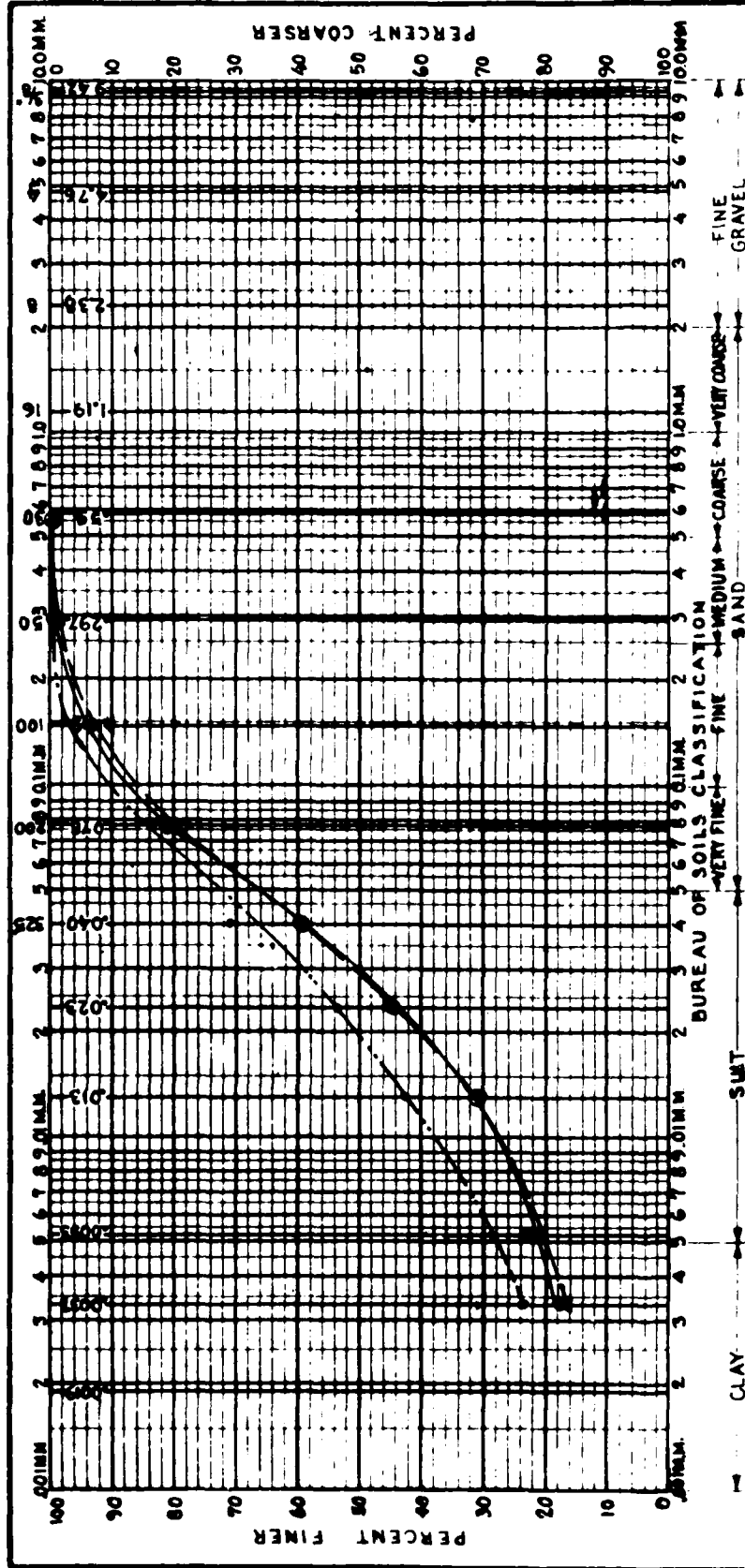
Tests. All consolidation tests to standard procedure in the consolidation equipment. Samples (143 mm) in diameter. Samples material and the more pervious material were 2-1/2 inches (64 mm) samples of very impervious material and weathered shale, were 1/4 inches (32 mm) thick.

and a few weathered-shale shear tests was accomplished tests, although most of the bench samples were preconsolidated in shear boxes.

Consolidated-shear tests on material, weathered shale and in the M.I.T. shear machine, tests on shell material and were made in the Zanesville quick-shear tests were made in shear machine. The shear (102 mm) square and

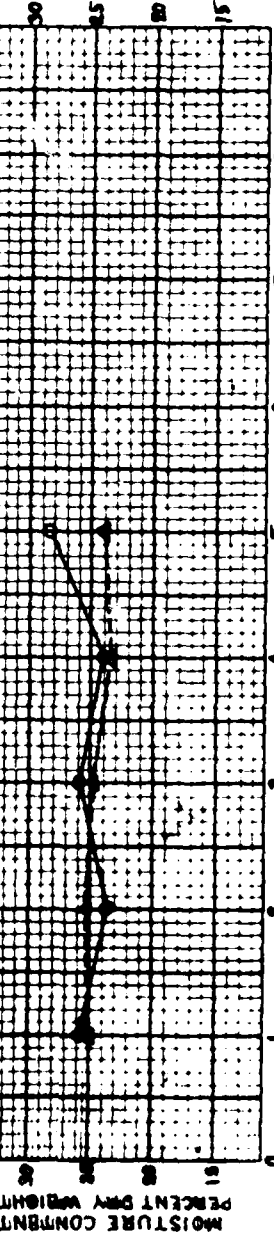
tests were made by first consolidating the desired load and then adding in increments and waiting before adding additional load. Tests were made with consolidation load being applied continuously occurred within a few minutes of the test.

3

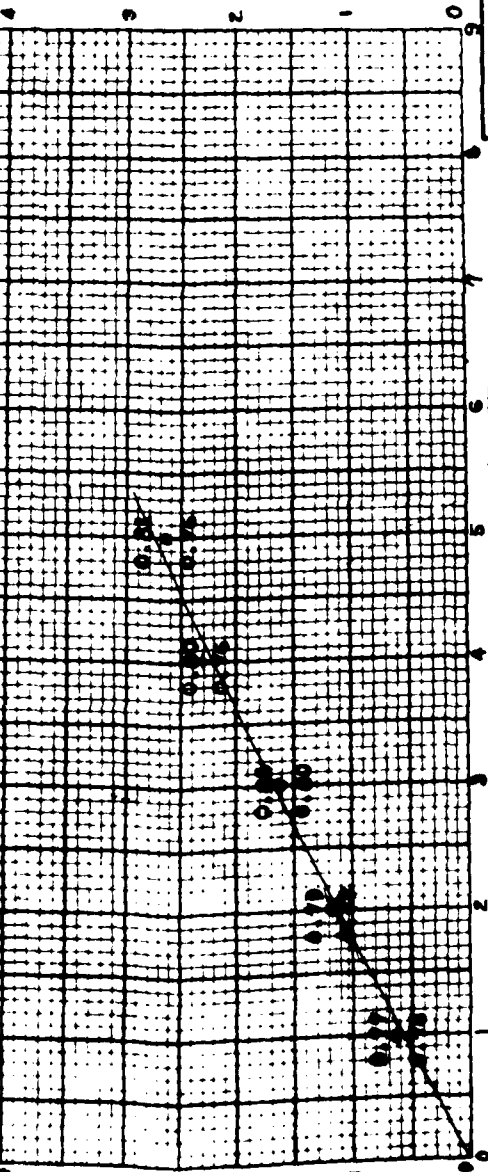


HORIZONTAL PRESSURE IN TONS/SQ FT VERTICAL AND HORIZONTAL MOVEMENT CURVES DURING TEST

MOISTURE CONTENT
PERCENT DRY WEIGHT



SHEARING RESISTANCE TONS/SQ FT



VERTICAL LOAD TONS/SQ FT NORMAL LOAD-SHEARING RESISTANCE CURVE

Notes: Undisturbed Sample

Consolidated Shear Tests

Increment Loading

Elevation 2047.0-2048.6

Gross Sectional Area of Sample 16.00 sq. in.

Initial Thickness = 1.00 inch

Sample Immersed in Water During Test.

Station 14+79.0 Range 0/87U

Section # 39

Shearing Resistance

$\tau = \frac{\text{Cohesion (Tons/Sq Ft)}}{\text{Vertical Load (Tons/Sq Ft)}}$

$\tau = 0.552$

$\phi = 28^{\circ}54'$

$c = \text{Cohesion} = 0.08/\text{sq. ft.}$

LEGEND-M.C.

Before Test $\bigcirc$ Undist.

After Test Δ ---

LEGEND

Δ --- = 1 T/sq. ft.

$\square$ --- = 2 T/sq. ft.

$\bigcirc$ --- = 3 T/sq. ft.

$+$ --- = 4 T/sq. ft.

$\bullet$ --- = 5 T/sq. ft.

MISSOURI RIVER IMPROVEMENT
NATIONAL FLOOD CONTROL, POWER, IRRIGATION

FORT PECK DAM

SLIDE INVESTIGATION

CONSOLIDATED SHEAR TESTS SERIPTS # 1*

MIXED MATERIAL FROM CALIX HOLE # 4

SECTION # 39 MONT 2-7-57

Approved: _____

Reviewed: _____

Checked: _____

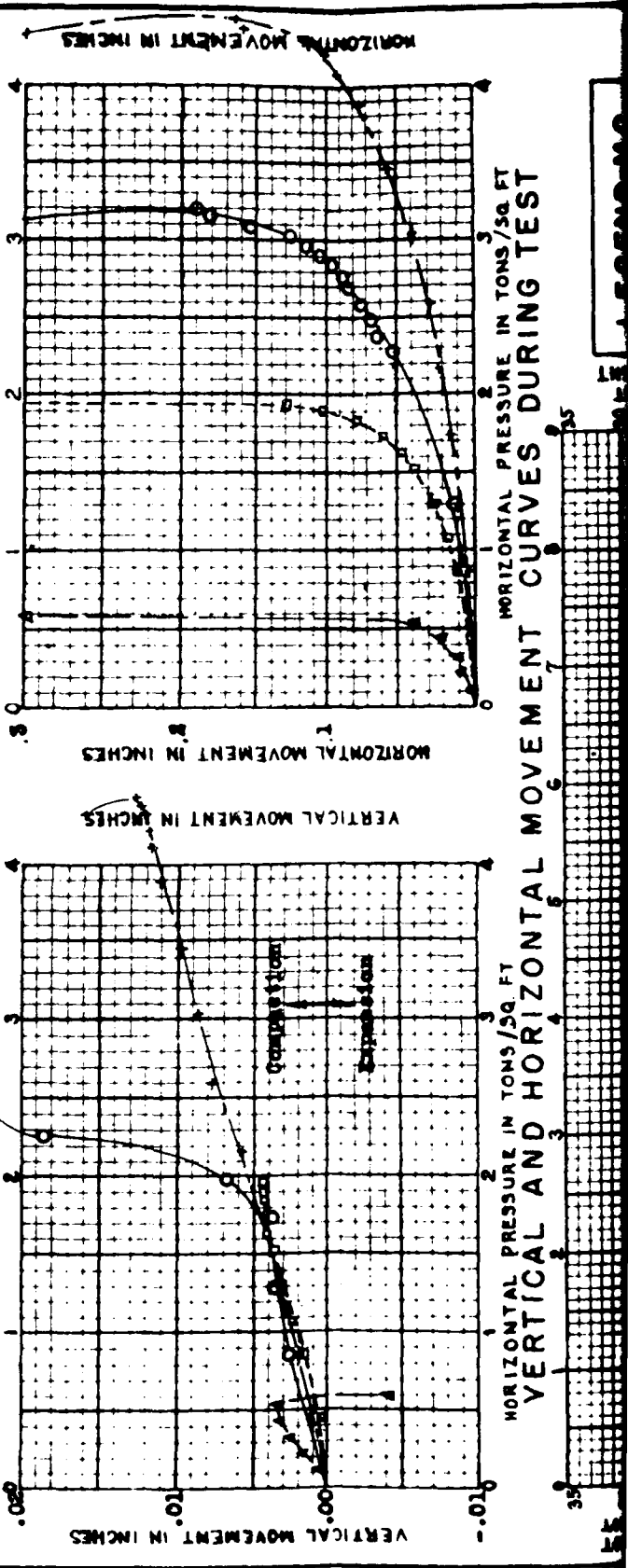
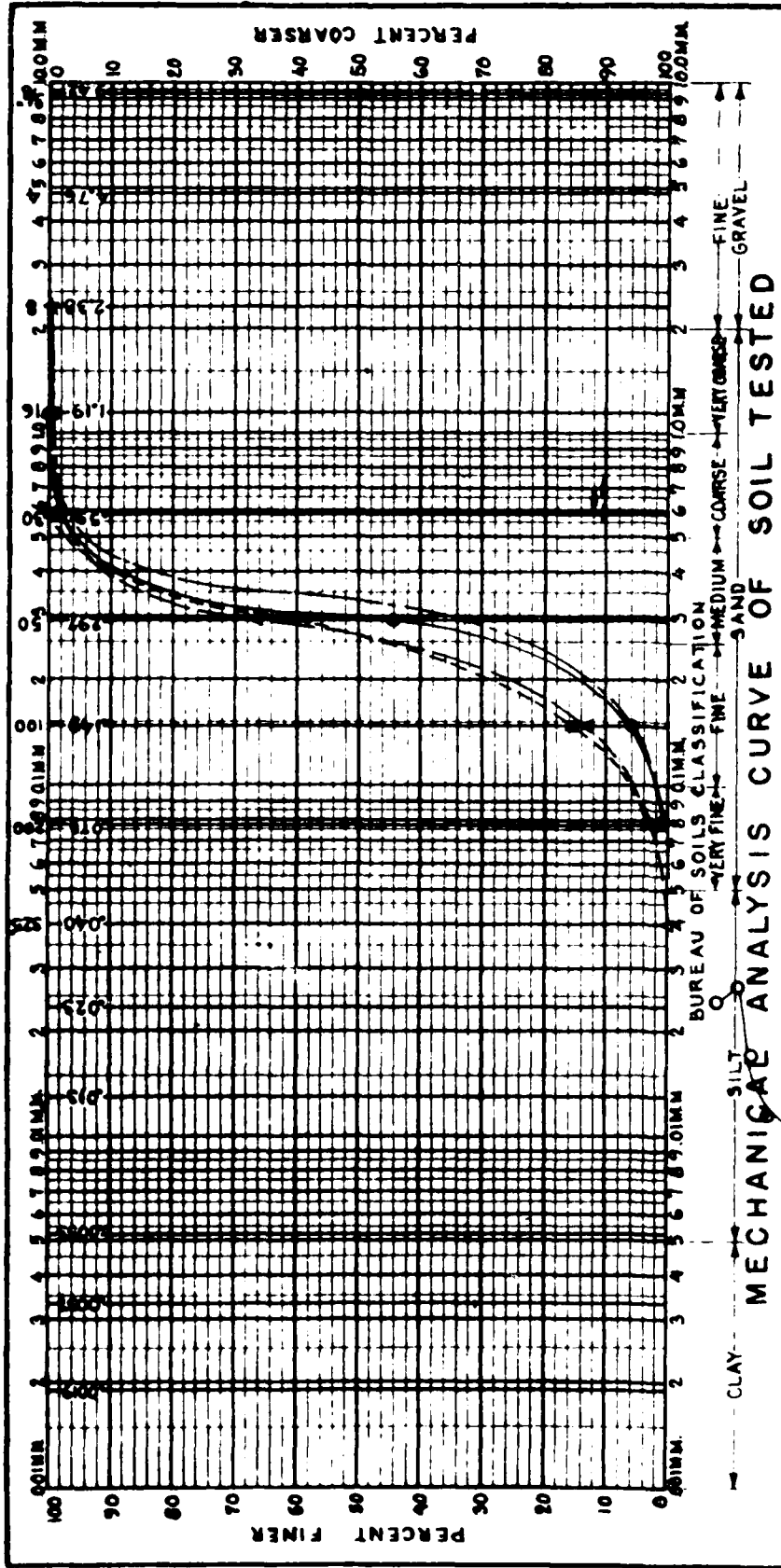
Drawn by: JLB JIC RIG

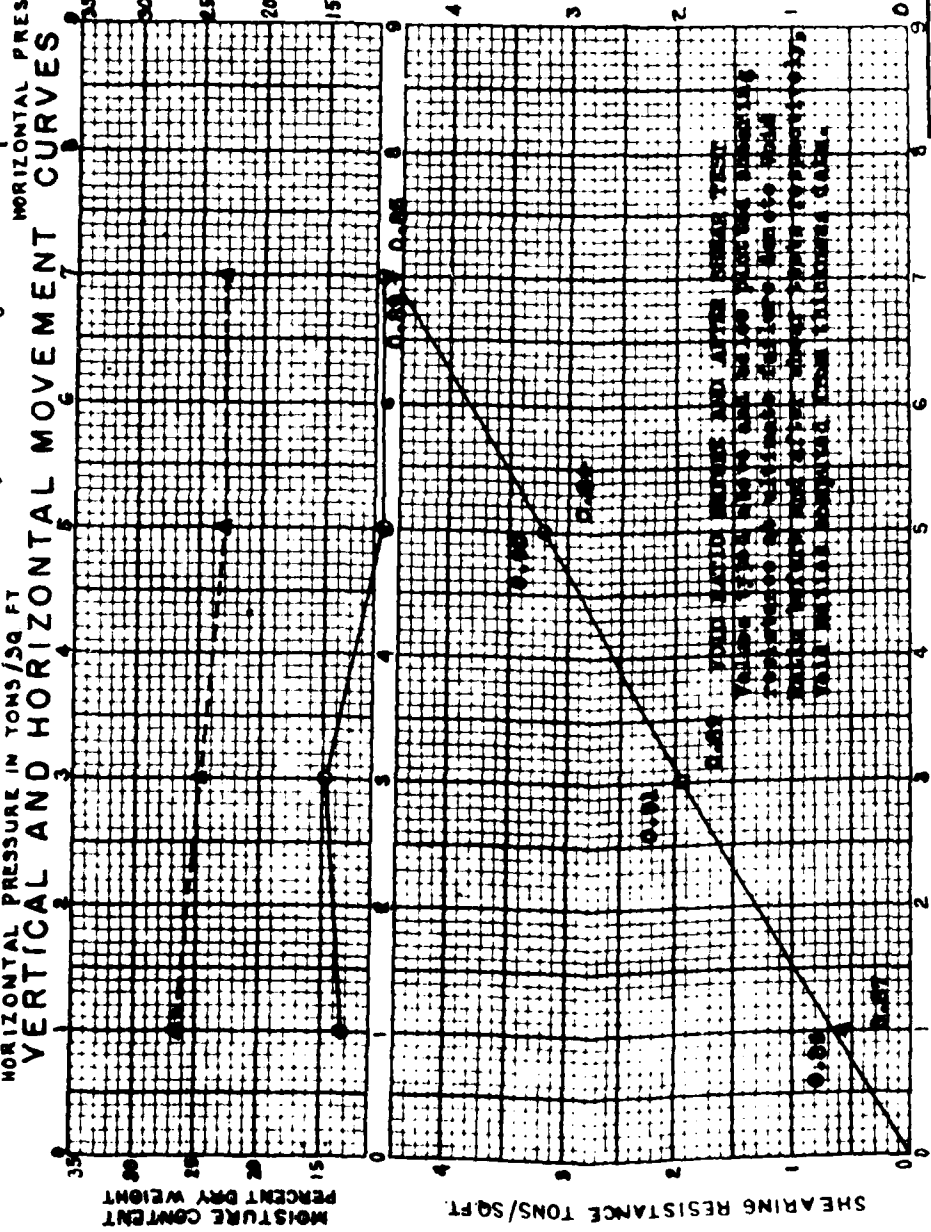
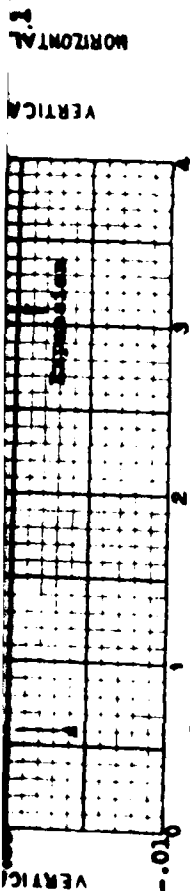
Transmitted in report: No

CALYX HOLE NO. 4—STATION 14+79, RANGE 0+87-U
(Original sheets 2 and 3)

Core No.	Elevation top of core	Specific gravity	Moisture content, percent	Void ratio "E"	Percent of voids
1.....	2,124.30	2.697	25.7	0.783	43.9
2.....	2,122.00	2.693	20.7	.627	38.5
3.....	2,119.70	2.701	21.5	.676	40.3
4.....	2,118.30	2.689	21.5	.635	38.8
5.....	2,116.50	2.693	19.3	.564	36.1
6.....	2,114.30	2.704	20.2	.603	37.6
7.....	2,112.90	2.684	21.1	.624	38.4
8.....	2,110.72	2.691	20.6	.601	37.5
9.....	2,108.90	2.690	17.6	.512	33.8
10.....	2,107.20	2.692	18.7	.542	35.1
11.....	2,105.59	2.712	17.1	.509	33.7
12.....	2,103.88	2.682	20.7	.604	37.7
13.....	2,101.39	2.677	23.9	.731	42.2
14.....	2,099.29	2.680	22.2	.696	41.0
15.....	2,097.36	2.675	21.5	.665	40.0
16 ¹	2,095.20				
17.....	2,092.70	2.676	22.6	.670	40.1
18.....	2,090.60	2.678	21.6	.645	39.2
19.....	2,088.57	2.664	22.0	.637	38.9
20.....	2,086.71	2.688	22.1	.654	39.5
21.....	2,085.20	2.690	20.7	.619	38.2
22.....	2,082.70	2.665	21.2	.607	37.8
23.....	2,080.74	2.675	23.8	.723	42.0
24.....	2,078.81	2.714	19.3	.708	41.5
25.....	2,077.25	2.694	21.0	.644	39.2
26.....	2,074.94	2.669	21.6	.650	39.4
27A.....	2,072.90	2.685	21.6	.674	40.3
B.....		2.691	21.7	.685	40.6
28.....	2,071.43	2.680	22.4	.673	40.2
29.....	2,069.20	2.703	19.2	.570	36.3
30.....	2,067.50	2.690	21.4	.639	39.0
31.....	2,064.90	2.692	21.4	.643	39.1
32.....	2,062.70	2.691	21.8	.648	39.3
33.....	2,061.00	2.697	21.7	.635	38.9
34.....	2,058.60	2.677	22.7	.666	39.9
35.....	2,056.10	2.692	21.4	.619	38.2
36.....	2,054.46	2.689	19.6	.568	36.2
37.....	2,052.20	2.688	19.1	.566	36.1
38.....	2,050.00	2.680	19.3	.551	35.5
39.....	2,048.90	2.743	26.6	.824	45.2
40.....	2,046.30	2.752	29.5	.680	40.5
41.....	2,043.60	2.697	28.3	.867	46.4
42.....	2,041.10	2.701	24.1	.750	42.8
43.....	2,039.70	2.727	22.7	.711	41.6

¹ First half destroyed, no sample obtained from other half of core.



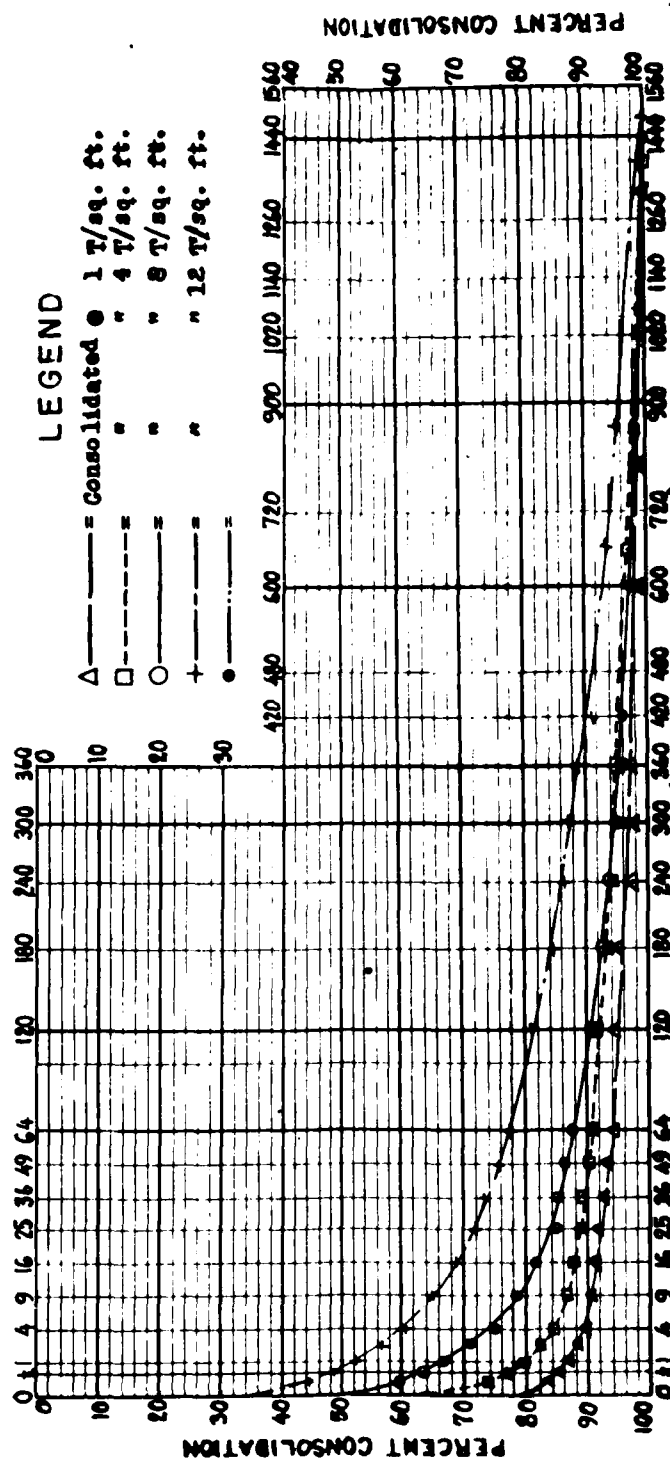
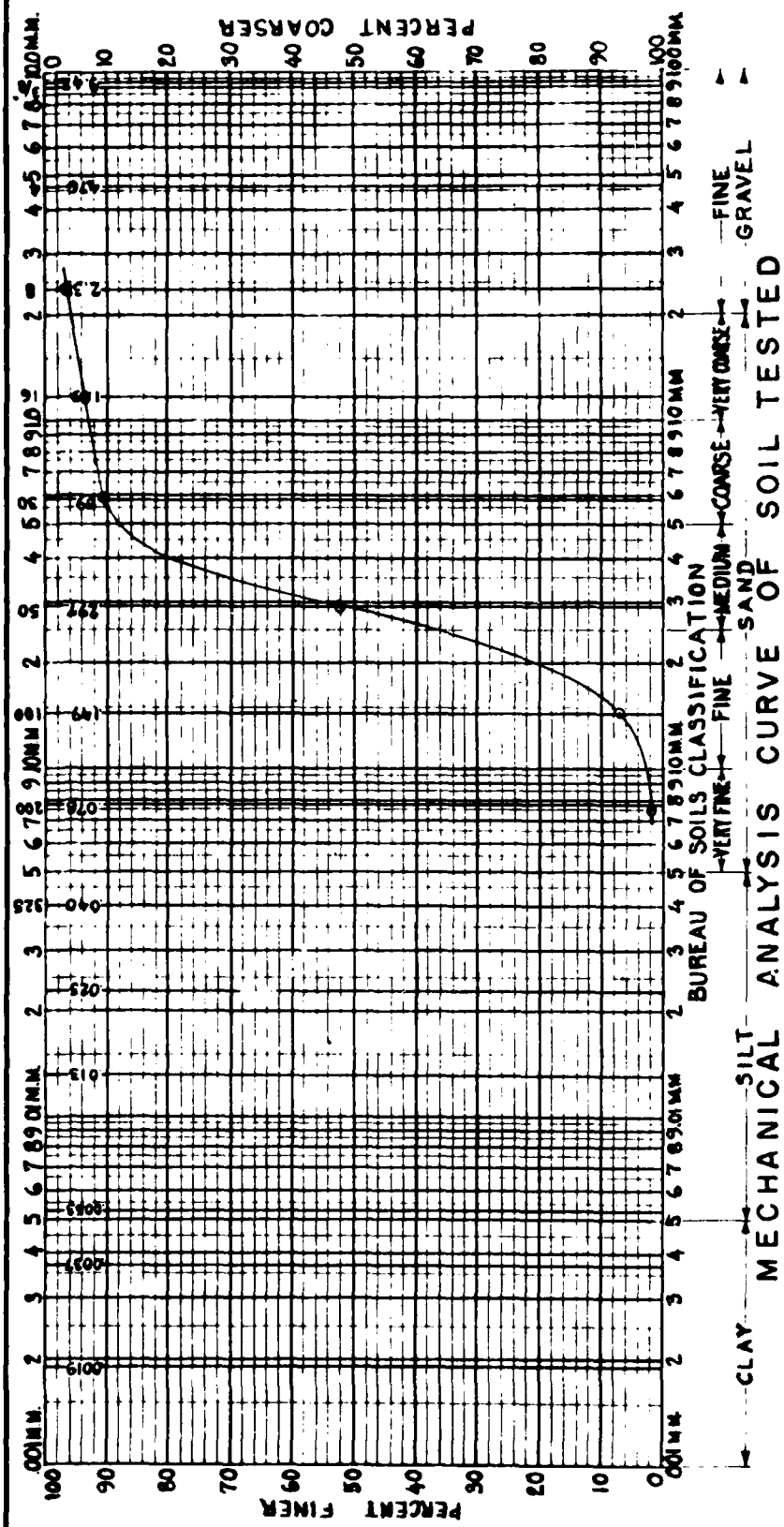
[illegible]
$$\text{Shearing Resistance} = \frac{\text{Cohesion (tons/sq ft)}}{\text{Vertical Load (tons/sq ft)}} = 0.640$$

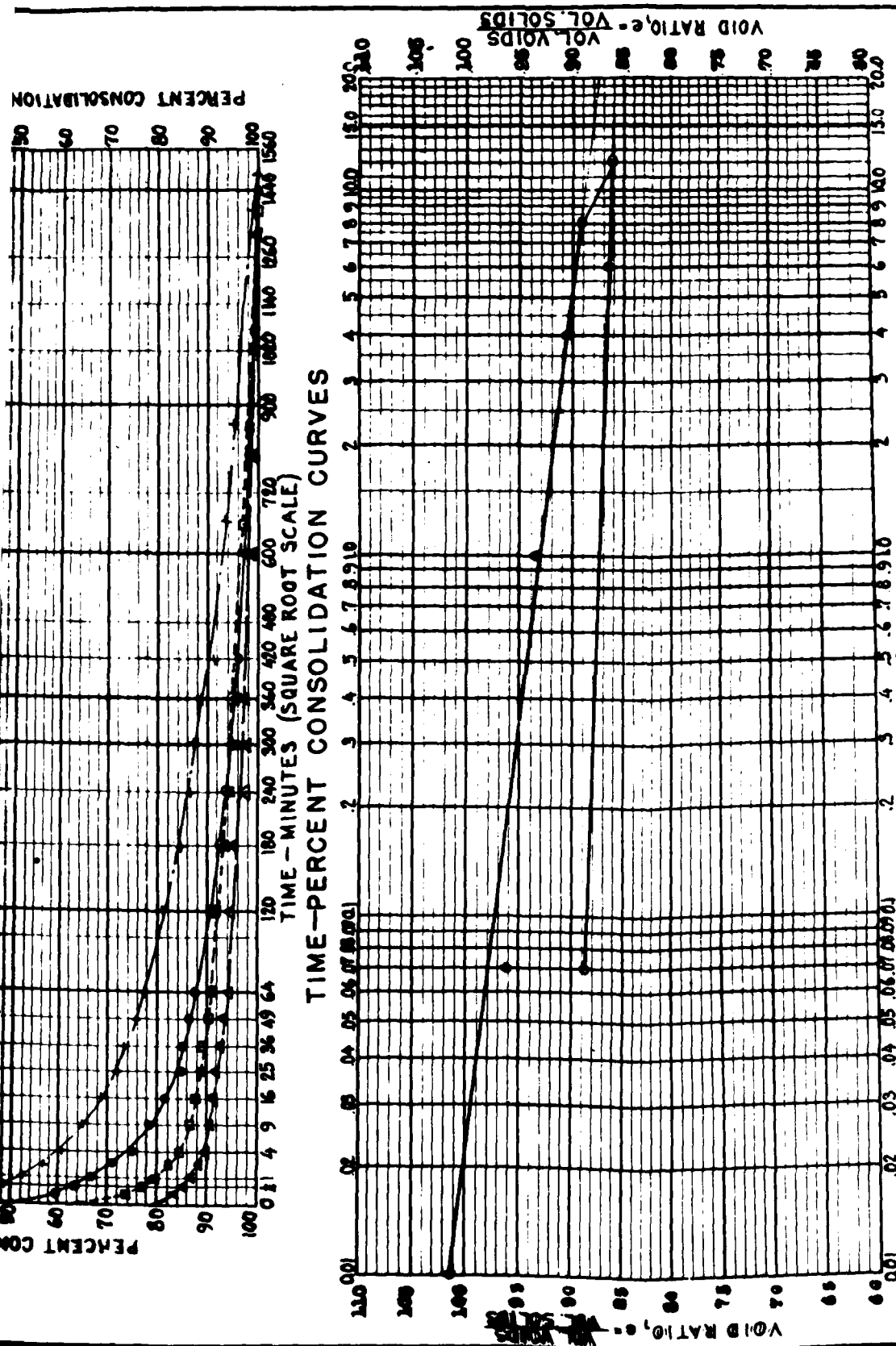
LEGEND-M.C.	Before Test	○ ~~Empty~~	After Test	A
-------------	-------------	--------------------	------------	---

LEGEND

A	1 T/
□	3 T/
○	5 T/
+	9 T/
●	—

MISSOURI RIVER IMPROVEMENT NATIONAL FLOOD CONTROL DISTRICT	FORT PECK DAM SLIDE INVESTIGATION CONSOLIDATED SHEAR TESTS SERIES #1 TRANSITION ZONE MATERIAL		DESIGNED BY C. E. BENTLEY, MONT. / 10-27-34	APPROVED BY [Signature]	DATE 10-27-34	NO. 1
JLB	KBC	DED	Checked by [Signature]	DATE 10-27-34	NO. 1	





VERTICAL LOAD TONS/SQ. FT.	COMPACTION PERCENT *
0.00	0.00
0.07	1.76
1.00	3.07
4.00	4.68
6.00	5.82
12.00	6.80
6.00	6.67
0.07	5.45

PRESSURE-VOID RATIO CURVE
Estimated Previous Consolidation - Tons/Sq. Ft.

Undisturbed Sample Immersed in Water during test
Station 41 + 00; Range 0 / 26-U
Initial Thickness 2.50 inch
Gross Sectional Area 24.80 sq. in.
Elevation 47.2; Depth 8'

* Total compaction in percent of original height of sample.

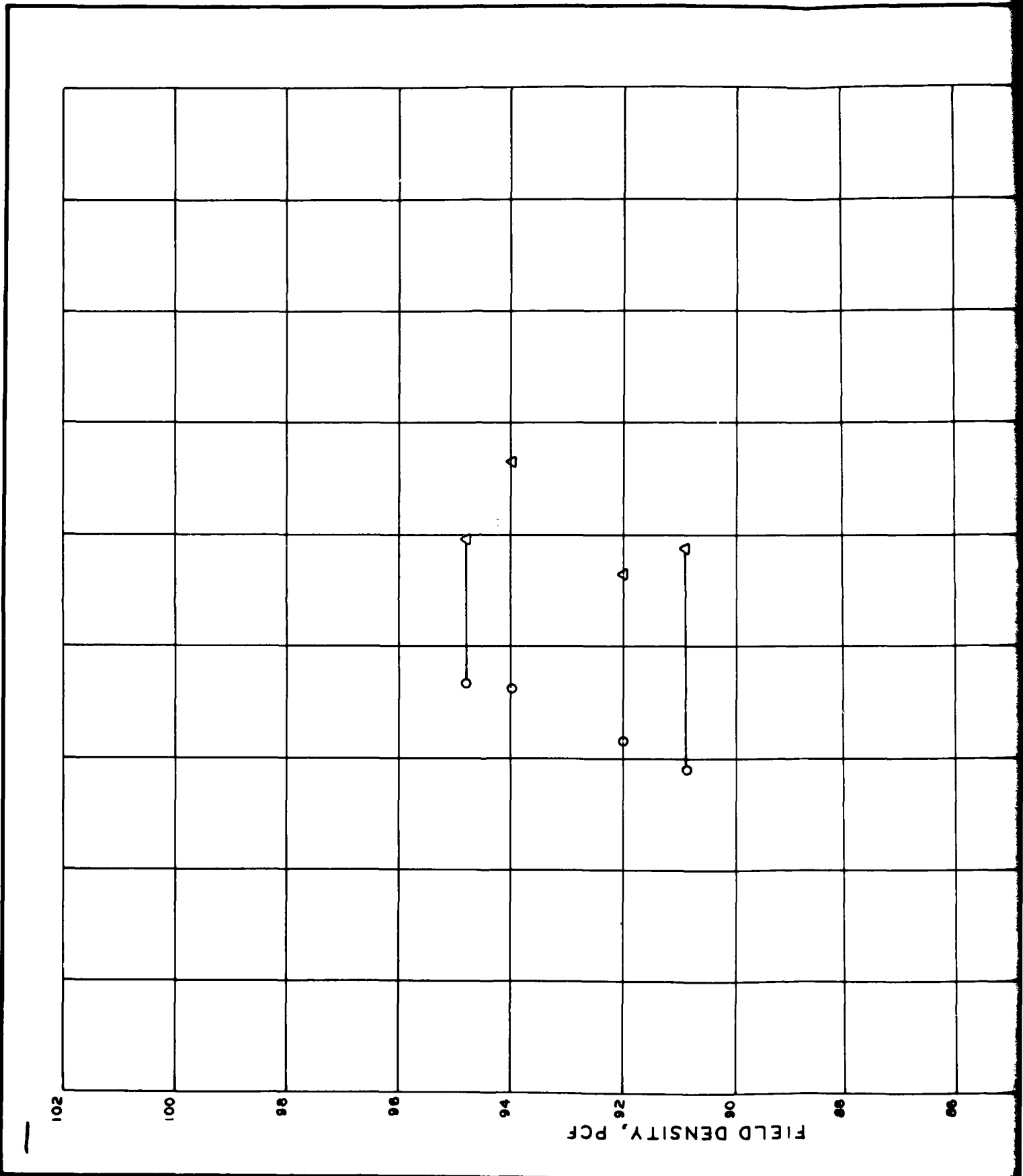
MISSOURI RIVER IMPROVEMENT
NAVIGATION, FLOOD CONTROL, POWER, IRRIGATION

FORT PECK DAM
SLIDE INVESTIGATION
CONSOLIDATION TEST, TRANSITION MATERIAL
TEST PIT NO. 5; SERIES #1

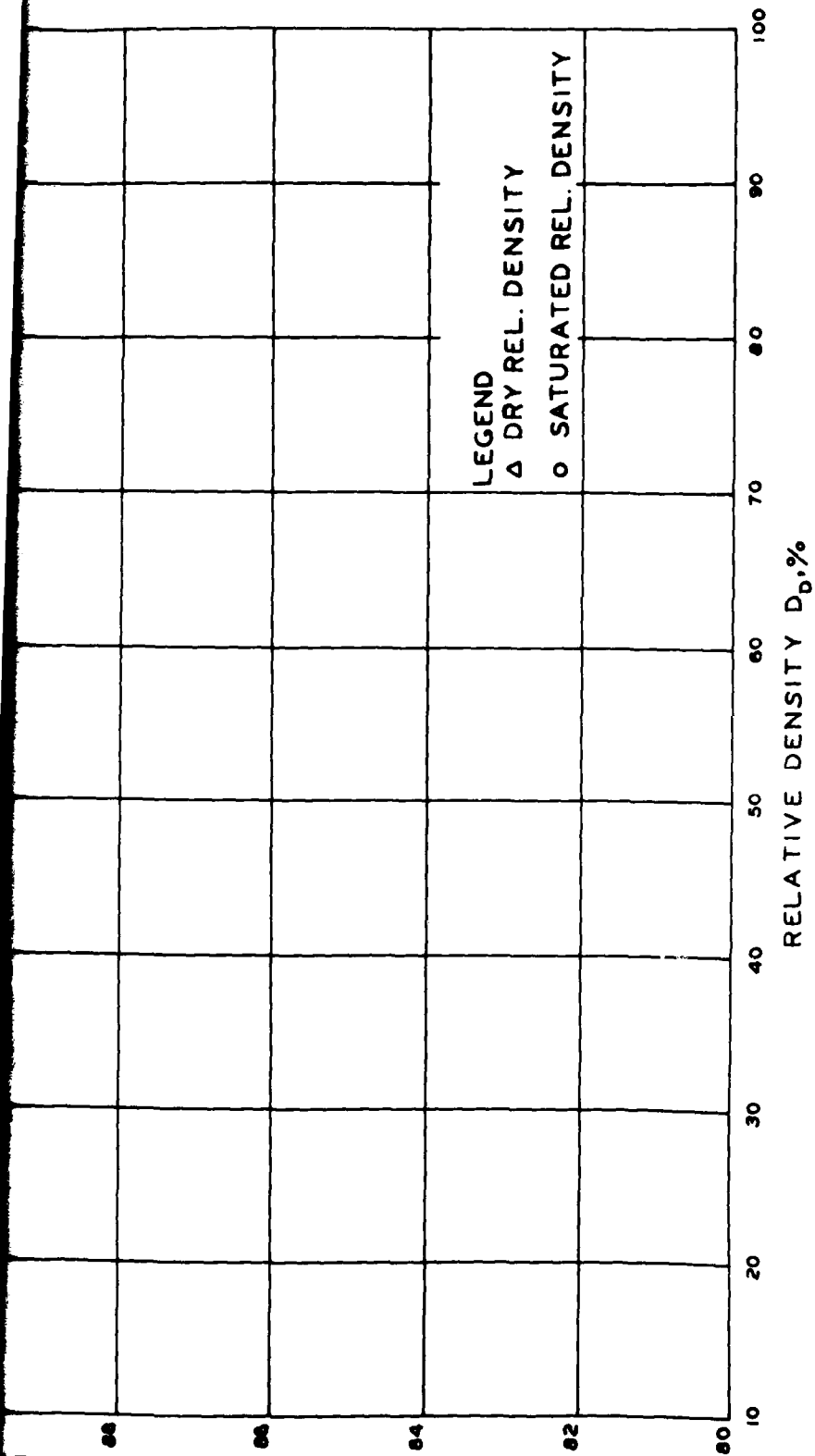
U.S. ENGINEER OFFICE, FORT PECK, MONT.

Submitted	Approval Recommended	Approved
Drawn by	Checked by	Transmitted with report
DNS	ERG	

Major Corps of Engineers
Civil Corps
Fort Peck, Montana

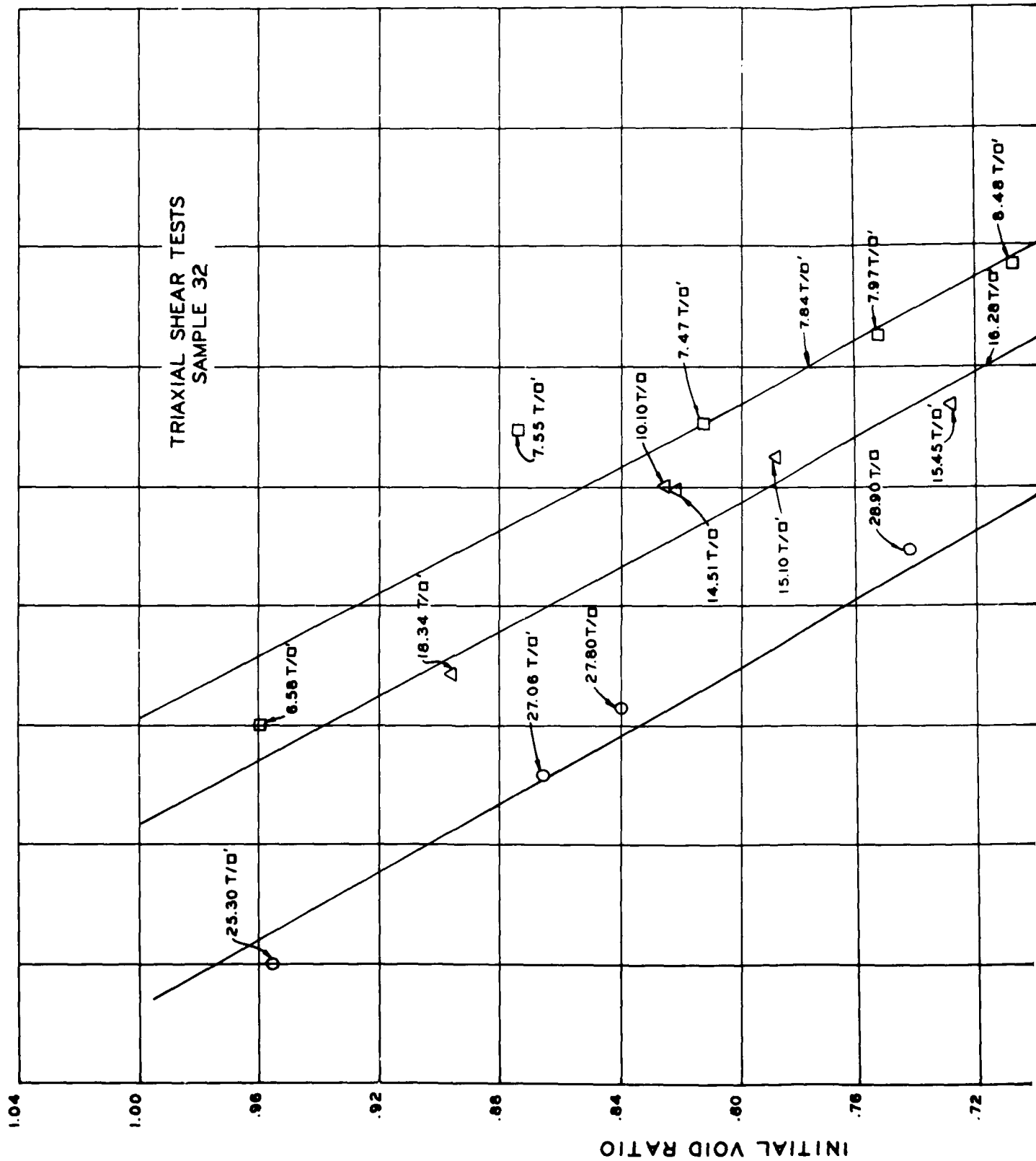


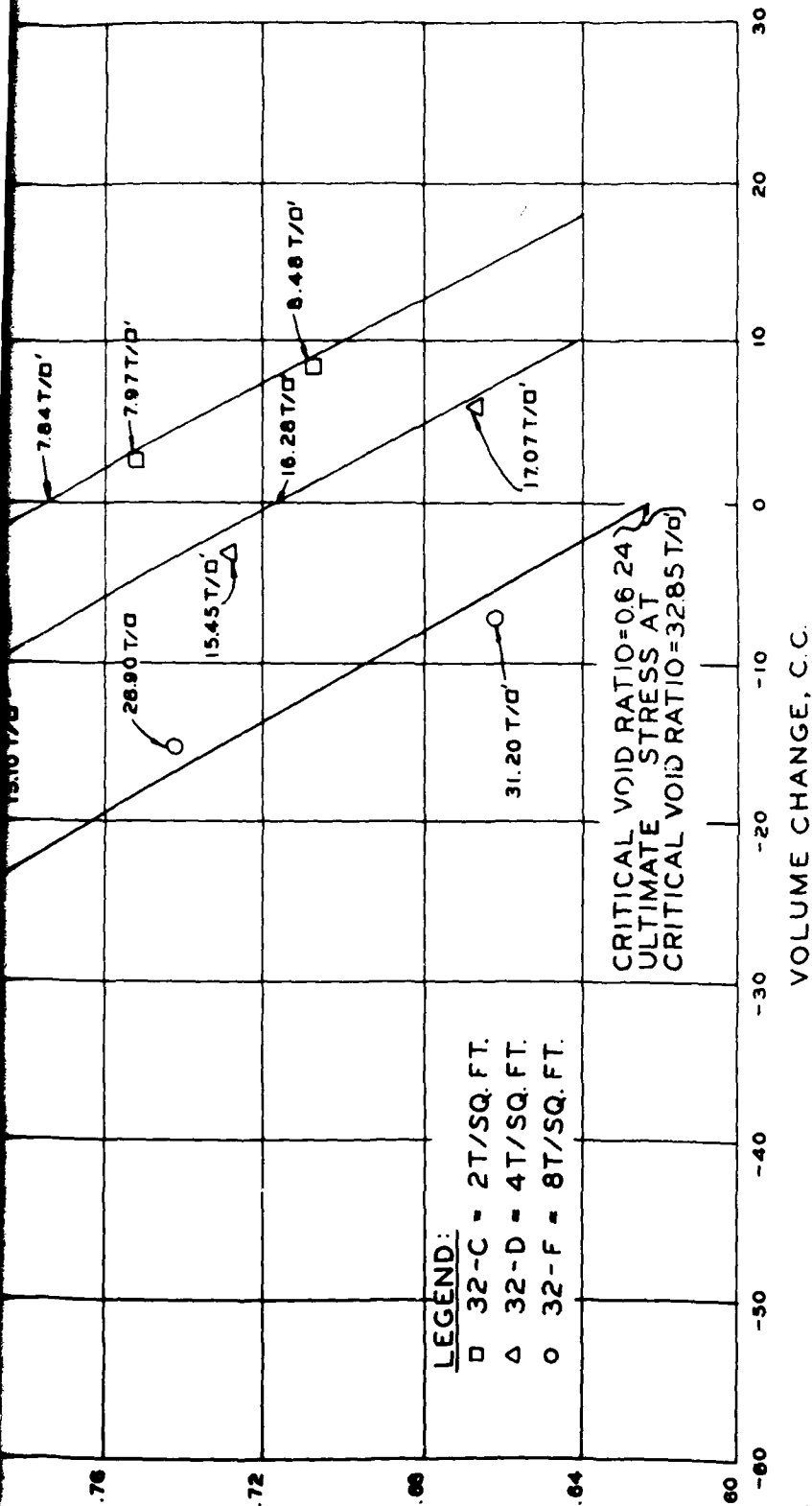
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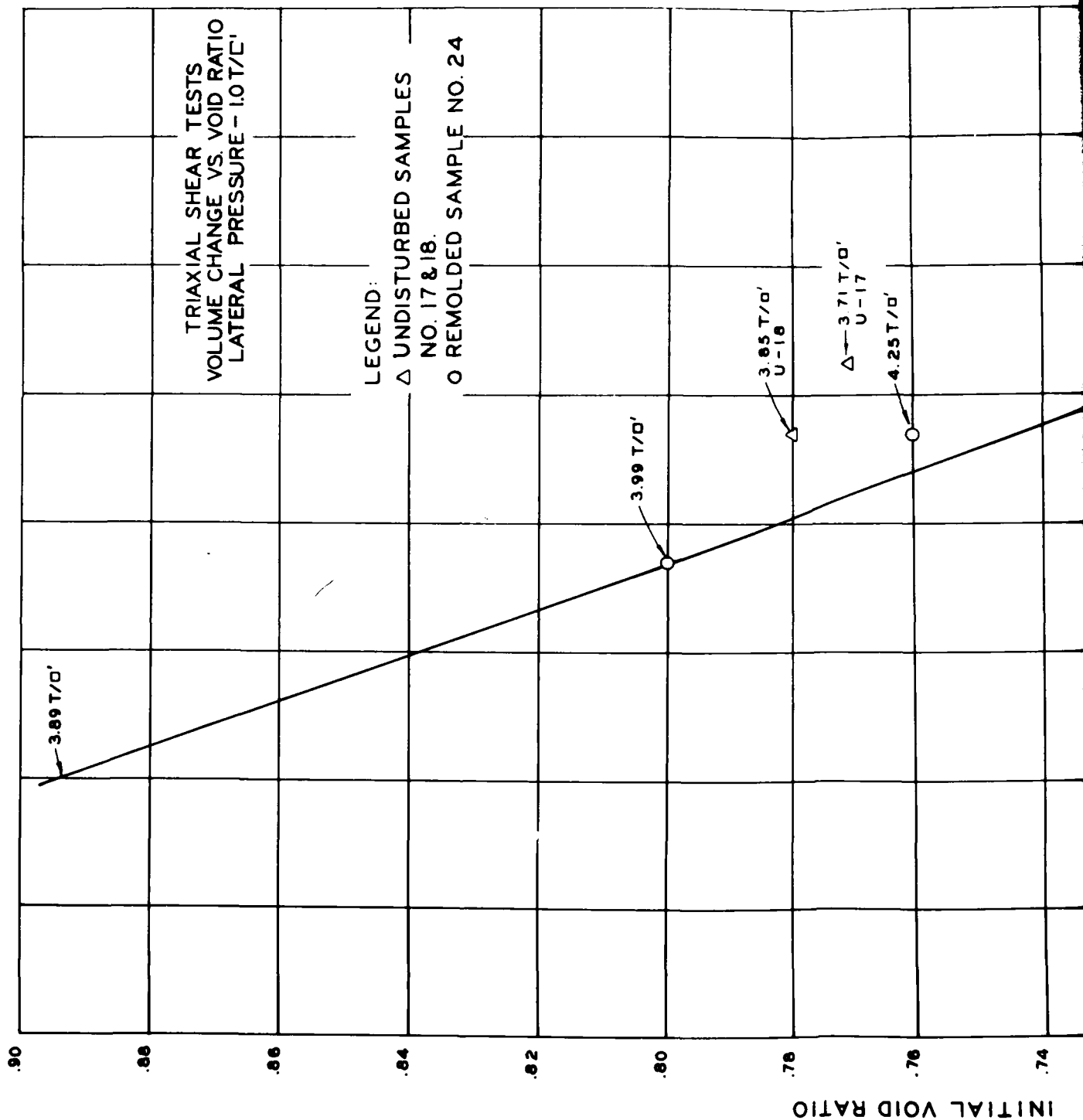
ITEM	RANGE OF VALUES
SPECIFIC GRAVITY	2.68 - 2.70
EFFECTIVE SIZE	0.11 - 0.24

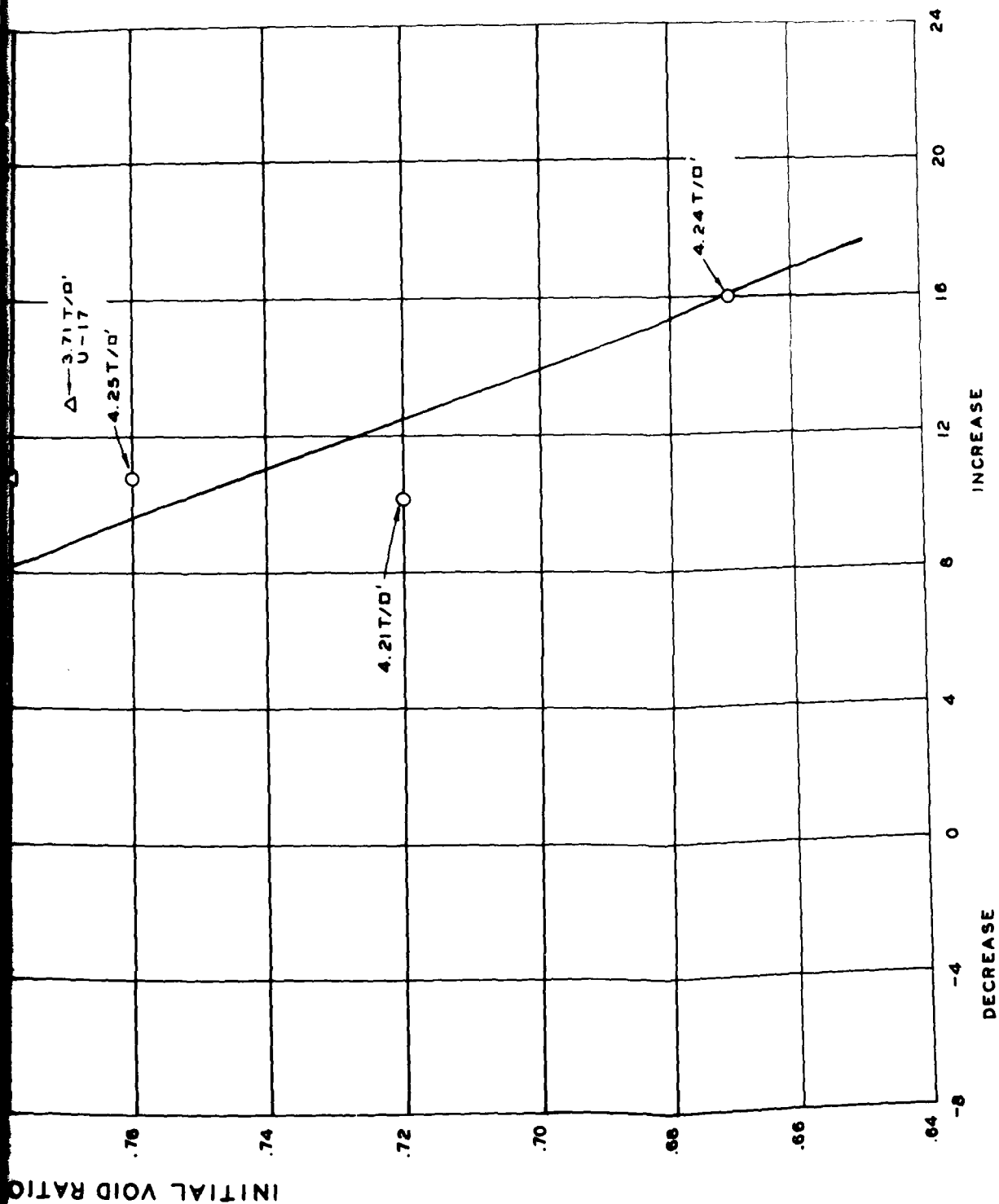
FORT PECK DAM
 RELATIVE DENSITY TESTS
 TRANSITION ZONE MATERIAL
 TEST PIT 5



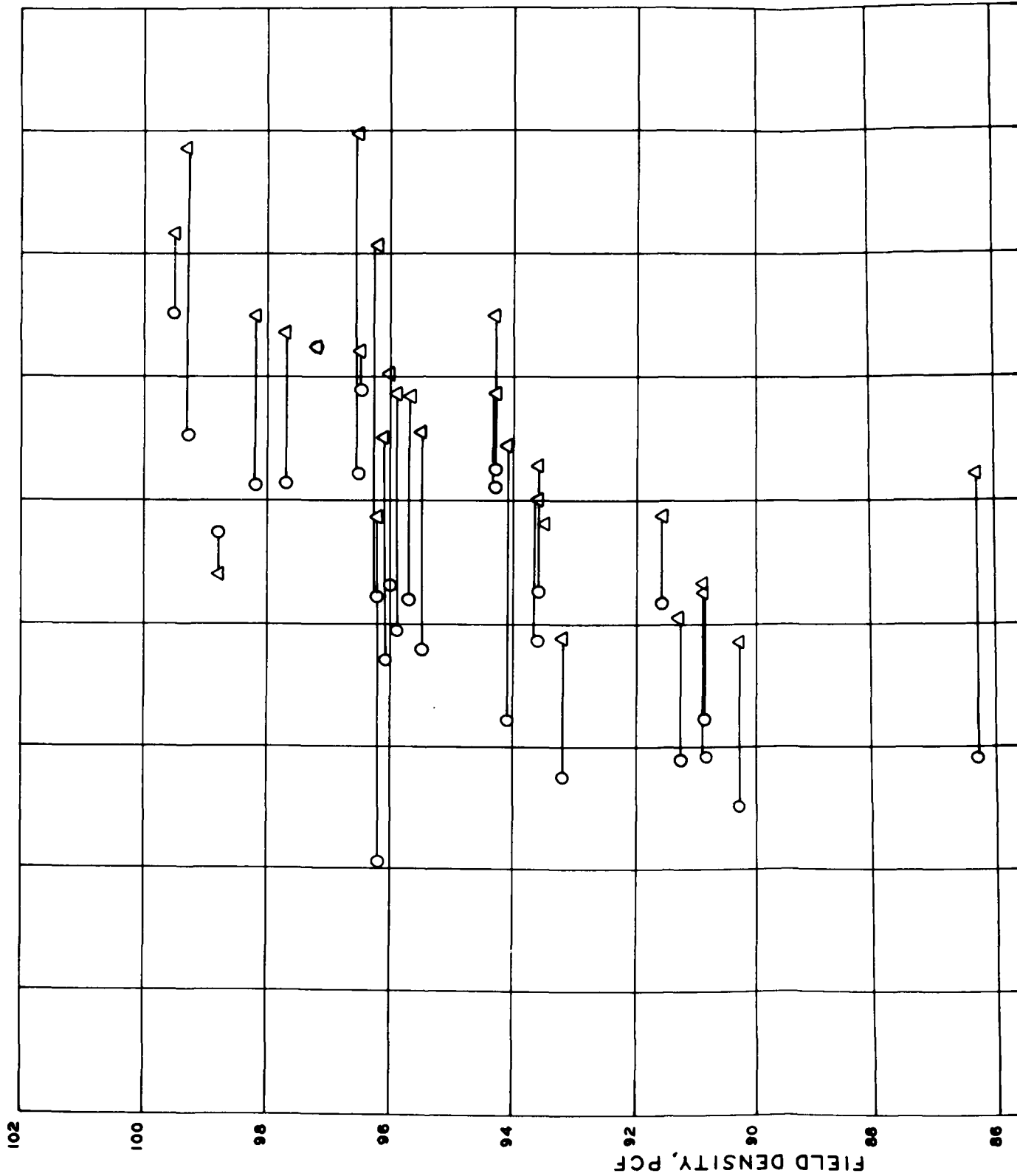


FORT PECK DAM
TYPICAL VOID RATIO CURVES FOR
REMOLDED SAMPLES
TRANSITION ZONE MATERIAL
TEST PIT 5

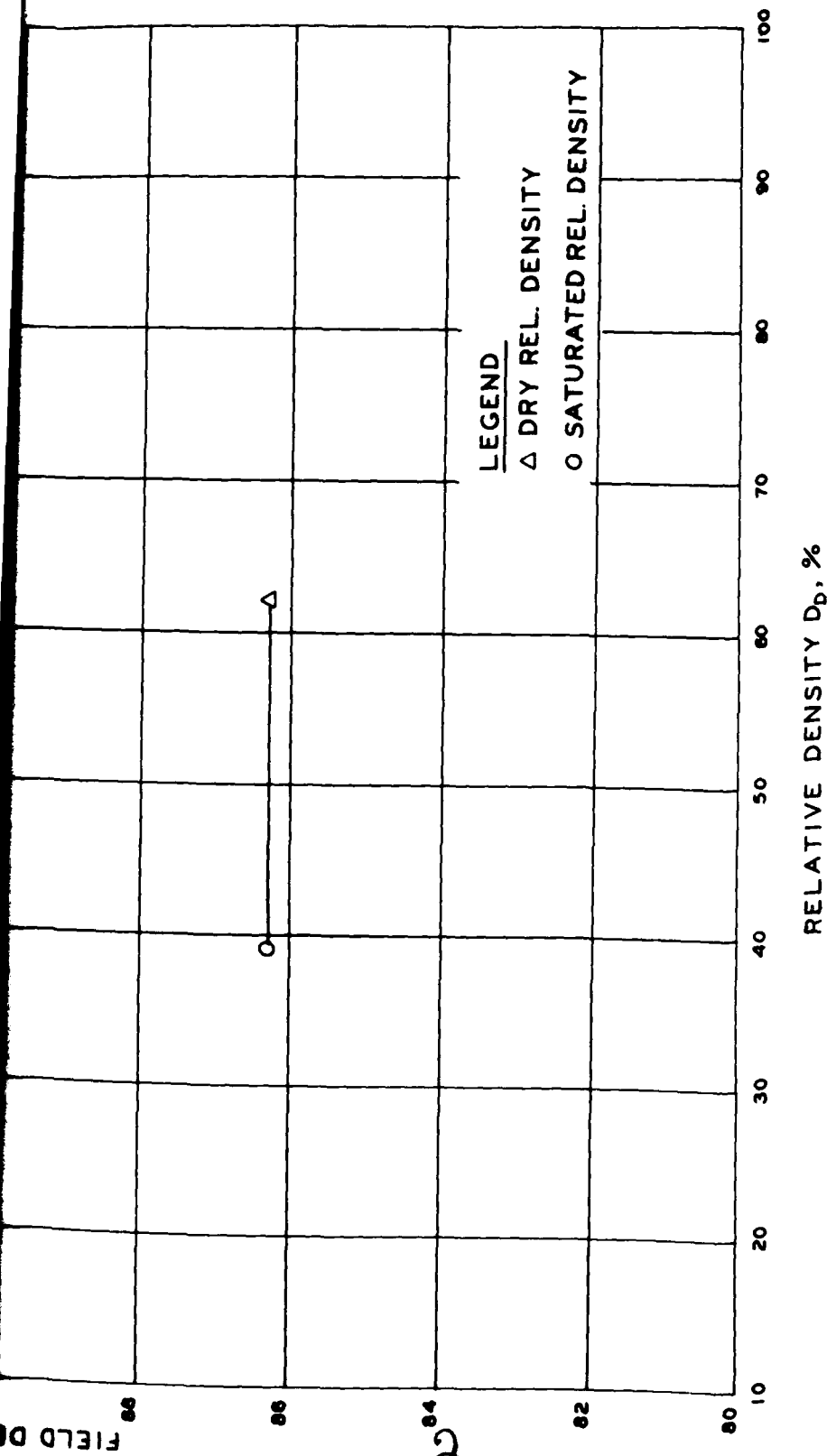




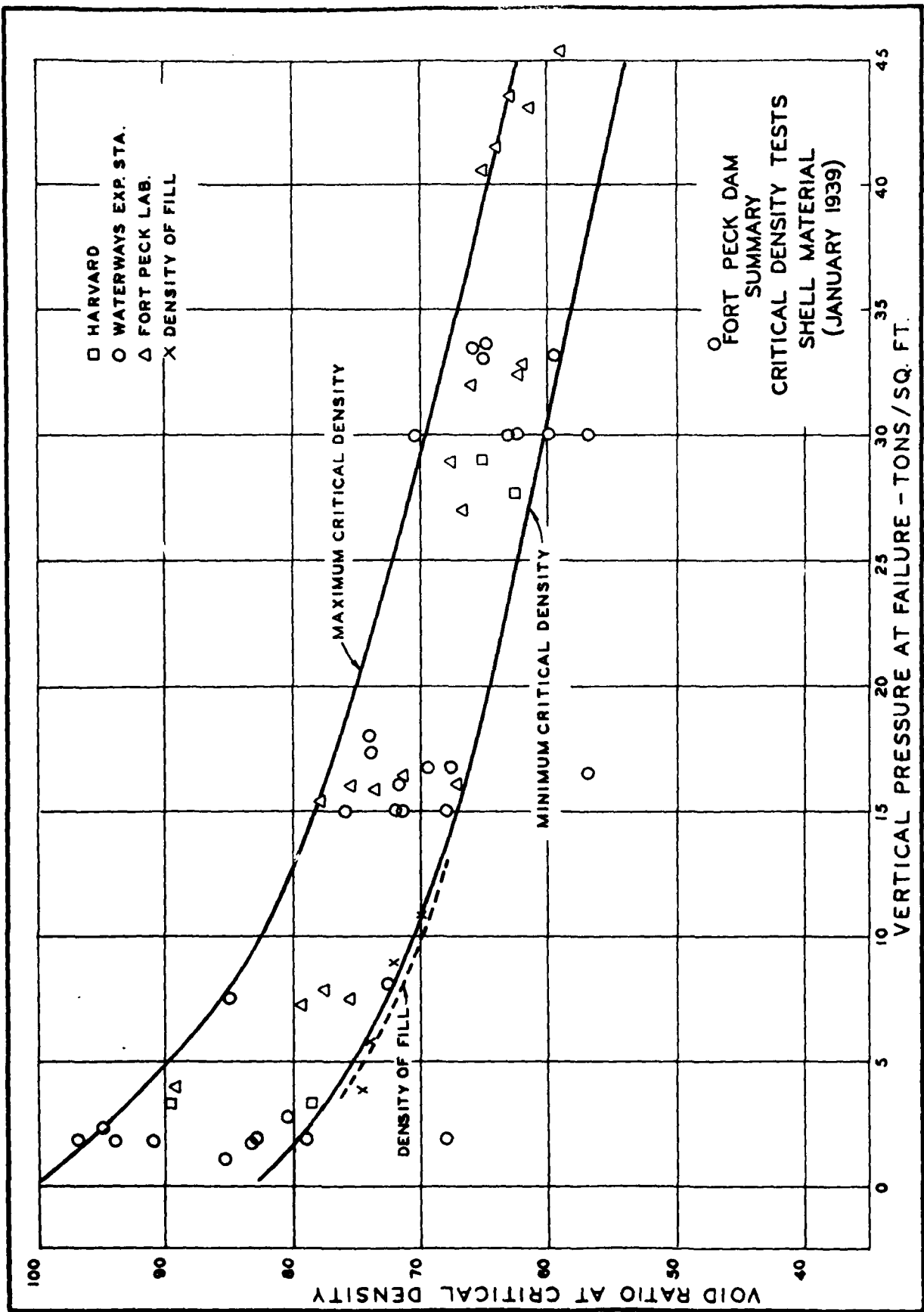
FORT PECK DAM
TYPICAL VOID RATIO CURVES FOR
UNDISTURBED AND REMOLDED SAMPLES
SHELL MATERIAL
TEST PIT 3



FORT PECK DAM
RELATIVE DENSITY TESTS
SHELL MATERIAL
TEST PIT 1



ITEM	RANGE OF VALUES
SPECIFIC GRAVITY	2.68 - 2.73
EFFECTIVE SIZE	0.11 - 0.21



**PETROGRAPHIC ANALYSIS OF SAND SAMPLE, FORT PECK,
NO. 1-A**

General Statement. The usual procedure in the petrographic analysis of a sand is to separate the sample into two fractions on the basis of the specific gravity of the constituents. The "light" fraction (sp. gr. less than 2.84) contains most of the material, but the "heavy" fraction (sp. gr. greater than 2.84) contains a greater variety of minerals. The percentage of each fraction is determined by weight, but the percentages of minerals and other constituents within each fraction is determined by counting grains, and hence is a frequency percentage, not a weight percentage. This procedure does not introduce any great error if the grains are fairly uniform in size, but in the present sample they are not. The grains range from fine gravel to clay size, so that frequency percentages determined on the whole sample would place an unwarranted emphasis on the minute grains, which are numerically abundant but constitute only a small percentage by weight of the whole sample. Since the various size grades of this sample show marked differences in composition, this factor is important, especially in the case of "light" fraction, which constitutes 97 percent of the sample. To eliminate this error it would be necessary to analyze each size grade, then multiply the percentage of each mineral in each size grade by the weight percentage of the size grade as determined by mechanical analysis (sieving). Totalling the products for each mineral would give its weight percentage in the sample as a whole, except for minor errors resulting from differences in the specific gravities of the minerals. This procedure, however, greatly increases the time required for an analysis, and hence would increase its cost considerably over the price quoted in the contract for analysis of this sample. I have therefore done the next best thing - analysed the "light" fraction of the two size grades which contain the greatest amount of the sample, the 35 to 48 mesh and 48 to 65 mesh grades. I have also included an analysis of the coarsest grade (.8 to 14 mesh) and an estimate of the composition of the finest material (passing the 200 mesh sieve). The "heavy" fraction constitutes such a small percentage (3 percent) of the whole sample that this procedure was not considered necessary.

Composition of the "light" fraction. The "light" fraction comprises 0.97 percent of the sample. The two size grades containing most of the material have the following composition:

Composition of the "light" fraction of the 35 to 48 and 48 to 65 mesh size grades.

(Frequency percentages on the basis of 100 percent)

	35-48 size grade	48-65 size grade
Rock grains:		
Chert	14	15
Shale	11	10
Sandstone and siltstone	6	3
Volcanic rocks	11	10
Granitic rocks	3	2
	45	40
Quartz	38	45
Feldspars:		
Plagioclase	10	8
Microcline	3	3
Orthoclase	2	2
Sandline	P	P
	15	13
Others:		
Muscovite	P	P
Chlorite	P	P
Calcite	P	1
Volcanic glass	1	P
Carbonaceous material (lignite) P		P
	2	2

NOTE - P = Present in amounts less than 1 percent.

The coarsest size grade (8-14 mesh), has the following composition: Rock grains 82 percent (chert 2 percent, shale 52 percent, sandstone and siltstone 26 percent, volcanic rocks 1 percent, granitic rocks 1 percent), quartz 10 percent, feldspars 5 percent, calcite 2 percent, volcanic glass and lignite in traces.

Percentages were not determined on the finest material (passing the 200 mesh), but inspection indicates that it has approximately the following composition: calcite 15-20 percent, clay mineral aggregates 15-20 percent, quartz and feldspar (together) 55-65 percent, others about 5 percent.

Composition of the "heavy" fraction. The "heavy" fraction constitutes 3 percent of the sample. About half of this material consists of the iron oxides, limonite and hematite. These occur as grains up to 3 mm in diameter, and their presence in such abundance so interfered with determination of the other

minerals
by boiling
for 10 m
gite is
in grains
other "h
percenta
its frequ

**Compositi
sample.**

Soluble
Chiefly
cent
and at
Insoluble
(Frequ
Opaque M
limonite
Leucos
Magne
Pyrite
Amphibole
Actinolite
Basalt
Blue-
Common
Micas:
Biotite
Muscovite
Pyroxene
Augite
diorite
Hypersthene

It was found necessary to remove them the "heavy fraction in 50 percent HCl res. Of the material not removed, auriferous far the most common mineral, occurring to 3 mm in length. Since most of the minerals are much smaller, the weight of augite is considerably higher than percentage.

Composition of the "heavy" fraction from the whole sample, continued.

percent HCl 50% by wt.
 Monite and hematite, with 1 to 2 percent the carbonates dolomite and siderite, 1 percent apatite.
 50 percent HCl.
 percentages on basis of 100 percent.)

Ornblende
 hornblende
 blende
 including some aegirine-augite and

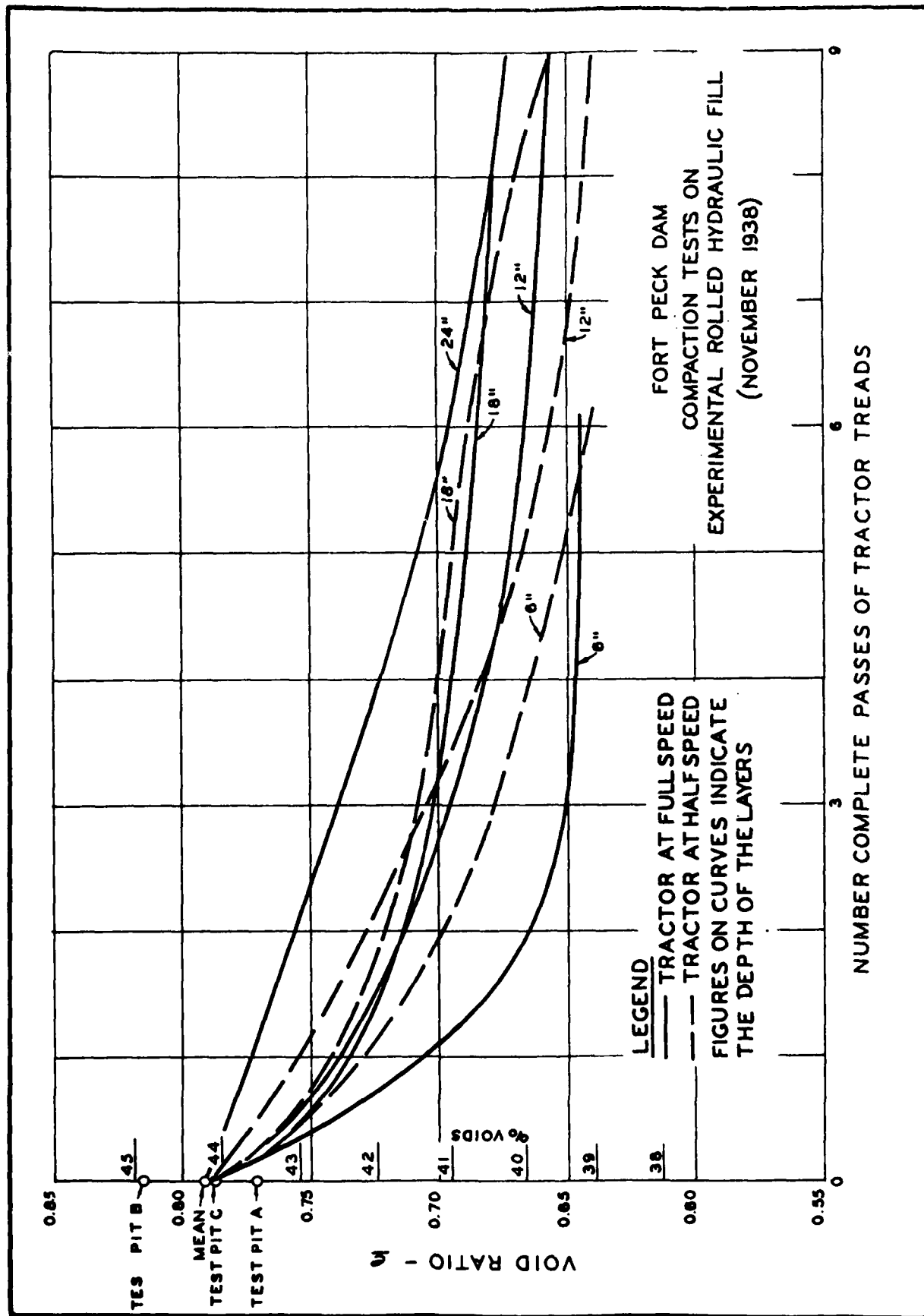
Composition of the "heavy" fraction from the whole sample, continued.

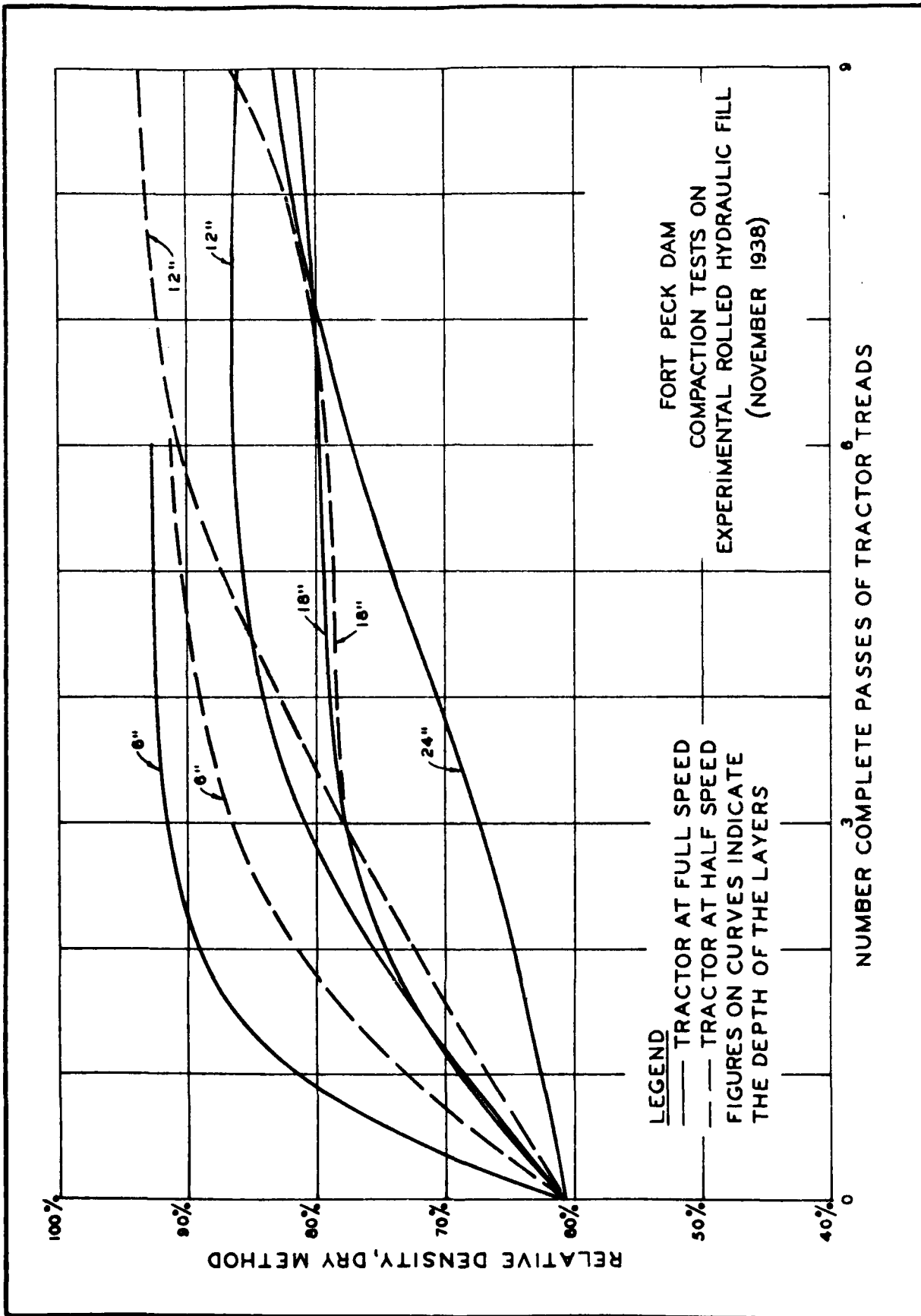
Others:	
Allanite	P
Barite	8
Collophane	P
Epidote	9
Garnet	6
Rutile	P
Staurolite	P
Titanite	2
Tourmaline	P
Zircon	3
Zoisite	P

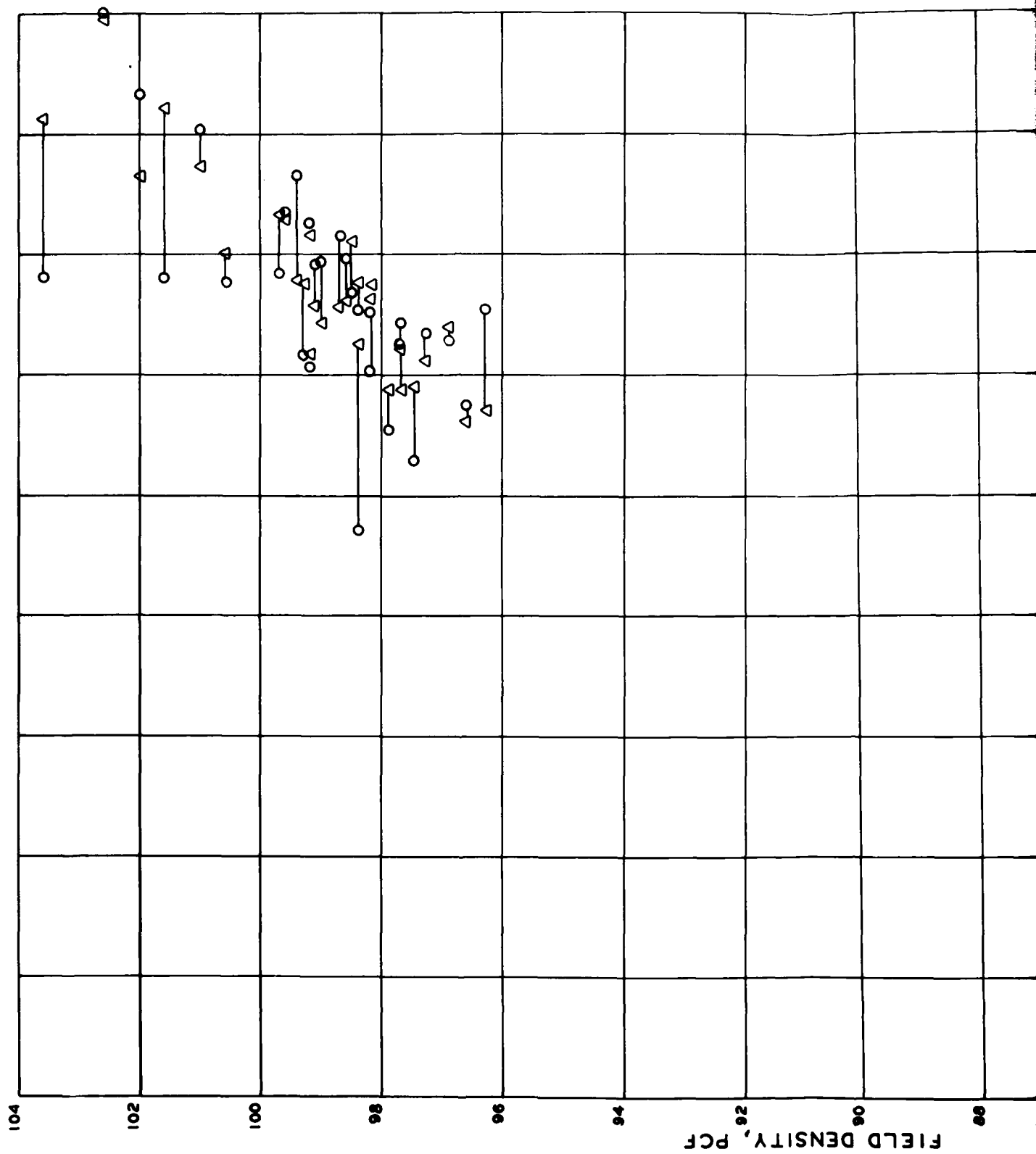
Note - P = Present in amounts less than 1 percent.

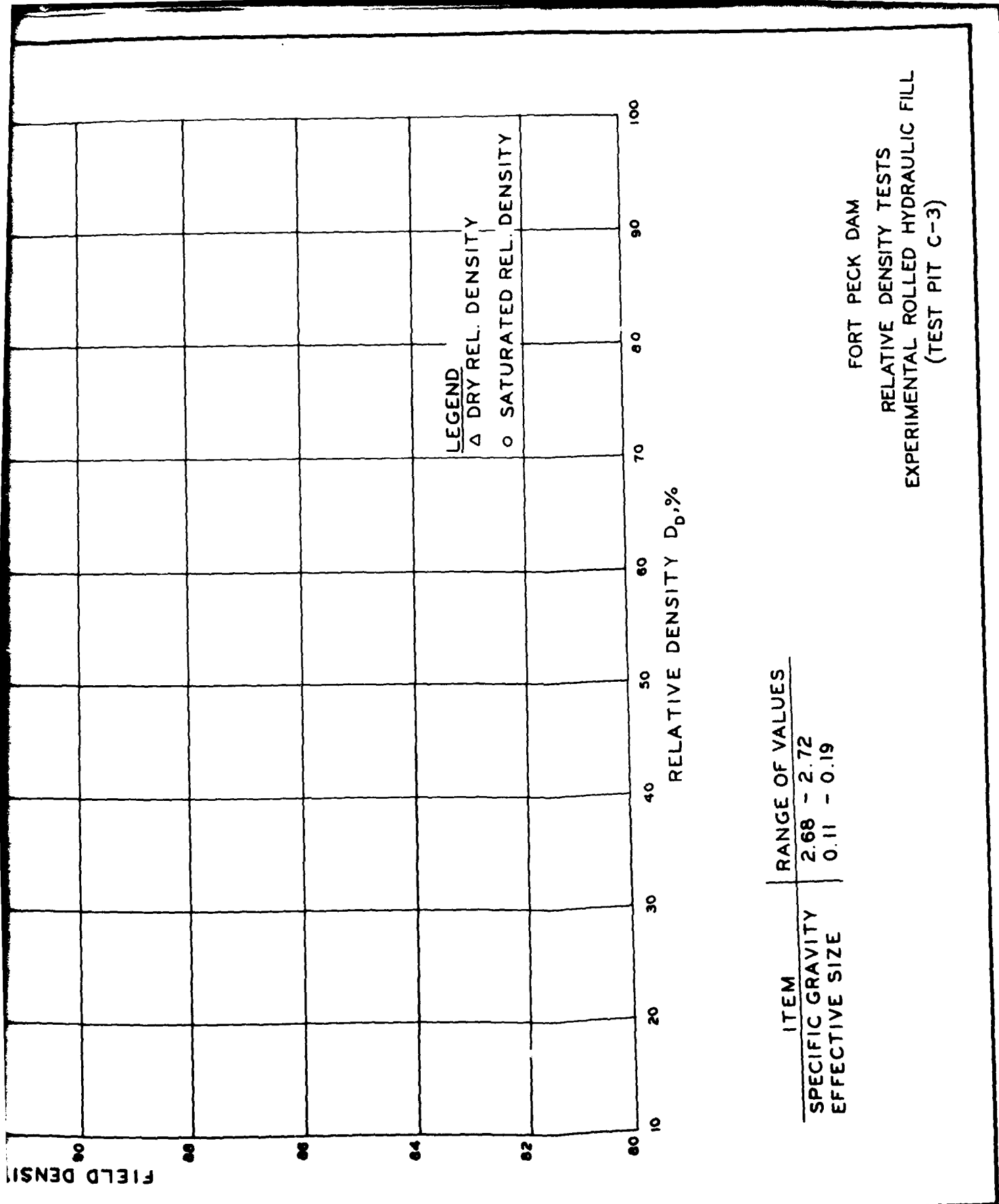
Conclusions. The abundance of shale fragments in the coarser size grades indicates contribution of this material from a nearby source, as these fragments could not withstand prolonged transportation. The other elements in the sample have been derived chiefly from intermediate to basic volcanic rocks (andesites and basalts), as indicated by the abundance of augite as well as of fragments of these rocks, and from previously formed sedimentary rocks. Other igneous rocks, particularly granitic types, have contributed some material, while metamorphic rock types furnished very little.

[s] R. DANA RUSSELL.



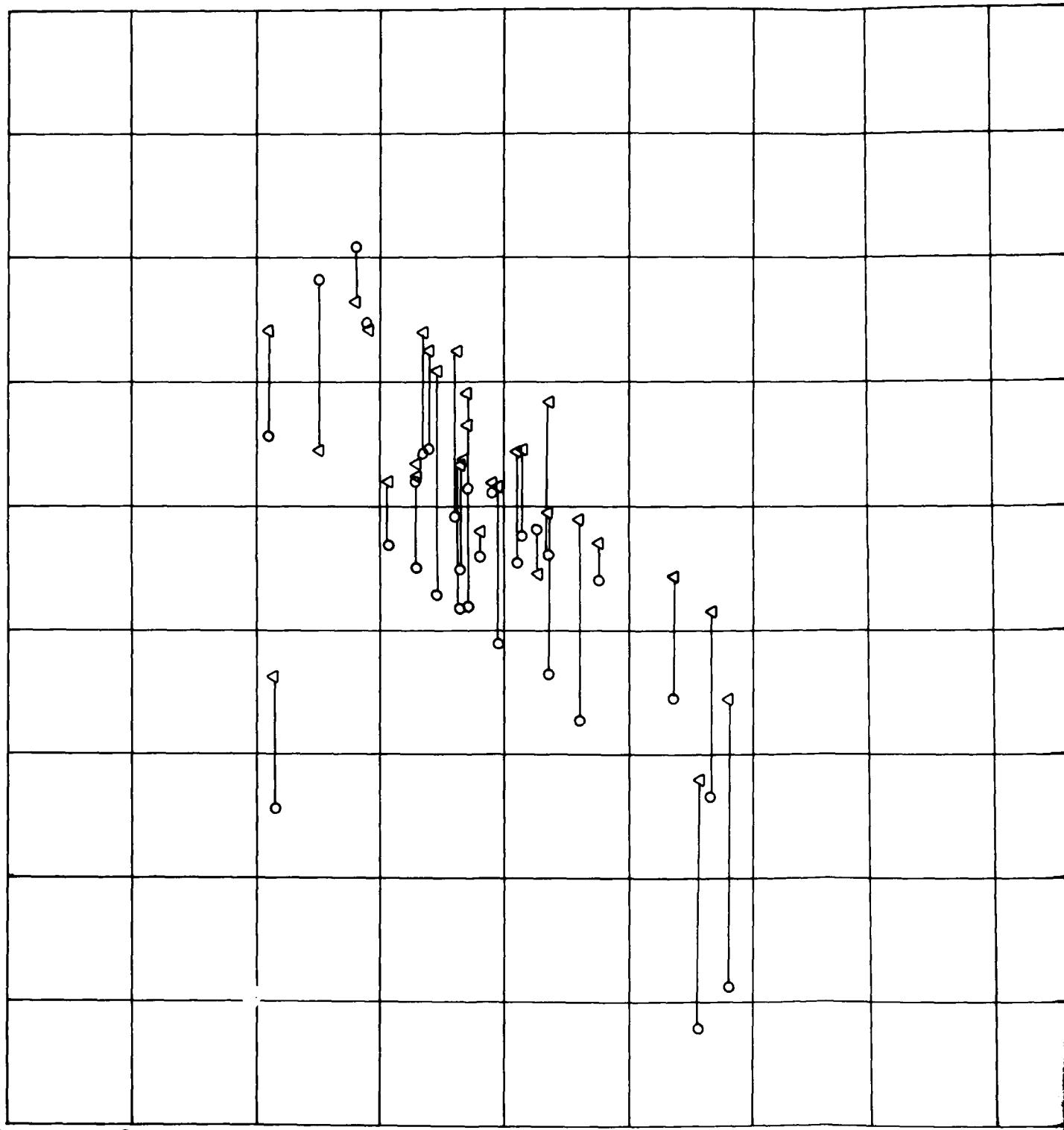


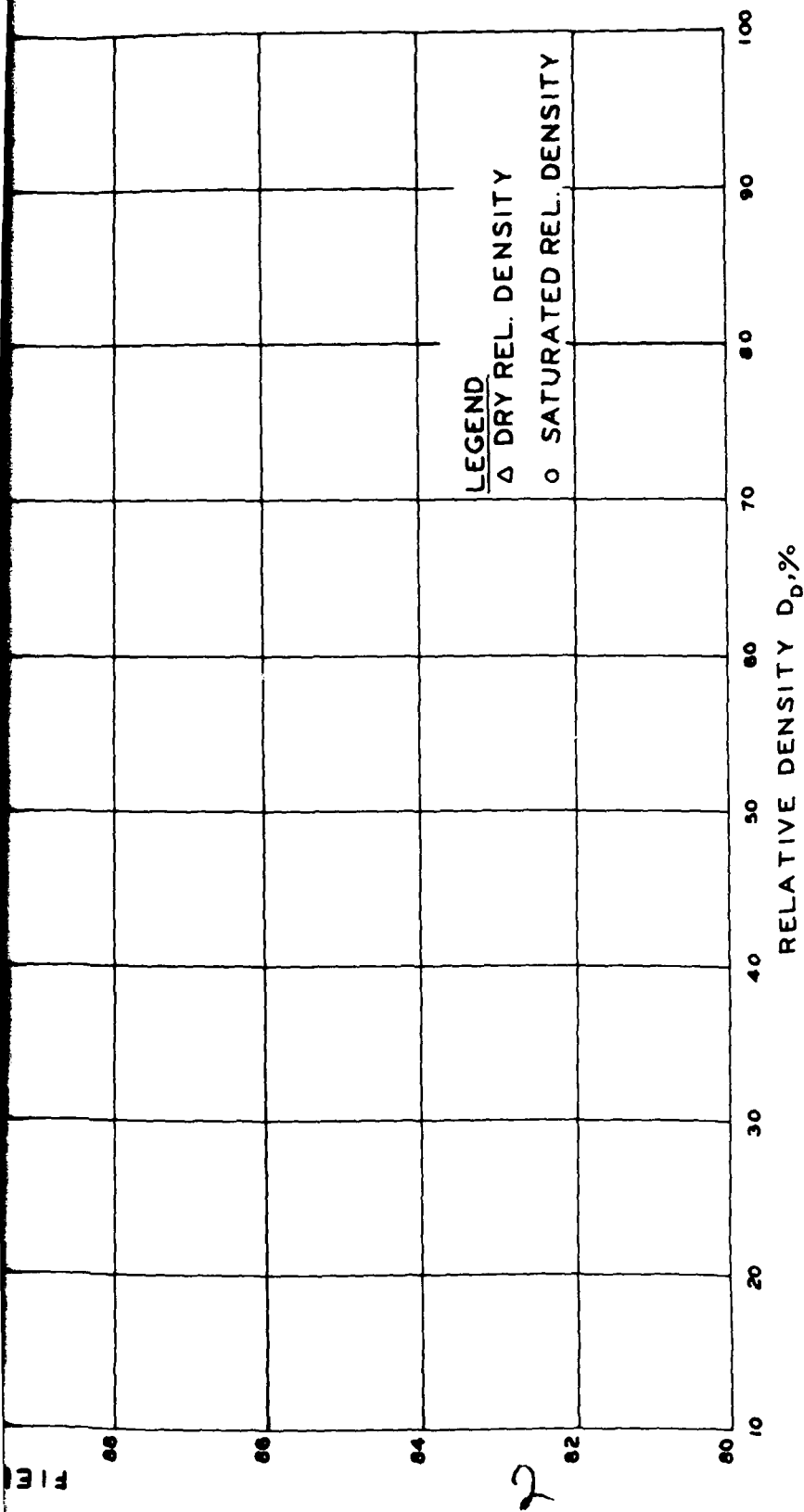




ITEM	RANGE OF VALUES
SPECIFIC GRAVITY	2.68 - 2.72
EFFECTIVE SIZE	0.11 - 0.19

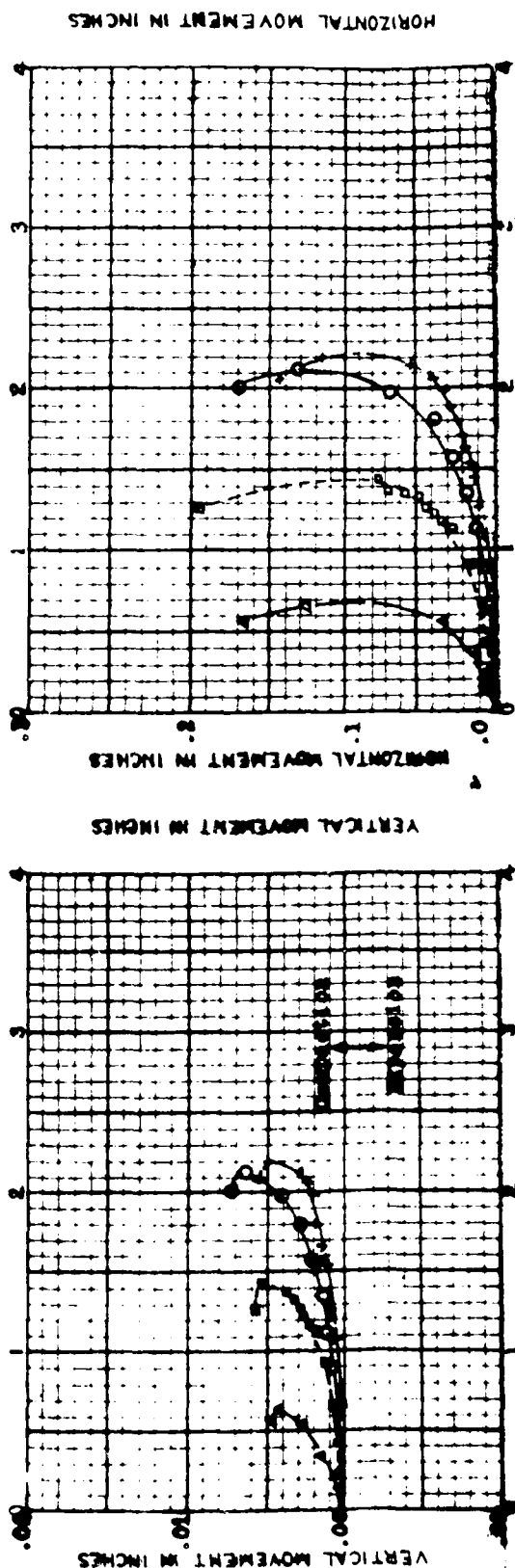
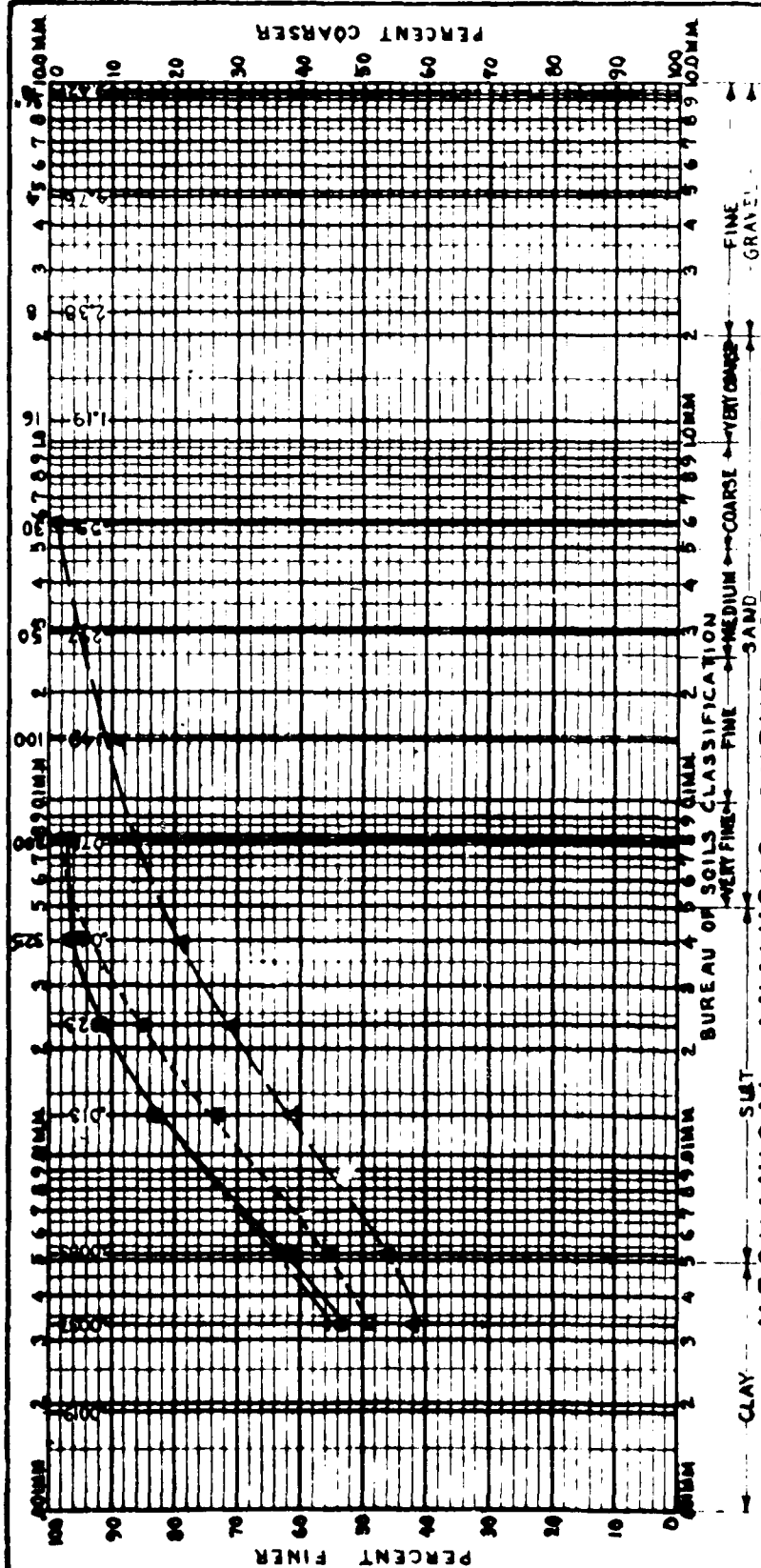
FORT PECK DAM
RELATIVE DENSITY TESTS
EXPERIMENTAL ROLLED HYDRAULIC FILL
(TEST PIT C-3)





ITEM	RANGE OF VALUES
SPECIFIC GRAVITY	2.67 - 2.71
EFFECTIVE SIZE	0.13 - 0.21

FORT PECK DAM
 RELATIVE DENSITY TESTS
 EXPERIMENTAL ROLLED HYDRAULIC FILL
 (TEST PIT C-X)



VERTICAL AND HORIZONTAL MOVEMENT CURVES DURING TEST

HORIZONTAL PRESSURE IN TONS/SQ. FT.

HORIZONTAL PRESSURE IN TONS/SQ. FT.

PERCENT DRY WEIGHT

PERCENT DRY WEIGHT

SHEARING RESISTANCE TONS/SQ. FT.

SHEARING RESISTANCE TONS/SQ. FT.

VOID RATIO BEFORE AND AFTER TEST

Values typed above and below plotted shearing resistance of ultimate failure denote void ratio before and after shear tests respectively.

VOID RATIO COMPUTED ASSUMING SAMPLE SATURATED

LEGEND-M.C.

Before Test ○

After Test △

Undisturbed □

LEGEND

△ --- 5 T/ Sq. Ft.

□ --- 5 T/ Sq. Ft.

○ --- 7 T/ Sq. Ft.

+ --- 9 T/ Sq. Ft.

● ---

NORMAL LOAD-SHEARING RESISTANCE CURVE

Notes: Undisturbed Samples

Consolidated Shearing Tests

Delta Loading

Elevation 2053.0-2050.5

Depth 46.7-47.5

Gross Sectional Area of Sample -16.00 sq. in.

Initial Thickness 0.75 inch

Sample Immersed in Water during Test

Station ON 27416 Range 20/25

Shearing Resistance
Cohesion (bars) 0.210
C = Cohesion = 0.00 T/ Sq. Ft.

φ = 11° 30'

MISSOURI RIVER IMPROVEMENT

FORT PECK DAM

SLIDE INVESTIGATION

SHEAR TESTS SURFACE CLAY

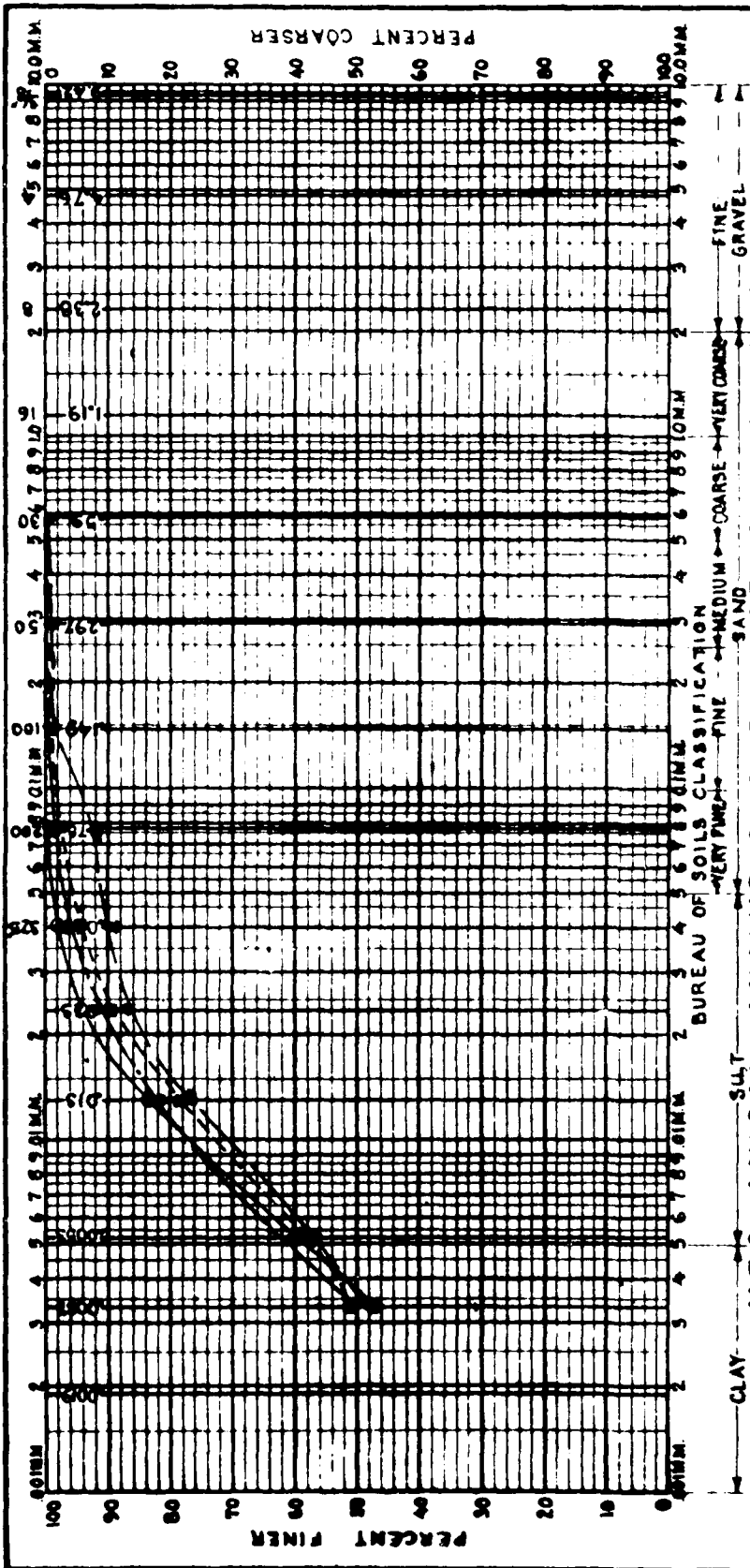
HOLE C-11 SAMPLE # 3.

APPROVED FOR RELEASE BY THE MISSOURI RIVER COMMISSION

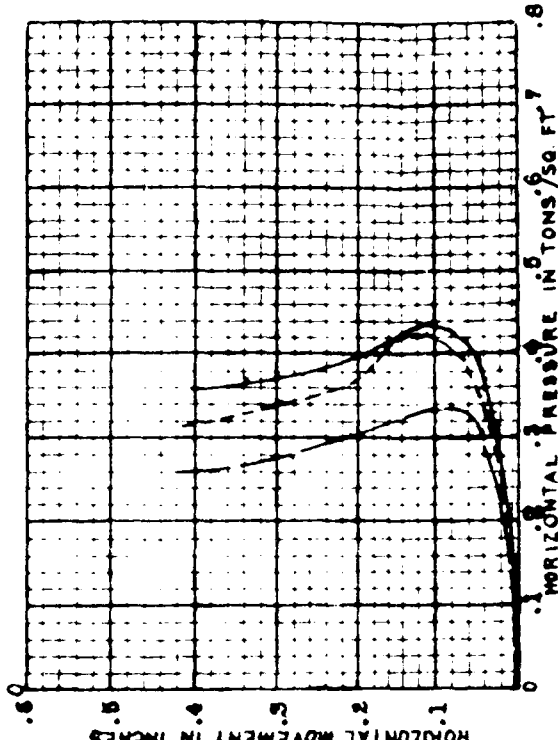
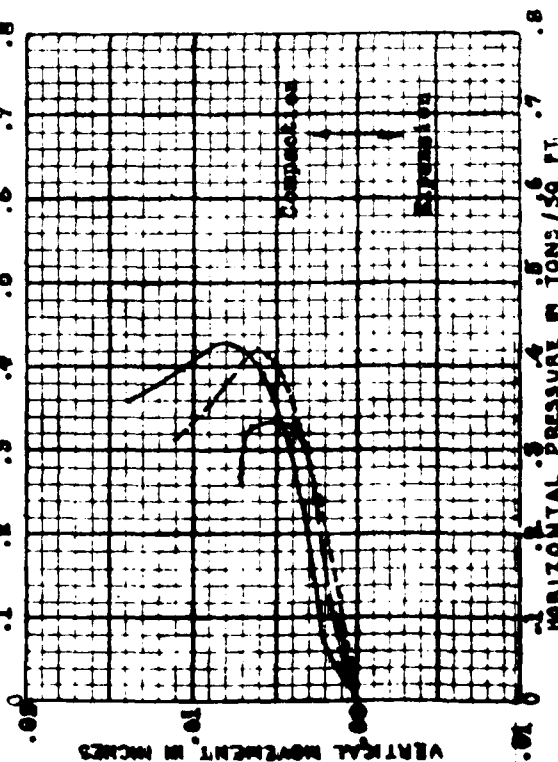
APPROVED FOR RELEASE BY THE MISSOURI RIVER COMMISSION

APPROVED FOR RELEASE BY THE MISSOURI RIVER COMMISSION

APPROVED FOR RELEASE BY THE MISSOURI RIVER COMMISSION



MECHANICAL ANALYSIS CURVE OF SOIL TESTED



HORIZONTAL

HORIZONTAL

VERTICAL

VERTICAL

HORIZONTAL PRESSURE IN TONS/SQ. FT. .8
HORIZONTAL PRESSURE IN TONS/SQ. FT. .7
HORIZONTAL PRESSURE IN TONS/SQ. FT. .6
HORIZONTAL PRESSURE IN TONS/SQ. FT. .5
HORIZONTAL PRESSURE IN TONS/SQ. FT. .4
HORIZONTAL PRESSURE IN TONS/SQ. FT. .3
HORIZONTAL PRESSURE IN TONS/SQ. FT. .2
HORIZONTAL PRESSURE IN TONS/SQ. FT. .1

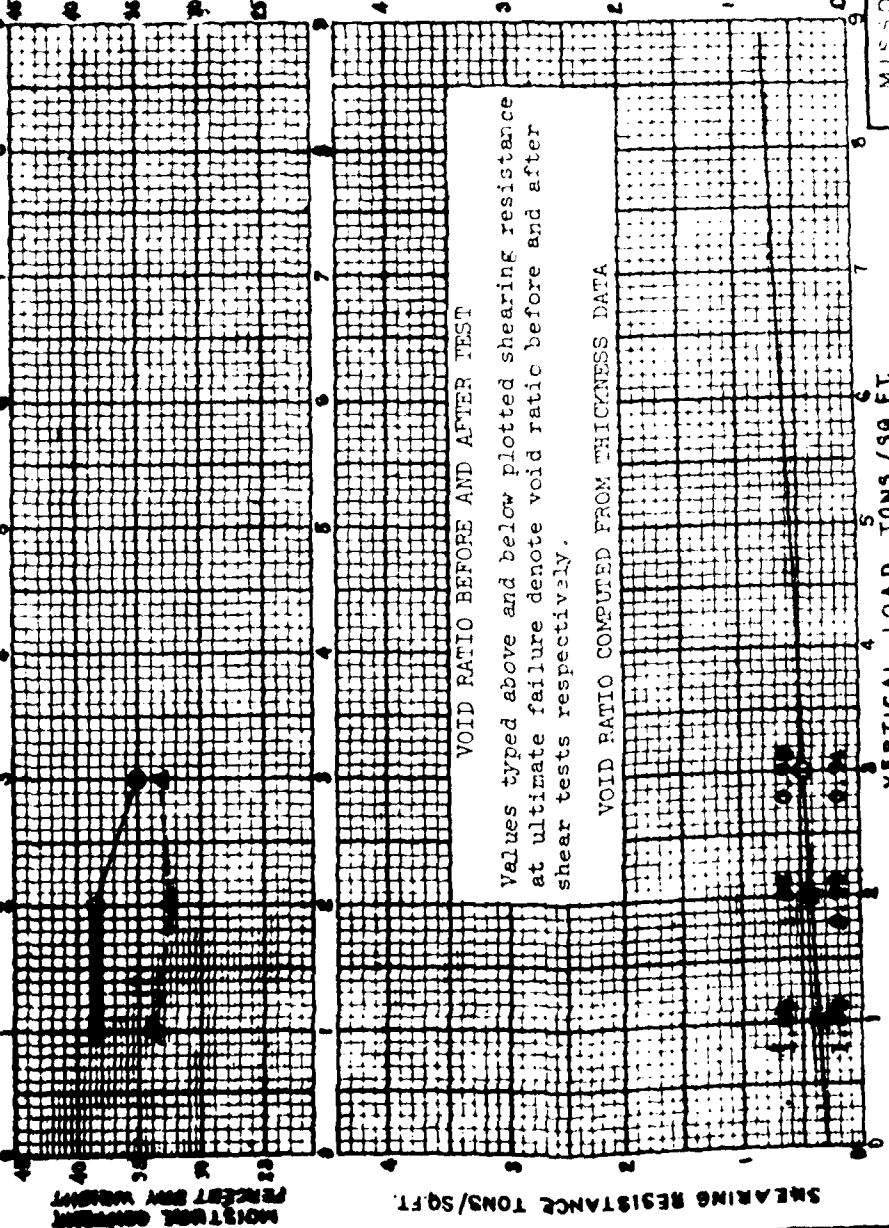
VERTICAL AND HORIZONTAL MOVEMENT CURVES DURING TEST

LEGEND-M.C.	
Before Test	○ Undist.
After Test	△

MOISTURE CONTENT PERCENT DRY WEIGHT

LEGEND	
△	1 T/24 ft.
□	2 T/24 ft.
○	3 T/24 ft.
+	4 T/24 ft.
●	5 T/24 ft.
○	Average
○	M.A. Grading & tests
○	Series # 1

SHEARING RESISTANCE TONS/SQ. FT.



VOID RATIO BEFORE AND AFTER TEST
Values typed above and below plotted shearing resistance at ultimate failure denote void ratio before and after shear tests respectively.

VOID RATIO COMPUTED FROM THICKNESS DATA

NORMAL LOAD-SHEARING RESISTANCE CURVE

Notes: Undisturbed Sample

Quick Shear Tests

Constant Strain Grading

Elevation 2052.1-2052.5

Depth 45.5-46.5

Area of Sample 18.00 sq. ft.

Initial Moisture Content 20.5%

Water Content at Failure 22.5%

Shearing Resistance
Cohesion (c) = 0.051
c = 2.855

c = Cohesion = 0.30 T/sq. ft.

MISSOURI RIVER IMPROVEMENT
FORT PECK DAM

SLIDE INVESTIGATION

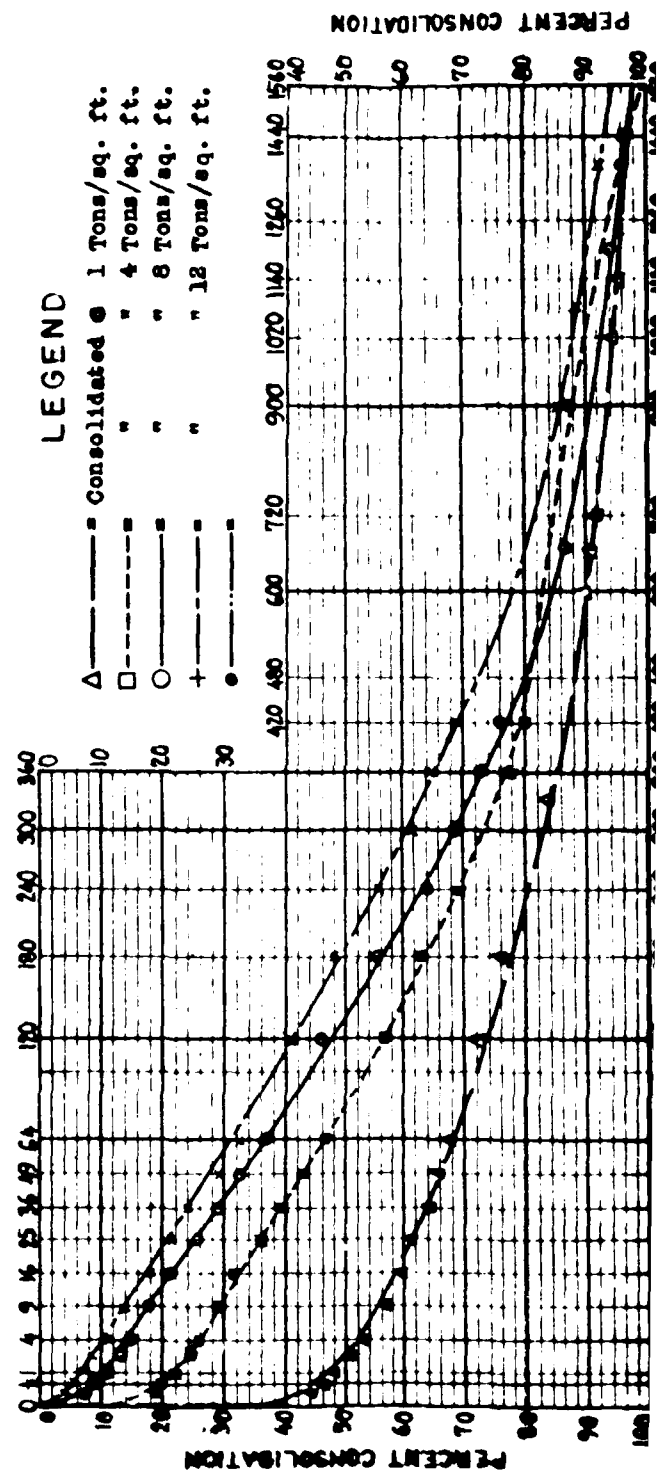
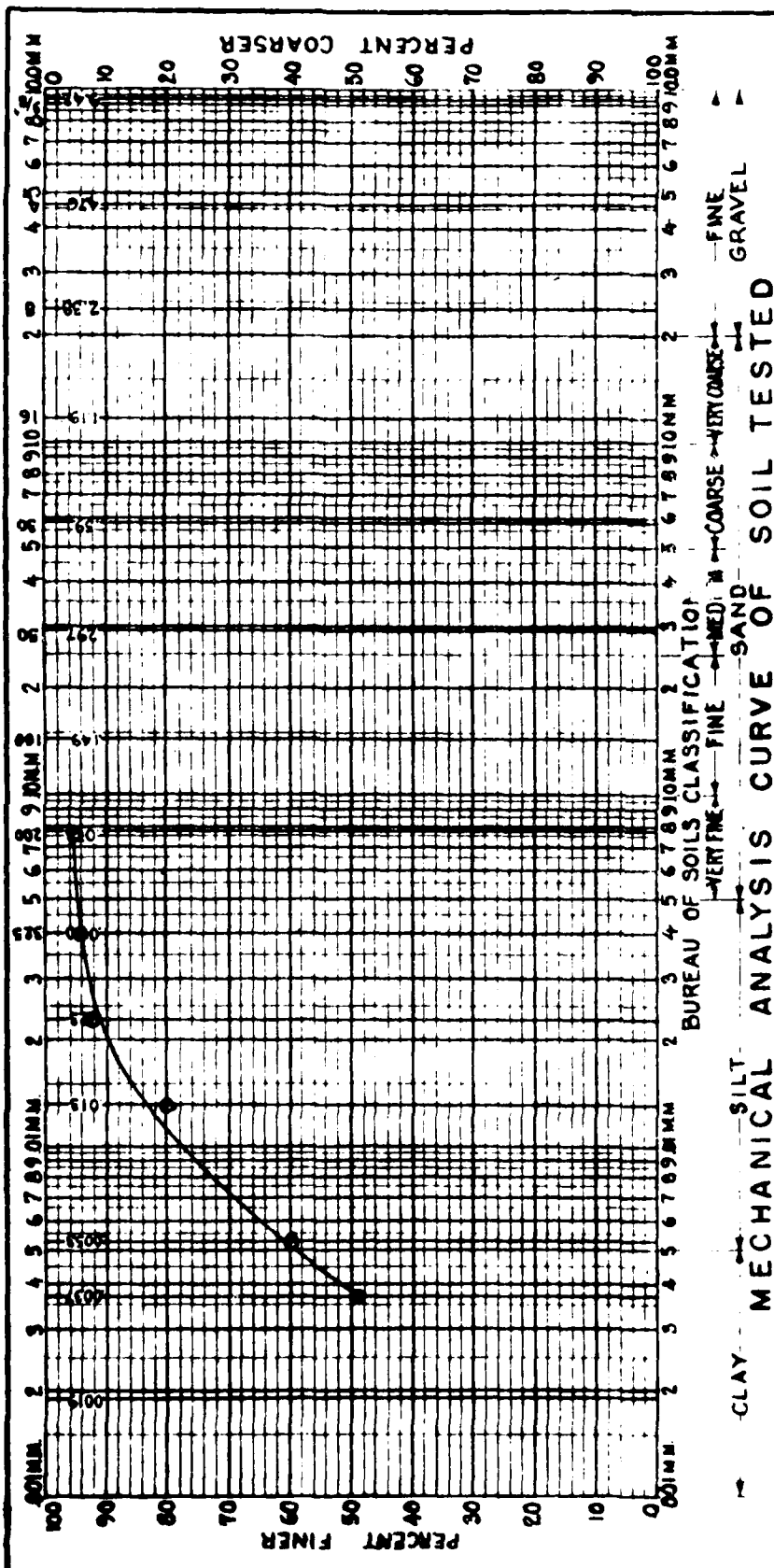
Quick Shear Tests-Series # 3

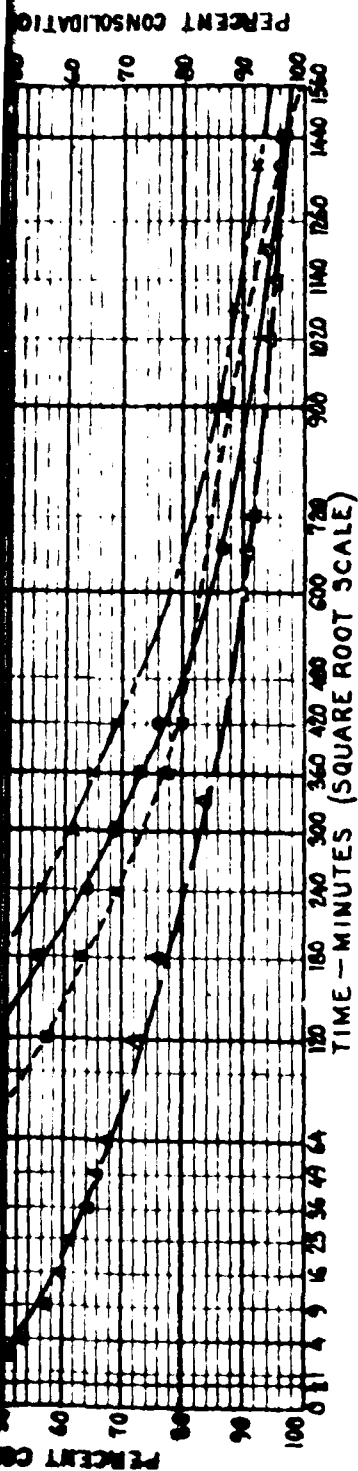
SURFACE CLAY-HOLEC-11 Sample # 2

APPROVED FOR SUBMITTAL
Approved Recommended Approved

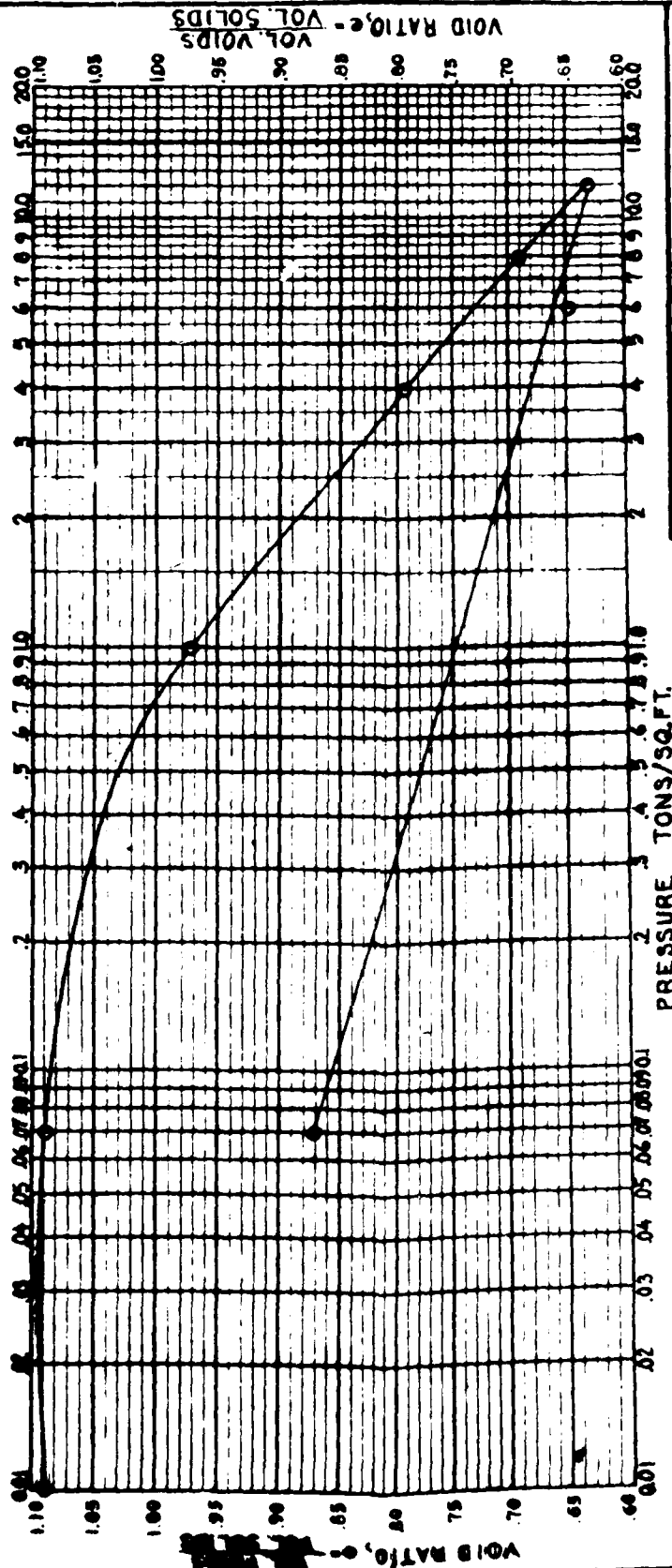
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TIME-PERCENT CONSOLIDATION CURVES



PRESSURE-VOID RATIO CURVE

Estimated Previous Consolidation - Tons/Sq. Ft.

Undisturbed Sample Immersed in Water during test
 Station 27 / 16, Range 22 / 22-U
 Initial Thickness 1.00 inch
 Cross Sectional Area 24.80 sq. in.
 Elevation - 2051.8 - Depth 46.5'

VERTICAL LOAD TONS/SQ. FT.	COMPACTION PERCENT
0.00	0.00
0.07	0.00
1.00	5.58
4.00	14.10
8.00	19.11
12.00	21.75
16.00	21.92
20.07	10.17

* Total compaction in percent of original height of sample

MISSOURI RIVER IMPROVEMENT
 NAVIGATION, FLOOD CONTROL, POWER, IRRIGATION

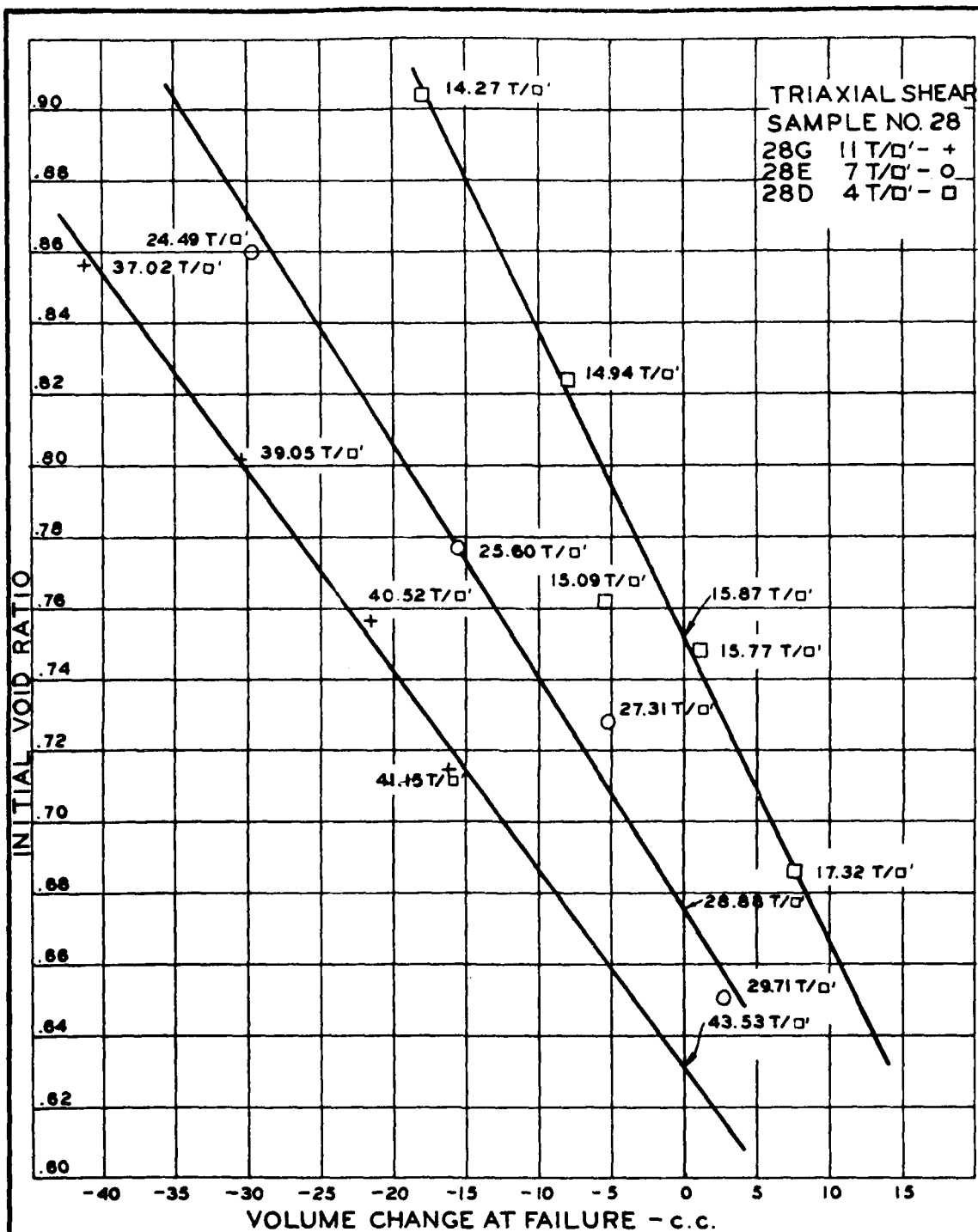
FORT PECK DAM

SLIDE INVESTIGATION
 CONSOLIDATION TEST SURFACE CLAY
 HOLE C-11, SAMPLE NO. 3

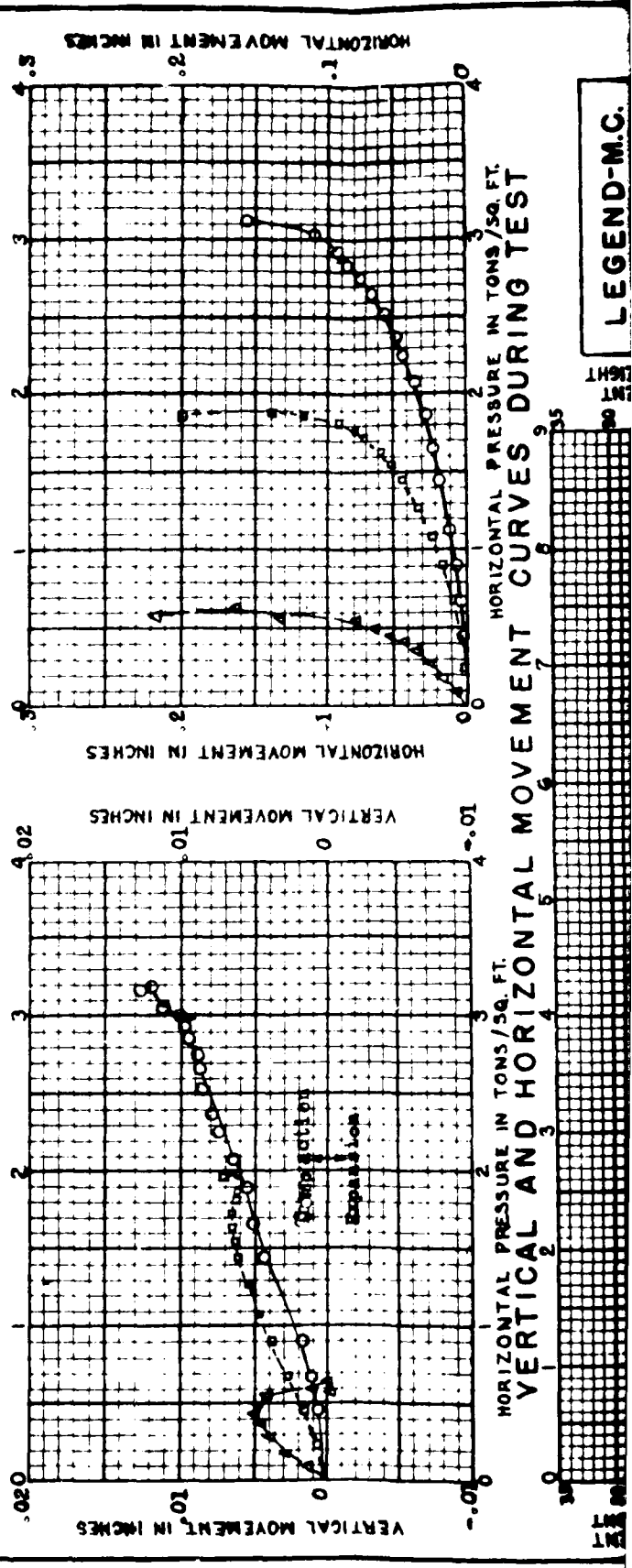
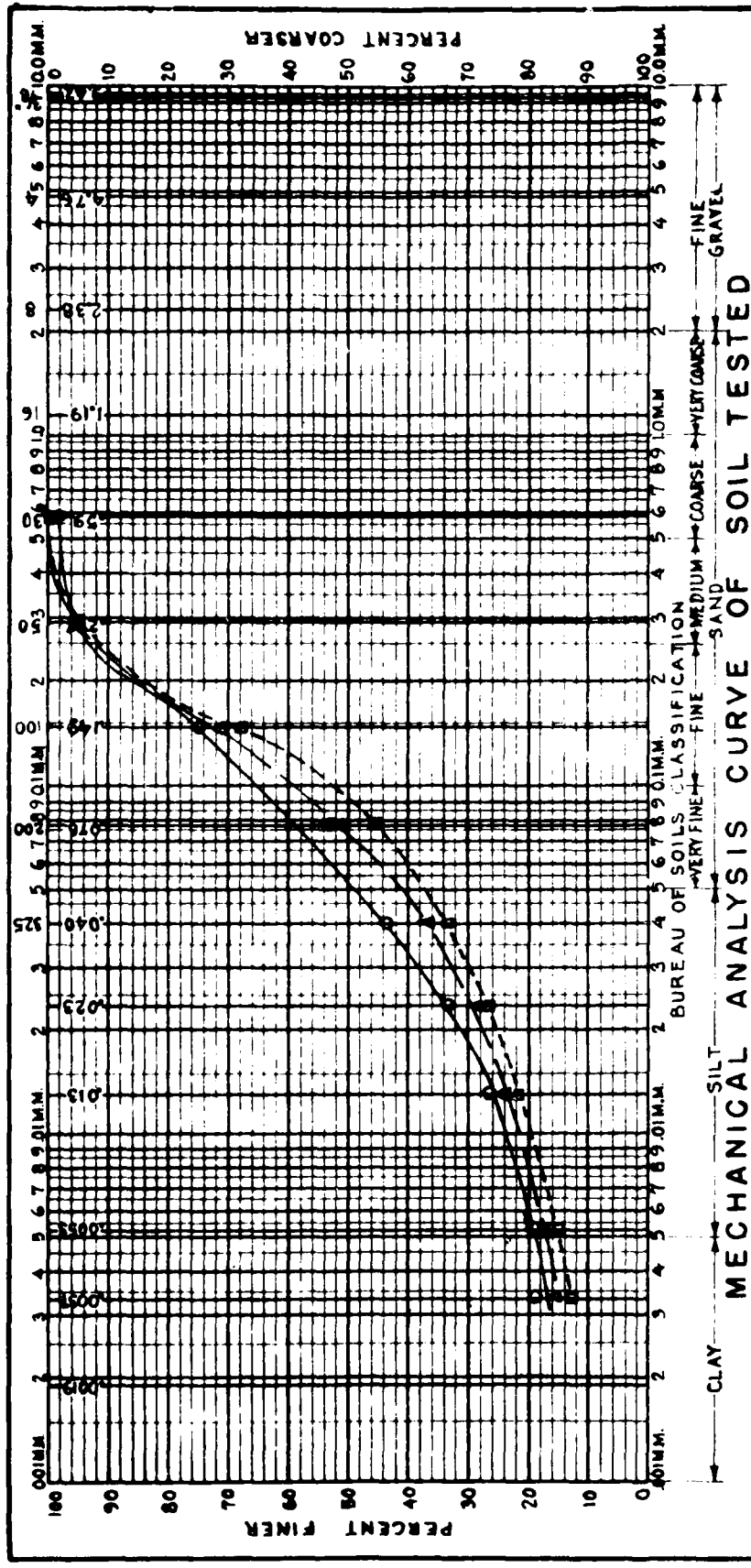
U.S. ENGINEER OFFICE, FORT PECK, MONT. 1-13-39

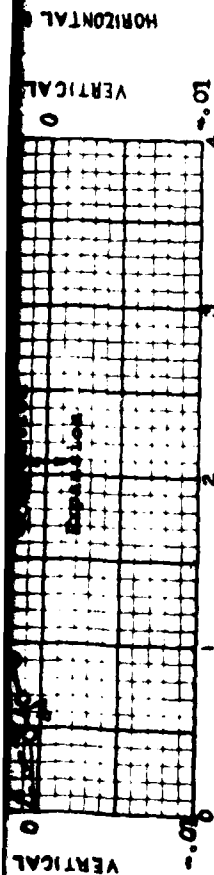
Submitted _____ Approved _____

Checked by _____
 Drawn by _____
 EBC WA dated _____



FORT PECK DAM
TYPICAL CRITICAL VOID RATIO TESTS
ON FOUNDATION SANDS





VERTICAL AND HORIZONTAL MOVEMENT CURVES DURING TEST

HORIZONTAL PRESSURE IN TONS/SQ. FT.

MOISTURE CONTENT
PERCENT DRY WEIGHT

MOISTURE CONTENT
PERCENT DRY WEIGHT

LEGEND-M.C.	
Before Test	○
After Test	△

SHEARING RESISTANCE TONS/SQ. FT.

SHEARING RESISTANCE TONS/SQ. FT.

LEGEND	
△	= 1 T/sq. ft.
□	= 3 T/sq. ft.
○	= 5 T/sq. ft.
+	= 7 T/sq. ft.
●	= 9 T/sq. ft.

NORMAL LOAD-SHEARING RESISTANCE CURVE

Notes: Undisturbed Sample
Consolidated at 10.0 tons/sq. ft.
Increment Load 2.0 tons/sq. ft.
Elevation 2230.1 - 2231.0
Depth 14.0 - 14.7
Cross Sectional Area of Sample 10.0 sq. in.
Initial Moisture Content 0.75
Sample Impressed in Water during Test
Station 60 + 0.0 Sample C-360

Shearing Resistance
 $\tau = \frac{\text{Shearing Force (tons)}}{\text{Vertical Load (tons/sq. ft.)}}$
 $= 0.635$

$\phi = 32^\circ 20'$

$c = \text{Cohesion} = 0.0 \text{ tons/sq. ft.}$

MISSOURI RIVER IMPROVEMENT

NAVIGATION, FLOOD CONTROL, POWER, IRRIGATION

FORT PECK DAM

SLIDE INVESTIGATION

SHEAR TESTS ON CORE MATERIAL

HOLE C-7 - SAMPLE #3

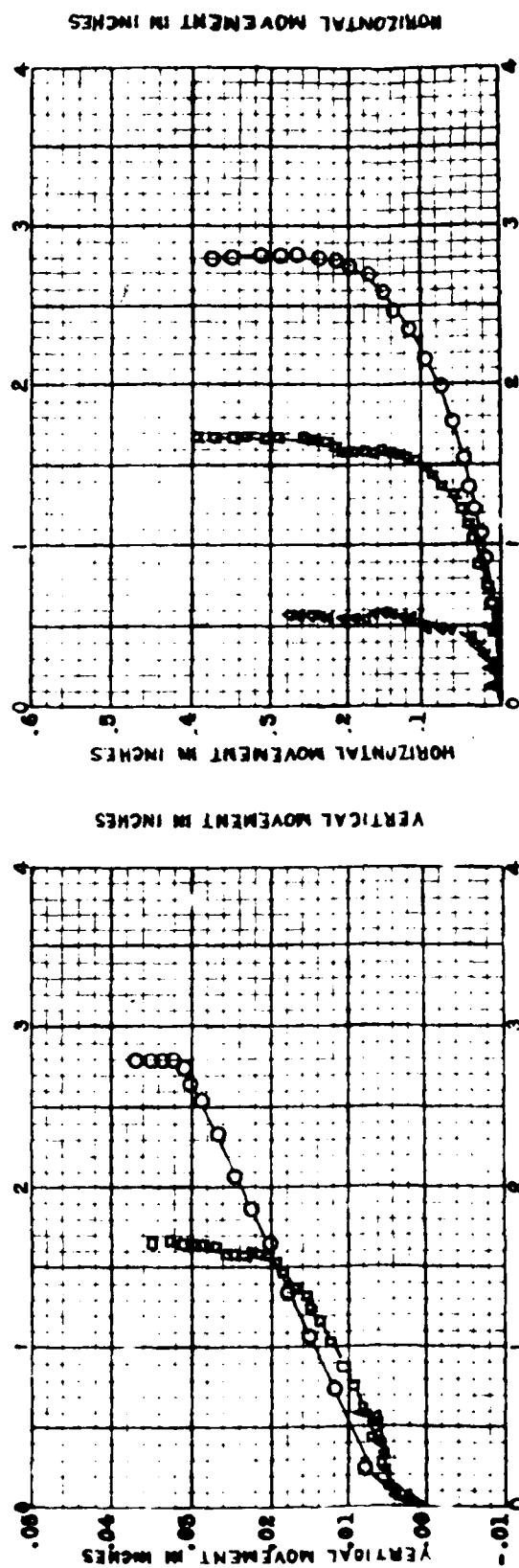
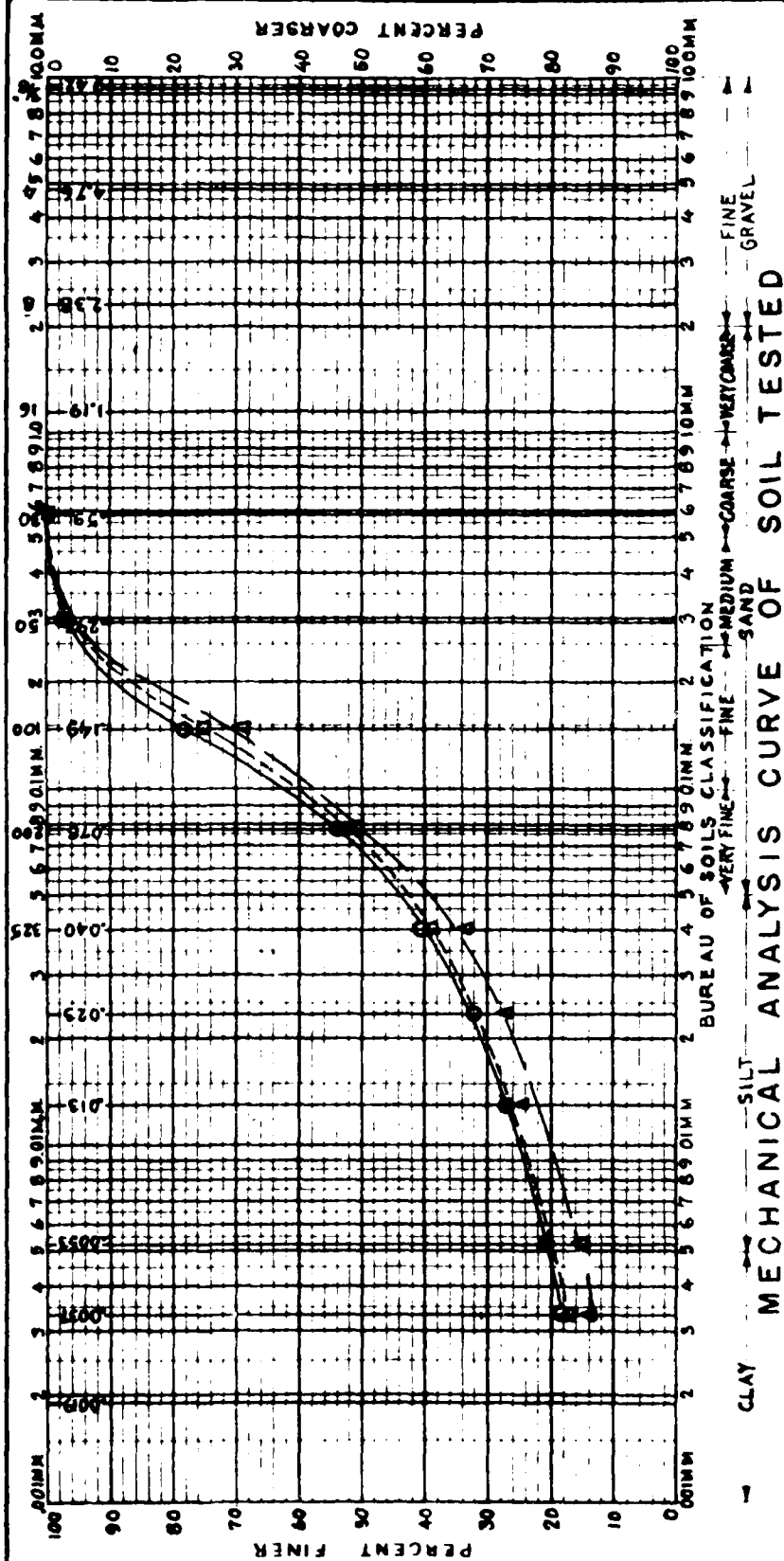
U.S. ENGINEER OFFICE, FORT PECK, MONT 1-3-29

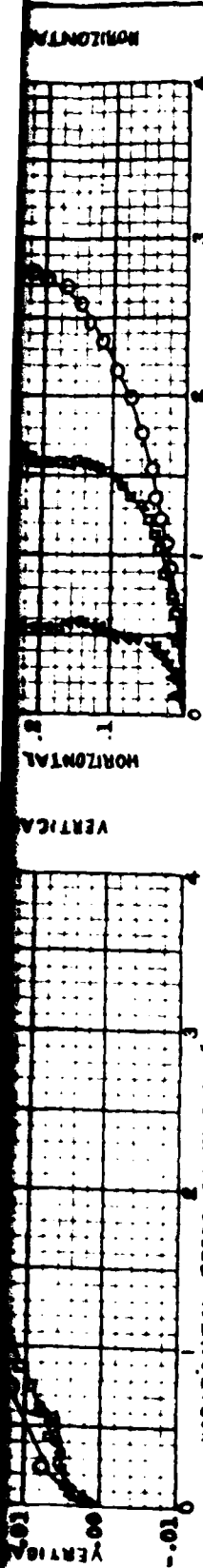
Approval Recommended

Major General of Engineers, U.S. Army, Fort Peck, Montana

Checked by Transmitted with report

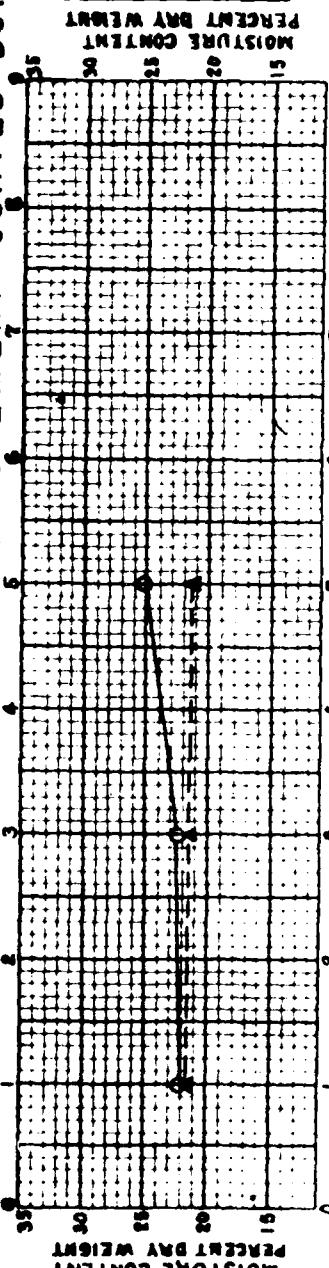
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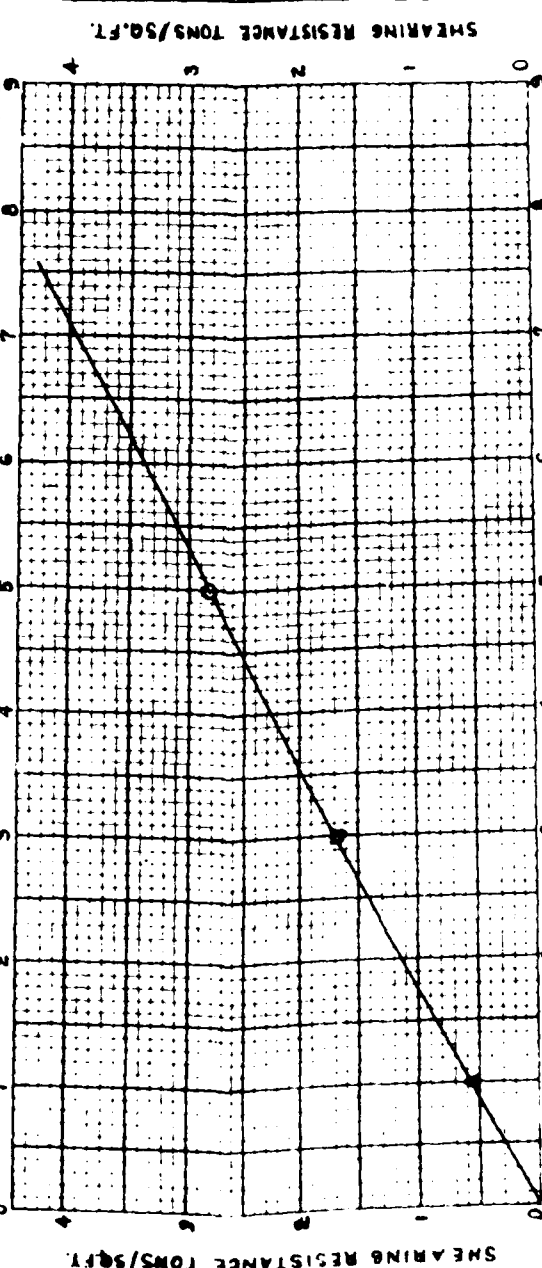


VERTICAL AND HORIZONTAL MOVEMENT CURVES DURING TEST

LEGEND-M.C.
 Before Test ○ Distort.
 After Test △



LEGEND
 △ --- = 1 T/q.ft.
 □ --- = 3 T/q.ft.
 ○ --- = 5 T/q.ft.
 + --- =
 ● --- =



NORMAL LOAD-SHEARING RESISTANCE CURVE

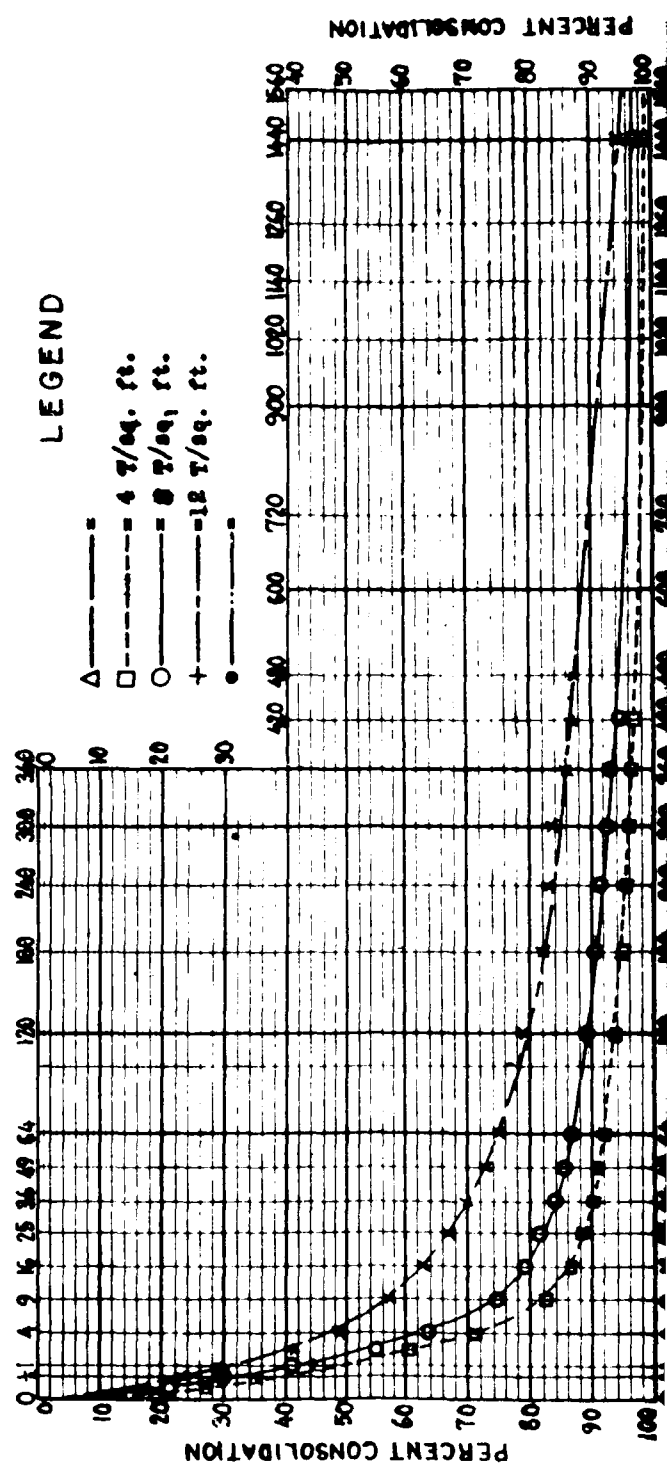
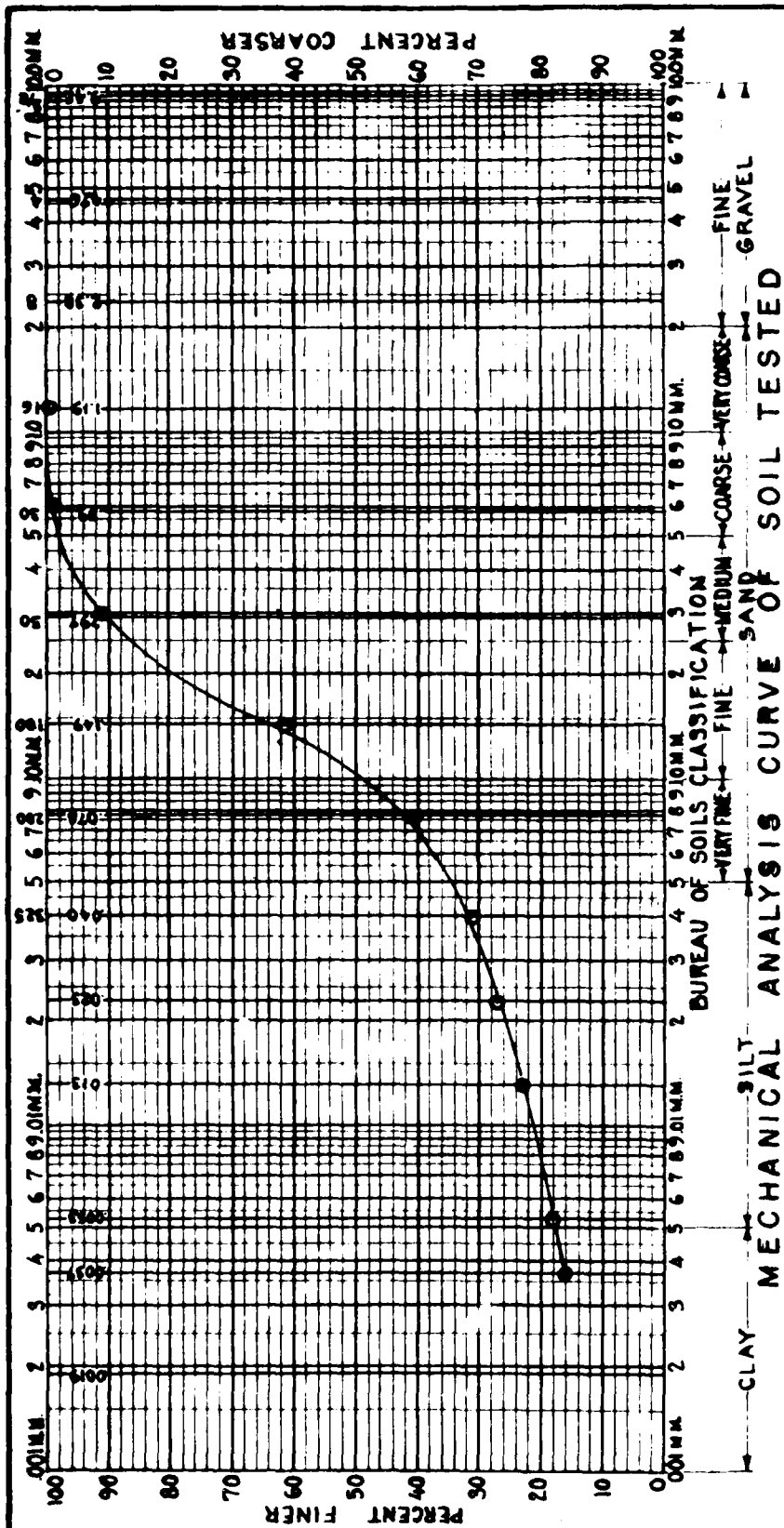
Notes: Undisturbed Sample
 Quick Shear Tests
 Constant Strain Loading
 Maximum rate of horizontal movement 0.021"/min
 Elevation 2226.8 - 2226.3
 Depth 20.9 - 21.4
 Cross Sectional Area of Sample 16.00 sq. in.
 Initial Thickness 0.75 inch.
 Sample Immersed in Water during test

Shearing Resistance
 $\frac{Cohesion (tons/sq.ft.)}{Vertical Load (tons/sq.ft.)} = 0.584$
 $\phi = 29^\circ 25'$
 $c = Cohesion = 0.0 T/sq.ft.$

MISSOURI RIVER IMPROVEMENT
 NATIONAL FLOOD CONTROL DISTRICT
FORT PECK DAM
 SLIDE INVESTIGATION
 QUICK SHEAR TESTS - CORE MATERIAL
 HOLE C-7, SAMPLE #5, SERIES #1

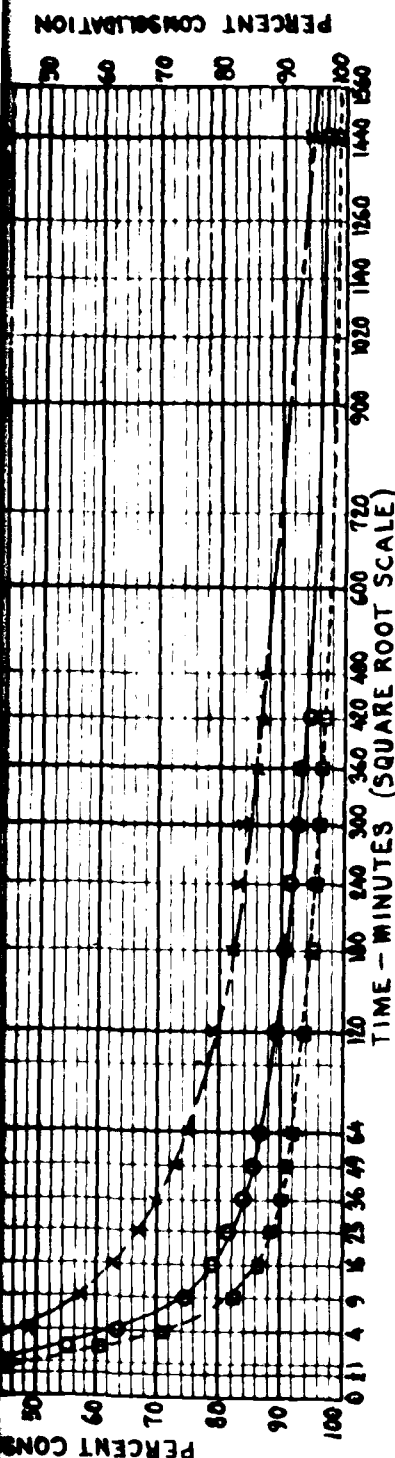
TEST NO.	DATE	TESTED BY	REMARKS

JLB EBC

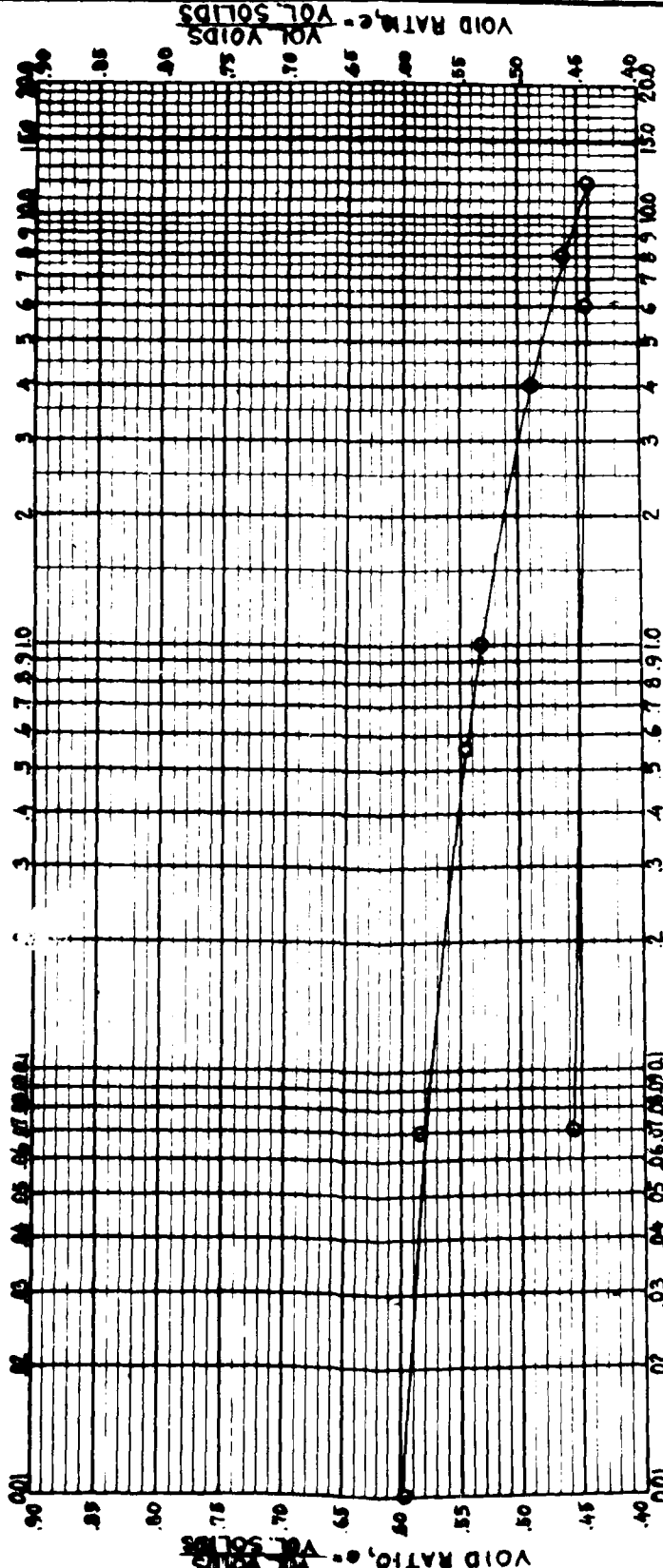


LEGEND

- △ — 4 T/eq. ft.
- — 8 T/eq. ft.
- — 12 T/eq. ft.
- + — 16 T/eq. ft.
- — 20 T/eq. ft.



TIME-PERCENT CONSOLIDATION CURVES



PRESSURE-VOID RATIO CURVE

Estimated Previous Consolidation = Tons/Sq. Ft.

Undisturbed sample
 Immersed in water during test
 Station 60 + 00 Range 0 + 35D
 Depth 13.5 Elev. 2234.2
 Initial Thickness 2.50"
 Cross Sectional Area of sample 24.8 sq. in.
 Natural Moisture Content 23.0%

* Total compaction in percent of original height of sample.

VERTICAL LOAD TONS/SQ. FT.	COMPACTION PERCENT*
0	0
0.07	58
0.56	3.34
1.00	4.00
4.00	6.71
8.00	8.22
12.00	9.70
6.00	9.60
0.07	8.65

MISSOURI RIVER IMPROVEMENT
 NAVIGATION, FLOOD CONTROL, POWER, IRRIGATION

FORT PECK DAM

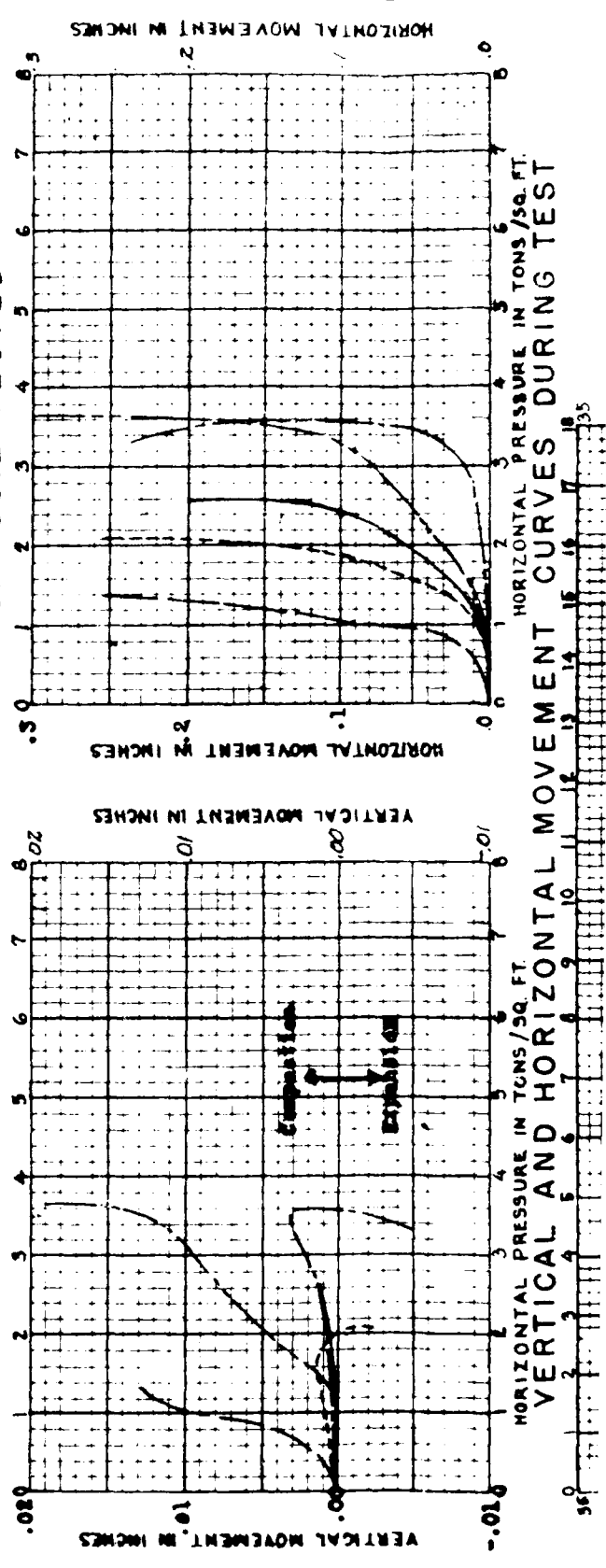
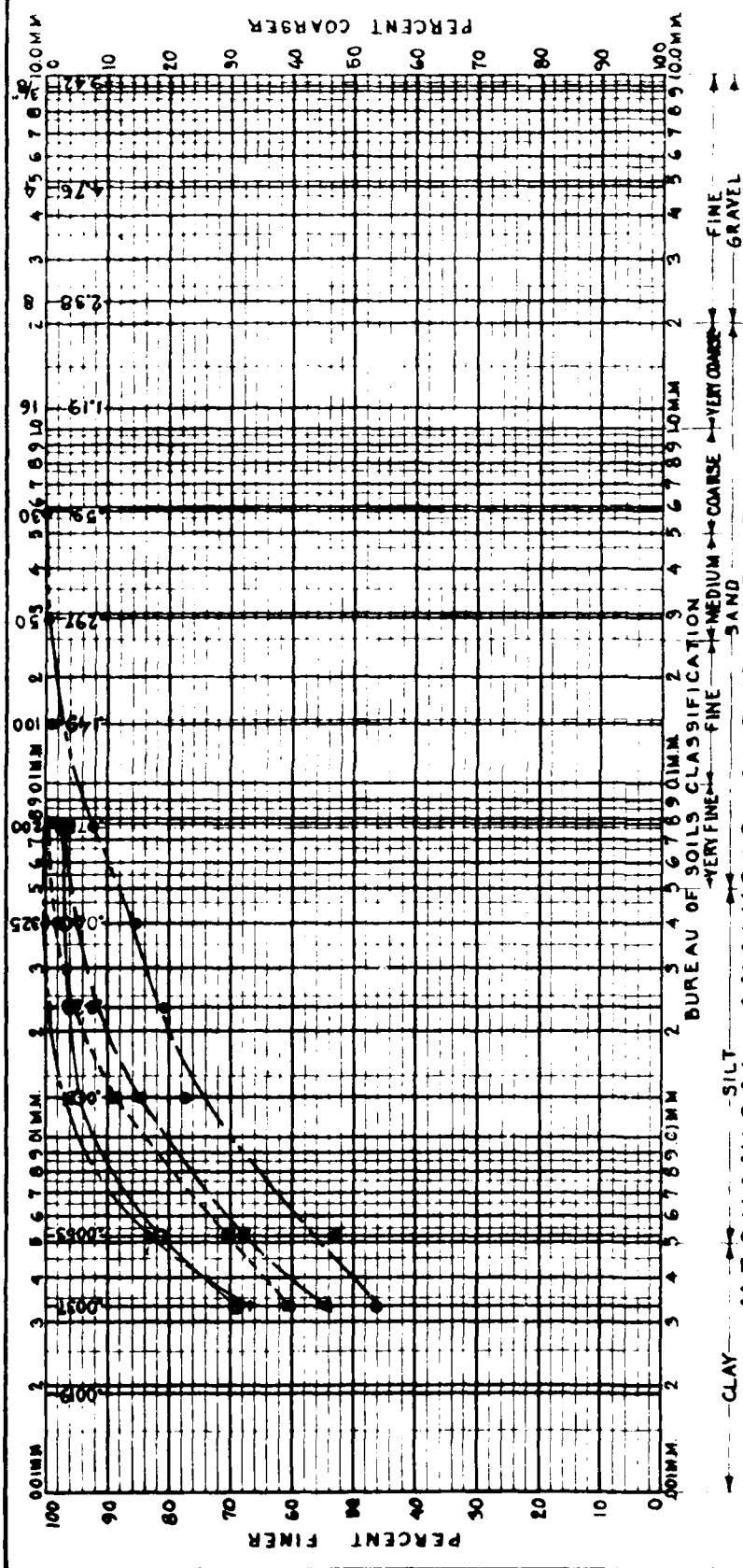
SLIDE INVESTIGATION
 CONSOLIDATION TESTS ON CORE MATERIAL
 HOLE C-7 - SAMPLE #2
 12-13-36

U.S. ENGINEER OFFICE, FORT PECK, MONT.

Submitted: _____
 Checked by: _____
 Approved: _____

Drawn by: _____
 Traced by: _____
 DMS: _____

Water Control Engineer: _____
 Checked by: _____
 Transmitted with report: _____
 File No: _____



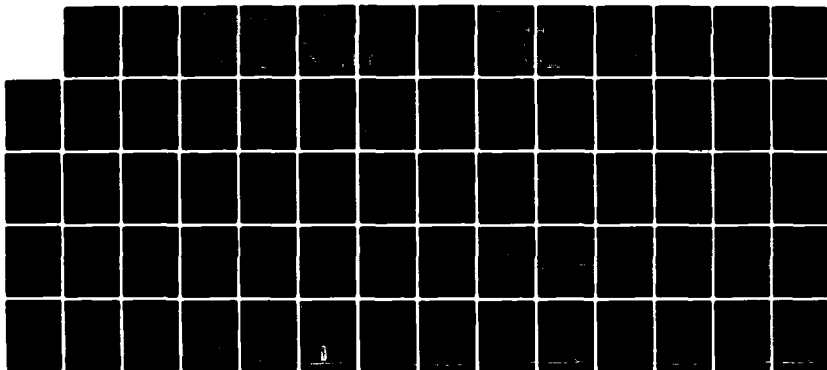
AD-A123 608

EMBANKMENT CRITERIA AND PERFORMANCE REPORT MISSOURI
RIVER FORT PECK LAKE MONTANA VOLUME II DRAWINGS(U) ARMY
ENGINEER DISTRICT OMAHA NEBR SEP 82

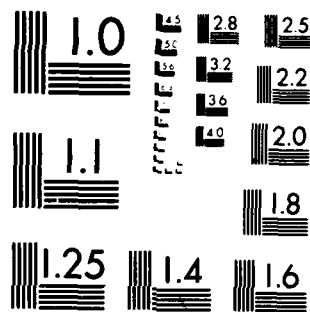
2/2

UNCLASSIFIED

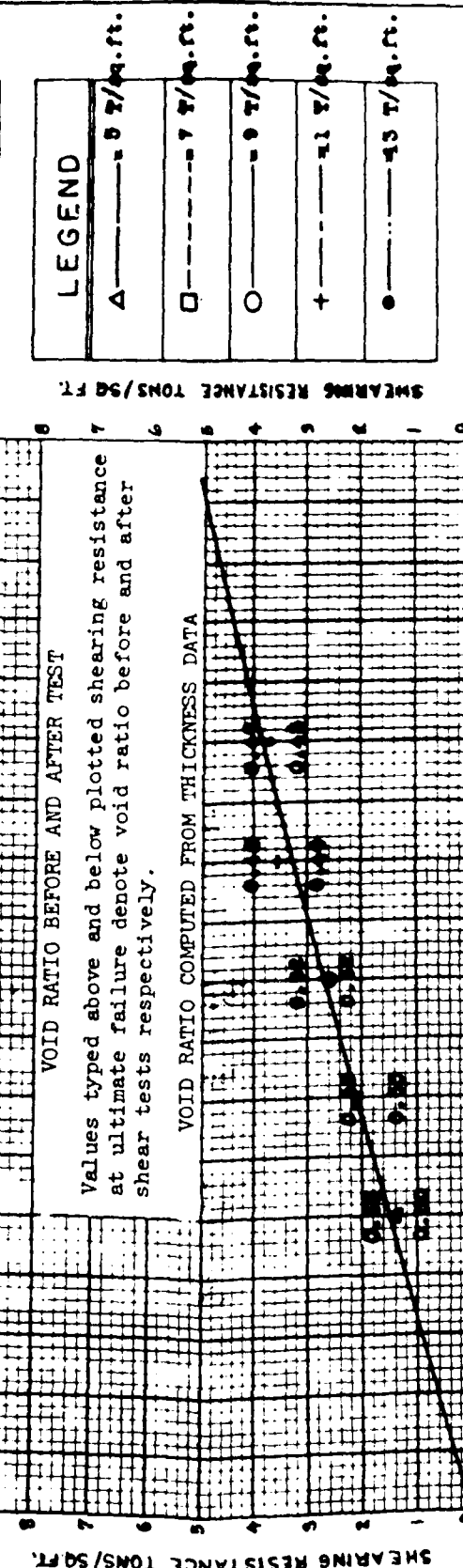
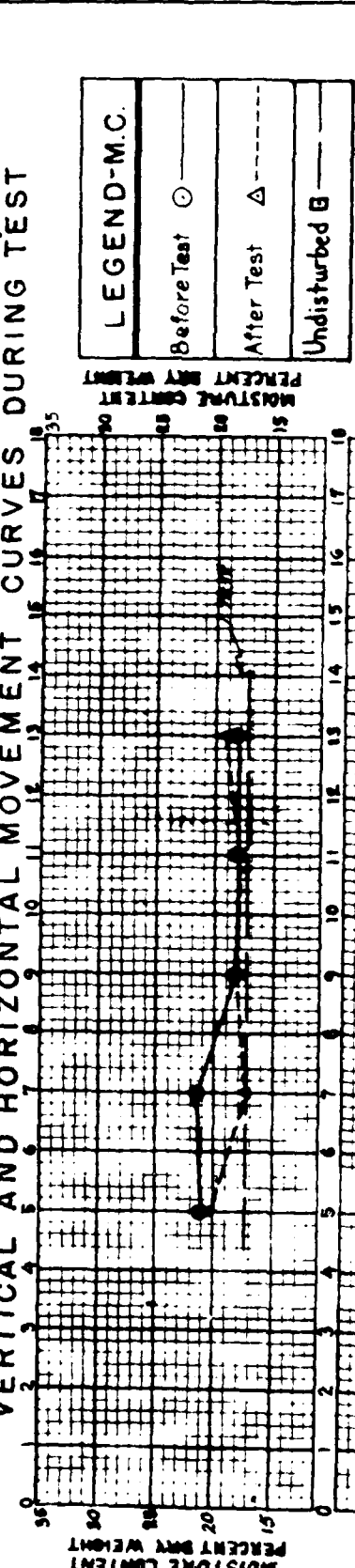
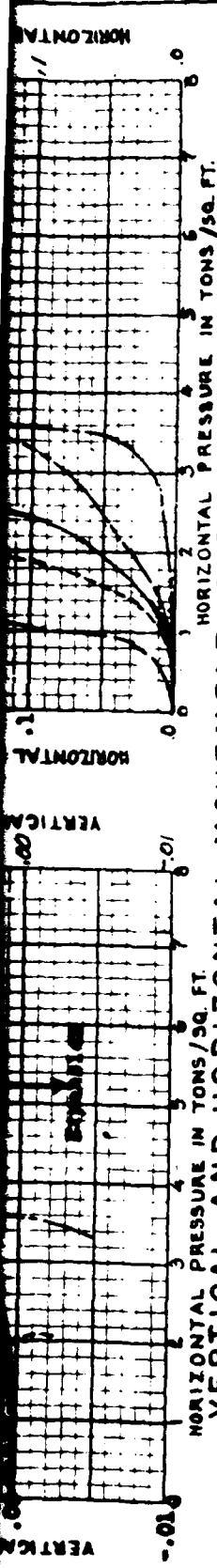
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END
DATE
FILMED
8-83
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



LEGEND-M.C.	
Before Test	○
After Test	△
Undisturbed	□

LEGEND	
△	5 T/4. ft.
□	7 T/4. ft.
○	9 T/4. ft.
+	11 T/4. ft.
●	13 T/4. ft.

VOID RATIO BEFORE AND AFTER TEST
Values typed above and below plotted shearing resistance at ultimate failure denote void ratio before and after shear tests respectively.

VOID RATIO COMPUTED FROM THICKNESS DATA

NORMAL LOAD-SHEARING RESISTANCE CURVE

Notes

- Undisturbed Sample
- Consolidates shear tests
- Delta Loading
- Gross Sectional Area of Sample 10.00 sq. in
- Initial Thickness 0.75 inch
- Sample Immersed in Water During Test
- Note: Sample taken from block of soft shale in weathered zone in drift above inlet portals.

Shearing Resistance
Cohesion (tons/sq. ft.)
= 0.294

$\phi = 16^{\circ} 25'$

$c = \text{Cohesion} = 0.07/\text{sq. ft.}$

FORT PECK DAM

SLIDE INVESTIGATION

CONSOLIDATED SHEAR TESTS SERIES # 1*

UND. WEATHERED SHALE--INLET PORTALS.

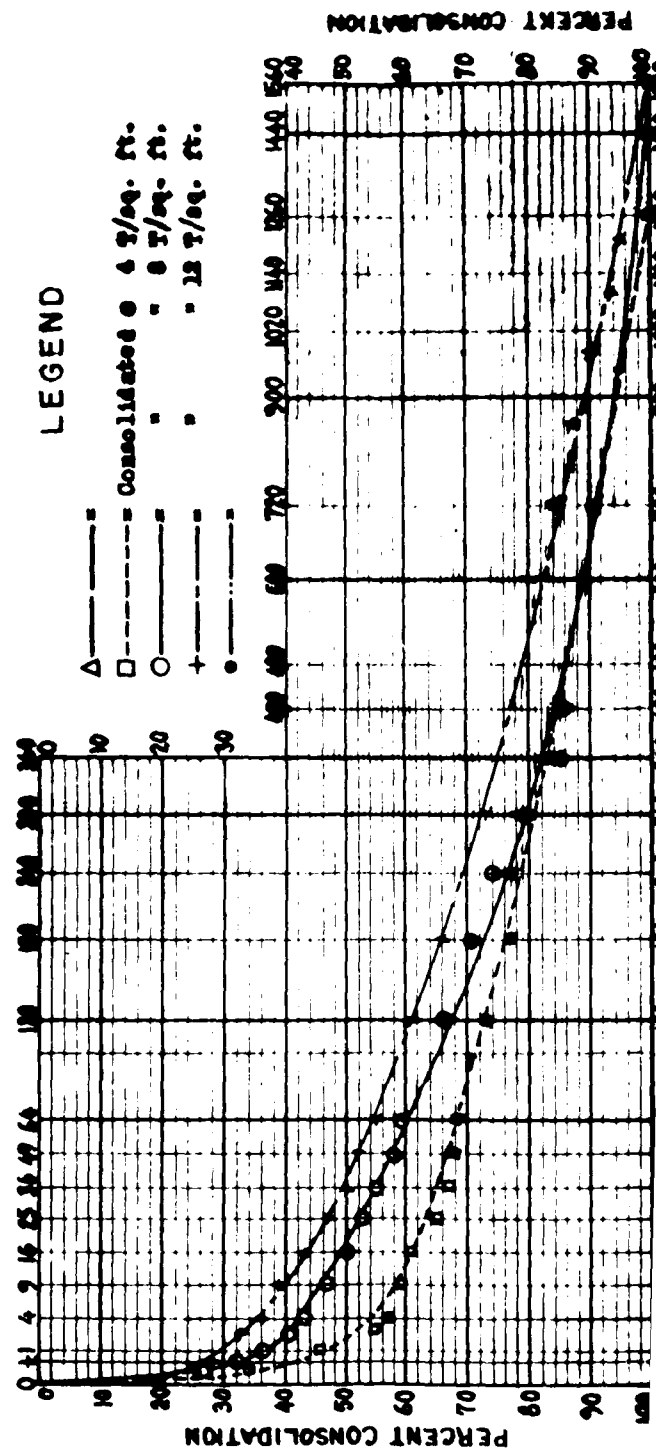
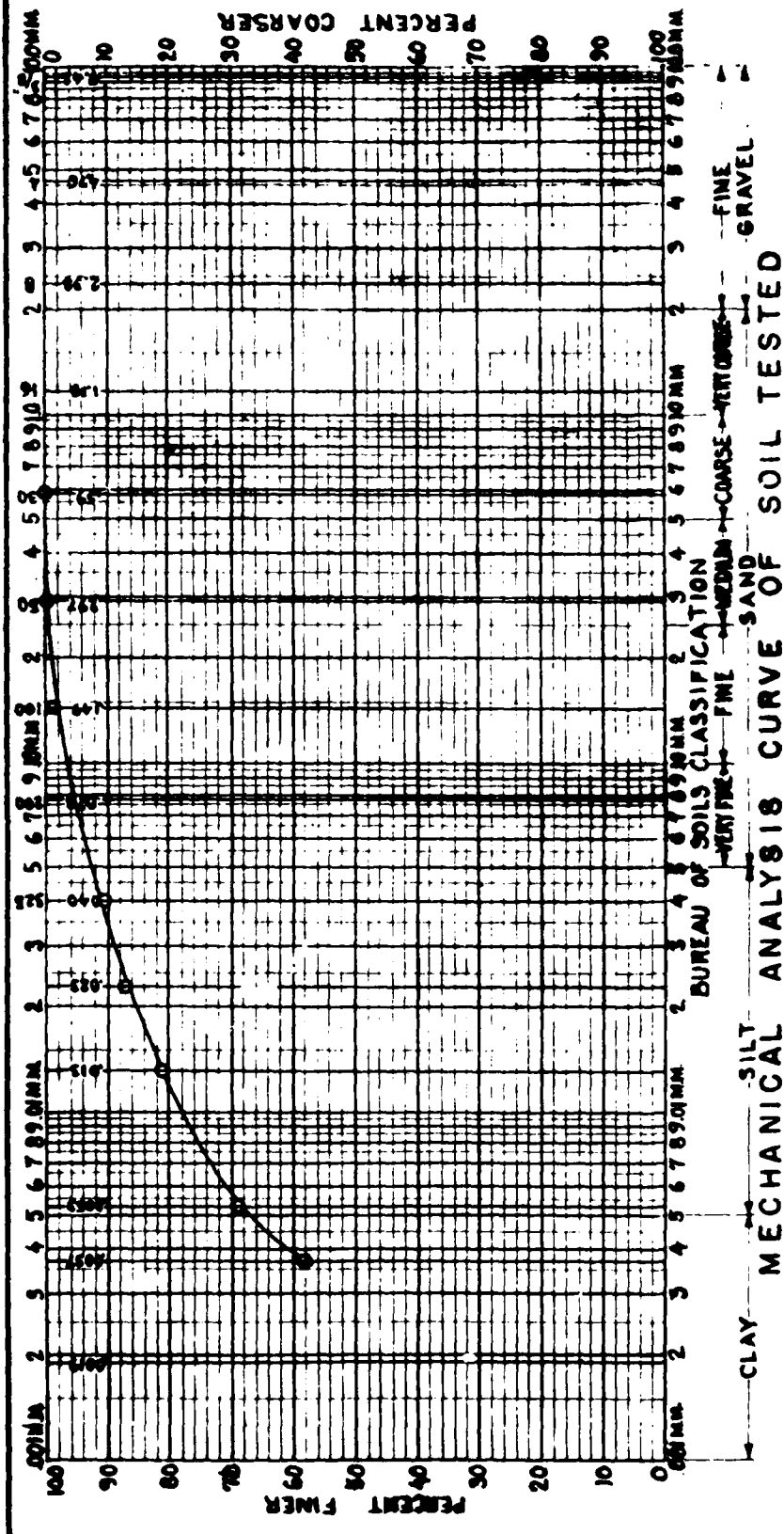
MISSOURI RIVER IMPROVEMENT

DESIGNED BY: [Signature] / 10-20-50

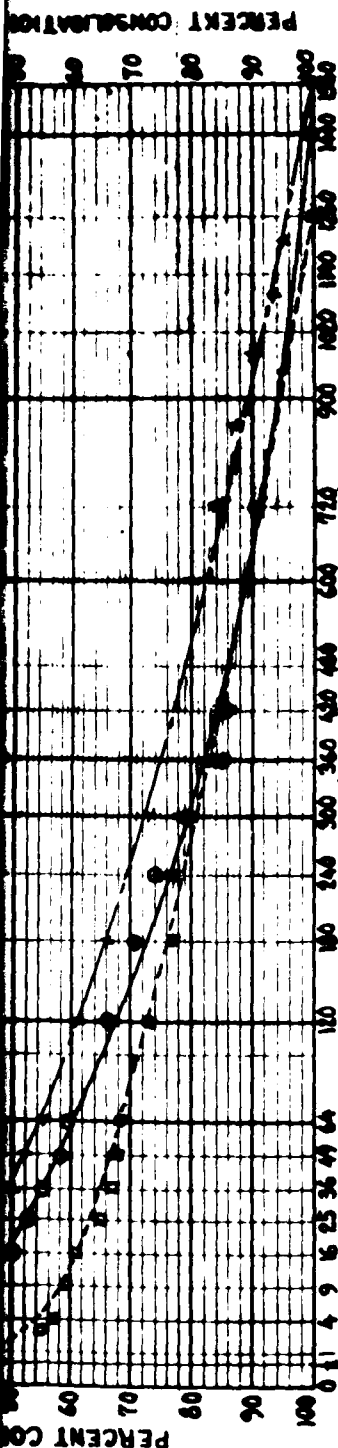
APPROVED BY: [Signature] / 10-20-50

DATE: 10-20-50

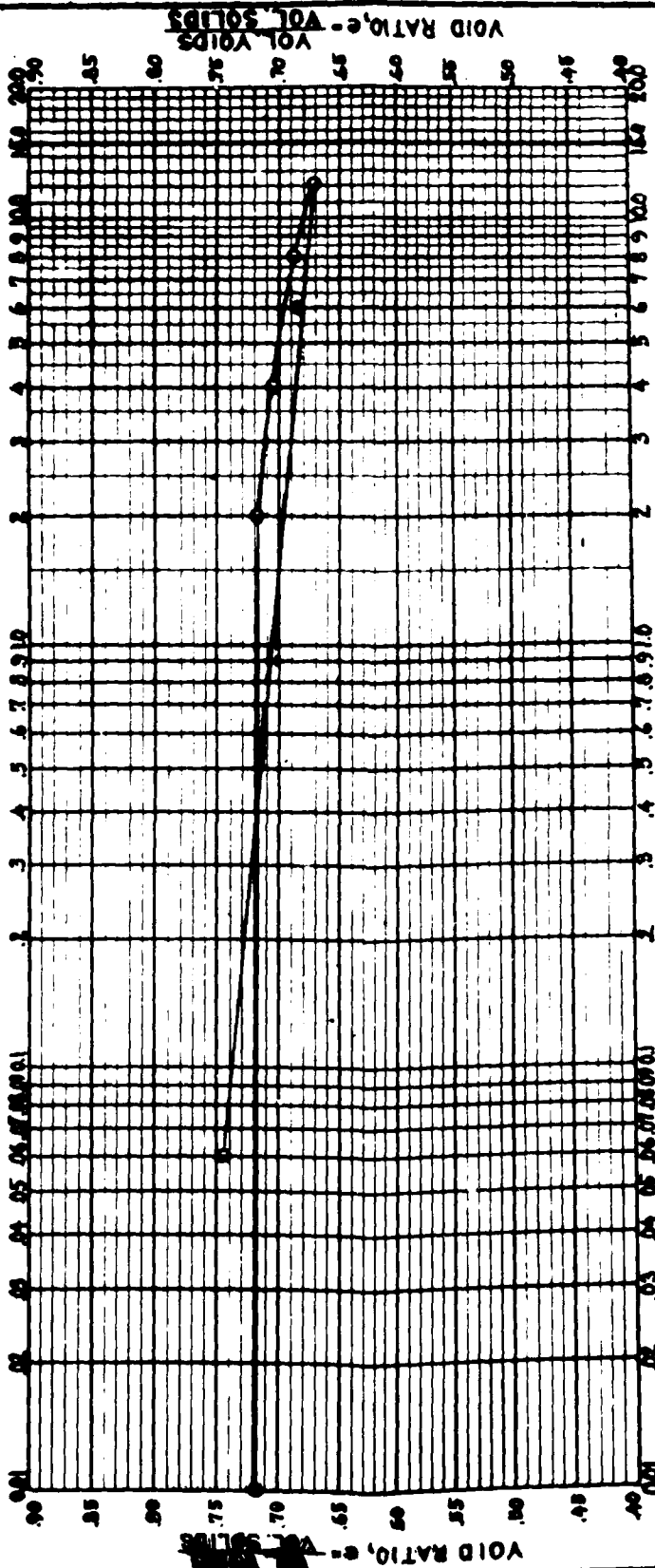
BY: [Signature]



2



TIME-PERCENT CONSOLIDATION CURVES



PRESSURE-VOID RATIO CURVE

Estimated Previous Consolidation = ... Tons/Sq. Ft.
 Undisturbed sample of weathered shale from
 Merriman Drift above Inlet Portals.
 Immersed in water during test.
 Initial Thickness 1.25 inches.
 Cross Sectional Area 24.80 sq. in.

VERTICAL LOAD TONS/SQ. FT.	COMPACTION PERCENT
0.00	0.00
8.00	0.08
4.00	0.80
8.00	1.88
12.00	2.04
6.00	2.24
0.07	- 1.86

* Total compaction in percent of original height of sample.

MISSOURI RIVER IMPROVEMENT
 NAVIGATION, FLOOD CONTROL, POWER, IRRIGATION

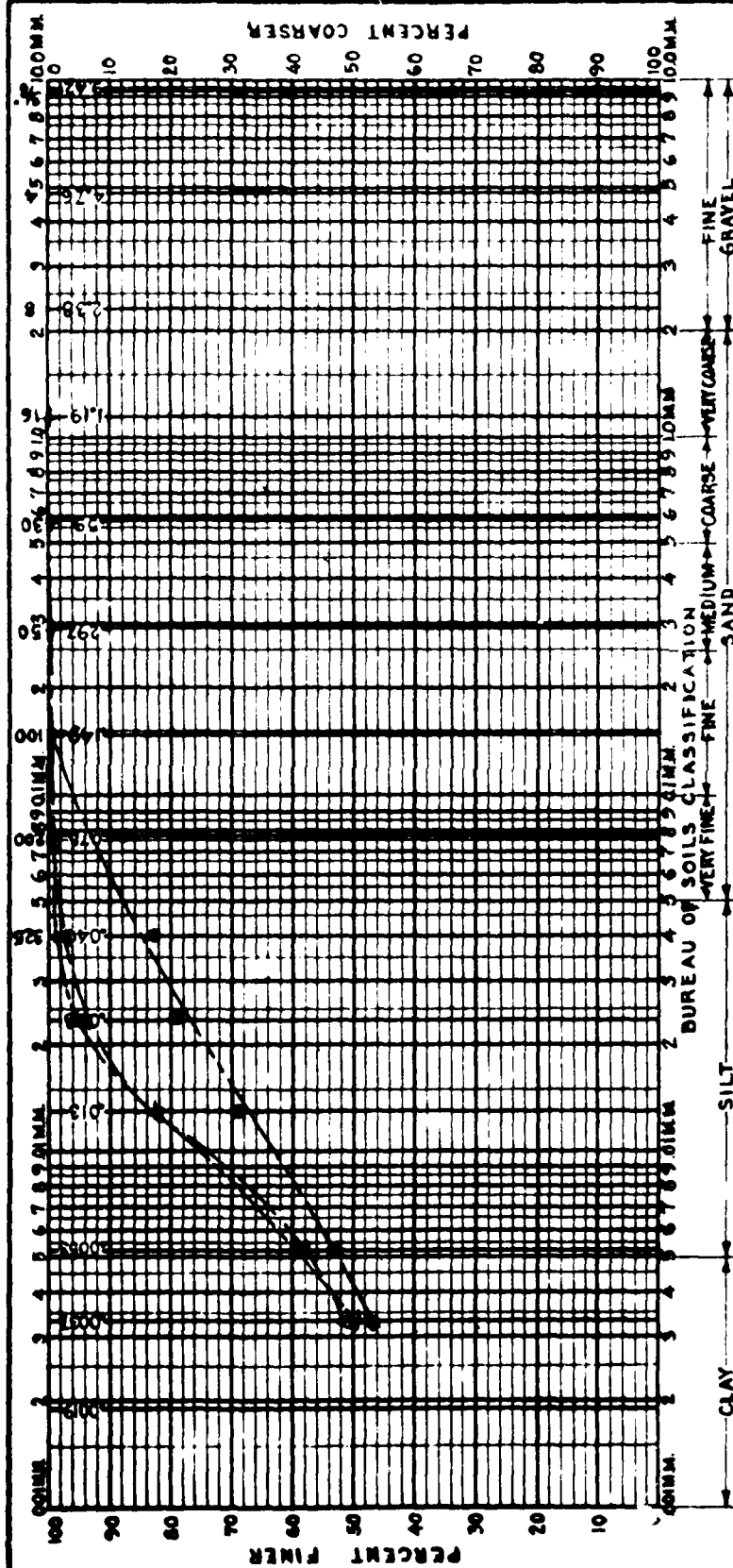
FORT PECK DAM

SLIDE INVESTIGATION
 CONSOLIDATION TEST WEATHERED SHALE
 MERRIMAN DRIFT; SAMPLE #1

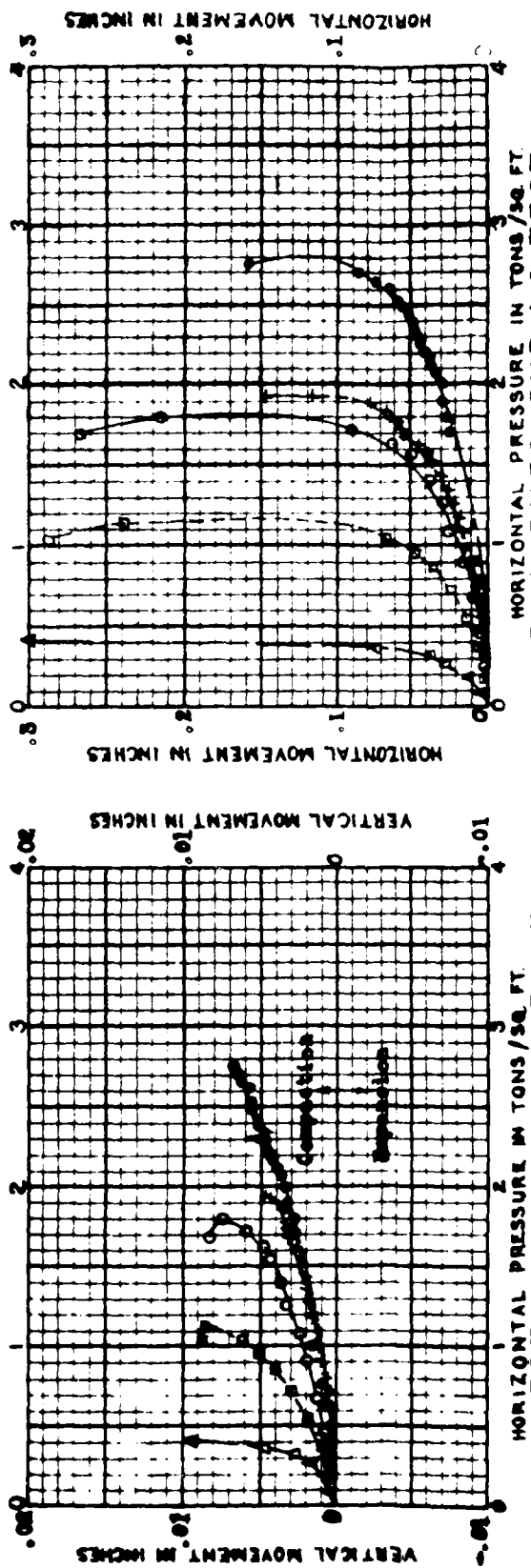
U.S. ENGINEER OFFICE, FORT PECK, MONT. 1-80-88

Submitted: _____ Approval Recommended: _____ Approved: _____

Drawn by: DWS JBC
 Checked by: _____
 Major: _____
 Title: _____
 Date: _____

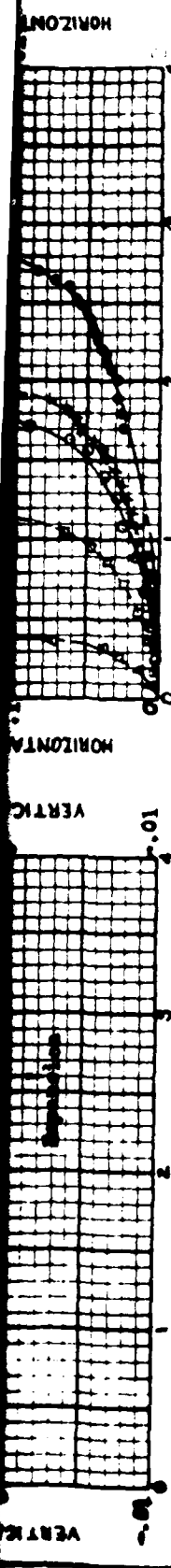


MECHANICAL ANALYSIS CURVE OF SOIL TESTED

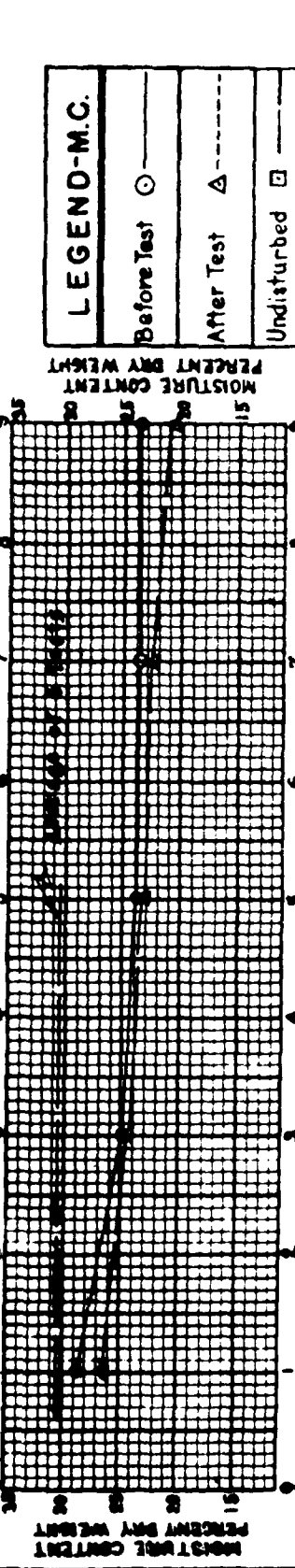


VERTICAL AND HORIZONTAL MOVEMENT CURVES DURING TEST

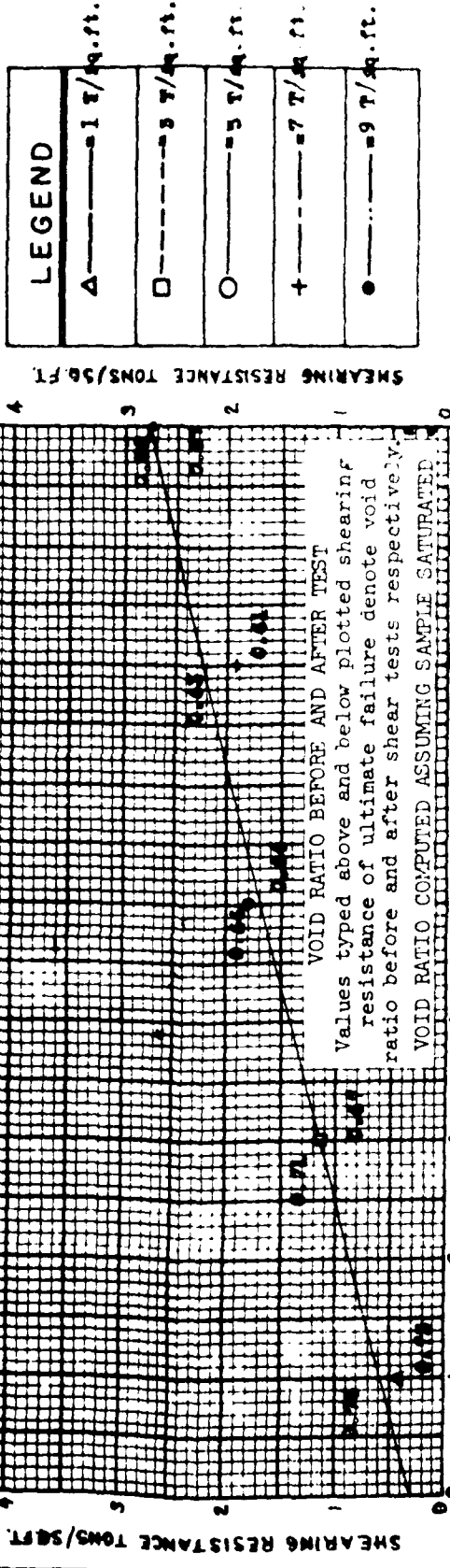
LEGEND-M.C.



HORIZONTAL PRESSURE IN TONS/SQ. FT.
VERTICAL AND HORIZONTAL MOVEMENT CURVES DURING TEST



MOISTURE CONTENT
SHEARING RESISTANCE TONS/SQ. FT.



VERTICAL LOAD TONS/SQ. FT.
NORMAL LOAD-SHEARING RESISTANCE CURVE

Notes: Undisturbed Sample
Consolidated Shear Tests
Incremental Loading
Elevation 2115.0 - 2114.0
Depth 0.0 - 1.0
Cross Sectional Area of Sample 10.00 Sq. In.
Initial Thickness 0.75 inch
Sample immersed in water during test
Station 13 + 5 Range 14 + 50

Shearing Resistance
Cohesion (tons/sq. ft.)
C = 0.275

$\phi = 18^\circ 25'$

C = Cohesion = 0.80 T/sq. ft.

LEGEND-M.C.	
Before Test	○
After Test	△
Undisturbed	□

LEGEND	
△	1 T/sq. ft.
□	3 T/sq. ft.
○	5 T/sq. ft.
+	7 T/sq. ft.
●	9 T/sq. ft.

MISSOURI RIVER IMPROVEMENT
NAVIGATION, FLOOD CONTROL, POWER, IRRIGATION

FORT PECK DAM
SLIDE INVESTIGATION
SHEAR TESTS ON UNDISTURBED SAMPLES OF
DISTURBED WEATHERED SHALE

U.S. ENGINEER OFFICE, FORT PECK, MONT 1-4-38

Approved: _____
Checked by: JLB EBC
Drawn by: JLB EBC
Date: _____

Results of tests on undisturbed samples of shale taken in the Fort
Peck Dam Foundation, downstream, with 6-inch sampler

(Original sheets 30-31)

1	2	3	4	5	6	7	8	9
Sample No.	Sam- ple depth in feet	Depth into shale in feet	Equi- valent load in tons/ sq. ft.	Mois- ture content, percent dry weight	Shearing strength in tons/ sq. ft.	Computed shearing strength tons/sq. ft. with Tan $\phi = 18$, C = .20	Ratio $\frac{6}{7}$	Type test
HOLE C-12 STATION 10+75, RANGE 8+00 D								
6.....	14.6	1.4	0.53	31.3	0.43	0.35	1.85	Quick.
7.....	14.6	3.4	.97	22.8	.86	.37	2.32	Consol.
8.....	14.6	5.4	1.89	23.3	.89	.40	2.2	Quick.
9.....	14.6	7.4	1.21	20.6	.84	.42	1.94	Quick.
HOLE C-13 STATION 12+00, RANGE 8+00 D								
2.....	24.5	6.6	1.39	26.6	1.39	0.43	2.9	Quick.
3.....	24.5	8.6	1.29	27.7	1.66	.44	2.5	Consol.
4.....	24.5	2.6	1.44	45.5	.94	.45	2.1	Quick.
5.....	24.5	4.6	1.53	25.0	2.00	.46	4.3	Quick.
6.....	24.5	6.6	1.66	25.5	1.13	.39	2.3	Quick.
7.....	24.5	8.6	1.65	28.0	1.35	.39	3.1	Consol.
8.....	24.5	10.4	1.90	25.0	1.23	.54	2.3	Quick.
9.....	24.5	12.0	2.01	26.0	1.26	.56	2.3	Quick.
HOLE C-14 STATION 12+00, RANGE 8+00 D								
2.....	46.3	1.7	2.48	20.0	2.25	0.65	3.3	Quick.
3.....	46.3	3.7	2.60	24.5	1.30	.67	1.9	Consol.
4.....	46.3	5.7	2.72	21.2	2.4	.69	3.5	Quick.
5.....	46.3	7.7	2.84	20.2	1.98	.71	2.7	Quick.
6.....	46.3	18.3	3.18	23.5	1.50	.77	1.96	Quick.
HOLE C-15 STATION 13+25, RANGE 8+00 D								
2.....	71.5	2.0	3.87	25.5	1.39	0.90	1.55	Quick.
3.....	71.5	3.5	3.96	25.7	1.51	.92	1.64	Consol.
4.....	71.5	7.75	4.21	25.5	2.59	.96	2.7	Quick.
7.....	71.5	11.75	4.46	25.0	2.05	1.05	1.96	Quick.
HOLE C-16 STATION 14+40, RANGE 8+00 D								
2.....	100	1.6	5.78	27.7	2.54	1.26	2.04	Quick.
3.....	100	3.6	5.90	27.1	3.02	1.26	2.40	Consol.
4.....	100	7.9	6.16	28.8	1.89	1.39	1.45	Quick.
TEST SHAFT, STATION 15+00, RANGE 8+00 D								
0.....	24.5	1.3	1.36	28.1	0.73	0.44	1.64	Quick.
1.....	24.5	1.3	1.36	34.1	.94	.44	2.13	Quick.
2.....	24.5	3.3	1.73	28.2	1.44	.53	2.77	Quick.
GLACIAL TILL FROM HOLE AT STATION 106+00, RANGE 0+00 D								
3.....	40.5	3.5	2.34	13.7	1.30	0.53	1.64	Quick.
4.....	40.5	5.5	2.46	19.6	1.56	.56	1.82	Quick.
5.....	40.5	7.5	2.58	28.4	1.49	.59	1.57	Consol.
6.....	40.5	9.5	2.70	27.8	1.44	.59	1.57	Quick.

¹ After test.

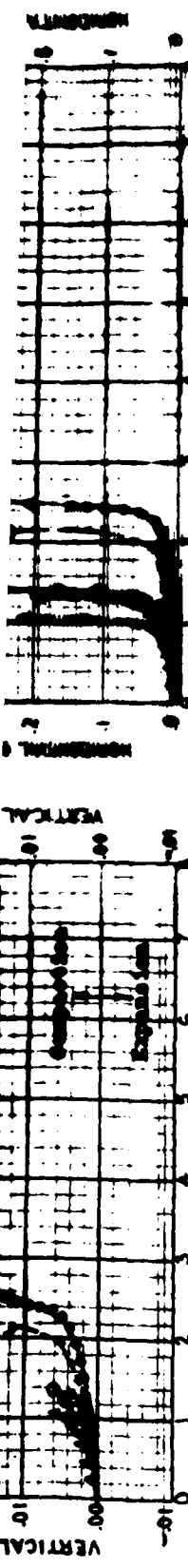
NOTE.—Except for samples 1 and 2 from the test shaft all samples were 6" drive samples.

Duration of test for Quick shear varied from 1.5 to 3 minutes.

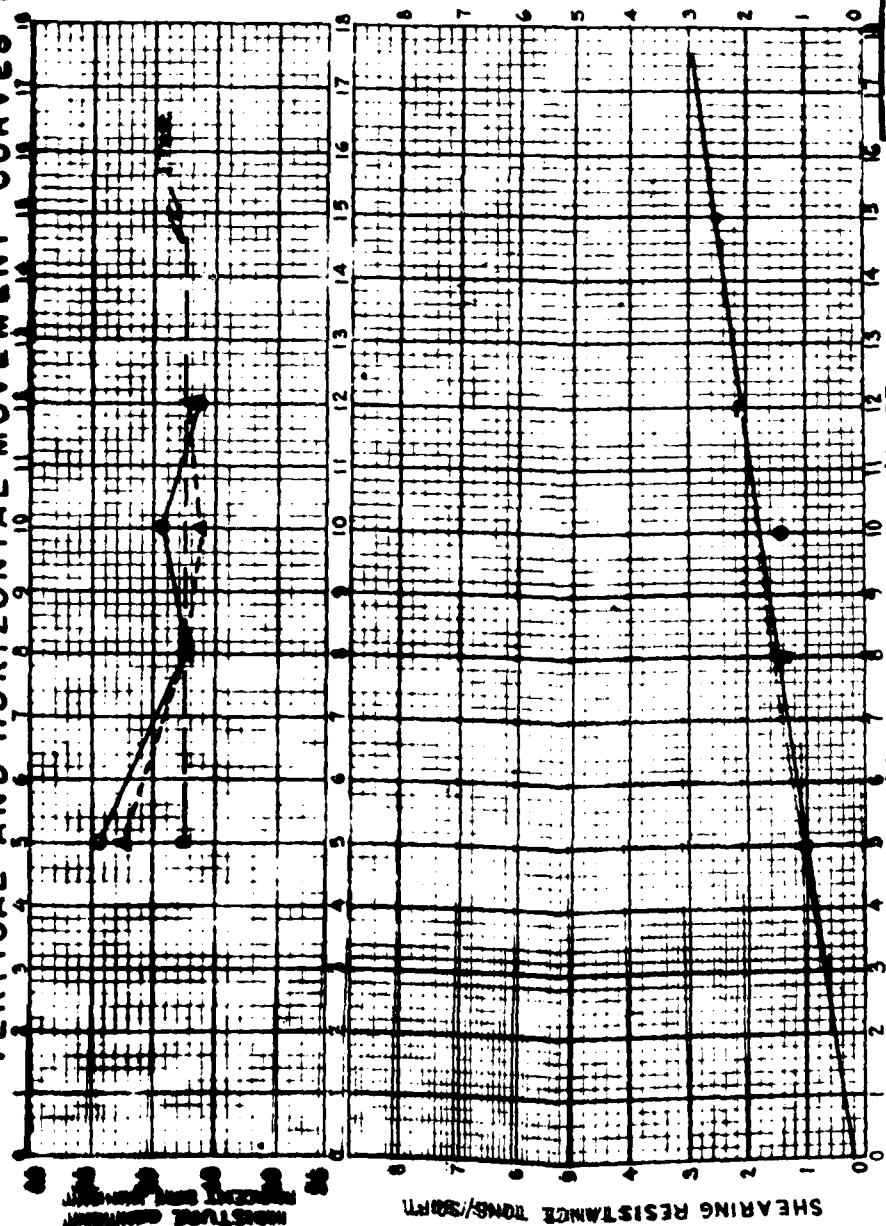
The vertical load for the duration of the test was as indicated in Column 4.

Tan $\phi = 0.18$, C = 0.20 were coefficients used in the design of the reconstruction in the slide area.

For computed shearing strength for Glacial Till from Hole S. D. 106/9.96 coefficients used were Tan $\phi = .25$, C = .23.



HORIZONTAL PRESSURE IN TONS/SQ. FT.
VERTICAL AND HORIZONTAL MOVEMENT CURVES DURING TEST



MOISTURE DRY WEIGHT
PERCENT DRY WEIGHT

LEGEND-M.C.	
Before Test	○
After Test	△
Undisturbed	□

SHEARING RESISTANCE TONS/SQ. FT.

LEGEND	
△	— = 8 7/8 sq. ft.
□	— = 8 7/8 sq. ft.
○	— = 10 7/8 sq. ft.
+	— = 12 7/8 sq. ft.
●	— = 15 7/8 sq. ft.

NORMAL LOAD-SHEARING RESISTANCE CURVE

Notes:

- Shearing Resistance
- $\tan \phi = \frac{\text{Cohesion (tons/sq. ft.)}}{\text{Vertical Load (tons/sq. ft.)}}$
- $\phi = 6^\circ 50'$
- $c = \text{Cohesion} = 0.80 \text{ t/sq. ft.}$
- Undisturbed Sample
- Consolidated Shear Tests
- Increment Loading
- Gross Sectional Area 16.00 sq. in.
- Initial Thickness 0.76 inch.
- Sample Immersed in Water during Test.

MIS. RIVER IMPROVEMENT
SLIDE INVESTIGATION

FORT PECK DAM
CONSOLIDATED SHEAR TESTS - SERIES #1
REYNOLDS FROM CROSSY DRIFT

DATE	1-27-39
BY	AD. JONES
CHKD.	
APP.	
DATE	1-27-39
BY	
CHKD.	
APP.	

LEGEND

Δ	1.5 Tons/sq. ft.
□	1.0 Tons/sq. ft.
◇	0.5 Tons/sq. ft.
+	0.2 Tons/sq. ft.
•	0.1 Tons/sq. ft.

Notes: Undisturbed Sample from Harrison Drift above Inlet Portals
Quick Shear Tests
Moisture content of Shales 17.5% (over Fair Gravel)
Moisture content of Bentonite = 44.0% (over Fair Gravel)
Sample Immersed in Water during test.
Initial Thickness of Sample = 1.00 inch
Cross Sectional Area of Sample = 16.00 sq. in.

$c = 0.125$
 $\phi = 9^{\circ}10'$
 $Cu = 0.60 \text{ T/sq. ft.}$

1.2 TONS PER SQ. FT. - EQUIVALENT TENSION

11 12 13 14 15

MISSOURI RIVER IMPROVEMENT

FORT PECK DAM

SLIDE INVESTIGATION

QUICK SHEAR TESTS SERIES # 1

BENTONITE STRAM ON SPURLET NO.

SCALE:

U. S. ENGINEER OFFICE FORT PECK, MONTANA

Submitted:

Approved Recommended:

Approved:

Checked by: J. J. B.	Major, Corps of Engineers	Major, Corps of Engineers
Drawn by: E. B. G.	Technician with report	File No.

VERTICAL LOAD - TON PER SQ. FT.
0 .02 .04 .06 .08 .10 .12 .14 .16 .18 .20

HORIZONTAL MOVEMENT IN INCHES

FIGURE 16.—Results of shear tests.

All tests are consolidated unless otherwise noted

Transition zone material:

Tan ϕ	c
0.712	0.0
0.640	0.0

Stratified material from Calyx No. 4:

Tan ϕ	c
0.520	0.0

Bentonite from Merriman drift:

Tan ϕ	c
0.136	0.40

Bentonite from Crosby drift:

Tan ϕ	c
0.155	0.20

Bentonite from Calyx No. 8 (Hard, impure bentonite, considerable volcanic ash):

Tan ϕ	c
0.247	0.90

Bentonite from near outlet portals:

Tan ϕ	c
0.241	0.70

Bentonite from Calyx No. 2:

Tan ϕ	c
0.139	0.80

Shale and bentonite from Calyx No. 4 (Sample consisted of fractured shale with the fractures filled with thin seams of bentonite):

Tan ϕ	c
0.180	0.80

Bentonite on shale (Field test material):
Quick shear

Tan ϕ	c
0.120	0.0
0.126	0.4

Weathered shale:

a. Undisturbed sample of disturbed weathered shale in slide area:

Consolidated		Quick shear	
Tan ϕ	c	Tan ϕ	c
0.234	0.28	0.037	0.34
0.275	0.30	0.037	0.30
0.205	0.20	0.291	0.40

b. Gouge material from Crosby drift:

Tan ϕ	c
0.182 (quick shear)	0.20
0.210 (consolidated)	0.50

c. Sample taken from block of soft shale from weathered zone in Merriman drift at inlet portals:

Tan ϕ	c
0.302	0.40
0.282	1.00
0.294	0.00

d. Field Shear Test. Shale on bentonite.

Tan ϕ	c
0.151	0.05

e. Weathered shale from Calyx No. 2:

Tan ϕ	c
0.262	0.00

f. Undisturbed weathered shale from Calyx No. 3:

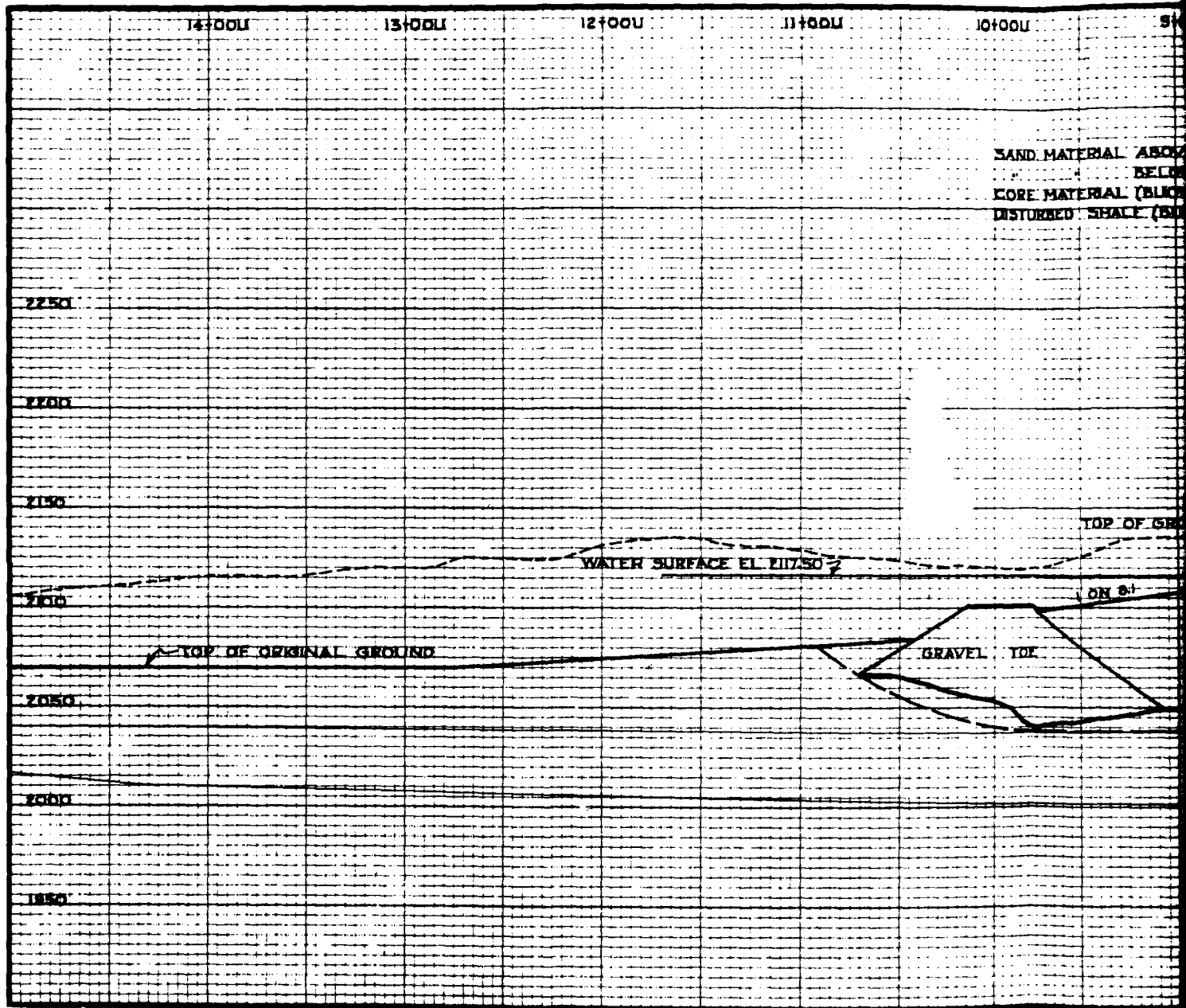
Tan ϕ	c
0.298	0.20

Surface clay:

Consolidated		Quick shear	
Tan ϕ	c	Tan ϕ	c
0.210	0.40	0.067	0.25
0.153	0.50	0.014	0.41
0.158	0.50	0.014	0.40
		0.050	0.20
		0.051	0.31

CORE MATERIAL

Hole	Sample	Tan ϕ	Cohesion
C-7-----	3	0.633	0.0
	4	.702	0.0
	5	.564	0.0
	6	.675	0.0
	8	.694	0.0
	18	.579	0.0
	19	.787	0.0
	22	.698	0.0
	28	.696	0.0
	36	.367	0.15
	40	.616	0.00
	45	.656	0.00
	50	.523	0.20
	55	.607	0.10
	60	.750	0.00
	64	.684	0.00
	76	.653	0.00
	80	.682	0.05
C-8-----	1	.485	0.00
	2	.705	0.00
	3	.687	0.00
	10	.727	0.00
	14	.463	0.10
	17	.741	0.00
	19	.628	0.00
	22	.787	0.00
	29	.575	0.00
	34	.500	0.10
	39	.673	0.00
	44	.673	0.05
C-9-----	49	.667	0.00
	53	.667	0.00
	57	.610	0.00
	58	.750	0.00
	67	.750	0.00
	1	.482	0.1
	3	.692	0.0
	6	.585	0.2
	8	.414	0.22
	12	.631	0.0
	17	.714	0.0
	21	.547	0.0
	27	.628	0.0

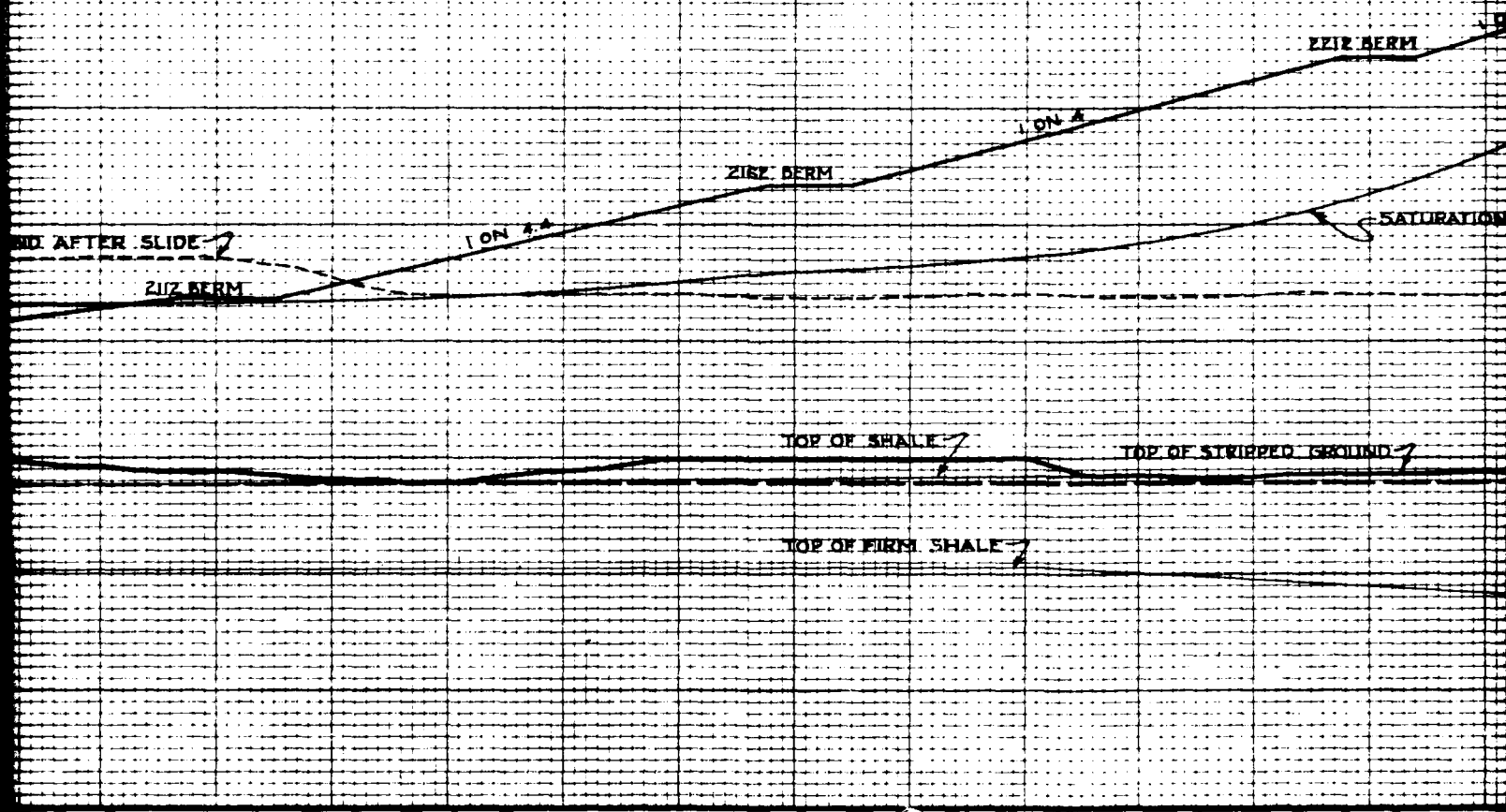


(Face p. 14) No. 16

8+00U 7+00U 6+00U 5+00U 4+00U 3+00U

TABLE OF WEIGHTS

SATURATION LINE	105 LB/CU.FT
(BUOYED)	60 LB/CU.FT
(D)	65 LB/CU.FT
(ED)	78 LB/CU.FT



2+00U

1+00U

AXIS

1+00D

2+00D

VALUES
REQUIRED
PRIOR TO
OF L.O.

FOR

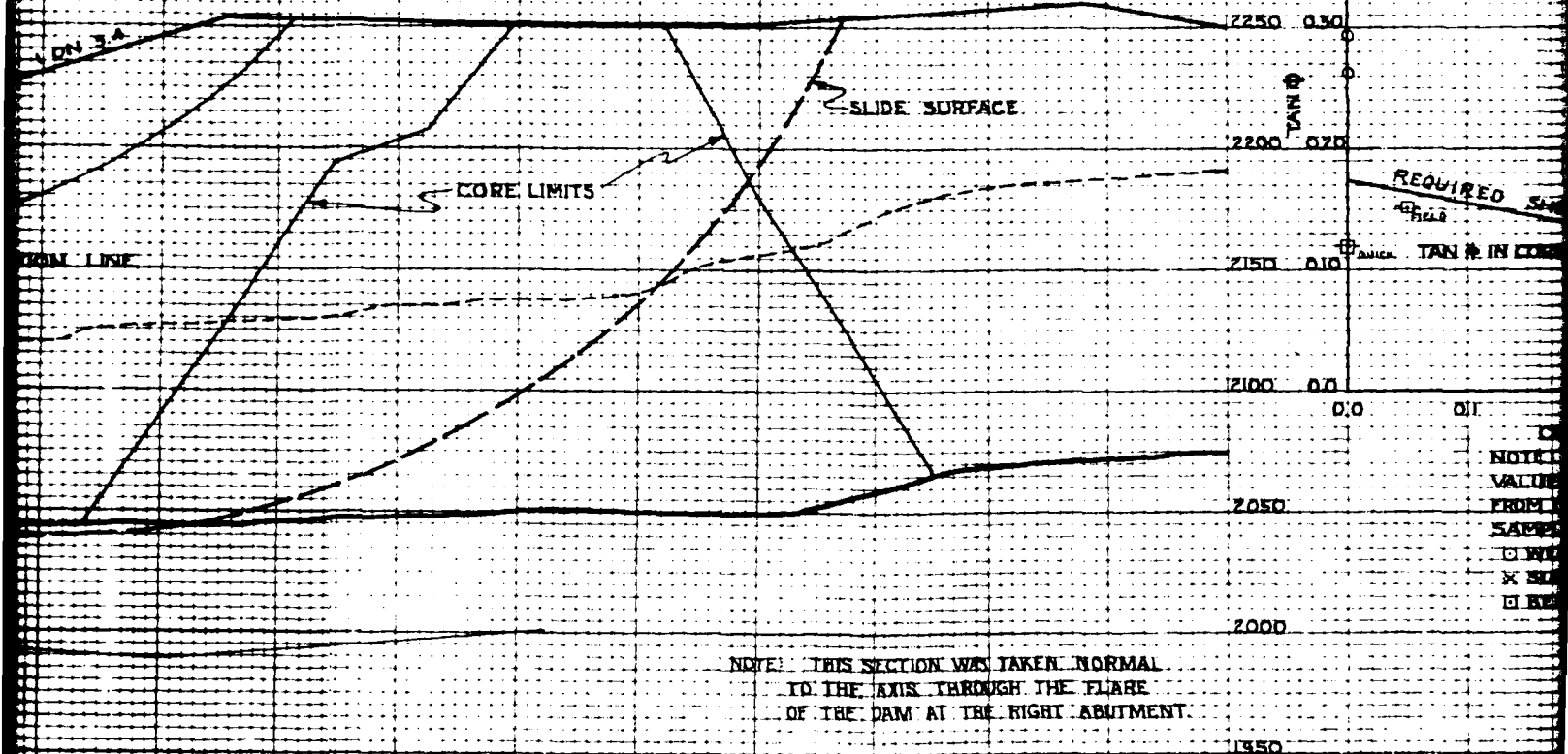


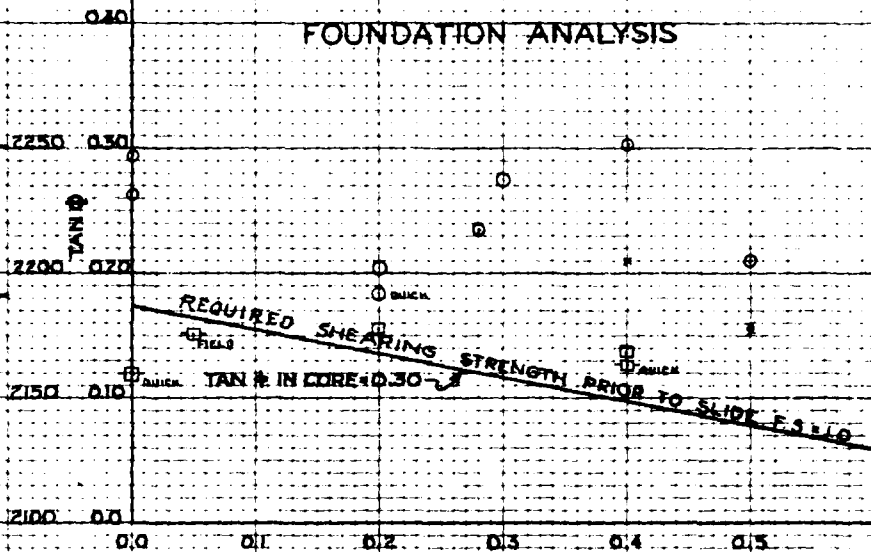
Figure 12

STA 12+75

STATIC SLIDE ANALYSIS

VALUES OF FRICTION & COHESION
REQUIRED ALONG BASE OF DAM JUST
PRIOR TO SLIDE FOR FACTOR OF SAFETY
OF 1.0

FOUNDATION ANALYSIS



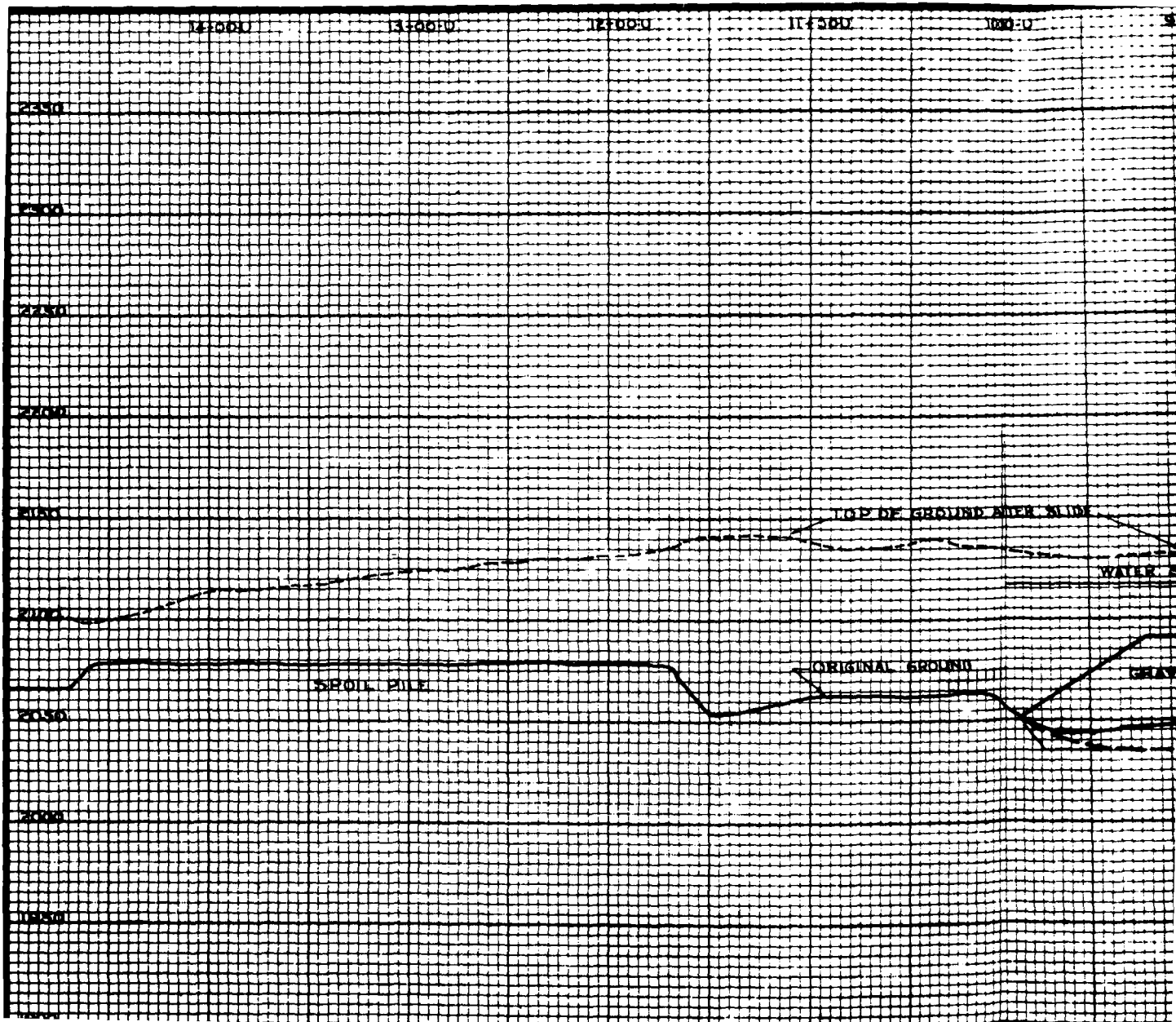
NOTE:
VALUES OF FRICTION AND COHESION DETERMINED
FROM CONSOLIDATED SHEAR TESTS ON UNDISTURBED
SAMPLES ARE INDICATED THUS:

- WEATHERED SHALE INVOLVED IN SLIDE
- × SURFACE CLAY
- BENTONITE □ BENTONITE QUICK SHEAR

FORT PECK DAM STABILITY ANALYSIS

UPSTREAM SLOPE AT STA. 12+75

PRIOR TO SLIDE
COMPILED BY D.H.M.
2-4-39



9400-10

SECRET

7400:U

二五七〇〇—五

5-00-0

4-000-02

食

TABLE OF WEIGHTS

SAND MATERIAL ABOVE SATURATION LINE	105 LB/CU FT
BELOW (BOUYED)	60
CORE MATERIAL (BOUYED)	65
DISTURBED SHALE (BOUYED)	78

3+00-U

2+00-U

1+00-U

AXIS

1+00-D

2+00-D

2401 BERM

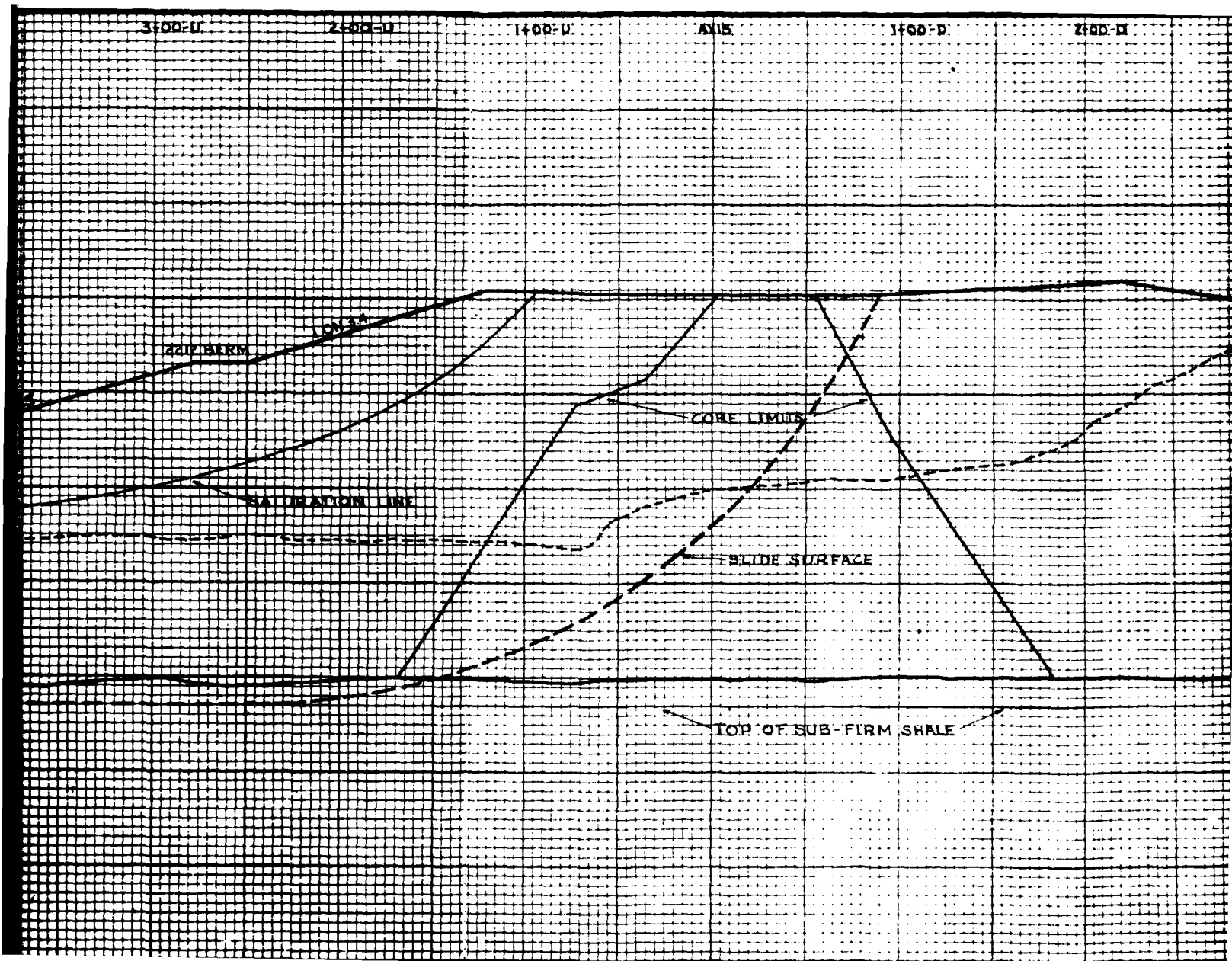
LOW 3A

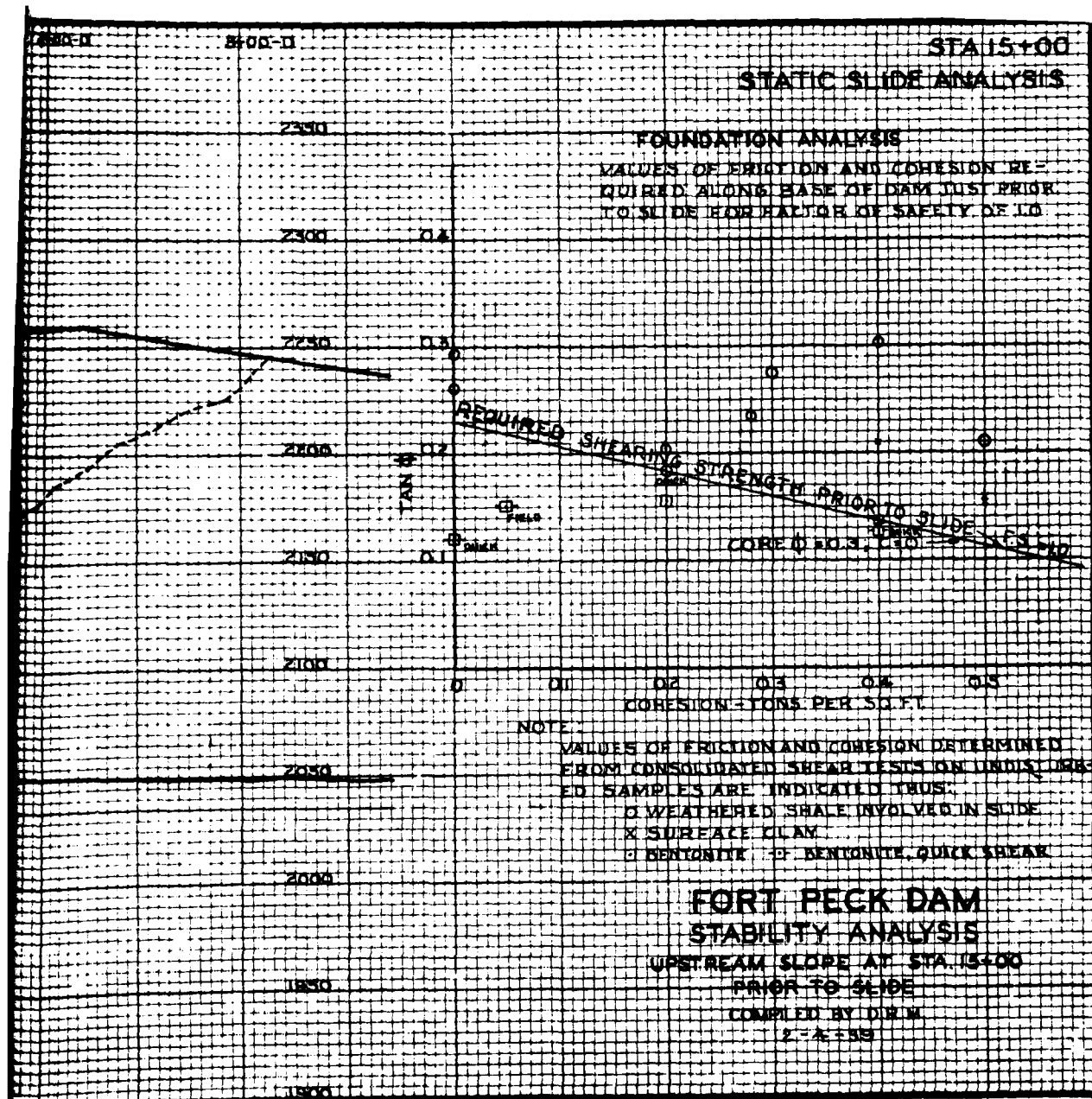
CORE LIMITS

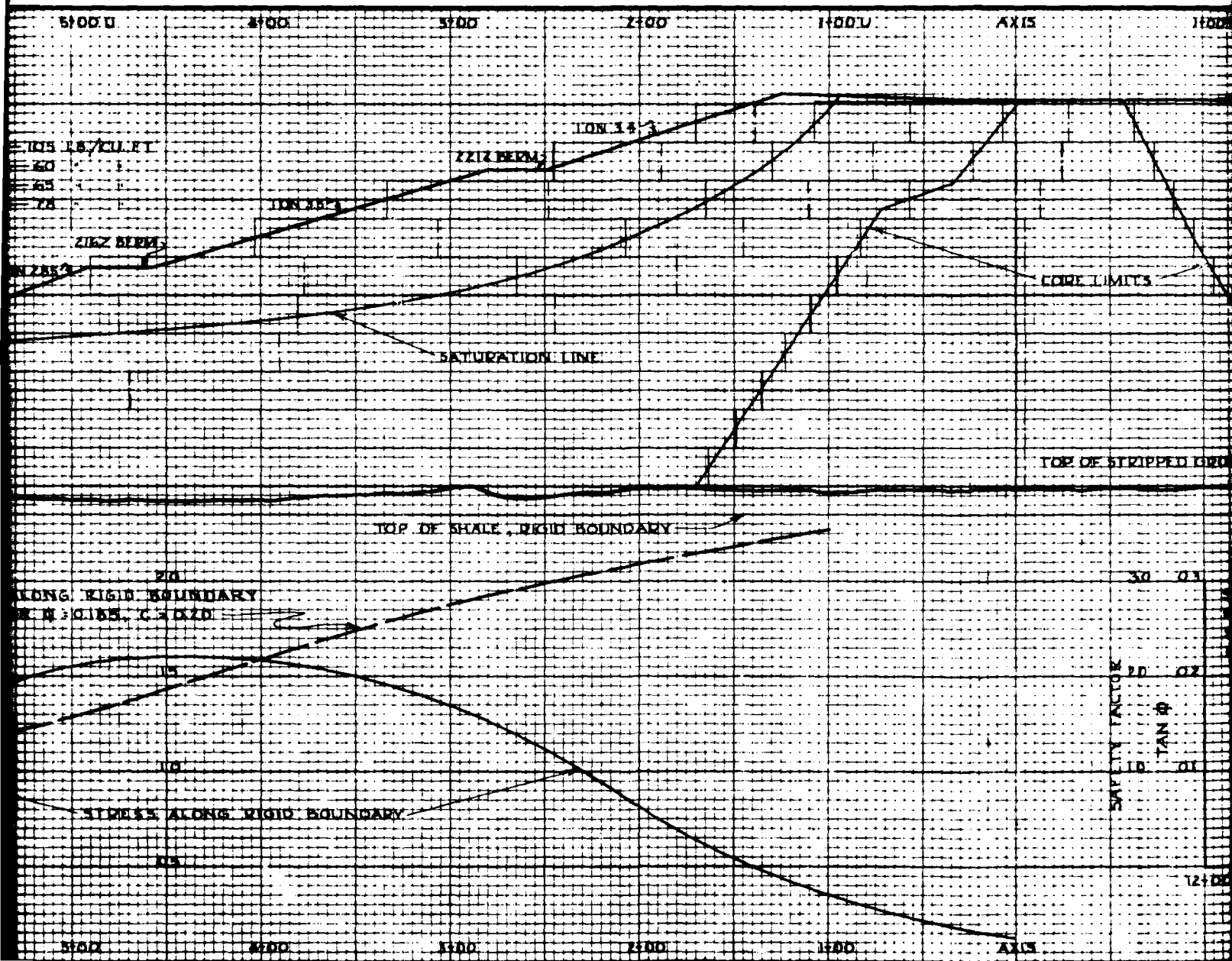
SATURATION LINE

SLIDE SURFACE

TOP OF SUB-FIRM SHALE

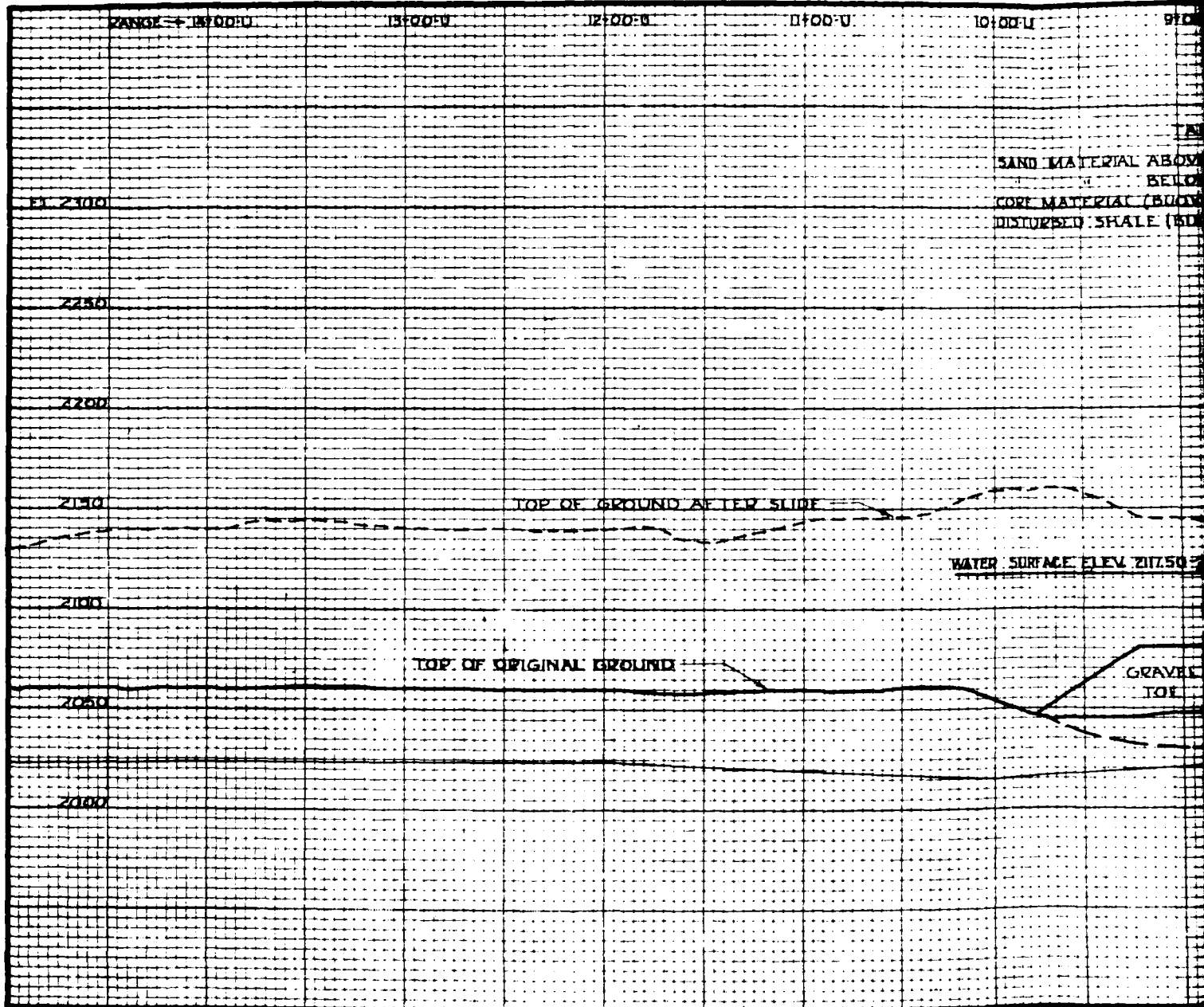






STA 15+00

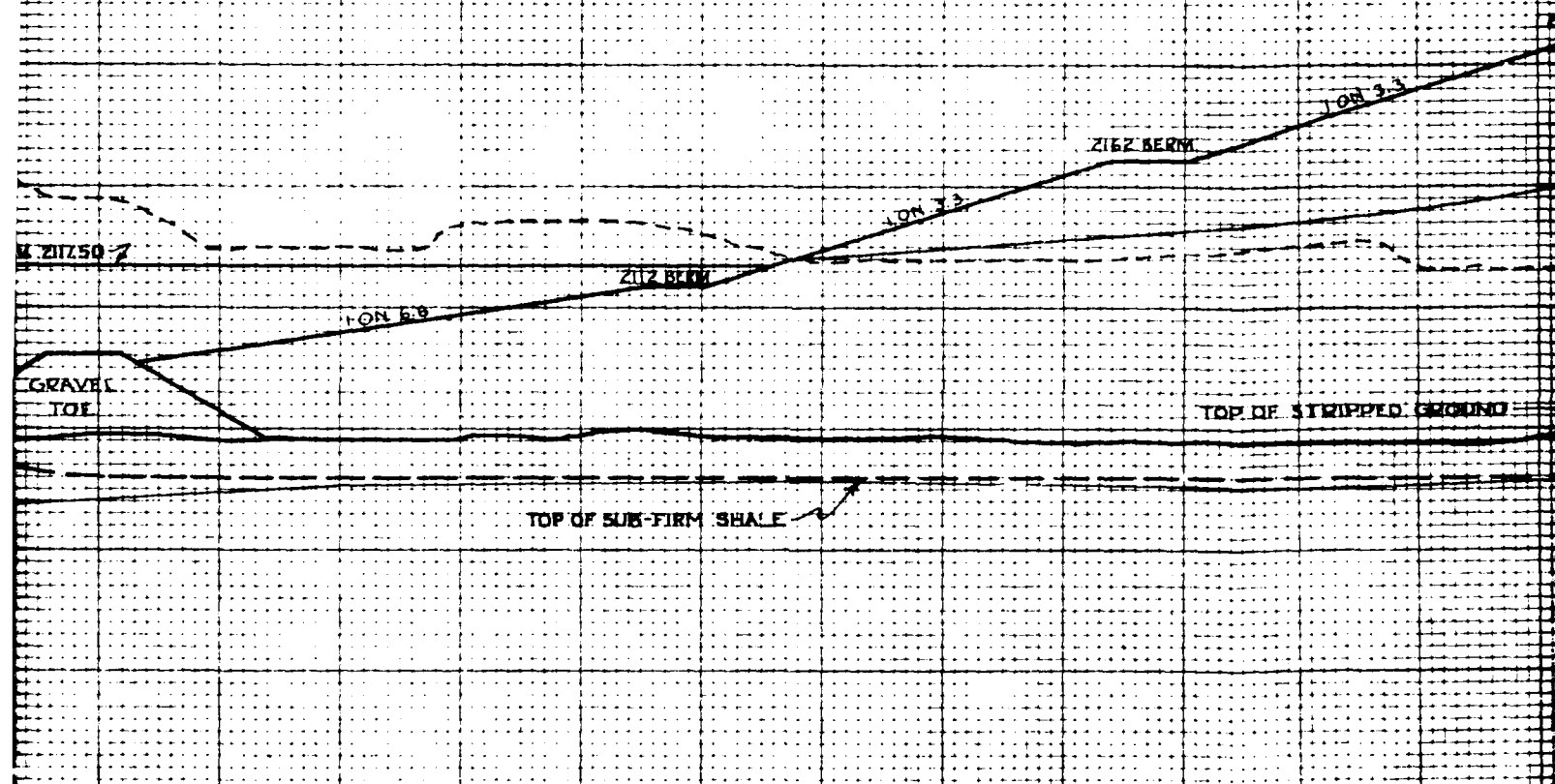




(Face p. 14) No. 19

Figure 2

AL ABOVE SATURATION LINE	105 LB./CU.FT.
BELOW (BUOYED)	60 "
IT (BUOYED)	65 "
ALE (BUOYED)	78 "



2

3000 FT

2500 FT

2000 FT

AXIS

1500 FT

1000 FT

2300

2250

2200

2150

2100

2050

2000

2212 BERM

1000

SATURATION LINE

CORE LIMITS

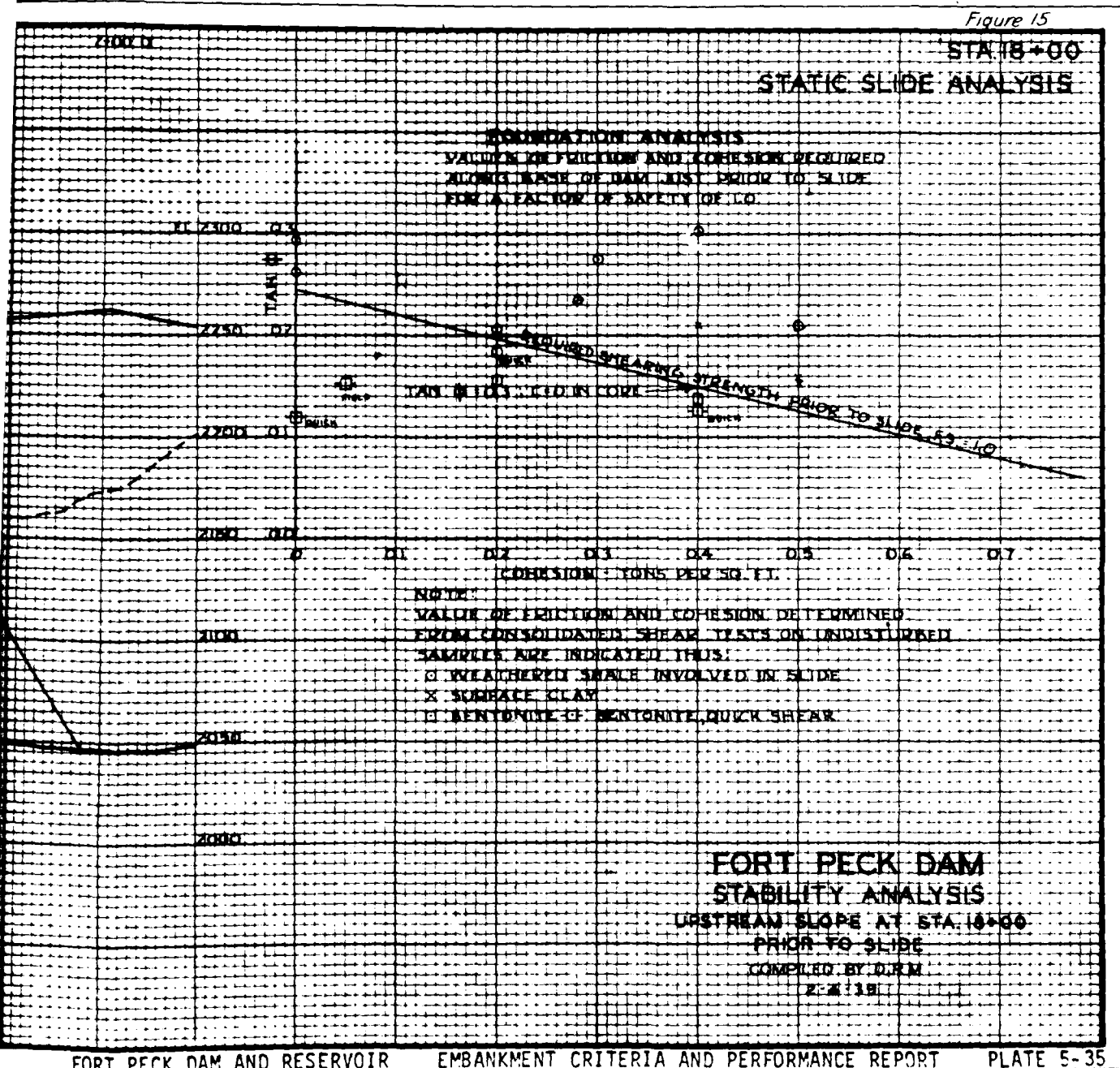
SLIDE SURFACE

W. GROUND

FORT PECK DAM

3

Figure 15



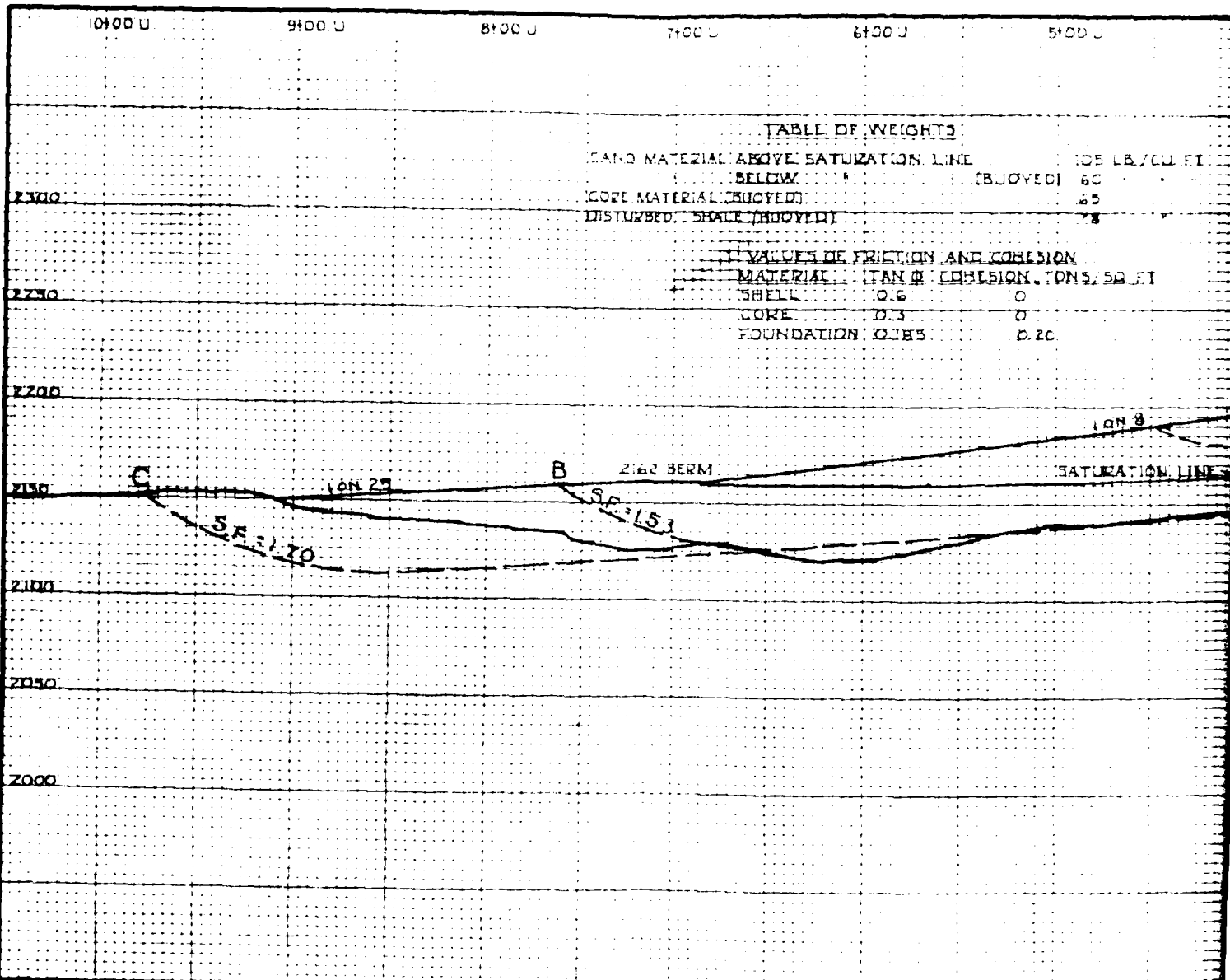
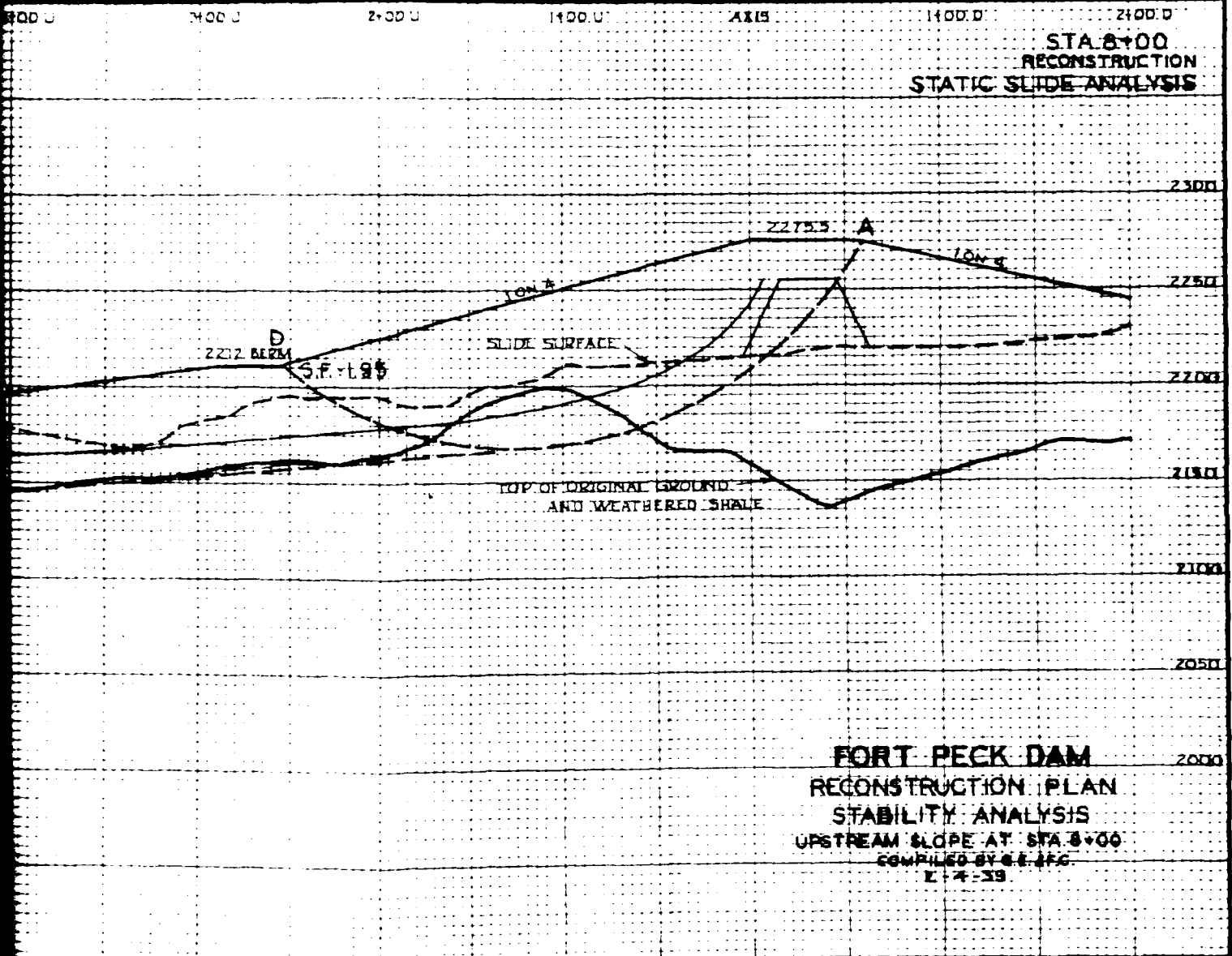


Figure 17



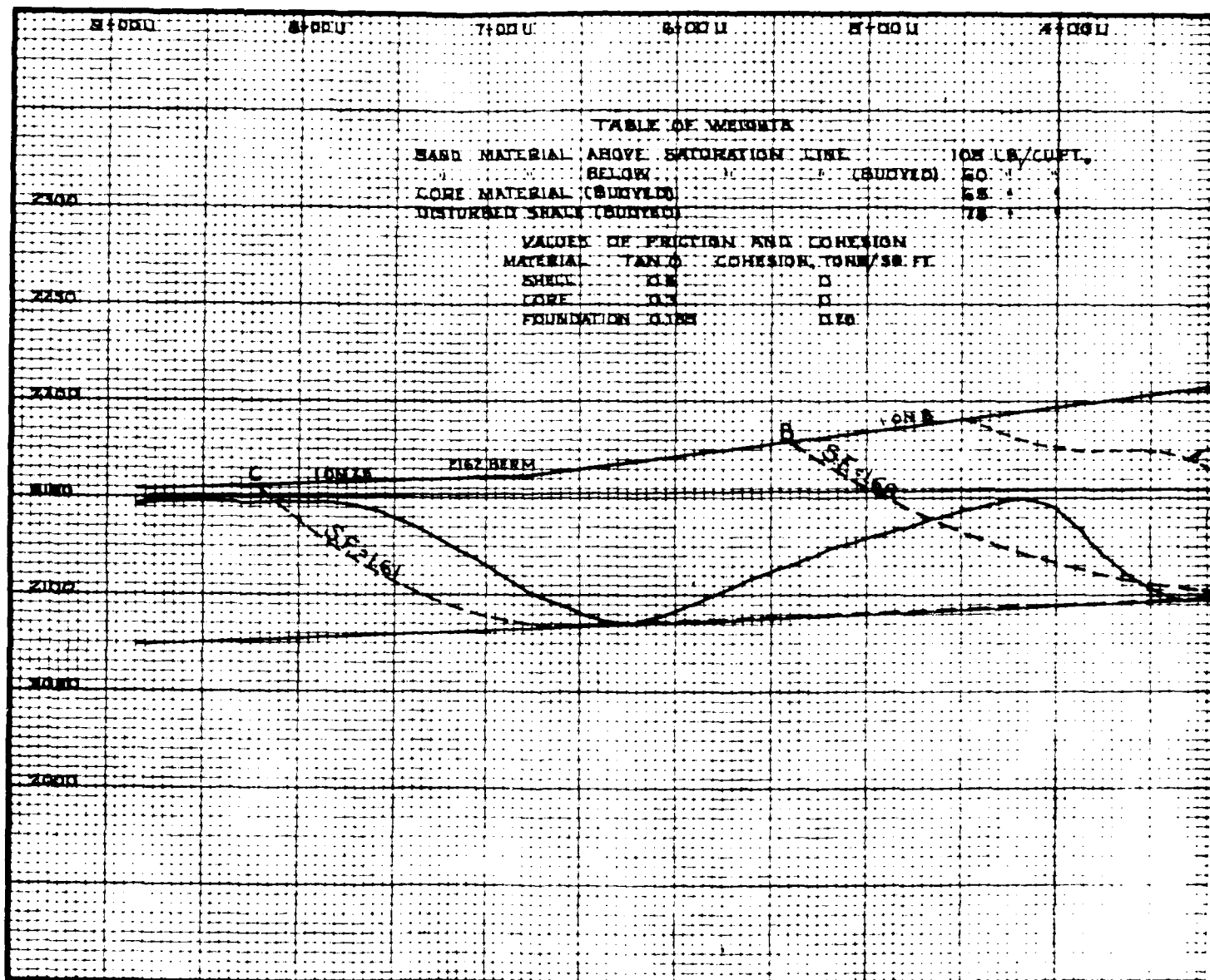
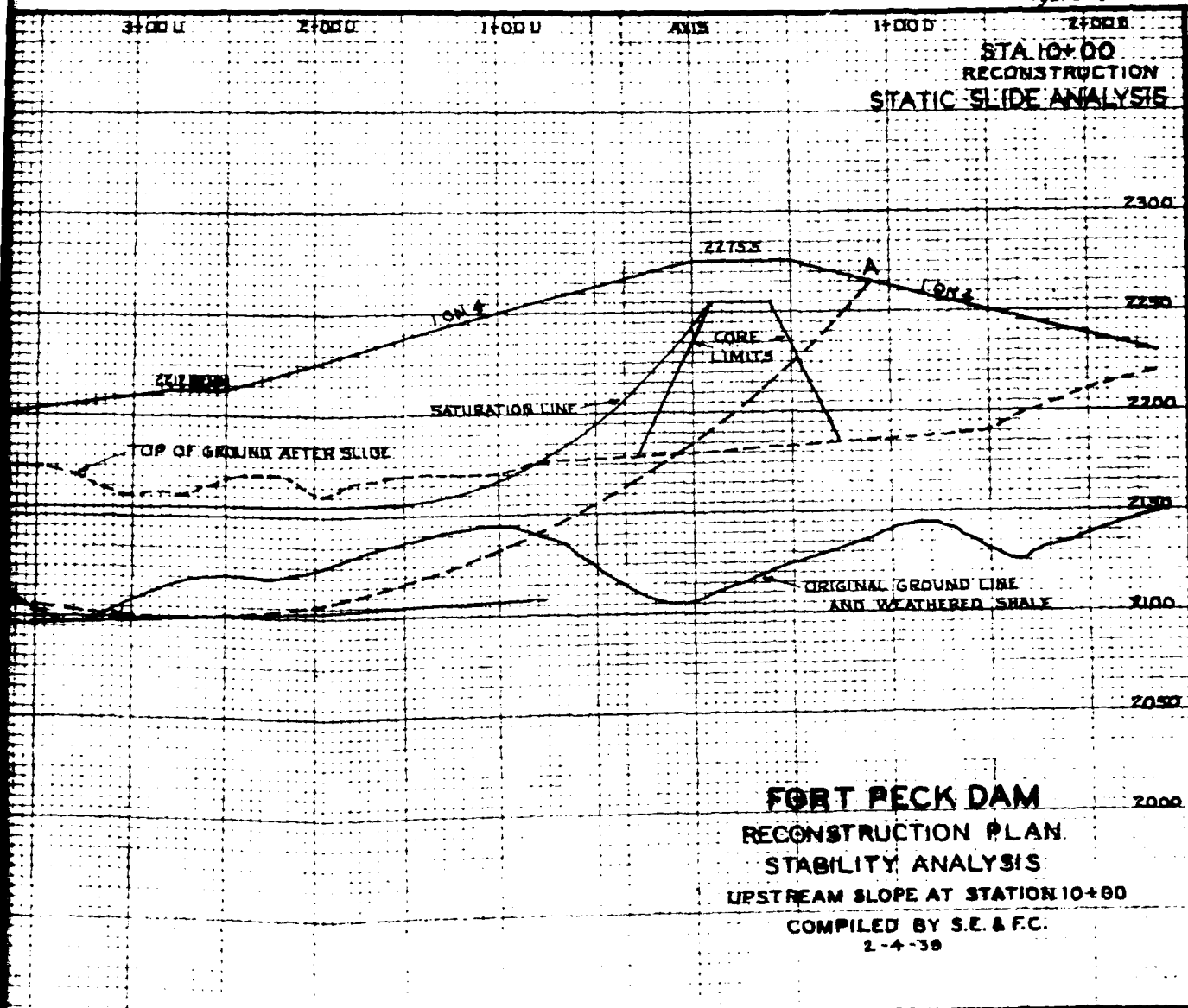
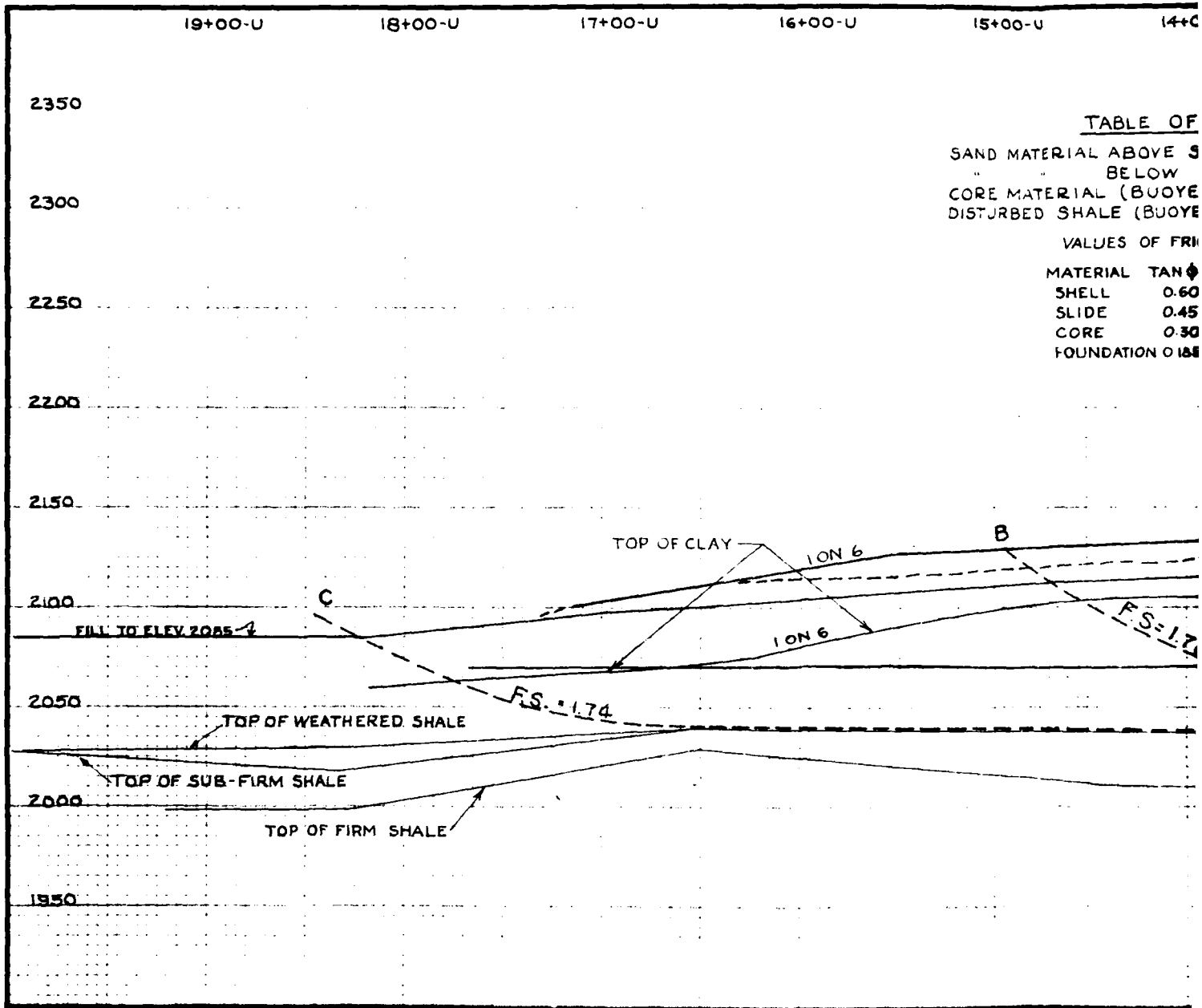


Figure 18





15+00-U

14+00-U

13+00-U

12+00-U

11+00-U

10+00-U

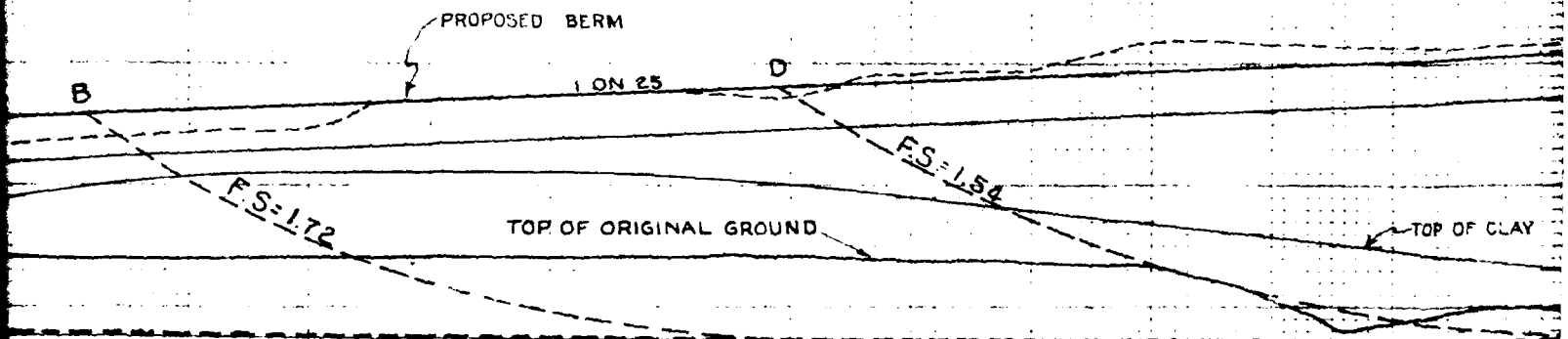
9+00-U

TABLE OF WEIGHTS

SAND MATERIAL ABOVE SATURATION LINE 105 LB./CU.FT.
 " " BELOW " " (BUOYED) 60 " "
 CORE MATERIAL (BUOYED) 65 " "
 DISTURBED SHALE (BUOYED) 78 " "

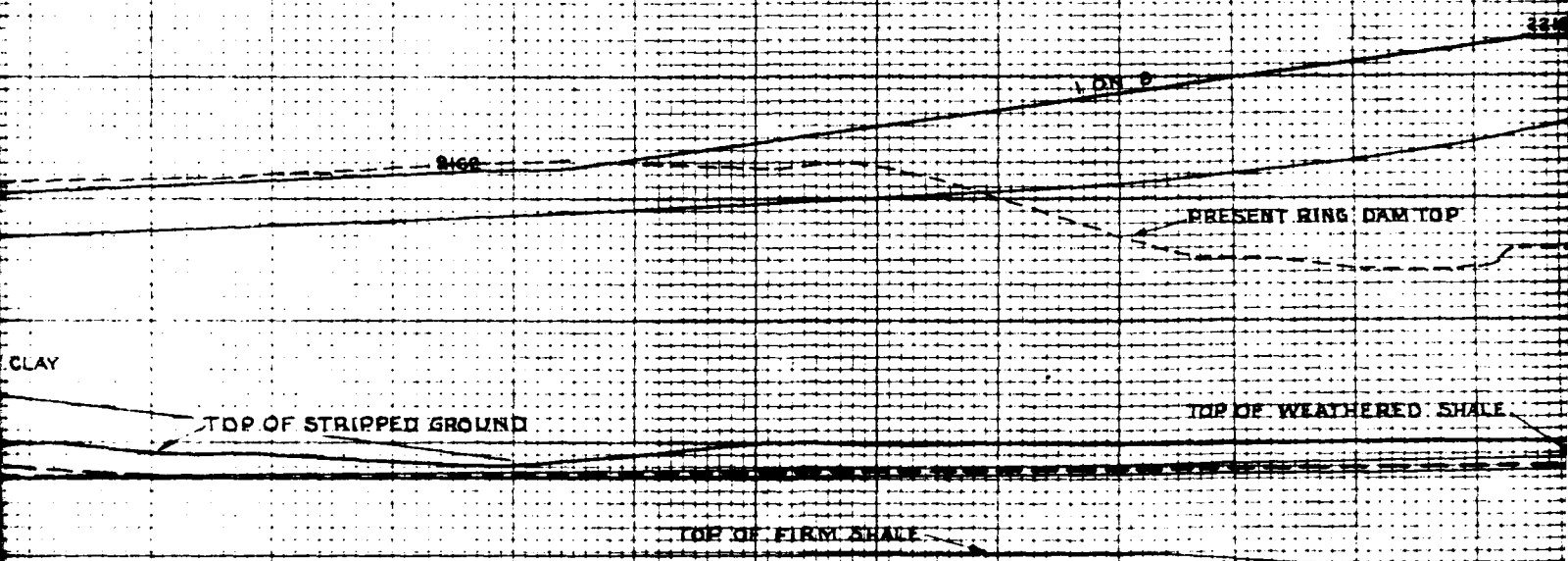
VALUES OF FRICTION AND COHESION

MATERIAL	TAN ϕ	COHESION TONS/SQ.FT.
SHELL	0.60	0.0
SLIDE	0.45	0.0
CORE	0.30	0.0
FOUNDATION	0.185	0.20



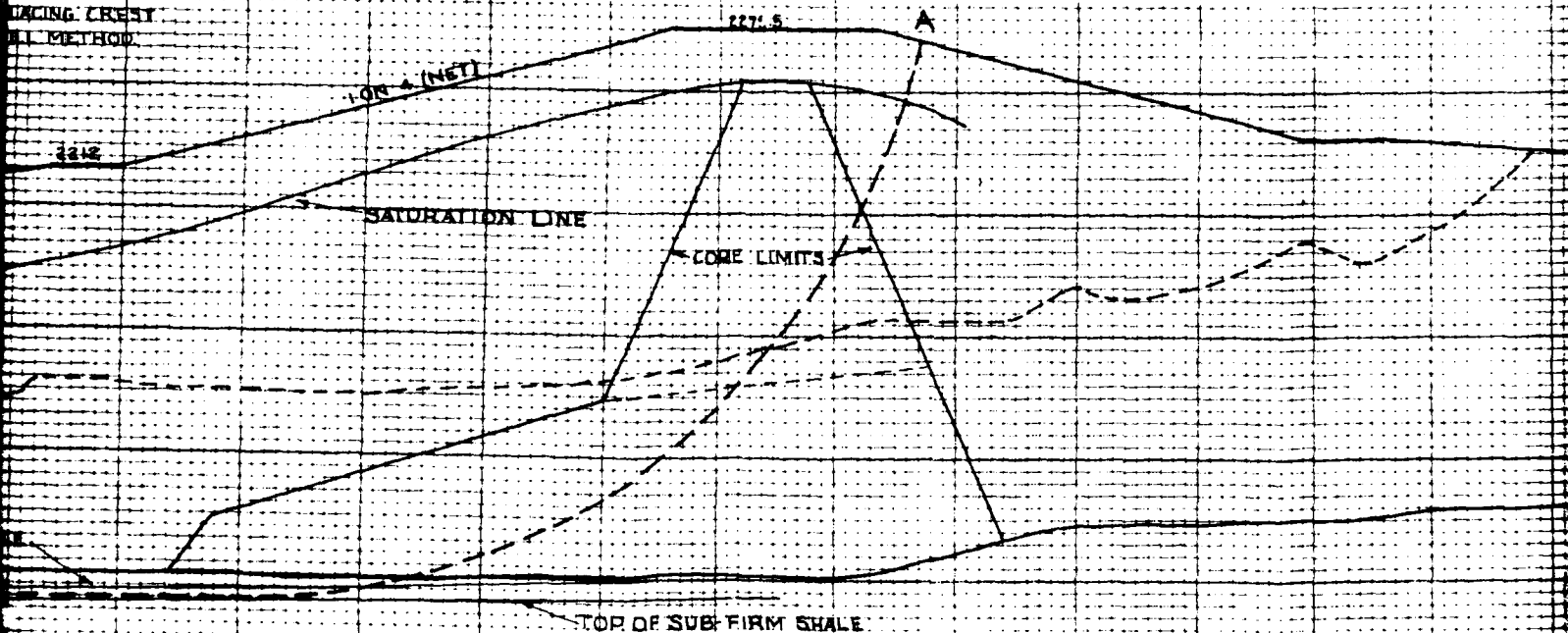
9+00-U 8+00-U 7+00-U 6+00-U 5+00-U 4+00-U 3+00-U

NOTE:
SATURATION LINE AS SHOWN FOR
FOR EXTREME CONDITIONS WHICH
BE DEVELOPED ONLY BY Raising
OF DAM BY HYDRAULIC FILL METHOD



00-U 2+00-U 1+00-U AXIS 1+00-D 2+00-D 3+00-D

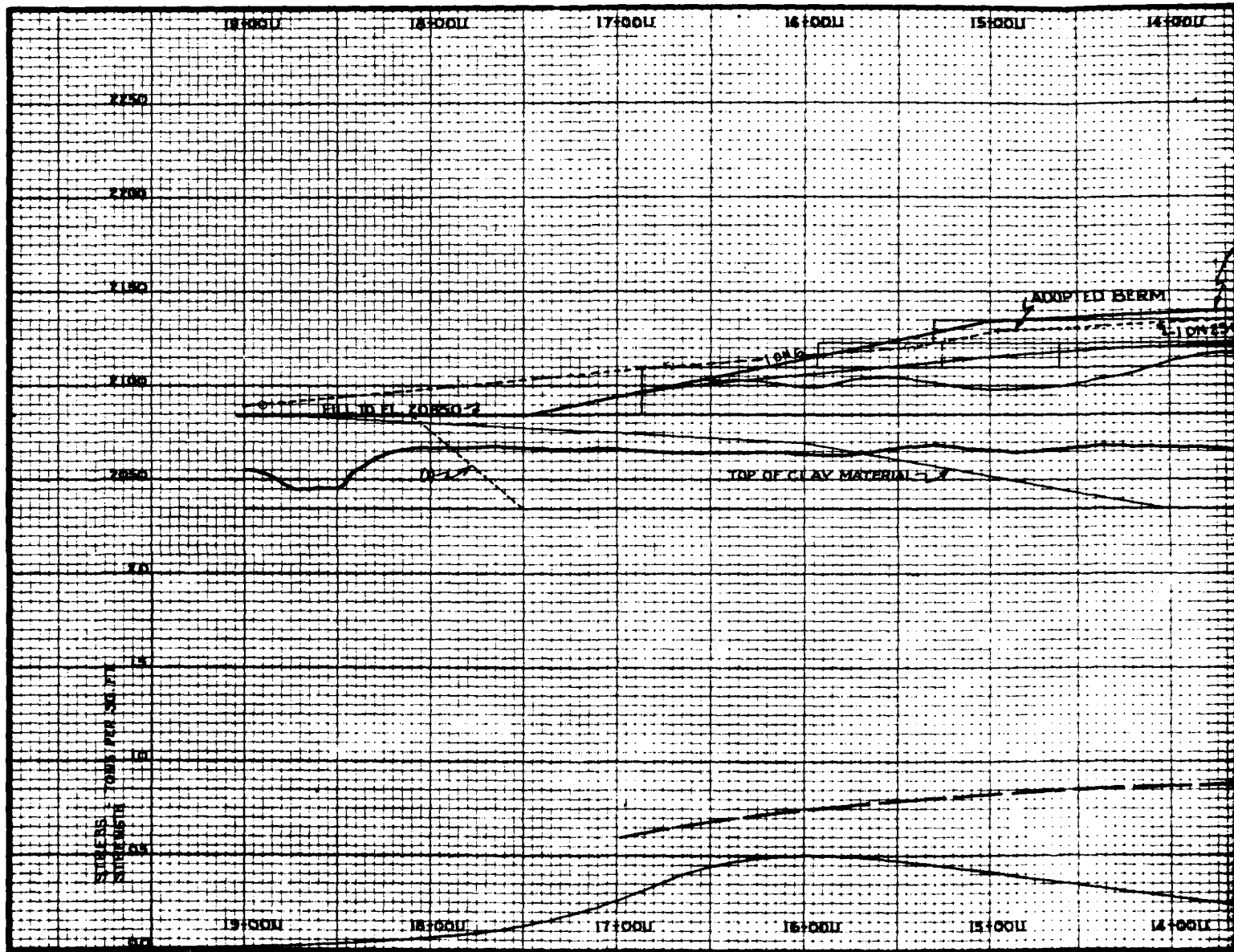
OWN PROVIDES
S WHICH WOULD
LACING CREST
M METHOD



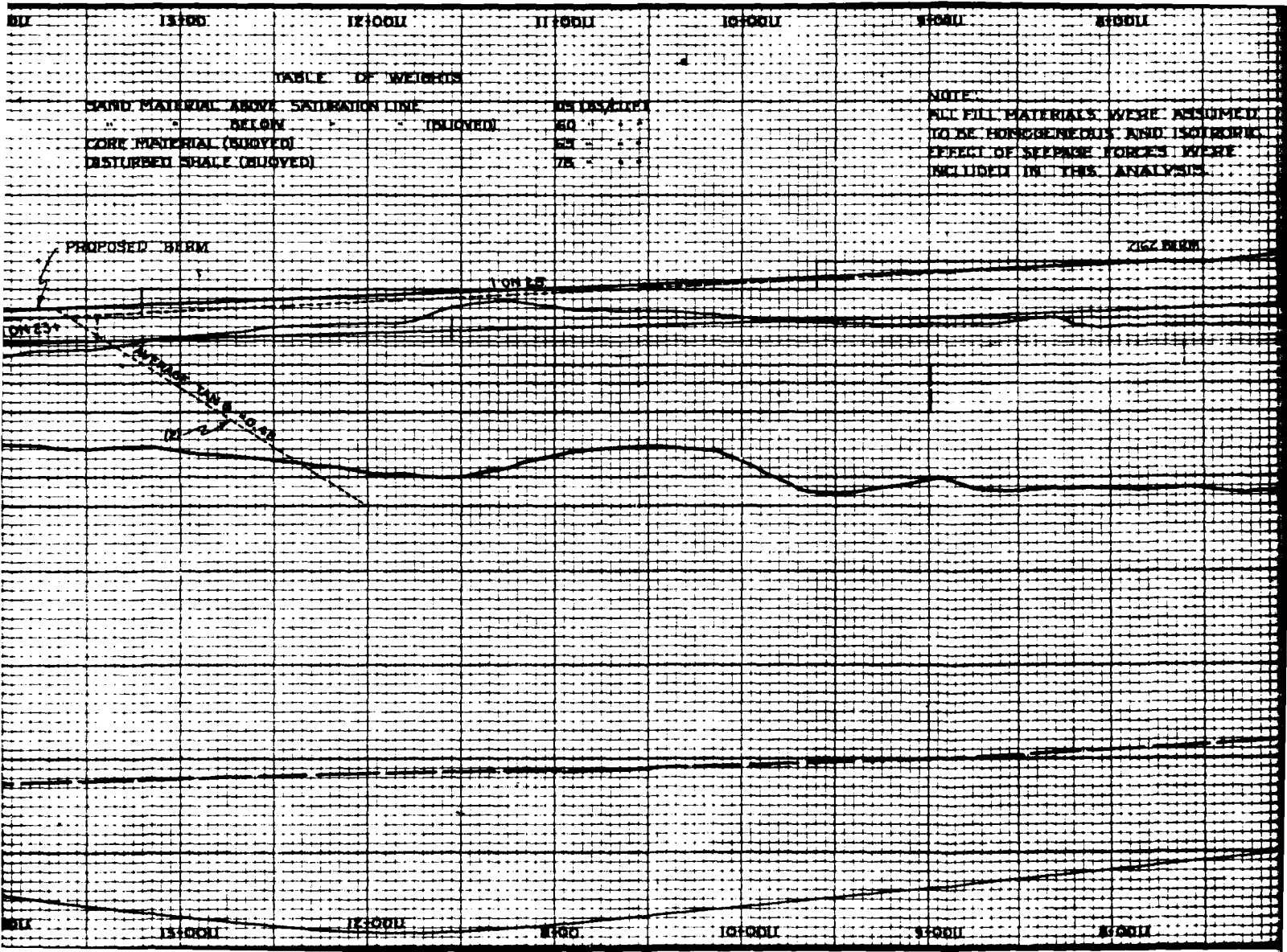
STA. 12+75
RECONSTRUCTION
SIDE ANALYSIS

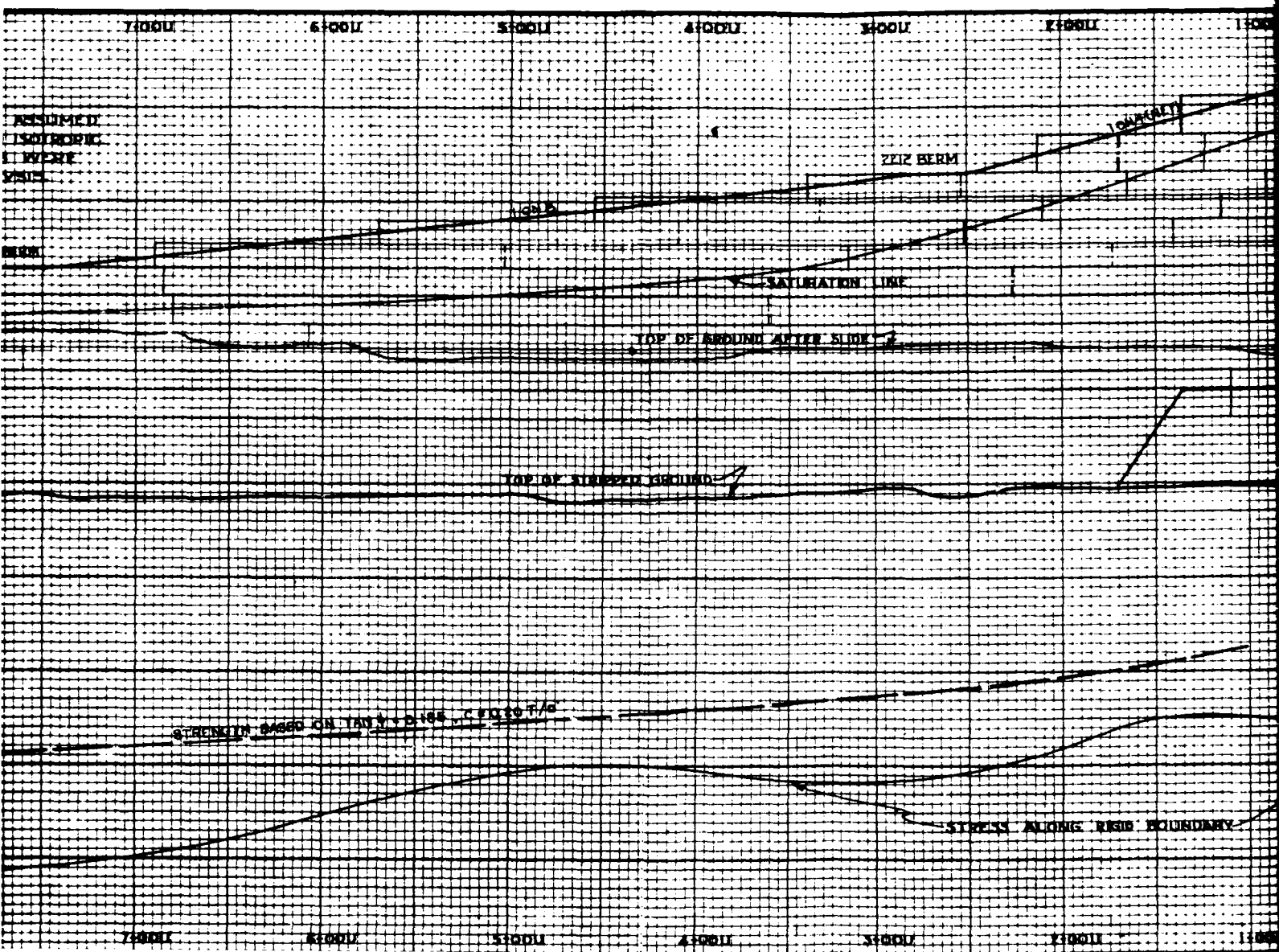


5-



(Face p. 16) No. 4





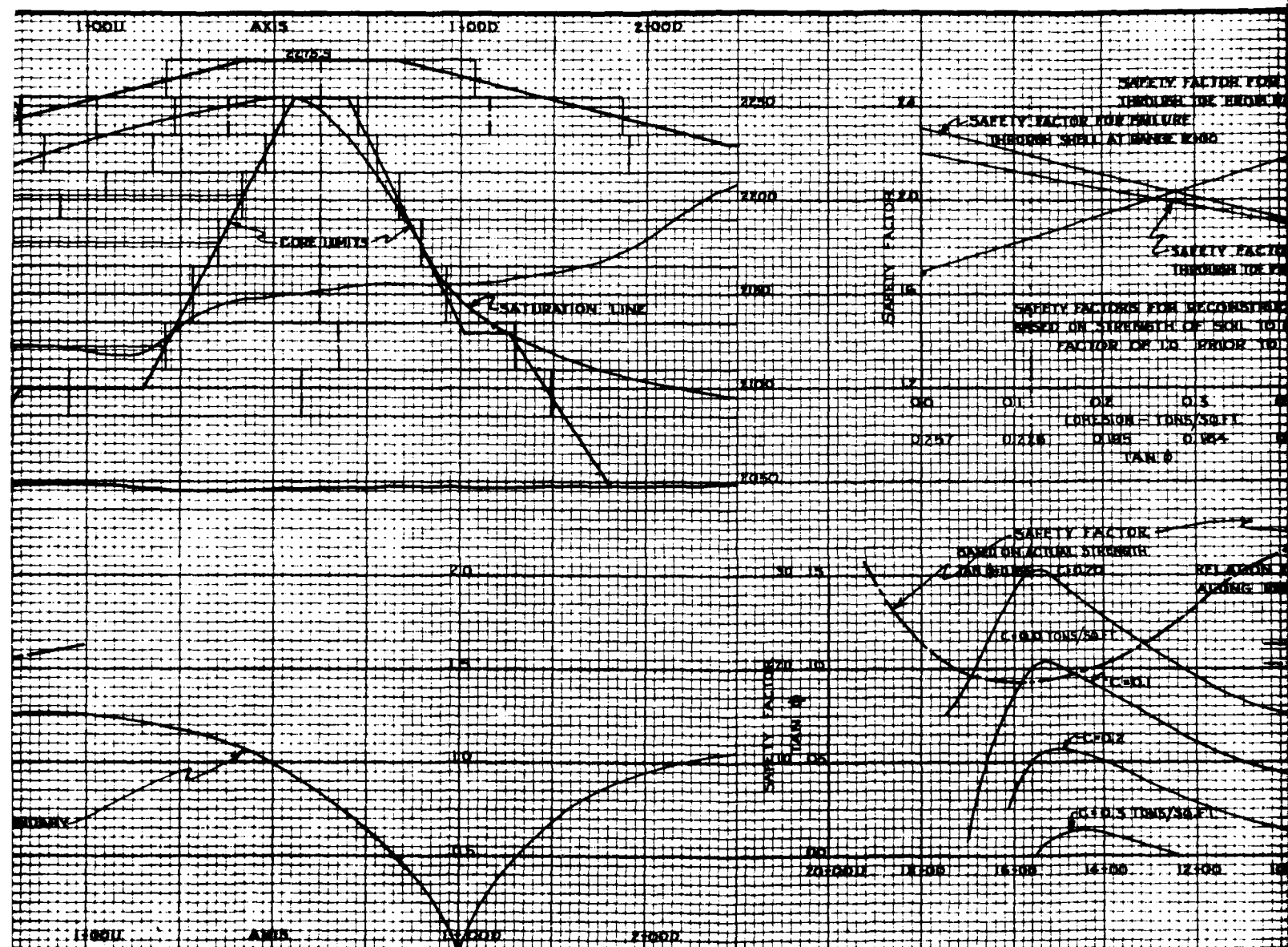
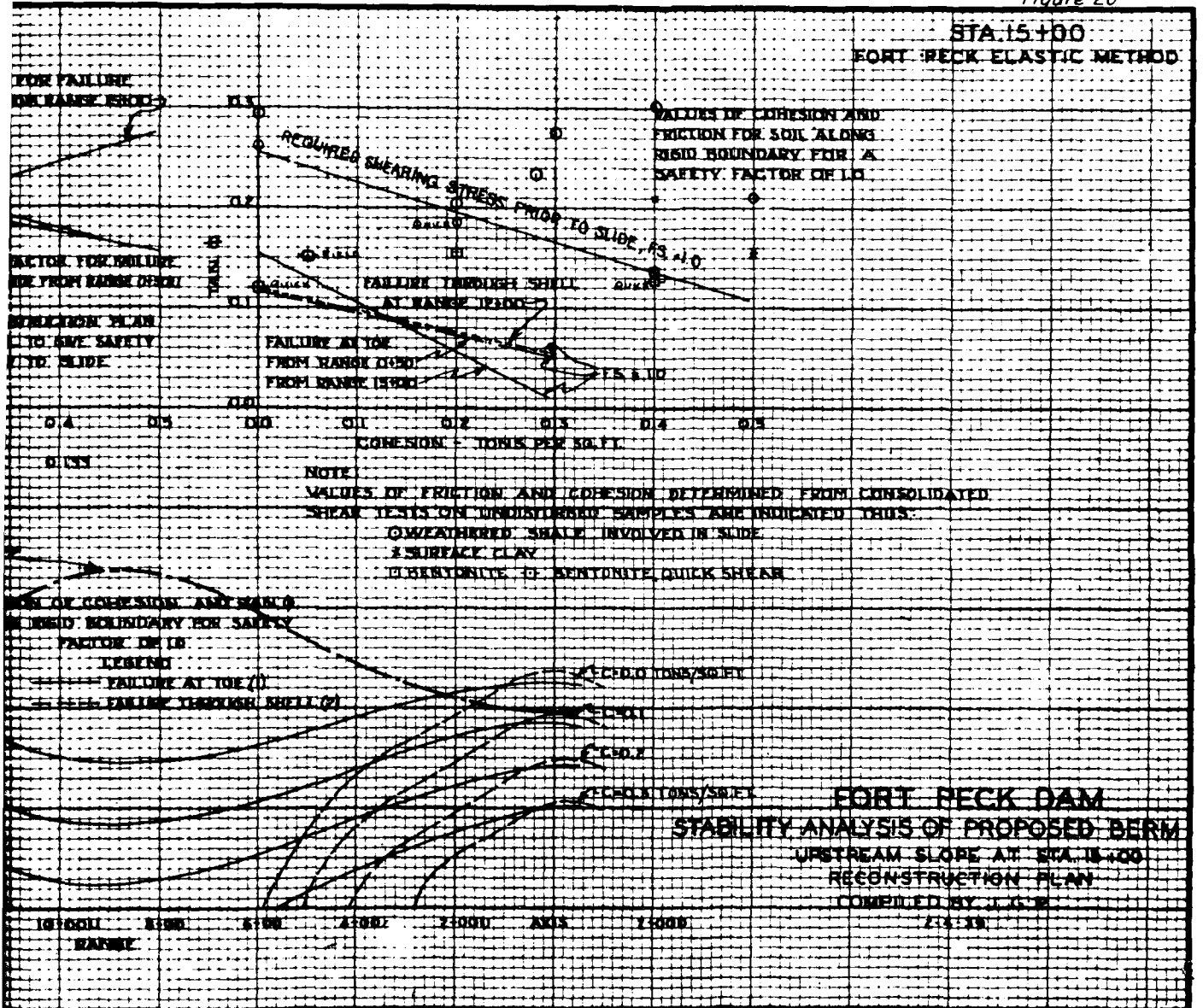
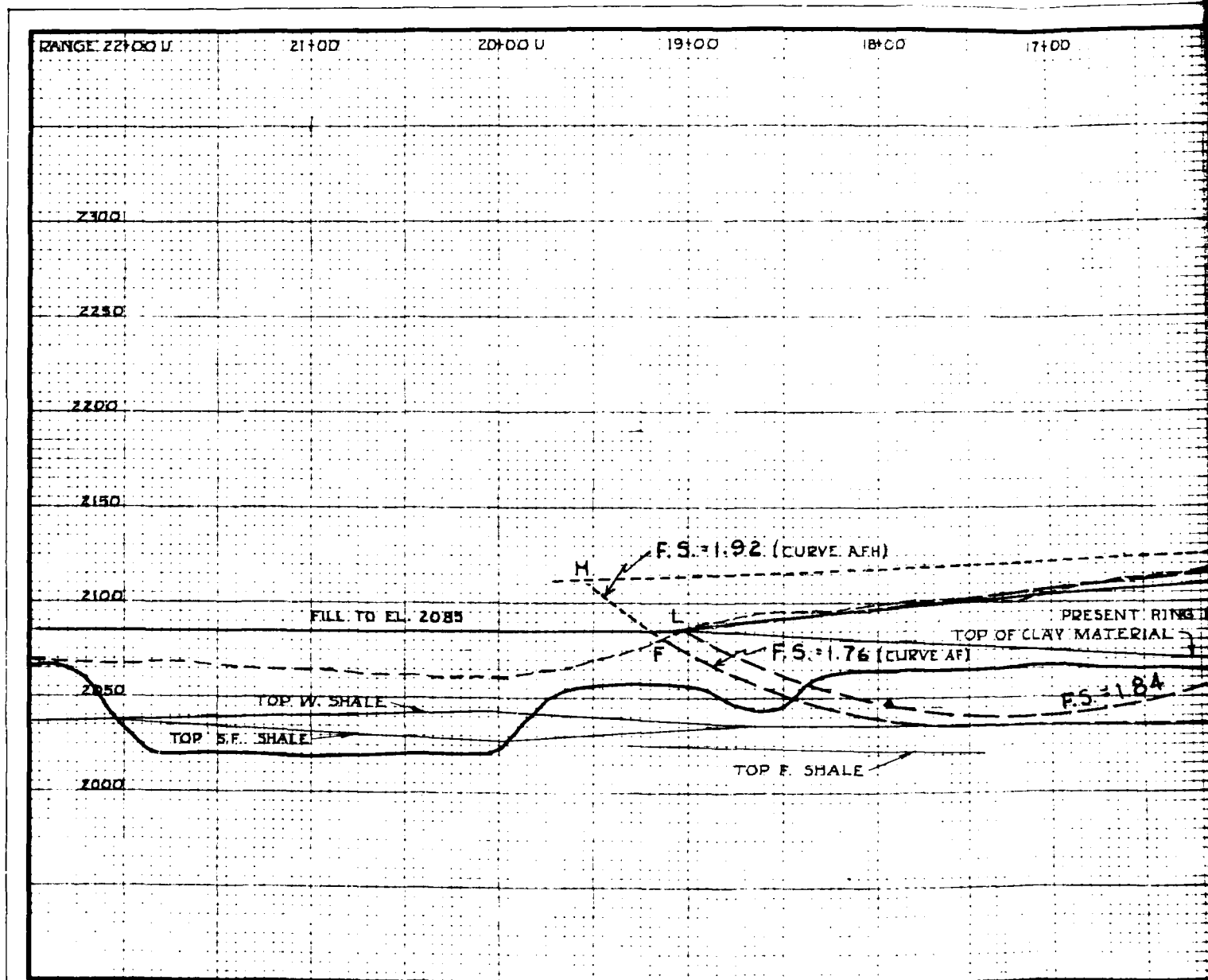


Figure 20





(Face p. 16) No. 5

16+00

15+00 U

14+00

13+00

12+00

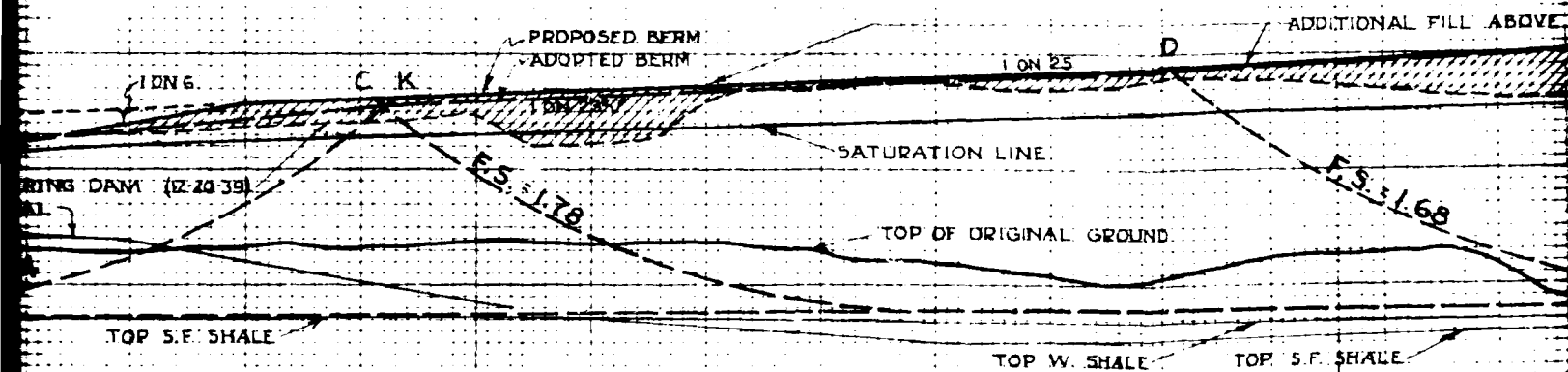
11+00

10+00 U

SAND

CORE

DISTUR



10+00 U 9+00 8+00 7+00 6+00 5+00 U 4+00

TABLE OF WEIGHTS

SAND MATERIAL ABOVE SATURATION LINE	105 LB/CU FT
BELOW (BUOYED)	80
CORE MATERIAL (BUOYED)	65
DISTURBED MATERIAL (BUOYED)	75

VALUES OF FRICTION AND COHESION

MATERIAL	TAN ϕ	COHESION (TONS/30 FT)
SHELL	0.60	0
SLIDE	0.45	0
CORE	0.30	0
FOUNDATION	0.185	0.20

LL ABOVE PRESENT RING DAM

Y F THE BERM

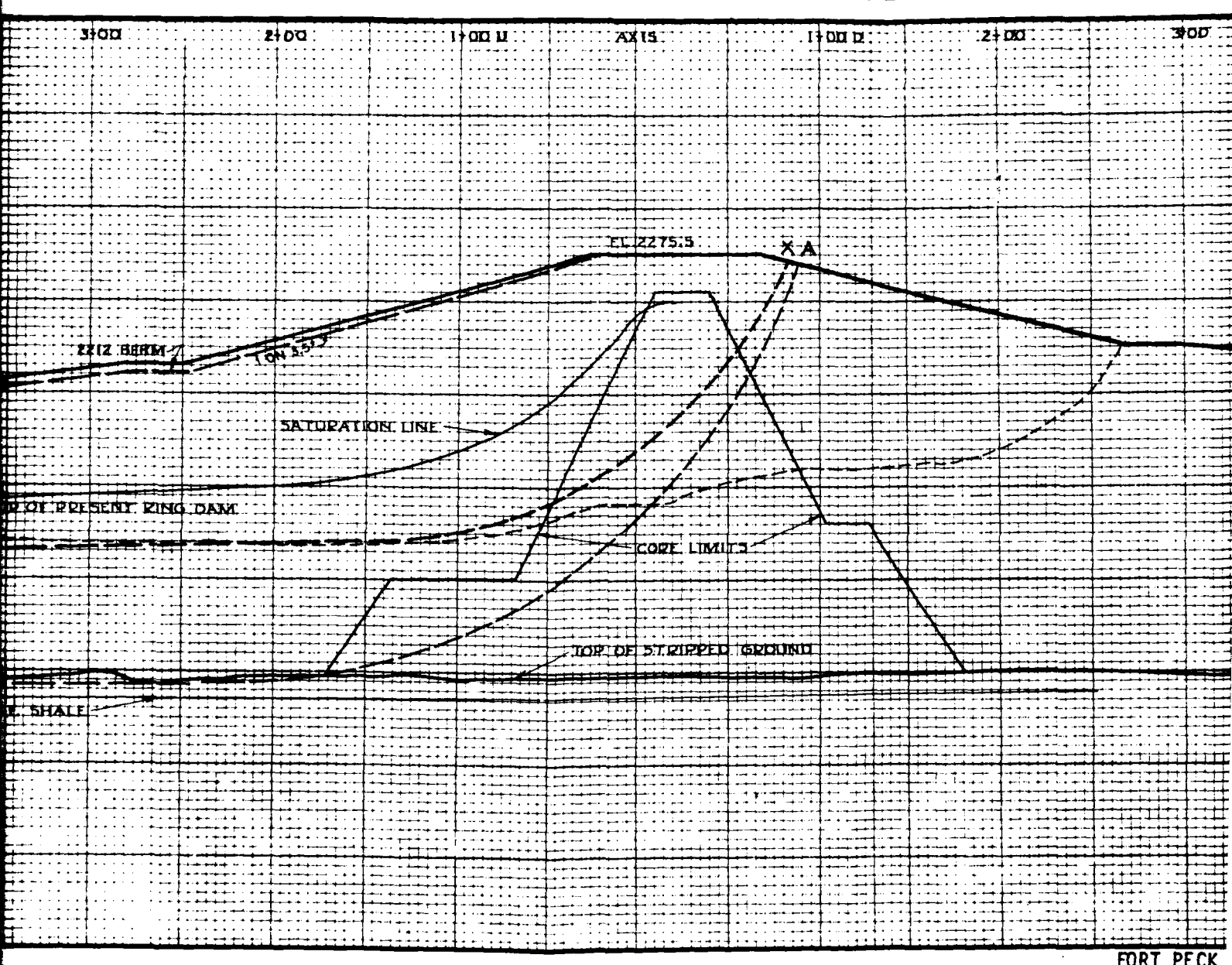
TAN $\phi = 0.2$

F₃ = 2.0

F₃ = 1.64

TOP F. SHALE

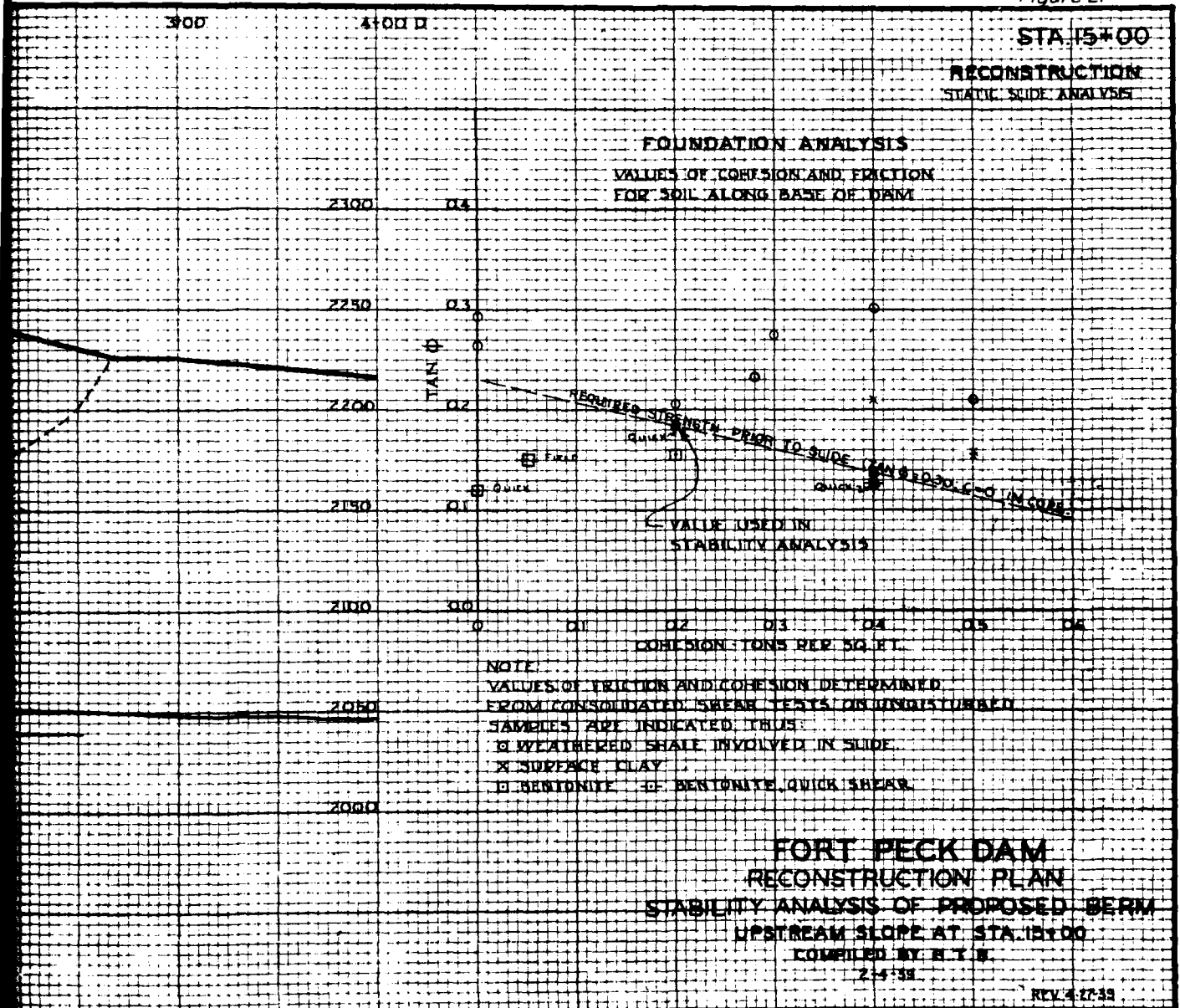
3



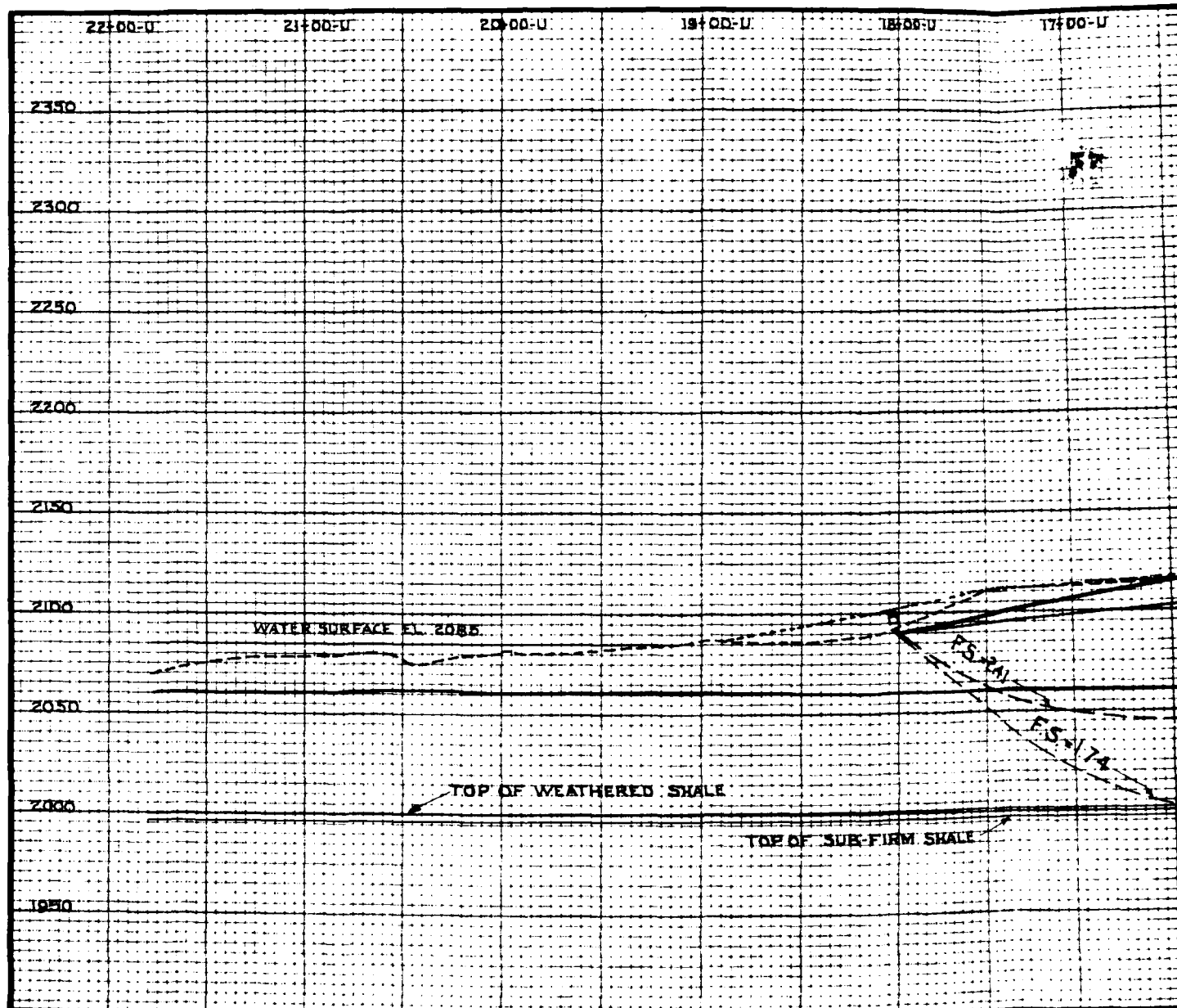
FORT PECK

4

Figure 21



5



16+00-U

15+00-U

14+00-U

13+00-U

12+00-U

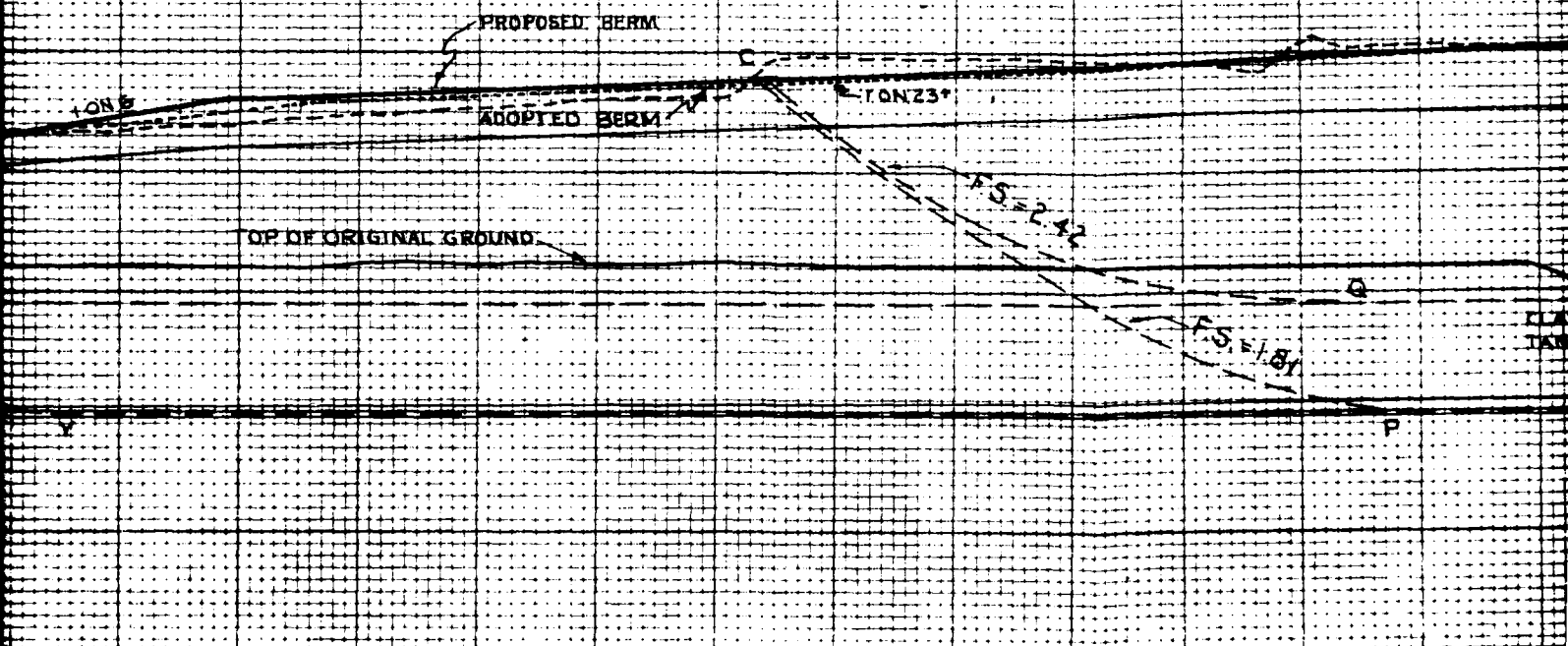
11+00-U

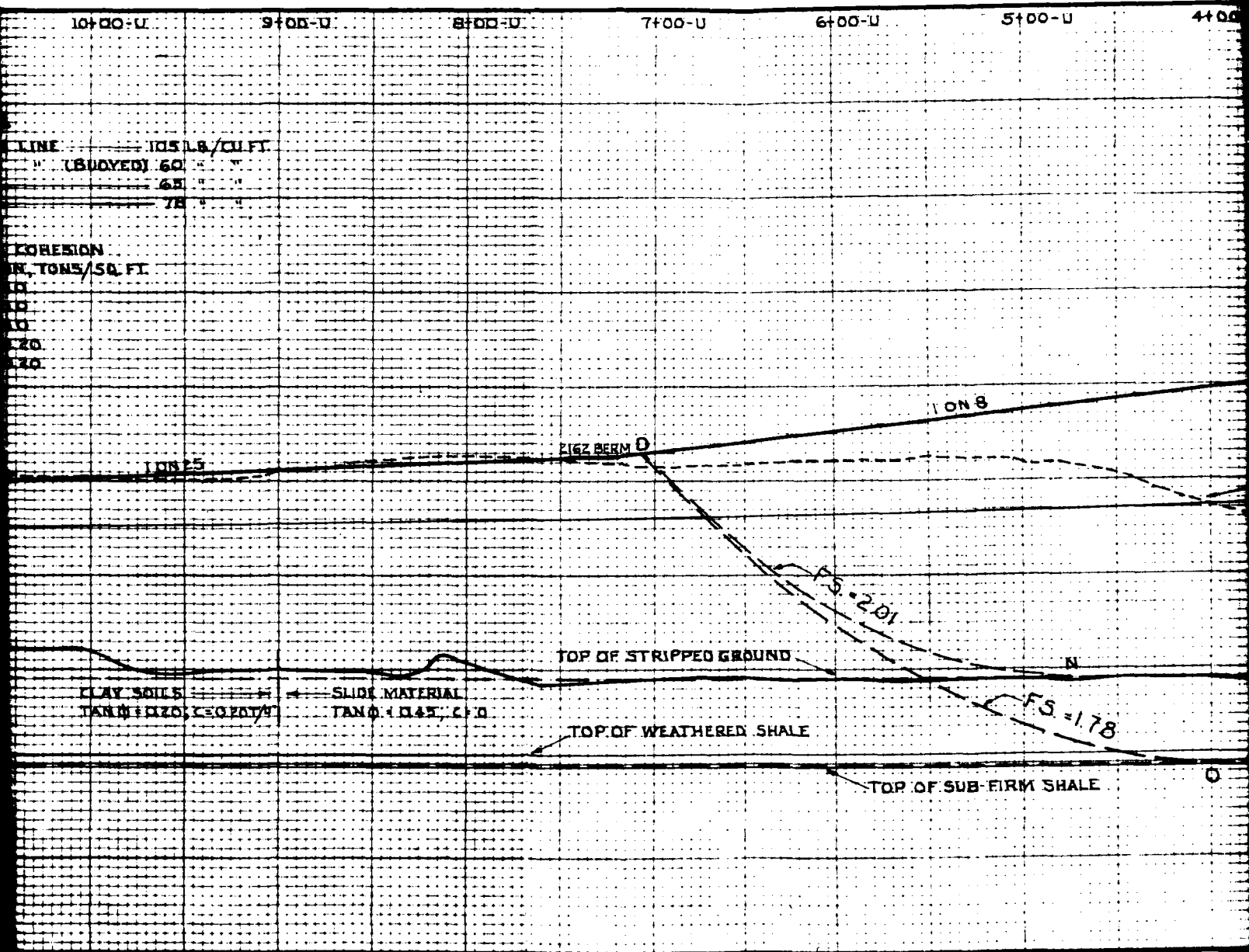
10+00

TABLE OF WEIGHTS

SAND MATERIAL ABOVE SATURATION LINE
 BELOW (BUOY)
 CORE MATERIAL (BUOYED)
 DISTURBED SHALE (BUOYED)

VALUES OF FRICTION AND COHESION
 MATERIAL TANG COHESION, TONS/50
 SHELL 0.30 0.0
 SLIDE 0.45 0.0
 CORE 0.30 0.0
 CLAY SOILS 0.20 0.20
 FOUNDATION 0.15 0.20





3

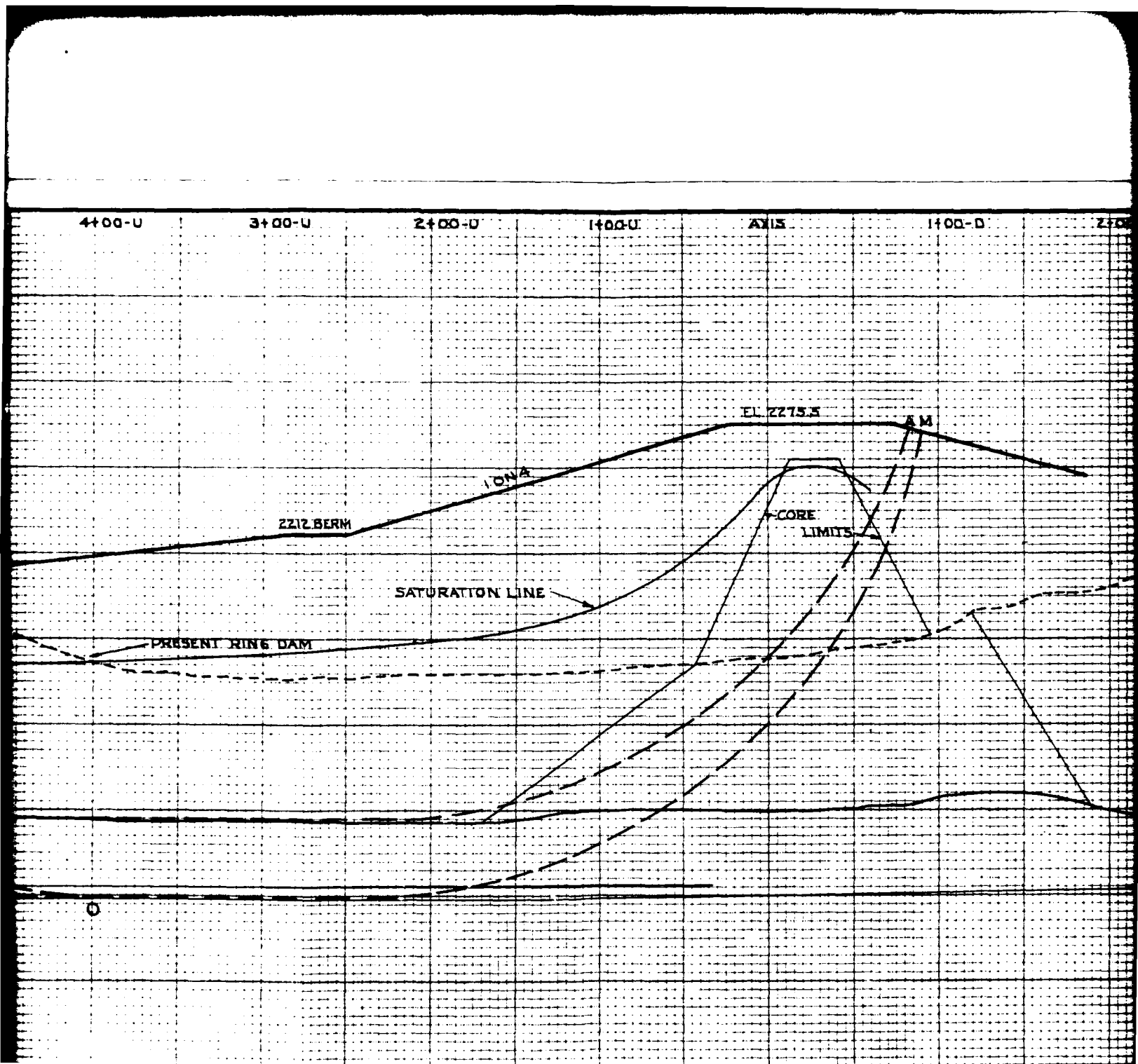
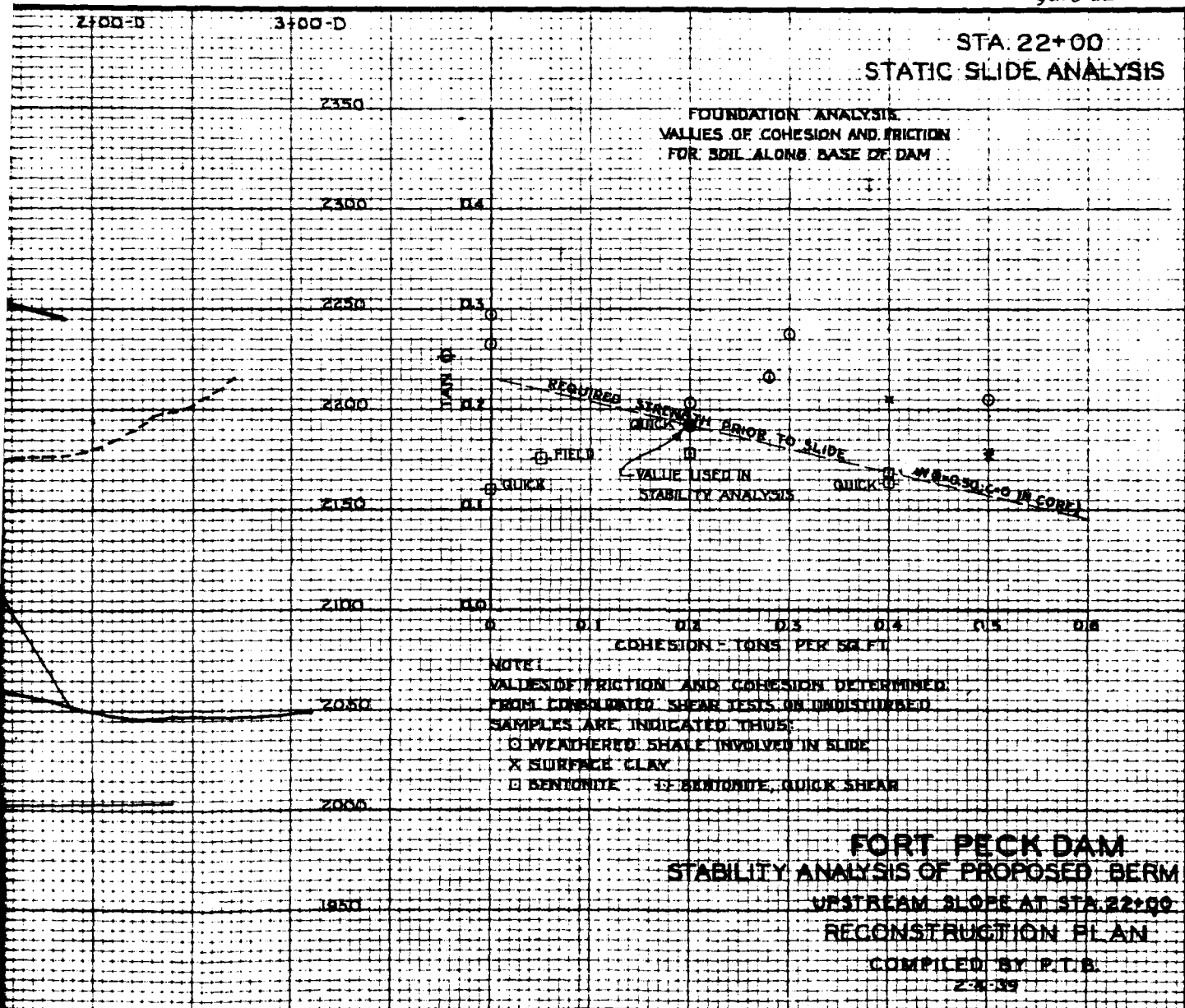
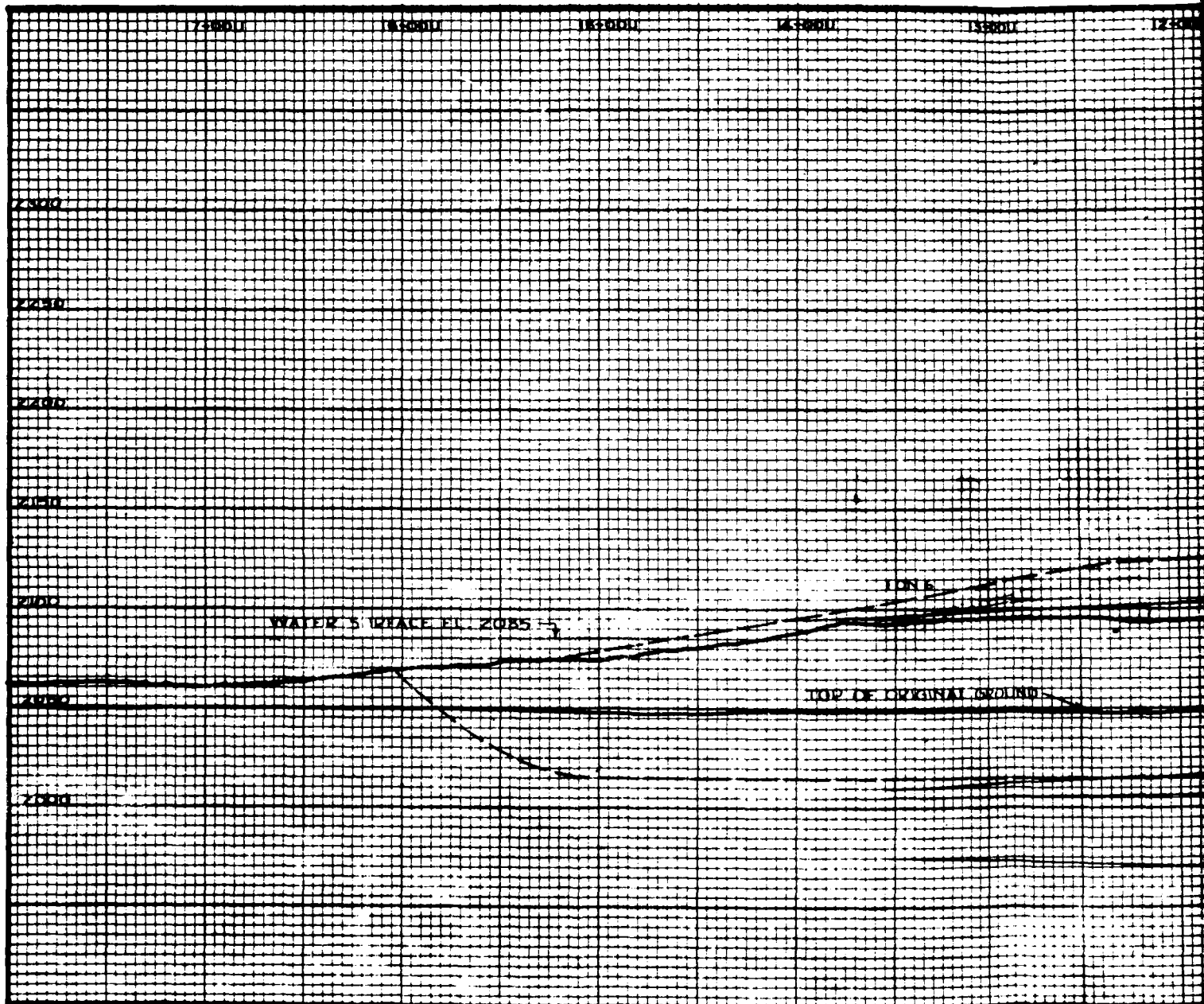


Figure 22



5



(Page 16) No. 7

12+000

11+000

10+000

9+000

8+000

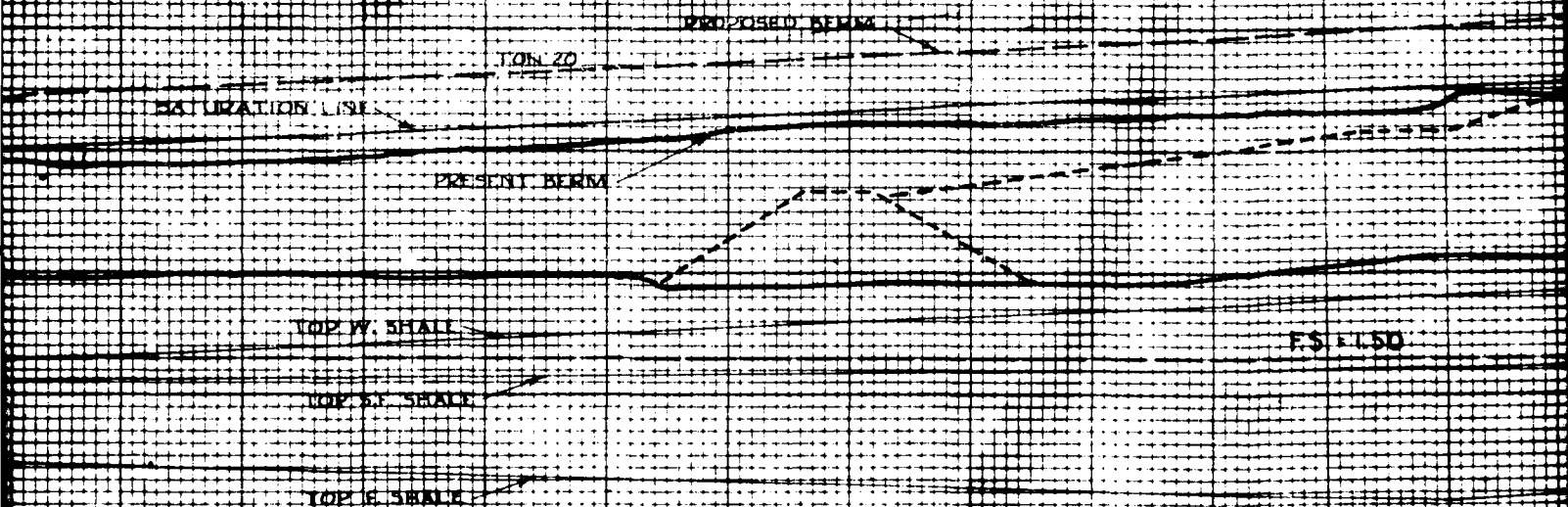
7+000

TABLE OF WEIGHTS

SAND MATERIAL ABOVE SATURATION LINE	63 LB./CU. FT.
BELOW (SLOPED)	60 " " " "
CORE MATERIAL (SLOPED)	65 " " " "

VALUES OF FRICTION AND COHESION

MATERIAL	TAN ϕ	COHESION
SHELL	0.40	0.0
CORE	0.30	0.0
FOUNDATION	0.20	0.25



6000

5000

4000

3000

2000

1000

PROPOSED CREST

104.33

2212.8174

104.13

2142.8174

104.33

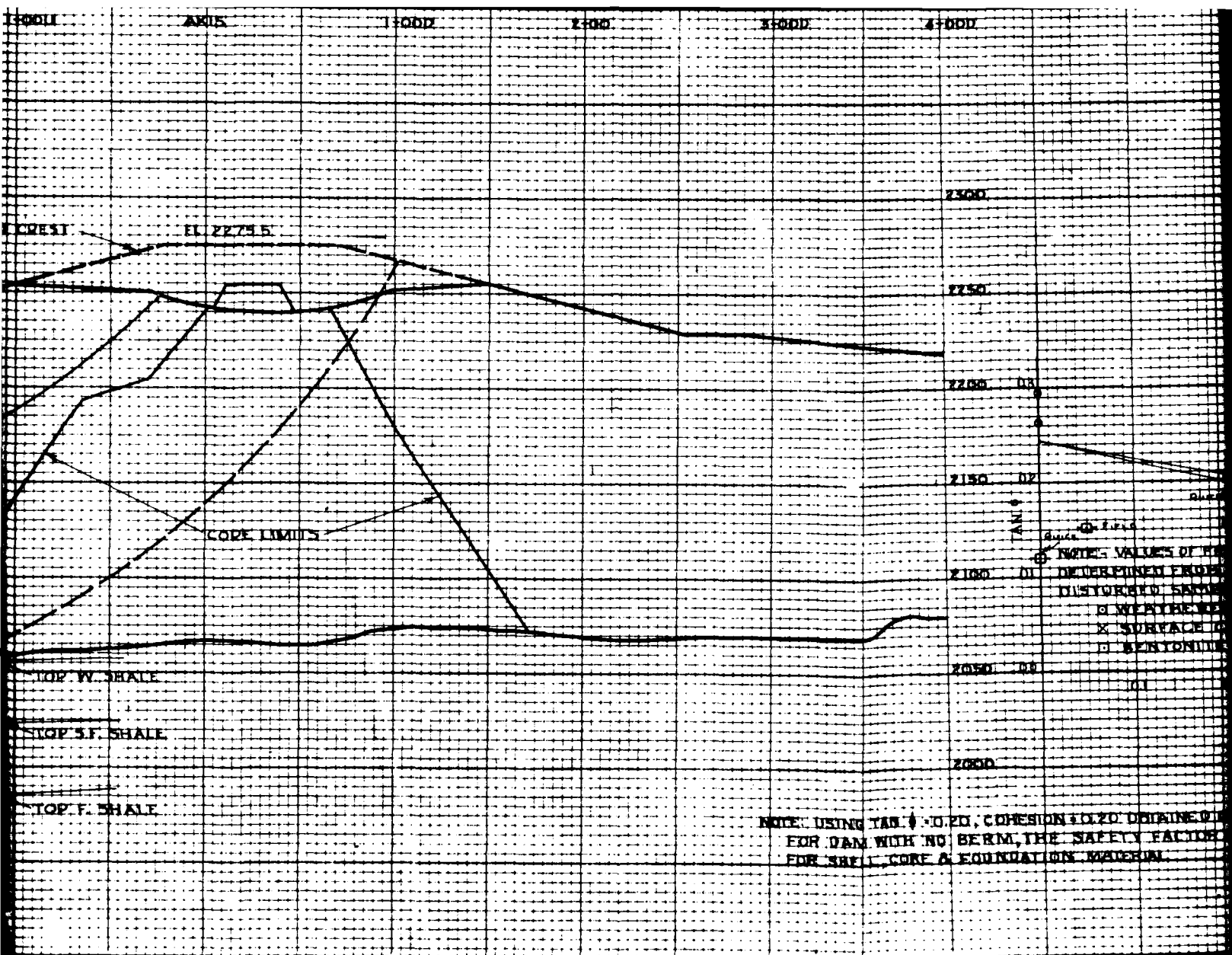
SATURATION LINE

TOP W. 30'

TOP 1.5'

TOP F. 50'

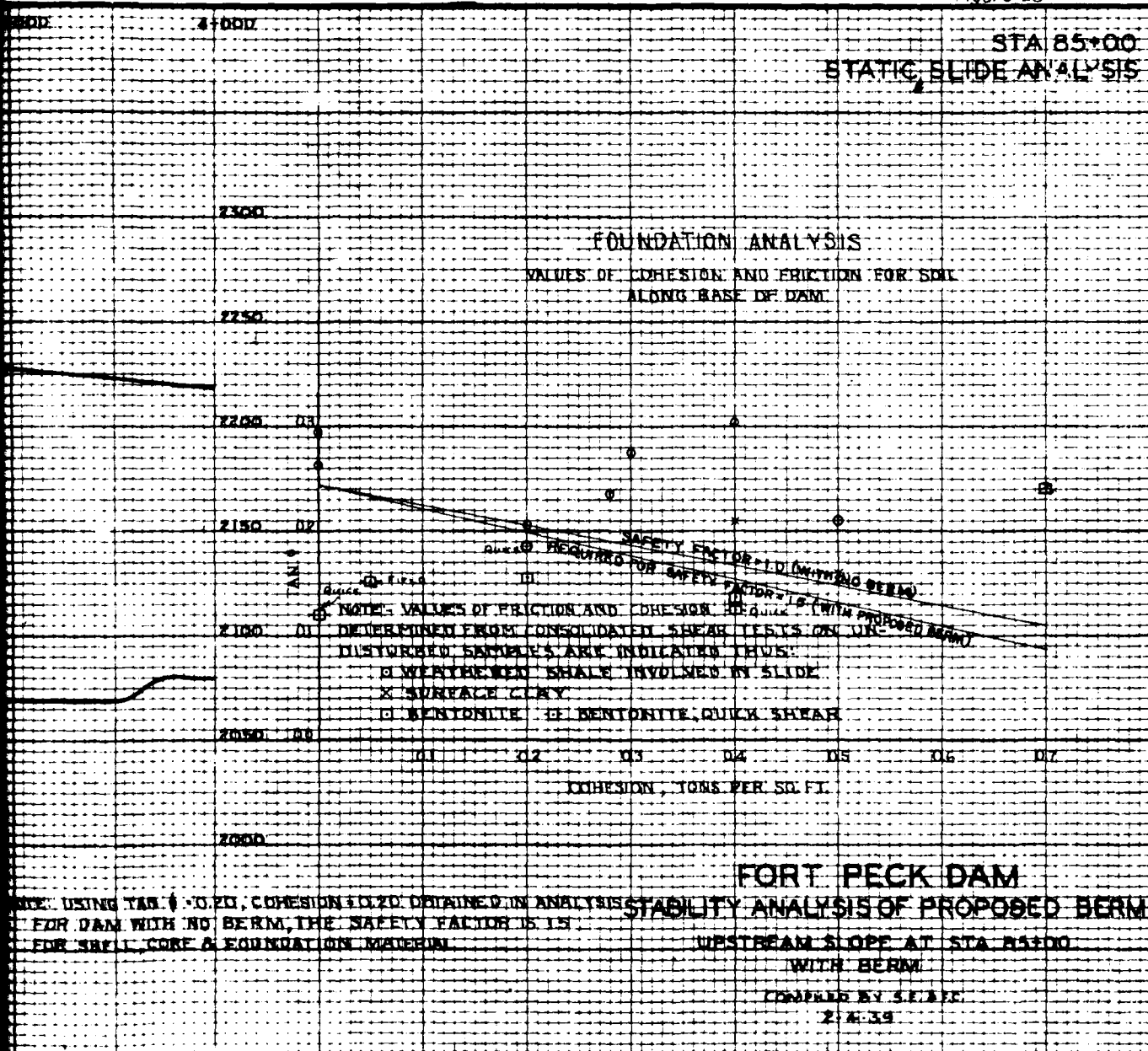
3

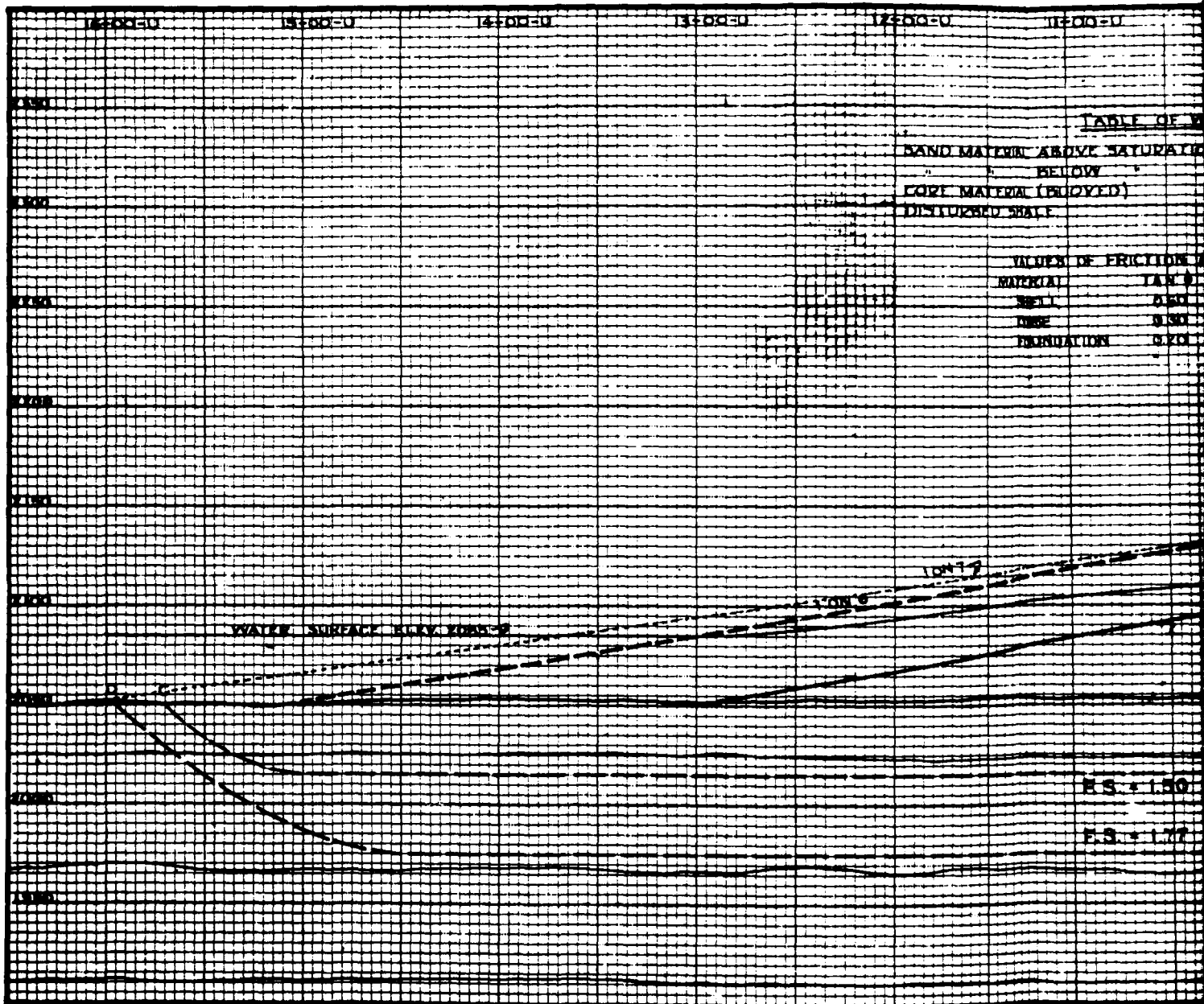


FORT PECK DAM AND RESERVOIR EIBA

4

Figure 23





(Face p. 16) No. 8

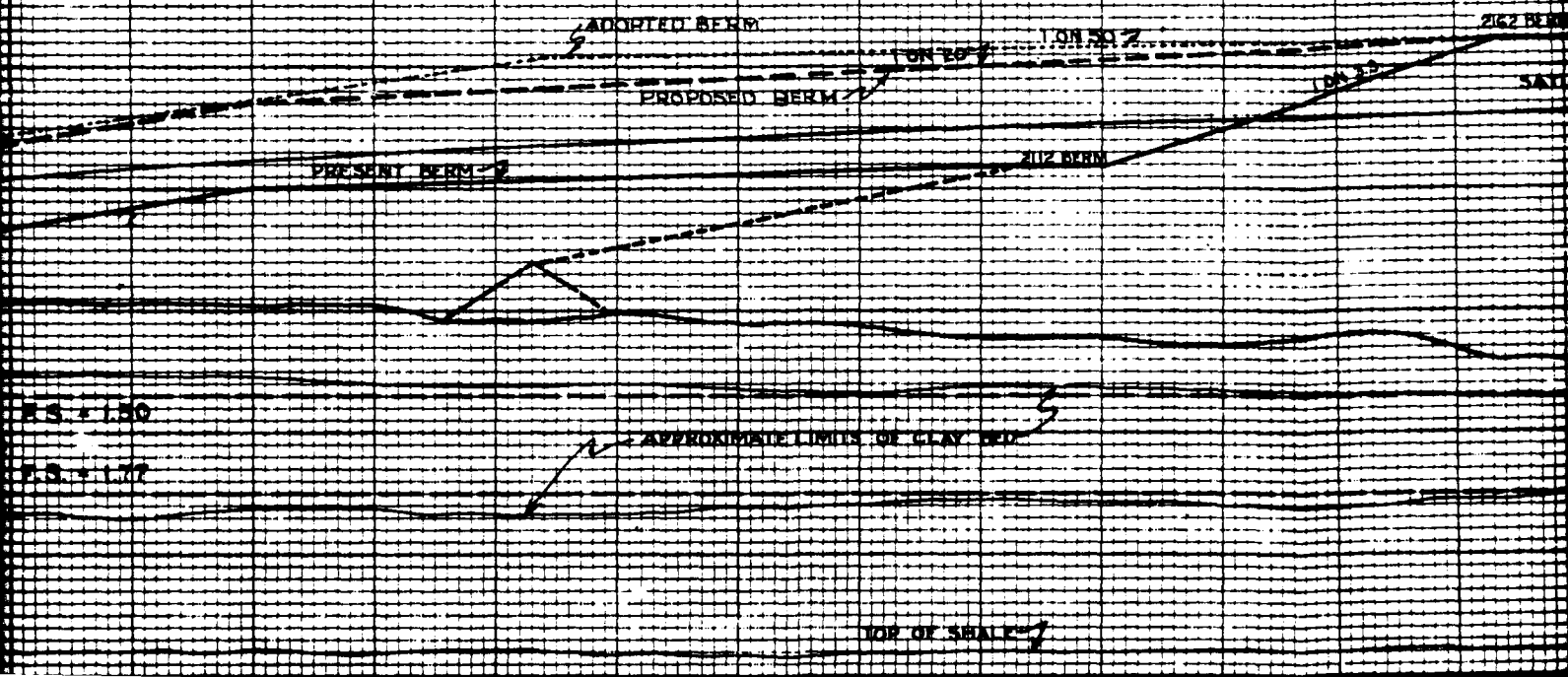
6000-U 10000-U 20000-U 30000-U 40000-U 50000-U 60000-U 70000-U 80000-U

TABLE OF WEIGHTS

WATER SATURATION LINE	105 (B/CU FT)
ADJ	(ADJUSTED) 60 " " "
ADJ	65 " " "
ADJ	70 " " "

TABLE OF FRICTION AND COHESION

TAN ϕ	COHESION
0.50	0.0
0.30	0.0
0.20	0.20



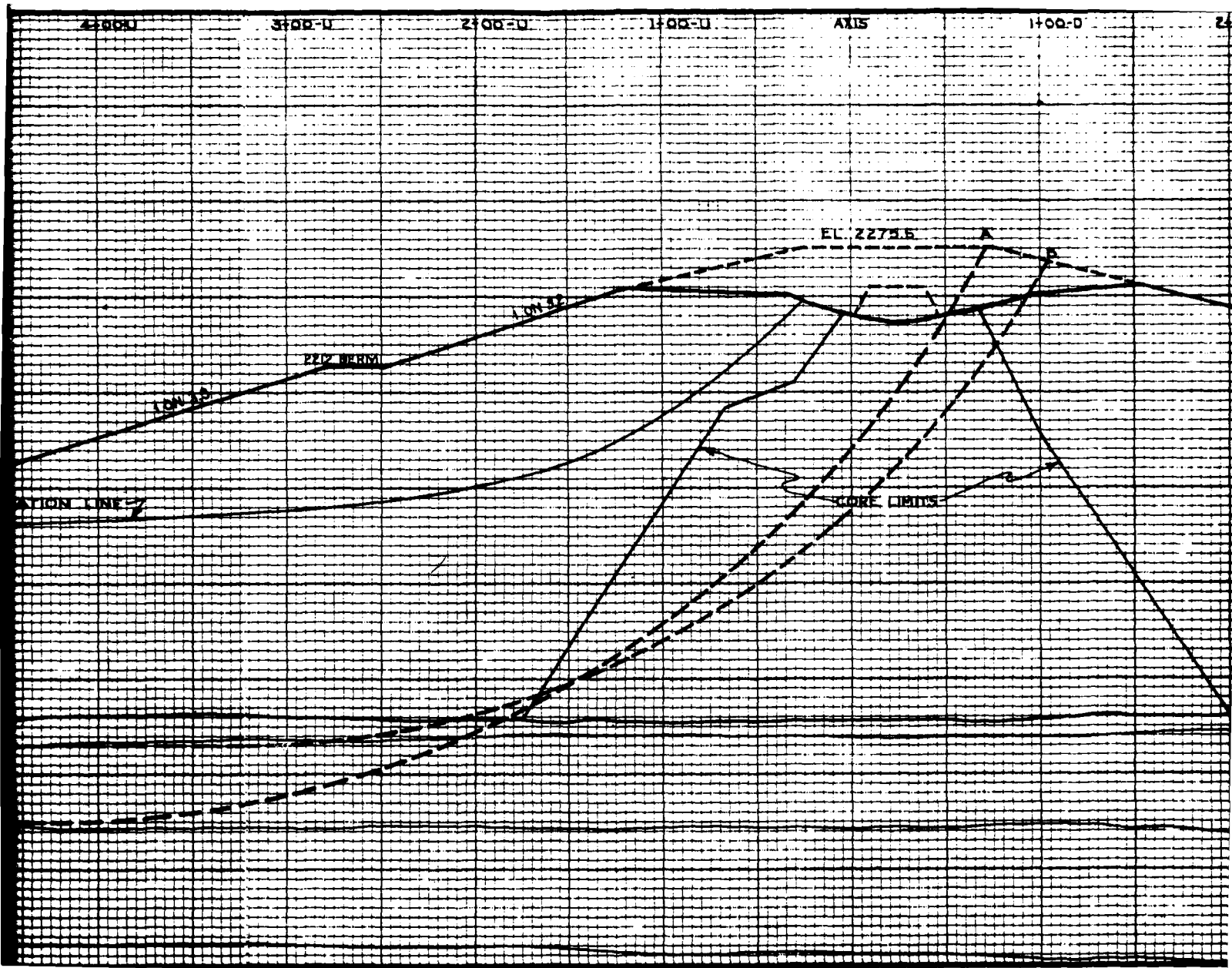
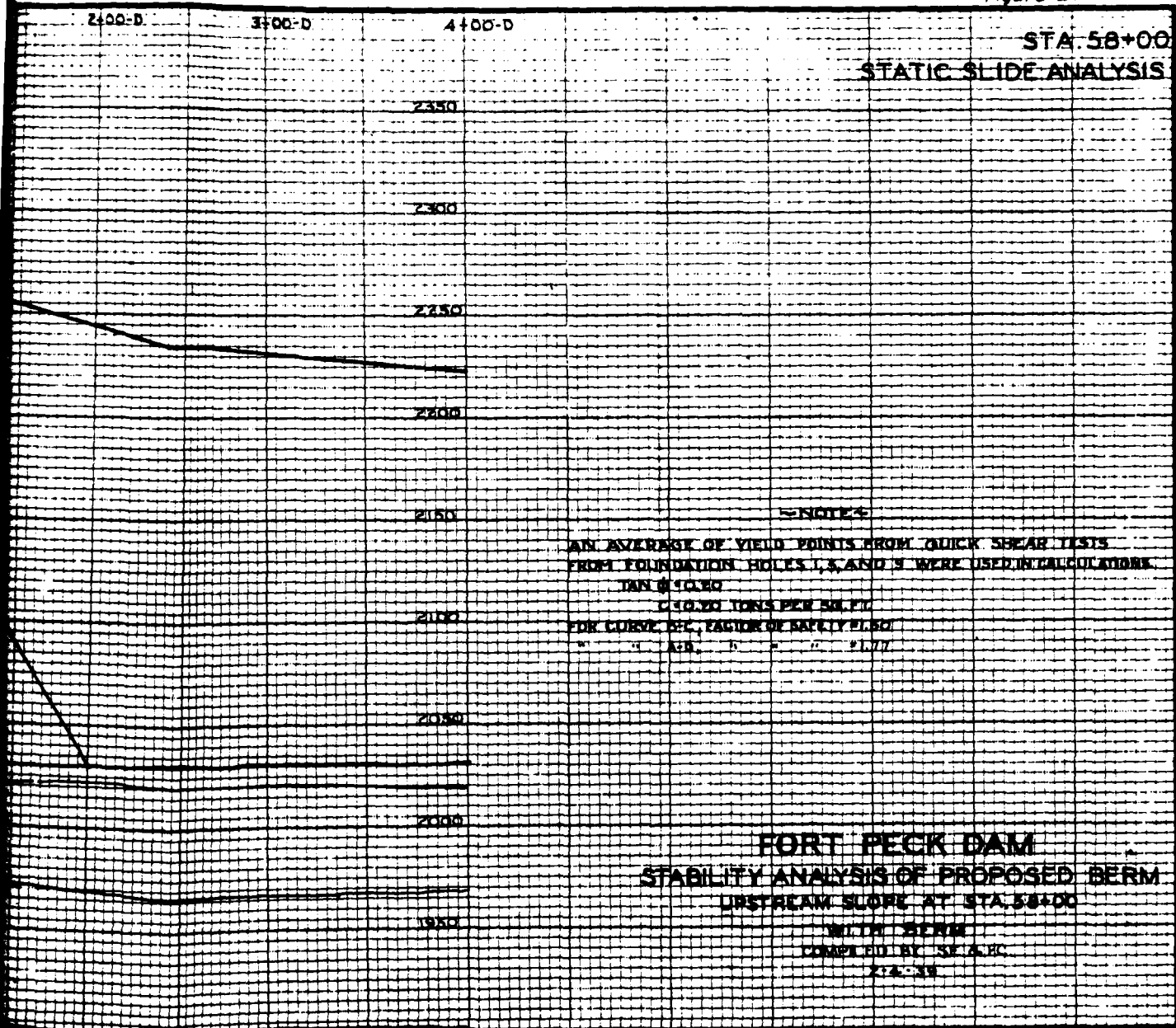


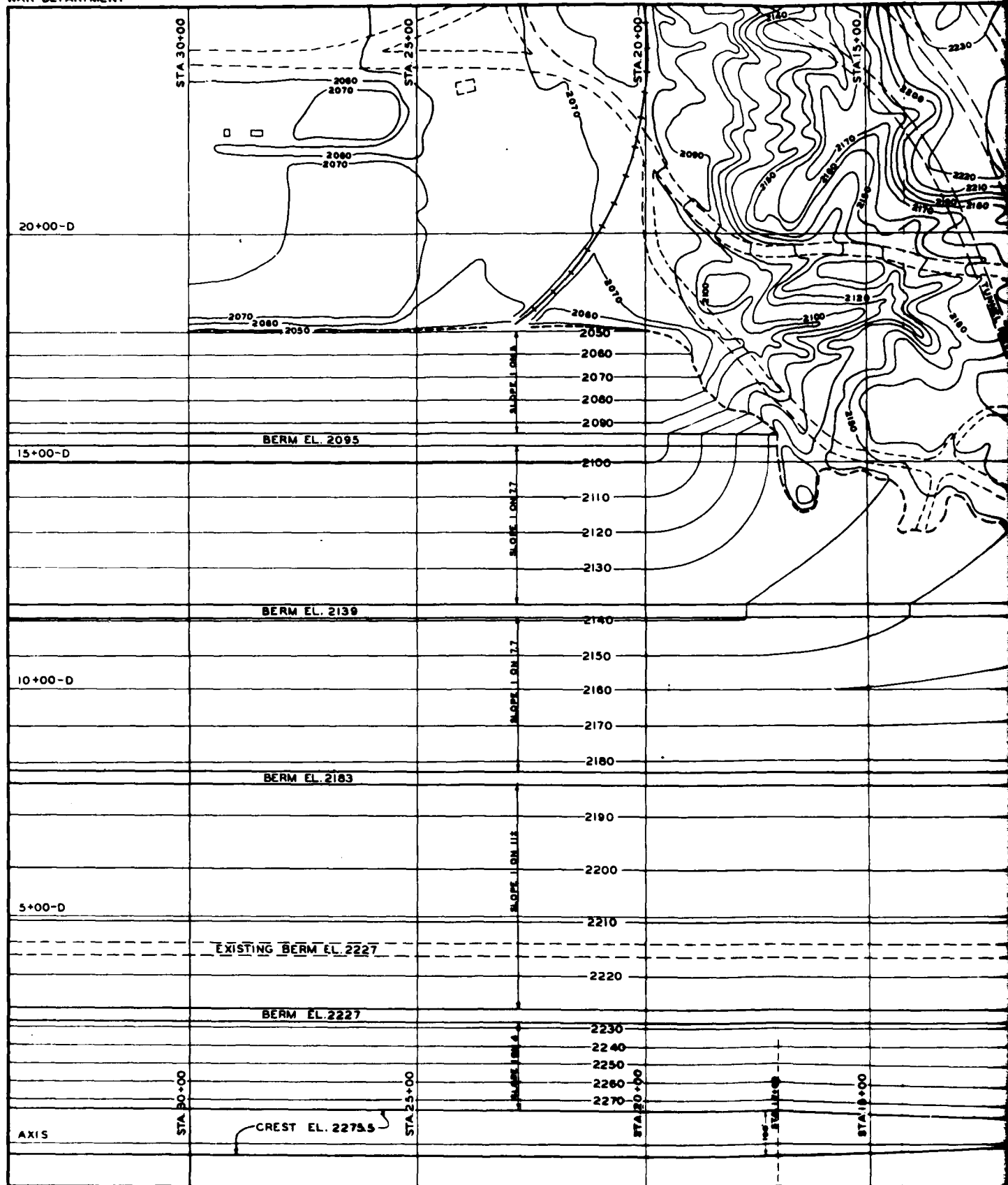
Figure 24



4



WAR DEPARTMENT



FORT P



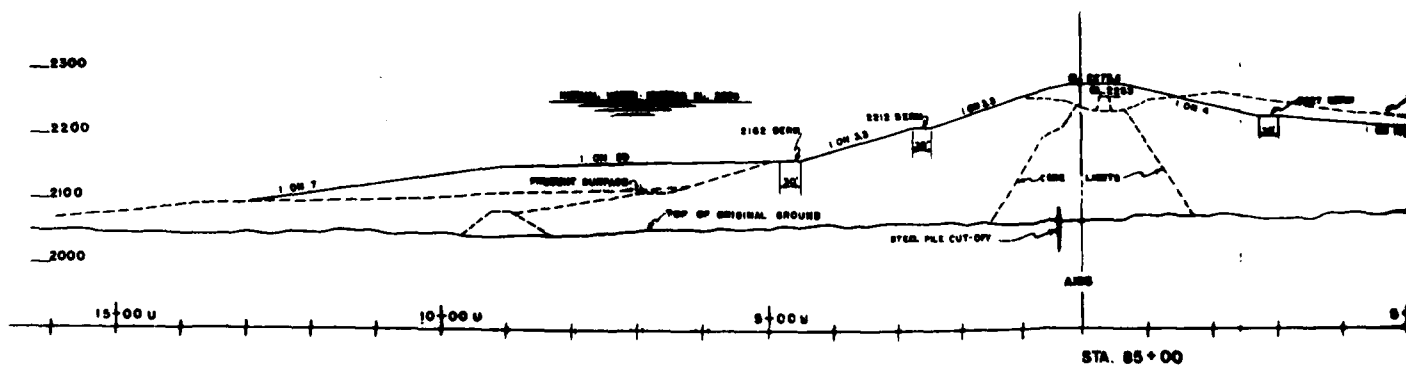
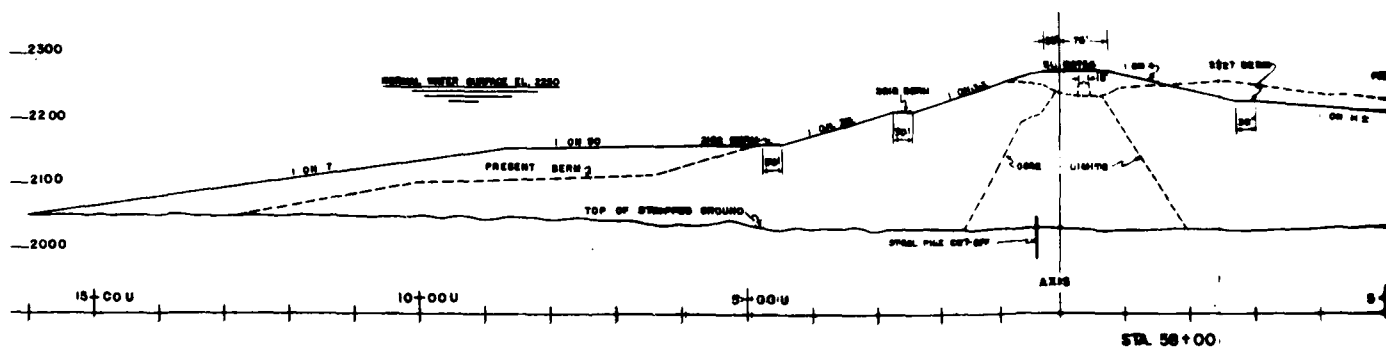
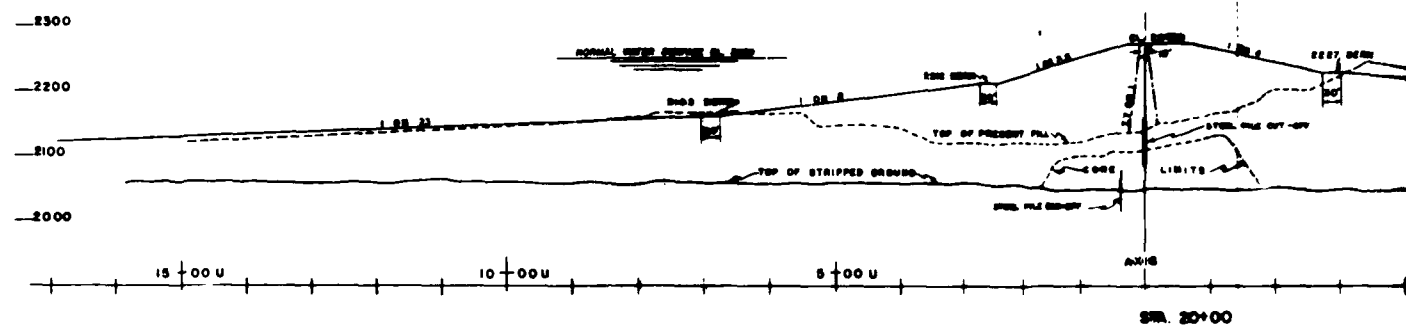
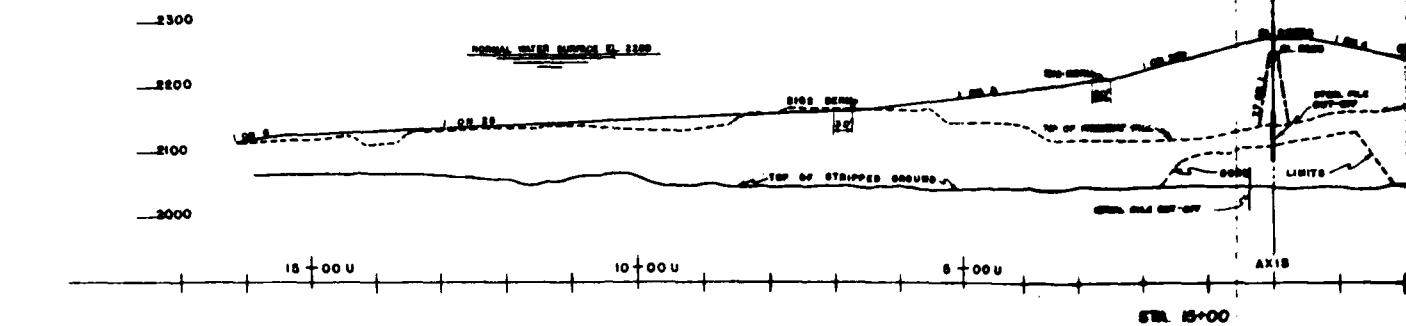
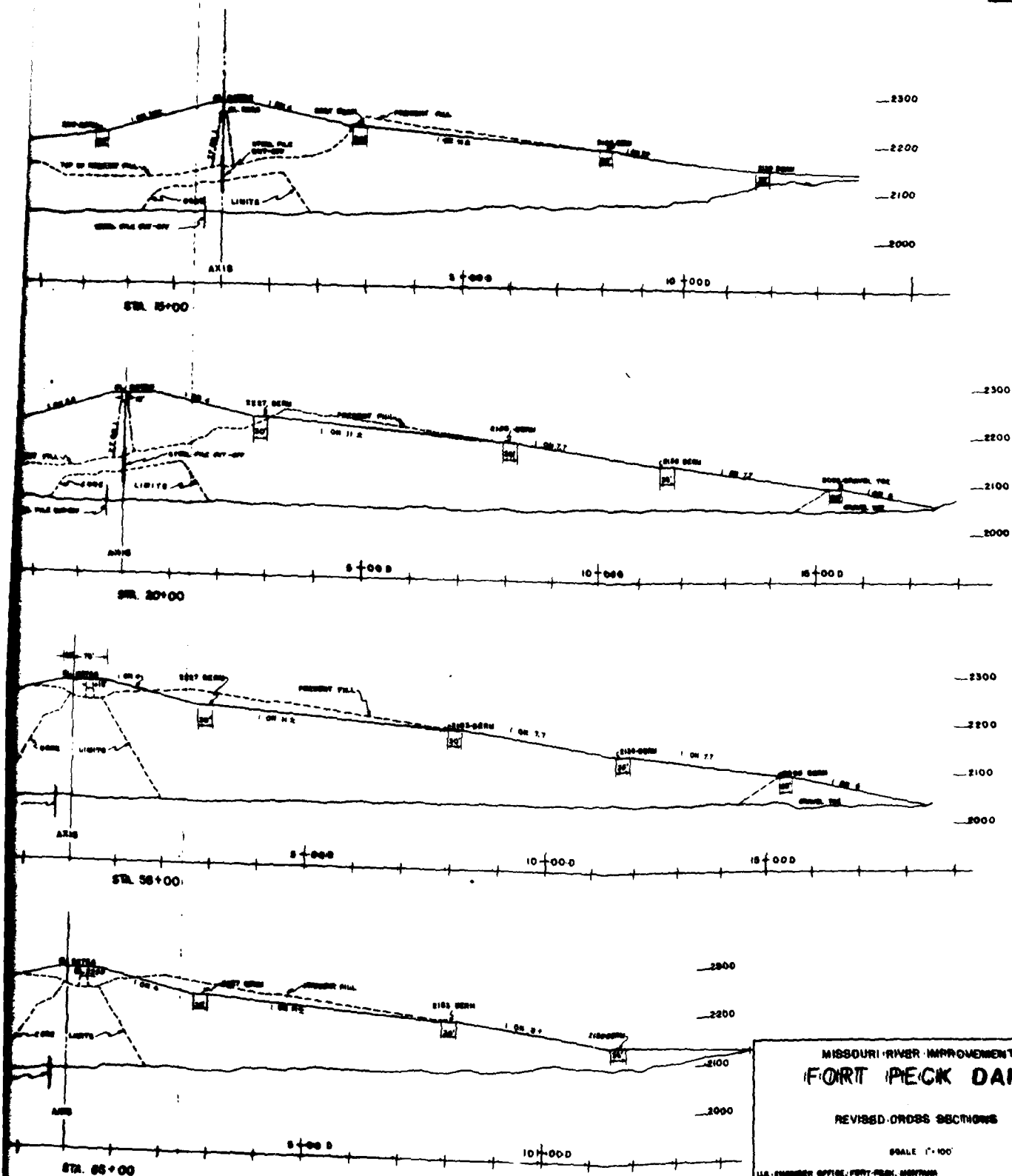


FIGURE 25



MISSOURI RIVER IMPROVEMENT
FORT PECK DAM

REVISED CROSS SECTIONS

SCALE 1" = 100'

U.S. ENERGY OFFICE, FORT RICK, MONTANA

MARCH 2, 1939

Drawn by T. J.	Transd. by E. M. S.	Checked by J. M. S.	Forwarded with letter J. M. S.	File No 32-30
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WAR DEPARTMENT

STA. 75+00

STA. 80+00

STA. 85+00

STA. 90+00

STA. 95+00

STA. 98+00

STA. 100+00

AXIS

2270
2260
2250
2240
2230
2220

2210
2200
2190
2180
2170

2160

2150

2140 R. 10+00.11

2130

2120

2110

2100

2090

2080

2070 R. 15+00.11

2060

100'

AV. SLOPE 1 ON 33

SLOPE 1 ON 34

SLOPE 1 ON 50

SLOPE 1 ON 7

CREST EL. 2275.5

2160

2170

2180

2190

2200

2210

2220

R. 8+00.11

R. 10+00.11

R. 15+00.11

FORT PEG

FIGURE 28

STA. 75+00

STA. 80+00

STA. 85+00

STA. 90+00

STA. 95+00

STA. 100+00

MISSOURI RIVER IMPROVEMENT
FORT PECK DAM
 PLAN OF LEFT ABUTMENT
 UPSTREAM

SCALE 1"=100'

U.S. ENGINEER OFFICE, FORT PECK, MONTANA, MARCH 2, 1938

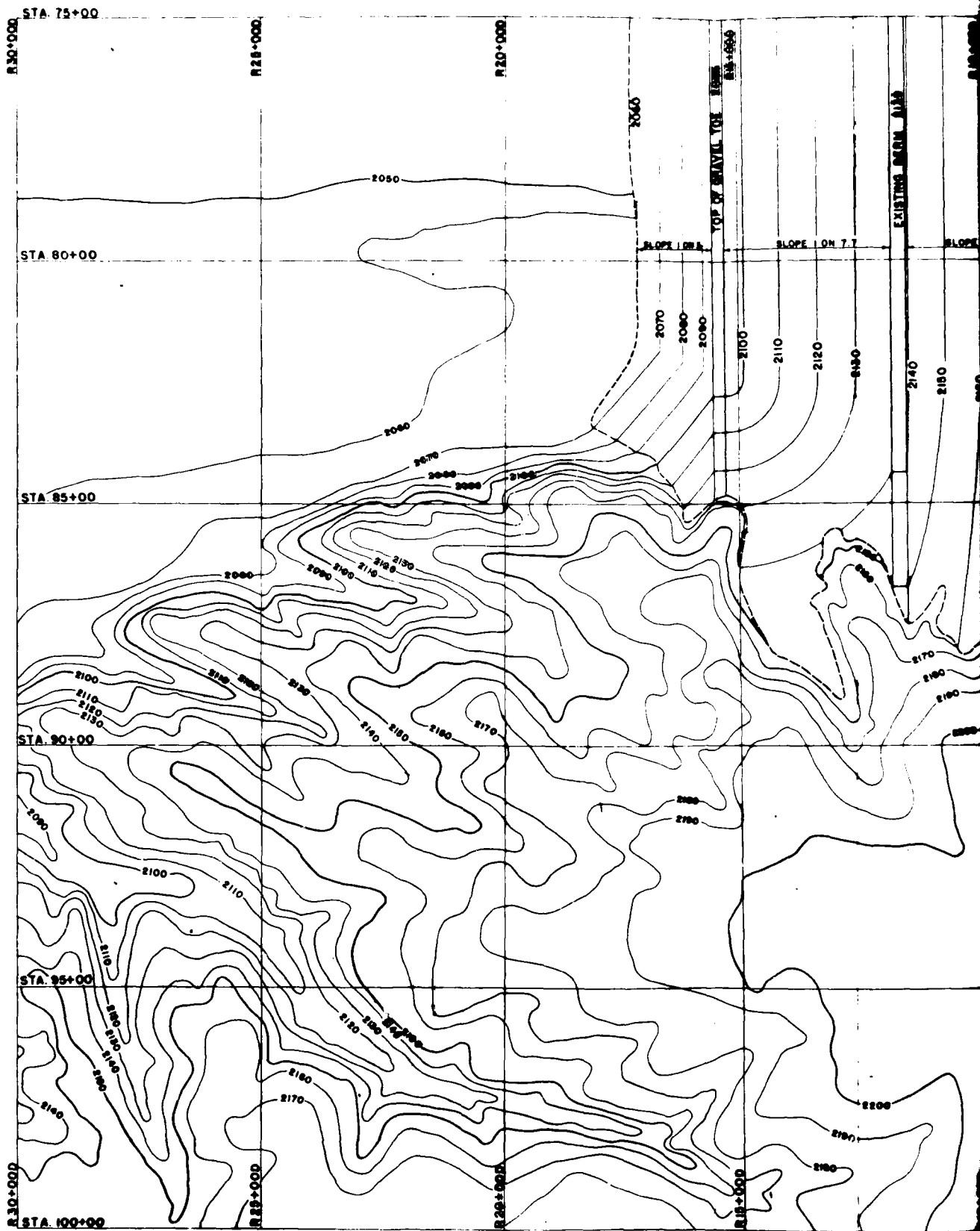
By	Checked by	Approved by	Special Agent in Charge
<i>W. J. ...</i>	<i>R. ...</i>	<i>...</i>	<i>...</i>
186	186	186	186

12 32

FORT PECK DAM AND REMEDIATION

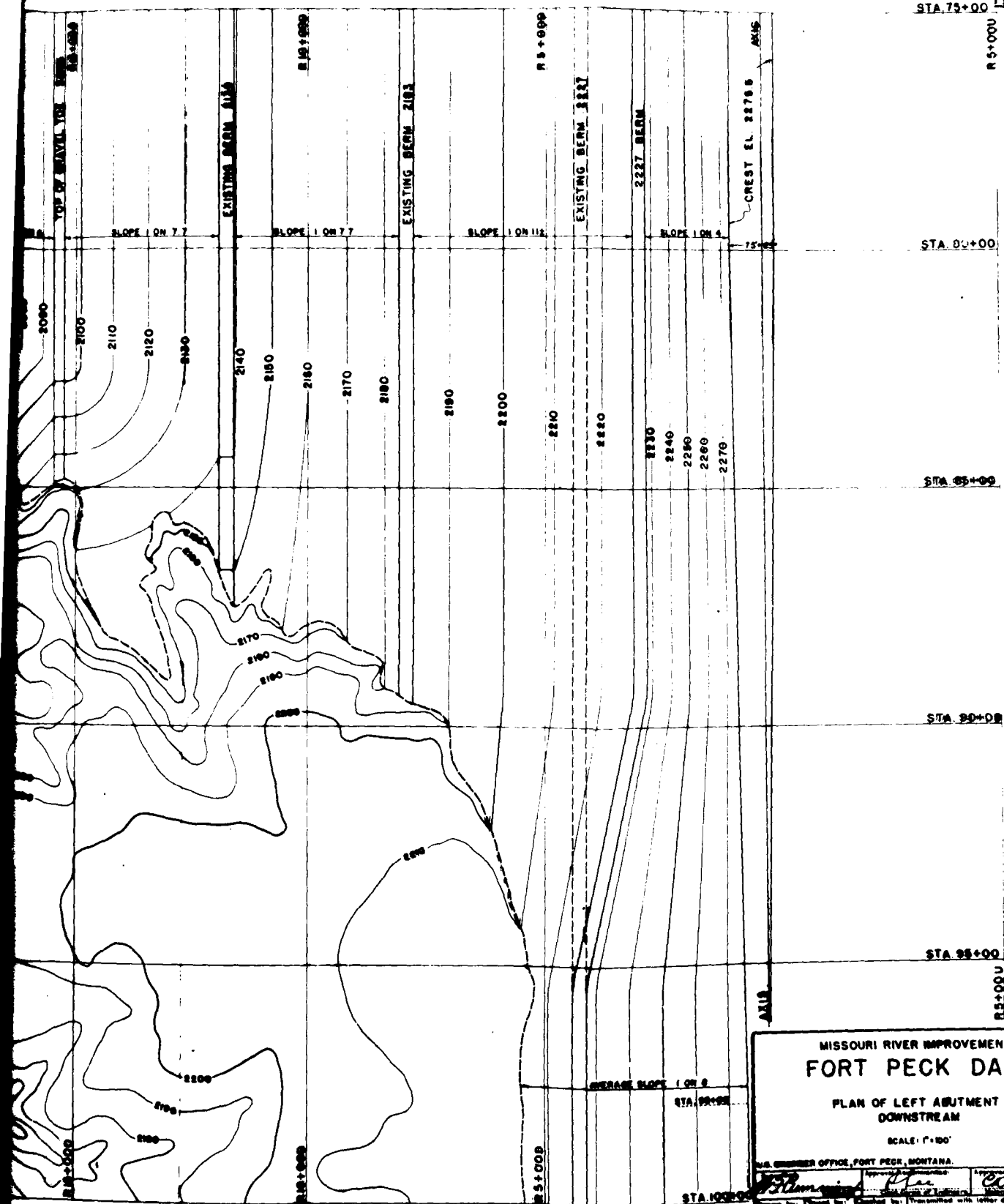
EMBANKMENT CRITERIA AND PERFORMANCE REPORT

PLATE 5-47



STA. 75+00 **FIGURE 28**

R 5+000



MISSOURI RIVER IMPROVEMENT FORT PECK DAM

PLAN OF LEFT ABUTMENT
DOWNSTREAM

SCALE: 1"=100'

U.S. ENGINEER OFFICE, FORT PECK, MONTANA.

MARCH 2, 1939.

Drawn by	Checked by	Transmitted with letter dated	File No.
W.A.W.	W.A.W.	3-2-39	32-33

MISSOURI RIVER IMPROVEMENT CRITERIA AND PERFORMANCE REPORT **PLATE 5-48**

S.P.O.—180810

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