CORPS OF ENGINEERS, U. S. ARMY

DETERMINATION OF REQUIRED PILE LENGTHS
COMBINED MORGANZA FLOODWAY
CONTROL STRUCTURE

TECHNICAL MEMORANDUM NO. 3-317

CONDUCTED FOR

THE PRESIDENT, MISSISSIPPI RIVER COMMISSION
CORPS OF ENGINEERS, U. S. ARMY

BY

WATERWAYS EXPERIMENT STATION
VICKSBURG, MISSISSIPPI

ARMY-MRC-WES VICKSBURG, MISS.

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Introduction

1. This report contains the results of analysis of additional borings made at the site of the combined Morganza Floodway control structure. This additional study was authorized in the 1st Indorsement to a letter from the Waterways Experiment Station to the President, Mississippi River Commission, subject "Driving of Piles, Combined Morganza Control Structure," dated 8 February 1950, to determine definitely the top of the sand stratum into which the piles are to be driven. The general foundation conditions and results of the over-all boring program are given in Waterways Experiment Station Technical Memorandum No. 3-278, "Combined Morganza Floodway Control Structure, Texas and Pacific Railroad and Louisiana State Highway No. 30, Soils Investigation," dated May 1949. The results of the pile tests performed at the site are described in Waterways Experiment Station Technical Memorandum No. 3-308, "Pile Loading Tests, Combined Morganza Floodway Control Structure," dated January 1950. This report covers only the additional study, and reference should be made to the two above-mentioned reports for complete detailed information on the previous investigations.

2. As a result of opinions expressed at the pre-bid meeting, it was decided that the Government would bear the responsibility of determining the length of piles to be cast for the structure. In order to accomplish this, 67 additional borings were made at the site of the structure. These borings were made on about 100-ft centers along the

structure to obtain the longitudinal variation in the top of the sand. At several stations additional borings were made to determine the variation transverse to the structure. The borings east of the structure were at about the location of the center of the tips of the pile groups battered upstream. Because of conditions at the site the borings west of the structure were just outside the locations of the tips of the piles battered downstream.

3. Sixty-three of the additional borings were made with a standard 1-1/2-in. split-spoon sampler, using a 140-lb hammer with a 30-in. drop. Four borings were 3-in. Shelby tube borings to obtain undisturbed samples of the foundation sand. Six of the borings were put to significant depth into the sand by fishtailing to check the continuity of the sand. The plan of all borings made at the site of the gated portion of the structure and a detailed boring log profile from sta 712 to 721 are shown on plate 1. A profile for the full length of the structure is shown on plate 2 and cross sections are plotted on plate 3.

4. A general analysis of the borings is given below followed by a detailed discussion of each reach along the structure.

General Analysis of Boring Data

Description of foundation sand

5. The foundation sand is a uniformly graded fine to medium sand. The range of grain-size curves is shown on plate 4. There are thin lenses of lignite scattered through the sands and a few thicker strata of lignitic material were reported. With increasing depth small gravel is found, and considerable gravel was indicated by fishtailing below

the last samples obtained. The relative densities of the sand indicated by tests on the 3-in. Shelby tube samples are given in table 1 and are generally between 70 and 90 per cent. Lower relative density values were indicated by samples containing lignite.

Settlement considerations

6. Strata of clay were found within the general sand stratum at several locations. In order to eliminate differential settlement to the maximum possible extent, it would be necessary to drive the piles to such a penetration that the pile tips would be below all compressible strata. However, cost studies indicate that the most economical design is one based on allowable differential settlements of 1 in. Differential settlement of the pile groups under the piers of a monolith will cause a tilting in the line of the structure, which in turn results in a shortening of some gate openings and lengthening of others. The gates and superstructure have been designed to absorb a differential settlement of 1 in. between piers in one monolith. Therefore, penetration through compressible strata will not be required where settlement analyses indicate differential settlements of less than 1 in.

7. From sta 717+50 to the north abutment, the maximum computed total settlement is 1.4 in. which should result in differential settlements between monoliths of less than 1 in. In addition, the clay strata in this reach are at such a depth beneath the top of the sand that it does not appear practicable to attempt to penetrate the clay strata north of sta 717+50 by driving.

8. At three locations, sta 677+50 (south abutment) to sta 681+50, sta 693+40 to sta 697+50, and sta 715+00 to sta 717+20, strata of clay

exist which might cause differential settlement of more than 1 in. It appears from the split-spoon driving records that by requiring driving in excess of that stated in the specifications in these locations the piles can be driven through the sand overlying the clay and into the bearing sand beneath the clay. In the above locations the piles should either be driven through the compressible strata in the upper part of the sand stratum or driven to refusal as defined below. It is possible that there may be a few places where the increased driving will not produce penetrations sufficient to go through the sand above the compressible strata through which penetration is desired.

9. In a few locations where the compressible strata in the upper part of the sand foundation are not penetrated, differential settlements greater than 1 in. may occur. At these locations the gates between adjacent monoliths may be affected adversely, and as a result some future maintenance and repairs may be necessary. However, due to the monetary saving involved it is believed that the possibility of a few gates requiring some future maintenance is a proper calculated engineering or economic risk. If the piles are driven according to the procedures outlined in greater detail later in the report, it is believed that the differential settlements between most monoliths should not be more than 1/2 in. with a maximum of 1 in.

Driving to refusal

10. The driving resistances to be considered refusal, where the tips of the piles are above compressible strata, are given in the following table which is based upon presently available information on driving

concrete piles:

Hammer Energy ft-lb	Blows Per Foot Octagonal Pile	Square Pile
30,000	525	585
35,000	450	500
37,500	420	465
51,000	305	345

The above driving resistances were selected as being somewhat conservative with regard to possible damage of the piles, but, at the same time, it is believed that this degree of driving in excess of that required in the present specifications will, in most cases, result in the desired penetration of the compressible clay strata in the upper part of the sand foundation. The above values should be modified in the field if the driving experience indicates such is necessary or desirable.

Correlation of recent and earlier split-spoon borings

11. Borings M-36, -37, and -38 were made in December 1948 with the same type split-spoon sampler used in the recent borings. At that time the water table was 5 to 6 ft below the ground surface. When borings M-39 to -95 were made, the Mississippi River was high and there were artesian heads in the underlying sand as much as 11 ft above the natural ground surface. If it is assumed that the driving resistance in blows per foot is directly proportional to the effective overburden pressure, 40 blows per foot in a recent boring made from the natural ground surface is about equivalent to 50 blows per foot in borings M-36, -37, or -38. This assumption is reasonable according to information from other sites and also according to the results obtained in the

recent borings. Some of the recent borings were made through the preload fills in place near each end of the structure, so the effective overburden pressure at depth was equal to or greater than that at the time the original three split-spoon borings were made. Therefore, in sand equivalent to 50-blow sand in M-36, -37, and -38, the driving resistance in these borings would be equal to or more than 50 blows per foot. Borings M-87 through -92 were made in the excavation for the structure from which about 3 ft of soil had been removed. This would cause the blows per foot in sand equivalent to 50 blows per foot in M-36, -37, and -38 to be slightly less than the 40 blows per foot given above. As an over-all value, about 40 blows per foot in the M-39 to -95 borings were assumed to be equivalent to 50 blows per foot in the 1948 borings, and the same relative proportion should hold for all other driving resistances. At the time borings M-96 to -109 were made, the water table was below the ground surface again and the driving resistances in these borings were assumed to be directly comparable to those from borings M-36 to -38.

Correlation of split-spoon
and test-pile driving resistances

12. The top of the bearing sand is defined in the specifications as the point where the pile driving resistance becomes 75 blows per foot with a 30,000-ft-lb hammer. Correspondingly lesser blows have been established for higher energy hammers. In order that the split-spoon data could be used to estimate the top of the bearing sand (hereafter called 75-blow sand) a comparison was made of split-spoon and test-pile driving resistances. The analysis indicates that 35 to 40 blows per foot on the

split spoon in borings M-39 to -95 is about equivalent to 75 blows per foot on a pile with a 30,000-ft-lb hammer. Therefore, the top of the 75-blow sand in borings M-39 to -95 was taken as the elevation where the split-spoon driving resistance became 35 to 40 blows per foot. Some allowance was made for the amount of material having a split-spoon driving resistance of 20 to 35 blows per foot. In borings M-36 to -38 and M-96 to -109, the top of the sand was taken at 45 to 50 blows per foot. A line indicating the most probable value for the average top of the 75-blow sand is shown in profile on plate 2. The average top of the 75-blow sand at the cross sections plotted on plate 3 was taken at the nearest foot at the center of the pile group. The center of the pile group is between the center line and 20 ft east of the center line.

13. Analysis of the driving records of the test piles indicates that the piles penetrated on the average 4.3 ft into 75-blow sand. As some of these piles were not driven as hard as is required by the specifications for the structure, a value of 5 ft was selected as the average penetration into the 75-blow sand. The specifications require a 5-ft penetration unless the driving resistance exceeds 350 blows per foot (with a 30,000-ft-lb hammer) before a 5-ft penetration is obtained.

Variation in top
<u>of 75-blow sand</u>

14. Study of the cross sections plotted on plate 3 shows that there may be considerable and inconsistent variation in the top of the 75-blow sand. Variations as much as ± 4 ft from the average are indicated. Study of the variation of the top of the 75-blow sand indicated in profile shows that with one exception the variation is not

more than ± 4 ft for a distance equivalent to the spread of the pile tips beneath one pier. From sta 711 to 715 the profile indicates a possible variation of ± 6 ft. Cost studies show that it will be less expensive to cast all the piles at any pier as long as the greatest estimated length for that pier than to cast the piles somewhat shorter and splice a few piles. Therefore, except near sta 712, it is recommended that all piles not to be overdriven be cast 4 ft longer than is required for the average elevation of the top of the 75-blow sand indicated at each pier. Near sta 712 it is recommended that 6 ft be added to the casting length.

15. At locations where the piles are to be overdriven, if necessary, the bottom of the compressible strata to be penetrated was taken as the top of the bearing sand. The addition of 2 ft to the length required to obtain 5-ft penetration into the bearing sand should be made to allow for variation in driving except near sta 696 where no allowance is recommended.

Detailed Analysis of Foundation and Determination of Pile Lengths

Sta 677+50 to 681+50, south abutment pier through pier 3

16. Borings M-36, -40, and -82 indicate strata of clay within the sand with a total thickness up to 3-1/2 ft overlain by 5 to 8 ft of sand. Boring M-81 indicates a stratum of sand with a low driving resistance. A maximum settlement of 2.6 in. is indicated at boring M-36 if the pile tips should be at elev -41 above the clay. It is believed that the piles can probably be driven through the clay by driving alone to at least the

elevation indicated by the line "Top of Bearing Sand," plate 2. The piles should not be stopped with the pile tips above this elevation unless the piles are driven to refusal as given in paragraph 10. A 2-ft addition to the casting length should be made to allow for driving variations.

South wing walls

17. As the conditions indicated in the cross section for sta 680+75 on plate 3 for the upstream wing wall are similar to those given in the preceding paragraph, all piles for this area should be overdriven, if necessary, to get the tips below the "Top of Bearing Sand" line shown on plate 3, unless the piles are driven to refusal above the line. Under the downstream wing wall, all piles within 53 ft of the center line should be overdriven, if necessary, to penetrate the underlying compressible or low driving resistance strata in the sand foundation. A 2-ft addition in length should be made for all piles in this reach on which possible overdriving is contemplated. All piles under the downstream wing wall beyond 53 ft from the center line need not be overdriven, but a 4-ft addition to the casting length as allowance for variation in driving should be made for those piles. The top of the 75-blow sand and the top of the bearing sand is shown in the cross section for sta 680+75 on plate 3.

Sta 681+50 to 693+40,
piers 4 through 41

18. In this reach no compressible strata within the sand were disclosed by the borings. Therefore, the piles will not need overdriving.

The top of the 75-blow sand is plotted on plate 2. An allowance of 4 ft for variation in driving is recommended for all piles in this reach.

Sta 693+40 to 697+50,
piers 42 through 54

19. Borings M-53 through M-56 indicate a compressible stratum of clay and lignite within the sand. A settlement of 1.5 in. has been computed at M-54 if the pile tips are at elev -54. Overdriving probably will not be necessary to penetrate through the sand overlying the clay and lignite at borings M-54 and -56, as the split-spoon resistances were low. However, the medium resistances obtained in M-53 and the high resistances in M-55 and -88 indicate that the sand at these locations might not be penetrated without driving in excess of that given in the specifications. It is recommended that all piles in this location be driven into the "Bearing Sand" indicated on plate 2 or, if this is not possible, to refusal. No allowance for variation is recommended for piers 49, 50, and 51 but an addition of 2 ft to the casting length should be made for all other piers in this reach.

Sta 697+50 to 712+50,
piers 55 through 102

20. The borings do not indicate any compressible or low driving resistance strata within the sand in this portion. Therefore, no piles need be overdriven. An additional length of 4 ft for variation in driving is recommended for piers 55 through 97. The profile of the top of the 75-blow sand on plate 2 indicates a possible variation of ± 6 ft between sta 711 and 712; therefore, an additional 6 ft is recommended for piers 98 through 102.

Sta 712+50 to 715+00,
piers 103 through 110

21. Within this reach, many of the borings had "no recovery" reported between elev -70 and -80. However, the majority of the samples lost had ample driving resistances. The samples in boring M-100 which had low driving resistances were inspected and found to be very fine to fine sand. It is believed that there are no compressible strata within the sand in this reach and that overdriving will not be necessary. As there is a wider variation in the profile of the top of the 75-blow sand here than between sta 698 and 711, and as the piles may penetrate farther into the very fine sand, an addition of 6 ft is recommended to allow for variation in driving.

Sta 715+00 to 717+20,
piers 111 through 117

22. Borings M-74, -75, -105, and -106 indicate strata of clay within the sand. A settlement of as much as 4.3 in. is estimated at boring M-105 if the piles are not driven through the clay. It is believed by requiring, if necessary, driving in excess of the specified driving resistance that the piles probably can be driven through the clay. The bottom of these clay strata is at about elev -66, so that elevation has been taken as the top of the bearing sand for the piles to be overdriven in this reach. The piles should not be stopped above this elevation unless they are driven to refusal. Borings M-74 and -104 did indicate a 2-ft stratum of lignite and sand at about elev -73 which has a low driving resistance. About 25 per cent of this material by volume is lignitic, but it is believed that this stratum is not sufficiently compressible

to cause deterimental settlement of the structure. An additional 2 ft in length is recommended for variation in driving in this reach.

Sta 717+20 to 721+10,
<u>piers 118 through north abutment</u>

23. The borings in this stretch indicate strata of soft clay with a total thickness up to 4-1/2 ft at about elev -70. The sand overlying the clay is 12 to 20 ft thick. It is believed that it would not be practicable to attempt to drive the piles so that they will penetrate through the clay. Therefore, the length of piling should be based on the top of the 75-blow sand shown on plates 1 and 2, with a 4-ft allowance for variation in driving. Following this procedure it is estimated that the structure may settle as much as 1.4 in. at boring M-94 if the pile tips stop at elev -64; however, the resulting differential settlement between monoliths will probably be less than 1 in.

<u>North wing wall</u>

24. Some clay is indicated in borings M-77A and M-83 but it is believed to be too deep within the sand to be driven through. Therefore, the top of the sand should be taken as indicated on plate 3 in the cross section at sta 720+10. An addition of 4 ft to the casting length is recommended for allowance for variation.

<u>Computation of casting length</u>

25. To determine the length of pile to be cast for any pier, the following procedure should be followed:

<u>a</u>. From plate 1 or 2 take off the elevation of the top of "75-blow sand" or "Top of Bearing Sand," whichever is lower.

b. Determine the estimated lowest tip elevation by subtracting from the elevation of the top of the sand 5 ft and the allowance for variation.

c. Using the cutoff elevation, compute the vertical distance between the cutoff and lowest tip elevation.

d. To "c" apply a length factor dependent upon the batter to obtain the slant length of the pile between cutoff and lowest tip elevations.

e. To "d" add the length required for reinforcement extension as given in the contract drawings. This sum rounded off to the nearest foot is the length of pile to be cast for that pier.

Effect of Mississippi River stage

26. It is possible that the driving resistance of the piles will be affected by variations in the stage of the Mississippi River and hydrostatic pressure in the sand foundation in the same manner as indicated by the split-spoon driving resistance. The required driving resistances were based on the driving records of the test piles which were driven between 5 May and 28 June 1950. During that period the gage reading at Baton Rouge was between 16.2 and 24.4 which is normal for the early part of the summer. Thus, when the Mississippi River is at a stage higher than that at which the test piles were driven, it may be easier to drive the piles into the sand than was indicated by the test piles. Therefore, at river stages higher than those given above a lower driving resistance might conceivably be allowed for definition of the top of the sand, the minimum resistance, and the maximum resistance, and vice versa, with the same pile capacity obtained. It is also possible, however, that natural soil variations, compaction of the sand due to driving, etc, will mask any effect of the stage of the river on the pile driving resistance.

No attempt has been made to include the possible effect of variations in the Mississippi River stage on the specified driving resistances because not enough is known about this factor to establish a quantitative relationship. However, it is suggested that the Contracting Officer's representative at the site bear in mind the possible effect of the river stage on pile driving resistances. It is also barely possible that the influence of stage variations in the Mississippi River would have enough effect so that the piles which are to be overdriven could achieve the desired penetration at high stages but not at low river stages. It is suggested that this possibility be reviewed from time to time, for it is conceivable that the pile driving schedule might be revised without any undue delay if it would permit the piles to penetrate to the desired depth.

Summary

27. The driving resistance requirements as stated in the specifications are summarized as follows: All piles shall be driven 5 ft into sand (as defined in paragraph 12) having a driving resistance as listed in the following table, unless the driving resistance becomes the maximum given in the table before a 5-ft penetration is reached. All piles shall be driven to the minimum driving resistance given below, even though penetration into sand greather than 5 ft is necessary.

Hammer Energy per Blow ft-lb	Top of Sand blows/ft	Driving Resistance Minimum blows/ft	Driving Resistance Maximum blows/ft
30,000	75	200	350
37,500	50	140	250
51,000	30	80	180

The resistance for hammers with striking energies between those given may be obtained by interpolation. After the piles have reached the specified sand they shall be driven continuously, insofar as is practicable, until the required driving resistance is obtained. No splicing shall be done after the sand is reached until the required driving resistance is obtained.

28. Driving of piles in excess of the driving resistances stated in the specifications should be required, if necessary to obtain penetration through compressible strata in the upper part of the sand stratum. Overdriving based on the best information available should be required for the piles beneath the upstream south wing wall, a portion of the downstream south wing wall, south abutment pier through pier 3, pier 42 through pier 54, and pier 111 through pier 117. Driving of the piles should not be stopped if the pile tip is above the line "Top of Bearing Sand" shown on plates 1, 2 and 3, unless the piles are driven to refusal. Refusal in overdriving should be taken to mean a driving resistance with a 35,000-ft-lb hammer of 450 blows per ft on an octagonal pile and 500 blows per ft on a square pile, modified, if necessary, in accordance with job experience. At tip elevations below the top of bearing sand line, the original specifications should govern.

29. The average elevation of top of the 75-blow sand with a 30,000-ft-lb hammer was determined at each pier from the split-spoon driving resistances and was based on a correlation of the split-spoon and test-pile driving resistances. The average elevation of the pile tips at any pier was taken as 5 ft below the top of the 75-blow sand.

30. Cost studies indicate that economies will be effected by casting

all the piles at any one pier as long as the longest pile required for that pier. Therefore, the lowest estimated tip elevation at any pier was taken as the elevation of the top of the 75-blow sand minus 5 ft for the average penetration into the sand minus an allowance for variation in driving resistance. The recommended allowances for variations for each reach are given earlier in this report.

31. The length of pile to be cast should be computed from the cut-off elevation, estimated lowest tip elevation, batter, and length required for reinforcement extension.

32. The settlement of the structure for about 75 per cent of its length, where no compressible strata in the sand were found, should be inappreciable. The settlement where the piles are driven through clay strata within the sand should also be very small. At the locations where the piles are not driven through the compressible strata in the sand foundation, the differential settlements between most of the monoliths are expected to be not more than 1/2 in. with a maximum of 1 in; however, it is possible that differential settlements of more than 1 in. may occur between 2 or 3 monoliths.

33. The river stage may have some effect on the driving resistance of the piles. The inspecting forces should be cognizant of this factor to insure that all piles are properly driven, even if a modification of the specified driving resistances is necessary.

34. It is not anticipated that splices will be eliminated as a result of the additional borings and study. However, it is believed that the number of splices required will be a minimum. The data contained in this report regarding pile lengths are definite and are considered

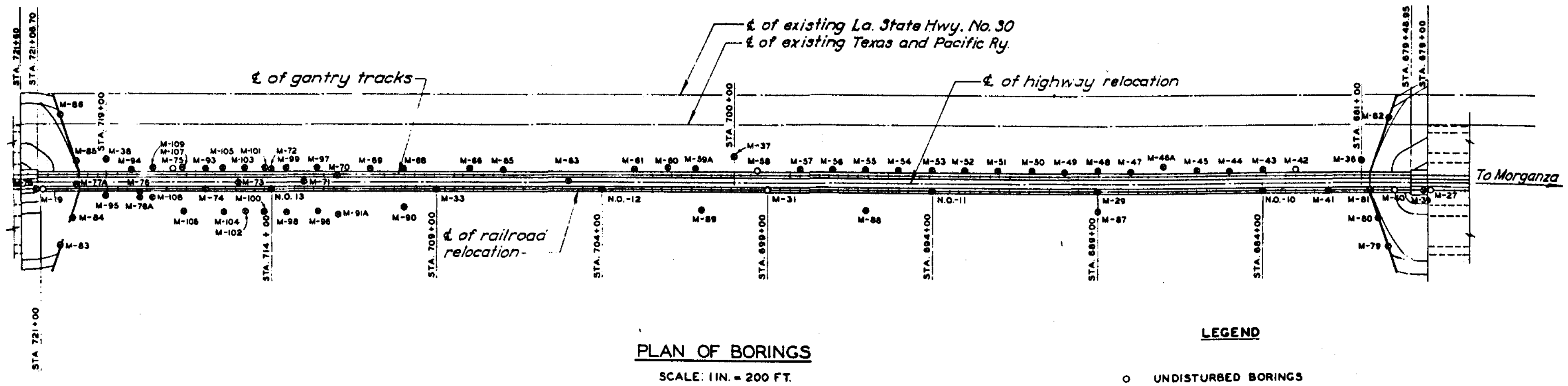
reasonably satisfactory. However, experiences during construction may modify some of the results given herein and every effort should be made as the work progresses to revise the estimated pile lengths as indicated by the specific results being obtained in the field.

TABLE 1

Relative Density of Sand

Combined Morganza Floodway Control Structure

					Density	
Boring	Sample	Specimen	Elev mGL	Classification	Natural Lb/Cu Ft	Relative %
M-40	5	5	-51.6	Sand, fine, uniform	102.0	83.7
		7	-52.1	Sand, fine, stratified	101.9	83.0
	6	3	-55.2	Sand, fine, stratified	101.4	84.3
	7	7	-60.8	Sand, fine, stratified	96.8	78.4
	8	1	-64.3	Sand, fine, stratified	97.7	75.2
M-42	1	2	~~-43.9~~	~~Sand, fine, uniform~~	~~100.9~~	~~83.3~~
		6	-45.9	Sand, fine, stratified	102.1	86.7
	3	2	-49.0	Sand, fine, uniform	99.2	81.3
		6	-50.0	Sand, fine, uniform	103.4	88.7
	5	5	-54.5	Sand, fine to medium, uniform	103.2	88.3
	7	3	-59.0	Sand, fine, uniform	105.1	91.9
		6	-59.8	Sand, fine, uniform	99.6	85.3
M-58	2	3	-46.1	Silty sand, uniform	90.7	78.5
	3	3	-52.2	Sand, medium, stratified	103.3	72.0
		7	-53.4	Sand, medium to fine, stratified	101.7	82.3
	4	7	-58.1	Sand, fine, uniform	96.7	72.7
	5	5	-62.8	Sand, fine, stratified	101.6	83.0
M-75	1	4	-54.0	Sand, fine, uniform	102.1	91.0
	5	1	-62.2	Sand, fine, stratified	99.2	77.8
		5	-63.2	Sand, medium, uniform	104.3	81.9
	7	2	-68.5	Sand, fine, uniform	101.3	73.5
		6	-69.5	Sand, fine, stratified, with trace of lignite	100.6	76.0
	9	1	-73.2	Sand, fine, stratified, with trace of lignite	96.6	70.9
		6	-74.5	Sand, fine, stratified	98.7	76.3
	11	2	-78.5	Sand, fine, stratified, with trace of lignite	94.9	60.3
		5	-79.2	Sand, fine, stratified, with trace of lignite	97.5	76.6



PLAN OF BORINGS

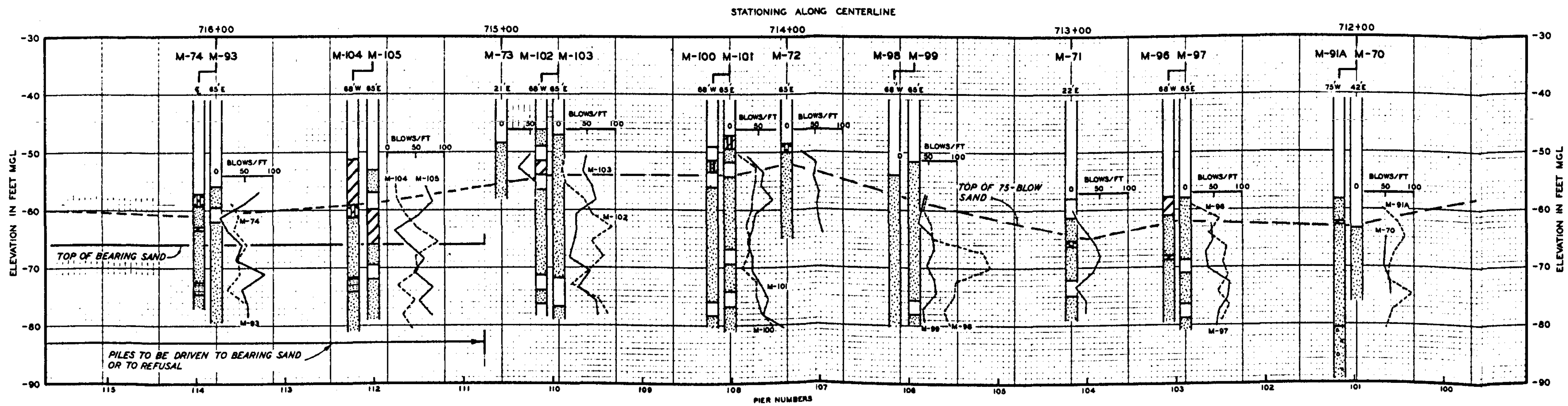
SCALE: 1 IN. = 200 FT.

LEGEND

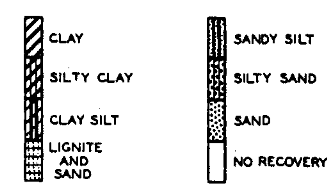
○ UNDISTURBED BORINGS
● GENERAL SAMPLE BORINGS
● DRIVE BORINGS

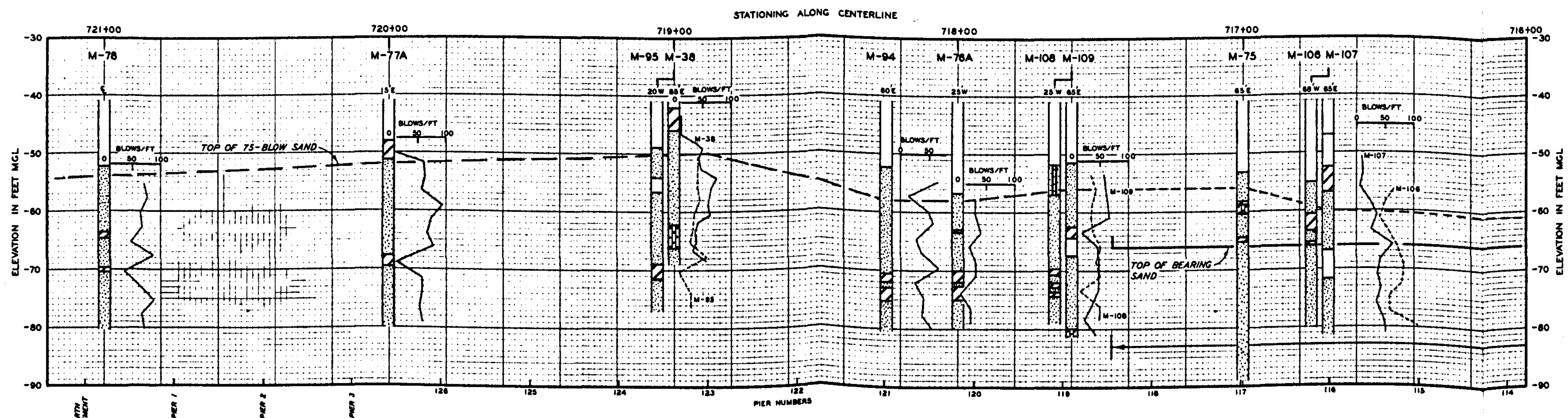
NOTES:

1. BORINGS N.O. 10 THRU N.O. 13 MADE WITH 1-3/4-INCH CUP-TYPE SAMPLER IN DECEMBER 1938 BY NEW ORLEANS DISTRICT, C.E.
2. BORINGS M-29 AND M-33 MADE WITH AUGER AND BAILER IN FEBRUARY 1948.
3. UNDISTURBED SAMPLE BORINGS M-19, 27, AND 31 MADE WITH 5-INCH VACUUM SHELBY TUBE SAMPLER IN FEBRUARY AND MARCH, 1948.
4. DRIVE BORINGS MADE WITH 1-1/2-INCH SPLIT-SPOON SAMPLER AND FISHTAIL. DRIVING RESISTANCES PLOTTED TO RIGHT OF BORINGS OBTAINED USING 140-LB HAMMER WITH 30-INCH DROP. BORINGS M-36,-37, AND-38 MADE IN DECEMBER 1948. BORINGS M-39 THRU M-109 MADE IN MARCH THRU MAY 1950. BORINGS FISHTAILED WITHOUT SAMPLING TO ELEVATION INDICATED BY TOP OF SOIL SYMBOL AND BELOW THE LOWEST ELEVATION OF DRIVING RESISTANCES.
5. BORINGS M-40,-42,-58, AND-75 MADE WITH 3-INCH PISTON SHELBY TUBE SAMPLER AND FISHTAIL. BORINGS FISHTAILED WITHOUT SAMPLING TO ELEVATION INDICATED BY TOP OF SOIL SYMBOL.
6. FIGURES ABOVE BORINGS ARE DISTANCES BORINGS ARE OFFSET FROM CENTERLINE.
7. LINE INDICATING TOP OF 75-BLOW SAND IS ESTIMATED ELEVATION WHERE PILE DRIVING RESISTANCE WILL BECOME 75 BLOWS PER FOOT WITH A 30,000-FT LB HAMMER.
8. PIER 1 IS AT STATION 680+75.70.



LEGEND





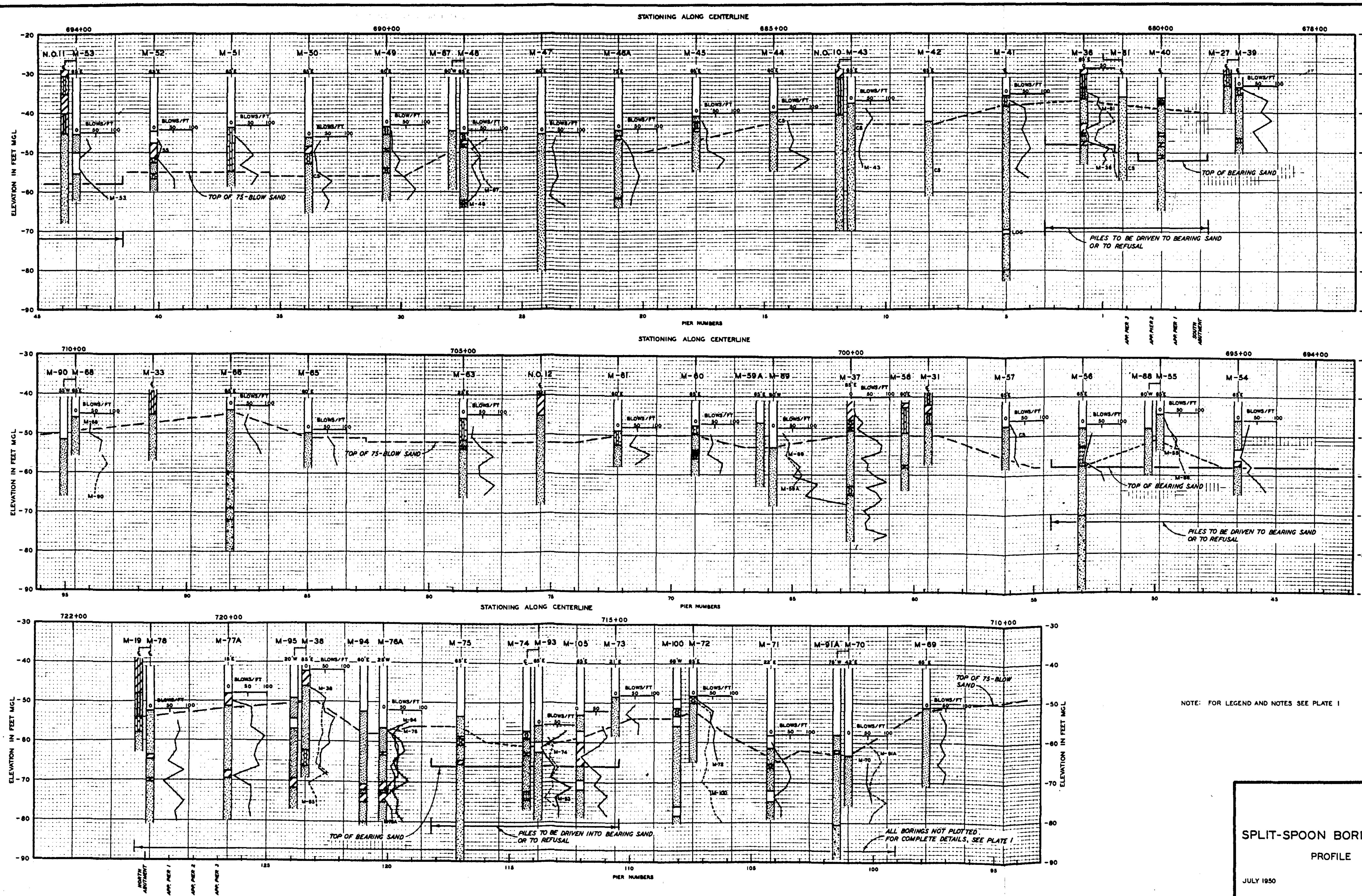
PARTIAL PROFILE

SPLIT-SPOON BORING LOGS

PLAN AND PARTIAL PROFILE

JULY 1950 FILE 3028

PLATE 1



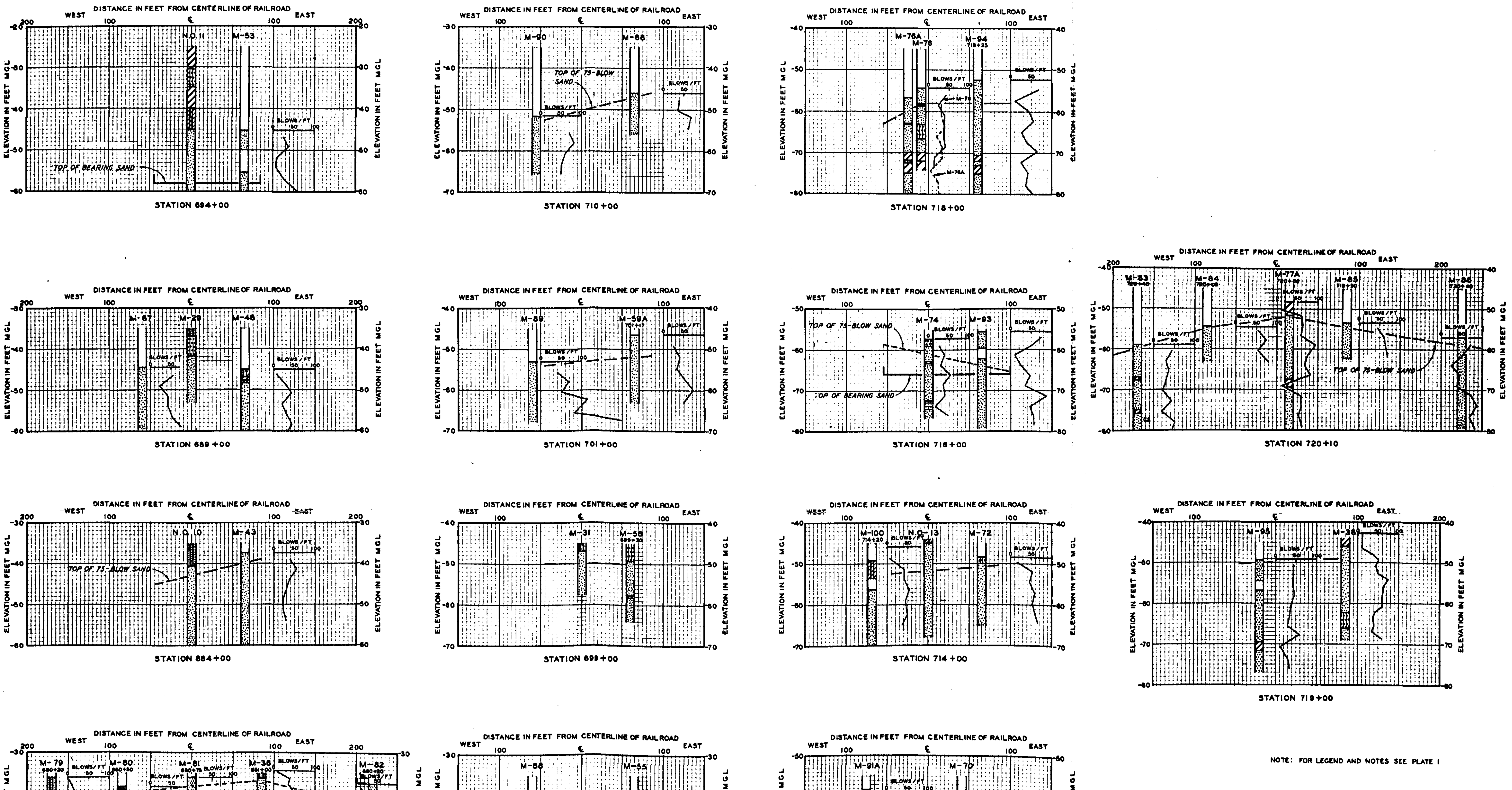
SPLIT-SPOON BORING LOGS

PROFILE

JULY 1950

FILE 3028

PLATE 2



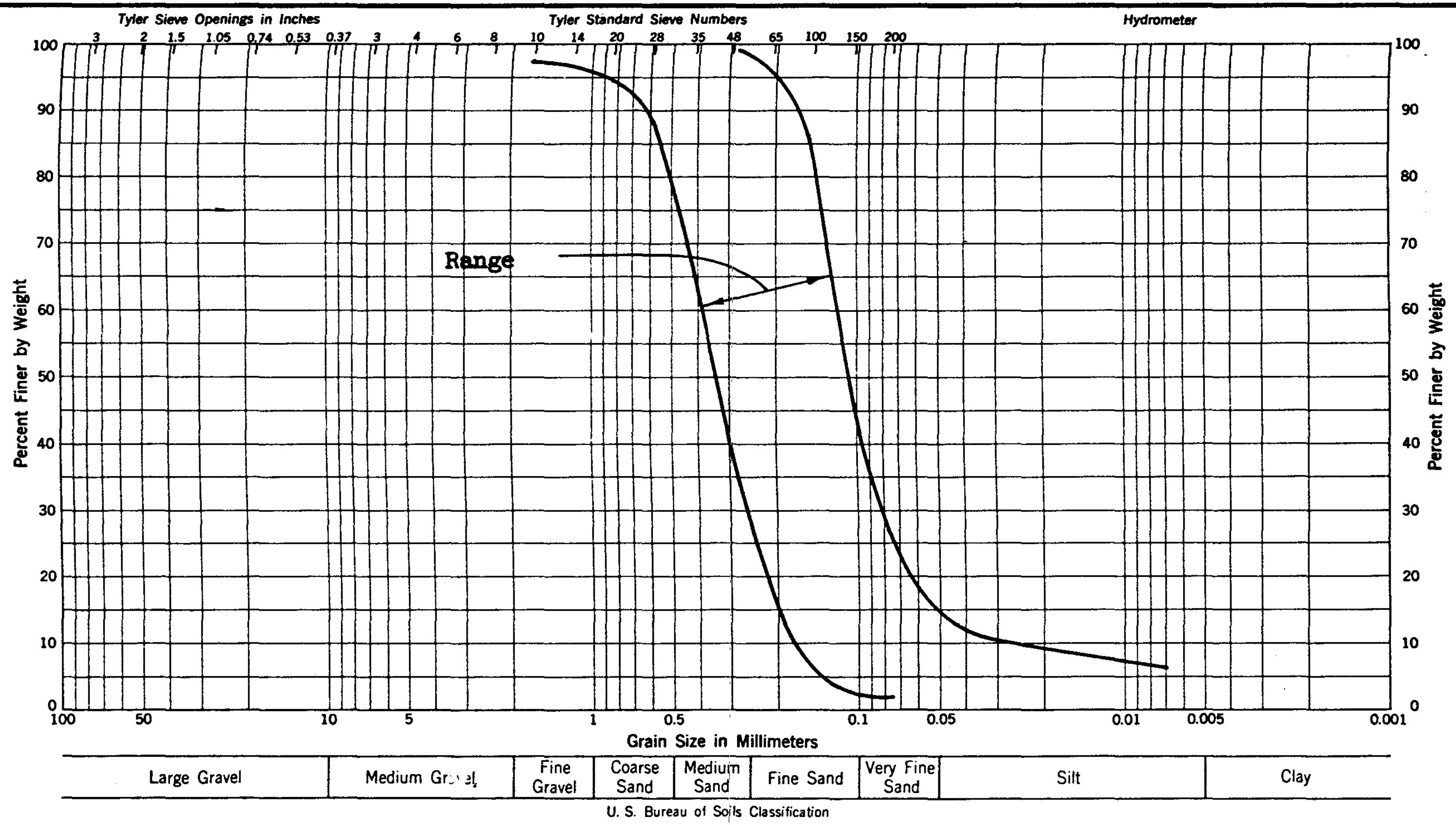
NOTE: FOR LEGEND AND NOTES SEE PLATE 1

SPLIT-SPOON BORING LOGS

CROSS SECTIONS

JULY 1950 FILE 3026

PLATE 3



FOUNDATION SAND GRAIN SIZE

June 1950 File 3028

Plate 4

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