CORPS OF ENGINEERS, U. S. ARMY

MISSISSIPPI RIVER COMMISSION

GEOLOGICAL INVESTIGATION OF MISSISSIPPI RIVER ACTIVITY

MEMPHIS, TENNESSEE, TO MOUTH OF ARKANSAS RIVER

TECHNICAL MEMORANDUM NO. 3-288

WATERWAYS EXPERIMENT STATION

VICKSBURG, MISSISSIPPI

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PREFACE

This project was authorized by the President, Mississippi River Commission, during the summer of 1946. The authorization was cited in the government contract between Dr. H. N. Fisk, consultant, and the Mississippi River Commission.

Much of the data utilized in this study was obtained from the Memphis District Office, over a period of years. These data include hydrographic survey sheets; levee, revetment, channel stabilization and other borings made during the past several years; channel stabilization plan sheets; Memphis District revetment and dike sheets; and project and index maps of the Memphis District. Miscellaneous maps, quadrangles, aerial photographs, and early stream channel maps were obtained from the Mississippi River Commission. Additional data were obtained from field inspection trips and from discussions with personnel of the Memphis District.

Preliminary work on this study was accomplished by members of the geological staff of the Waterways Experiment Station under the supervision of Dr. H. N. Fisk, consultant. Final assembly of data and writing of the report were accomplished by P. R. Mabrey, W. B. Steinriede, Jr., and A. Osanik under the supervision of W. J. Turnbull.

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GEOLOGICAL INVESTIGATION OF MISSISSIPPI RIVER ACTIVITY

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PART I: INTRODUCTION

1. This report presents the initial results of a study of past Mississippi River activity and prediction of its future behavior between Cairo, Illinois, and the Gulf of Mexico. The specific purposes of the study are to determine the detailed history of the Mississippi River during the past two hundred years from plotted positions of all important historic bankline surveys; to determine the nature and distribution of the various types of bed and bank materials of the Mississippi River and the effects of these materials on river activity; to determine and outline areas which will experience excessive bank caving within the next few years; and to attompt the prediction of future banklino positions of the river.

2. This report is concerned with the segment of the Mississippi River from Memphis, Tennessee, to the mouth of the Arkansas River. It has been prepared for the purpose of presenting the results of the study thus far accomplished in order that it may be determined whether such investigations should be continued to include the remainder of the river.

PART II: GENERAL GEOLOGY

3. The area under consideration in this report is a portion of the alluvial valley of the Lower Mississippi River. A brief summation of its general geology is presented in the following paragraphs. Much of the data was derived from previous geological investigations of the valley.*

Physiography

4. Several distinct physiographic divisions of the Mississippi Alluvial Valley are crossed by the Mississippi River in that portion of its course between Memphis, Tennessee, and Rosedale, Mississippi. The segment of the river from Memphis to Helena, Arkansas, flows southwestward paralleling the St. Francis Basin which forms the southern portion of the Eastern Lowlands (see plate 1). These lowlands, which form one of the major physiographic divisions of the alluvial valley, are outlined on the east by the valley walls and on the west by Crowleys Ridge. From Helena to Rosedale the Mississippi River continues southwestward, flowing across the widest portion of the alluvial plain. Here, the present meander belt of the Mississippi River forms a boundary between the extensive Yazoo Basin to the east and the lowlands of the White and Arkansas Rivers to the west. Within the distance of approximately 200 river miles from Memphis to Rosedale, the river has constructed its meander belt across several older physiographic units. Within the St. Francis Basin is the

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* For additional details on the geology of the Lower Mississippi River see the published report by H. N. Fisk, entitled "Geological Investigation of the Alluvial Valley of the Lower Mississippi River," Mississippi River Commission, 1944.

St. Francis segment of an ancient course of the Mississippi River which roughly parallels the eastern side of Crowleys Ridge and is truncated by the present meander belt of the river near Helena, Arkansas. North of Helena a broad flood basin separates this ancient meander belt from the present. The Yazoo Basin, bordering the present river's meander belt from Memphis to Rosedale, is divided into smaller basins by two low meander belt ridges. These ridges are, from east to west, the abandoned Yazoo meander belt of the Mississippi and Ohio Rivers, a complex group of minor ridges and basins, and the abandoned Sunflower meander belt of the Mississippi River. To the west of the Mississippi River, between Helena and Grand Prairie Ridge, is the southern extremity of the Western Lowlands. The northern part of this area is a surface formed by ancient braided channels of the Mississippi River. Separating this old braided surface from Grand Prairie Ridge is the floodplain of the White River. The Arkansas Lowland, which separates Grand Prairie Ridge from the uplands to the southwest, forms the boundary between the southern extremity of the area under investigation and the Boeuf Basin.

Stratigraphy

Tertiary system

5. The stratigraphic section of the Tertiary system (see table 1) between Memphis, Tennessee, and Rosedale, Mississippi, is restricted to the Eocene series. The Wilcox, Claiborne and Jackson groups comprise the Eocene in this general region and compose the bedrock underlying the alluvial deposits. The Claiborne is the predominant bedrock formation, underlying approximately two-thirds of the present course of the segment of river

Table 1

Age and Lithologic Characteristics of Deposits Forming the Bed and Bank Materials of the Mississippi River between Memphis, Tennessee, and Rosedale, Mississippi

ERA	SYSTEM	SERIES	GROUP	FORMATION	LITHOLOGIC CHARACTERISTICS
Cenozoic	Quaternary	Recent	Alluvium	River meander belt deposits	Composed of clays and silty clays filling abandoned channels; silty sand forming point bars; and fine-grained sediments forming the natural levees.
				Braided stream deposits	Poorly sorted clays, silts, and sands laid down by braided streams during early stages in alluvial plain development
				Loess	Non-stratified, calcareous, fossiliferous silt.
		Pleistocene	Terrace Deposits	Prairie Montgomery Bentley Williana	Each formation consists of a basal sand and gravel section overlain by clays and silts. May be distinguished from Recent deposits by their oxidized nature and red to brown color. Clays and silts relatively much firmer and tougher than those of Recent.
	Tertiary	Eocene	Jackson	Danville Landing	Predominantly marine, calcareous clays and shales.
				Yazoo Clay	Clays, lignitic clays, interbedded marine and brackish-water silts.
				Moodys Branch	Glauconitic shell marl and clays.
			Claiborne	Cockfield	Lignitic sands, silts and clays.
				Cook Mt.	Glauconitic clays, silts and sands
			Wilcox	Grenada	Lignitic sands, silty sands, silt.
				Holly Springs	Coarse lignitic sands, locally graveliferous, with sandy clays, clay lentils and fossil leaves.

studied, while the Jackson comprises the remaining one-third. The Wilcox is entirely absent in the limited area which was studied. The distribution of these older sediments underlying the Recent deposits, as determined from deep borings, is shown on plate 2. Although these deposits differ little from the Recent deposits found in the present alluvial valley in point of origin and composition, they show a decided difference in density and amount of compaction. Being more indurated than are Recent sediments, they offer more resistance to erosion and exert a greater control of river alignment where they form the bed and bank materials. However, as they are exposed to river erosion at only a few localities, their combined effect on river activity is of a minor nature.

Quaternary system

6. Pleistocene. The Pleistocene deposits of the Central Gulf Coastal Plain are divided into four formations: the Williana, Bentley, Montgomery and Prairie, in order of decreasing age. These formations are related to the four interglacial stages of the Pleistocene era. Each formation in this area underlies a fluvial surface which has been uplifted to form a terrace and each exhibits a similar sequence of alluvial materials grading upward from basal gravels and coarse sands through sands and into silts and clays.

7. Recent. The deposits of Recent age, which partially fill the entrenched valley system of the Mississippi River, are of irregular thickness, grade upward from coarse graveliferous sands into progressively finer deposits of sands, silts and clays in the same general sequence as is found in the Pleistocene terrace deposits. It is possible to divide the section roughly into a substratum of sands and gravels and a topstratum

of fine-grained nongraveliferous beds, thus producing two fairly distinct units. The relation of these units to each other to the present river is shown on plate 3; section A-A' is a cross section of Tertiary and Quaternary deposits along a traverse line from Pine Bluff, Arkansas, to Memphis, Tennessee, and section B-B' presents similar relationships between Mellwood, Arkansas, and Farrell, Mississippi. In the area north of Rosedale, Mississippi, sands and gravels extend to depths of 50 ft below sea level thus providing graveliferous and sandy sections as much as 100 to 150 ft in thickness. Although the basal gravels are resting on a highly irregular floor (see plate 2) the upper sandy surface is fairly uniform and grades, sometimes abruptly, into the section of finer sediments. The profile drawn on top of the sandy substratum, presented on plate 4, shows the depth to the substratum in basins adjoining the Mississippi River. The fine-grained topstratum, overlying the sands, has developed chiefly as the result of meandering conditions of the river and, consequently, is composed of several distinct types of deposits which are discussed in detail in Part III.

Late Geological History

8. The principal geological event which has left its mark on the Pleistocene and Recent history of the Mississippi Alluvial Valley is the cyclical rise and fall of sea level which accompanied continental glaciation during Pleistocene time. With each lowering of sea level, as a result of water being trapped on the continents in the form of ice, the streams draining the Mississippi Valley experienced overly steepened gradients and thus were enabled to scour out deep valleys. As a result

of this excessive erosion, tremendous tonnages of sediments were deposited along the Gulf shore where continuous downwarping of the earth's crust resulted. As an isostatic adjustment to this downwarping, a contemporaneous uplift was taking place inland from the Gulf. The periods of erosion were followed by periods of deposition when sea level rose as a result of the melting of the continental glaciers. These cycles of erosion and deposition, coupled with the contemporaneous uplifting of the land, caused the development of the four depositional terraces (see paragraph 6) which are found in the uplands bordering the Mississippi Alluvial Valley.

River entrenchment

9. During Late Wisconsin time, the last of the glacial stages, sea level was between 400 and 450 ft lower than it is at present so that the Gulf shoreline was situated near the edge of the continental shelf. Greatly increased gradients caused streams within the Mississippi Valley to deeply incise their courses into the bedrock underlying the present mantle of Recent alluvium. The resultant hill-and-valley topography is expressed by contours on plate 2 which shows the entrenched valley system of the Mississippi River. During this time, the Mississippi River flowed in a trench to the west of Crowleys Ridge while the Ohio and its tributaries flowed to the east of the ridge, the junction of the two major streams being in the vicinity of Rosedale, Mississippi.

Recent alluviation

10. With the waning of the last period of glaciation on the continents, meltwaters from the glaciers returned to the oceanic basins and

caused a gradual rise in sea level. The oversteepened gradients of the streams were gradually reduced as sea level rose and, as a consequence, deposition of sediments by the streams began to take place. During the first phases of this depositional period, coarse materials were laid down near the coast. As sea level continued to rise a gradual wave of alluviation moved up the major and tributary valleys, with the basal coarse sediments being followed by sands, silts and finally clays as the stream gradients were progressively reduced. The result is a sedimentary sequence in which lenticular gravels and coarse sands at the base grade upward into "clean" sands and thence into fine sediments near the surface. During the early stages of this period of alluviation, the Ohio and Mississippi Rivers were so overloaded as to be in a braided condition and, as a result, the rapid deposition of sediments which characterized the Mississippi and Ohio Rivers during the last rise in sea level resulted in significant shifts in their courses. In the upper portion of the valley, Crowleys Ridge served as a barrier between the Mississippi River to the west and the Ohio River to the east. Each river deposited sediments independently of the other and built out huge alluvial cones which gradually filled their respective valleys. Eventually, because of erosion of the divide between the two valleys and greater alluviation in the western valley, the Mississippi was diverted from the Western Lowland to the Eastern Lowland where it joined the Ohio near Cleveland, Mississippi. Subsequent diversions and changes in the courses of the two streams resulted finally in the Mississippi crossing Crowleys Ridge at Thebes Gap and forming its junction with the Ohio at its present position at Cairo, Illinois. As the alluvial valley gradually filled and sea level reached its present stand, the stream gradients were greatly reduced and the streams gradually changed from their former overloaded, braided form to a meandering habit. In the latter, the flow is confined to a single channel with deep scouring action, periodic flooding, and rapid lateral migration. New environments of deposition were developed by these changes and much of the old braided stream deposits was reworked and redeposited elsewhere or was covered by sediments laid down in flood basins flanking the meandering courses of the streams.

Structure

11. The axis of the Mississippi Structural Trough is generally considered as roughly paralleling and probably to a great extent as having determined the present course of the Mississippi River. Faulting in this area, both on a minor and a major scale, follows an earth-grid pattern comparable to major fault directions elsewhere on the continent. In general the faults are aligned in northeast to southwest and northwest to southeast trends. These alignments are reflected in the drainage. The Mississippi River from Memphis to Rosedale, follows a grid orientation from northeast to southwest, although in other parts of its course the alternate trend is followed. This southwestward course conforms to the Big Creek Fault Zone which is partially responsible for the abrupt termination of the ancient Mississippi alluvial cone southwest of Helena and possibly for the southern termination of Crowleys Ridge.

PART III: ALLUVIAL DEPOSITS ALONG THE RIVER*

12. Previous studies of the Mississippi Alluvial Valley have shown that the deposits through which the river is flowing are of alluvial origin, are related to the past history of river activity, and, in the area from Memphis, Tennessee, to the mouth of the Arkansas River, are divisible into three main types:

- a. Meander belt deposits. Sediments which were laid down by the meandering river during the latest stage in alluvial plain development.
- b. Backswamp deposits. Sediments deposited in flood basins. In the area under discussion, they occur as a mantle overlying old braided stream deposits.
- c. Braided stream deposits. Sediments laid down by the Mississippi River and its tributaries prior to the establishment of the Mississippi as a meandering stream.

The following is a discussion of these various types of deposits. Emphasis is placed on the origin, physical properties, thickness, and distribution. Plate 4 shows the distribution of the alluvial deposits along the Mississippi River. Plates 5 and 6 present typical cross sections (for locations see plates 10 to 20 inclusive) and plate 7 presents grain-size distribution curves of the various soil types.

Meander Belt Deposits

13. Meander belt deposits can be divided into three main types on the basis of the environment in which they were laid down. These are

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* The older sedimentary rocks of Wilcox, Claiborne, Jackson and Pleistocene age, discussed in Part II, occur only locally along the river and are not discussed in this chapter.

point bar, channel fillings and natural levee deposits.

Point bar deposits

14. It is evident, from plate 4, that the present meander belt of the Mississippi River is composed largely of point bar sediments. They comprise well over seventy-five percent of the bank and bed materials and are fairly uniform in their areal distribution. Point bars develop through accretion of river silts and sands in the form of fill along the rims of growing meander cores as the meander loops enlarge (see figures 1, 3 and 5). Thus there is a continuous addition of materials in the form of thin crescentic strips with the downstream portion being somewhat better developed. This is in accordance with a tendency of meanders to move downstream. Although the point bar is built out continuously by accretion, deposition is not uniform for all stages of the river. Low-stage point bars form near water level and have submerged downstream ridge-like extensions which separate deadwater portions of the river from the channel. During high stages, the bars become flooded and currents develop through the low-stage deadwater areas and often scour deep narrow channels back of the bar ridge. Together with the scouring,high-water deposition takes place on the low-stage bar. During the following low stages, the channel remains as a slough behind the bar ridge and again forms a deadwater area. The process is repeated during successive high stages, and, as channel migration continues the bar ridge is built up and the slough may be completely cut off from the river to form a lake which gradually fills with fine-grained sediments. As the point bar grows, a series of crescentic ridges and intervening swales is developed (see figure 3). Point bar deposits may therefore be separated into bar ridge deposits and slough

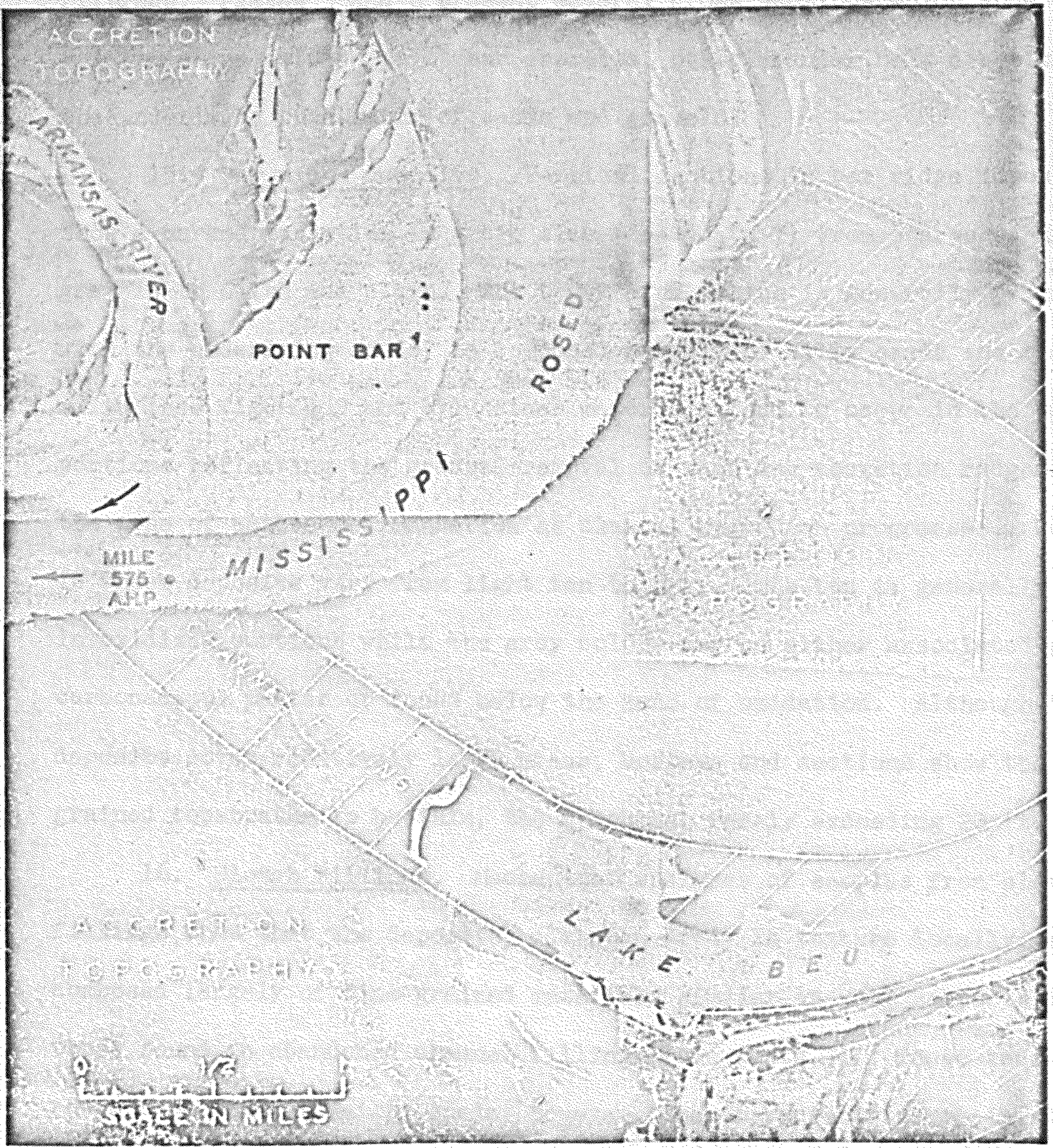

Figure 1: Abandoned channels, point bar deposits and ridges and swales of accretion topography
Lake Beulah, Mississippi. Mile 575 A.H.P.
Gage, mouth of White River 28 Nov 1947, 5.83 ft

Figure 2. Typical section of point bar deposits overlain by thin blanket of natural levee silts and clayey silts. Lower end of pilot cut for Hardin Cut-off, mile 676 A.H.P.

Slough fillings vary widely in thickness and in their shape and size as expressed on the surface. These variations are due in part to the variety in the shapes and sizes of Mississippi River bends and in part to the rate of channel migration within the bends. The fillings show a general range in width on the surface of from 100 to 500 ft, and thicknesses may range from a few feet to over 80 ft.

Abandoned channel fillings

17. The mapped distribution of meander belt deposits along the Mississippi River shows that abandonment and subsequent filling of cut-off meander loops has been a common occurrence (see plate 4). Meander loops are abandoned whenever the river can shorten its course. The two types of cut-offs by which this is accomplished are the chute cut-off and the neck cut-off.

18. Chute cut-offs occur as the result of the scouring of shorter channels in one of the old slough positions within a point bar. This process takes place slowly because the angle of diversion of the water down the shorter course is small and the increase in flow is gradual.

19. Natural cut-offs of the neck type result from the coalescence of the upper and lower arms of a meander loop. As this type of cut-off occurs late in the development of a meander loop, the abandoned segments are generally larger than those cut off by chutes. This type of cut-off is usually completed sooner than the chute type because of the greater angle of diversion and the greater increase in local stream gradient.

20. Abandoned channel segments are eventually completely cut off from low-water flow and form lakes which gradually fill with sediments derived from floodwaters (see figures 1, 4, and 5). The nature of the sediments as well as the rapidity with which the old channel is filled is

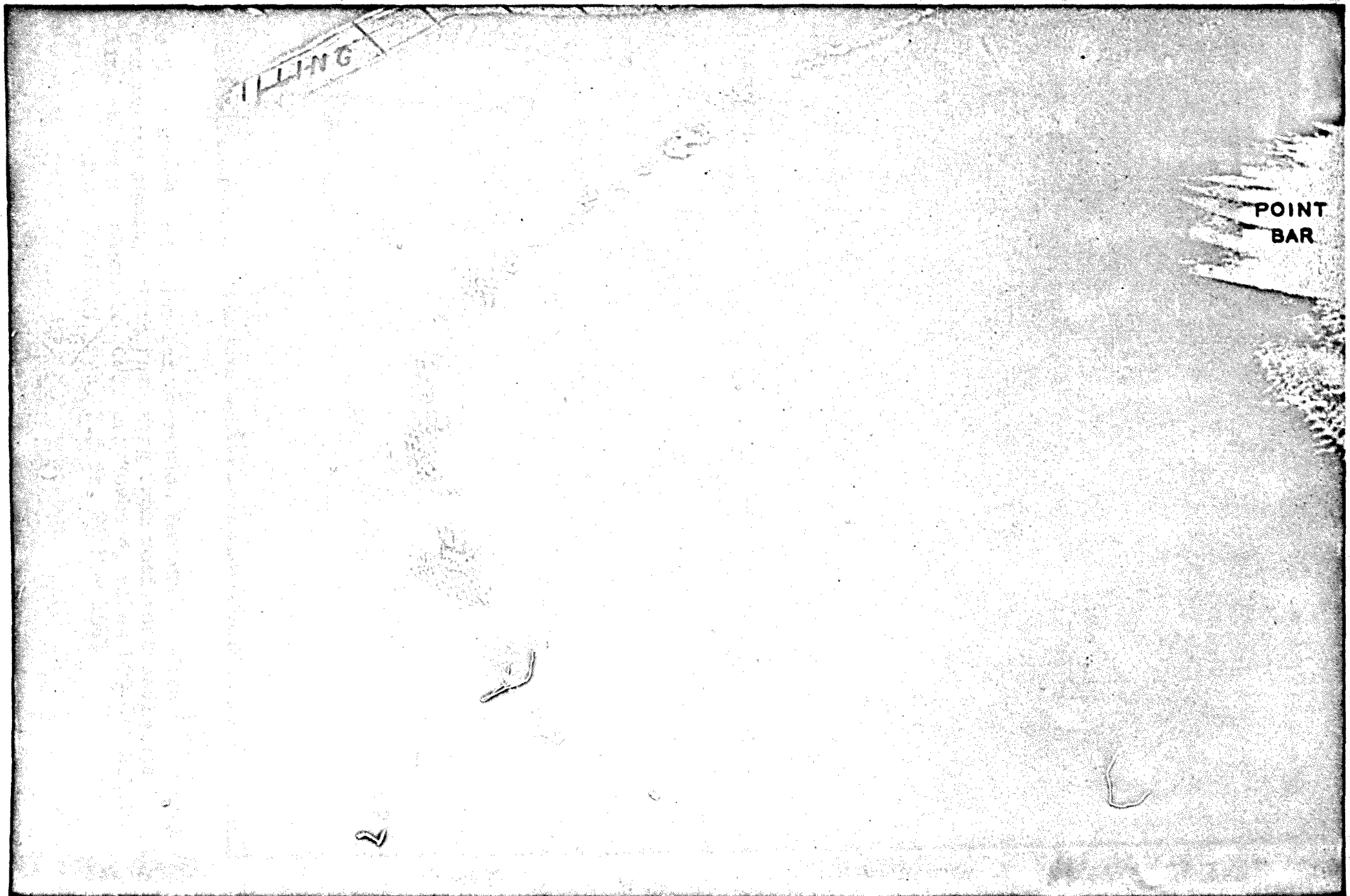

Figure 4. Caving bank near Fair Landing, Arkansas. Note arcuate shape of slump blocks. Mile 630 A.H.P.

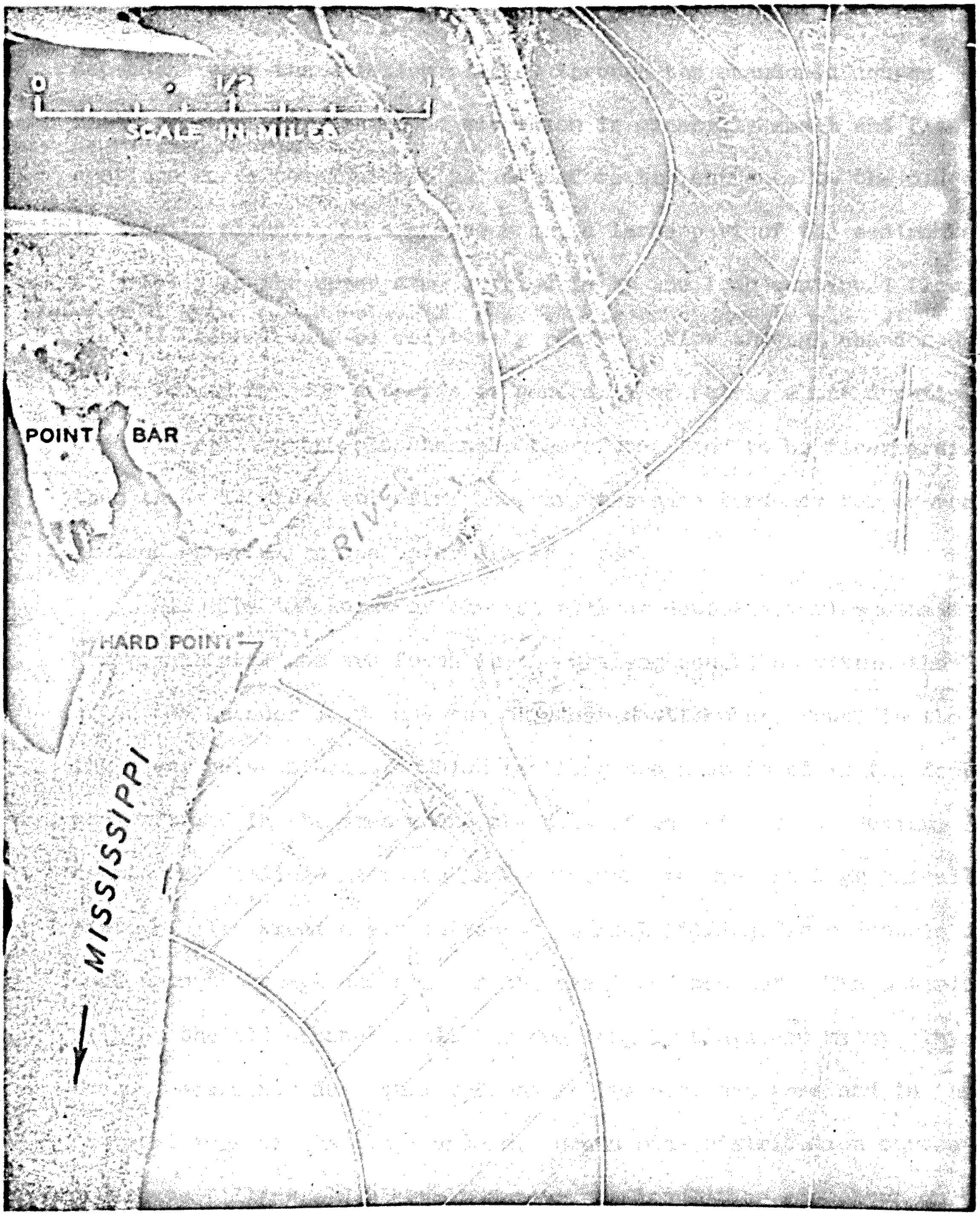

Figure 5. Channel and point bar accretion features. Note hard point and narrow channel width resulting from resistant sediments filling abandoned channel. Cessions Towhead, miles 609-611 A.H.P. Fair Landing, gage, 3.5 ft, 26 Nov 1947

dependent upon the duration of flow through the abandoned course. In chute cut-offs, the angle of diversion is generally small and flow may continue for a considerable period before the entrance to the old channel is finally closed. As a consequence, a large part of the sediments, especially in the upper arm, carried in by the long continued flow down the old channel, may be relatively coarse. Flow through abandoned segments formed by neck cut-offs is generally of fairly short duration. The deposits filling the old channel, therefore, tend to be finer grained than those in chute cut-offs; however, the same tendency for coarser grained material in the upper arm is noted.

21. The thickness of channel filling deposits varies considerably. Maximum thicknesses are found in the thalweg positions within the bendway of an old meander loop, and the thinnest sections are found in the crossing areas between bends. Thick sections are also found in the deep scour pools formed in the area where the cut-off was effected. Maximum depths of channel fillings near the present river are presented graphically on plate 4. The areal distribution of channel fillings is of course dependent upon the shape and size of the abandoned meander. The materials filling the old channel positions are largely clays and silty clays. Coarser sediments are usually found in the upstream arms and in the crossing positions of the old meanders. Grain size distribution curves of sediments filling old channels from these localities are shown on plate 7. Because of the nature of the environment of deposition and the fine texture of the sediments, water contents are generally high, ranging to over 150 per cent. The content of organic material is often high in the upper portions because of the dense growth of vegetation which forms a cover

soon after the channel is filled.

Natural levee deposits

22. The occurrence of these deposits is limited to a narrow zone bordering active and abandoned channels. They consist of sediments deposited from waters overtopping the banks during times of flood (see figures 2 and 6). After overflowing its banks, river water fans out and quickly loses velocity; consequently a large part of the load is dropped soon after leaving the channel. As a result, natural levee deposits are built up to form a low ridge near the river which gradually slopes down landward. The best development of natural levee deposits is found along the outside of bendways, although, even in these areas, the deposits rarely exceed a maximum of 15 ft in thickness near the channel, gradually lensing out landward. Mechanical analyses of natural levee deposits (see plate 7) show the sediments to consist principally of sandy silts, clay silts and silty clays. Tests on samples taken at intervals in a direction normal to the levee crest show a gradation in texture from coarse to fine landward. Natural levees generally have good drainage, and water contents of the deposits accordingly are low. As well-drained surfaces do not promote heavy growths of vegetation, the organic contents of the sediments are also low.

Backswamp Deposits

23. The sediments deposited in flood basins are limited in their occurrence to the west side of the Mississippi between Oldtown, Phillips County, Arkansas, and the mouth of the White River (see plate 4). However, the present channel of the Mississippi is actively cutting into these

Figure 6. Natural levee silty sands and clayey silts overlying point bar deposits. View along right bank at lower end of Jackson Cut-off, mile 622.5 A.H.P. Note sloughing of sandy point bar material.

sediments only at Scrubgrass Bend, north of Rosedale, Mississippi (see plate 4 and figure 3). Backswamp deposits in this area form a thin mantle over older braided stream deposits as shown by borings made at Cypress Bend, Arkansas (see plate 7). These deposits, laid down during periodic flood stages of rivers, consist largely of clays, silty clays and clay silts with relatively high water and organic contents. Colors range from grays in the northern part of the area to reddish-brown to the south, the red coloration being attributed to White River sediments.

Braided Stream Deposits

24. Sediments deposited by braided streams are limited in their occurrence to essentially the same area as that of the overlying backswamp materials (see plate 4). They are also being actively removed by the Mississippi River only at Scrubgrass Bend. North of Snow Lake, Arkansas, these deposits were laid down by ancient braided channels of the Mississippi River when its course lay to the west of Crowleys Ridge. To the south, the sediments are of White River origin. Traces of the old braided channels are still visible through the overlying blanket of backswamp sediments (see figure 3). Braided stream deposits are characteristically poorly sorted and show a wide range in grain size with a gradual decrease in size from north to south and also upward in the section. The deposits laid down by the White River, being near the southern extremity of braided stream deposits, are relatively fine in texture. Although no actual data are available as to grain sizes nor thicknesses of the White River deposits they should be very similar in all respects to those laid down by the Arkansas River. Borings made at Cypress Bend, Arkansas, reveal

the texture of the sediments (see plate 7) and show the thickness to be from 20 to 30 ft. The color of White River as well as Arkansas River braided stream deposits is a characteristic reddish-brown as compared with the prevailing gray of Mississippi River sediments.

PART IV: MISSISSIPPI RIVER ACTIVITY

Introduction

25. The continuous migration of its channel is one of the most impressive features of the Mississippi River. A comparison of maps of the present course of the river with those of early surveyed courses presents graphically the great amount of channel migration which has taken place during historical time. This constant shifting is the result of the erosional and depositional activities of the river. The concave banks within bendways are continually under attack by the scouring action of the river and gradually recede as portions are undercut and removed by caving. The recession of a caving bank is accompanied by a contemporaneous advance of the opposite bank through accretion of sands derived from upstream points of scour and deposited in the slackwater area in the convex portion of the bendway. Continuation of these processes (see paragraph 17) may eventually result in the formation of a meander loop which becomes cut off from the river by the coalescence of the upper and lower arms of the loop. Cut-offs may also be brought about by the enlargement of chutes across point bar accretion areas. The past history of the activity of the river is shown on historic mapped courses* of the river dating back to 1765 and also on aerial photographs of the alluvial plain, on which traces of prehistoric courses of the migrating stream are clearly shown.

26. A study of the various surveyed courses of the Mississippi

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* "Early Stream Channels, Mississippi River, Cairo, Illinois to Baton Rouge, Louisiana," Mississippi River Commission, 1941.

River reveals that the rate of migration of bends, and portions of bends, is not uniform, but highly variable. The primary factor affecting the nature of the bends is the erodibility of the bed and bank materials through which the river flows. Certain types of sediments are easily eroded and permit rapid channel migration where they occur, whereas other types are highly resistant to scour and, consequently, channel migration is relatively slow where they predominate.

Factors Affecting River Activity

27. Following the last rise in sea level, the Mississippi River gradually became adjusted to the load which it carries, to the valley slope, and to the material through which it flows. Since the river reached this poised condition, the discharge, bed load, and slope have remained relatively constant except for seasonal changes in discharge, localized variations in bed load, and local changes in slope as the result of natural and artificial cut-offs. The most important variable is considered to be the nature of the bed and bank materials.

Load

28. This variable is considered by some as being of primary importance in affecting the rate of bank caving. One concept is that in cases where an abnormally large supply of sand from one bend is transmitted downstream and deposited in the convex portion of the next bend, the accelerated growth of the bar causes the current to be directed against the opposite bank, thereby increasing caving.

Slope

29. The slope of the Mississippi River, when taken in its entirety,

is considered to be constant; however, changes do occur locally which affect the activity of the river. Chief among such changes occur at points of cut-off. Cut-offs materially shorten the length of the river thus creating a local increase in slope and increased activity as the river seeks to restore the former slope. Slopes are also increased in bendway areas where resistant materials prevent the lateral migration of the channel. In such instances the river tends to deepen and narrow its channel opposite the resistant feature with a resultant increase in velocity.

Discharge

30. Generally speaking annual discharge of the Mississippi does not change materially from year to year and therefore, taken as a whole, probably is not a great influence on river activity. However, seasonal fluctuations can vary considerably during any one year and over a period of years and influence bank caving correspondingly. As such unusual fluctuations cannot be anticipated they cannot be given specific consideration in this report.

River activity and alluvial materials

31. Bed and bank materials affect river activity through their control of bank caving. Thereby, they regulate rates of channel migration, and control amounts of locally derived bed load as well as local changes in channel alignment and cross sections. The principal and most apparent effect of bed and bank materials is the influence which they exert on rates of channel migration. Wherever thick masses of fine-grained sediments form river banks, channel migration is appreciably

retarded. In places where the river cuts into sandy deposits, bank recession is rapid and the rate of channel migration is at a maximum. The degree of resistance which the bed and bank materials offer to channel migration results in several secondary effects on river activity. Variations in the channel cross section affect local stream velocities, thus bringing about changes in the local bed load carrying capacity of the stream. Stream alignments are altered either by rapid recession of the bank, in coarse sediments, or by very slow bank recession where a thick mass of fine-grained sediment locally retards normal enlargement of a meander loop and changes the stream directive.

32. As discussed in Part III, alluvial deposits found along the segment of the Mississippi River from Memphis, Tennessee, to the mouth of the Arkansas River are of two major types; meander belt deposits and braided stream-backswamp deposits. The meander belt materials may be further subdivided into abandoned channel fillings, point bar deposits and natural levee deposits. Because these deposits vary in thickness, nature, and distribution, their effects on Mississippi River activity are consequently varied. The thick, cohesive clay masses filling many abandoned channel segments are highly resistant to the river's scouring action, whereas the loosely consolidated sands in bar ridges are easily removed. Backswamp sediments found in the southern part of the alluvial valley form thick, wide-spread, fine-grained deposits which are comparable to the channel fillings in their resistance to erosion; those found in the segment of river under study, however, occur only locally as a relatively thin blanket overlying ancient braided stream deposits, and therefore offer little resistance to bank attack by the river. Natural levee

deposits, which are found as a thin veneer bordering the channel of the river, are unimportant with regard to their influence on river migration.

33. Channel migration. The lateral movement of the channel does not proceed at a uniform rate in all parts of the river nor even over a period of time in localized areas. Bank recession is at a minimum in the southern portion of the river where thick masses of fine-grained sediments form the bed and banks. However, in the segment of the river under study, deposits comparable to those in the lower river are found only locally, as the fillings of abandoned channels. As these areas are localized, they often form prominent hard points (clay plugs) in the river because of the more rapid rate of channel migration to either side. Bank recession proceeds at a maximum rate in sandy point bar deposits which are relatively ineffectual in retarding channel migration and which form a major portion of the banks from Memphis to the mouth of the Arkansas River.

34. Although scouring in the thalweg of the river is the direct cause of bank caving, the manner of caving as well as the rapidity with which a bank caves is determined by the nature of the sediments forming the bed and bank. In areas where thick clayey masses comprise the upper bank materials, caving generally takes the form of slumping of large blocks of the bank (see figure 7). The cohesive nature of these sediments delays caving until scouring has steepened or undercut the face of the bank to such an extent that failure in shear is produced and a large scalloped block of the bank slumps into the river. Such large slump blocks often remain for considerable periods before being removed, during which time they act as natural revetments preventing further scouring. In sandy sediments where the topstratum is relatively thin, such as those composing

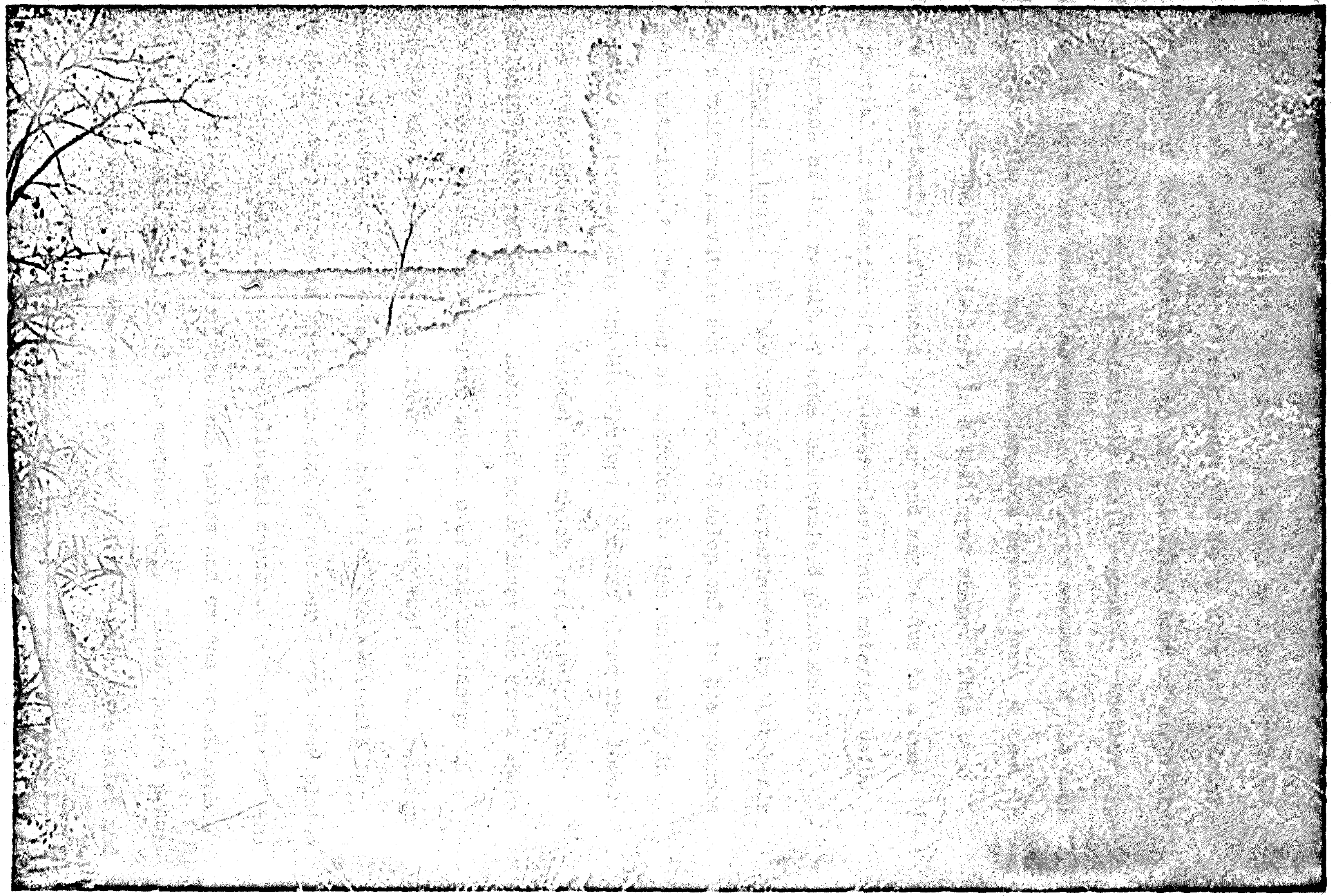

Figure 7. Large slump block developed in fine-grained deposits filling abandoned swale position. Right bank, mile 647.5 A.H.P., near Westover, Ark.

much of the point bar deposits, caving of the banks is a more or less continuous process. One type of bank recession is by slow attrition caused by scour of the underwater slope and resulting loss of stability and caving of the upper bank in relatively small segments. Another type of failure is the rather sudden movement of a large segment of the bank into the river. The segment may be as large as several hundred feet in length and depth. The bank is left in a scalloped shape. This type of failure is certainly influenced by scour and may be due to a complete or partial liquifaction of the cohesionless bank material below the water surface as the result of some undetermined phenomenon.

35. Shape of bends. It has been shown experimentally that bends exhibiting a uniform curvature and size can develop only in homogeneous bed and bank materials.* The nearest approach to this uniformity in shape and size of bends along the Mississippi is found along the lower part of the river where it flows through the thick, relatively homogeneous deltaic plain sediments. Localized occurrences are found where relatively uniform sediments which are spread over fairly widespread areas form the bank materials (see figure 3). Along most of the portion of the river under study the heterogeneous nature of the sediments is reflected in the variations in shape and size of meander loops (see plates 9-21). Where coarse- and fine-grained alluvial deposits occur in the same area the degree of erodibility of the bank varies and causes considerable variations in the shape and size of the meander loop. "Hard" points previously mentioned protrude into the river where resistant materials exist and

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* Friedkin, J. F., "Laboratory Study of the Meandering of Alluvial Rivers," Waterways Experiment Station, 1945.

"false coves" widen out in stretches of more readily erodible sediments (see figure 5).

36. In areas where bank materials are relatively uniform smoothly curving bends develop, and channel alignment changes only with the enlargement of the meander loop. If, during the process of enlargement, however, the river impinges against barriers to its lateral movement, projections in the bankline develop and alter the local channel alignment. As a result, the point of river attack may be shifted in downstream areas initiating further changes in channel alignment.

37. Channel cross section. In bendways where widespread, thick, resistant sediments occur, the channel cross section is usually narrow and deep. This may result from the tendency of the river to scour downward when lateral migration is prevented or retarded and the ability of such cohesive soils to retain a relatively steep slope. The deepening is accompanied by a narrowing of the channel as the bar grows outward from the opposite or convex side of the bendway. Examples of the narrowing and deepening of channel cross sections are found throughout the alluvial valley. In the section of the river under study, such examples are found at points where thick channel fillings or other erosion resistant features occur (see plate 5, sections E-E' and F-F', plate 6, section G-G' and figures 1 and 5). In areas where sandy deposits occur, the channel is more symmetrical, wider and shallower. The less resistant nature of such deposits results in the rapid lateral migration of the river which lessens its tendency to scour downward and thus deepen its channel. (See plate 5, section D-D'.) Often in areas where the sediments are sandy, the river divides forming an island or shallow between the major streams of flow (see plate 5, section A-A').

PART V: PREDICTION OF FUTURE RIVER BEHAVIOR

Introduction

38. The study reported herein is primarily concerned with the prediction of future river behavior. It has been based upon consideration of the influences of bed and bank materials on channel migration, as discussed previously, together with information on soil types and distribution and past activity of the river in the specific area included in the study. It is emphasized that even though predictions made herein are for a specified period of ten years they can be regarded as only qualitative in nature. So many natural and artificial influences exist, singly and in combination, that it is not believed possible to predict bank movement quantitatively. It is believed, however, that the predictions serve to indicate probable trends and to differentiate between those localities where material bank movement can be expected and those where only nominal or very little movement is likely to take place.

39. The history during the past 200 years of the segment of the Mississippi River from Memphis, Tennessee, to the mouth of the Arkansas River was investigated. Study maps (not reproduced in this report) on a scale of 1:10,000 were constructed on which the positions of banklines from as early as 1765 were plotted. Bankline surveys made during the following years were included:

1765	1925
1820-30	1933
1881	1940
1904	1942
1913	1945

In addition to the bankline surveys, accurate hydrographic surveys were available for various periods following 1877. The positions of revetments, levees, dikes and other artificial works were also added to the maps. From previous studies* the distribution of alluvial sediments within the valley was available and this information was indicated on the maps. Although no data are available as to the thickness and extent of materials already removed by the river, fairly accurate reconstructions are possible from maps of ancient courses of the Mississippi** and comparisons with sediments still existing in the area.

40. A brief examination of aerial photographs of the alluvial valley suffices to show that the materials forming the bed and banks of the river in the past were of a very heterogeneous nature. The great number of natural cut-offs which have occurred during the history of the river and the abandoned meander loops which exhibit a wide variety of shapes and sizes attest to this fact. Although the general types of alluvial deposits are but few in number, there exist so many variations in the conditions of deposition within the individual types and relative location of types that it is questionable whether two localities could be found in which the sediments are exactly similar in character over any appreciable area. Thus a study of historic mapped courses of the river shows that the rate and form of bank recession is not uniform, but varies from place to place and year to year. It is believed, however, that rough correlations can be made between the rate of bank recession observed in

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* Fisk, H. N., "Fine-Grained Alluvial Deposits and Their Effects on Mississippi River Activity," Waterways Experiment Station, 1947.

** Fisk, H. N., "Geological Investigation of the Alluvial Valley of the Lower Mississippi River," Mississippi River Commission, 1944.

the past at any specific locality, the type of sediments forming the bed and banks, and probable future migrations. Obviously, simple or direct extrapolation based on past events is not possible: e.g., a section of bank which receded 75 ft per year for the past 5 years will not necessarily recede at the same rate for the next 5 years. Any factors which will directly or indirectly affect the activity of the river at a localized area in the future must be considered before any predictions can be made. Consideration must be given to any changes in types of alluvial materials into which the bed is encroaching, to the directive of the current, and to changes in alignment of the river upstream which may alter the directive of the current at bends downstream. Furthermore, any artificial works along the river, such as cut-offs, dredging, revetments, etc., may initiate major changes in the activity of the river in the vicinity of the works and in other areas. The problem of predicting the future activity of the river is, therefore, one of considerable complexity.

41. From the discussions in previous paragraphs, and observation of the historic mapped courses of the Mississippi River it can be seen that the river wanders constantly with continuous change in meander patterns. The initial formation of a bend, its gradual enlargement, and finally its severance from the main channel of the river by a cut-off might be thought of as a cycle in the history of a localized segment of the river, with the cut-off segment as the end product. Mapped courses, as well as observed characteristics of the surface of the alluvial valley itself which retains clearly discernible traces of ancient courses, show countless such cycles. An excellent example, very nearly complete, is shown in the history of the area at Rosedale Bend from 1765 to the present.

The history of the formation of the old Lake Beulah meander can be traced from the earliest recorded bankline surveys to the time of cut-off in 1863. Subsequent to the cut-off a new bend was initiated which at the present time has reached nearly the same proportions as that found in the area in 1765.

Example at Rosedale Bend

42. A detailed discussion of the history of the river in the Rosedale Bend area is given below and is graphically illustrated on plates 8 and 8A. This detailed discussion and presentation of data serve as an example of the analysis which was applied to the remainder of that portion of the river under consideration, but for which detailed discussion and graphical data are not included.

43. River courses presented on plate 8 are 1765, 1820-30, 1881, 1913, 1946, and the predicted position of the 1957 course. Cross sections A-A' and B-B' (plate 3) show typical sediments found in the area. Clay plugs and courses of the river are assigned stage numbers as determined by Dr. H. N. Fisk.* Graphical plots were made of the yearly movements of the caving bank at the various sections shown on plate 8A. Extrapolation from these plots, modified as judgment dictated after consideration of obvious influencing factors, were made for the ten-year predictions. Most of the plots showed such marked effect of other influencing factors during the past ten years that anything approximating direct extrapolation was

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* Fisk, H. N., "Geological Investigation of the Alluvial Valley of the Lower Mississippi River," Mississippi River Commission, 1944.

not possible. A typical example of this is at range 26 where the cutting bank (left) migrated landward about 250 ft during 1938 and 1939 and then remained practically stationary until the end of 1946, after which activity suddenly began to increase and during the next year the bank moved approximately 1600 ft. One variable which affected the accuracy of the plotted bank movements was the differences at some locations between the positions for the same year from the bankline and hydrographic surveys, respectively (see plate 8A).

1765 course (stage 17)

44. This earliest of recorded courses flowed in a general southerly direction in a broad, open bend, to a point north of Rosedale where it encountered an old channel filling (stage 10). The fine-grained sediments filling the old channel, reaching a tested thickness of almost 90 ft, effectively retarded eastward migration of the channel in this area. Another clay plug (stage 7), south of Rosedale, probably also aided in the retardation of eastward migration. In addition to slowing channel migration, the thick channel fillings caused a distinct flattening of the bend. The channel began its trend to the east upon reaching the southern limit of the old channel fillings. No evidences of clay plugs are found on the east bank of the river in the area of the present Riverton revetment and the 1765 channel probably migrated rapidly in old bar materials. Untested channel fillings on the west bank of the river probably aided in initiating the formation of the bend to the east which eventually became the upper arm of Lake Beulah Bend.

1820-30 course (stage 18)

45. By 1820 upstream changes had caused an alteration in directive of the current in the channel north of Rosedale. The broad, open bend of the 1765 course had become sharper and the angle of attack on the clay plug (stage 10) had become more direct. The old channel filling again caused a definite flattening of the bend. Measurements of the amount of channel migration in this area from 1765 to 1820, show it to range from a minor amount at the north end of the old clay plug to about 1300 ft, 2 miles downstream. This would give a maximum of about 25 ft per year for the 55-year period. To the south, the channel followed a similar trend as did the 1765 course. Downstream migration extended the reach slightly before the channel turned into the upper arm of the Lake Beulah meander. Migration was undoubtedly retarded by the abandoned channel fillings in the west bank of the river. Channel migration within the Lake Beulah meander was comparatively rapid in the loose point bar materials and the rate of eastward migration of the bend ranged from 60 to 70 ft per year from 1765 to 1820. By 1820 the bend had almost reached its present eastern limit, as defined by Lake Beulah.

Napoleon Cut-off (1863)

46. Between 1820 and 1863 the upper arm of the Lake Beulah meander migrated downstream rapidly. Evidently the channel, during this time, moved downstream past the clay plugs on the west bank. Loose bar materials in this area had little effect in retarding the migration of the channel southward and a cut-off was effected in 1863.

1881 course (stage 19)

47. Following the Napoleon Cut-off in 1863 the river moved westward away from the point of cut-off and by 1881 the openings to the abandoned segment of the river had been sealed off from low-water flow. The eastward limit of channel migration following Napoleon Cut-off and at its southerly end is marked by the abandoned channel filling (stage 19) truncating the lower arm of the Lake Beulah meander. A relatively straight reach was formed as a result of the cut-off. Channel migration upstream caused changes in the directive of the flow in the northern part of the area shown on plate 8 and the channel gradually moved westward away from the old channel filling north of Rosedale. The cut-off of 1863 could be considered as the conclusion of a cycle of channel migration. By 1881 the beginning of another cycle had been initiated.

1913 course

48. During the 32-year period, from 1881 to 1913, pronounced changes took place in the position and appearance of the river in this vicinity. The most obvious was the change from the broad reach channel of 1881 to the narrower bendway of 1913. In the northern part of the area the channel, with the clay plug (stage 7) to the south of Rosedale acting as a hinge point, swung to the west. To the south the channel recurved to the southeast into the upper arm of the newly forming bend, which eventually developed into Rosedale Bend. The distinct flattening apparent in the lower part of the 1913 bend was undoubtedly caused by the resistant sediments filling the extension of the upper arm of Lake Beulah meander (stage 18) and the clay plug (stage 19) to the south which

truncates the lower arm of the old meander. The narrowing of the channel in the bendway, opposite the resistant sediments, is especially apparent.

Riverton revetment (1919)

49. Following 1913, bank caving became excessive in the upper part of Rosedale Bend. The outer limit of the clay plug (stage 7) south of Rosedale acted as a hinge point and the channel moved rapidly to the east, immediately downstream from the plug, in easily eroded point bar deposits. Within approximately 6 years the bankline receded over 1500 ft in this immediate area. The main-line levee was considered endangered and Riverton revetment was constructed. Gradual downstream shifting of the point of attack was taking place and extensions were added to the revetment as late as 1928. The channel shifting has continued until at present the revetment is totally inactive during low stages of the river.

1946 course

50. The latest course shown on plate 8 is that of 1946. Considerable changes took place during the period from 1913 to 1946. A point about a mile upstream from Rosedale has acted as a pivot as the river migrated to the east. South of this point the river developed more pronounced bendways with the migration of Rosedale Bend about a mile southward. Rosedale Bend enlarged appreciably especially in the point bar sediments between the upper and lower arms of the abandoned Lake Beulah meander. In the 33-year period from 1913 to 1946 bank recession in this immediate area amounted to approximately 5000 ft, or an average of about 150 ft per year. However, this recession has not been constant; during the period from 1913 to 1925 recession averaged slightly over 100 ft per

year; from 1925 to 1937 it was slightly less than 50 ft per year; from 1937 to 1940 there was a great increase in the rate of bank recession, the average for the three-year period being only a little less than 900 ft per year. A sharp decrease was noted during the years following 1940 and the average rate dropped to about 55 ft per year for the period from 1940 to 1946. There has been another marked acceleration in bank caving noted in the past year. Comparison of maps of the Mississippi River issued by the Mississippi River Commission for the years 1947 and 1948 show bank recession in this immediate area to exceed 1800 ft for the single year.

Ten-year study

51. In an effort to extrapolate the river's behavior during the last ten years over the next ten years, plate 8A has been prepared as a typical example. This plate shows courses of the river for the years 1937, 1942, and 1948. Additional courses have not been plotted in order to preclude confusion of lines. It will be noted that the hydrographic survey has been plotted for each year, as well as the bankline from the yearly river books. The hydrographic surveys are more accurate, but their coverage is more limited than that of the bankline surveys. The numbered lines 22 to 27, inclusive, represent ranges at which the year-to-year rate of bank cutting has been estimated. In this study intermediate yearly river book banklines, even though not shown on plate 8A, were utilized. Study plots of the accumulative movement versus time were drawn. Based on this study it was evident that direct extrapolation of future river behavior could not be made.

52. The following remarks cover what appear to be the outstanding developments during the last ten-year period. During the years 1938 and 1939 the river showed pronounced bank cutting, the greatest amount being at ranges 24, 25, and 26. At range 24 the bank cutting was on the right, while at ranges 25 and 26 it was on the left. The average yearly movement was about 800 ft at range 24, 1100 ft at range 25, and 1300 ft at range 26. The clay plug on the outside of the bend above range 25 appeared to restrict migration eastward. The whole bend migrated downstream. At range 22 very little bank cutting has occurred since 1939. At range 23 the bank has moved to the right, with some fluctuation in the reverse direction, a distance of about 1300 ft since 1939. At range 24 most of the bank cutting during the years 1938 to 1942 took place in the first two years. Since 1942 the bank has moved to the right at an average yearly rate of about 300 ft. Very little movement of the bank at range 25 took place during 1940 and 1941; however, since 1942 it has moved to the left an average of about 250 ft per year. Very little bank movement took place at range 26 from 1939 until 1948 at which time the bank migrated about 1800 ft left or down-valley. The left or cutting bank at range 27 was quite stable during the period 1938 to 1947. In 1948 the bank moved about 1800 ft to the left into what appears to be a sizable clay plug. Prior to 1948 it appeared that the clay plug was materially helping to retard migration of the river. No explanation is readily apparent for the sudden migration of the bank at this range; however, it must have occurred because of more direct current attack, probably resulting from a shift in the relationship of the flows from the Arkansas and Mississippi Rivers. With movement of the bank at range 27 into the clay plug, the

bank at range 26 was readily eroded since no erosion-resistant material exists at the latter range. The net result during the ten-year period has been a material shifting of Rosedale Bend about a mile down-valley with a tendency of the downstream arm of the bend to be less restricted than formerly.

Conclusions regarding Rosedale Bend

53. The nature of the sediments played a major role in controlling the activity of the river in the vicinity of Rosedale Bend. It is evident that the earliest mapped courses were influenced greatly by the thick, resistant fine-grained sediments filling the old channel position (stage 10) at and immediately upstream from Rosedale (see section A-A', plate 8). This plug formed an effective barrier to eastward migration in this area, for in the period from 1765 to 1820 the maximum amount of migration within the plug was less than 25 ft per year. The alignment of this clay plug had an important bearing on the control of the river. As the long axis was parallel to the stream it acted as a natural revetment for a distance of approximately 2 miles. The upper end of the plug is under attack at the present time and although a much smaller section is affected, maps of recent years show very little recession at this point. The clay plug (stage 7) immediately south of Rosedale apparently aided materially in controlling the river. Since only a short distance separates this plug from the one to the north, it acted essentially as an extension of the larger one. The excessive bank recession which necessitated the construction of the Riverton revetment occurred in sandy point bar sediments lying between two clay plugs. The revetment prevented further recession until

downstream migration rendered it inactive. If the revetment had not been built, it is possible that eastward migration might not have continued much farther than it did, since the attack would have been directed more and more against the clay plug forming the upper end of the old Lake Beulah meander. Normal migration downstream, as it actually occurred, might have shifted the attack and removed the danger to the levees. The upper and lower arms of the old Lake Beulah meander and the plug (stage 19) directly downstream have been instrumental in shaping Rosedale Bend by preventing the development of a broad, open bend. The clay in the upper arm has shown less resistance to erosion than that of the downstream arm. This is due probably to two factors: the directive of the channel has been maintained against this area for a considerable time; and secondly, the openings to the upper arms of cut-offs are generally filled with coarser sediments than other portions of the meander loop and offer less resistance to channel migration. Until 1948 the clay plugs immediately downstream apparently were quite effective in resisting bank erosion. In 1948 rapid erosion of the clay plugs referred to above took place, probably the result of a severe change in current directive against the plugs due to some major change in the confluence of the Arkansas and Mississippi Rivers.

54. The right bank of the river contains very little resistant sediments as compared to the left bank in this area. However, the alignment of the river, until only recently, has been such that attack has not been concentrated on this bank. In the last few years changes in upstream alignment have been taking place and attack is being centered on the right bank area upstream from Rosedale Bend (see plate 8). One untested clay

plug has been found opposite Rosedale which appears to be resisting river migration; the main attack is directed at loose point bar sediments further downstream, and channel migration has been quite rapid.

Future River Activity

55. As a result of the type of study just described, predictions have been made regarding the future behavior of the Mississippi River in the segment from the vicinity of Memphis, Tennessee, to the mouth of the Arkansas River. The following paragraphs contain a discussion of future changes in the river, the delineation of areas where bank caving may endanger levees in the next few years and the location of the predicted course of the river in 1957.

56. The predicted course has been plotted on sheets (plates 9-21) of the 1948 edition of Mississippi River navigation charts published by the Mississippi River Commission. On these charts the more important clay plugs bordering the river are also shown. The discussion in the following paragraphs deals individually with segments of the river beginning with Brandywine Chute just north of Memphis. The qualitative nature of these predictions due to the unpredictable influence of many factors is again emphasized.

Brandywine Chute -- mile 750

57. For many years this chute has been a short cut or outlet for flood waters east of Centennial Bend. For the past several years the volume of discharge through it has been increasing, and by 1957 it is presumed that it will carry practically all of bankfull flow. It is

believed that, together with the increase in flow, a gradual enlargement and westward migration of the chute will take place.

Reach between Centennial Bend and Memphis -- miles 745-733

58. Slight westward migration at the north end of Beef Island is expected; an alignment change resulting from the increase of flow through Brandywine Chute. This should cause but slight change in directive and will not greatly affect the wide, shallow channel to Memphis, which should remain fairly stable through this reach. Bar islands may develop and those in existence may disappear. (See section A-A', plate 5.)

City of Memphis -- mile 732

59. Since 1820 the river has been directed against the hard Tertiary clays underlying the city of Memphis, and its channel has been confined to a width of less than 2000 ft. There was no appreciable bank recession between 1820 and 1880, and even without the construction of the Memphis Harbor revetment (1882), bank recession would have been minor.

Presidents Island -- mile 730-723

60. The northeast portion of the island has been receding at the rate of 240 ft per year since 1941. Because of the southwesterly migration of the bend at miles 730 and 731, the angle of inflow to Tennessee Chute has been flattening and the flow through the chute has been gradually decreasing. Due to the artificial closing of Tennessee Chute, the entire volume of flow will follow the channel around Presidents Island, probably increasing the attack along the Bauxippi-Wyanoke revetment. The Bauxippi-Wyanoke revetment was initially constructed in 1919 and at

present extends for about 23,000 ft. This revetment has definitely retarded westward migration of the channel. Its serviceability may have been increased because of the fact that it is a continuous structure anchored at numerous points to clay plugs, and because the curvature of the bend is broad, open and regular. If recession were permitted to continue in the northeast portion of Presidents Island, there is a possibility that the angle of attack would, in time, be reflected to the west bank at the head of the Bauxippi-Wyanoke revetment, necessitating upstream extension of the bank protection. A 2560-ft willow-mattress revetment, constructed in November and December 1948, should halt the recession and should prevent upstream shifting of the attack against the west bank.

Mouth of Tennessee Chute to Cow Island Bend -- miles 722-714

61. The channel in this section will continue to be wide and shallow with bars and islands forming. Some eastward and southerly migration of the channel is to be expected in this area but as no levees will be endangered, the migration will not become critical.

Cow Island Bend -- mile 713

62. Extensions of the four clay plugs west of Cow Island Bend retarded the westward shifting of early channels. The Cow Island Bend revetment, laid down in 1925, extends from just below the upper clay plug to the vicinity of Pickney Landing. A 4000-ft downstream extension, presumably to prevent possible flanking, was installed in 1946. Bank recession was less than 50 ft per year between 1904 and 1925 when the bank protection was constructed (see section B-B', plate 5). The combination of revetment with clay plugs has held migration of the bend. If the

revetment is not maintained, there is a possibility that bank erosion between the second and third clay plugs might endanger the levee. Also, if the revetment extension is not maintained, down-valley migration past the clay plugs would probably occur. A normal downstream shift in the upper arm of the bend is the only material movement expected in the next ten years.

Cat Island Bend -- mile 706

63. There are a series of clay plugs lining Cat Island Bend on the outside for a distance of about 14,000 ft; the fine-grained sediments filling these old channels reach a depth of over 40 ft. That these plugs have been effective is shown by the fact that there was but 700 ft of migration in the center of the bend between 1880 and 1918 when bank protection was installed (see section C-C', plate 5). The points of bank attack in this bend have shifted greatly in the past because islands have developed and stream flow has been divided; chutes have been common. Some migration has occurred during the past year at the upper end of Norfolk revetment. This may possibly be caused by a slight change in alignment resulting from the downstream extension of Cow Island Bend revetment in 1946. Maintenance should be continued to prevent possible flanking. The southern end of Norfolk revetment is anchored in a clay plug which should materially assist in preventing flanking. The southern end of Star Landing revetment (constructed in 1941) gives partial protection to an area of sandy sediments at the downstream end of Cat Island Bend. The thalweg at present swings across to the opposite bank and this revetment is not under direct attack. However, if the Norfolk revetment

is not maintained, Star Landing revetment may be flanked as the thalweg shifts downstream, and bank recession will endanger the nearby levee system. While floodwaters may be directed through the chute west of Cat Island Towhead, it is believed that the main flow will continue to follow the channel. With adequate revetment maintenance very little change in the bank alignment is expected to take place.

Porter Lake revetment area -- mile 700

64. From 1881 to 1904 recession of about 45 ft per year occurred in the clay plugs filling the arms of the abandoned Porter Lake meander loop. In 1911 the Porter Lake revetment was built with its upper end on the clay plug filling the downstream arm of the loop. Minor oscillations of the channel have been noted in the past between Star Landing and Porter Lake. In recent years the channel has gradually been swinging to the southeast and at the present time the upper end of Porter Lake revetment is inactive. The thalweg swings to the west around a bar between miles 700 and 698 bringing the lower end of the revetment under attack; this necessitated a downstream extension in 1947. This area is expected to remain relatively stable.

Reach between Porter Lake and Council Lake -- miles 700-693

65. In 1915 Polk Landing revetment (5000 ft) was constructed. By 1929 extensions bringing the total length up to 12,000 ft had been installed. Probably as a result of change in river current directive this revetment is now blanketed by bar deposits. Very little variation is anticipated in the upper portion of the reach area. A gradual downstream migration will probably occur in the sandy point bar sediments in the

lower portion directly upstream from Council Lake Bend.

Bend below Council Lake -- miles 687-693

66. From 1880 to 1946, there was an average westward migration of less than 15 ft per year in the bend at mile 691. This channel shifting was within the mass of two clay plugs, the uppermost of which was thicker and had a more definite retarding effect upon the westward movement of the bend as well as a control over river alignment. This plug fills the lower arm of the Council Lake meander loop which was abandoned by the Commerce Cut-off in 1874. Section D-D', plate 5, drawn directly south of the lower clay plug, shows the deepening of the channel and narrowing of its cross section which accompanied westward movement of the channel against the clay plug.

67. Following 1946, bank recession became excessive in the bend area at the lower clay plug probably as a result of some upstream change in alignment and has necessitated a setback of the levee. The attack has been gradually shifting downstream away from the plug filling the old Council Lake meander, into the sandier sediments directly downstream. A distinct indentation between the clay plugs has resulted from attack in these sediments. The thick clays filling the old channel position at mile 690 (lower clay plug) have resisted bank attack and now form a "hard point" with a pronounced narrowing of the channel opposite. It is not anticipated that the new levee setback will be endangered; the clay plug should retard westward migration of the channel sufficiently to permit normal downstream shifting of the bendway to gradually direct the attack away from the critical area. A material movement to the southwest of the

lower arm of the bendway into relatively cohesionless point bar deposits will probably occur in the future.

Mhoon Bend -- mile 684

68. Two clay plugs on the east bank of Mhoon Bend have been effective in slowing down the eastward migration of the bend between 1880 and 1931 (see section E-E', plate 5). In 1932 Mhoon Bend revetment was connected to the upper clay plug extending nearly to the downstream plug. The revetment is still active in retarding down-valley shifting of the river. At intervals during the past, islands have formed which have kept the river relatively wide at this bendway. Islands may continue to form but no appreciable changes in the east bankline at the center of the bend should occur within the next ten years if the revetment is maintained.

69. Bank recession in the lower end of Mhoon Bend, below the clay plugs, has taken place at a greatly accelerated rate since 1941. This excessive channel shifting was probably due to two factors: (1) the normal downstream shift of a bend; and (2) the opening of Hardin Cut-off in 1942 which greatly increased the velocity and locally changed the river alignment. This migration probably will continue to some degree within the next ten years as the sediments comprising this bank are easily eroded. This migration will not become critical as no levee system will be endangered.

Walnut Bend -- mile 680

70. A clay plug (opposite mile 678) on the west bank of the upper portion of Walnut Bend has acted as a pivot point for channel shifting since 1904. There was but 1300 ft of recession in the clay plug while

during the same period there was about 5000 ft of bank recession in the sandy sediments one mile to the south of the plug. A revetment was constructed in Walnut Bend between 1907 and 1911 and was located upstream from the clay plug. The upper end of this structure was buried inland by 1930 and the lower end was destroyed during the downstream migration of the bend. After the opening of the Hardin Cut-off in 1942, the alignment of the river changed and the west bank in Walnut Bend retreated at a rate of about 400 ft per year. Local levee set-backs were made and a new revetment, extending from mile 680-677, was constructed. The construction of this revetment halted the rapid migration of the river and no appreciable movement of the bankline other than normal downstream shifting in the upper end is anticipated for the next ten years.

Reach between upper end of Hardin Cut-off
and Prairie Point Towhead -- mile 677 to mile 666

71. There are three clay plugs on the west bank which apparently have acted as effective barriers to westward migration of the channel in this reach, one of which is shown on section F-F', plate 5. The change in alignment apparently due to Hardin Cut-off, caused the point of bank attack to shift from the first clay plug (mile 674) to the second (mile 672). It is believed that this plug (mile 672) together with the plug at mile 668, will continue to maintain channel alignment. Below the lower plug considerable downstream shift of the bankline is expected.

Bend above Helena -- mile 664

72. Upstream extensions of the Trotter Landing revetment prevented flanking of the structure during the period of eastward shifting of the

bend. There is an island within the bend which has divided the river flow since 1820. Bank attack, as a result, has never been excessive because there has been a shifting of the principal current from the course around the island to the chute. Two minor clay plugs on the east bank probably assisted in strengthening the revetments and giving them longer and more stable life. The recently constructed southern extension of the Trotter Landing revetment should maintain the directive against the Helena revetment, should prevent an otherwise rapid normal down-valley shift of the lower arm of the bend in sandy sediments, and will assist in maintaining the relatively straight Helena reach. It will be noted that some down-valley shift of the central portion and upper arm of the bend is expected.

Helena -- mile 659

73. The channel since 1880 has impinged against the 90-ft-thick clay plug at the Helena front (see section G-G', plate 6). The Helena revetment was built upon the plug in 1885. This area is extremely resistant to bank attack and is one of the very resistant "hard points" along the river.

Helena reach -- miles 659-653

74. Within this reach several clay plugs have acted as retarding factors to the westward migration of the river. Unless the flow of the river is maintained against the revetment and clay plug at Helena front, an increased amount of erosion must be expected in the sandy sediments immediately below. The present bankline is only 1300 ft from the levee system and should the river succeed in flanking the downstream end of the revetment, this system would become endangered. However, on the basis of

the present outlook the bankline of the reach for the next ten years is expected to continue with few irregularities.

Montezuma Bend -- mile 652

75. Since 1820 the channel has been confined between clay plugs on opposite banks of the river at mile 653. Montezuma Bend at mile 652 is at present slowly enlarging eastward into the plug forming the filling of the upper arm of the old Moon Lake abandoned meander. There was a slow southeastward shifting of the channel during bend development until 1915 when the Delta revetment was constructed. Bend migration continued and as the result of a tendency toward flanking the lower end of the revetment, downstream extensions were made in 1945 and 1946. Under present conditions of migration, the bend will probably continue to shift downstream and the lower end of the present revetment will probably be flanked by 1957, thus requiring further revetment extension or levee setback.

Friar Point reach area -- miles 649-644

76. The Friar Point revetment was constructed in 1922. Ten years later the thalweg had shifted to the opposite bank and the revetment became inactive. This shifting caused the point of attack to become centered on the west bank at about mile 647.5 just below a thick clay plug. Continued westward migration endangered the mainline levee and Westover revetment was recently constructed from mile 648 to mile 646.5. With maintenance of the latter revetment little change is expected in this reach except for some down-valley migration below the clay plug at mile 645.5.

Old Town Bend -- miles 644-637

77. The upper arm of this bend is expected to undergo normal down-valley shift into point bar sediments. The upper end of Old Town revetment was built on a thick clay plug at mile 641.7, which long retarded earlier channel migration. The lower end of this revetment has been subjected to repeated attack of the river as the channel shifted down-valley. Destruction of a portion of the downstream end in 1947 exposed the sandy area between the clay plug at mile 641.7 and that at mile 639, and bank recession became very rapid.

78. The wide clay plug at mile 639 has been effective in controlling channel migration and since 1880 there has been an average of less than 30 ft per year of bank recession in this plug. Due to changes in river alignment a gradual shift eastward from the plug took place. However, the recent downstream shift of the bend into the sandier sediments has again brought the river against this plug. A downstream extension (7000 ft) of the revetment was installed during the latter part of 1948, and this revetment extension, being anchored on the clay plug, should halt further bank recession; however, some normal down-valley shift is expected immediately below the plug.

Island No. 63 Bend -- miles 637-632

79. Island No. 63 which acts as the concave bank in this bend is composed of sediments offering very little resistance to bank recession. With the change in alignment upstream it is believed that further recession will occur within this bend. At the southern end and in the central portion of the bend, clay plugs have in the past limited recession of the

left bank. By chute cut-off the river has pulled away from the upper end of these clay plugs; however, the lower one should retard bank retreat. The migration of this bend should not become critical as chuting has been a regular occurrence in the past and the levees are far removed from the present bank. Some down-valley migration of the left bank will continue.

Robson Towhead Bend -- miles 632-628

80. There has been an acceleration of bank retreat in this area presumably as a result of the Jackson and Sunflower Cut-offs which probably caused changes in river alignment and increased velocities. The left bank between miles 630 and 633 moved down-valley approximately 1000 ft between 1941 and 1946. This area was remote from any levees, therefore, no critical condition was created. A material amount of bank recession is expected to continue in this area.

81. Fair Landing revetment was erected on the west bank in 1928 and later extensions were made upstream; however, by 1940 the upper half had been destroyed and by 1948 the entire revetment was gone. Normal downstream shifting of the bend has largely by-passed the thick clay plug in the upper portion of the bend and bank recession has been rapid in the shallower clay plugs and sandy sediments to the south. Ten thousand feet of the bank was revetted during November and December 1948. This revetment should halt migration thus relieving the threat to the levee which at present is only about 1000 ft from the river at its nearest point. With maintenance of the revetment no further movement is expected.

Jackson-Sunflower Cut-offs -- miles 627-620

82. Since the opening of Jackson and Sunflower Cut-offs the river

has concentrated its attack on first one bank and then the other. In the east bank, just above the entrance to Jackson Cut-off, there is an old channel with clays to depths of over 40 ft. This plug should materially retard the indicated tendency toward eastward migration of the river. Below this clay plug the river is free to move in sandy materials. The major recession will be on the east bank; however, no levees are within this area and no critical conditions should arise.

Island No. 67 Bend -- miles 620-614

83. From the lower end of Sunflower Cut-off to Knowlton revetment, there will be considerable down-valley shift of the left bank. This recession apart from possible effects on downstream river alignment will cause no critical situations to arise. The Knowlton revetment was placed in 1933 with the upper 1500 ft of its length in contact with a clay plug (mile 615.3) which has served as a retarding influence to westward channel migration since 1765. The lower half of the revetment built on point bar sands, was destroyed as the bend shifted downstream and by 1948 the 3000 ft left in place was in poor condition. It is anticipated that considerable westward movement will take place in the loose sands in the lower portion of Jug Harris Towhead immediately above the clay plug. The clay plug and revetment should retard migration; however, there is the possibility that the levee may be endangered.

Cessions Towhead Bend -- mile 610

84. Since 1880 there has been periodic development of chute channels west of Cessions Towhead. With the development of the sharp bend during the past several years, it is probable that the present chute

channel will remain. From 1941 to 1944 the recession between miles 610 and 611 in the bend north of Cessions Landing became so excessive that it necessitated a levee setback and the construction of a revetment in 1944. Prior to the construction of the revetment, migration had been controlled to some degree by a thick clay plug on the east bank at mile 609.6. This plug locally retarded bank recession so that a sharp bend developed directly upstream in sandy sediments. A downstream extension of the Cessions revetment, of 2750 ft, constructed in October 1948, was anchored to the thick clay plug, mile 608.8. The latter has been very effective in retarding eastward migration of the river (see section I-I', plate 6). This clay plug, which has acted as a "hard point" for the past few years, should continue to limit recession of the east bank. As a result of the downstream extension of the revetment no major change in bank alignment in the lower portion of the bend is anticipated; however, some possibility of a chute cut-off exists. There is expected to be a material shift down-valley of the upstream arm of the bend.

Island No. 69 to Concordia Bend -- miles 608-600

85. Since 1881, there has been a slow constant southward shift in the bend at mile 606, averaging 80 ft per year. Due to the nearness of the levee system in this area a 10,500-ft revetment (Dennis Landing) was constructed in October 1947. The 1200-ft downstream extension to the revetment, which was placed in November 1948, should prevent flanking of the revetment in the sandy sediments immediately downstream. The upper end of the revetment is anchored in the thicker portion of a clay plug at mile 605.9 (see section J-J'). There is the possibility of flanking

occurring in the thinner portions of the plug directly upstream from the revetment as well as recession further upstream in sandy point bar sediments. If the flanking becomes excessive it may necessitate an upstream extension of the revetment. Downstream from the revetment a moderate amount of recession will continue to take place.

86. At Henrico (mile 600) the gentle southerly bend of the channel continues in a southwesterly direction. The bend thus formed is buttressed by a series of shallow clay plugs (see section K-K', plate 6). The recession of the right bank of the bend has been relatively slow but due to the nearness of the levee system a 6900-ft revetment was constructed in November and December 1947. This revetment together with the 900-ft downstream and 300-ft upstream extensions constructed in October and November 1948 should effectively stop this migration. No major movement is anticipated by 1957.

Concordia Bend -- mile 598

87. The wide and thick clay plug at the center of Concordia Bend has retarded the southward migration of the bend since 1880. This plug is considered to be a definite hard point, consequently no appreciable migration is expected into the plug. However, bank attack is now largely directed at the sandy point bar deposits downstream from the plug and recession has been increasing rapidly, especially during the past year. The recent (1948) sudden acceleration in bank recession may have been partially caused by the effect of the two revetments (Henrico and Dennis Landing) upstream from the bend on the direction of attack of the current. It is probable that bank recession downstream from the plug will decrease

somewhat in the next few years but will still remain high. As the main-line levees are not endangered the condition will not become critical.

Scrubgrass Bend -- mile 593

88. Scrubgrass Bend has been shifting downstream and westward since 1820. This down-valley shifting has been fairly rapid as the materials comprising the bank in this area are sandy braided stream deposits overlain by a thin blanket of backswamp clays. These sediments being easily eroded have not hindered stream migration. The clay plug on the right bank to the south of the bend (near mile 591) apparently is not large enough nor thick enough to have materially retarded bank recession; however, it probably caused the flattening of the bend in that area. Migration has taken place at an average of 500 ft per year for a ten-year period previous to 1947. Following 1947, however, a very marked increase in bank recession occurred. At its point of greatest recession the bankline had retreated over 2000 ft in about one year. This corresponds to the similar increase at Concordia Bend and probably indicates that the effects of sharp increases in bank caving are translated downstream for some distances. The predicted line for 1957 shows continued migration of the river in a southwestward and southerly direction. The amount of recession will probably be largely dependent upon conditions which develop upstream at Concordia Bend. It is possible that interception of the White River will occur, resulting in the latter entering the Mississippi River about 6 miles upstream from its present point of entrance.

Victoria Bend -- mile 587

89. There has been a gentle southeastward migration of Victoria

Bend at the average rate of 100 ft per year between 1880 and 1947. During 1947, however, 500 ft of recession (mostly eastward) occurred in the bend probably due to the change in directive of flow induced by the rapid recession upstream of Scrubgrass Bend. This shifting has been largely in sandy materials. Some retarding effect is noticeable due to the minor clay plug in the east bank at mile 586.4. It is believed that channel migration has not been as excessive within this bend as at Scrubgrass and Concordia Bends because of its broad open shape. No critical conditions are expected in this bend by 1957; however, material migration of the east bank will continue and may increase if attack becomes more direct as a result of changes upstream in Scrubgrass Bend.

Mile 585 to mile 580

90. At mile 585 on the east bank, there is a thick clay plug which has been receding at an average rate of 65 ft per year as a result of river erosion. Migration to the east at this point will continue to be minor as the fine-grained sediments reach a depth of over 80 ft in the clay plug. The attack has been shifting downstream and has crossed to the west bank in the vicinity of mile 582 where a clay plug of untested thickness is encountered in the bankline. The river prior to 1820 had been against this plug; by 1820 it had moved across against the plug on the east bank. It is believed the plug on the west bank at mile 582 will materially retard bank recession. Increased recession was noted in the lower portion of this area following 1947; however, it has not been so severe as at Scrubgrass and Concordia Bends, which is because of the broad, even curvature of the bend. Considerable recession along the west

bank will continue from the vicinity of the clay plug at mile 582 down into Rosedale Bend. No critical areas are anticipated in this sector of the river.

Rosedale Bend to mouth of the Arkansas River -- miles 580-575

91. Normal downstream shifting of Rosedale Bend caused the Riverton revetment, constructed in 1919, to become inactive. As downstream shifting of the bend continued the river impinged against a thick clay plug in the upper arm of the Lake Beulah meander on the east bank at mile 577.5. This plug, having over 70 ft of fine-grained sediments, has effectively held migration to a minimum. With the downstream shifting of the bend, the clay plug has offered less resistance to bend migration and by 1957 this plug will probably be completely by-passed. The sandy sediments within this old Lake Beulah meander are much less resistant and migration has occurred and will continue at a fairly fast rate.

92. The confluence of two clay plugs opposite the mouth of the Arkansas River has acted as a hard point against river attack for ten years prior to 1947. The presence of these plugs in Rosedale Bend has effected a very definite flattening of the bend. Between 1947 and 1948 an excessive amount of erosion in this plug was caused probably by upstream changes in alignment as a result of rapid migration into the point bar deposits between the arms of the Lake Beulah Bend. The great amount of bank retreat here as compared with that in the two bends directly upstream is believed to be a result of the very sharp curvature of Rosedale Bend. Recession at Rosedale Bend has been comparable to that at Scrubgrass Bend. This erosion will probably decrease somewhat as the thicker

sections of fine-grained materials within the lower arm of Lake Beulah meander come into contact with the river. The fine-grained materials within this plug reach a depth of over 70 ft. Rapid bank retreat will continue in this bendway as long as channel migration remains excessive in upstream bends. No critical conditions should arise as levees are far removed from the river.

PART VI: SUMMARY

93. This study has shown that the alluvial materials forming the bed and banks of the Mississippi River were of primary importance in the past in influencing the activity of the river. Clay plugs constituted the major restrictive influences on river activity, until the use of revetments in modern times, and have been instrumental in determining the history of the Mississippi. The number of artificial controls, such as revetments, cut-offs, etc., is increasing and their effects on the behavior of the river are becoming more and more important. Present artificial controls and those to be constructed increase the difficulty of predicting the future activity of the river by adding to the complexities of its behavior.

94. The modern Mississippi River is considered to be a poised stream which implies that the volume of the stream is adjusted to the valley slope, to the bed materials through which it flows, and to the load which it transports. It can be considered that, with respect to the entire length of the river, a delicate balance exists between these various factors. During the history of the river, disturbances have occurred which have upset this state of balance with subsequent readjustments being made to return the river to what might be considered a normal condition. The causes of such disturbances ranged from very localized conditions, such as sudden changes in the nature of the bank materials, to natural cut-offs of meander loops and to major diversions of the river. Although no major diversions of the river have been attempted artificially, numerous cut-offs of meander loops have been completed. The outstanding

effect on the river, other than the shortening of its course, is the acceleration in stream activity caused by the increased velocity and local change in alignment. Pronounced increases in bank recession were noted following Caulk Cut-off (1937), Jackson and Sunflower Cut-offs (1941 and 1942), and Hardin Cut-off (1942). Although it cannot be definitely stated that revetments are major causes of sudden increases in bank recession it is felt that in some cases their presence has contributed materially to these increases. The very great acceleration in bank recession during the past year in the segment of the river from Concordia Bend (mile 598) to Cypress Bend (mile 562) is considered to be caused in part by the installation of revetments upstream from the caving areas.

95. Under normal conditions a gradual shifting in the alignment of the river is continually under way. The angle of attack upon a bank varies with alignment shifting and with river stage, thus tending to limit the time of major attack against any limited area. Prior to 1947 a bend was in the initial stages of formation between Cessions Towhead and Concordia Bend. It is possible that the construction in the summer of 1947 of Dennis and Henrico revetments, which halted lateral migration of the river, stabilized the alignment of the channel in such a manner that continued direct attack is now maintained against a section of bank further downstream. The greatly increased bank recession was first noted at Concordia Bend immediately below Henrico revetment, and next in order at Scrubgrass Bend. The amount of bank caving has not been as marked at Victoria Bend, probably because it is a broad open bend, but has increased sharply again at Rosedale Bend, the southern extent of the present study.

Investigations downstream from this area show that marked increases in bank caving for the 1947-48 period continue as far south as Cypress Bend. It is interesting to note that in the distance from Concordia Bend to Cypress Bend no active revetments are found. It is quite possible that the changes were translated downstream progressively with no revetments to hinder the progress. It is not believed that the revetments were the only cause of the increase in bank caving noted above, for it is difficult to visualize so great an amount of recession as occurred in the few months separating the time of construction of the revetments and the 1948 survey of the river as being due to the construction of the revetments alone.

96. This study has indicated that predictions of future river activity should be considered as intelligeht estimates of qualitative nature only. It is obviously impossible to ascertain quantitatively where the river will be ten years hence, largely because of the variety of unforeseen influences and changes that can occur in the meantime. Future artificial controls as well as new soils or hydrographic data must be taken into consideration as they occur or become known, and predictions altered accordingly. Full knowledge of the many factors mentioned in this report, particularly the effects of resistant clay plugs and easily eroded sands. on river activity are believed essential to the engineer in planning, locating, and designing future works along the river and in better understanding the behavior of the river. Full use of such knowledge, together with additional information to be gained from continued field investigations and experimental work, should permit in the future increased accuracy and dependability in prediction of river activity.


TUNICA
COAHOMA
QUITMAN
TALLAHATCHIE
SUNFLOWER
LEFLORE
LEGEND
FLOOD PLAIN
OLDER ALLUVIAL PLAINS LOCALLY ABOVE FLOOD PLAIN
UPLANDS - INCLUDES RIDGES WITHIN ALLUVIAL VALLEY
PHYSIOGRAPHIC MAP
GEOLOGICAL INVESTIGATION OF MISSISSIPPI RIVER ACTIVITY
MEMPHIS TENN. TO MOUTH OF ARKANSAS RIVER
SCALE
10 0 10 MILES

PLATE I

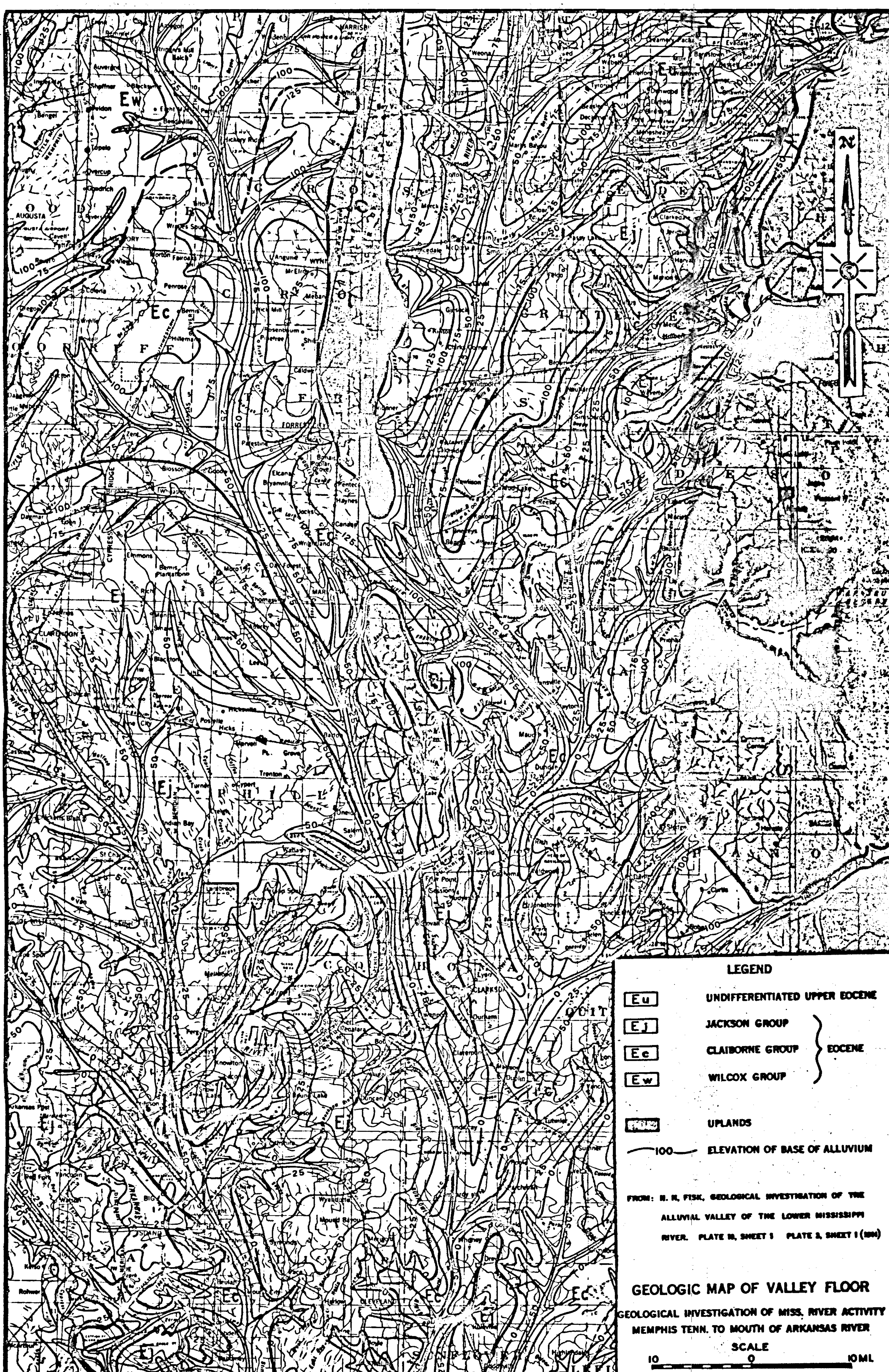
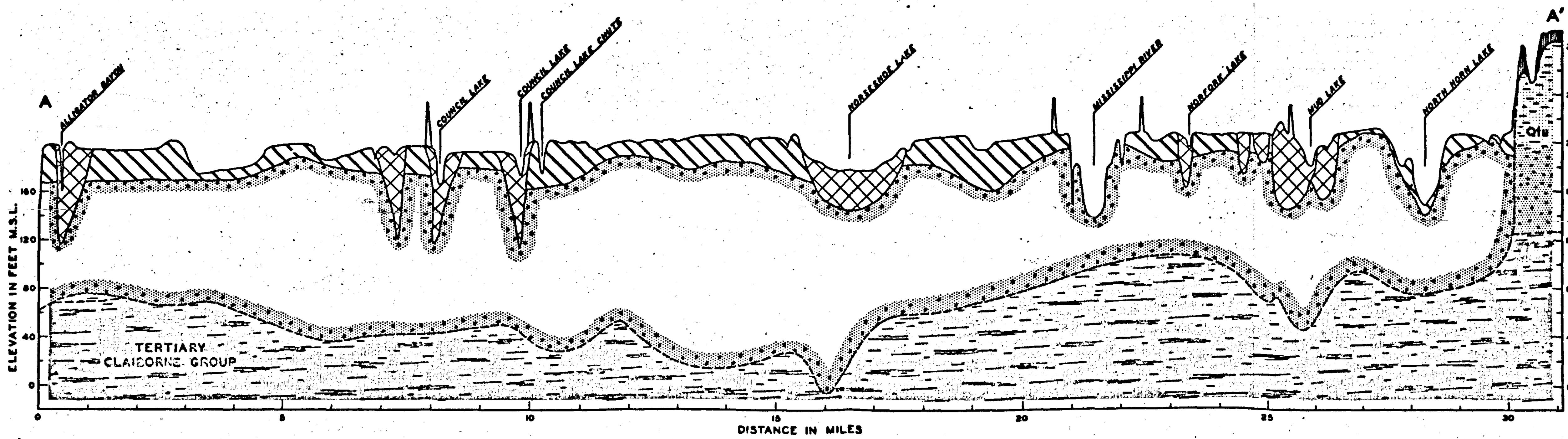
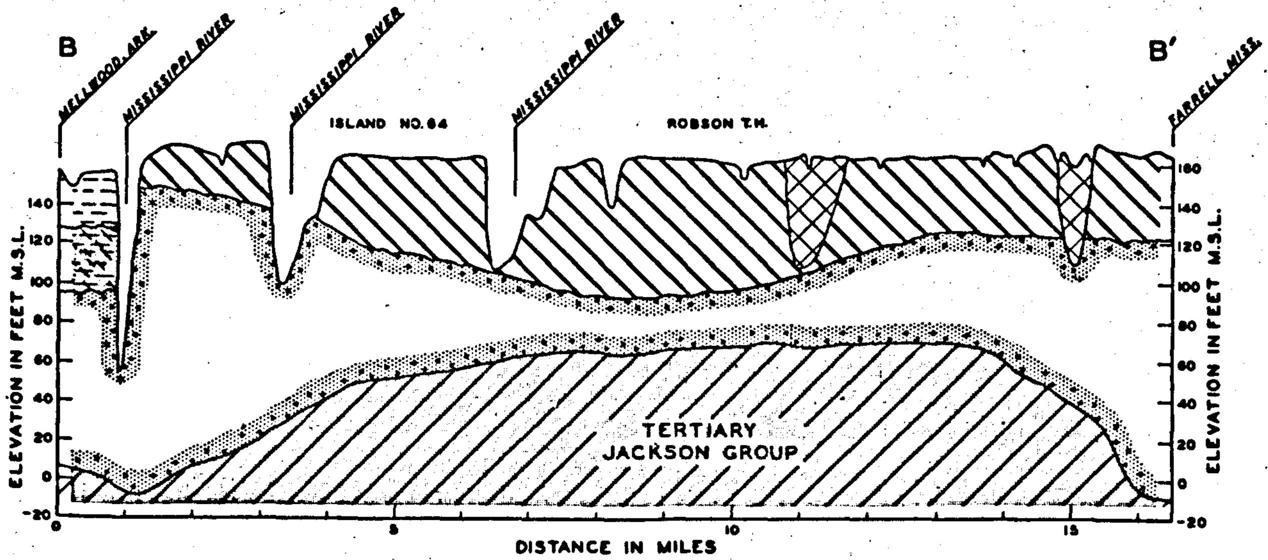

LEGEND
Eu UNDIFFERENTIATED UPPER EOCENE
Ej JACKSON GROUP
Ec CLAIBORNE GROUP
Ew WILCOX GROUP
EOCENE
UPLANDS
100 ELEVATION OF BASE OF ALLUVIUM
FROM: H. N. FISK, GEOLOGICAL INVESTIGATION OF THE ALLUVIAL VALLEY OF THE LOWER MISSISSIPPI RIVER.
GEOLOGIC MAP OF VALLEY FLOOR
GEOLOGICAL INVESTIGATION OF MISS. RIVER ACTIVITY
MEMPHIS TENN. TO MOUTH OF ARKANSAS RIVER
SCALE
10 0 10 MI.

PLATE 2



CROSS SECTION A-A'



CROSS SECTION B-B'

LEGEND

CHANNEL FILLING (CLAY PLUGS, SILTS AND CLAYS)

FINE GRAINED TOP STRATUM (POINT BAR SILTS AND SILTY SANDS OVERLAIN BY THIN NATURAL LEVEE DEPOSITS)

BACKSWAMP DEPOSITS (SILTS AND CLAYS)

BRAIDED STREAM DEPOSITS (SANDS, SILTS, CLAYS AND GRAVELS)

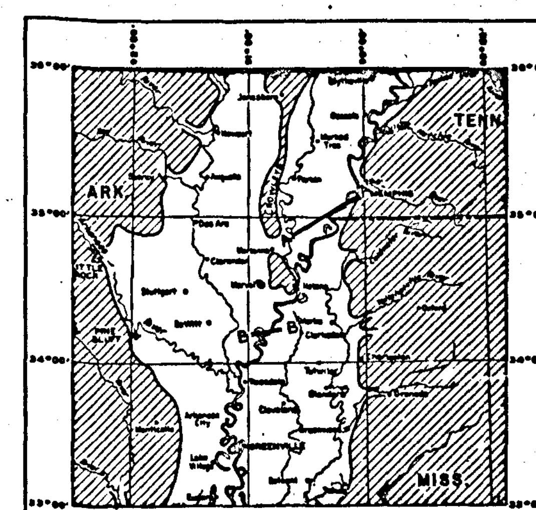
SAND AND GRAVELS

LOESS (HOMOGENEOUS CALCAREOUS SILT)

Qtu QUATERNARY UNDIFFERENTIATED (BASAL SANDS AND GRAVELS GRADING UPWARD TO SILTS AND CLAYS)

JACKSON UNDIFFERENTIATED (CALCAREOUS CLAYS AND SILTS)

CLAIBORNE UNDIFFERENTIATED (LIGNITIC AND MICACEOUS CLAYS AND SANDS)



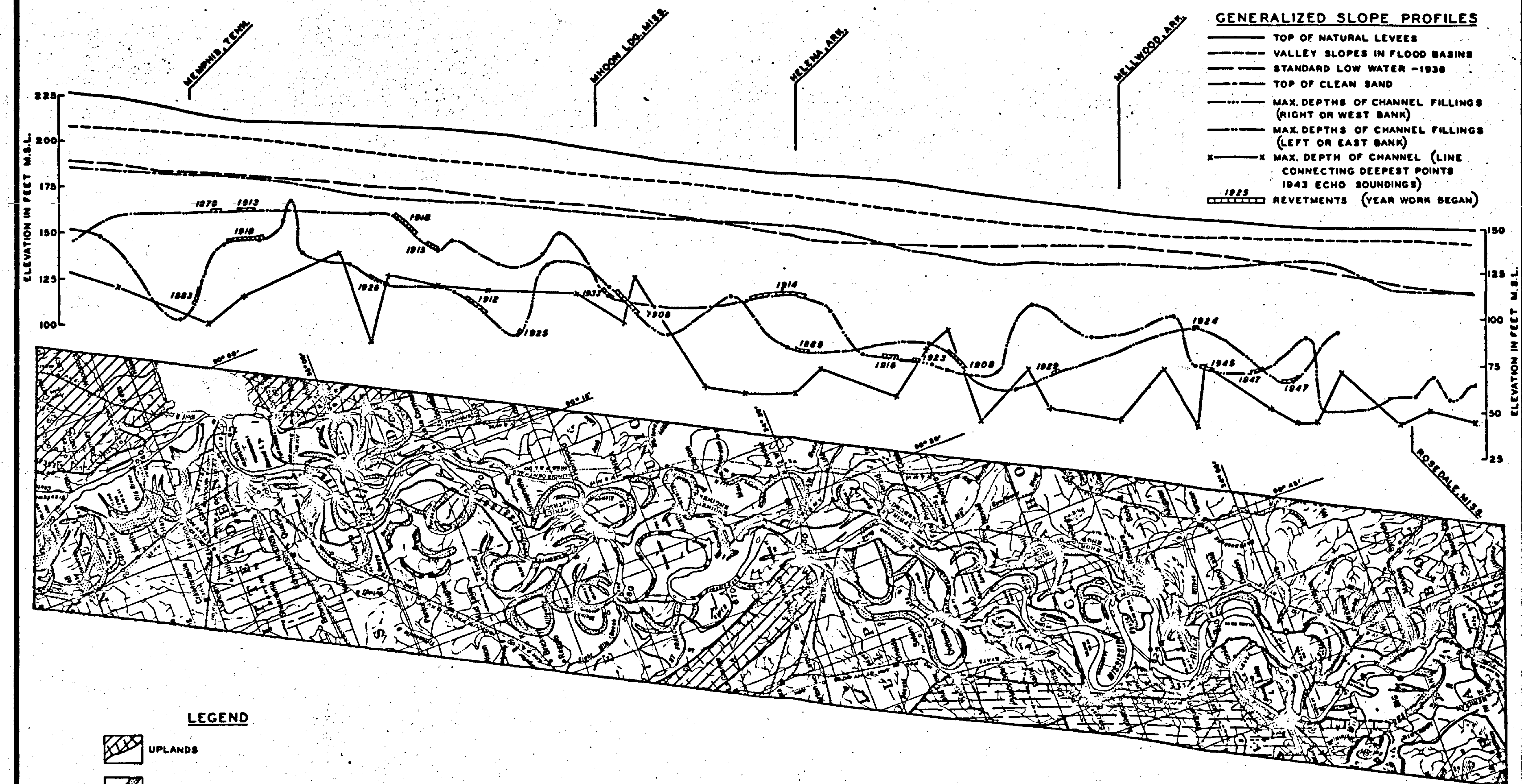
LOCATION MAP

SCALE IN MILES

REGIONAL CROSS SECTIONS
A-A' AND B-B'

GEOLOGICAL INVESTIGATION OF MISSISSIPPI RIVER ACTIVITY
MEMPHIS, TENN. TO MOUTH OF ARKANSAS RIVER
SCALES AS SHOWN

PLATE 3



LEGEND

UPLANDS

ABANDONED FILLED CHANNELS

BACKSWAMP DEPOSITS

MEANDER BELT.
DOMINANTLY POINT BAR DEPOSITS OVERLAIN IN PART BY THIN NATURAL LEVEE SEDIMENTS

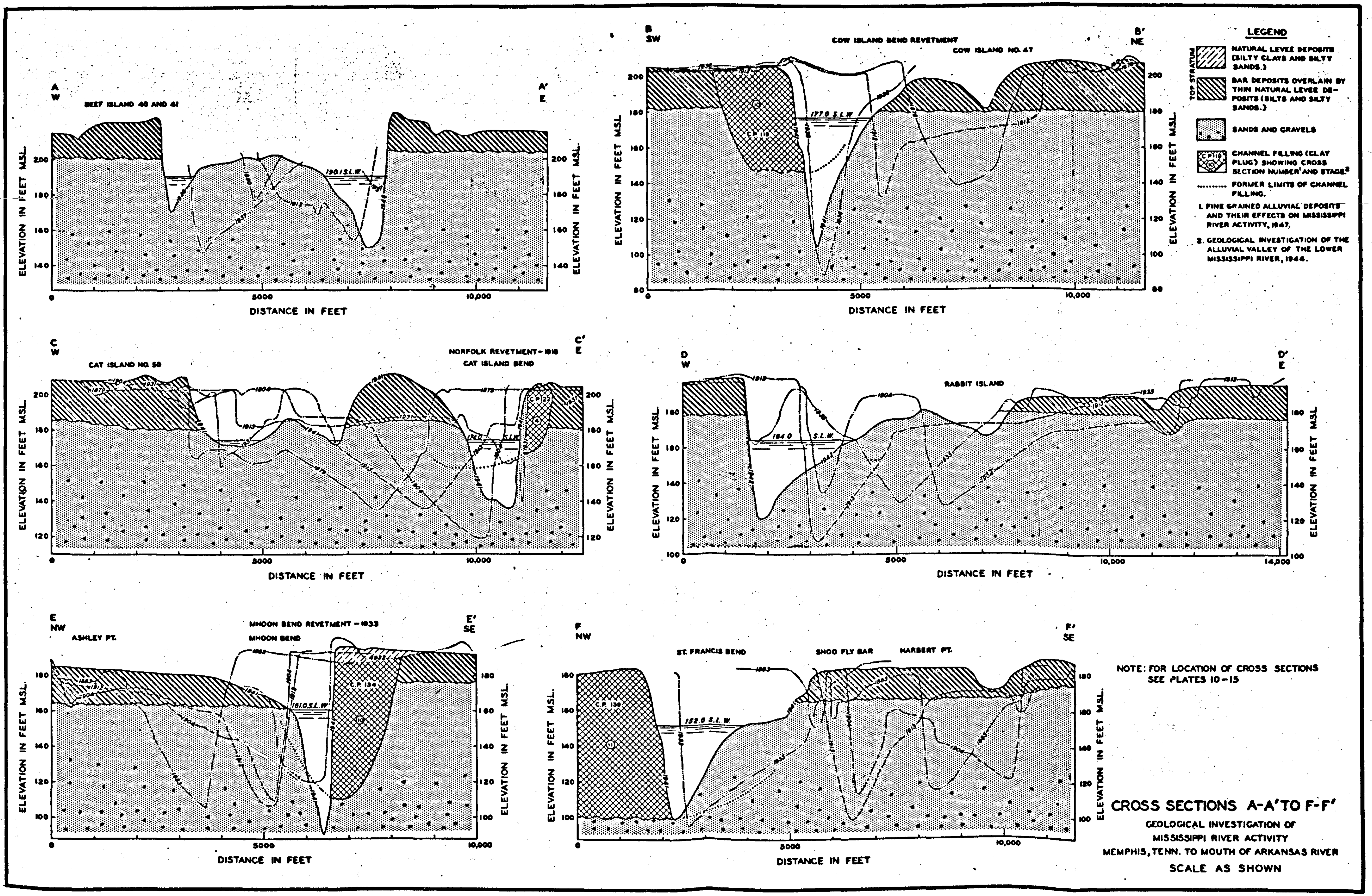
DISTANCE IN MILES

10 0 10 20

BASE MAP: SHEET NO. 2, ST. FRANCIS BASIN OF THE ALLUVIAL VALLEY OF THE MISSISSIPPI RIVER. SCALE- 1:250,000. PREPARED BY THE MISSISSIPPI RIVER COMMISSION. 1939 EDITION, REISSUED 1942.

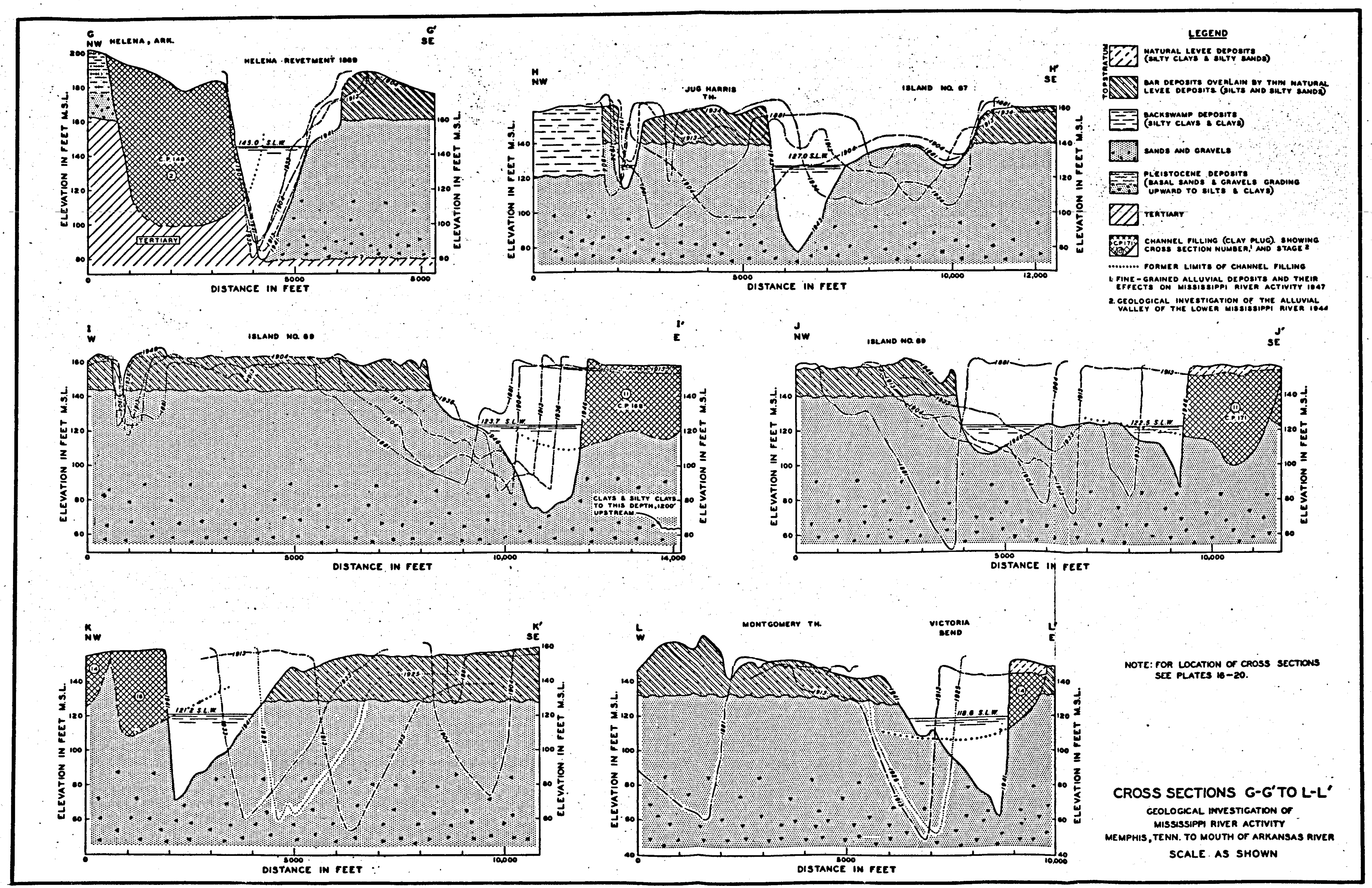
DISTRIBUTION OF ALLUVIAL DEPOSITS
AND
SLOPE RELATIONSHIPS

GEOLOGICAL INVESTIGATION OF MISSISSIPPI RIVER ACTIVITY
MEMPHIS, TENN. TO MOUTH OF ARKANSAS RIVER
SCALES AS SHOWN



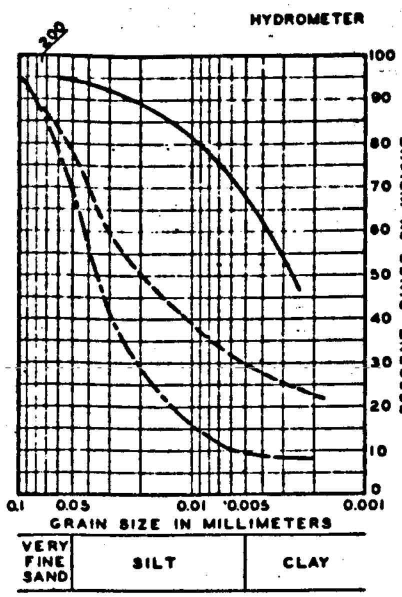
CROSS SECTIONS A-A' TO F-F'

GEOLOGICAL INVESTIGATION OF
MISSISSIPPI RIVER ACTIVITY
MEMPHIS, TENN. TO MOUTH OF ARKANSAS RIVER
SCALE AS SHOWN



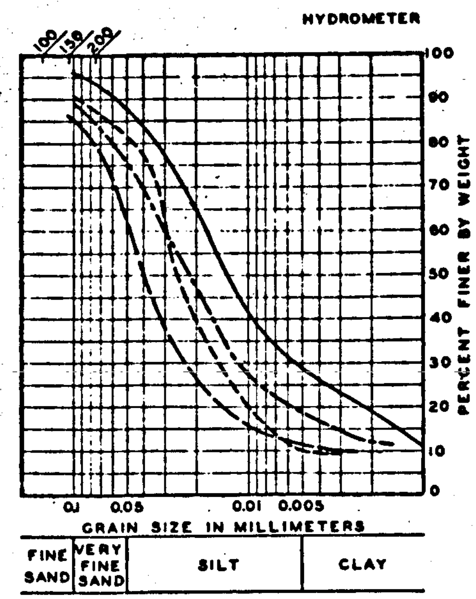
LEGEND
TOPSTRATUM
NATURAL LEVEE DEPOSITS (SILTY CLAYS & SILTY SANDS)
BAR DEPOSITS OVERLAIN BY THIN NATURAL LEVEE DEPOSITS (SILTS AND SILTY SANDS)
BACKSWAMP DEPOSITS (SILTY CLAYS & CLAYS)
SANDS AND GRAVELS
PLEISTOCENE DEPOSITS (BASAL SANDS & GRAVELS GRADING UPWARD TO SILTS & CLAYS)
TERTIARY
CHANNEL FILLING (CLAY PLUG). SHOWING CROSS SECTION NUMBER,¹ AND STAGE ²
FORMER LIMITS OF CHANNEL FILLING
1. FINE-GRAINED ALLUVIAL DEPOSITS AND THEIR EFFECTS ON MISSISSIPPI RIVER ACTIVITY 1947
2. GEOLOGICAL INVESTIGATION OF THE ALLUVIAL VALLEY OF THE LOWER MISSISSIPPI RIVER 1944
G NW HELENA, ARK.
G' SE
HELENA REVETMENT 1889
145.0 S.L.W.
C.P.149
TERTIARY
H NW
H' SE
JUG HARRIS TH.
ISLAND NO. 67
127.0 S.L.W.
I W
I' E
ISLAND NO. 69
123.7 S.L.W.
C.P.169
CLAYS & SILTY CLAYS TO THIS DEPTH, 1200' UPSTREAM
J NW
J' SE
ISLAND NO. 69
122.5 S.L.W.
C.P.171
K NW
K' SE
121.2 S.L.W.
L W
L' E
MONTGOMERY TH.
VICTORIA BEND
118.6 S.L.W.
ELEVATION IN FEET M.S.L.
DISTANCE IN FEET
NOTE: FOR LOCATION OF CROSS SECTIONS SEE PLATES 16-20.
CROSS SECTIONS G-G' TO L-L'
GEOLOGICAL INVESTIGATION OF MISSISSIPPI RIVER ACTIVITY
MEMPHIS, TENN. TO MOUTH OF ARKANSAS RIVER
SCALE AS SHOWN

PLATE 6



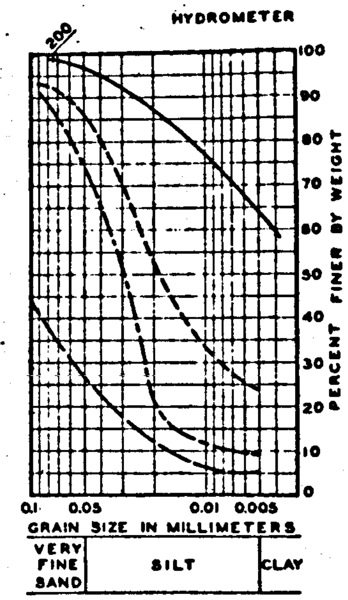
NATURAL LEVEE DEPOSITS
HORN LAKE, MISS.

8.5-90' (1/1+50, 850'L.S.)
5.5-6.0' (1/3+00, 100'R.S.)
8.5-9.0' (3/3+00, 126'R.S.)



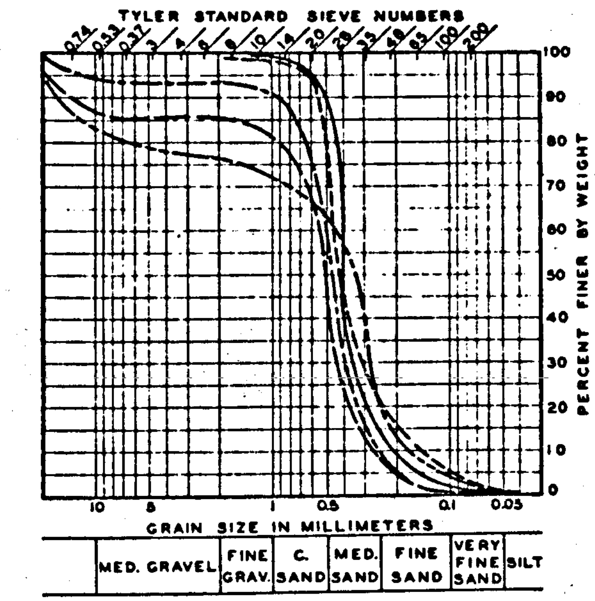
NATURAL LEVEE DEPOSITS
MELLWOOD, ARK.
(AVENUE SITE)

5.0' HOLE 2
5.0' HOLE 4
5.0' HOLE 8
5.0' HOLE 19A



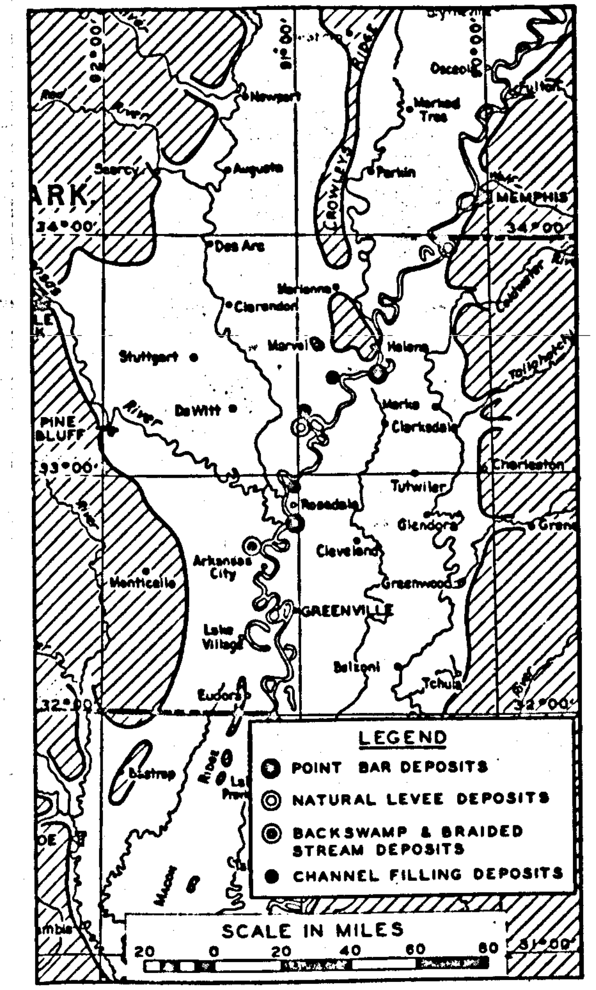
POINT BAR DEPOSITS
LAKE BEULAH, MISS.
E.B.M. STA. 1750+00 197' R.S.

10.5-12.0'
14.0-15.0'
18.0'
28.0'

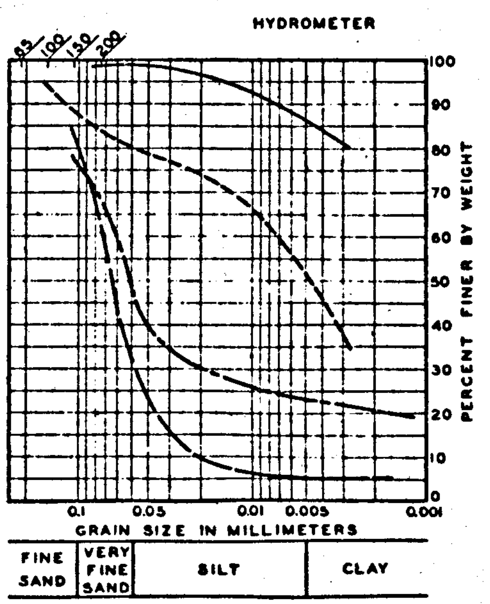


POINT BAR DEPOSITS
BELOW HELENA, ARK.
DELTA REVETMENT STA. 103/00 HOLE NO.103

12.0'
36.0'
45.0'
60.0'
72.0'

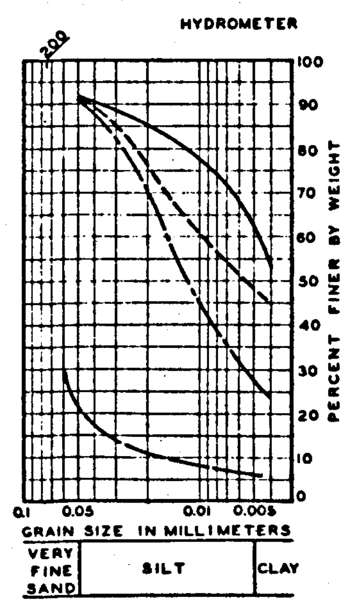


NOTE: TYLER STANDARD SIEVE NUMBERS & U.S. BUREAU OF SOILS CLASSIFICATION USED.



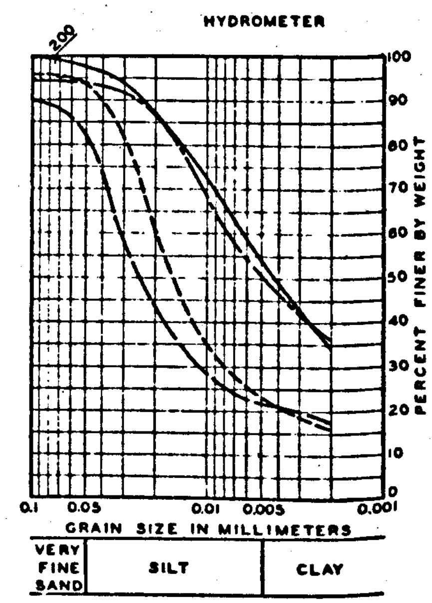
BACKSWAMP & BRAIDED STREAM DEPOSITS
CYPRESS BEND, ARK.

BACKSWAMP
10.0' (400+00, 218' L.S.)
14.0' (400+00, 218' L.S.)
BRAIDED STREAM
17.0' (452+00, 181' L.S.)
20.0' (452+00, 181' L.S.)



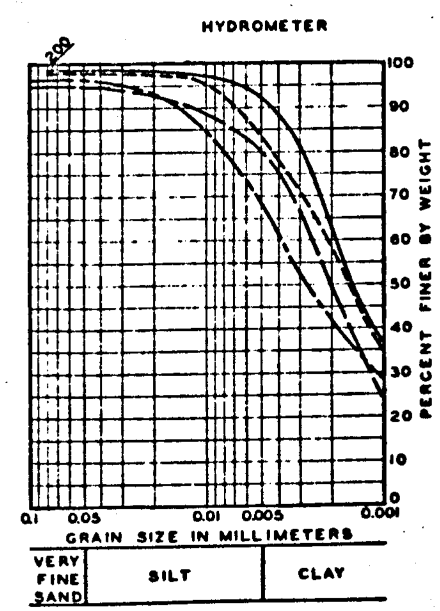
CHANNEL FILLING DEPOSITS
NORTH OF ROSEDALE, MISS.
U-E.B.M., STA. 1060+00 167 L.S

3.5'
39.0'
24.3'- 25.1'
83.0'



CHANNEL FILLING DEPOSITS
OLDTOWN, ARK. LEVEE
STA. 23/37+00 130' R.S. HOLE B

3.0'-3.5'
15.0'-16.0'
29.0'-29.2'
43.0'-43.2'



CHANNEL FILLING DEPOSITS
MELLWOOD, ARK.
(AVENUE SITE)

15.0' HOLE 21
20.0' HOLE 4
28.0' HOLE 4
45.0' HOLE 4

GRAIN SIZE DISTRIBUTION CURVES OF ALLUVIAL DEPOSITS

GEOLOGICAL INVESTIGATION OF MISSISSIPPI RIVER ACTIVITY
MEMPHIS, TENN. TO MOUTH OF ARKANSAS RIVER

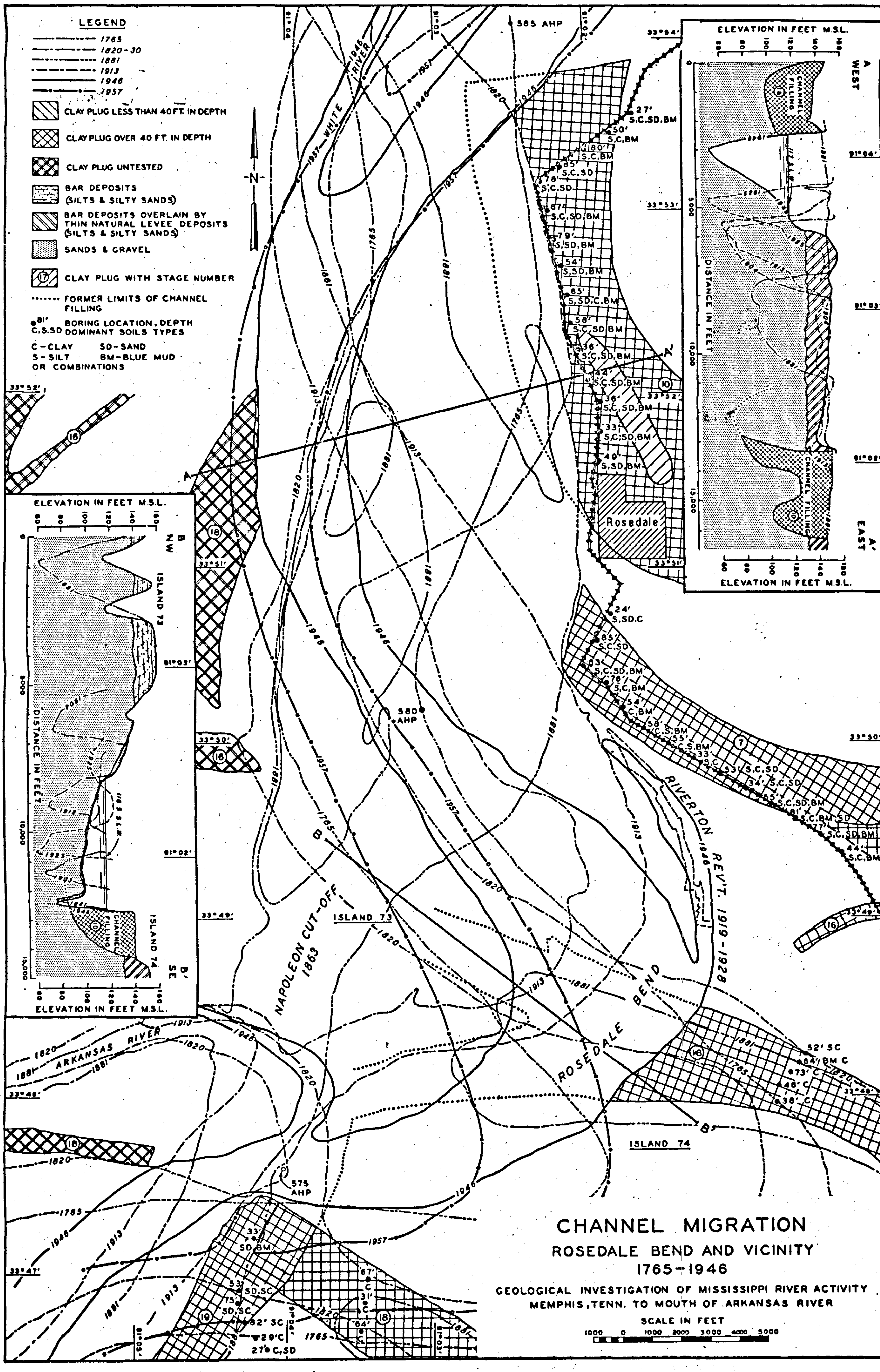

LEGEND
1765
1820-30
1881
1913
1946
1957
CLAY PLUG LESS THAN 40 FT. IN DEPTH
CLAY PLUG OVER 40 FT. IN DEPTH
CLAY PLUG UNTESTED
BAR DEPOSITS (SILTS & SILTY SANDS)
BAR DEPOSITS OVERLAIN BY THIN NATURAL LEVEE DEPOSITS (SILTS & SILTY SANDS)
SANDS & GRAVEL
CLAY PLUG WITH STAGE NUMBER
FORMER LIMITS OF CHANNEL FILLING
BORING LOCATION, DEPTH DOMINANT SOILS TYPES
C-CLAY SD-SAND
S-SILT BM-BLUE MUD
OR COMBINATIONS
-N-
WHITE RIVER
585 AHP
580 AHP
575 AHP
Rosedale
RIVERTON REV'T. 1919-1928
NAPOLEON CUT-OFF 1863
ISLAND 73
ISLAND 74
ROSEDALE BEND
ARKANSAS RIVER
ELEVATION IN FEET M.S.L.
DISTANCE IN FEET
CHANNEL FILLING
A WEST
A' EAST
B NW
B' SE
CHANNEL MIGRATION
ROSEDALE BEND AND VICINITY
1765-1946
GEOLOGICAL INVESTIGATION OF MISSISSIPPI RIVER ACTIVITY
MEMPHIS, TENN. TO MOUTH OF ARKANSAS RIVER
SCALE IN FEET
1000 0 1000 2000 3000 4000 5000

PLATE 8

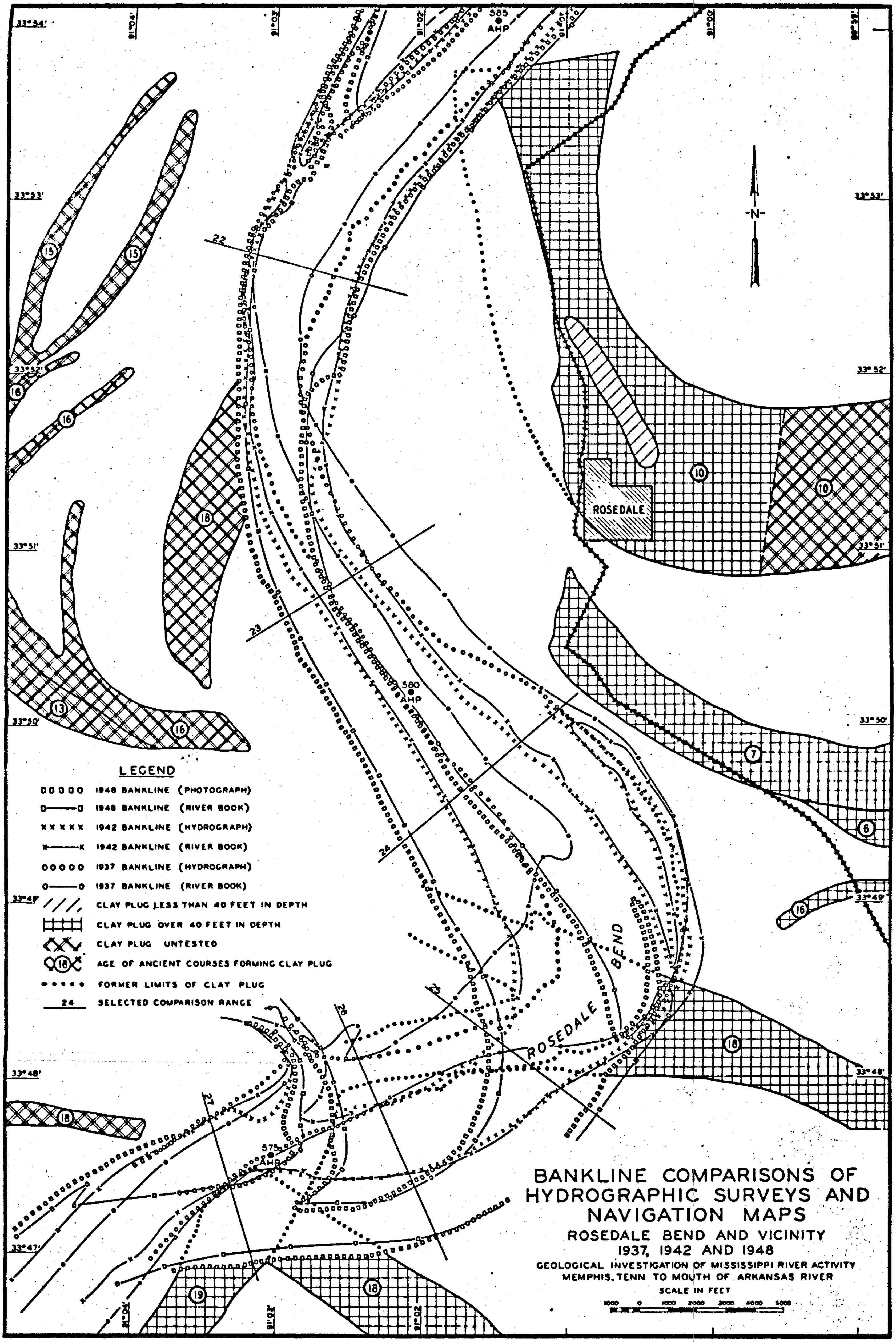
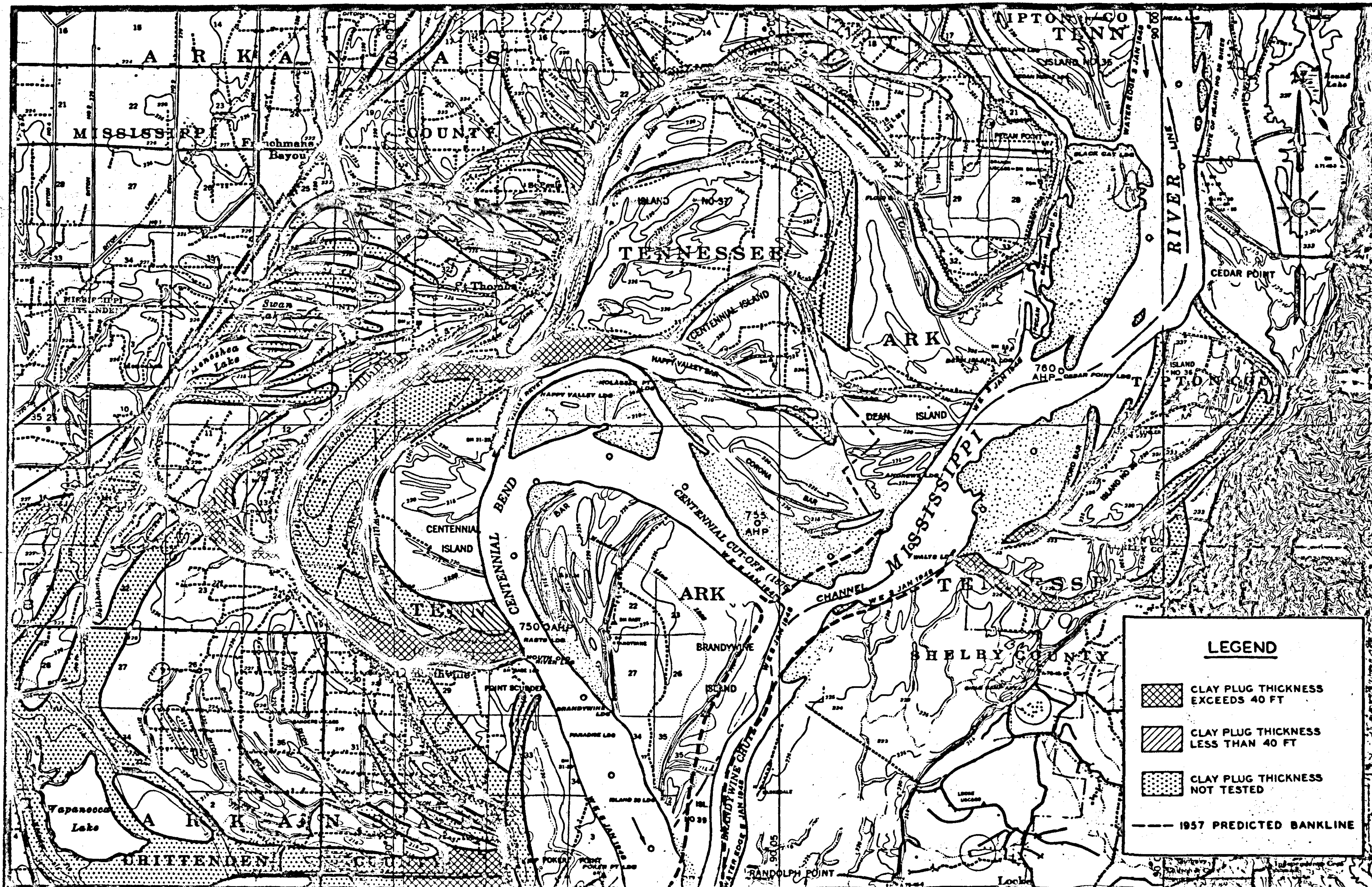

BANKLINE COMPARISONS OF
HYDROGRAPHIC SURVEYS AND
NAVIGATION MAPS
ROSEDALE BEND AND VICINITY
1937, 1942 AND 1948
GEOLOGICAL INVESTIGATION OF MISSISSIPPI RIVER ACTIVITY
MEMPHIS, TENN. TO MOUTH OF ARKANSAS RIVER
SCALE IN FEET
1000 0 1000 2000 3000 4000 5000
LEGEND
1948 BANKLINE (PHOTOGRAPH)
1948 BANKLINE (RIVER BOOK)
1942 BANKLINE (HYDROGRAPH)
1942 BANKLINE (RIVER BOOK)
1937 BANKLINE (HYDROGRAPH)
1937 BANKLINE (RIVER BOOK)
CLAY PLUG LESS THAN 40 FEET IN DEPTH
CLAY PLUG OVER 40 FEET IN DEPTH
CLAY PLUG UNTESTED
16 AGE OF ANCIENT COURSES FORMING CLAY PLUG
FORMER LIMITS OF CLAY PLUG
24 SELECTED COMPARISON RANGE
ROSEDALE
ROSEDALE BEND
585 AHP
580 AHP
575 AHP
33°54'
33°53'
33°52'
33°51'
33°50'
33°49'
33°48'
33°47'
91°04'
91°03'
91°02'
91°01'
91°00'
90°59'
N

PLATE 8A



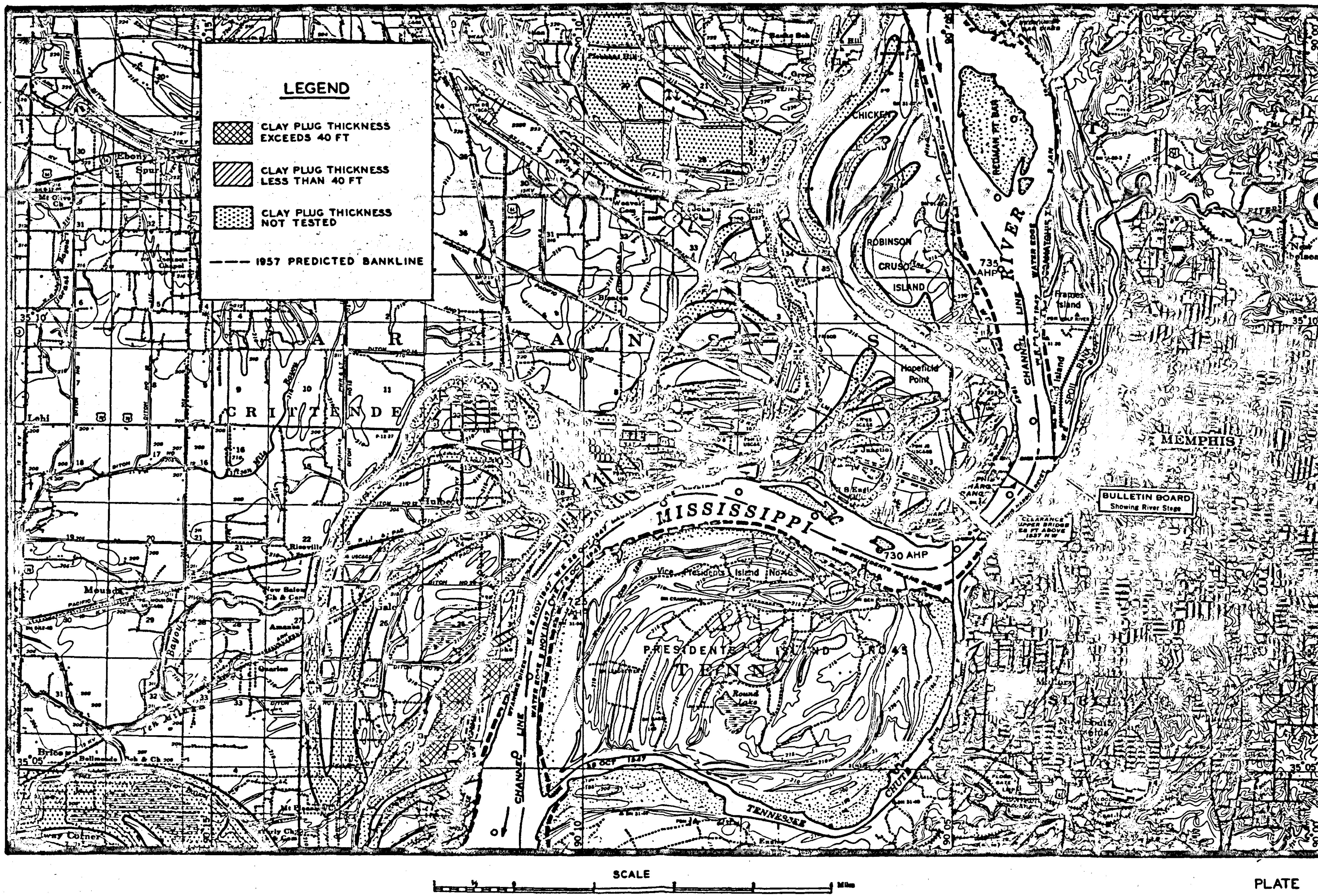
SCALE

Miles

PLATE 9

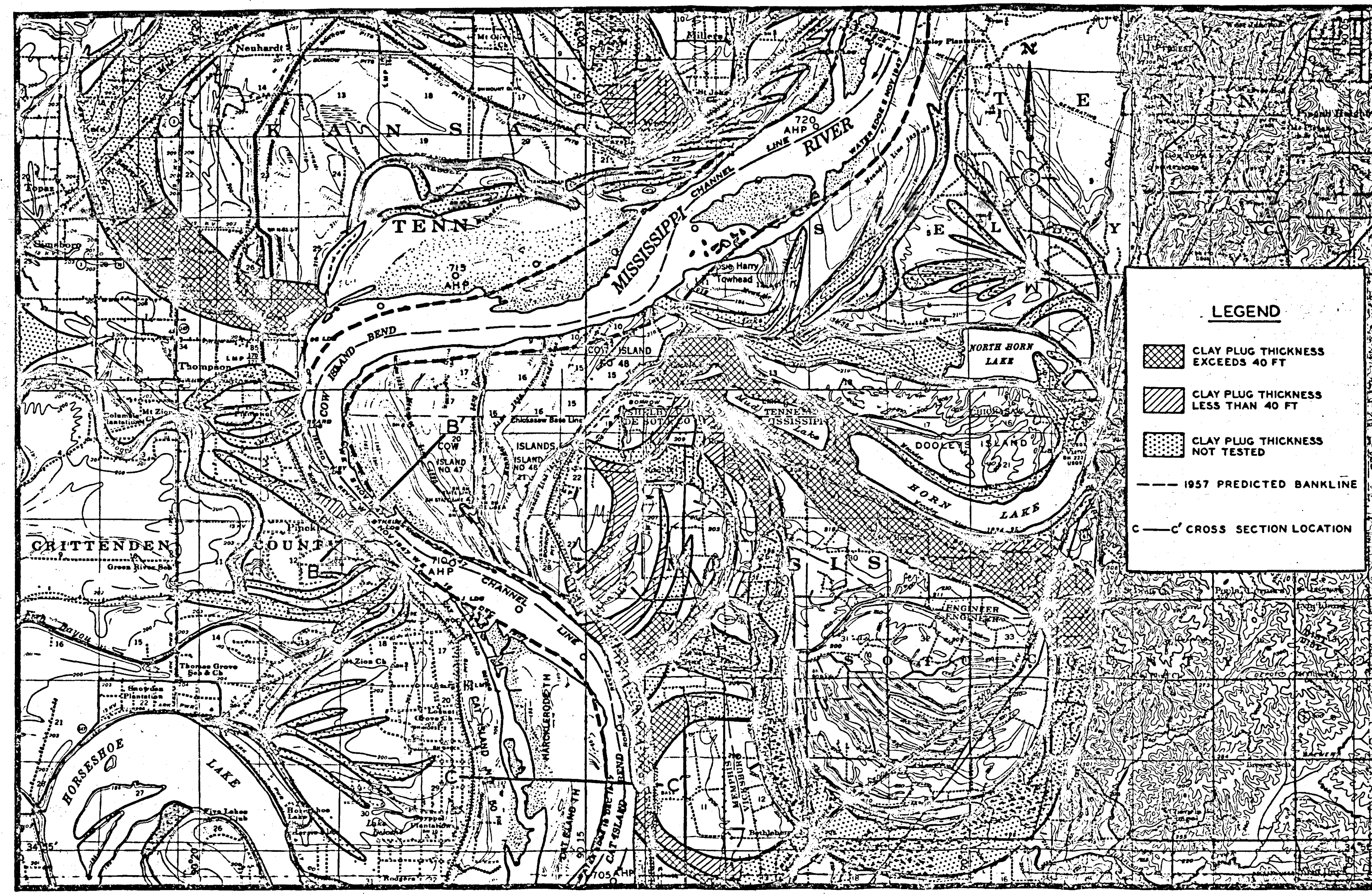

LEGEND
CLAY PLUG THICKNESS EXCEEDS 40 FT
CLAY PLUG THICKNESS LESS THAN 40 FT
CLAY PLUG THICKNESS NOT TESTED
1957 PREDICTED BANKLINE
A—A' CROSS SECTION LOCATION
MISSISSIPPI RIVER
TENNESSEE
SHELBY COUNTY
CRITTENDEN COUNTY
ARKANSAS
Wapanocca Lake
ISLAND NO 39
BEEF ISLAND
ISLANDS 40 & 41
TENN
BRANDYWINE ISLAND
BRANDYWINE CHUTE
RANDOLPH POINT
745 AHP
740 AHP
750 AHP
35°20'
SCALE

PLATE 10



LEGEND
CLAY PLUG THICKNESS EXCEEDS 40 FT
CLAY PLUG THICKNESS LESS THAN 40 FT
CLAY PLUG THICKNESS NOT TESTED
1957 PREDICTED BANKLINE
ARKANSAS
CRITTENDEN
MISSISSIPPI
RIVER
MEMPHIS
TENN
PRESIDENTS ISLAND NO 45
Vice Presidents Island No 45
ROBINSON CRUSO ISLAND
730 AHP
735 AHP
BULLETIN BOARD
Showing River Stage
CHANNEL LINE
TENNESSEE CHUTE
Round Lake
Hopefield Point
Mounds
Riceville
Lehi
SCALE

PLATE II



LEGEND
CLAY PLUG THICKNESS EXCEEDS 40 FT
CLAY PLUG THICKNESS LESS THAN 40 FT
CLAY PLUG THICKNESS NOT TESTED
1957 PREDICTED BANKLINE
C —— C' CROSS SECTION LOCATION
MISSISSIPPI RIVER
COW ISLAND BEND
CRITTENDEN COUNTY
HORSESHOE LAKE
HORN LAKE
NORTH HORN LAKE
DOOLEYS ISLAND
CAT ISLAND
715 AHP
720 AHP
710 AHP
705 AHP
SCALE

PLATE 12

LEGEND
CLAY PLUG THICKNESS EXCEEDS 40 FT
CLAY PLUG THICKNESS LESS THAN 40 FT
CLAY PLUG THICKNESS NOT TESTED
1957 PREDICTED BANKLINE
D——D' CROSS SECTION LOCATION
MISSISSIPPI RIVER
CHANNEL
COUNCIL LAKE
PORTER LAKE
CAT ISLAND BEND
RABBIT ISLAND
700 AHP
695 OAHP
690 OAHP
DE SOTO CO
TUNICA CO
Robinsonville
34°50'
SCALE

PLATE 13

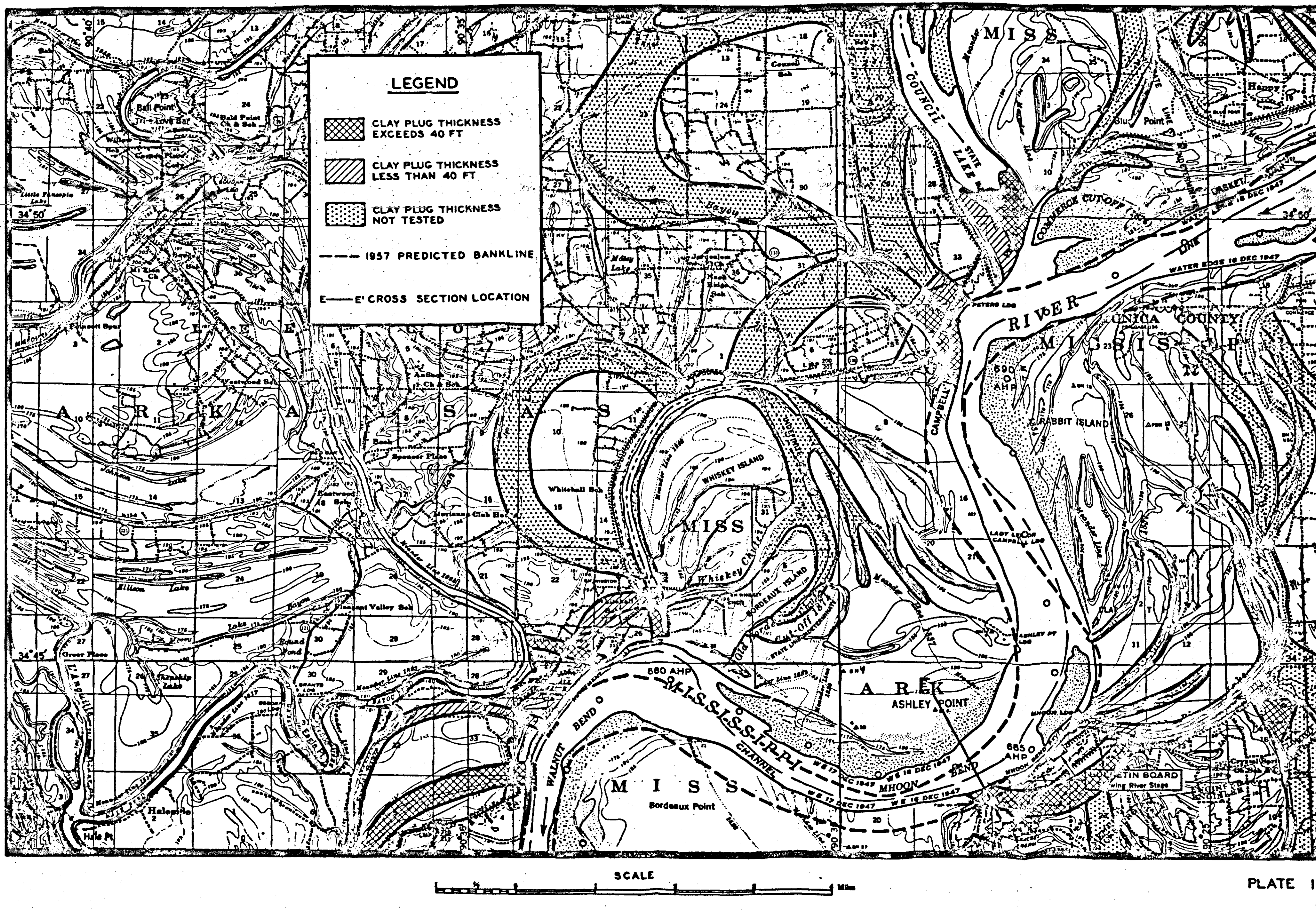
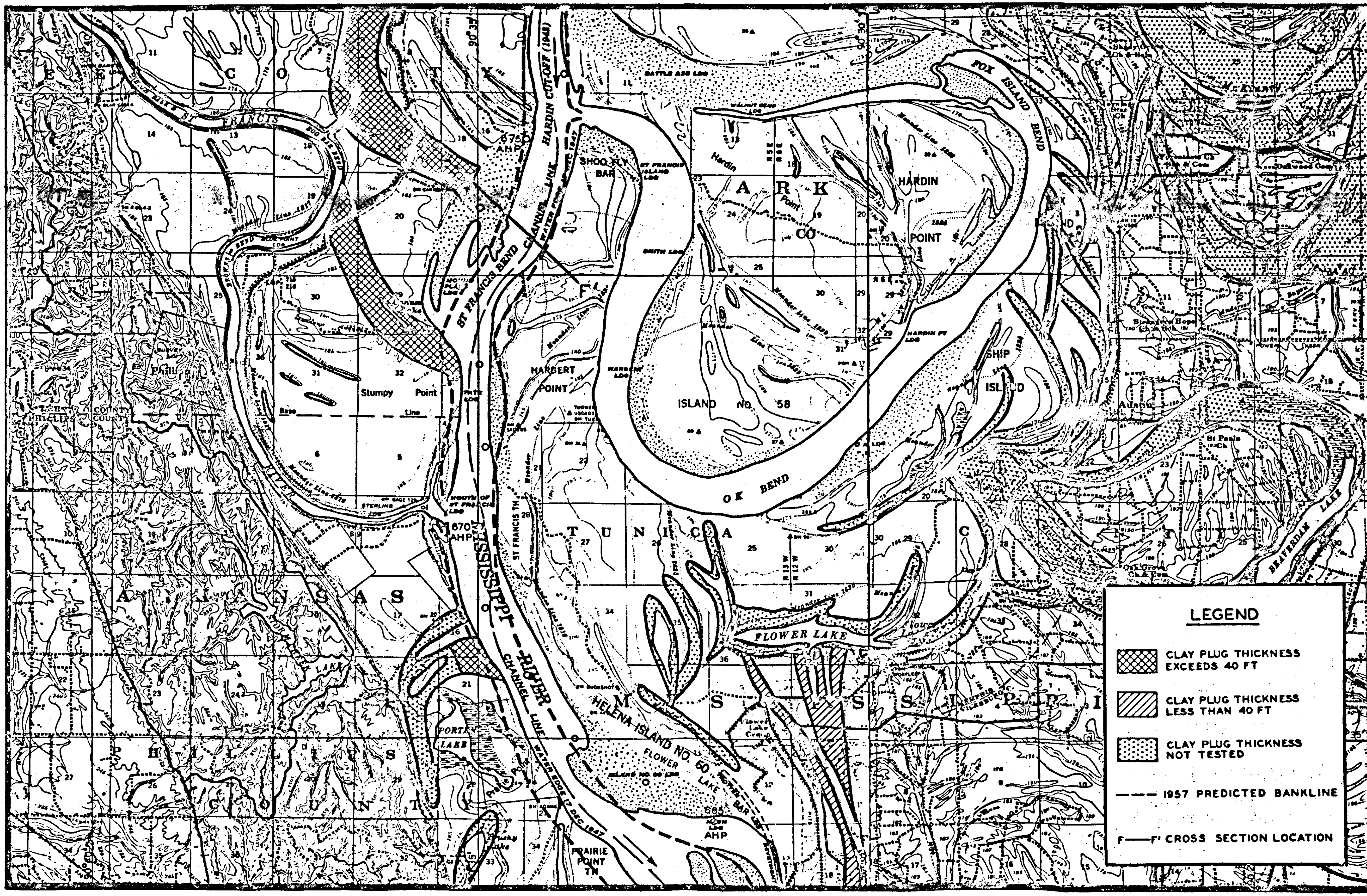

LEGEND
CLAY PLUG THICKNESS EXCEEDS 40 FT
CLAY PLUG THICKNESS LESS THAN 40 FT
CLAY PLUG THICKNESS NOT TESTED
1957 PREDICTED BANKLINE
E—E' CROSS SECTION LOCATION
ARKANSAS
MISS
MISSISSIPPI
RIVER
MISSISSIPPI CHANNEL
WHISKEY ISLAND
Whiskey Chute
BORDEAUX ISLAND
RABBIT ISLAND
ASHLEY POINT
MHOON BEND
WALNUT BEND
Bordeaux Point
COUNCIL STATE LAKE
CAMPBELL
TUNICA COUNTY
Johnson Lake
Ellison Lake
Whitehall Sch
680 AHP
685 AHP
690 AHP
34°50'
34°45'
90°40'
90°35'
90°30'
90°25'
SCALE

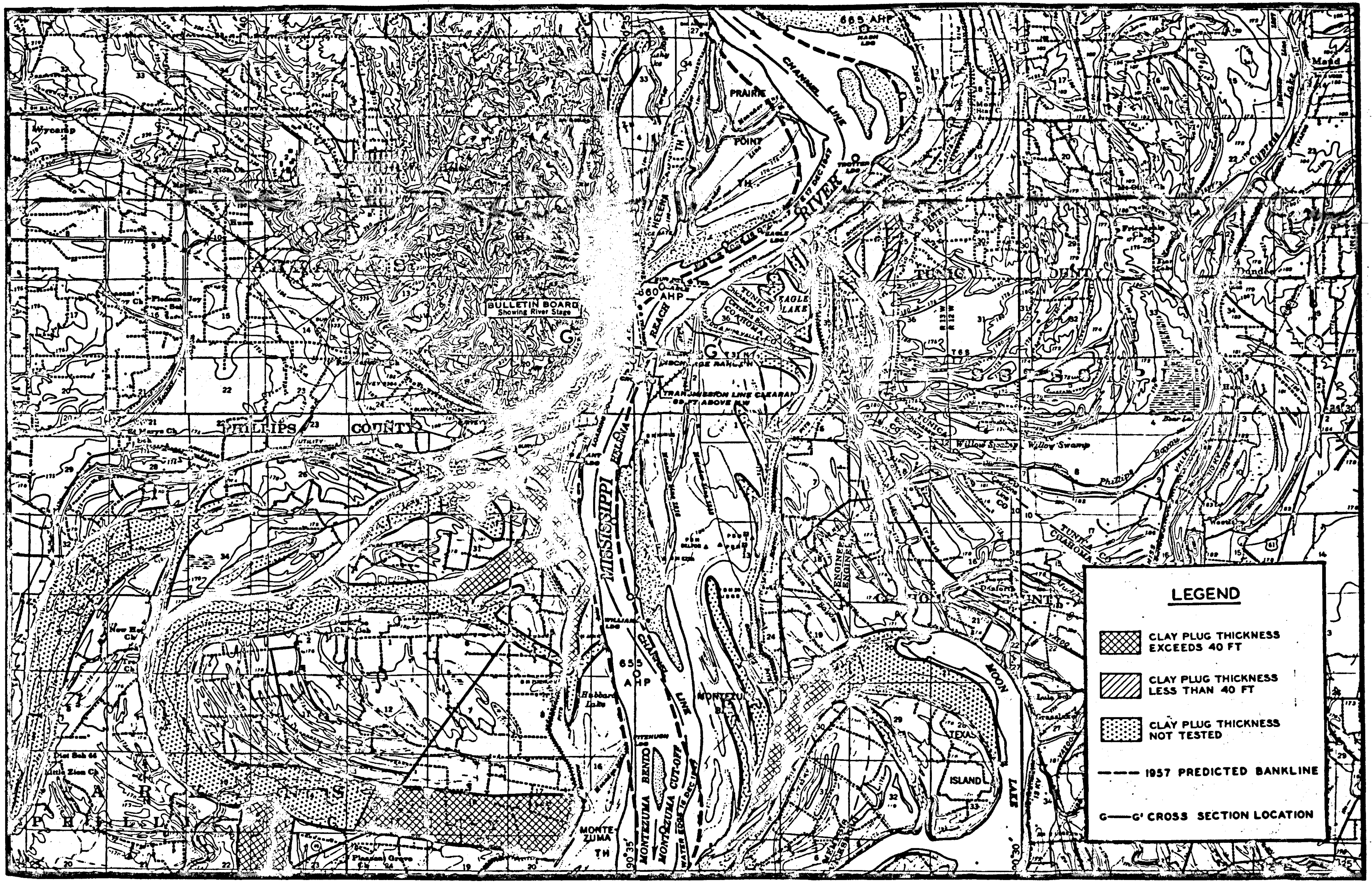
PLATE 14



SCALE

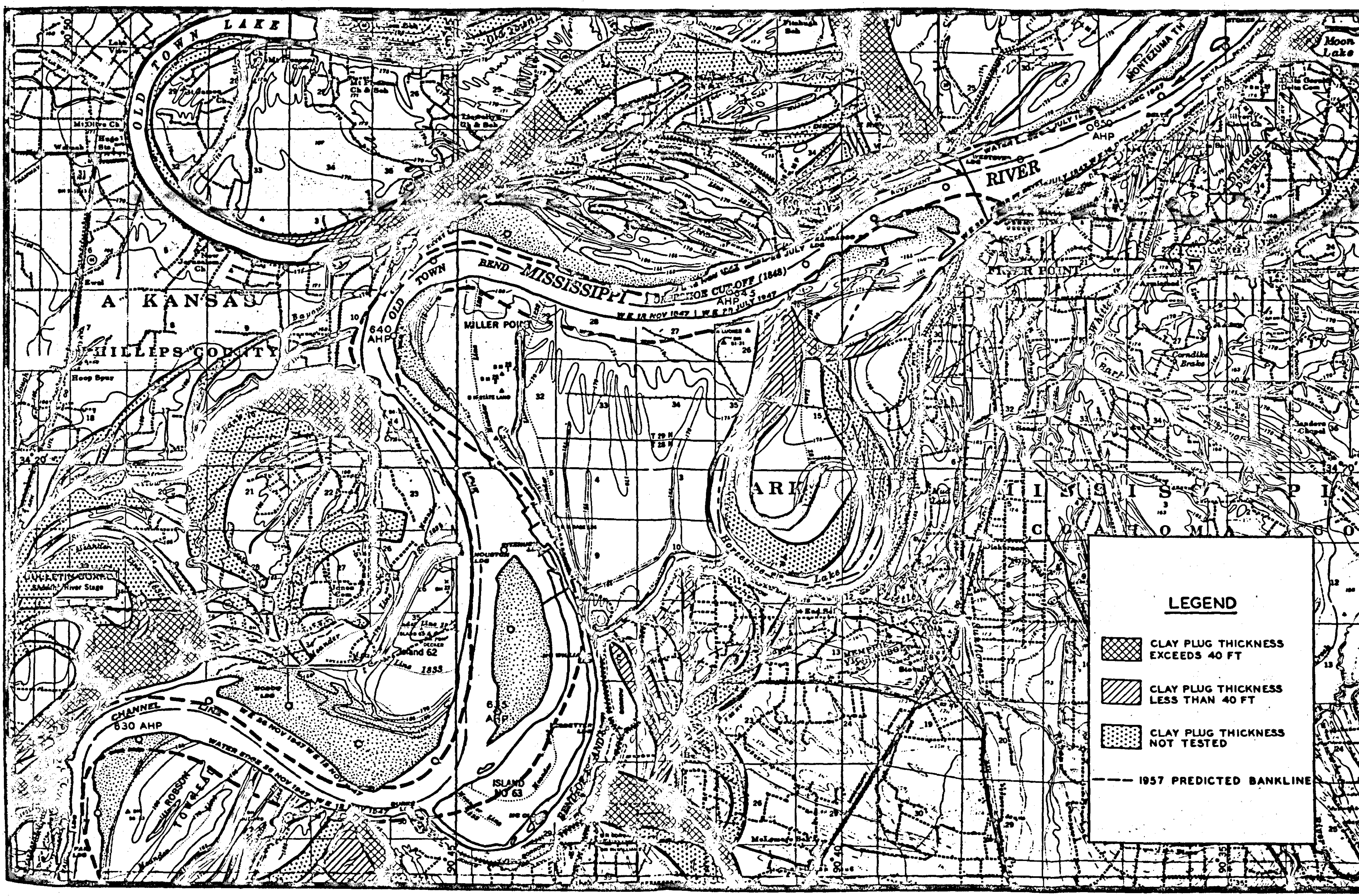
Miles

PLATE 15



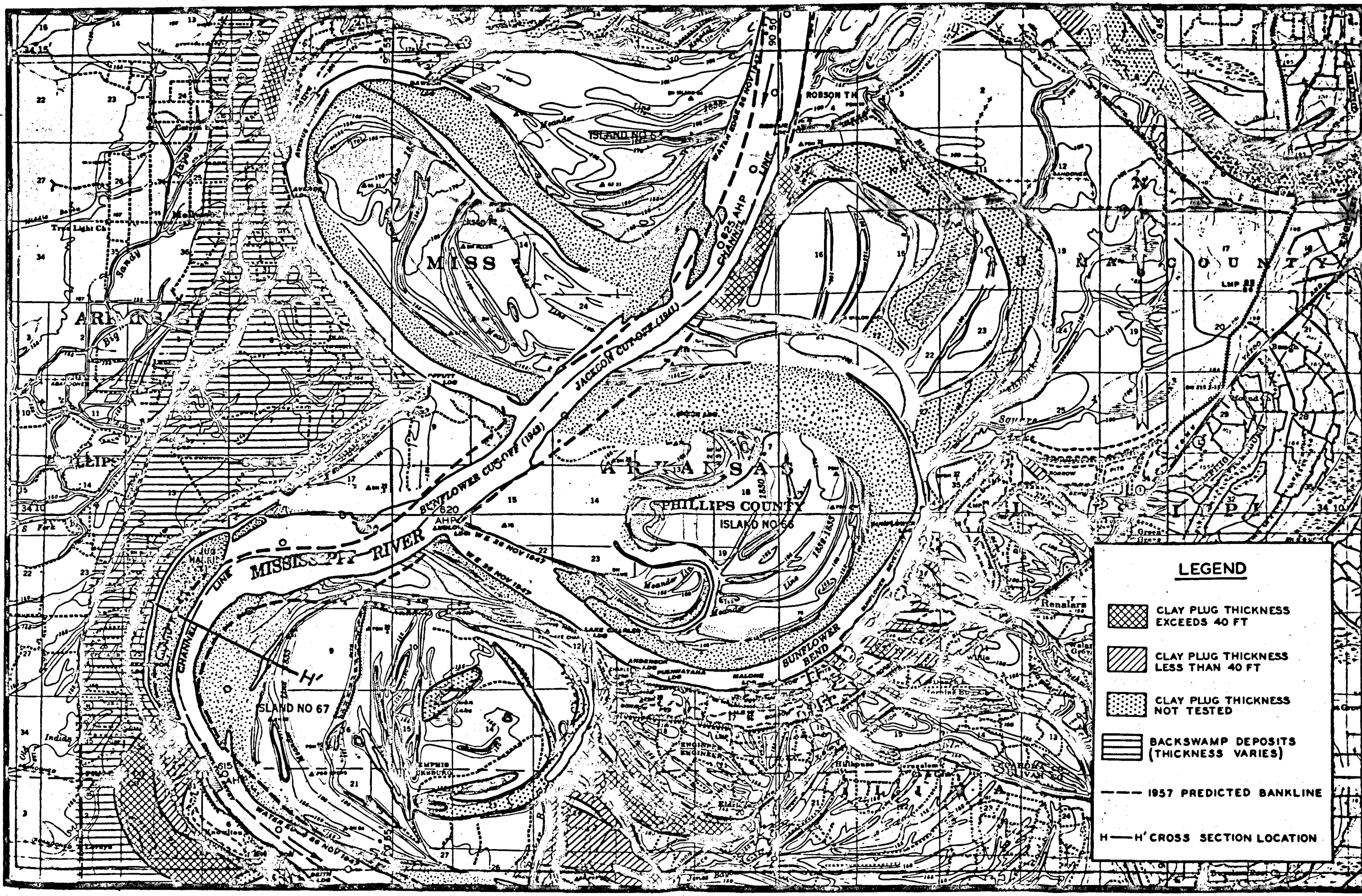
SCALE

PLATE 16



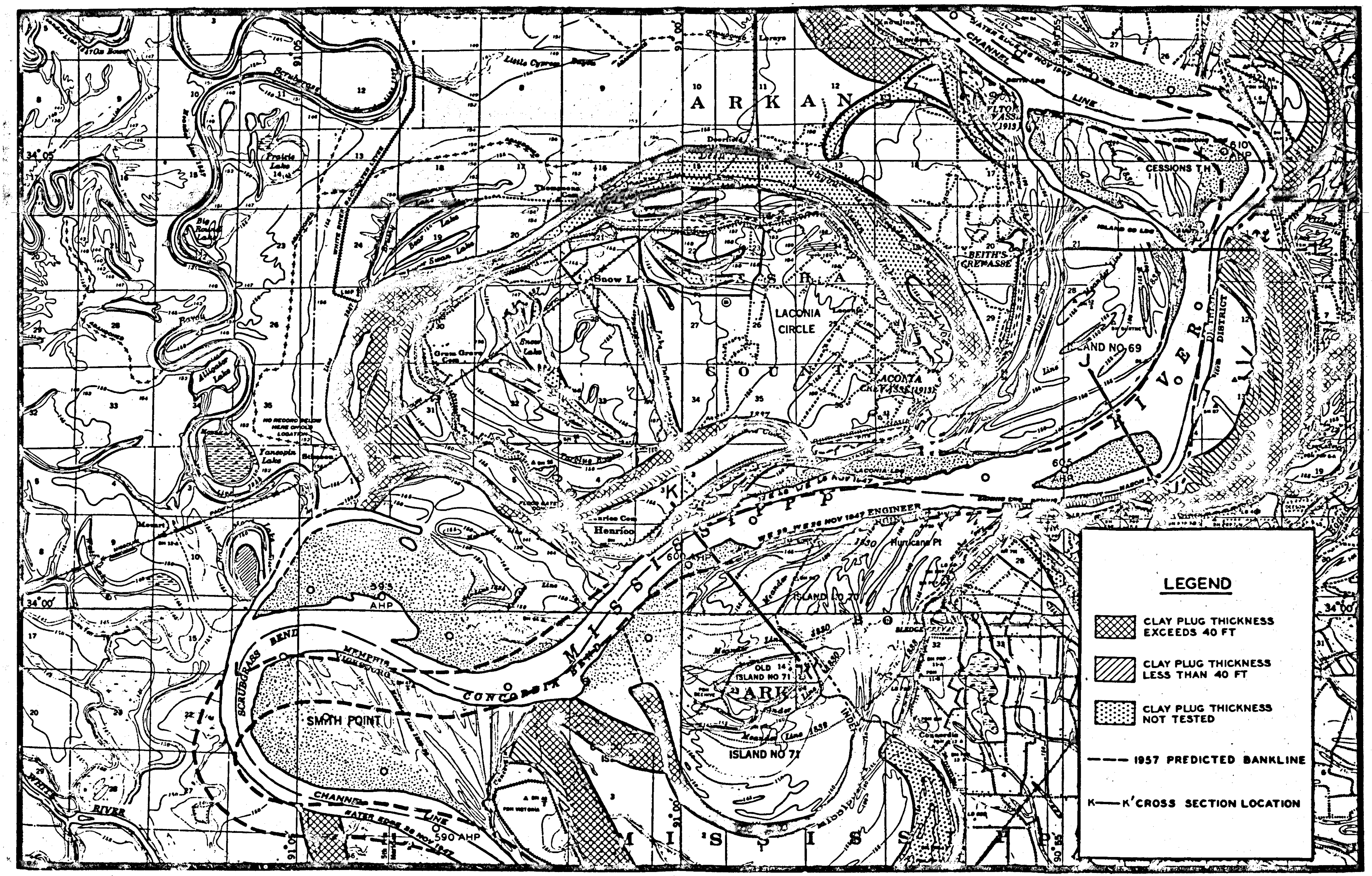
OLD TOWN LAKE
MISSISSIPPI
RIVER
OLD TOWN BEND
ARKANSAS
PHILLIPS COUNTY
MILLER POINT
640 AHP
645 AHP
650 AHP
630 AHP
ISLAND NO 63
Island 62
Horseshoe Lake
Moon Lake
MONTEZUMA
COAHOMA CO
CHANNEL
LEGEND
CLAY PLUG THICKNESS EXCEEDS 40 FT
CLAY PLUG THICKNESS LESS THAN 40 FT
CLAY PLUG THICKNESS NOT TESTED
1957 PREDICTED BANKLINE
SCALE

PLATE 17



LEGEND
CLAY PLUG THICKNESS EXCEEDS 40 FT
CLAY PLUG THICKNESS LESS THAN 40 FT
CLAY PLUG THICKNESS NOT TESTED
BACKSWAMP DEPOSITS (THICKNESS VARIES)
1957 PREDICTED BANKLINE
H—H' CROSS SECTION LOCATION
MISSISSIPPI RIVER
JACKSON CUT-OFF (1941)
SUNFLOWER CUT-OFF (1942)
SUNFLOWER BEND
PHILLIPS COUNTY
ISLAND NO 66
ISLAND NO 67
ROBSON TH
Renalara
SCALE

PLATE 18



LEGEND
CLAY PLUG THICKNESS EXCEEDS 40 FT
CLAY PLUG THICKNESS LESS THAN 40 FT
CLAY PLUG THICKNESS NOT TESTED
1957 PREDICTED BANKLINE
K——K' CROSS SECTION LOCATION
ARKANSAS
LACONIA CIRCLE
COUNTY
SMITH POINT
ISLAND NO 71
OLD ISLAND NO 71
ISLAND NO 69
CESSIONS T.H.
MISSISSIPPI RIVER
WHITE RIVER
SCRUBGRASS BEND
CONCORDIA BEND
Henrico
Hurricane Pt
BEITH'S CREVASSE
LACONIA CREVASSE (1913)
593 AHP
600 AHP
605 AHP
610 AHP
590 AHP
34°05'
34°00'
91°05'
91°00'
90°55'
SCALE

PLATE 19

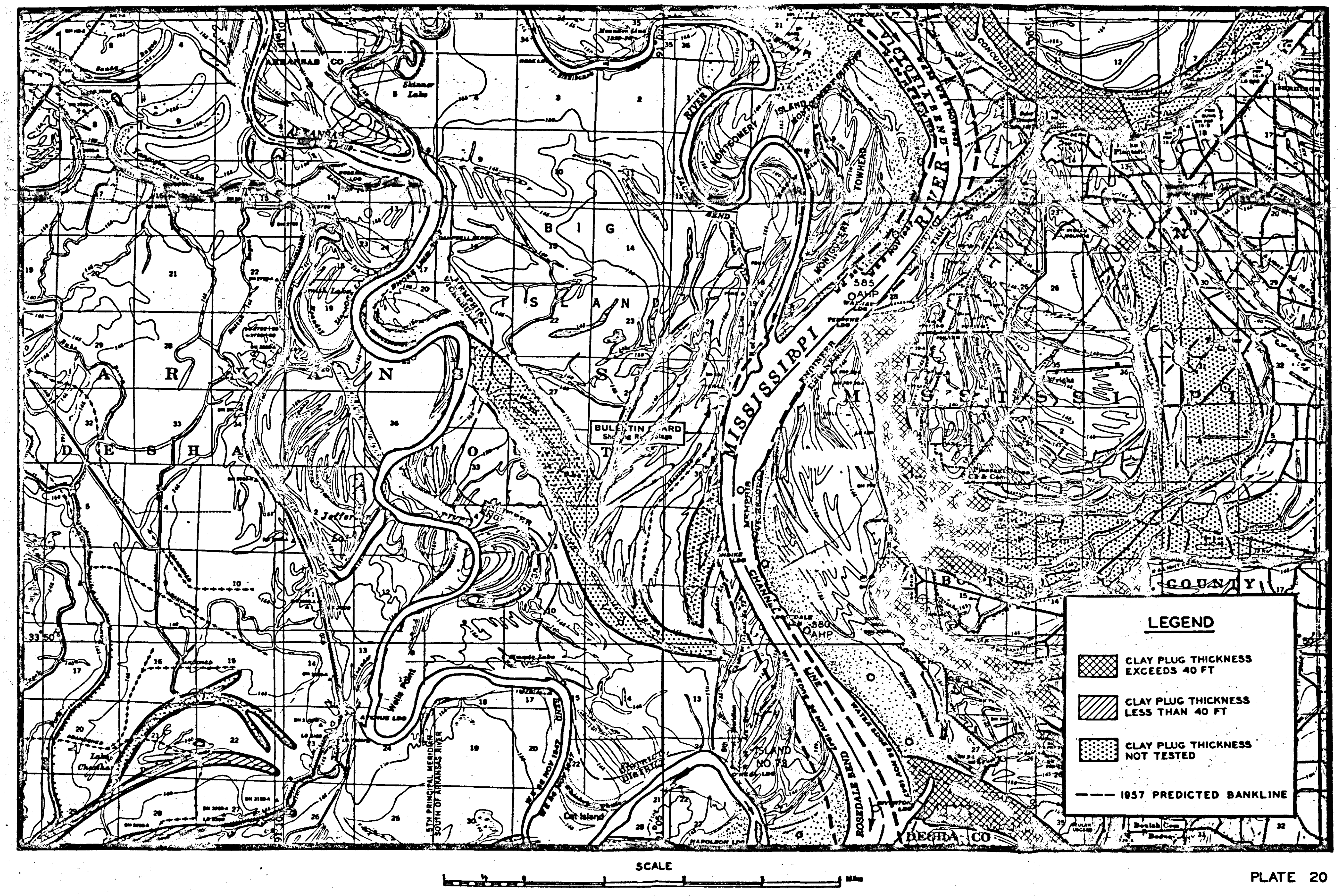
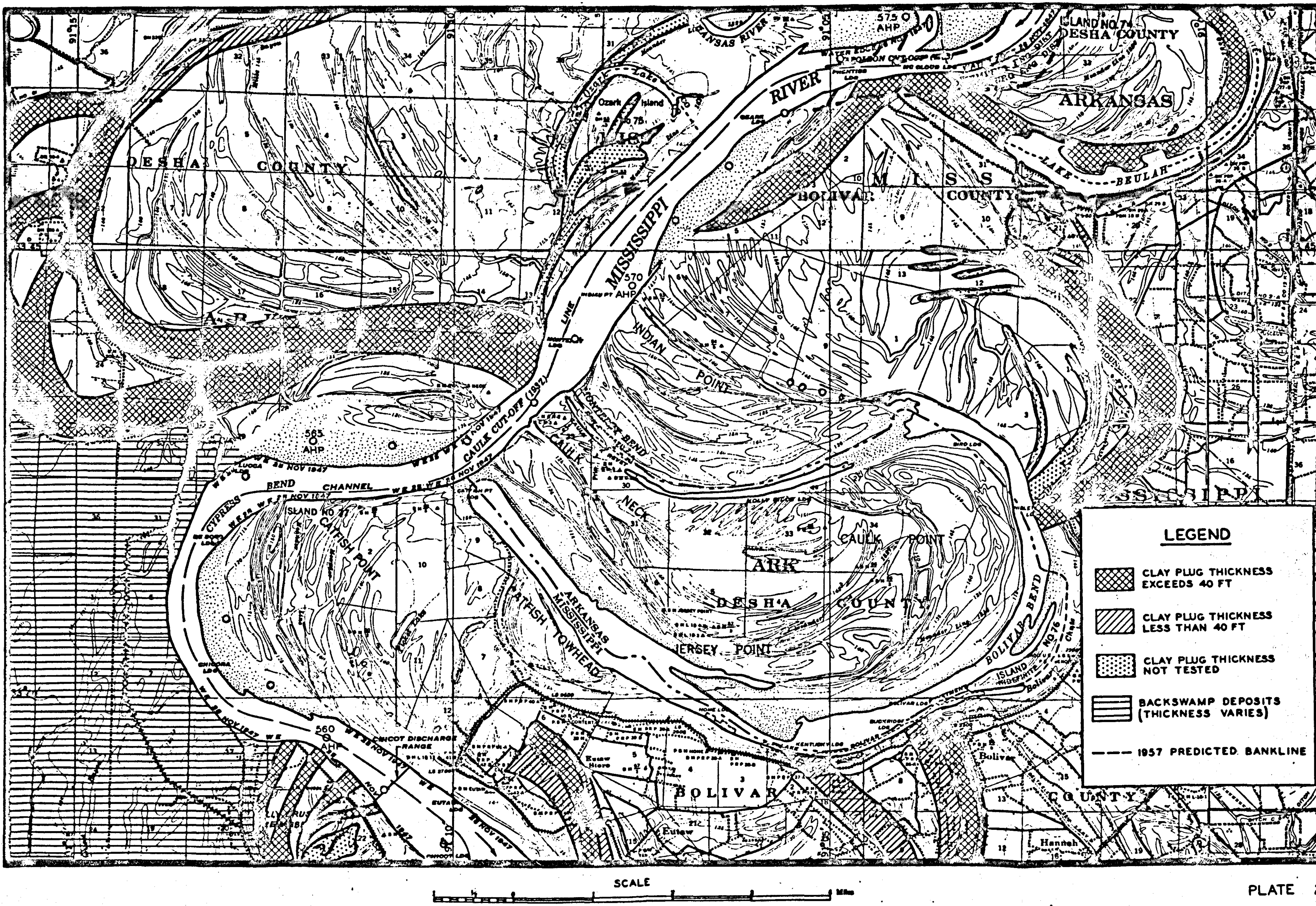

LEGEND
CLAY PLUG THICKNESS EXCEEDS 40 FT
CLAY PLUG THICKNESS LESS THAN 40 FT
CLAY PLUG THICKNESS NOT TESTED
1957 PREDICTED BANKLINE
MISSISSIPPI RIVER
ARKANSAS
MISSISSIPPI
DESHA
BIG ISLAND
BULLETIN BOARD
ROSEDALE BEND
VICTORIA BEND
ENGINEER CHANNEL
ARKANSAS CO
DESHA CO
Skinner Lake
Wells Point
Cat Island
ISLAND NO 75
MONTGOMERY ISLAND
TOWHEAD
585 AHP
580 AHP
5TH PRINCIPAL MERIDIAN SOUTH OF ARKANSAS RIVER
33°50'
SCALE

PLATE 20


LEGEND
CLAY PLUG THICKNESS EXCEEDS 40 FT
CLAY PLUG THICKNESS LESS THAN 40 FT
CLAY PLUG THICKNESS NOT TESTED
BACKSWAMP DEPOSITS (THICKNESS VARIES)
1957 PREDICTED BANKLINE
MISSISSIPPI RIVER
DESHA COUNTY
ARKANSAS
BOLIVAR COUNTY
CAULK CUT-OFF (1942)
CYPRESS BEND CHANNEL
INDIAN POINT
CAULK NECK
CAULK POINT
CATFISH POINT
CATFISH TOWHEAD
JERSEY POINT
BOLIVAR BEND
LAKE BEULAH
ISLAND NO. 74
ISLAND NO. 76
ISLAND NO. 77
565 AHP
570 AHP
575 AHP
560 AHP
CHICOT DISCHARGE RANGE
Bolivar
Eutaw
SCALE

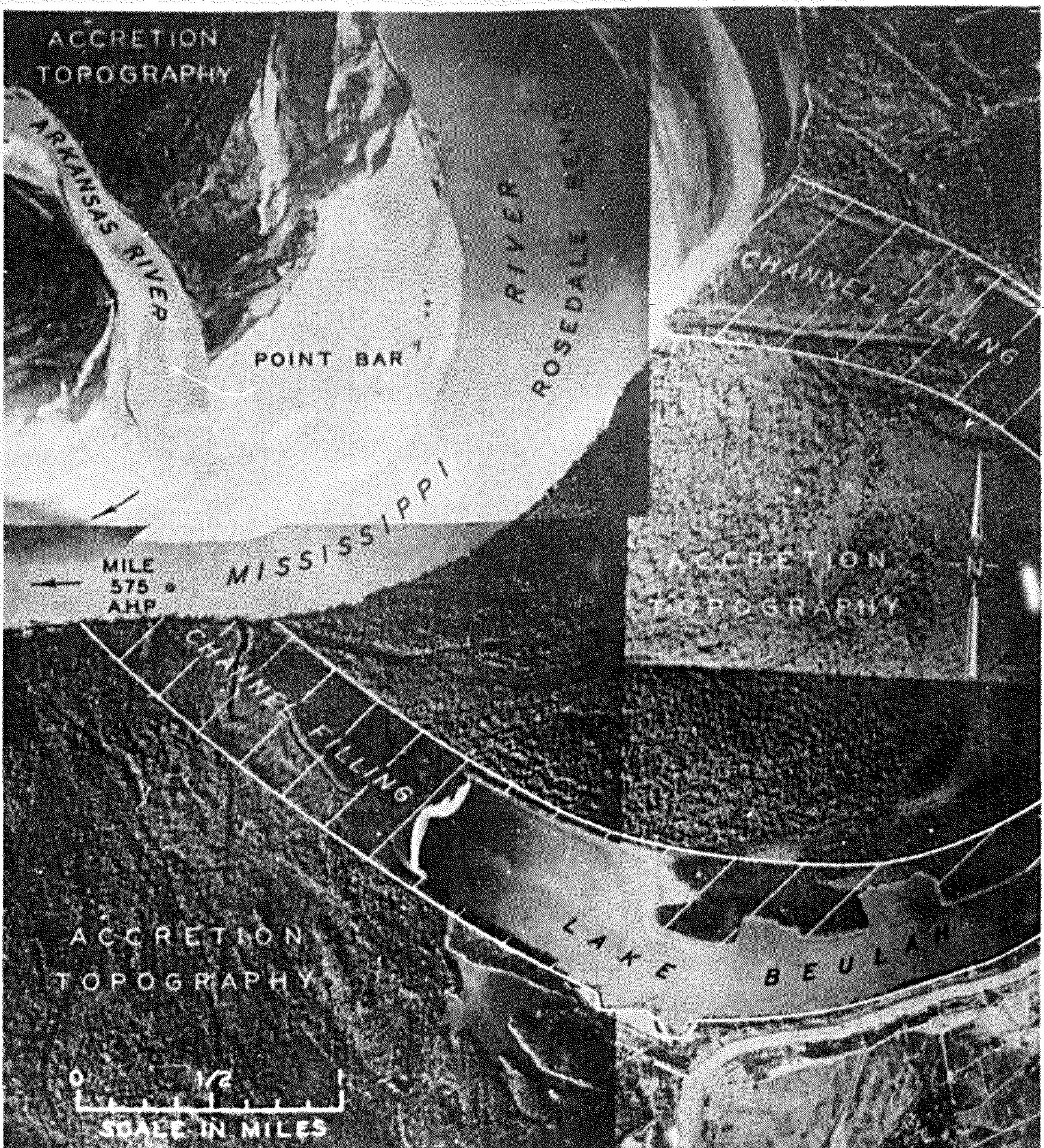


Figure 1: Abandoned channels, point bar deposits and ridges and swales of accretion topography
Lake Beulah, Mississippi. Mile 575 A.H.P.
Gage, mouth of White River 28 Nov 1947, 5.83 ft

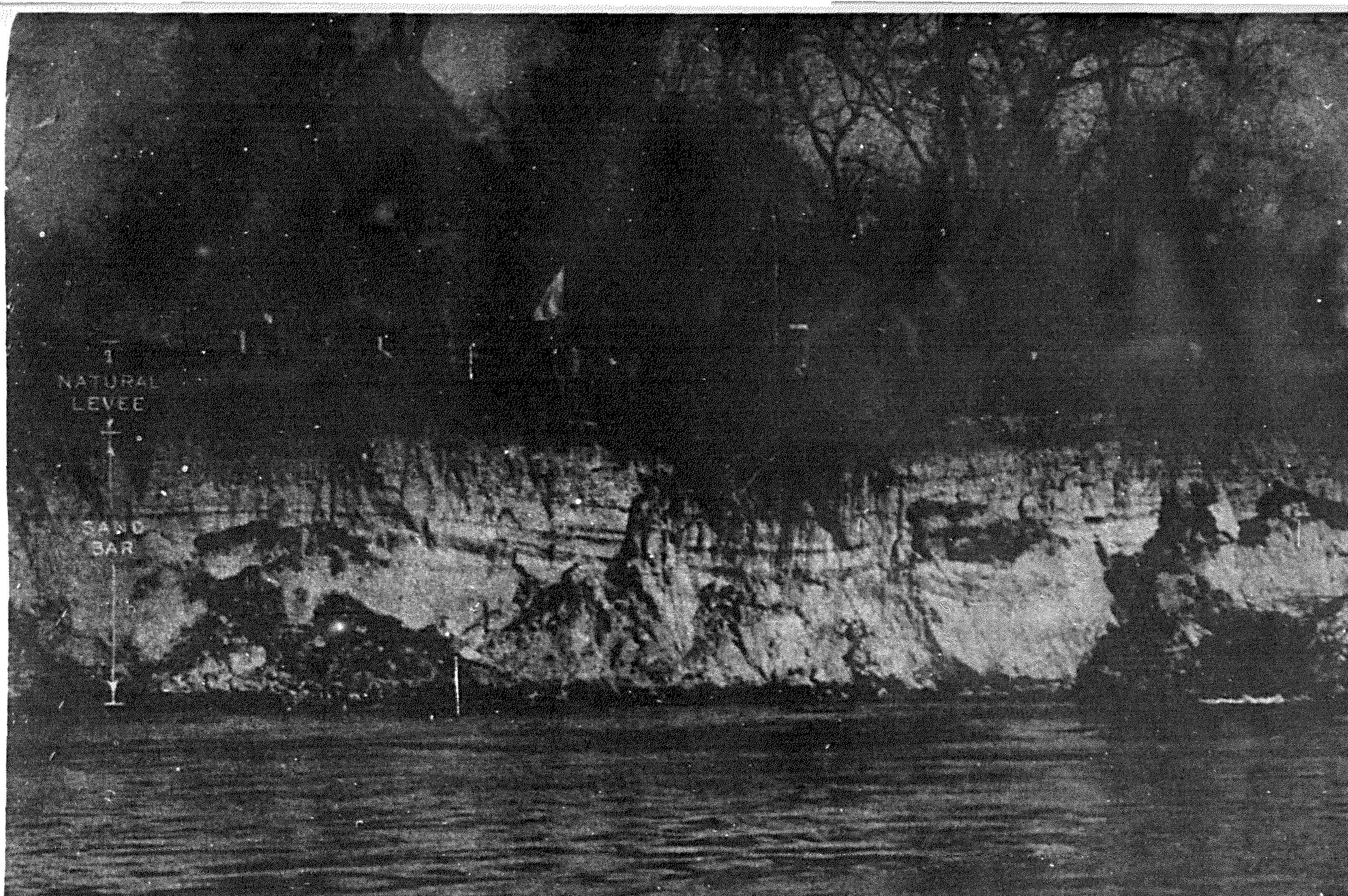


Figure 2. Typical section of point bar deposits overlain by thin blanket of natural levee silts and clayey silts. Lower end of pilot cut for Hardin Cut-off, mile 676 A.H.P.

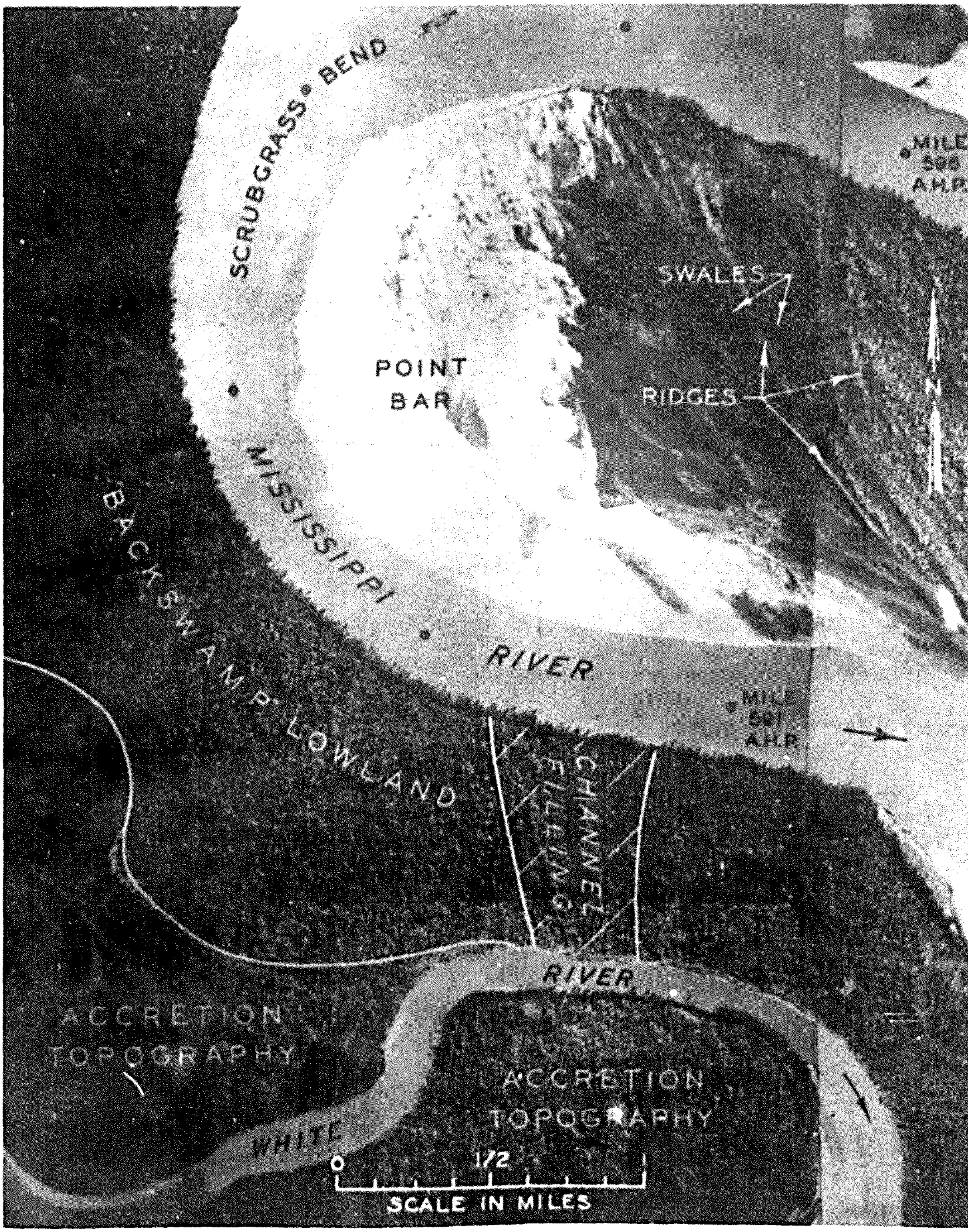


Figure 3. Mississippi and White River channel, point bar and backswamp features.

Traces of ancient braided stream channels are visible through the overlying White River backswamp deposits. Scrubgrass Bend, miles 596-590 A.H.P. Mouth of White River, Ark., gage, 5.9 ft, 28 Nov 1947

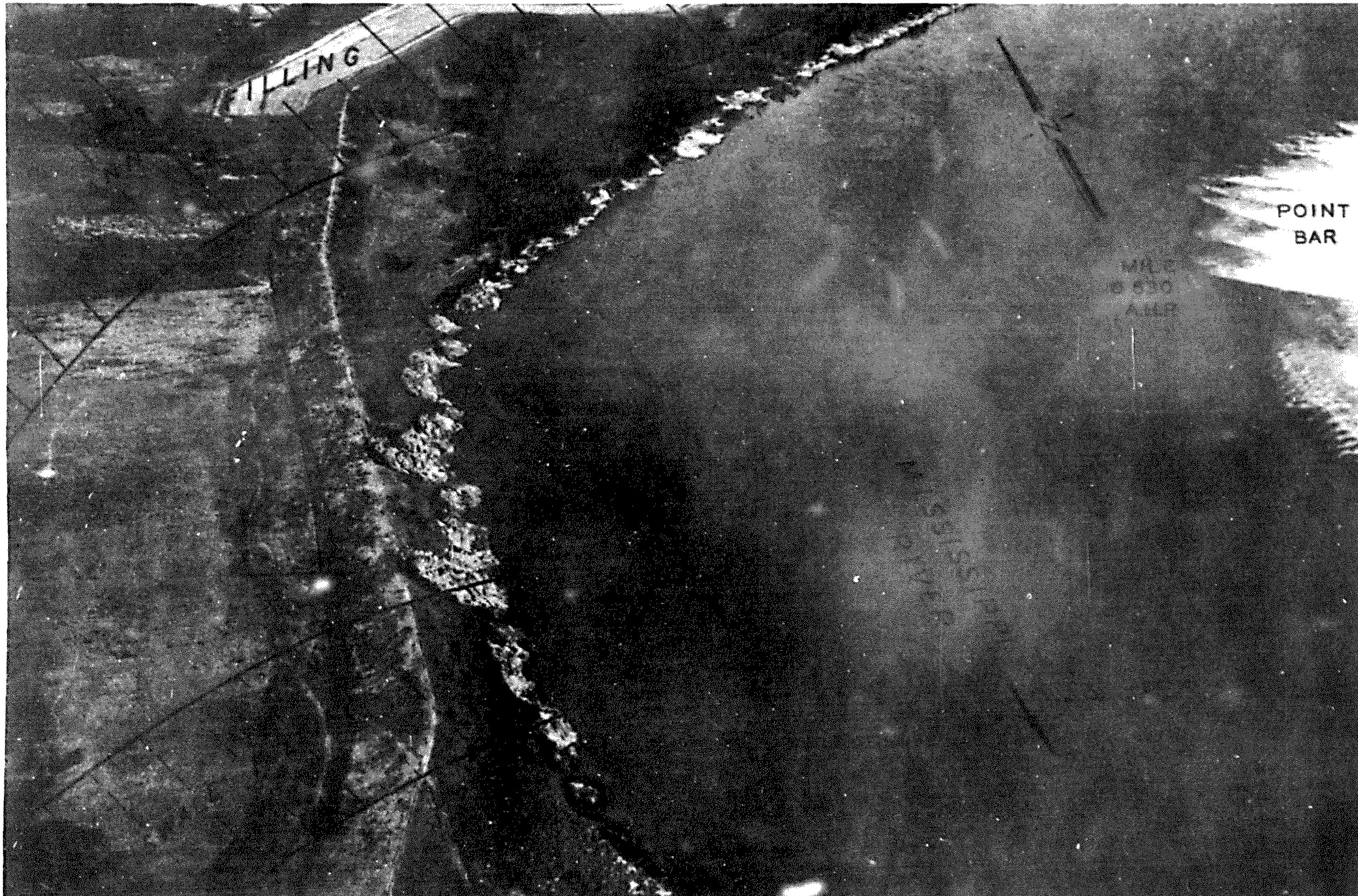


Figure 4. Caving bank near Fair Landing, Arkansas. Note arcuate shape of slump blocks. Mile 630 A.H.P.

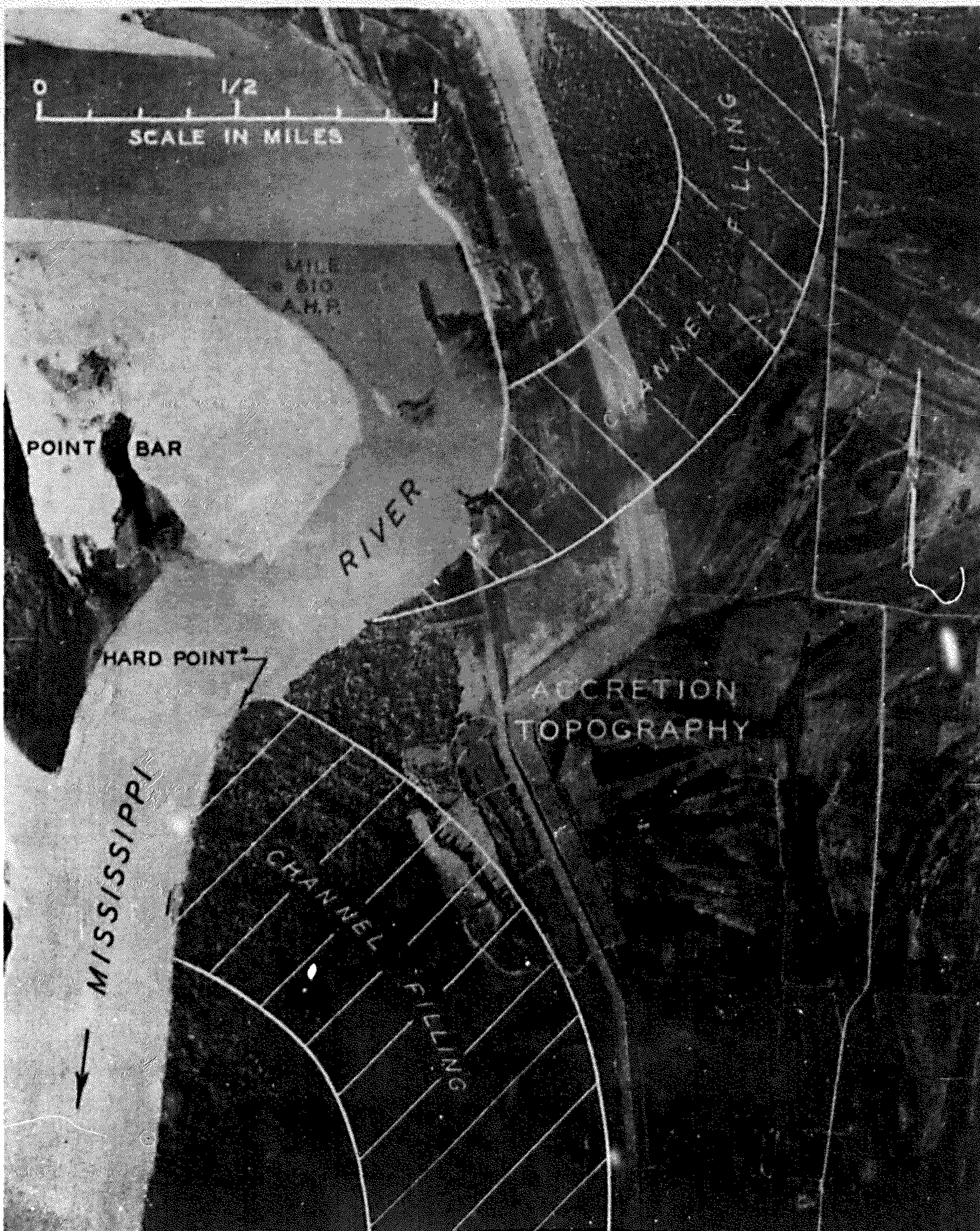


Figure 5. Channel and point bar accretion features. Note hard point and narrow channel width resulting from resistant sediments filling abandoned channel. Cessions Towhead, miles 609-611 A.H.P. Fair Landing, gage, 3.5 ft, 26 Nov 1947

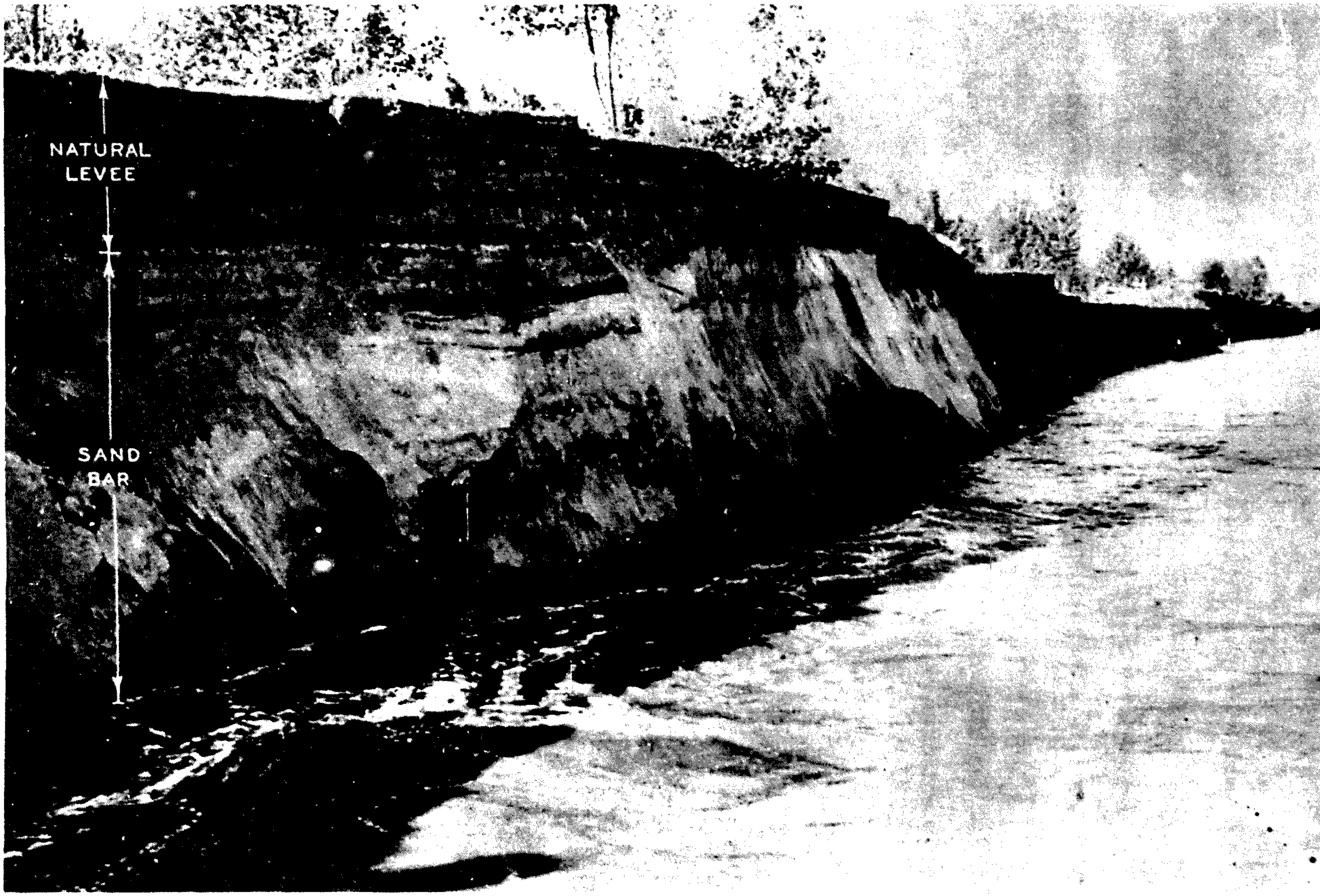


Figure 6. Natural levee silty sands and clayey silts overlying point bar deposits. View along right bank at lower end of Jackson Cut-off, mile 622.5 A.H.P. Note sloughing of sandy point bar material.

Figure 7. Large slump block developed in fine-grained deposits filling abandoned swale position. Right bank, mile 647.5 A.H.P., near Westover, Ark.