Gh Brown

BACKGROUND REPORT

YAZOO BASIN, MISSISSIPPI

by

Wallace H. Walters Jr.

Colorado State University
February, 1977

GEOLOGY

Introduction

The drainage basin of the Yazoo River System encompasses 13,355 square miles bordered on the north by the drainage divides of the Wolf and Hatchie river basins in Tennessee, on the east and south by the divide of the Tomhighee and Big Black river basins, and on the west by the artificial levees which flank the Mississippi River. Major tributaries of the Yazoo are the Tallahatchie, Coldwater, and Yalobusha rivers, and the Big Sunflower-Steele's Bayou system. Nearly the entire drainage enters the Mississippi at Vicksburg where a canal diverts the Yazoo flow into an abandoned meander loop and through this to the Mississippi River.

Before the main line levees were constructed along the Mississippi River, the basin received overflows almost annually. Because of the overflow, navigation was possible throughout most of the year but farming was limited to the higher elevations only. These higher elevations were located along the natural levees of the Mississippi River and its ancient abandoned river courses. Following levee construction, overflow was prevented and navigation became much more difficult and unreliable. But settlement and farming was now possible over almost the entire alluvial plain area of the basin. Meanwhile, settlement of the eastern upland portion of the basin had uninterrupted, except for the Civil War period, during the 1800's. The upland area was not troubled near as often by flooding but did have severe erosion and sedimentation problems. Flooding did begin to be a problem on the upland streams during the early 1900's because of sedimentation in the drainage system. Straightening and canalizing of these streams began during this period causing severe sedimentation at lower elevations and out on the alluvial plain. The drainage system of the alluvial plain (Yazoo Delta) was undergoing its own changes. Because the drainage system was not subjected to Mississippi River overflows the channel geometry was decreasing in dimension by the progressive building of terraces with the top bank lines of the major Delta rivers. At the same time sediment from the upland streams was assisting in the filling of the Delta stream channels further aggravating a serious problem.

The overall result of the changing situation in the Yazoo Basin was a steady increase in Federal involvement regarding flood control, soil conservation, and drainage. State and local entities did not have the financial resources to alleviate the problem. When they did attempt improvement projects, they usually compounded the problem and also extended it downstream on their neighbors.

The Federal Government funded and constructed flood control projects with some success but flooding and sedimentation still persist. One of the more common practices of regaining channel capacity is by dredging which is done frequently but another problem arises. The material dredged from the channel must be placed somewhere, therefore, good farmland and equally good wildlife habitat has to be condemned for disposal areas. There seems to be no end in sight to the sedimentation problem so dredge material disposal areas will continually be needed and available farmland or wildlife habitat will continually shrink.

GEOLOGY

Introduction

There are five distinct physiographic provinces which make up the Yazoo Basin. Beginning with the higher elevations in the northeastern portion of the basin these provinces are: (a) Pontotoc Ridge, (b) the Flatwoods, (c) the North Central Hills, (d) the Loess Bluffs, and (e) the Mississippi Alluvial Plain, commonly called the Yazoo Delta (Figure 1).

The youngest materials forming the surface are located within the Mississippi Alluvial Plain and in the Loess Bluffs. Ages range from 25,000 years to the present. In contrast, geologic formations ranging in age from Late Cretaceous (100,000,000 years) to middle Eocene (50,000,000 years) form the surface of Pontotoc Ridge, the Flatwoods, and the North Central Hills. Most of the older geologic formations consist of soil in that the material can be crumbled easily by hand. They may be very dense but offer little resistance to erosion. Erosion by area streams, by sheet flow, and by wind have stripped the less dense and easily erodible soils from one area and deposited them on another. Smaller channels with narrow flat floodplains merge with larger downstream floodplains and these with floodplains along the principal tributaries to the Yazoo River System.

The older geologic formations dip at fairly shallow angles toward the west and southwest so that the oldest materials lie in the northeast corner of the basin and successively younger soils form the surface as it nears the Yazoo Delta region. Farther to the west the older geologic horizons are buried beneath a cover of Pleistocene loess underlain by sand and gravel or by the thick Holocene or Recent deposits of the Yazoo Delta.

Pontotoc Ridge

The three oldest geologic formations in the basin are, from the oldest to youngest, the Cretaceous Ripley and Prairie Bluff formations and the Paleocene Clayton. They form the physiographic province known as Pontotoc Ridge, a densely wooded area with pronounced relief. The highest elevations in the basin, on the order of 700 feet, are found in this province.

The Pontotoc Ridge reflects the presence of the various strata which underlie it and which, as a group, are more resistant to erosion than materials elsewhere in the Yazoo Basin. The series of ridges rises to conspicuous heights above the Flatwoods province to the west. Dips of the strata are on the order of 30 feet per mile.

Flatwoods

West of the Pontotoc Ridge is a flat area which has been called the Flatwoods since 1860 or earlier. Elevations range from 300 to 400 feet. It is underlain by the Porter's Creek clay which offers little resistance to erosion and yields a heavy stiff soil which is difficult to cultivate. Unpaved roads in the area are practically impassable in wet weather. There are relatively few hills, and most of those that are present are erosional remnants of the overlying red Wilcox sand.

The Porter's Creek clay is a dark-gray montmorillonitic marine clay, which weathers to a sticky clay soil at the surface. It is about 300 feet thick in the northeast Yazoo Basin. Much of the unweathered material shows no stratification, but possesses an ability to break out into lumps from one to four inches in diameter. When cut with a knife, its texture is much like soap.

North Central Hills

This physiographic province is characterized by thorough stream dissection, moderate to gentle slopes, flats developed along streams from their mouths well up toward their heads, and terraces or second bottoms bordering the floodplains of larger streams. The region is well drained by a complex of streams forming a dendritic pattern. Hills and ridge tops are well rounded and lineations of hills and ridges follow the strikes of the underlying geologic formations. The contact between the Claiborne and Wilcox groups, for example, stands out as a series of disconnected ridges.

The clays of the Wilcox formations form red silty loam at the surface; the sands form fine silty micaceous soils which are some of the poorest in the Yazoo Basin for agricultural purposes. The clays form low rolling hills and ridges, whereas the sands form hills and ridges more rugged and of greater relief. Landslides are common in the Wilcox clays after long periods of rainfall along the hillsides, road cuts, and gullies.

The Loess Bluffs

The Loess Bluffs are formed of the most distinctive and homogeneous of the soils in the Yazoo Basin. They consist of tan to buff-colored silt that characteristically forms pronounced vertical bluffs. Under appropriate conditions these bluffs will retain there near vertical faces for decades. A closer examination and laboratory tests of loess reveal it to consist of more than 95 percent angular silt-size particles. The particles are stacked in random fashion resulting in a high-porosity material of low density. Calcareous clay binds the silt particles together. As long as the cement is effective, the material will stand vertically. Wetting quickly breaks down this bond between the particles; and when this occurs, the soil loses strength and quickly fails. As a result, dissection by running water has carved the loess into some of the most intricate relief found within the Yazoo Basin.

The deposit is about 90 feet thick, on the average, at the bluffs and gradually, but irregularly, thins eastward. Beyond this eastern boundary of the Loess Bluffs, and extending for another 30 to 40 miles farther east, is a sporadic deposit generally called "brown loam." It varies from a few feet to about 10 feet in thickness and is considered to be windblown silt and clay similar in origin to the loess but reworked by physical, chemical, and alluvial processes to the point where it no longer has the properties or the general appearance of the undisturbed loess of the Loess Bluffs. It also will not stand vertically. Much of the North Central Hills of the Yazoo Basin are covered with "brown loam" and distinctions are possible between it and residual soils developed on the ancient Tertiary formations.

More pertinent perhaps has been the history of agriculture in the Loess Bluffs. There is evidence that early settlers found large flat areas within the Loess Bluffs which they promptly cleared of their forests and planted or used for pasture. Today such flat uplands are extremely rare. There is good evidence that the headward growth of gullies became pronounced in a few decades, so much so that farming the Loess Bluffs became impracticable and even grazing became marginal economically. The amount of loessial silt that moved down the many small creeks in the Mississippi Alluvial Plain was great and the effect of gullying and siltation has continued, at a lesser rate, through to the present.

At the present time agricultural practices are less responsible for continued sedimentation problems than is the extensive grading and other earth-moving necessary for construction of highways, housing developments, industries, channelization of creeks and rivers, etc. Equally troublesome from the standpoint of adverse sedimentation is the mining of the sand and gravel which often lies beneath the loess.

The origin of the Pleistocene sand-and-gravel units is thought to be the same as that of the sand-and-gravel substratum which underlies the present Mississippi Alluvial Plain. The sand-and-gravel units beneath the loess are considered to be remnants of older alluvial plains of the Mississippi formed during previous ice advances and retreats and now uplifted to higher elevations.

The Mississippi Alluvial Plain

The Mississippi Alluvial Plain covers approximately two-thirds of the Yazoo Basin, an immense flatland oval shaped with Memphis at its northern end and Vicksburg at its southern end. The area is referred to as the Yazoo Delta although the Yazoo River has no true delta of its own.

The Yazoo Delta is one of the most fertile and productive regions in the state of Mississippi. Its lack of relief and its high concentration of sluggish streams and lakes contrasts markedly with the upland areas of the Yazoo Basin. The eastern border of the delta is well defined by the steep escarpment of the Loess Bluffs. Its western border, also the western border of the Yazoo Basin, is along the top of the artificial levee which borders the Mississippi River.

Natural drainage follows arcs, loops and the generally curved patterns characteristic of meandering streams rather than the dendritic patterns characteristic of the upland areas of the Yazoo Basin. It is obvious from an aerial view that small streams quite often follow broad arcuate patterns that are not of their own making. In many instances these smaller streams have formed small tightly looped meanders, dependent on their flows, within the broad arcs left by relict Mississippi River courses. Plowed fields reveal the remnants of huge meanders now marked only by light and dark-colored arcs that extend for miles in either direction. Ox-bow lakes that were once obviously bendways of the Mississippi River are now miles in distance from the Mississippi. In some instances the Yazoo River, the Big Sunflower, and other streams follow along the huge arcs left by earlier courses of the Mississippi. In other instances they disregard these abandoned courses and have formed their own channels in the lowland areas away from the larger, formerly occupied channels.

In summary, the Mississippi Alluvial Plain is the result of a complex history of occupation and deposition by ancient meandering courses of the Mississippi River and its tributaries. Contrasting with the widespread areas of meander scars and meandering drainage are isolated remnants of <u>two</u> distinctively different landforms. One consists of low-lying areas of interior drainage, the backswamp, where floodwaters ponded before artificial levees restricted overflow from the Mississippi and where clays have been deposited to depths of 50 feet or more. The other landform consists of silts and sands laid down by an anastomosing network of shallow drainage channels left behind when the Mississippi was a braided rather than a meandering stream. These are the remnants of the oldest soils which form the <u>surface</u> of the Yazoo Delta.

The Mississippi River began its meandering perhaps as long as 8000 years ago in the Yazoo Delta. Detailed geological and engineering soils mapping (Kolb et al., 1968) delineates deposits left by four or possibly five distinct meander belts that have crossed the area. Sancier (1974) has assigned dates to these meander belts based on recent archeological and carbon-14 determinations and has fit them into a consistent chronological sequence. Sancier differs from Fisk, who attempted a similar chronologic assessment in 1944, principally in that he considers Fisk's age assignments too recent. Current data suggest that the various meander belts are older, sometimes as much as two or three times older, than Fisk had proposed.

The oldest meander belts are along the eastern valley wall. Because of their age and the few segments exposed at the surface, the history of these belts is far from certain. It is possible to distinguish two separate meander belts which occupied essentially the same area as that currently occupied by most of the Coldwater-Tallahatchie-Yazoo river system. The two meander belts were active from about 9000 to 6000 years ago. The deltas associated with these two meander belts are probably buried beneath the present deltaic plain.

The Big Sunflower River now follows a previous meander belt of the Mississippi that is broad, well defined, and well preserved. It probably began by diversion from the two combined meander belts along the eastern valley wall about 6000 years ago and was occupied by a full-flow Mississippi River for about 1500 years.

About 4500 years ago it is believed that the meander belt now occupied by the Big Sunflower River was gradually abandoned and a divided flow condition developed. This consisted of two separate channels; the western arm followed essentially the present Mississippi River meander belt along the Yazoo front and the eastern arm followed basically the same trace as the two earlier combined meander belts along the eastern valley wall. Due to the split flow condition the meanders were smaller. The smaller meanders are particularly well preserved along the valley wall where many are now followed by the Yazoo and the Tallahatchie rivers.

It is estimated that flow was divided as described until about 2500 years ago when eventually the western arm enlarged enough to accept the full flow of Mississippi and the present meander belt was formed.

Alluvial environments of deposition within the Yazoo Delta are divided into (a) braided stream remnants, (b) backswamp, (c) point bar, (d) abandoned channels and abandoned courses, (e) natural levees, and (f) alluvial aprons. Each classification represents a specific depositional process and has its own individual set of soil properties. The different types of topstratum present can provide a key to patterns of stream behavior. For example, in the more cohesive soils, stream meanders migrate very slowly and banklines demonstrate a degree of stability not found in predominantly sandy soils. Channels in sandy alluvium tend to be wider with more rapid migration rates and form islands much easier.

Braided Stream

Braided stream deposits are the oldest deposits exposed in the Alluvial Plain. They were laid down by a network of shallow shifting streams and the greater mass of the sediment was coarse grained. However, a thin, fine-grained portion is present as topstratum which also includes alluvial fan and apron deposits near the valley wall.

Braided stream deposits are exposed in the northeastern and west-central portion of the Yazoo Delta. These areas are remnants of once larger masses now situated between meander belts or a meander belt and the valley wall and are essentially at the same level or only slightly higher than the bordering alluvial environments. Because of this slight elevation difference the braided surfaces were chosen early for farming.

Backswamp

Backswamp deposits consist of fine-grained sediments laid down in broad, shallow basins within the floodplain during periods of flooding. The sediment-laden floodwater may be ponded between the natural levee ridges on separate meander belts, or between natural levee ridges and the uplands. Backswamp areas typically have very low relief and a distinctive, dendritic drainage pattern in which channels alternately serve as tributaries and distributaries at different times of the flood cycle.

Backswamp deposits are present in various portions of the Yazoo Delta, but are widespread only in the southern portion where they occur between meander belts. Soils consist of heavy plastic and organic clays which settle out in sheets that vary from paper thin to inches thick. Some of these clayey deposits are 50 or more feet thick. These low-lying areas were not necessarily used for farming until comparatively recent times. As cultivation increases, however, many of these areas are cleared of timber and drained artificially.

Point Bar

Point bar deposits consist of sediments laid down on the insides of river bends as the river meanders. There are two types of deposits

Abandoned courses, as distinguished from abandoned channels are long segments of the river abandoned when the river shifted into an entirely new meander belt. They mark the final position of the river before it was abandoned. The abandoned courses are often occupied by smaller streams and bayous. On being abandoned by the Mississippi, these naturally available drainage-ways became the ancestral courses for minor drainage within the Yazoo Delta. The Yazoo, the Tallahatchie, the Coldwater, and the Big Sunflower rivers use segments of the abandoned courses.

Natural Levees

Natural levees are broad, low ridges which flank both sides of streams that periodically overflow their banks. Since the coarsest and greatest quantities of sediment are deposited closest to the stream channels, the natural levees are highest and thickest in these areas and gradually thin away from the channels.

The largest and most widespread natural levees in the Yazoo Basin occur along the present course and abandoned courses of the Mississippi River. They attain crest heights of 10 to 15 feet above the adjacent backswamp elevation and may be as much as two miles in width. Typical natural levee deposits consist of stiff to hard, light tan to grayish-brown silts and silty clays. They are usually well drained and because of their height were the first areas that were inhabited and cultivated within the Delta.

Alluvial Aprons

Alluvial aprons are broad, gently sloping features composed of both alluvial and colluvial deposits that concentrate at the base of the valley walls. Typically, symmetrical alluvial fans are present at the mouths of streams that drain the uplands. When the streams are closely spaced, the fans coalesce to form the alluvial aprons. When the streams are widely spaced, the fans are separated and the intervening portions of the aprons are less well developed and composed mainly of sediments introduced from the uplands.

These aprons occur at the base of the valley wall from Memphis to Vicksburg. They are well developed at the points where streams, such as the Tallahatchie River, discharge from the uplands and have constructed large alluvial fans. Because of the extent and close proximity of the Loess Bluffs, the aprons are mostly composed of silt with lesser amounts of clay and fine sand. Occasional gravel and large rock masses are present where Pleistocene and Tertiary formations are exposed nearby in the uplands. The apron deposits are generally fairly high with respect to the remainder of the Delta and are well drained.

YAZOO BASIN DEVELOPMENT

Early Exploration and Settlement

Desoto, the first white man to enter the region, observed the Mississippi in flood. He recorded that flooding began about the 10th of March, 1543, and that the river returned to its banks by the end of May, having been in flood for about eighty days. The Indians who lived along the river's banks and within the basin climbed into their huts built on stilts or traveled to higher ground until the flood subsided. Long after the Mississippi had returned to its channel, floodwaters remained ponded in numerous low areas within the poorly drained Yazoo Delta. Because of this the early explorers and naturalists characterized most of the Delta as swamp and in many places to be impenetrable.

As late as the 1830's the only means of travel within the Delta was along the rivers and bayous that drained the area and along a few Indian trails open during the dry season. But the early travelers also recognized its great agricultural potential if properly drained and protected from flooding.

The Yazoo Delta's early settlers took the higher lands immediately adjacent to the rivers. The natural levees bordering the Mississippi were taken first because of their immediate availability to the river commerce. Later arrivers settled along the natural levees of the Yazoo Delta streams. Settlement thus concentrated along the strips of natural levees separated by low-lying swamp lands. Because of the higher elevation of the natural levees and because floodwaters were allowed to spread throughout and be temporarily stored in the lower areas, the lands of the earlier settlers were only inundated by the larger floods and then to depths of only a few inches. Therefore, low embankments along the edge of the river with wings or lateral banks running back into the swamp afforded ample protection. Gradually as more and more floodwaters were confined between these small levee systems it became apparent that where once levees three feet high did a reasonable job in protecting against flood flow, flood stages were now so high that heights of six to nine feet were needed to do a comparable job. Eventually the levees lengthened and increased in size. Where the levee of 1882 was about an average height of 9 feet with a cross-sectional area of 300 square feet, levees at the present time are about 30 feet high and 5000 square feet in cross section, on the average.

An important change in the storage and drainage characteristics of the Yazoo Basin occurred with the construction of levee embankments along the Mississippi River. Prior to levees, the basin carried and temporarily stored a large flood overflow from the Mississippi of over 500,000 c.f.s. with a large percentage of the overflow being carried by the Yazoo and Sunflower systems. Both river systems were actually distributaries of the Mississippi and the basin itself functioned as a reservoir for floodwaters.

The Yazoo River system was originally connected to the Mississippi by an outlet called Yazoo Pass located about ten miles below Helena, Arkansas. The pass connected with the Coldwater River which was tributary to the Tallahatchie. The Tallahatchie combined with the Yalobusha to form the Yazoo. There were numerous other outlets feeding into the basin from the Mississippi whose channels beds varied from 5 to 15 feet below the top bank elevation of the Mississippi. As the stage of the Mississippi rose to these outlet levels, overflow began to pass into the basin. The Yazoo River acted as the primary collector whose volume was progressively increased by the contribution of a system of large swamp drains and bayous. The Big Sunflower, Deer Creek, and Steele Bayou were the principal ones. This volume was returned by the Yazoo to the Mississippi above Vicksburg.

When floods reached overbank proportions, the overflow from the St. Francis Basin and the Mississippi River would enter the Yazoo Basin between Memphis and Commerce Cutoff near Helena and move through slowly as a large wave re-entering the Mississippi between the present Cottonwood Bar and Vicksburg.

Yazoo Pass was closed by a levee section about 1852. The entire Yazoo Basin front was leveed by 1858, but the flood of that same year overtopped and destroyed much of the levee line. Although levees were not immediately successful, they became more efficient during the late 1800's and early 1900's. Since the 1927 flood, the Yazoo Front levees have not been breached or overtopped. Thus, following the construction of levees, the Yazoo Basin ceased to function as a flood storage reservoir, and its river systems became tributaries to the Mississippi instead of distributaries. They are now required to carry only local runoff as Mississippi River floodwaters are now confined between levee embankments. The channels of the Yazoo and Sunflower systems gradually decreased in size except for the hill tributaries which drain the uplands (Yalobusha, Yocona, Little Tallahatchie, etc.). The hill tributaries had never been subjected to overflows and were sized according to the local runoff they had always carried. As the Delta streams gradually decreased in size, the flood volume from the hill line streams had not. These floods were becoming increasingly more serious due to the decrease in capacity of the Yazoo River and the worsening Mississippi River backwater. Although flood flows were contained between levees, backwater effects were now extending up the tributaries of the Mississippi since the flood stages between levees were now 10 to 15 feet above top bank. Another factor in the worsening Yazoo Delta backwater problem is the fact that its drainage surface is at a slightly lower elevation than the Mississippi. This causes backwater effects to be felt a considerable distance upstream on the tributaries.

Early Navigation in the Yazoo Basin

The Yazoo Delta was settled and developed as part of the expanding cotton empire during the quarter of a century before the Civil War. It was slow to develop compared to other areas of the south because of the dense forest and underbrush, flood and drainage problems, and lack of transportation facilities to handle bulk cargo.

The early plantations were located along the banks of the Mississippi and Yazoo rivers because of the rich soils of the elevated natural levees but also because the streams were the only transportation outlets in the early days. Railroads had not been developed and roads were impassable during long periods of the year.

The Yazoo River system began to grow in importance as the speed and service of the river steamers improved. Before Yazoo Pass was closed the Coldwater-Tallahatchie-Yazoo river system was the direct route from Memphis to Yazoo City, Mississippi during high water. At high water the steamboats could leave the Mississippi at Yazoo Pass and float across the submerged bottoms to the Coldwater River. Once there they could proceed down the Tallahatchie to its confluence with the Yalobusha and follow the Yazoo River past Greenwood and Yazoo City, rejoining the Mississippi again at Vicksburg.

Even after Yazoo Pass was closed during the 1850's the Yazoo River system was the only transportation link the Delta settlements had with the Mississippi River. Humphreys and Abbot (1861) furnish the following description of the Yazoo River navigation system as follows:

> "...At its high stage it is navigable for steamboats drawing 5 or 6 feet of water, as far as Panola, on the Tallahatchie River, and as far as Grenada, on the Yallabusha River. It is navigable for boats drawing from 2 to 3 feet water, as far as Greenwood, a distance of 240 miles, at all seasons of the year..."

By the 1880's steamboat navigation was on the decline. The building of more and better railroads was certainly a primary reason for the decline of river navigation in the Delta but equally effective was the increased efficiency of the main line Mississippi River levees. As more and more overflow was prevented from entering the basin the Delta river systems were caused to decrease their cross-sectional areas by constructing terraces within the confines of their top banks and by a general overall filling of the channels with farmland sediment. Due to drastically decreased flood flows, vegetation was permitted to encroach more into the channel further choking it and retarding flow. The following extract from a letter, dated June 1, 1914, to Capt. Ernest Grave from a citizens committee of Grenada, Mississippi concerning navigation of the Yalobusha exemplifies the problem:

> "...That in former times Grenada was the port of distribution for all this section of the country, and that parts of Tallahatchie, all of Yalobusha, parts of Calhoun, Webster, northern Montgomery, northern Carroll, and Grenada counties were supplied almost exclusively with this commerce in the early days of the country from merchandise brought to Grenada by boats from New Orleans and Vicksburg and distributed from here, and that as many as thirty and forty thousand bales of cotton annually went out of the Yalobusha bound for New Orleans and Vicksburg markets; that as many as 12 steamboats at one time were tied up at the Wharves

at Grenada, loading and unloading their cargoes and that one steamboat by the name of Unicorn cleared from Grenada bound for New Orleans with 2,400 bales of cotton on board; that with the channel of the river free of obstructions the stream would afford better navigation now than in the past by reason of the fact that it is more canal-like on account of the large deposits of silt that have formed on its bank. . ."

During the late 1800's and early 1900's some clearing and snagging work was accomplished by the Corps of Engineers but navigation never has returned to what it was in the early years of settlement.

UPPER VALLEY EROSION AND SEDIMENTATION

There are two areas of the Yazoo Basin which have had much more severe erosion problems than any other. These areas are the North Central Hills and the Loess Bluffs.

The early settlers in the area often chose the loessial hills for homesites because such sites were well above the floods of the Yazoo Delta and were large, undissected flats which could be used for farming. Clearing the timber from the flats and cultivating them, immediately subjected the loess hill country to excessive erosion and within an undetermined but very short period, erosion on a massive scale radically changed the topography of the area. The inflow of sediment into the creeks and rivers over a relatively short period of time must have caused significant changes in channel capacity and the rate of growth of alluvial fans at the base of the bluffs.

Farming has all but ceased in the Loess Bluffs but increased occupation, grading for roads, subdivisions and commercial sites continually expose soil to erosive forces. Perhaps the most serious activity is the exploitation of the sand and gravel deposits which often lie beneath the loess. This produces a serious effect on the rates of erosion, and in turn, on sedimentation within the bluffs and in the Yazoo Delta flatland downstream.

The North Central Hills have had a very similar history and where valley sedimentation is associated with culturally accelerated soil erosion. This fact was recognized as early as the 1860's about 20 years after the initial settlement of the country when land clearing and farming caused erosion of the silty upland soils and gullying of the underlying Coastal Plain sedimentary formations which are mostly sand.

The eroded material was washed into the valleys and covered the original floodplains with several feet of sediment deposits.

Happ (1968) describes the characteristics of these deposits, sometimes referred to as post-settlement deposition, as follows:

> "In headwater sections of the valleys, a dark soil horizon was commonly found buried a few feet beneath lighter colored, brownish, usually sandy and often clearly stratified sediment. The buried dark soil could be traced laterally into obvious continuity with surface soils of the valley sides. Farther down the valleys the buried dark soils were discontinuous or less conspicuous, but contrasting pale colors and abundant small hard concretions were commonly found at depths consistent with underlying old subsoils found where the dark topsoil was recognizable."

This criteria was used to approximate the thickness of modern floodplain sediment. In rare instances as much as 10 feet was identified, but in most places there was less than 5 feet. The average was only 3.5 feet.

A 1937 survey of the Toby Tubby--Hurricane Creek system showed the modern deposits to be about 55 percent silt, 30 percent sand, and 15 percent clay. Both creeks are tributary to the Little Tallahatchie River at the upper end of Sardis Reservoir. The greater part of the sediment had accumulated in the upper sections of the valleys, mostly in local concentrations on alluvial fans at mouths of tributaries and in areas upstream from completely filled segments of stream channels. The channel filling forced all flow overbank causing extensive deposition on the surrounding floodplain. Some "valley plugs" had formed at sections downstream of artificially straightened channel segments and some formed on large alluvial fans at tributary mouths. Still others had formed in natural channels where no outside influences were apparent.

The sediment deposits thin in a downstream direction continuing to the Tallahatchie floodplain where the deposits were about one foot thick, on the average (Happ, 1968).

THE BEGINNING OF FLOOD CONTROL AND NAVIGATION PROJECTS

The Yazoo Delta portion of the basin can be divided into three sub-basins: (1) the Coldwater-Tallahatchie-Yazoo drainage system on the north and east, (2) the Steele's Bayou drainage area lying adjacent to the Mississippi River, and (3) the Sunflower River drainage system lying between the other two. The divider separating the sub-basins is the remains of natural levee deposits of abandoned ancient river courses of the Mississippi River. They are low elevation ridges, poorly defined in many places, and are cut across at several points by secondary streams of the Delta.

Before settlement of the basin the flood discharges of the Coldwater-Tallahatchie-Yazoo system would overflow into the Sunflower River sub-basin through Yazoo Pass, Cassidy Bayou, Quiver River and through Silver and Panther creeks. The Sunflower system served as a temporary storage reservoir and also passed a quantity of the floodwater through its system to the Yazoo River at a point just above Vicksburg, Mississippi. This function was essentially the same as a floodway which bypasses a main system. Before the Mississippi River levees prevented overflow into the Yazoo Delta area the Sunflower and Steele's Bayou systems would receive Mississippi River overflow which would, in turn, flow into the Coldwater-Tallahatchie-Yazoo system through the same secondary, connecting streams. Depending on which sub-basin was flooding, flow through the secondary streams could occur in either direction.

Most of the interconnecting bayous and creeks were eventually closed by various types of dams with the hope of preventing flooding or improving navigation. While closing off outlets or constructing diversions may alleviate flooding in one area, it usually resulted in a worsened condition elsewhere.

The involvement of the Federal Government in the development of the Yazoo Basin began in 1879, the same year the Mississippi River Commission was established. The original project was authorized by a River and Harbor Act approved in 1879. The work consisted mainly of surveying and mapping various streams and recommending particular streams or reaches of streams for navigation improvement. The improvement for navigation involved clearing leaning trees, removal of snags and sunken wrecks. Many steamboats were sunk or scuttled by opposing forces during the Civil War and had remained a hinderance to navigation. This work was mostly completed during the next several years.

There was not much Federal participation during the 1890's and the early 1900's. Practically all the emphasis by the Federal Government was turned toward the construction of main line levees along the Mississippi River in an effort to prevent Mississippi River overflow from the Yazoo Basin and other basins in the Lower Mississippi Valley. In some instances the Federal Government did not necessarily feel further work was justified and rightly so. The basin was a sparsely populated area and expensive projects would have benefited only a few.

During the time period from shortly after 1900 to the 1930's drainage districts were responsible for most of the drainage and flood control works in the basin. Their purpose appears to have been to appropriate funds and formulate plans for draining or protecting, by some method, the area encompassed by their respective districts. No thought seems to have been given to the effects of their projects on other areas. The ensuing problems from erosion and deposition of sediment were completely overlooked.

Following the 1927 flood in the Lower Mississippi Valley, the main line levees along the Mississippi River were raised and strengthened. Since that time, the only flooding from the Mississippi River has been from backwater effects. Although backwater flooding could be extensive, especially in the lower Yazoo Delta, it was also becoming apparent that headwater flooding, mainly from the hill tributaries was a severe problem. Headwater flooding in the upper Yazoo Delta resulted directly from heavy precipitation in the hill areas draining into the Delta streams at a much more rapid rate than these streams could carry such floods to the Mississippi. The principal flood area was the hills north and east of Greenwood, Mississippi drained by the Coldwater, Little Tallahatchie, Yocona, and Yalobusha rivers. Flood flows from the Delta area alone were capable of filling streams to near capacity and may have produced some slight local flooding, but in themselves could not produce the destructive general flooding throughout the basin. Flooding in the Delta had been further aggravated by the decrease in channel capacity of the Coldwater-Tallahatchie-Yazoo river system which was not adequate to pass even minor flood flows from the hills. This decrease in channel capacity was a direct result of the main line levee system preventing Mississippi River overflow from reaching the Delta streams. Under natural conditions they had been sized to carry a portion of these flows.

Authorization for Federal Projects after 1900

There is probably a long list of River and Harbor Acts, Flood Control Acts, Public Laws, etc., beginning in 1879, that have authorized various surveys, investigations, and channel work projects in the Yazoo Basin. Most of the authorizations were later amended to include more territory when it was realized that the problem area was more extensive than originally anticipated. A summary of the authorized projects for the Yazoo Basin follows:

1. The Mississippi River and Tributaries Project was authorized by the Flood Control Act approved 15 May 1928. It includes several projects in the Yazoo Basin, as amended and described below:

(a) Yazoo Headwater Project. Authority covering flood control in the Yazoo Basin was initially contained in two public laws approved by Congress on 15 June 1936 and 28 August 1937. The function of any proposed plan was limited to the control of headwater floods and the methods to be used (reservoir, levees, floodways, auxiliary channels, etc.) was left to the discretion of the Chief of Engineers.

The plan of flood control consisted of (a) a system of seven detention reservoirs on the hill tributaries and (b) a levee along the east bank of the Yazoo River from the vicinity of Morgan City to the vicinity of Eden and a hillside floodway from the Bee Lake to the exit of Abiaca Creek from the hills. The locations of the seven reservoirs were as follows: (1) Coldwater and Arkabutla reservoirs on the Coldwater River; (2) Sardis Reservoir on the Little Tallahatchie River; (3) Enid Reservoir on the Yocona River; (4) Coffeeville, Grenada and Holcomb reservoirs on the Yalobusha River.

The proposed plan was supposed to provide essentially complete protection to the greater portion of the area subject to headwater overflow.

The original plan involving seven reservoirs was superceded in 1941 a "four reservoir plan" endorsed by the Chief of Engineers on 4 August 1941. The four reservoirs proposed were (1) Arkabutla

Reservoir on the Coldwater River; (2) Sardis Reservoir on the Little Tallahatchie River; (3) Enid Reservoir on the Yocona River; (4) Grenada Reservoir on the Yalobusha River. Other work included cutoffs, channel clearing and enlargement, levee construction, and two auxiliary channels.

The headwater project was amended by the Flood Control Act of 1946. This act provided for an extension of the authorized headwater project to include improvements in the area between the Yazoo-Tallahatchie-Coldwater River System and the hills (valley wall) to protect against overflow from the main stem and hill tributaries in such cases and by such means as deemed necessary by the Chief of Engineers.

(b) Yazoo Backwater Project. This project was authorized by the Flood Control Act approved 18 August 1941. Its function is to prevent flooding of the extreme lower portion of the Yazoo Delta by a levee line along the Yazoo River. The project includes about 97.5 miles of levees, a connecting channel about 25 miles long, and several drainage structures.

(c) The Big Sunflower River and Tributaries Project. This project was authorized by the River and Harbor Act of 22 December 1944, as amended. The purpose is to control floods originating within the Sunflower River Basin. The project area includes approximately 4100 square miles of alluvial lands and about 725 miles of stream channel improvement.

2. The Yazoo River Navigation Project. This project was authorized by the River and Harbor Act of 1968. It is to provide a dependable 9-foot navigation channel to Greenwood, Mississippi. The project consists of a lock and dam near Vicksburg, channel realignment and dredging, and additional storage in Sardis Lake.

EARLY PROJECTS AND PROBLEMS

There has been much artificial change in the Yazoo Basin since the original project was adopted in 1879. A considerable amount of the work was done by drainage districts and other private groups, particularly from about 1900 to the 1930's. There is very little information published on these projects and their effects on the river systems involved. Information on a few of these early works has been found in the correspondence of the Vicksburg District, Corps of Engineers, covering the approximate same time period. Most of the information is scattered and is not complete on any one project but considering all the information together, a general picture of the problems in the basin evolves. The resulting problems can be easily appreciated when considering the geology and soils of the hill drainage area compared to the flat delta plain.

Coldwater-Tallahatchie River System

Before the construction of the Mississippi River levees, the Tallahatchie River had a high water connection with the Mississippi River opposite Helena, Arkansas, through Yazoo Pass and the Coldwater River. In its original condition the Tallahatchie River was navigable during high stages for all traffic to Sharkey, about 65 miles above its mouth, but passage was difficult and dangerous on account of wrecks and snags in the channel and leaning trees along the banks. The channel varied from 70 to 400 feet in width, with a minimum usable low-water depth of one foot. Because of similar obstructions the Tallahatchie above Sharkey and the Coldwater River were not navigable.

The early concern about the Tallahatchie and Coldwater rivers was the lack of year-around navigation depths. The project approved by the

River and Harbor Act of 3 March 1879 provided appropriations for clearing and snagging work and was completed on the Tallahatchie in 1892. Work on the Coldwater was stopped in 1881 but was resumed again under a provision of the River and Harbor Act of 3 March 1905.

Attention was focused on flood control and drainage after the turn of the century. The Tallahatchie Drainage Commission was created by a special act of the state legislature in 1908 and was dissolved in 1912 by repeal of the same act. While the Commission was effective it proposed four separate plans for flood control. The plans were as described below:

1. Bypass Plan. This plan involved clearing and some enlargement of the Tallahatchie and Coldwater rivers, clearing the secondary waterways to the east, making some cutoffs, and providing high-water bypasses controlled by headworks at certain bendways in the two main streams.

2. Floodway Plan. Drainage from the hill area was to be conveyed through a broad floodway between levees down the eastern part of the Delta, with storage reservoirs to restrain the peak of large floods.

3. Diversion Plan. The Coldwater River was to be diverted up Hurricane Creek across a divide into Johnson Creek and then northward to Horn Lake, an oxbow on the eastern side of the Mississippi River. The Tallahatchie and Yocona rivers were to be controlled as in the floodway plan.

4. Diversion-Retarding Basin Plan. This plan proposed to supplement the diversion plan by retarding basins in the hill valleys of the Tallahatchie and Yocona rivers.

A report of a study by the Morgan Engineering Co., dated 15 April 1914, who investigated both the "floodway" and "diversion" plan proposed another diversion plan consisting of two basic parts:

1. Control of high discharges of the Coldwater River by a retarding basin located a short distance above the point where the river leaves the hills.

2. Clearing of the Delta segment of the Coldwater River and other natural channels and the construction of supplementary channels to carry part of the floodwater.

The Elliott and Harmon Engineering Co. plan was submitted in 1920. It was called the "New River Plan" and contemplated controlling the high discharge of all hill streams flowing into the Delta from the Coldwater River southward to Tcheva Creek, by a floodway down the eastern edge of the Delta from the Coldwater to the limits of the Mississippi River backwater in the Yazoo River.

Section 12 of the River and Harbor Act of 22 September 1922, authorized and directed surveys to be made at the localities of the Tallahatchie and Coldwater rivers. The purpose was to devise plans for flood protection and to determine the extent to which the United States should cooperate with the state in carrying out such plans with its share being based on the value of protection to navigation.

In 1923 the Corps of Engineers recommended a combination of the "New River Plan" and the retarding basin principle, that is, the floodway would be used both as a carrier of floodwater but also as a retarding basin carrying a portion of the higher flows and allowing the Delta streams to carry what they could so as not to injure navigation.

By 1923 while the Federal Government was beginning to get more involved in the Yazoo Basin, at least on a survey and planning basis, the drainage districts had long been at work.

The Pritchard Drainage District had constructed a levee on the right bank of the Coldwater, beginning near the mouth of Buck Island

Bayou and extending about 3 miles downstream. The Indian Creek Drainage District had built an 11-mile levee from the Coldwater, below the head of David Bayou, to the river again at a point 40 miles downstream, then along the river a farther distance of 2 miles. A canal had been excavated on the west of the levee, from river to river. The Sledge Bayou District had constructed a levee down the east bank of the Coldwater from the vicinity of Marks to the mouth of the river. The Marks District had dammed the head of Cassidy Bayou and the Newsum Lake District had leveed the west bank of the Coldwater and Tallahatchie from a point 4 miles below the town of Marks to within 7 miles of Tillatoba Creek.

The Panola-Quitman Drainage District had plans to construct a levee beginning at the valley wall above where the Little Tallahatchie River enters the Delta and extending southward, crossing the Little Tallahatchie and Yocona rivers, to the Tallahatchie River a short distance above the mouth of Tillatoba Creek. A canal was planned to run parallel to the levee about one-half mile east of it, from the Yocona to Tillatoba Creek. This levee and canal system became what is known as the Panola-Quitman Floodway.

By the 1950's reservoirs on the Coldwater (Arkabutla Reservoir), Little Tallahatchie (Sardis Reservoir), and the Yocona (Enid Reservoir) had been completed. The Panola-Quitman Floodway had bypassed most of the Tallahatchie River and was carrying the combined discharges of the Little Tallahatchie and Yocona rivers to a point near where Tillatoba Creek emptied into the Tallahatchie. Cutoffs were made on Coldwater, Tallahatchie, Yocona, and Little Tallahatchie rivers. The segment of Tillatoba Creek crossing the Delta was straightened to such an extent that it was more of a canal than a natural drainage creek.

As a result of reservoir construction and cutoffs a tremendous volume of sediment was eroded from the channel bottom and banks of the Little Tallahatchie and Yocona rivers and transported downstream to the Panola-Quitman Floodway. Because of the much flatter slope through the floodway channel the sediment deposited in the channel completely filling a segment of it. The result was that the flow took up along the line of borrow pits adjacent to the west levee line. A breach occurred at one point in the levee line near the upstream end of the floodway. Conditions such as the above have caused a considerable amount of money to be spent on maintaining the system with the severest problems occurring on the Panola-Quitman Floodway and the segment of the Tallahatchie River just below where the floodway empties into it.

An overall description of the conditions existing in the Coldwater-Tallahatchie River System is contained in field trip reports of inspection trips made from 26 June to 11 July 1950 and during June, 1954.

Coldwater River (26 June to 11 July 1950)

An inspection of the Coldwater River from Arkabutla Dam to its mouth revealed that the channel was in good condition overall. Only two reaches were showing any problems and these were in areas where cutoffs had been made.

The banks from mile 329.4 to mile 326.5 (lower end of Pompey Ditch) had numerous caving pockets. On the left bank some of the pockets had caved to within 10 feet of the levee. This problem area was at Coon Bayou Cutoff.

The reach from the mouth of the Coldwater and upstream about 4 miles through existing cutoffs was in very bad condition. There were numerous snags and overhanging trees in the channel.

Tallahatchie River (26 June to 11 July 1950)

The worst conditions found on the Tallahatchie were from the mouth of the Panola-Quitman Floodway (mile 274.8) to Swan Lake (mile 257.6). A considerable amount of bank caving had occurred causing numerous trees to slide into the channel. A number of small drifts had collected on trees, snags, and overhanging limbs.

The other reaches of river from the Camel White Bridge (mile 301.9) to the mouth (mile 188.1) contained a number of snags, fallen trees, and logs but no pronounced bank caving had occurred.

Little Tallahatchie River (26 June to 11 July 1950)

The reach from Sardis Dam (mile 322.8) to Porter's Ferry Bridge (mile 298.3) had very unstable banks and was constantly enlarging its cross section. A large number of trees and snags were in the channel.

From Porter's Ferry Bridge to the mouth of the Yocona River (mile 287.7) was in very poor condition particularly the upper reach of the Panola-Quitman Floodway. The center channel of the floodway from mile 291.6 to mile 291.1 was completely filled with sand and drift. The water was flowing overbank through the woods in order to bypass the obstruction. The lower one-half mile of reach (mile 288.2 to 287.7) was completely filled with sand and debris.

The floodway from the mouth of the Yocona River to the Paducah Wells Bridge (mile 279.0) was in similar condition. The upper 5 miles of this reach was completely filled with logs, drift, and sand. This condition had been remedied three times in the past few years and it was considered futile to try and keep the channel open until after Enid Dam on the Yocona River was completed.

The reach from Paducah Wells Bridge to the mouth (mile 274.8) was in fair condition but bank caving was apparent in numerous locations and had caused trees to fall in the channel.

Tallahatchie River (June, 1954)

During June, 1954, an inspection of the Tallahatchie River showed that the only problem area was that reach just below the mouth of the Panola-Quitman Floodway. For a distance of about 3.5 miles below the mouth of the floodway the channel was in the process of enlarging with active caving over practically the entire reach. There were many trees in the channel along the banklines. For the next 8 miles the banks were slowly receding but approaching a state of stability as there were many older slide areas evident but only intermittent recent slides.

Cassidy Bayou

This stream lies between the Coldwater-Tallahatchie River System on the east and the Big Sunflower River on the west. Its source is in Moores Bayou, Quitman County, Mississippi. Cassidy Bayou enters the Tallahatchie River one-half mile below Sharkey Landing and its length is about 80 miles.

Under the River and Harbor Act of 5 August 1886, an examination was made by Captain Willard of the Corps of Engineers who reported that the bayou had been cleared in 1860 by plantation owners and that the stream was worthy of improvement for navigation.

By an act of the State Legislature, approved 18 March 1886, a charter was granted the "Cassity Lock and Dam Company" giving exclusive right to improve and navigate Cassity Bayou for 30 years. Section 5 of the act declared the stream to be navigable and the said corporation to be a common carrier. Section 7 provided that the charter was subject to forfeiture upon failure of the corporation to commence work within 5 years.

Yalobusha River

Before regulation the Yalobusha River at high stages would discharge its overflow onto the flat alluvial lands and a large storage area adjacent to the hills provided a natural regulation of this flow which greatly reduced the peak flow of the Yalobusha into the Yazoo River.

The original condition of the river was such that navigation was possible at high stages to Grenada, and before the construction of a railroad bridge across the river at Grenada, navigation was possible up to Graysport about 12 miles upstream from that point. A medium and low stages passage was difficult and dangerous due to snags, stumps, sunken logs and leaning timber. The least available depth during high water was about 25 feet. Since about 1886 or 1887 steamboat traffic declined due not so much to stream conditions as to lack of cargoes favorable to steamboats.

The initial work by the Federal Government on the Yalobusha was sponsored by the River and Harbor Act of March 3, 1881. Previously, during the summer of 1878 the county of Grenada had some clearing along the bankline done. The approved project provided for the removal of leaning timber, wrack heaps and drift, and the most dangerous snags between Grenada and the mouth. The original project was completed in 1884 and maintenance was continued until 1886. From this point in time until 1932 there was no maintenance work on the channel.

An inspection of the stream was made on 26 July 1932. Two large drift jams were found about 2 miles above Whaley, Mississippi, 3 north of Leflore, Mississippi, and several other jams were reported but not inspected. One of jams above Whaley was about 300 feet long and extended entirely across the stream. The drift formations seemed to be caused by leaning timber catching drift brought in by large drainage ditches from sources other than the Yalobusha.

The debris jams were only a small part of the problem which developed on the Yalobusha River. Work by drainage districts on its tributaries caused severe sedimentation problems, especially on two particular tributaries; (1) Topashaw Creek which enters the Yalobusha above the present location of Grenada Dam, and (2) Potacocowa Creek which was not originally a tributary but was artificially connected to the Yalobusha by a diversion canal in the Yazoo Delta.

Topashaw Creek

Topashaw Creek rises in the hills in the western part of Chicasaw County and flows in a northwesterly direction for a distance of about 19 miles to its confluence with the Yalobusha River at a point about 106 miles above the mouth of that stream. The drainage area contains about 112 square miles of rolling to steep hill lands. About 1913 a 14-mile length of canal was excavated along the channel of Topashaw Creek. Immediately after its completion, erosion began to widen and deepen the central and upper sections of the channel. This material was deposited in the Yalobusha River and by 1930 had completely closed the river channel for about 1.2 miles. The fill extended for 0.4 miles above the mouth of Topashaw Creek to 0.8 miles below it. A new channel was excavated to pass Yalobusha River flow around the filled section and to provide a new outlet for Topashaw Canal. Upon completion of this bypass canal it also filled with sand and debris and consequently water remained ponded in the Yalobusha for a distance of about 6 miles upstream.

An interconnecting system of small natural drains was able to pass small flows around the filled section but discharges exceeding the capacity of these natural drains spilled over the top banks and bypassed the main channel as overbank flow. It occurred so frequently that it rendered a large area unsuitable for agriculture.

Potacocowa Creek

This creek rises in the hills in the northern part of Carroll County, Mississippi, and flows northwest for about 12 miles to its exit from the hills and then west for about 3 miles to its confluence with the old channel of the Yalobusha River. The creek has a drainage area of approximately 60 square miles, most of which is rugged hill land. Loess, fine silty clay, fine silty loam, and fine sandy loam soils are all present and can be severely eroded by the high velocities resulting from steep gradients in the watershed. Consequently, the hill segment of the creek is capable of transporting large volumes of sediment.

Prior to the organization of the Potacocowa Drainage District in 1917, flood flows from the steep hill portion of Potacocowa Creek watershed brought enormous quantities of sand and silt to the Delta section of the stream. This material obliterated the channel below the hill line and formed an alluvial fan having an area of several square miles at the exit of the creek from the hills. The stream, in seeking the steepest slope over the fan, frequently changed its course and flood flows spread over the alluvial valley lands adjacent to the old creek bed, rendering them unsuitable for profitable cultivation.

Before drainage district works made Potacocowa Creek a tributary to the Yalobusha River its entire flow was directed into a swamp area at the base of the valley wall and just south of its exit from the hills. The swamp acted as a storage reservoir and would probably release excess water slowly through numerous natural drains.

In 1921 or 1922 the taxpayers issued bonds and constructed the Potacocowa Drainage Canal. A silting basin, consisting of parallel levees spaced about 1000 feet apart, was constructed over the alluvial fan from the hills to a point about 1000 feet above the Yazoo and Mississppi Valley Railroad. From this point a diversion channel was excavated to Deer Lick Creek at a point 500 feet from its confluence with the Yalobusha River. This essentially made Potacocowa Creek tributary to the Yalobusha River.

About 1927 flood flows caused a crevasse to form in the north levee of the silting basin near its junction with the hills. Flow through the crevasse entered the borrow pit which had been excavated purposely on the landside of the levee so as to prevent formation of a channel in the silting basin. The steep slope through the borrow pit, about 10 feet per mile, produced high velocities and the concentrated flow soon eroded a large, deep channel through the alluvial fan. In a short time erosion in the borrow pit channel crevassed the north levee a distance downstream just above the Y. and M. V. Railroad and permitted the flow to enter the head of the channel excavated by the drainage district, thus diverting the flow around the silting basin.

Sediment from the hills and the eroded alluvial fan area was continually deposited in the Yalobusha River at the canal mouth. The deposits would cause a sandbar to form but this would be moved out as the river stage fell.

During December of 1932 very heavy rainfall occurred over the Potacocowa Creek watershed. Sediment transported by the creek completely filled the channel of the Yalobusha River at and above the mouth of the canal (Deer Lick Creek) as shown in Figure 2.

After this filling occurred, the normal flow of the Yalobusha River was bypassed through the interconnecting system of bayous and lakes northwest of the filled section into McIntyre Lake and then through Little Tippo Bayou into the open channel of the Yalobusha River just above Whaley, Mississippi (Figure 3). Flooding occurred above the filled section of the Yalobusha River after every storm of any magnitude over the upper Yalobusha River Basin and backwater during the dry season adversely affected the drainage of large areas in the Tippo and Yalobusha basins above the filled channel. It was estimated that due to the fill the head was raised about 4 feet. The sediment closing off the channel consisted mainly of sand and was matted for a probable depth of 15 feet with drift. The deposit of sand and drift material extended about 1000 feet above the mouth to about 6700 feet below it.

It was first thought that by opening up a pilot cut through the filled section above the creek and by turning the outlet of the creek (canal) downstream that the flow of the Yalobusha would cut off the plug. This was done but the pilot cut was quickly filled by sediment from the creek.

Measurements made during a field investigation in 1936 showed that about 1500 c.f.s. was being carried by the Yalobusha River just below the mouth of Potacocowa Creek Canal. About 6100 c.f.s. that would normally pass down the Yalobusha was being conveyed through McIntyre Lake and the interlacing system of lakes and bayous west of the mouth of the creek.

The Corps of Engineers believed that relief could only be obtained by the construction of a cutoff in the vicinity of the mouth of Potacocowa Creek. In 1939 the Government began constructing a cutoff to bypass the filled section of river. This was Avalon Cutoff and it bypassed a lengthy segment of the river.. Following the cutoff the old bendway quickly filled up further with sediment and debris. Flow through the river was resumed but flow through the canal spread out over the surrounding land. A new junction of the canal with the old bendway was eventually made downstream at some later date.

After the construction of Grenada Dam and Reservoir was completed in 1953, degradation below the dam was causing considerable bank caving. The input of large quantities of sediment into the channel resulted in an increase in meandering and further bank caving which lasted several years.

An inspection of the river in July, 1954, found the situation to be one of accelerated meandering but that at some locations channel stability was returning. The most serious reach of bank caving was between miles 42 and 30. Tree retards had been installed in 1953 at eight locations and were said to be effective at all except one location. From the dam, mile 45.5 to mile 42, the banks were fairly stable with only intermittent minor caving. Most of the reach showed that very active caving had occurred earlier. Between miles 20 and 16.5 the banks appeared to be reaching a state of stability. Also in this reach water depths were shallow indicating sediment deposition and shoaling beginning at mile 21 and ending at about mile 17.

By 1958 bank caving was still active in one general reach between miles 25.8 and 27.2. The caving had been intermittently active and dormant for a number of years. As early as 1953 the caving in this vicinity had reached or extended beyond the right-of-way limits. At mile 26.6 the right-of-way was exceeded by about 250 feet.

Drainage District Work on Other Streams

Many other hill streams such as Tillatoba, Ascalmore, Teoc, Big Sand, Pelucia, Abiaca, Chicopa, Farmegusha, Black, and Tcheva creeks were also "improved" by their respective drainage districts with similar results as on Potacocowa Creek.

Local interests attempted to control these principal streams in their Delta segments by constructing improvements under locally organized levee and drainage districts. Their efforts proved futile and in practically all cases they abandoned maintenance and requested assistance from the Corps of Engineers.

The improvements generally consisted of an excavated channel beginning at the hill line and extending downstream flanked on either side by guide levees formed of the excavated materials. The hill segments of each stream had much steeper slopes especially if artificially straightened and could transport large volumes of sediment. The sediment was deposited almost immediately when the flatter Delta area slopes were encountered. In several instances the deposited sediment filled the channels to such an extent that the stream bed became higher than the adjacent lands when assisted by levees. Consequently, the levees would usually crevasse following intensive rainfalls and allow sediment (mostly sand) to be deposited over the lands resulting in excessive flood damages.

Some information was found on several of these hill tributaries which adequately points out the ensuing problems following drainage district work.

Hickahala Creek

Hickahala Creek rises in Marshall County, Mississippi near Chulahoma and flows westerly about 18 miles to the Arkabutla Reservoir boundary. The drainage area above the reservoir is about 120 square miles. The stream slope varies from about 4 to 6 feet per mile.

The Hickahala Drainage District was organized in 1916 for the purpose of increasing the capacity by straightening and deepening of Hickahala Creek for passage of floodwaters and drainage of bottom lands. Immediately following construction the improvements became effective due to erosion of the channel bed but the enlargement was soon followed by sedimentation. Prior to 1939 the main canal filled from the Coldwater River upstream to within one-half mile of the Illinois Central Railroad and was ineffective for drainage purposes. The channel continued to fill progressively upstream and by 1949 the channel above the reservoir boundary varied in depth from 3 to 7 feet averaging about 9 feet of fill above the original design grade. There were areas of practically no drainage and the general area had become a major health problem regarding malaria according to state health authorities.

Local interests alleged that the operation of Arkabutla Reservoir caused the deterioration of the canal even though considerable fill occurred before reservoir completion in 1942. The Corps of Engineers stated that the channel bottom at reservoir limits was 240 feet m.s.l. at the time of completion in 1942 and that the highest reservoir stage to 1949 was 235.92 feet m.s.l.

Pidgeon Roost Creek

Pidgeon Roost Creek rises in Marshall County near Holly Springs, Mississippi and flows in a northeasterly direction for about 28 miles to its confluence (1936 outlet) with the Coldwater River about 6 miles above the boundary of Arkabutla Reservoir. Its drainage area is about 225 square miles practically all of which is rolling-hill land. The channel slope varies from 2.8 feet per mile in the lower reaches to about 10 feet per mile in the upper reaches.

The drainage district was organized in 1927 for the purpose of providing better agricultural drainage. The canal proved inadequate because the lower segment filled with sediment. It became necessary to excavate a second outlet in 1936 and a third in 1947. The drainage district expected that the third outlet would induce scour and enlarge the canal but observations by the Corps of Engineers in 1949 showed that it too had begun to deteriorate.

Abiaca Floodway

Abiaca Floodway was constructed sometime prior to 1938 by the Abiaca Drainage District for drainage improvement. Subsequent to the completion of this floodway the old channel of Abiaca Creek was filled to a considerable extent by sediment brought down from the hill area and which, in turn, was responsible for poor drainage of about 5700 acres.

Arkabutla and Strayhorn Creeks

Arkatbutla and Strayhorn creeks have both been canalized by respective drainage districts. Strayhorn Creek Canal discharges into Arkabutla Creek Canal. Because of steep slopes and the velocities in each of these streams the channel size increased considerably over the original excavated cross section. Apparently the canals did not fill because the velocities were high enough to prevent sediment and debris from depositing in the canals. However, fill was occurring in the old bendway channel of the Coldwater River just below the mouth of Arkabutla Canal. The concern of the drainage district was that the fill would eventually impair the canal outlet efficiency.

Levee Damage along Floodways

By 1949 the floodways constructed on these streams were rapidly becoming inadequate to carry anything but minor flows. The channels had filled to an extent that flows were taking up courses along the line of levee material borrow pits. This in turn was causing scour of the levee and ultimately the formation of crevasses.

Pelucia Creek had reached the point where ordinary repairs to the levees were not possible but required a levee setback over a mile in length to be necessary.

On the Panola-Quitman Floodway caving and scour damage of levees was very active at numerous locations. Flow through the floodway was being maintained for longer periods of time due to the emptying of Sardis Reservoir. The west levee had already crevassed below the latitude of Crowder, Mississippi because of scour in the west borrow pit area.

Heavy rainfall in the vicinity of Greenwood, Mississippi on the night of 20 February 1953 caused severe damage to the locally constructed levees along Teoc, Big Sand, Pelucia, and Abiaca creeks.

The rainfall which occurred over the Yazoo Basin on 20-21 March 1955 caused severe damage to the levees along Ascalmore, Potacocowa, Teoc, Big Sand, Pelucia, and Abiaca creeks. Ascalmore, Potacocowa, and Big Sand creeks all had five crevasses each. Teoc Creek had one crevasse on each bank. Pelucia Creek had one crevasse 500 feet long in the right bank plus severe damage along both banks above and below the crevasse.

Sunflower River System

The Sunflower River differs from other streams in the Yazoo Basin. It lies almost completely in an ancient abandoned meander course of the

Mississippi River, and is not fed by tributary streams gathering rainfall over higher elevated territory. None of the principal tributaries come from higher watersheds, but like the Big Sunflower itself, formerly carried surplus overflow of the adjacent rivers and now derive their supply from groundwater coming in as seepage from springs, and from the drainage improvements constructed by the many drainage districts. For this reason the Big Sunflower is not characteristically a muddy stream.

The original project for improvement adopted by the River and Harbor Act approved 3 March 1879, contemplated removing snags, sunken logs, leaning timber, and constructing pile and brush dams (spurs) to scour the channel at the shoals, between Clarksdale and its junction with the Yazoo River. This work was almost completed during the first three or four low water seasons after 1879, but the formation of new obstructions during subsequent years cast doubt on any permanent navigation project.

Further work was authorized by the River and Harbor Act approved 2 March 1907. The act provided for the closure of outlets, the construction of contraction works, and the removal of snags, leaning trees, and other obstructions, from the mouth to Baird, Mississippi. This work was completed in 1912.

The construction of lock and dam no. 1 at Little Callao Landing, 10 miles east of Hollandale, Mississippi authorized by the Act of 25 July 1912, was begun during the early part of the fiscal year 1914 and completed during March, 1918. The lock was 36 feet wide by 160 feet long, with a lift of 16.9 feet and a depth on the miter sill of 5.1 feet at low water. The structure was concrete with wooden lock gates and a movable needle dam. When full, the pool formed by the lock and dam together with open channel work, furnishes a depth of 4.5 feet to Pentecost, Mississippi, 124 miles above the mouth.

The original condition of the lower section of the Big Sunflower (96 miles) from the mouth to Baird, Mississippi was a succession of pools with obstructing sandbars between and many obstructions. The banks were considered to be stable.

From the mouth to lock and dam no. 1 (62.2 miles) the closure of outlets and open channel work improved this reach for navigation. The remains of brush and pile dikes constructed in 1879 were still evident by 1931 throughout this reach. Oliphant Bar (mile 0 to 15) and Muscle Shoals (mile 31 to 36) were the most difficult natural obstructions of this section. They were said to have been materially improved by open channel work and the construction of longitudinal and wing dikes. The average slope of the lower section was about 0.25 feet per mile.

The section above Baird to the mouth of the Huskpuckena River, which was considered to be the head of navigation, has an unusual slope condition and could be considered to have two separate segments with respect to slope. Pentecost (mile 124.5) is a division point between these two segments. Below Pentecost to Baird the slope averages 0.46 feet per mile.

Navigation on the Big Sunflower

Early commerce on the Big Sunflower River began several years prior to 1875. In 1879 navigation was possible the year around, though difficult and dangerous for about six months of each year. During years of unusual high water, boats navigated the river as far upstream as Clarksdale, but during low-water periods, navigation was confined to the lower 125 miles.

Improvements subsequent to 1879 increased the low water navigable depths sufficiently to permit larger boats to navigate the stream and for longer periods. Traffic gradually increased until 1908; it was constant until about 1924. The last peak in volume of traffic occurred in 1925 and 1926. Since that time, traffic began to gradually decline. The decline was primarily due to the development of railroad and overland transportation facilities and the withdrawal of preferential rail freight rates formerly enjoyed by Vicksburg as a river port.

GAGE RECORD ANALYSIS

Specific gage records were plotted from available stage and discharge data at various gagin stations on the Coldwater-Tallahatchie-Yazoo system and its tributaries. The measurements were intermittent at some gages while at others readings had been discontinued. Enough data was available to partially fill-in the picture of the effects of channel works on the regime of various streams and the system.

Little Tallahatchie River

Two gage records are available on the Little Tallahatchie. The first is located at the Belmont Bridge several miles downstream of Sardis Dam. The record is good from 1929 to 1943 but after that only the year 1962 had sufficient measurements for comparison (Figure 4).

The change of regime occurring in the vicinity of this gage was minimal. Only a slight amount of degradation was indicated after storage began in Sardis Reservoir in 1939. The overall effect on the rating curve was a downward shift of about 1 to 1.5 feet. But by the 1960's the rating curve was back up to its 1930 position or maybe a little higher (Figure 5). The upward shift of the rating curve indicates that aggradation was occurring in the channel in the vicinity and downstream of the Belmont Bridge gage location. This followed a short two- or three-year period of scour and degradation from the construction of Sardis Reservoir.

The other gage location is further downstream at Batesville near the river's junction with the Panola-Quitman Floodway. This gage location has a reasonably good record from 1940 to 1973. The specific gage record (Figure 6) shows a trend of degradation commencing about three years after reservoir storage began. During the interim three-year period a moderate filling is indicated (1940-42). This was probably caused by the deposition of material from upstream degradation near the damsite. About 1944 the channel regime in the vicinity of Batesville stabilized and then shortly thereafter began to aggrade. The aggradation continued until about the early 1950's when a gradual trend of degradation commenced and continues at the present time. From 1942 to 1946 the rating curve shifted downward for the lower range of discharges (0 to 8000 c.f.s.) while it remained practically the same for the higher discharges (Figure 7). This would indicate possibly a change in cross-sectional shape of the channel allowing for a deeper low water channel along with a wider channel for higher flows but with more roughness. The maximum drop in stage for a given discharge has been about three feet.

There are several possible reasons for the regime behavior of the Little Tallahatchie. The most obvious cause of degradation during the early 1940's was the construction of Sardis Reservoir. The aggrading of the channel during the late 1940's and early 1950's is much more difficult to explain. A preliminary comparison of over the last two decades reveals that the river has a long history of bank caving and pronounced meandering. There has also been much straightening of its tributaries below the dam which has forced more sediment into the parent stream. There is some evidence that rapid gate closure at the dam has contributed to bank caving on the Little Tallahatchie and degradation on its tributaries. The above mentioned events could have forced more sediment into the river than it could move through. The aggradation during the early 1950's corresponds to the filling of the Panola-Quitman Floodway about that time. The channel degradation occurring at the present time indicates a net removal of sediment from the channel near Batesville. The only place it could go is into the Panola-Quitman Floodway which, at the present time is introducing a tremendous quantity of sediment into the Tallahatchie River below the floodway mouth. It is assumed that some cutoffs were made on the Little Tallahatchie but the number and location are not available. This information would be necessary for a more reliable interpretation of regime changes.

Yocona River

Data for one set of specific gages was available at the Enid gage (Figure 8). The record is very good from 1929 to 1951 but readings were discontinued after that year. From 1929 to 1944 the channel regime was reasonably stable. After 1944, pronounced degradation began a full three years before construction commenced on Enid Reservoir in 1947. The degradation was still continuing in 1951 but to a lesser degree than it did from 1944 to 1950. The downward shift of the rating curve due to degradation is shown in Figure 9. Construction on the reservoir was completed in 1955, however, it cannot be determined what the full effects of this event were as no discharge data exists. The primary cause of the channel degradation was probably the straightening or canalizing of the river channel. The background information on this work is not available at the present time but it probably began around 1944. The straightening involves the complete channel from Enid Dam downstream to its outlet into the Panola-Quitman Floodway.

Due to the degradation beginning about 1944, the Yocona River must have been a prime contributor to the channel-filling that occurred in the Panola-Quitman Floodway. Its junction with the floodway is not too far downstream from the mouth of the Little Tallahatchie.

Yalobusha River

Adequate gage records were available at two locations on the Yalobusha. The bridge gage on Highway 51 is located on the outskirts of Grenada, Mississippi. The record is very good from 1929 to 1954 but from that time on discharge measurements were discontinued (Figure 10). Degradation due to the dam did not begin until after the fourth year of construction. When it did begin, it was extreme, accounting for a drop in stage of about 5 feet in two years. Prior to the construction of the reservoir there was a gradual trend of aggradation possibly a result of the Topashaw Creek problem which greatly increased the sediment load in the Yalobusha (Figure 11).

The other gage at Whaley, Mississippi, located well out into the Yazoo Delta did not show any degradation until storage began in Grenada Reservoir in 1953 (Figure 12). Over the next three years the degradation amounted to about 4 to 5 feet. After this, a very gradual trend in aggradation commenced and by 1969 about 2 feet of channel capacity had been lost. Prior to reservoir construction aggradation had been the trend from 1938 to 1953 and was about 3 to 5 feet over that time period.

The rating curve comparison in Figure 13 shows that the 1973 curve has been displaced upward to its approximate position in 1939 indicating a loss in channel capacity.

Tallahatchie River

There are two gage locations on the Tallahatchie with discharge data sufficient enough to indicate a trend. The upstream gage is near Locopolis, Mississippi and is about two miles or so below the confluence of the Panola-Quitman Floodway and Tillatoba Creek with the Tallahatchie River. The record is intermittent but extends from 1937 to 1973

(Figure 14). From 1937 to about 1943 the trend was one of degradation which was more than likely due to the number of cutoffs made in this vicinity during the late 1930's and early 1940's.

Beginning about the 1950's a very gradual trend of aggradation commenced and continued through the available record to 1973. The amount of aggradation from about 1943 to the present is approximately 2 to 3 feet. The probability here is that the major portion of the sediment contributing to aggradation came from the Panola-Quitman Floodway which has had sedimentation problems from the onset of its existence. The other source of sediment is probably Tillatoba Creek as it has also been straightened and canalized. It is very doubtful that much sediment comes from the reach of the Tallahatchie above the Panola-Quitman outlet since its discharge has been greatly reduced as it only receives any sizable flow from the Coldwater River. The flow of both the Little Tallahatchie and the Yocona are now passed down the Panola-Quitman Floodway. The rating curve comparison in Figure 15 indicates that aggradation has occurred in this reach of river since the late 1940's.

The other gage is several miles downstream below the mouth of Cassidy Bayou near Swan Lake, Mississippi. The record here is very good extending from 1933 to 1973 (Figure 16). A similar trend of degradation occurred from about 1937 to 1944 due primarily to the large number of cutoffs made on this reach of river. Then came a short period of aggradation from 1944 to 1947. From this point in time to 1973 the channel regime appears fairly stable but with a possible return to aggradation during the last two or three years of record.

This segment of the Tallahatchie is bypassed by the Panola-Quitman Floodway and from a comparison of rating curves (Figure 17) only degradation due to cutoffs has occurred. However, as illustrated by the 1973 curve some channel filling has occurred recently.

Concluding Remarks

There were two separate problems confronting early settlers of the Yazoo Basin depending on where one chose to settle. In the hill areas to the northeast the problem was one of extensive erosion following land clearing. In the Delta plain the problem was one of almost annual flooding from the Mississippi River overflow and the ponding of water in natural storage areas for lengthy time periods. The high flows passing through the Delta were ideal for early navigation of the Yazoo River system but the only areas reasonably safe from flooding were the low-lying ridges of natural levees which limited the development of agriculture in the Delta.

As settlement continued to progress in the uplands, erosion forced more and more sediment into the upper reaches of the hill tributaries and deposited several feet of sediment on the valleys between the bluffs and ridges. This occurred mostly during the last half of the 1800's. However, this sediment had not reached the Delta in any significant amount during this period. Drainage from the hill tributaries was not a severe problem because the major streams of the Yazoo system were of sufficient capacity to accommodate most tributary discharges. They were certainly not comparable to the large flood wave that would pass through the Delta from Mississippi River overflow.

With the construction of Mississippi River levees, flood flows were withheld from the Yazoo Delta streams. Since the streams were not required to carry the previous high flows, the cross sections of the major Delta streams gradually decreased in size over the decades of the late 1800's and early 1900's. Underfit planview geometries are visible from the air today in almost every location in the Yazoo Delta. Terraces lying between older top bank outlines can be seen in aerial photographs.

Although channel capacity was decreasing in the Delta streams, flooding had not reached the critical stage it would in later years during the 1930's. One reason for this was the fact that several of the smaller hill streams, such as Potacocowa Creek, Ascalmore Creek, etc., were not tributary to the main Delta streams. Instead they drained into low-lying swamp areas along the valley wall near their exit from the hills. Excess water from these streams was stored and released gradually through numerous small outlets after the stages on the major rivers fell. Evaporation and percolation probably took care of another portion of the stored water. These smaller streams were already having sedimentation problems by the turn of the century because of land clearing in the hills. But the sediment from these streams was probably not getting into the Delta drainage system but was being deposited on the already existing alluvial apron at the foot of the valley wall with some sediment carried to the swamps. In these situations sediment began to be a very serious problem when excessive amounts of it began obliterating the channels over the alluvial aprons and causing aggradation to work its way back upstream.

Similar conditions were developing on the larger tributaries draining the hill area (Little Tallahatchie, Yocona, and Yalobusha rivers). These rivers had their own smaller hill tributaries which were bringing sediment from the hills and forcing it into the larger parent streams in ever increasing amounts. In this way the two separate problems, valley sedimentation in the hills and Delta flooding began to be connected. Excess sediment was progressively working its way downstream into the Coldwater-Tallahatchie-Yazoo system. The slopes of the Delta streams were very flat compared to the hill tributaries and coarse sediment from the hills could not move through. Therefore, channel filling began in the Delta aggravating a problem that the main line Mississippi River levees had partially solved.

Beginning in the early 1900's many of the smaller hill tributaries that had formerly discharged into swamp areas were diverted to the Coldwater-Tallahatchie-Yazoo system by floodway channels. This augmented the normal flows already critical with respect to flooding and merely added to the problem. But this was not the worst condition to arise from these diversions. At about the same time the floodways were constructed the upstream reaches of the creeks were straightened, increasing the slope and sediment transport capacity. Tremendous quantities of sediment moved through the straightened channels into the floodways filling them up and then into the main Delta streams. In some cases channels were completely blocked, e.g., the Yalobusha River, while in others an increase in meandering would occur. In all streams various degrees of filling (aggradation) took place.

By this time flood problems had become impossible to cope with. In an effort to solve the problem of floods from the major hill tributaries, reservoirs were constructed on the four main streams. Flood peaks were subsequently lowered but degradation below the dams aided by cutoffs was forcing even more sediment into the Delta. At this time degradation seems to be continuing on at least one stream, the Little

Tallahatchie, which is adding to a serious problem that has existed in the Panola-Quitman Floodway since its construction. The floodway together with Tillatoba Creek is currently discharging sediment into the Tallahatchie River which requires frequent dredging to maintain a respectable capacity which for the larger floods it does not have.

Because of the required dredging another problem is developing. The material removed from the channel must be permanently stored somewhere. Therefore, farmland has to be purchased for dredge-material disposal areas which is the very land all of the early projects were supposed to protect.

REFERENCES

1. Corps of Engineers, 1971, Review Report Yazoo Basin Delta Area, Mississippi (Bank Stabilization), U.S. Army Engineer District, Vicksburg, Mississippi.

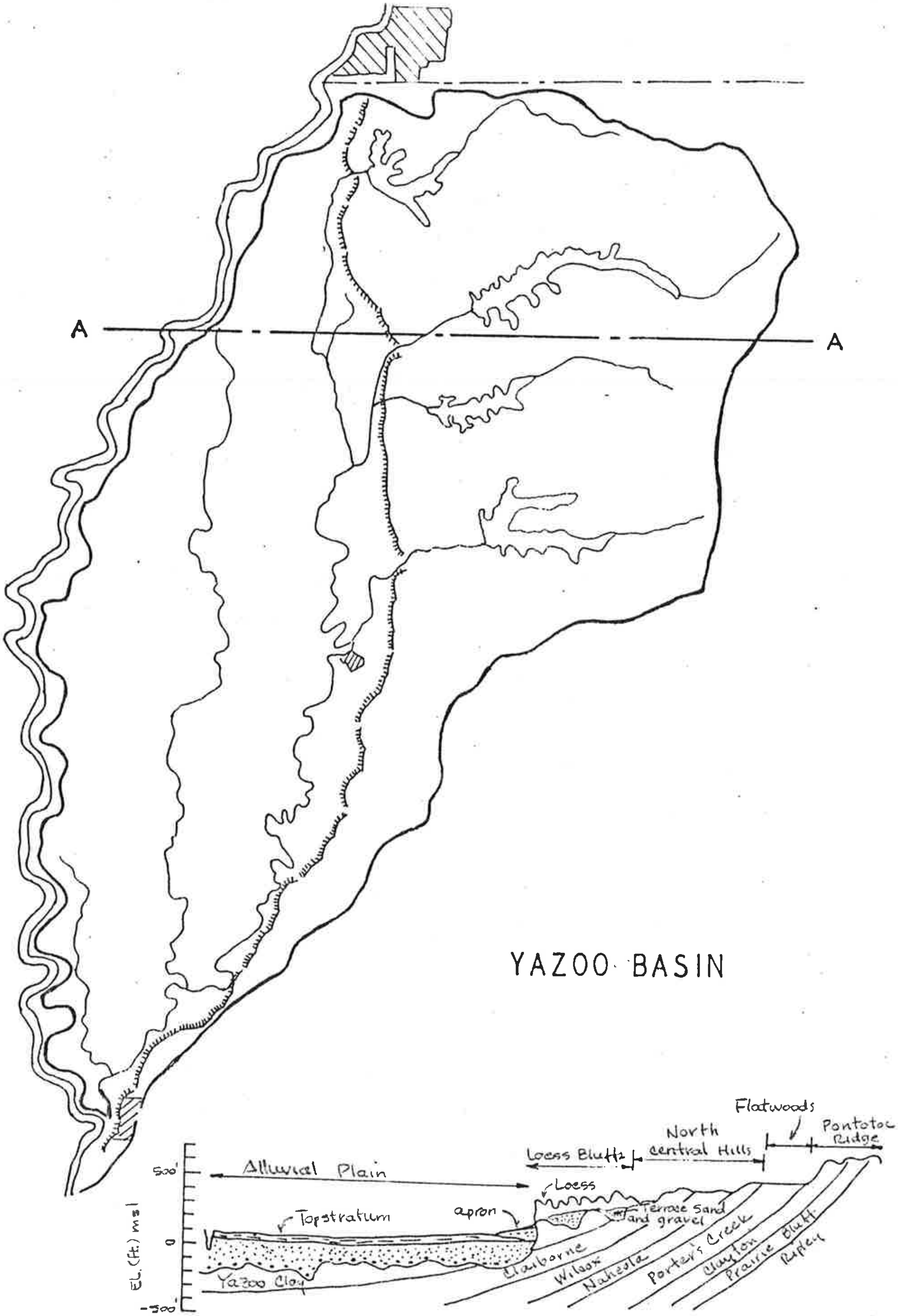
2. Fisk, H. N., 1944, Geological Investigation of the Alluvial Valley of the Lower Mississippi River, Miss. River Comm., Vicksburg, Mississippi.

3. Happ, Stafford C., 1968, "Valley Sedimentation in North Central Mississippi," presented at the Miss. Water Resources Conference, Jackson, Mississippi, April 9-10.

4. Kolb, C. R. and others, 1968, Geological Investigation of the Yazoo Basin, Tech. Rep. No. 3-480, W.E.S., Vicksburg, Mississippi.

5. Mississippi River Commission, 1944, Early Navigation and Commerce, Yazoo Basin, 1840-1884, Vicksburg, Mississippi.

6. Saucier, R. T., 1974, Quaternary Geology of the Lower Mississippi Valley, Arkansas Archeological Survey, Research Series No. 6.



SECTION A - A

Figure 1

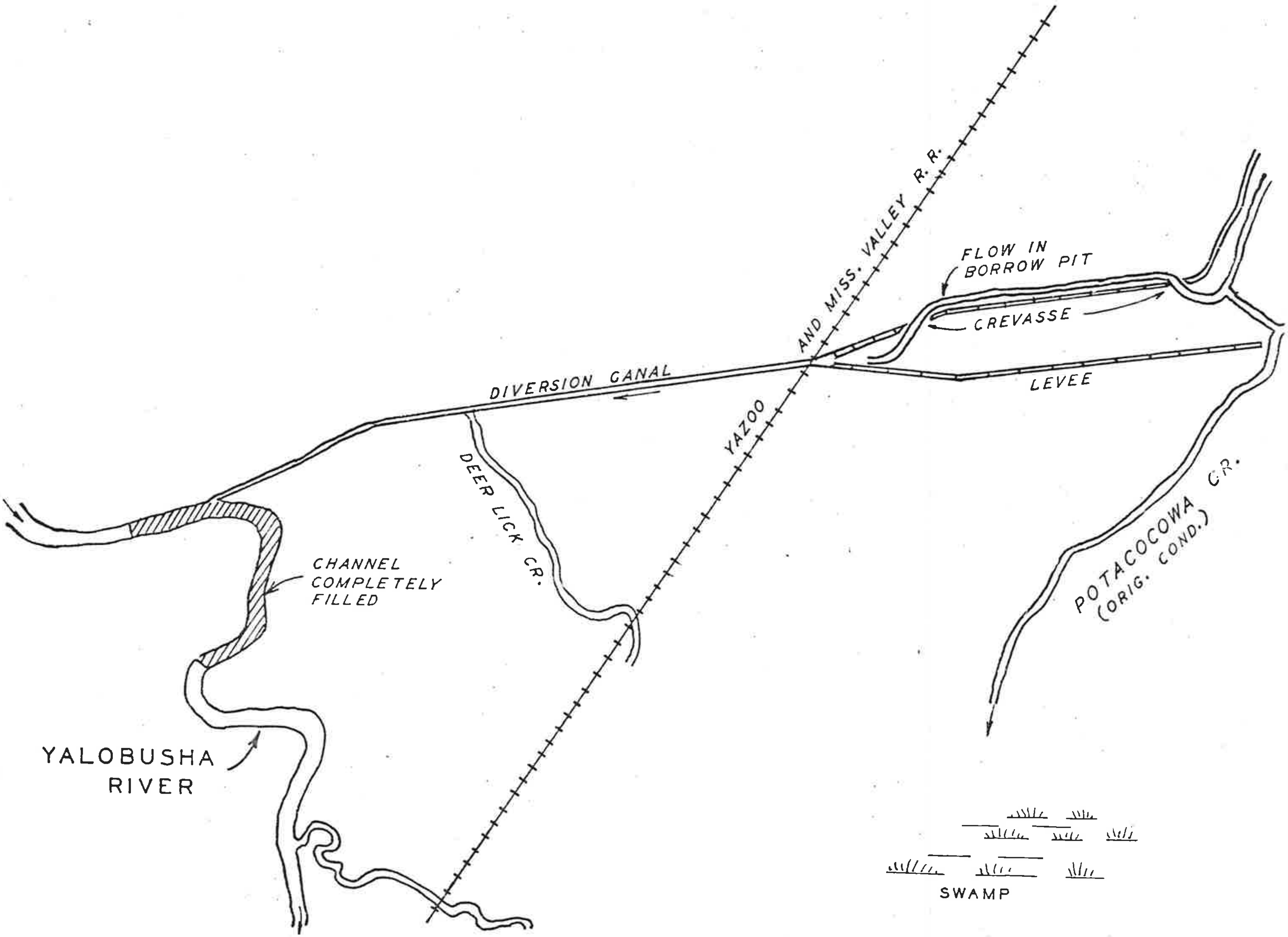

YAZOO AND MISS. VALLEY R.R.
FLOW IN BORROW PIT
CREVASSE
LEVEE
DIVERSION CANAL
DEER LICK CR.
POTACOCOWA CR. (ORIG. COND.)
CHANNEL COMPLETELY FILLED
YALOBUSHA RIVER
SWAMP

Figure 2

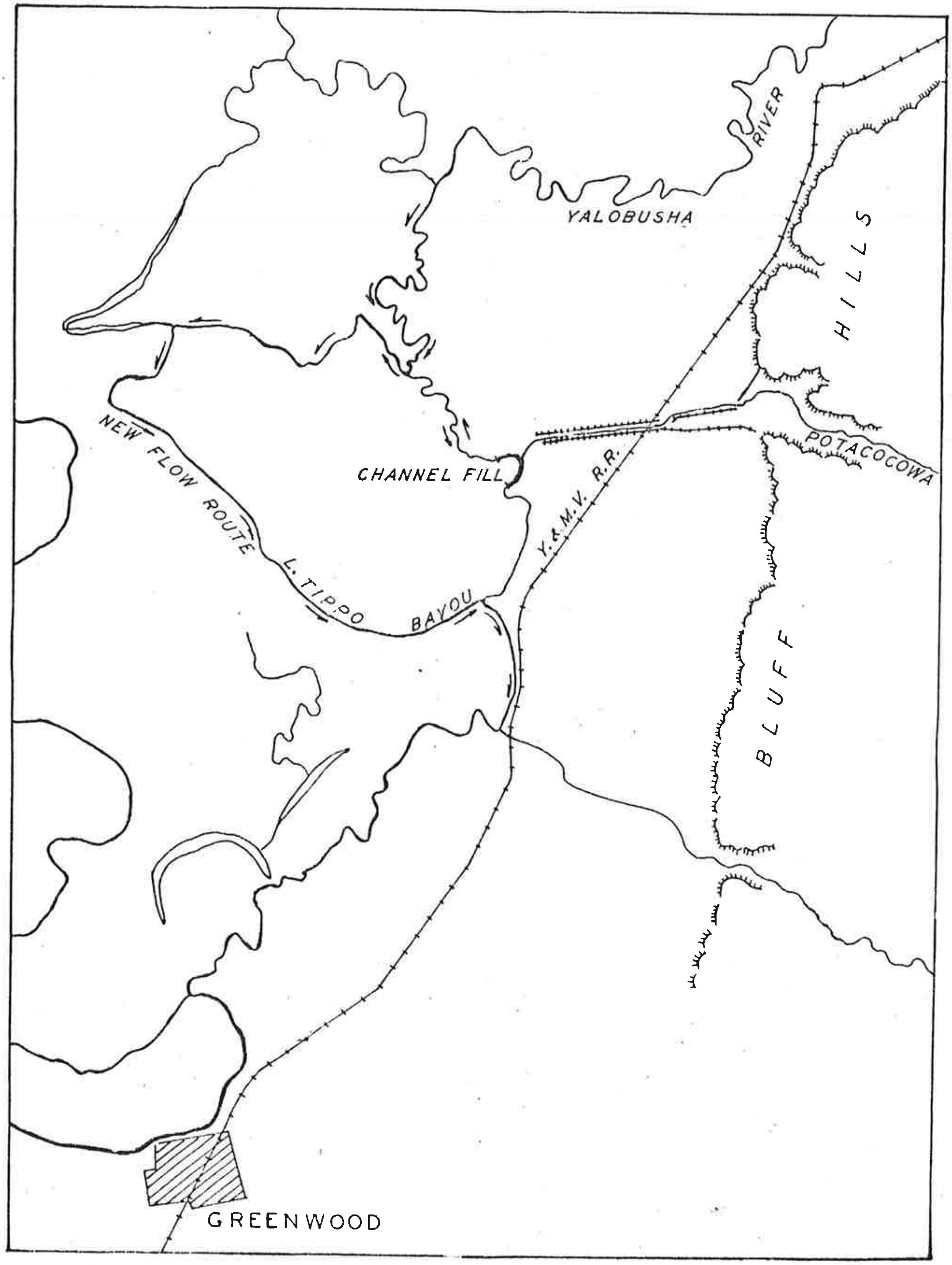

YALOBUSHA
RIVER
HILLS
POTACOCOWA
CHANNEL FILL
NEW FLOW ROUTE
L. TIPPO BAYOU
Y. & M.V. R.R.
BLUFF
GREENWOOD

Figure 3

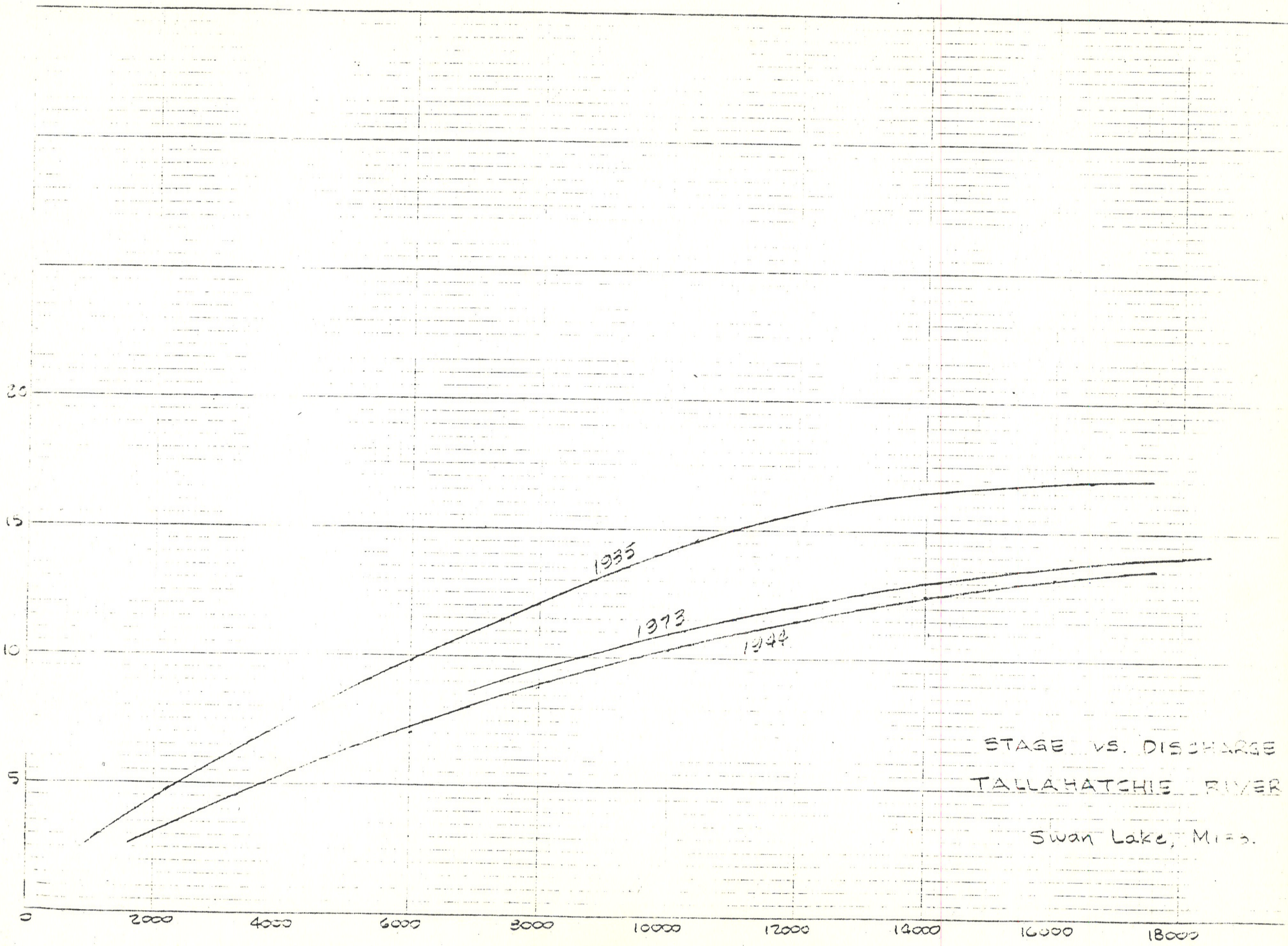
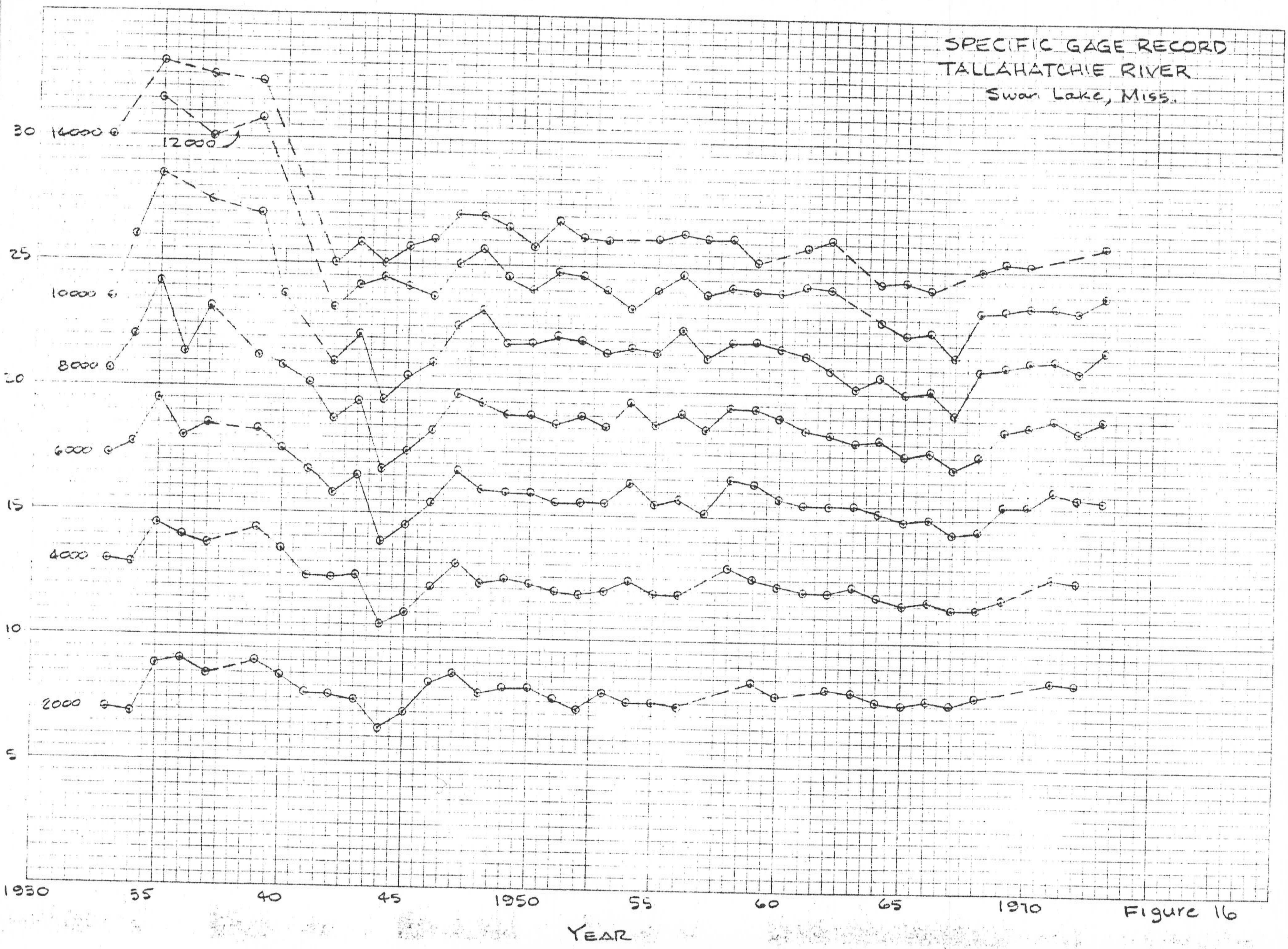
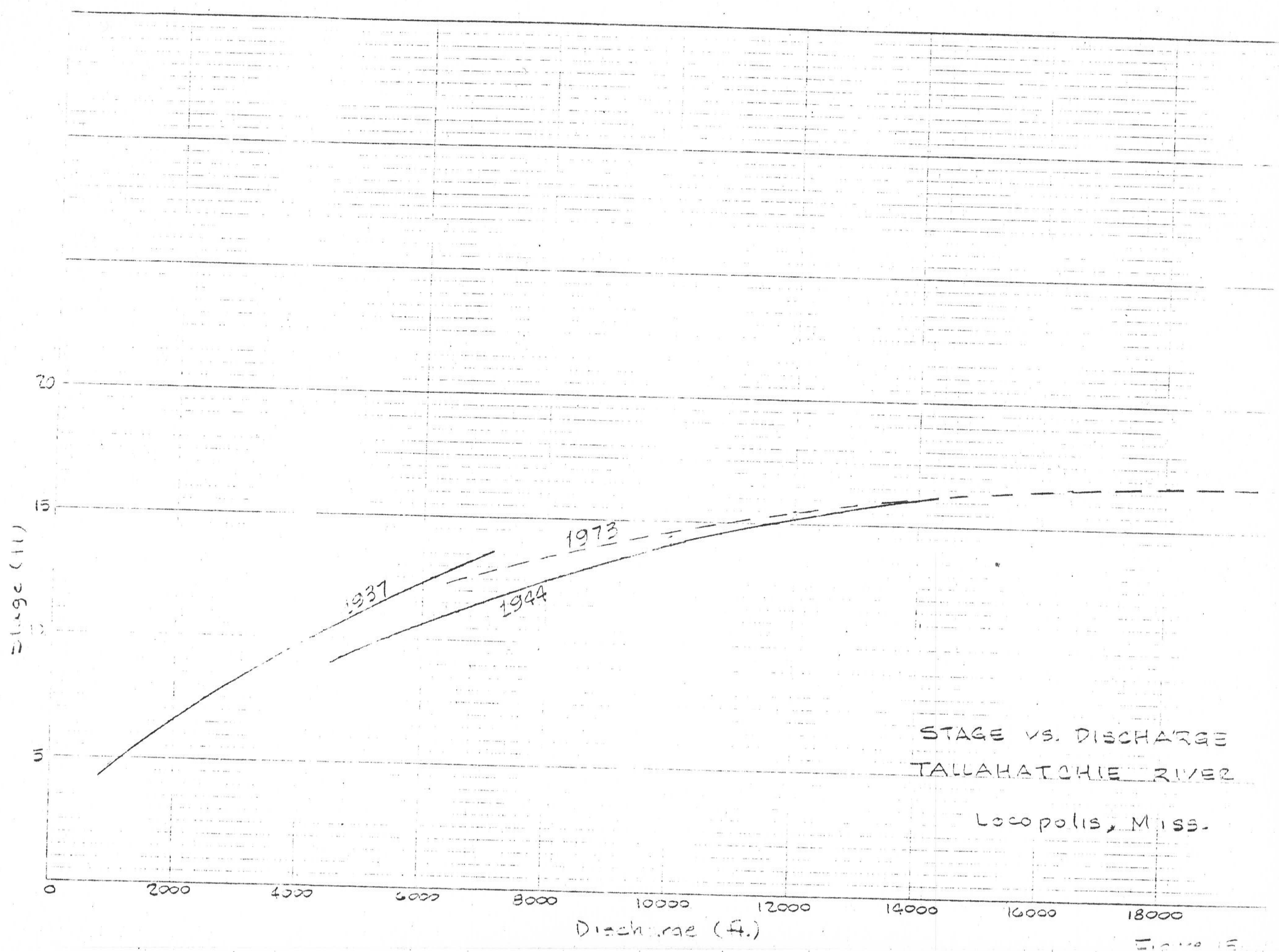

STAGE vs. DISCHARGE
TALLAHATCHIE RIVER
Swan Lake, Miss.
1935
1973
1977
0
5
10
15
20
2000
4000
6000
8000
10000
12000
14000
16000
18000

Figure 1



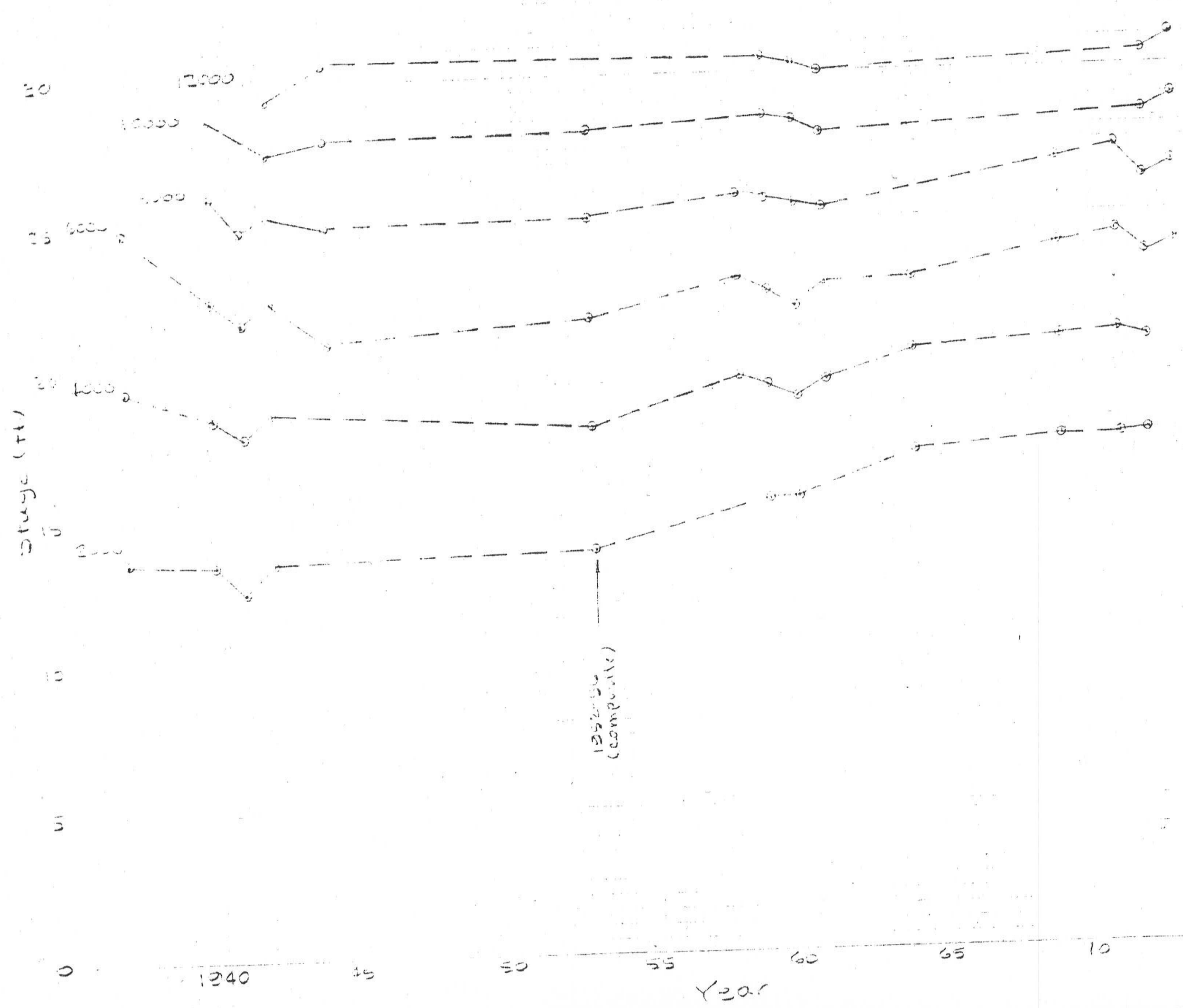
SPECIFIC GAGE RECORD
TALLAHATCHIE RIVER
Swan Lake, Miss.
16000
12000
10000
8000
6000
4000
2000
30
25
20
15
10
5
1930
35
40
45
1950
55
60
65
1970
YEAR

Figure 16

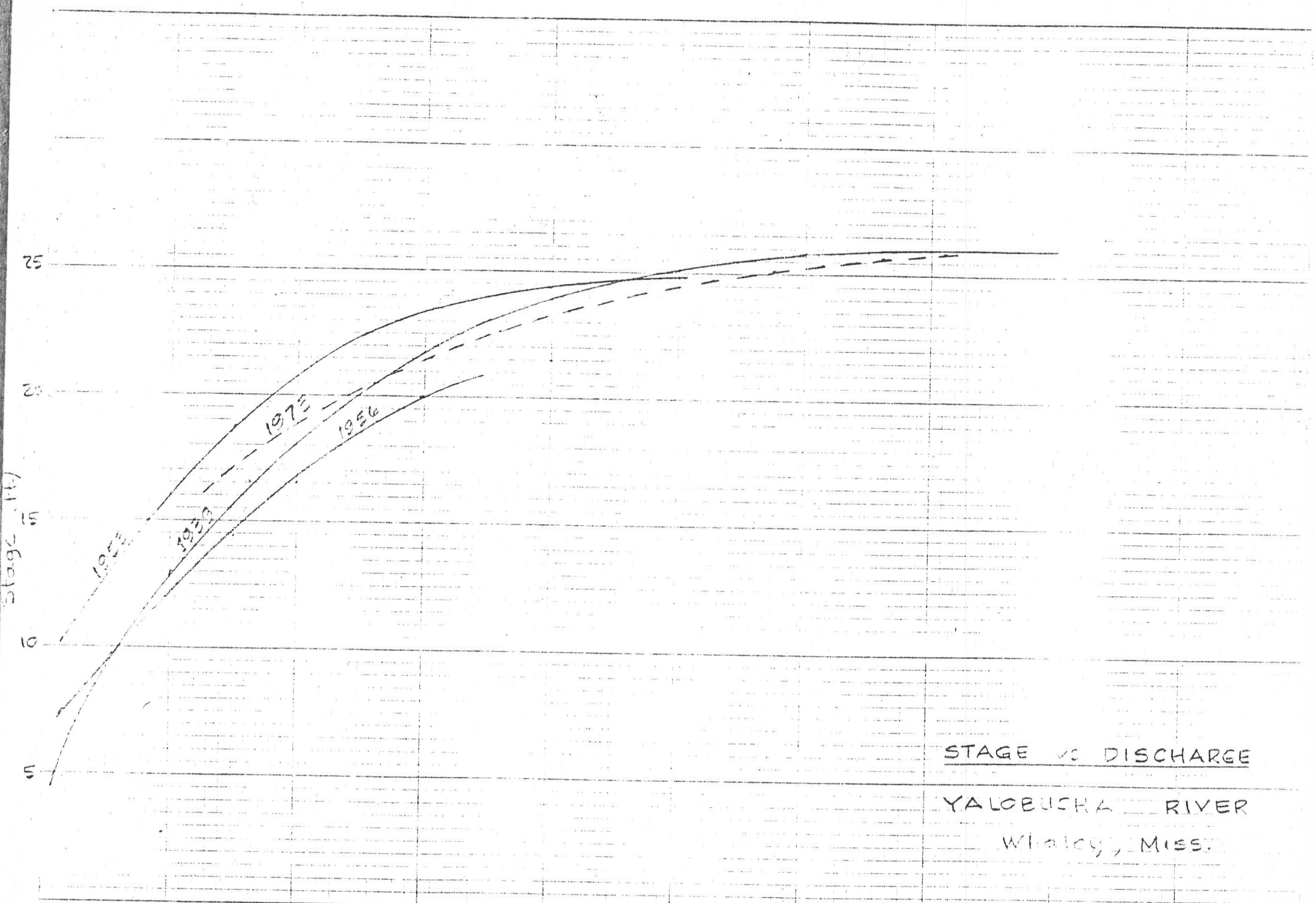


STAGE VS. DISCHARGE
TALLAHATCHIE RIVER
Locopolis, Miss.
1937
1944
1973
Stage (ft)
Discharge (ft.)
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
5
15
20

SPECIFIC GAGE RECOR[D]
TALLAHATCHIE RIVER
Locopolis, Miss.



Figu[re]



STAGE vs DISCHARGE
YALOBUSHA RIVER
Whaley, Miss.
Stage (ft)
25
20
15
10
5
0
2000
4000
6000
8000
10000
12000
14000
16000
Discharge (c.f.s.)
1956

Figure 13

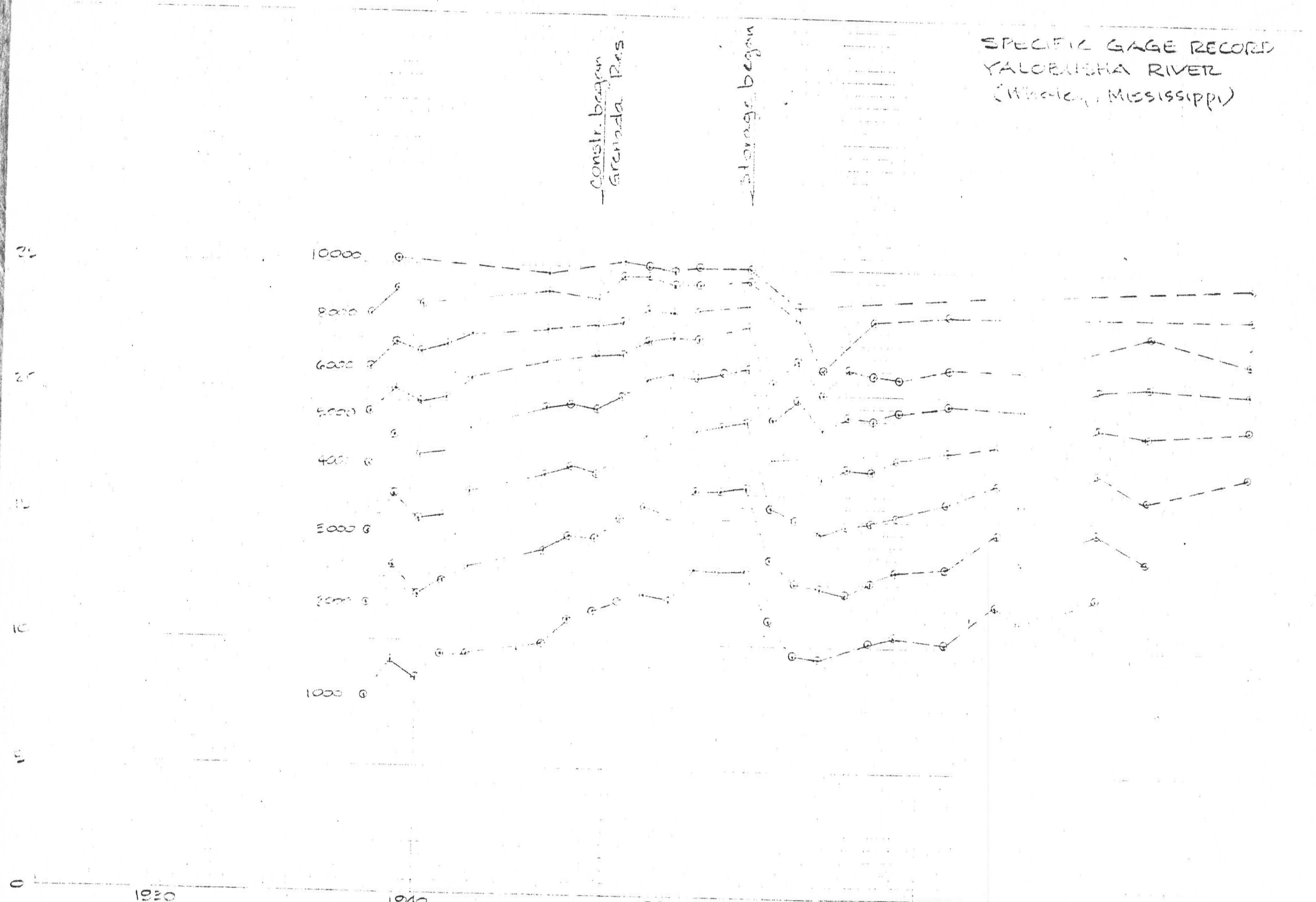
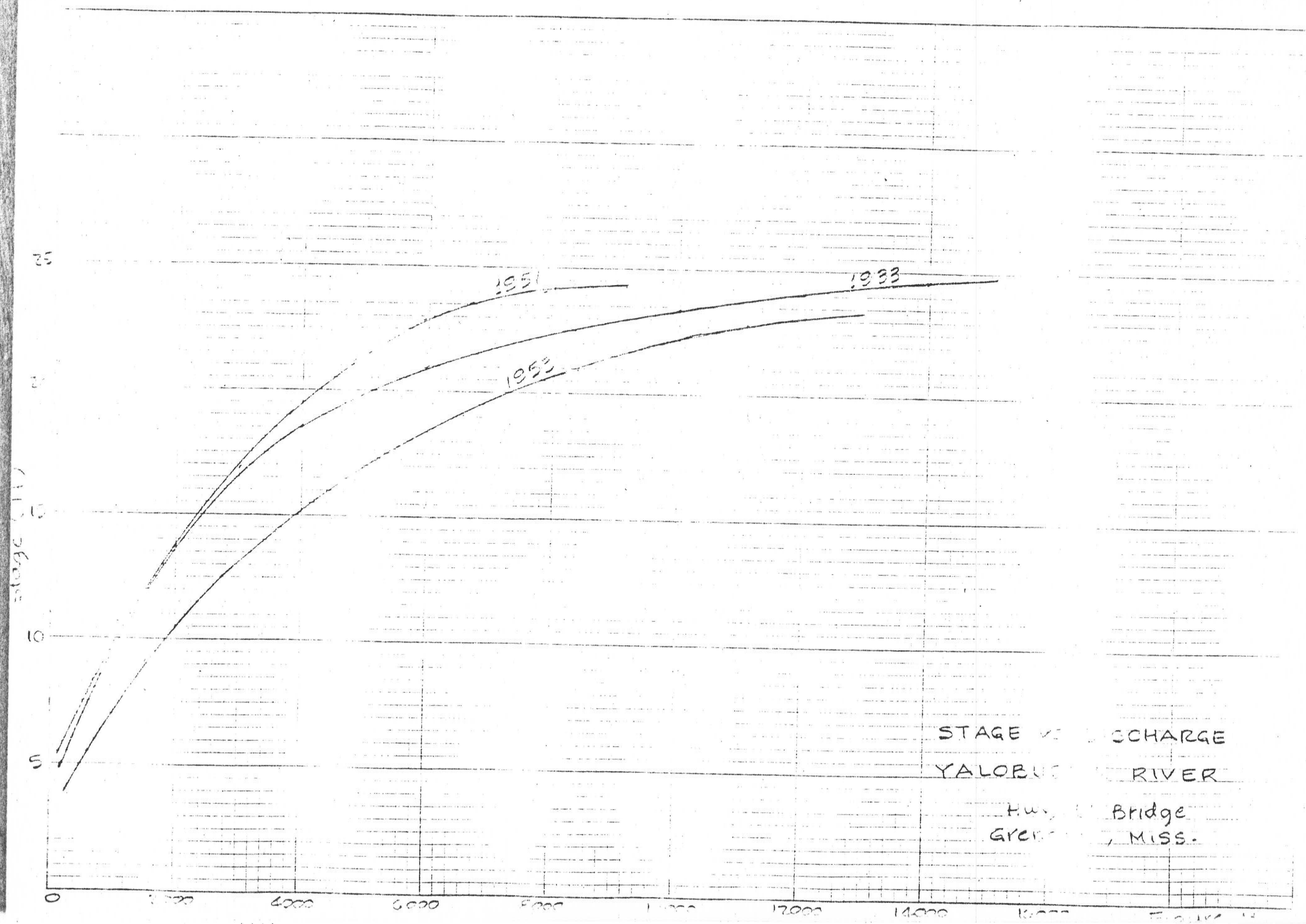

SPECIFIC GAGE RECORD
YALOBUSHA RIVER
(Whaley, Mississippi)
Constr. began Grenada Res.
Storage began
10000
8000
6000
5000
4000
3000
2000
1000
20
15
10
5
0
1930
1940
1950
1960
1970

Figure 12


STAGE VS. DISCHARGE
YALOBUSHA RIVER
Hwy. Bridge
Grenada, Miss.
1951
1933
1953
Stage (ft)
25
20
15
10
5
0
4000
6000
12000
14000

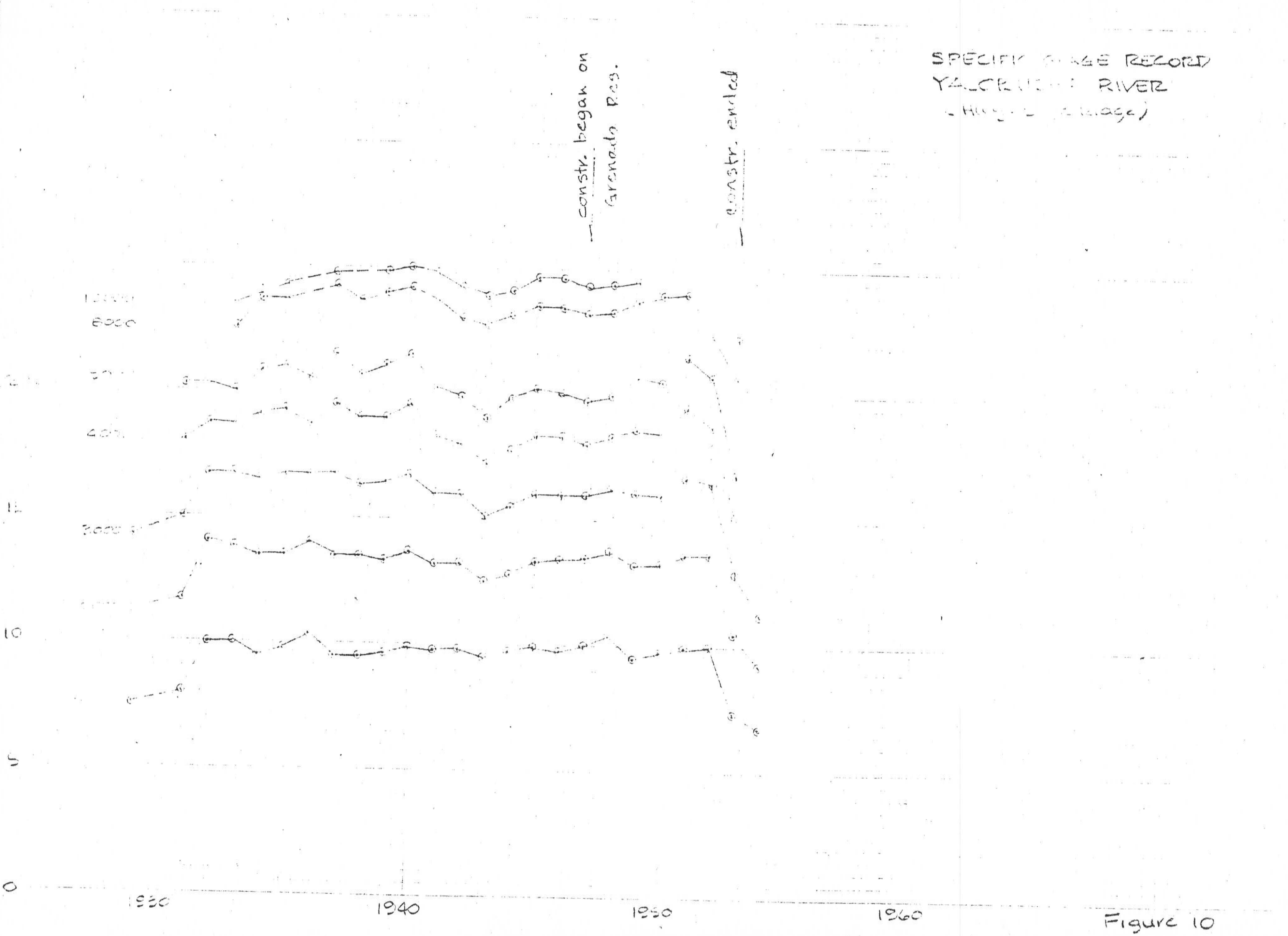

SPECIFIC GAGE RECORD
RIVER
constr. began on
Grenada Res.
constr. ended
10000
8000
4000
3000
10
5
0
1930
1940
1950
1960

Figure 10

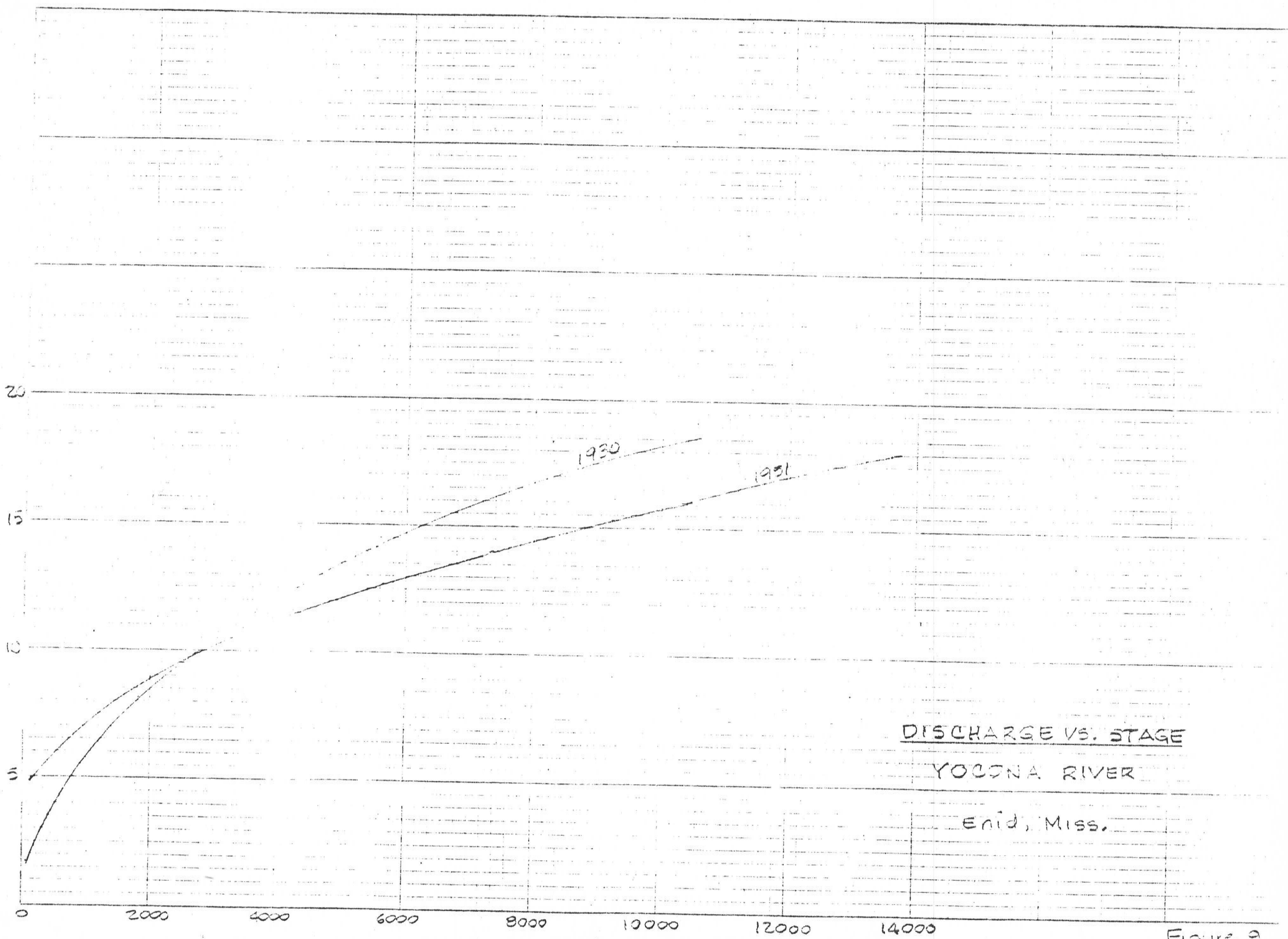

20
15
10
5
Stage (Ft.)
1930
1931
0
2000
4000
6000
8000
10000
12000
14000
DISCHARGE VS. STAGE
YOCONA RIVER
Enid, Miss.

Figure 9

SPECIFIC GAGE RECORD

YOCONA RIVER
Enid, Mississippi

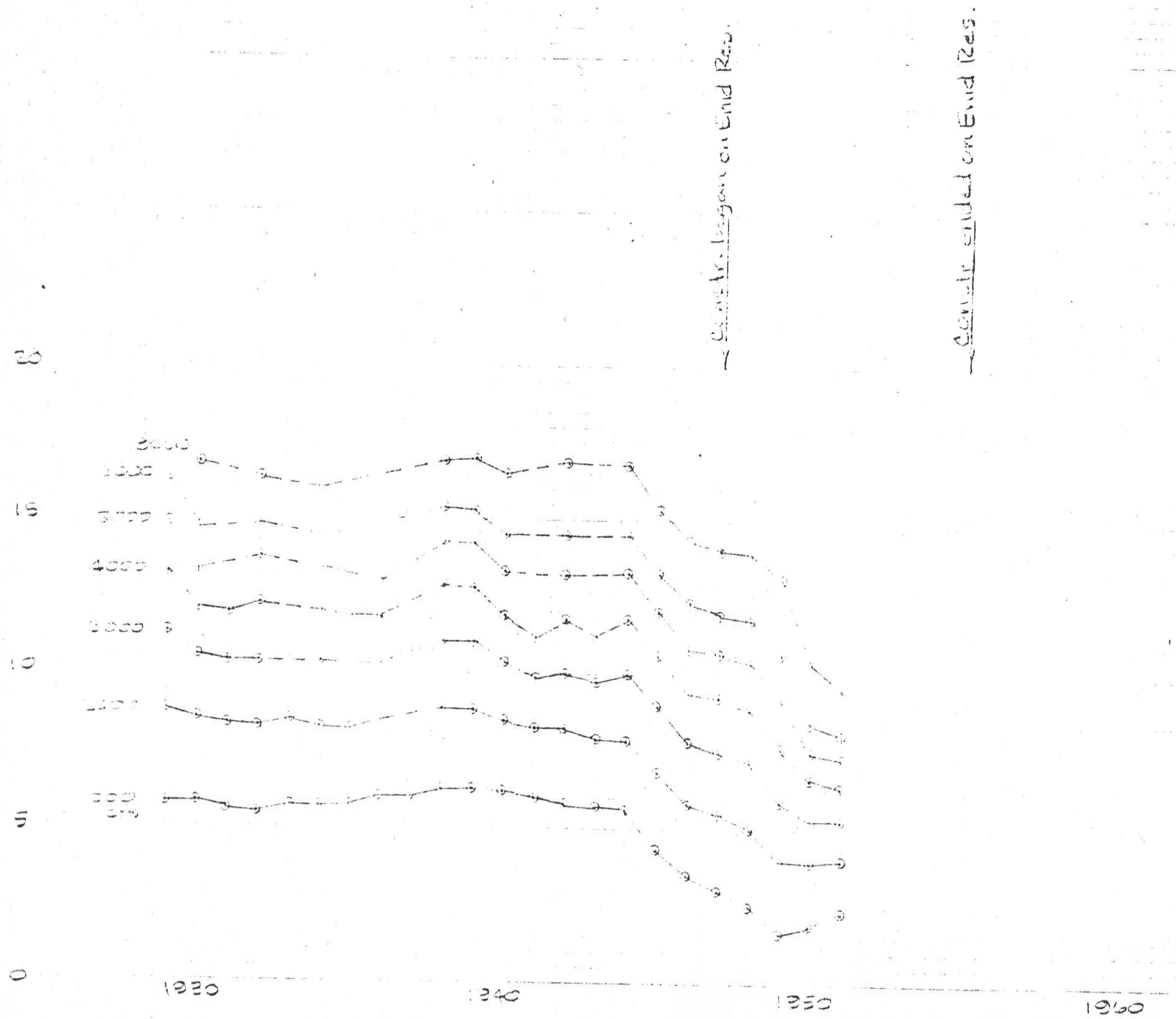


Figure 8

46 0703

SPECIFIC GAGE RECORD
LITTLE TALLAHATCHIE RIVER
BELMONT BRIDGE

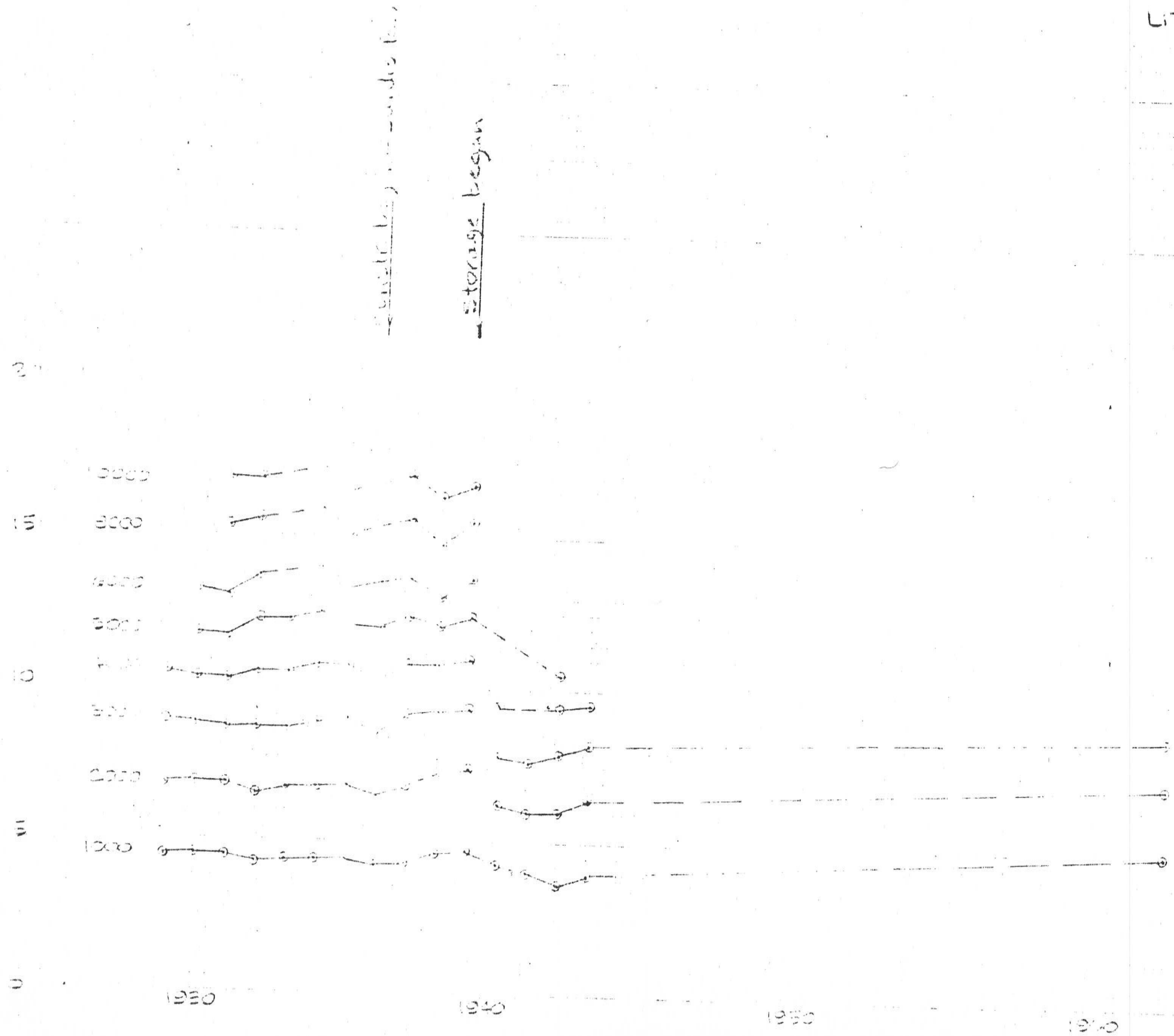


Figure 1

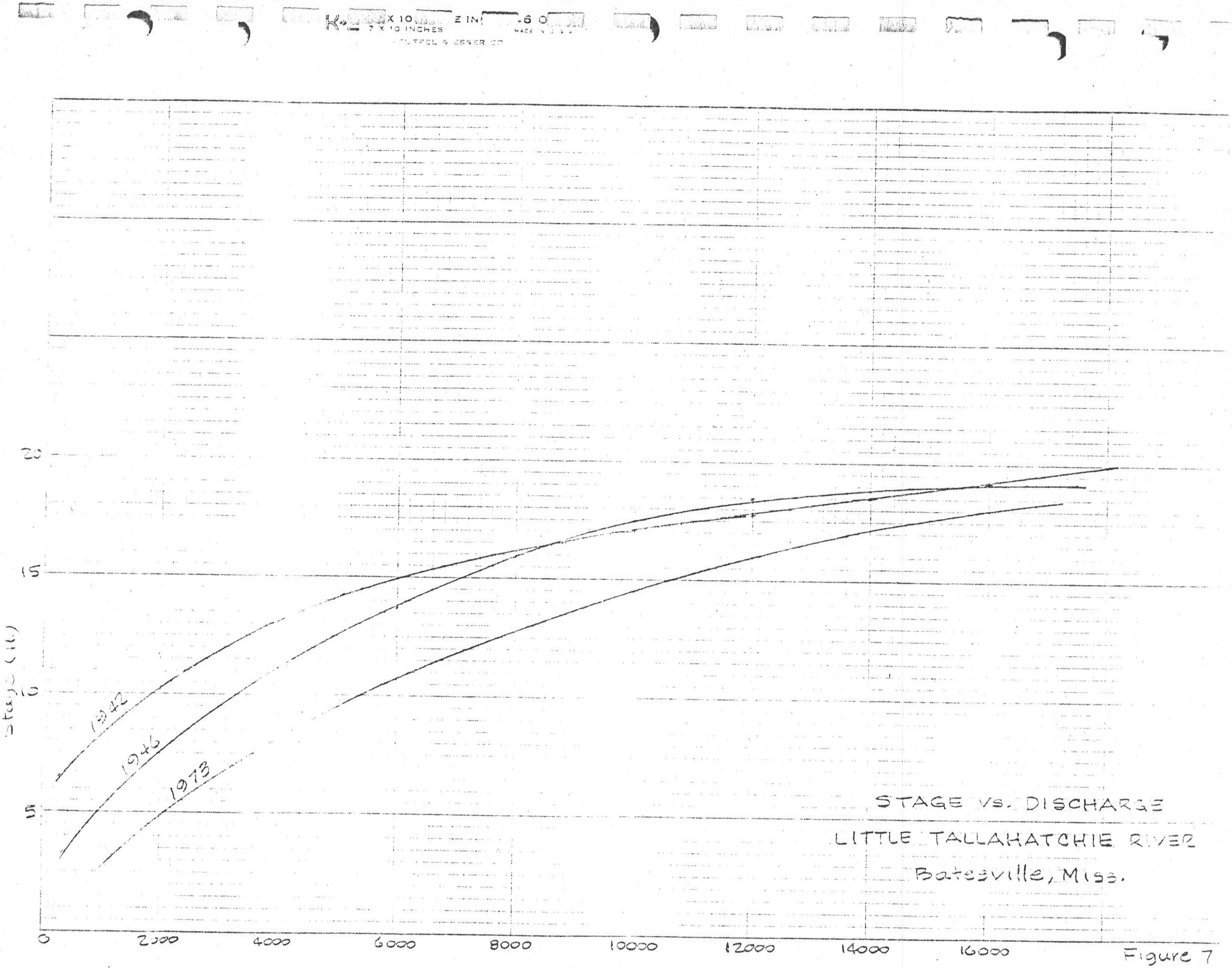
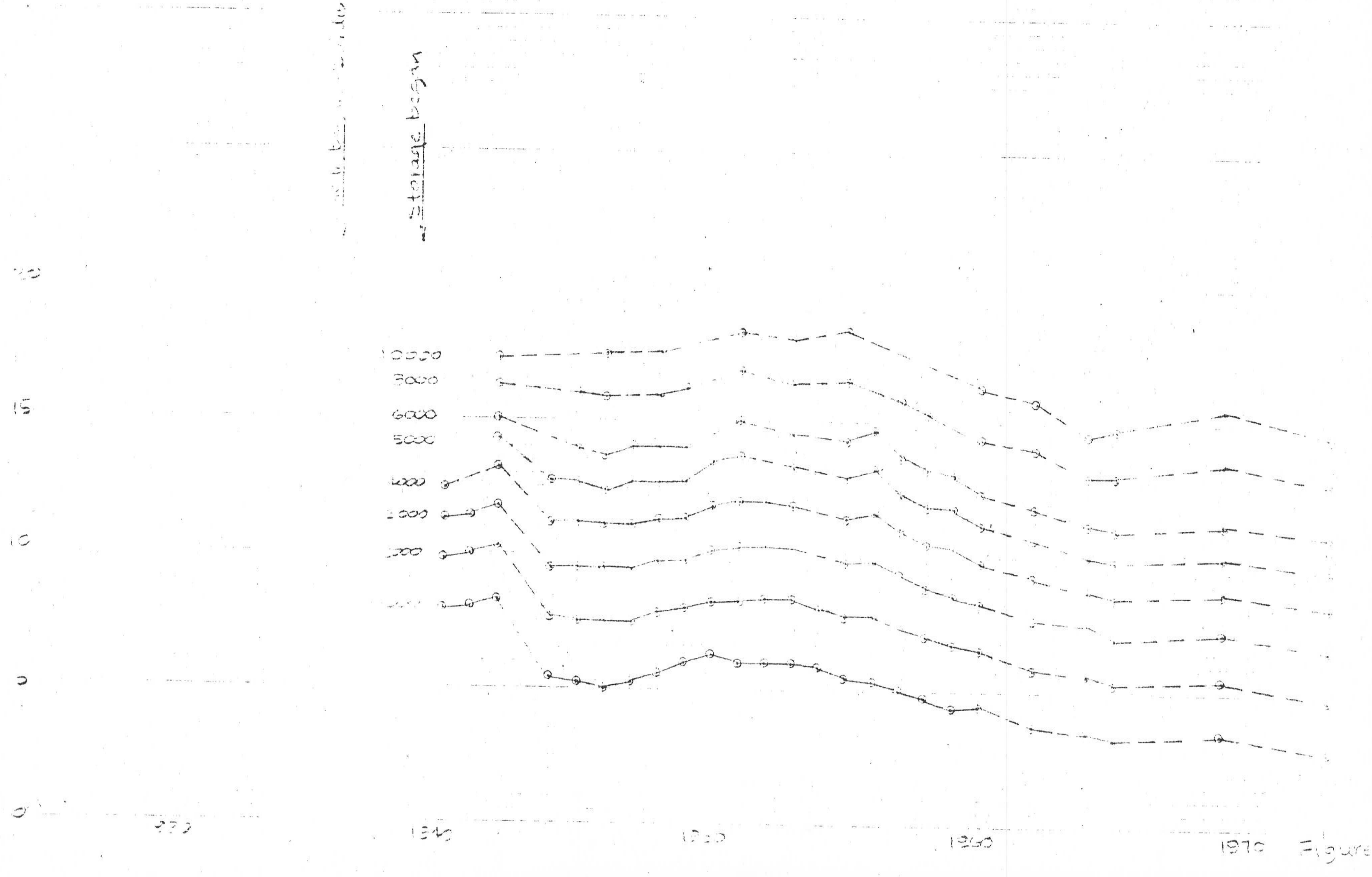
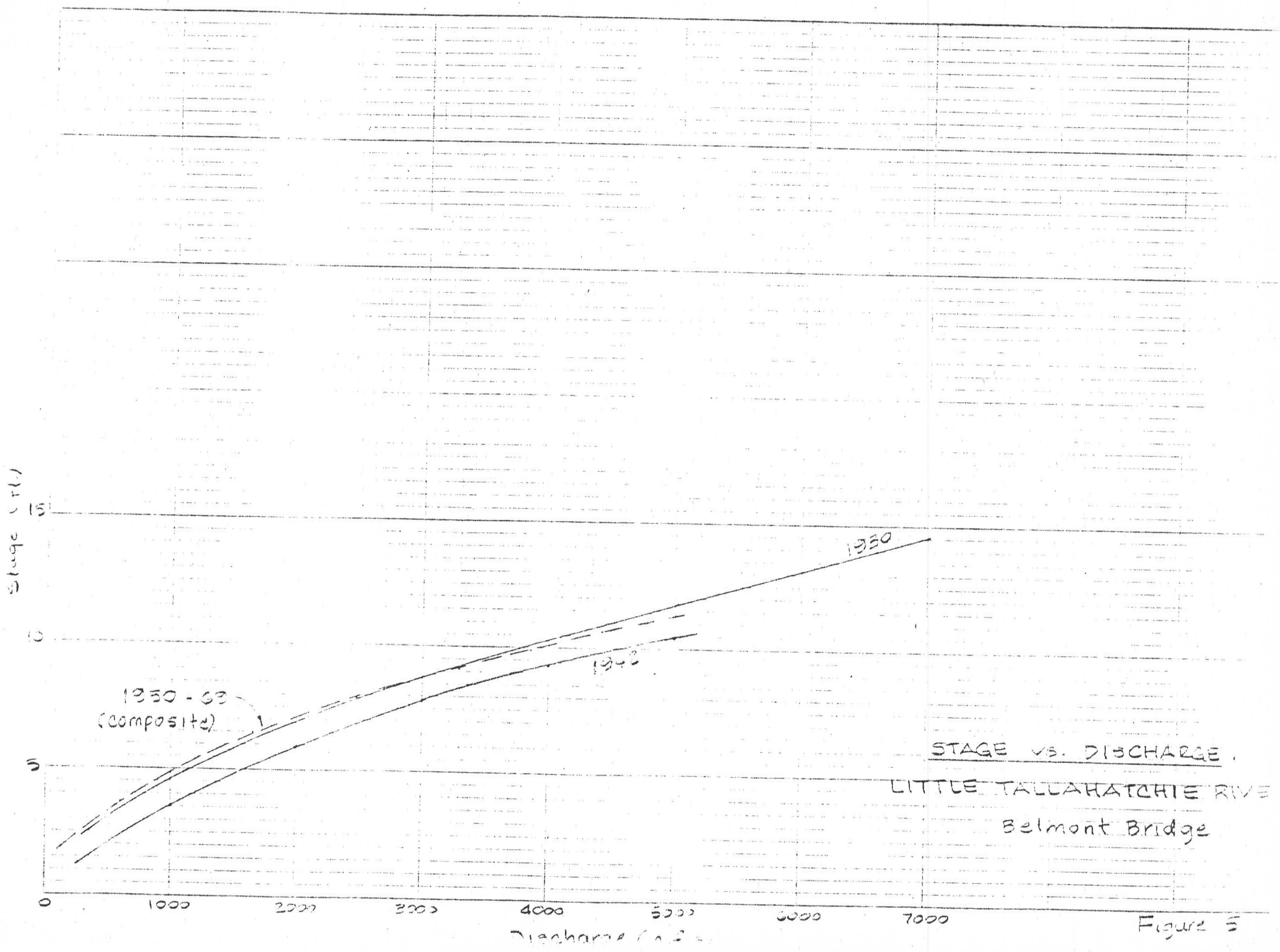

K+E 10 X 10 TO THE INCH 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.
Stage (ft)
20
15
10
5
0
2000
4000
6000
8000
10000
12000
14000
16000
1942
1946
1973
STAGE vs. DISCHARGE
LITTLE TALLAHATCHIE RIVER
Batesville, Miss.

Figure 7

SPECIFIC GAGE RECORD
LITTLE TALLAHATCHIE RIVER
Batesville, Mississippi





STAGE vs. DISCHARGE
LITTLE TALLAHATCHIE RIVE
Belmont Bridge
1950
1942
1950 - 63
(Composite)
Stage (ft)
0
5
10
15
1000
2000
3000
4000
5000
6000
7000

Figure 5