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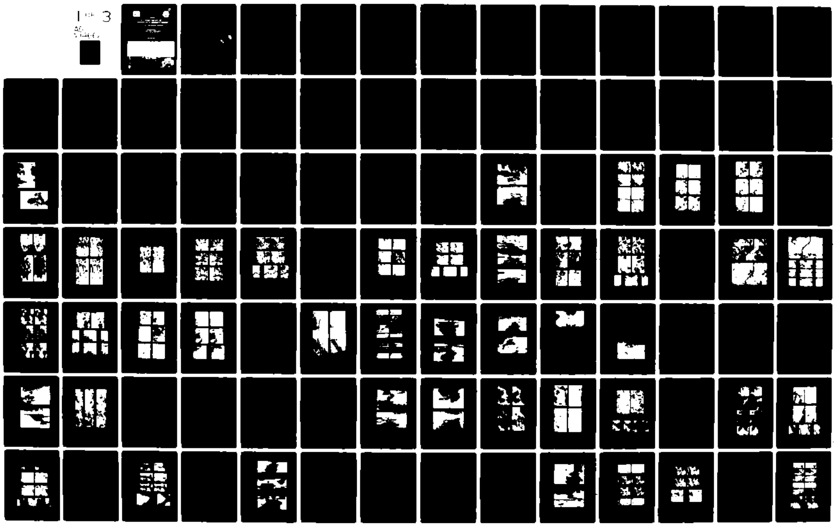

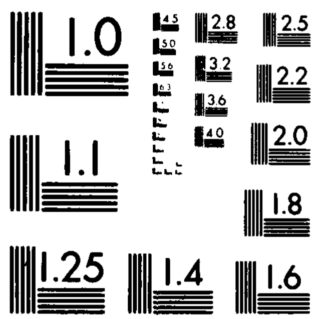

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Streambank erosion is occurring at an excessively fast rate in the upland or hill region of the Yazoo River Basin in northwest Mississippi. Four streams--Perry, Tillatoba, Goodwin, and Hotopha Creeks--were selected as study sites to determine the cause or causes of the excessive bank erosion. All four streams are located along or close to the bluff line.

Historical comparative analyses were used to identify significant changes

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in stream and basin geomorphology and to detect mechanisms that produced or could produce these changes. Chronological sequences of aerial photographs, field observations, maps, and survey data were the principal means used to measure the basic hydraulic and geomorphic conditions that define the fluvial geomorphic system. Stream width, stream depth, channel slope, and sinuosity were the more easily measurable variables, but general observations about the flow, sediment discharge, and sediment size could also be made.

The chronological sequence of historic events that affected the hydraulic and geomorphic conditions are:

a. Land use practices in the Delta from the 1800's to the present increased flow and sediment discharge.

b. Land use practices in the uplands during the 1800's and early 1900's increased flow and sediment discharge.

c. Channelization during the early 1900's increased channel slopes.

d. Meander cutoffs made on the Mississippi, Yazoo, Tallahatchie, and Coldwater Rivers from 1921 to 1953 increased channel slopes.

e. Conservation practices begun in the late 1930's decreased flow and sediment discharge in the uplands.

f. The construction of flood-control dams on the four major streams draining the Yazoo River Basin uplands during the 1940's and 1950's along with associated channelization below the dam increased degradation below the dam by increasing the channel slope and the release of sediment-free water below the dam.

g. Continued channelization of streams since the 1940's has increased channel slopes.

These changes in hydraulic and geomorphic conditions have caused streambed and streambank erosion as the streams adjust to the changes. Channelization has been the factor most responsible for streambed and streambank erosion. All of the major streams and many of the tributaries in the Yazoo River Basin and the Mississippi River Basin have been channelized to some extent. The stream distance to zero-base level (Gulf of Mexico) has been shortened approximately 10.5 to 13.6 percent. Channel degradation believed to be caused by the increased gradient and to a lesser degree the other mentioned causes is advancing up the major channels and their tributaries.

PREFACE

This report is the second of a series dealing with the engineering geology and geomorphology of streambank erosion. The study was conducted in the Geotechnical Laboratory (GL) of the U. S. Army Engineer Waterways Experiment Station (WES) and was funded by the Office, Chief of Engineers (OCE), U. S. Army, by authority of the Section 32 Program, "Streambank Erosion Control, Evaluation and Demonstration Act of 1974." This study was a part of Task II, "The Influence of Fluvial Geology on Streambank Erosion," which was a part of Work Unit 4, "Research on Soil Stability and Identification of Causes of Bank Erosion," of the Program.

The investigation was performed during the period June 1977 to August 1978 under the general supervision of Mr. James P. Sale, former Chief, GL; Dr. William F. Marcuson III, Chief, GL; Dr. Paul F. Hadala, Assistant Chief, GL; Dr. Don C. Banks, Chief, Engineering Geology and Rock Mechanics Division (EG&RMD); and Mr. Clifford L. McAnear, Chief, Soil Mechanics Division, and Principal Investigator, Work Unit 4. Mr. Charlie B. Whitten and Dr. David M. Patrick, EG&RMD, were the authors of this report. Dr. Patrick was the Principal Investigator of Task II.

This report was reviewed by Dr. Stanley A. Schumm, Colorado State University; Dr. Colin R. Thorne, University of East Anglia, England; Mr. B. R. Winkley, U. S. Army Corps of Engineers, Vicksburg District; and Mr. Thomas J. Pokrefke, Jr., Hydraulics Laboratory, WES.

Commanders and Directors of WES during the conduct of the study and the preparation of this report were COL John L. Cannon, CE, COL Nelson P. Conover, CE, and COL Tilford C. Creel, CE. The Technical Director was Mr. Fred R. Brown.

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CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI)
UNITS OF MEASUREMENT

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

Multiply	By	To Obtain
cubic feet per second	0.02831685	cubic metres per second
feet	0.3048	metres
inches	2.54	centimetres
miles (U. S. statute)	1.609347	kilometres
square miles	2.589998	square kilometres

ENGINEERING GEOLOGY AND GEOMORPHOLOGY OF STREAMBANK EROSION

YAZOO RIVER BASIN UPLANDS, MISSISSIPPI

PART I: INTRODUCTION

1. The Yazoo Basin Uplands in northwest Mississippi is a region in which rather severe bank erosion has occurred along many principal streams. Bank erosion has resulted in loss of agricultural land and has endangered bridges and culverts along the affected stream courses. There are indications, at least along certain streams, that the erosion has accelerated over the last few years. In order to control and minimize the land loss and other environmental hazards accompanying the erosion, the U. S. Army Corps of Engineers (CE) has initiated plans for certain hydraulic structures for bank protection and stream control as well as hydrologic research on the causes of erosion in this area.

2. The Yazoo Basin Uplands was selected as an area for streambank erosion studies in this work unit for several reasons. First, the erosion phenomena appear extensively throughout the area and are locally quite severe. Second, initial observations of stream geometry and other general characteristics suggested that fluvial change was occurring at an accelerated rate. The third reason was the extent to which the area and its streams had been subjected to human activities. These activities include overextensive agriculture, stream straightening, and construction of dams.

Objectives

3. The objectives of this study were:

   a. To describe bank erosion phenomena along selected streams in terms of fluvial geology and geomorphology.

   b. To quantitatively investigate historic changes in fluvial geomorphology along the selected streams by means of topographic maps, aerial photographs, and other records.

c. To relate the geomorphological phenomena and historic changes to geotechnical and hydraulic processes.

d. To determine the main causes of bank erosion along these streams.

Scope

4. Four perennial streams located wholly or in part in the Yazoo Basin Uplands were selected for study. These streams are Perry, Tillatoba, Goodwin, and Hotopha Creeks (Figure 1). These particular streams were selected for geomorphological analysis because they exhibit extensive bank erosion and because bank protection projects and hydraulic research have been proposed for them. Although the principal area of consideration was the Yazoo Basin Uplands, it was also necessary to investigate aspects of fluvial geology and geomorphology in the Delta portion of the Yazoo Basin onto which the flow of the four streams ultimately emerges. The Delta investigation was required since, as is often the case in studies of fluvial systems, upstream and downstream conditions may significantly influence local conditions. The objectives and conclusions of this study, although applied to specific streams in a rather small basin, are believed to be applicable to and correlative with many other regions in the United States.

Site Locations

Perry Creek

5. Perry Creek is located in north-central Mississippi at Grenada (Figure 2). It is a fifth-order stream, having a drainage basin of approximately 19 square miles.* Perry Creek flows into Batupan Bogue approximately 2 miles above the confluence of Batupan Bogue and the Yalobusha River.

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* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 3.

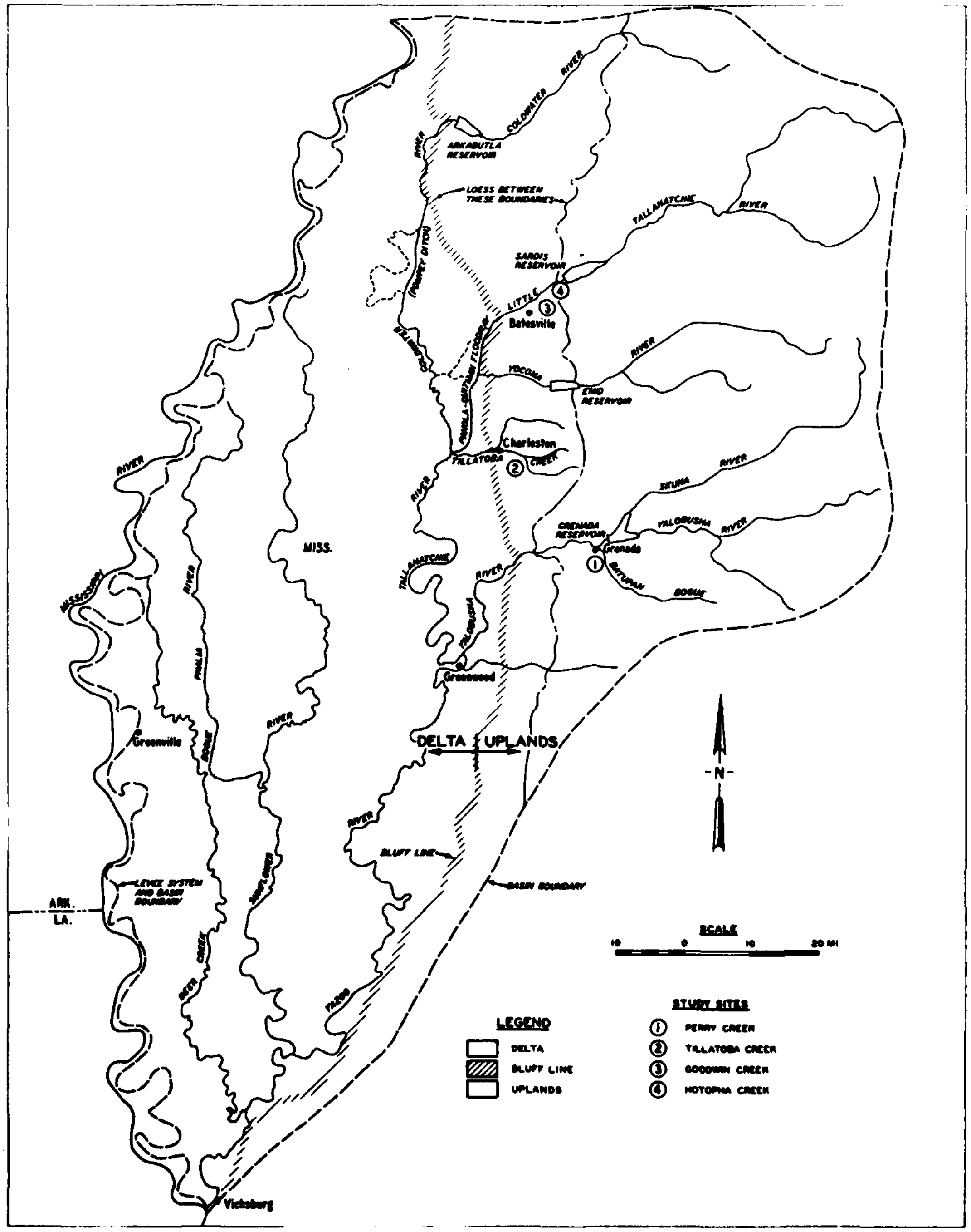

Figure 1. Yazoo River Basin

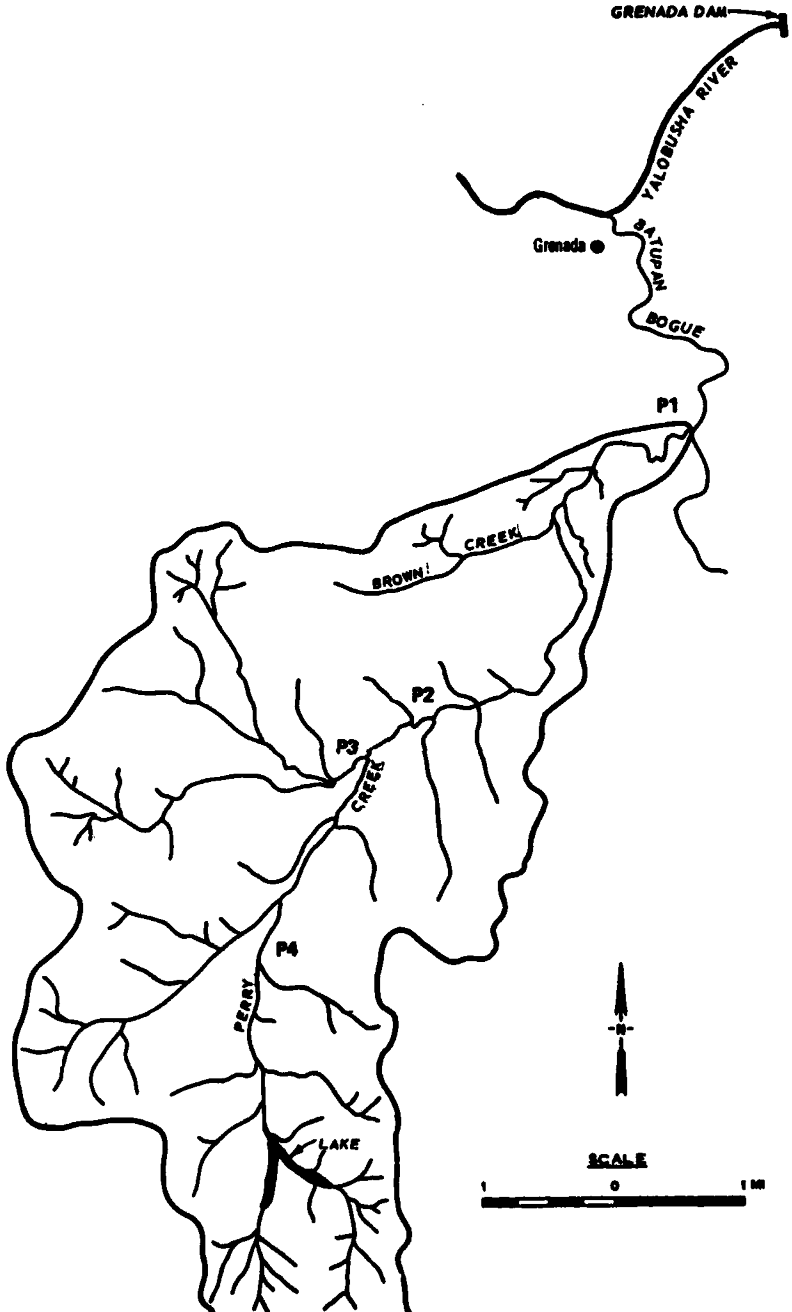

Figure 2. Perry Creek Basin with sites P1 through P4 located

Tillatoba Creek

6. Tillatoba Creek is a seventh-order stream located in north-central Mississippi at Charleston (Figure 3). The Tillatoba Creek Basin covers approximately 175 square miles, of which 173 square miles is in the uplands and 2 square miles is in the Delta.

7. Tillatoba Creek is formed by the junction of North Fork Tillatoba Creek and South Fork Tillatoba Creek at the bluff line. Tillatoba Creek flows westward from the bluff line across the delta flatlands to join the Tallahatchie River at the confluence of Tallahatchie River and the Panola-Quitman Floodway.

Goodwin Creek

8. Goodwin Creek is a fourth-order stream located in north-central Mississippi, approximately 2 miles east of Courtland (Figure 4). Goodwin Creek Basin covers approximately 8.8 square miles and empties into Long Creek.

Hotopha Creek

9. Hotopha Creek is a fifth-order stream located in north-central Mississippi, east of Batesville (Figure 5). The Hotopha Creek Basin covers appoximately 37 square miles and empties into the Little Tallahatchie River approximately 8 miles downstream from Sardis Dam.

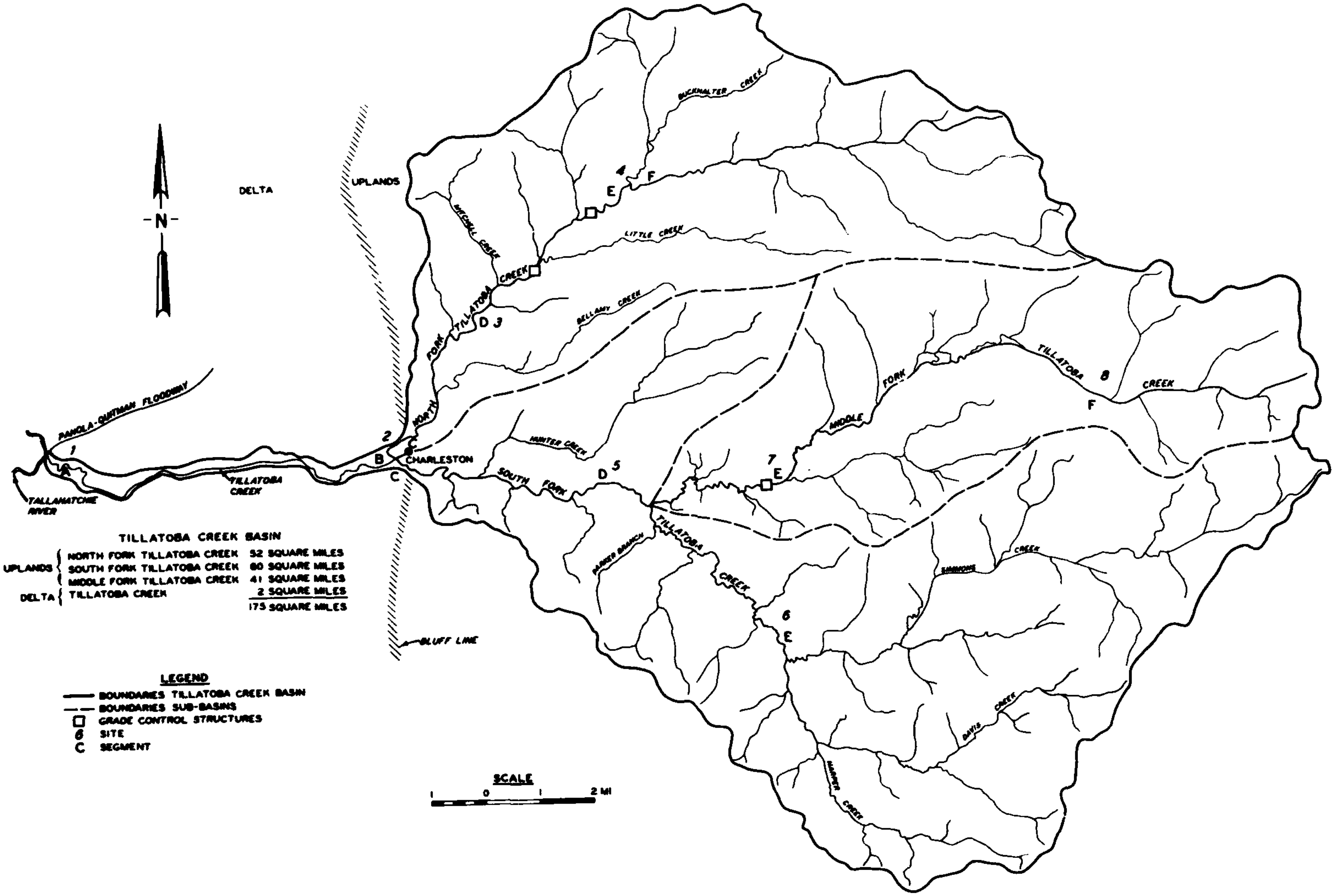

Figure 3. Tillatoba Creek Basin with sites T1 through T8 located

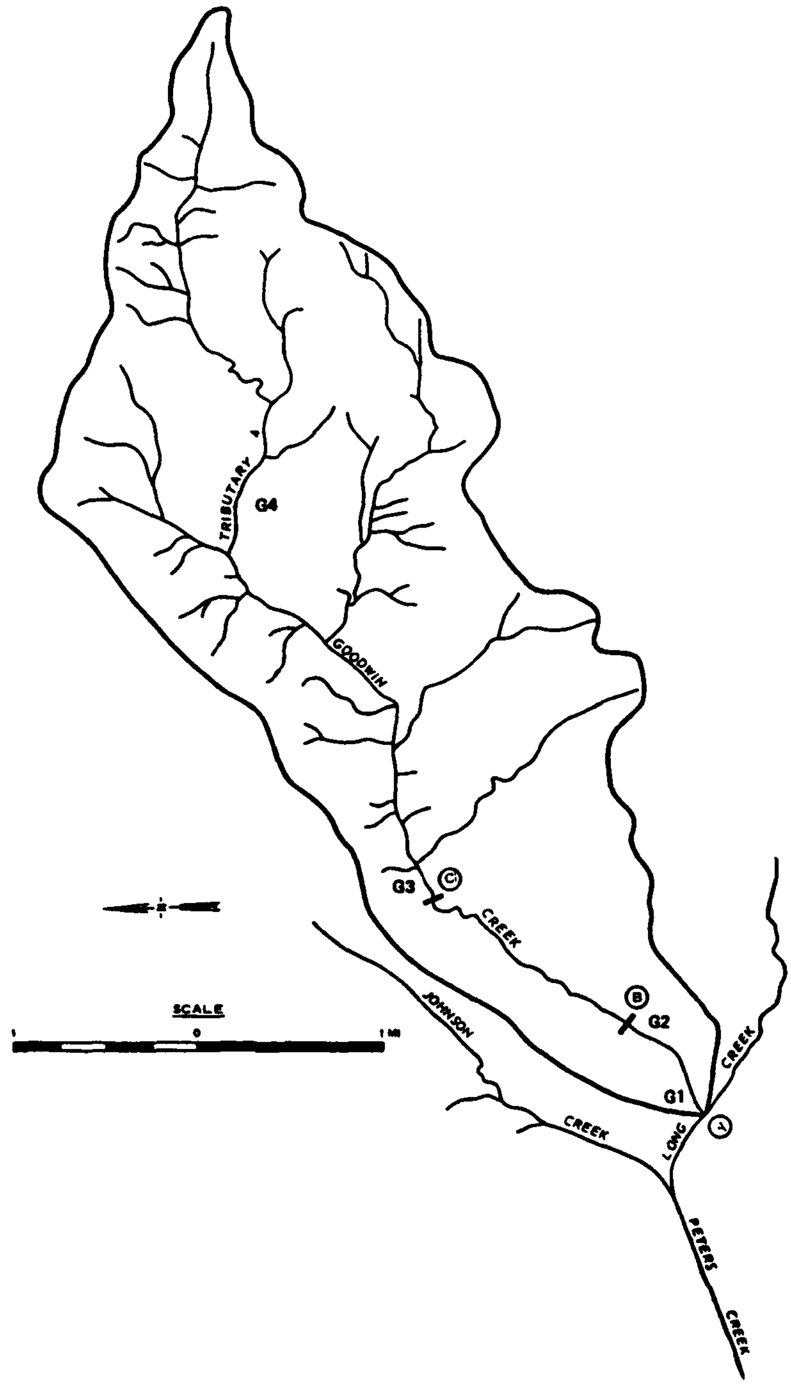

Figure 4. Goodwin Creek Basin with sites G1 through G4 located

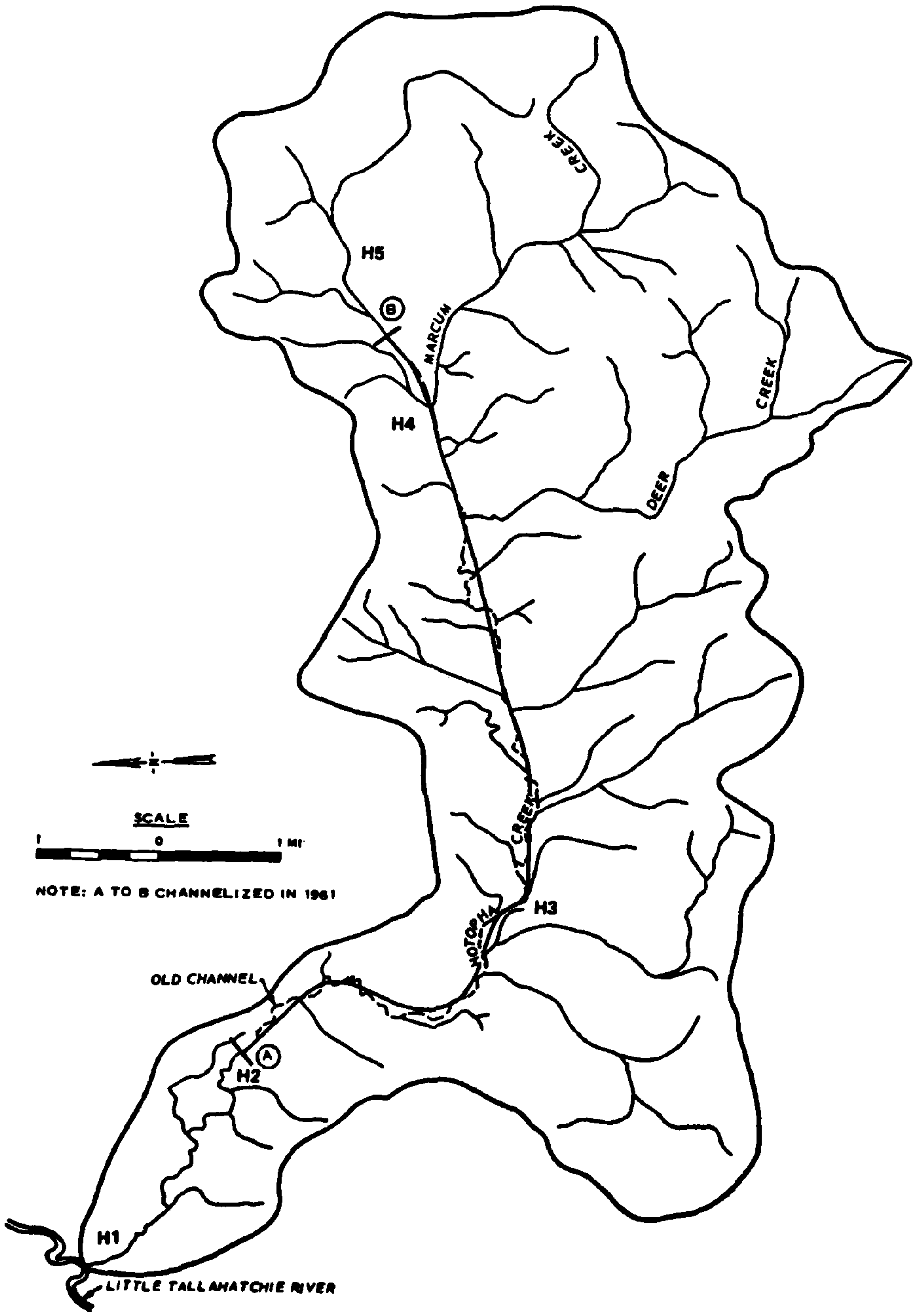

Figure 5. Hotopha Creek Basin with sites H1 through H5 located

PART II: HYDRAULIC AND GEOMORPHIC RELATIONSHIPS

Regime Proportionalities

10. As stated previously, one objective of this study was to identify and measure historic geomorphic changes in the four streams. The understanding of the nature and amount of change taking place should define trends and yield insight as to underlying causes of streambank erosion. In order to accomplish this objective, one should be able to measure variables which represent and are characteristic of the fluvial system being analyzed; ideally, also, one should identify baseline conditions against which the measured quantities may be compared. The measured variables must also be discernible from observations of aerial photographs and topographic maps.

11. The measurable variables that reflect the hydraulic geometry at or along a particular stream are: flow, sediment discharge, width, depth, channel and valley slopes, median sediment diameter, and sinuosity. These variables, which define hydraulic and geomorphic conditions, are interdependent and can be expressed by the five proportionalities given below:

Proportionality 1 $W \propto Q\,Q_s$

Proportionality 2 $W/d \propto Q_s$

Proportionality 3 $d \propto Q$

Proportionality 4 $S_c \propto \frac{Q_s\,D_{50}}{Q}$

Proportionality 5 $S \propto \frac{S_v}{Q_s}$

where

W = stream width

Q = water discharge

d = stream depth

Q_s = sediment discharge

S_c = channel slope

D_{50} = median sediment diameter

S = sinuosity

S_v = valley slope

These proportionalities were developed by Lane (1955), Leopold and Maddock (1953), and others from studies of changes occurring in the morphology of rivers and canals.

12. Basically, these relationships generally predict the direction of change of a particular variable when the magnitude of another variable is changed. These relationships also underscore the importance of sediment discharge Q_s as it may affect the magnitude of all the hydraulic-geomorphic variables.

Measuring Geomorphic Changes

13. Geomorphic changes in fluvial systems may be detected by measurements taken from maps, aerial photographs, and other imagery. Those variables most easily measured on maps and imagery are: width, depth, channel and valley slopes, and sinuosity. Generally, water discharge and sediment size and discharge must be measured by other means or determined from other studies. Although not quantitative, general observations taken from maps and aerial photographs will also yield certain information on general changes occurring along a stream. For example, the presence of knickpoints or waterfalls, the occurrence of changes in the character or amount of sediment, and the stability of point bars with respect to aggradation or degradation may be important qualitative data that can be seen on maps and more importantly, on aerial photographs.

Site and Nonsite Factors

14. A reach of a stream is only a portion of a larger system, i.e., the drainage basin. The stream of interest or a reach thereof is in some type of balance or equilibrium with the rest of the basin--

a balance or equilibrium which may be affected by influences occurring practically anywhere within the basin. Thus, a study of fluvial processes at a particular site or reach often requires that studies be conducted upstream and downstream of the particular site or reach and possibly at or along other tributary streams within the basin. The site or nonsite factors are in both cases the conditions that affect the hydraulic-geomorphic variables previously discussed. Generally these factors include geology, soils, topography, climate, hydrology, and human activities.

15. In this study, the site factors were those conditions occurring along the studied streams, i.e., Tillatoba, Perry, Goodwin, and Hotopha Creeks, as well as conditions occurring within their basins with the exception of land use. As mentioned in PART I, these basins lie, for the most part, in the Yazoo River Basin Uplands. The nonsite factors included conditions occurring on the trunk streams to which the studied streams are tributaries and conditions on the upland slope above the first-order creeks. Thus, the nonsite factors took into consideration conditions within the studied stream basins, the Delta or Yazoo Basin Lowlands, and the Mississippi River downstream of the Delta.

Causes of Erosion

16. Generally, the causes of natural phenomena such as streambank erosion cannot be categorically stated in terms of one or two specific and limited events, conditions, or circumstances. Ordinarily, natural phenomena are caused by several conditions operating concurrently and/or a sequence of interrelated events or circumstances. The sequentiality of events is of prime importance, and each specific event must be understood. The causative sequence also may pertain to space as well as time. For example, an extremely high intensity meteorologic event occurring in a restricted part of a drainage basin may contribute to a flood event of short duration in the downstream portion of the basin which results in localized bank loss. In such an example, the solution to the bank erosion downstream involves information on flow

characteristics at the site in question as well as particulars on the catchment in which the event occurred and data on the stream system between the catchment and the site which was eroded.

17. Material failures result from either or both increased shear stress or decreased shear strength. Changes in stress and strength usually result from changes in flow and/or hydraulic geometry (Thorne 1978, 1980). For example, increased flow may result in a higher and critical shear stress at the soil-water interface which results in the removal of the soil particles in the banks of the channel. The degradation or erosion of channel bottoms and the toes of channel walls (a change in hydraulic geometry) may result in overstressing the soil mass in the banks, slope instability, and failure of the banks. Decreased strengths may result from liquefaction from drawdown and weathering of exposed channel materials and from changes in water table conditions in the banks. The identification of stress-strength parameters and other geological and geotechnical characteristics of the soil and soil mass are ncessary for the implementation of remedial measures for bank protection; however, knowledge of these parameters may not necessarily provide insight into sequential conditions beyond the site in question.

18. A categorization of increased stress and decreased strength mechanisms of streambank erosion has been prepared by the American Society of Civil Engineers (ASCE) Task Committee on Channel Stabilization and is summarized below (Keown et al. 1977):

- a. Attack of the toe of the underwater slope, leading to bank failure and erosion. The period of greatest bank failure normally occurs in a falling river at the medium stage or lower.
- b. Erosion of soil along the bank caused by current action.
- c. Sloughing of saturated, cohesive banks, i.e., banks incapable of free drainage, due to rapid drawdown.
- d. Flow slides (liquefaction) in silty and sandy soil.
- e. Erosion of the soil by seepage out of the bank (piping).
- f. Erosion of upper bank, river bottom, or both due to wave action caused by wind or passing boats.

19. The mechanism or types of erosion given above provide

additional insight into the possible sequential events which lead to failure. Further insight into this sequence may be learned from examination of the geomorphological circumstances pertaining to erosion. Generally, streambank erosion may be categorized and manifested by three processes or mechanisms that relate to the hydraulic geometry (or morphology), which provide an indication of probable ultimate causes and may be quantified. These three processes are: channel widening, channel deepening, and changing planform.

20. Channel widening is a process which is evidenced by an increase in channel width, with or without a corresponding increase in channel depth. Widening occurs because of the adjustment of the channel to an increased sediment discharge, or to an increased sediment discharge accompanied by an increase in flow; when both sediment discharge and flow increase, widening and deepening occur. When only sediment load increases, width increases while depth may decrease (Smith and Patrick 1979). This type of streambank erosion roughly corresponds to ASCE type b. Another name for this process or type is an aggrading channel, implying that the channel has aggraded or filled in due to an excess of sediments.

21. Channel deepening is a process of channel degradation whereby the channel depth increases. The increased channel depth may result in bank loss due to loss of stability of the higher and possibly steeper banks. Thus, whether the bank loss actually occurs will be a function of the geotechnical properties of the bank materials and of the resulting bank geometry. The degradation results from increased flow without an appreciable increase in sediment discharge. The increased flow may result from an overall increase in the volume of water moving through the channel and/or an increase in channel slope.

22. Changing planform includes changes in the location of the channel. Examples of changing planform are: shifting of channels, cutting off of meander bends; the downstream migration of meander bends, and changes in the sinuosity or shape of meander bends. Generally, these changes represent an adjustment of channel slope to conform with changes in flow and/or sediment discharge.

23. Generally, of the three processes of bank erosion, widening and deepening are believed by the authors to be the most significant. All involve changes in stream gradient. Therefore, the measurement of gradients may, in many cases, reveal information on the nature of the cause of bank erosion. These data may be taken from standard topographic maps as well as from actual channel survey plots.

24. The longitudinal profile of most small streams (seventh- or eighth-order or smaller) determined from topographic maps will exhibit a relatively smooth, concave-up curve gradually steepening in an upstream direction. Abrupt changes in slope are knickpoints. Ordinarily, meandering sandbed streams flowing in an alluvial valley do not exhibit knickpoints, except for minor irregularities in bed load or bed form. Knickpoints are most common in streams flowing on cohesive sediments or flowing upon bedrock. For the bedrock-controlled stream, the longitudinal profile is affected by the relative resistance of the rocks and sediments over or in which the streams flow.

25. The detection of knickpoints or change in the position of knickpoints on profiles of sandbed streams is an indication of change in the stream's regime and evidence for the operation of the erosion mechanisms. Brush and Wolman's (1960) laboratory results describe the channel alterations that occur as a knickpoint moves upstream in an oversteepened sandbed channel. These channel alterations were:

- a. The slope of the water surface and the slope of bed below the knickpoint decreases with time.
- b. As the knickpoint moves upstream, the channel directly above the knickpoint first steepens and narrows.
- c. Following the steepening, the slope becomes progressively less.
- d. At the lower end of the oversteepened reach, sediment eroded from above is deposited as a dune, which advances downstream and causes the channel to widen and locally to steepen.
- e. Following the passage of the dune, the slope again flattens.

Factors Initiating Bank Erosion

26. Having described these three causes of bank erosion, one must consider why streams widen, deepen, or change their sinuosity. One could also consider reasons for the changes in magnitude of the variables related by proportionalities 1-5.

27. Generally and rather simplistically stated, the hydraulic geometry may be changed by either natural conditions or human activities resulting in the initiation of an erosion mechanism. Natural changes in the hydraulic geometry can be initiated by the periodic variation in climate. Climatic events, particularly climatic extremes, are probably the single most important naturally induced cause of erosion and of other changes in fluvial systems. The common case of meander changes and consequent bank erosion in sinuous streams brought about by large floods is a familiar phenomenon. Human effects include changes in land use, dam construction, and channel modification. A detailed discussion of the effects of human activities is given in PART IV.

PART III: SITE FACTORS AND CONDITIONS

28. This Part addresses the following two principal elements: (a) those site factors such as geology and physiography and their influence on erosion susceptibility and (b) the geomorphic condition or character of the sites. The geologic and physiographic factors described below will form a basis for introducing the geomorphology of the sites, and because of the general nature of these factors, they are also pertinent to the discussion of nonsite factors, given in PART IV. The geomorphology of the sites will be presented in terms of present conditions and the identification of historical geomorphic changes by observations from conventional aerial photography.

Physiography

29. The Yazoo River Basin is in the Coastal Plains Physiographic Province. The basin can be divided into two distinct topographic sections: (a) the Delta or flatlands to the west and (b) the hills or uplands to the east (Figure 1). The uplands area is the region of principal concern in this report.

30. The Delta section, which covers approximately 6600 square miles, is a part of the Mississippi River floodplain, but is now protected from Mississippi River overflows by levees. The Delta is a relatively flat alluvial plain, sloping 0.7 ft/mile to the south-southwest with local relief generally less than 40 ft.

31. The hills section covers approximately 6800 square miles in the eastern half of the basin. The area is gently rolling hill land with up to 400 ft of relief. The greatest local relief occurs along the bluff line separating the hills and the Delta.

32. The major tributaries of the Yazoo River in the Delta section are Deer Creek, Bogue Phalia River, Sunflower River, and Tallahatchie River. The original highly meandering patterns of these streams, as well as the Yazoo River, have been extensively altered by channelization, levee construction, and channel clearing.

33. The major tributaries of the Yazoo River with headwaters in the hills are from north to south, the Coldwater, Little Tallahatchie, Yocona, and Yalobusha Rivers. The highly meandering patterns of these streams have also been altered by channel clearing and channelization. Flood control dams have been built on all four of these rivers.

34. There are several regional physiographic aspects of the uplands area which, at least to a certain extent, control fluvial erosion. Perhaps the most influential is the valley morphology. Generally, the breadth of even the smaller valleys such as those of Perry and Hotopha Creeks is quite wide. From observations of historical aerial photographs, one sees that the meander belt of each of these small creeks (prior to channelization) occupied only a small portion of their valley and are thus underfit streams. A portion of these valleys consists of small, low terraces. Regardless of the details of the age of these valley deposits, the breadth of the valleys in respect to the natural meander configuration provides ample space for changes in meander configuration and meander amplitudes without appreciable influence from the restraining effects of the valley walls.

35. With respect to channel degradation, the thickness of alluvial fill in these valleys may also be significant. There are indications that the alluvial fill may be quite shallow--possibly no thicker than 10 to 50 ft. It seems reasonable to presume that the relative susceptibility to erosion of the alluvial fill material is greater than that of the underlying Tertiary strata. The difference in susceptibility is due to the more lithified nature of most of the Tertiary material. Thus knickpoints can develop once degradation had proceeded through the alluvial fill into the Tertiary strata. Once entrenched, erosion and further degradation depend upon the relative lithification of the Tertiary units.

Geology

36. The bedrock geology in the stream basins under consideration consists of weakly lithified to unlithified Tertiary clays, silts, sands,

and gravels; generally these Tertiary materials represent ancient fluvial environments. The geologic map and idealized stratigraphic column are shown in Figure 6 and Table 1, respectively (Bicker 1969, Bennison 1975). Along the western edge of the uplands, the Tertiary sediments are overlain by gravelly terrace deposits of the Citronelle Formation (Pliocene or Pleistocene), which in turn are capped by Pleistocene loess. Isolated exposures of Citronelle also are found capping hills to the east beyond the bluff line. The Quaternary alluvium occurring in the broad, flat valleys consists primarily of fine-grained floodplain deposits that apparently are rather thin.

37. From the standpoint of erosion, either sheet or fluvial, the materials within the basins (including bedrock and residual and transported soils) possess several characteristics that enhance their erosion susceptibility. They are as follows:

a. Clastic character. The relatively high proportion of clastic materials, particularly sands and silts and the absence of carbonates results in a high natural erosion potential for the area.

b. Lack of lithification. The absence of appreciable cements in the clastics produces materials so weakly bound together that erosion is aggravated.

c. Dispersiveness. The fine-grained (Tertiary) clastics (silts and clays) as well as the transported and residual soils possess a mineralogical and geochemical composition by which the discrete silt and clay particles will disperse or go into suspension with very little or no agitation. These materials are highly susceptible to both sheet and fluvial erosion.

38. Bed-load sediments in the upland streams of the Yazoo River Basin range from clay to gravel. The gravel is derived from the Citronelle and terrace deposits located along the western edge of the uplands. The bulk of the finer grain materials is derived from the Pleistocene loess and Tertiary and Cretaceous beds, which dip gently to the west-southwest.

39. The streambeds of Perry, Tillatoba, Hotopha, and Goodwin Creeks are cut into Quaternary alluvial deposits (Figure 7). The carbon-14 age dating of wood samples, such as shown in Figure 8, placed

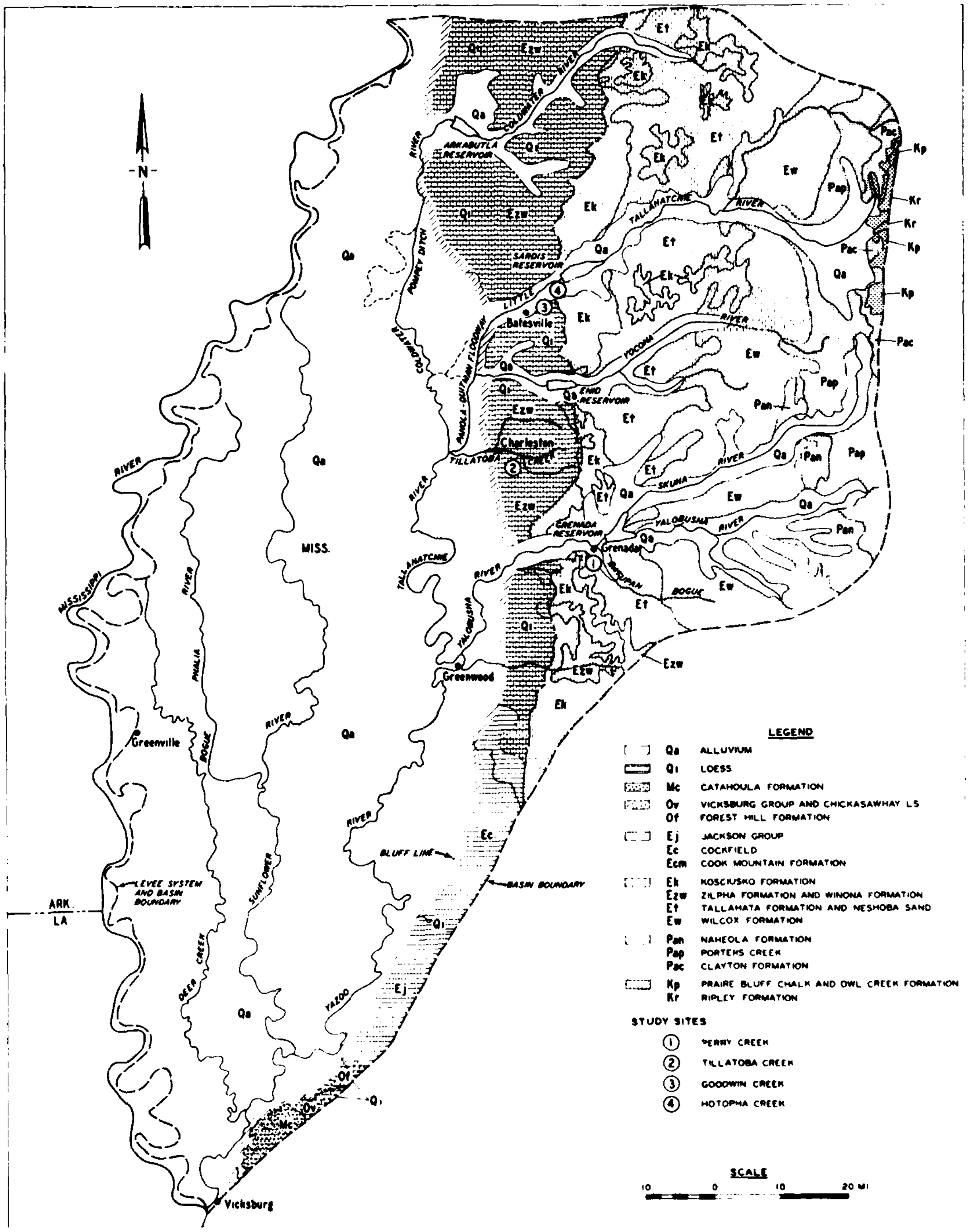

Figure 6. Geologic map of the Yazoo River Basin (Bicker 1969)

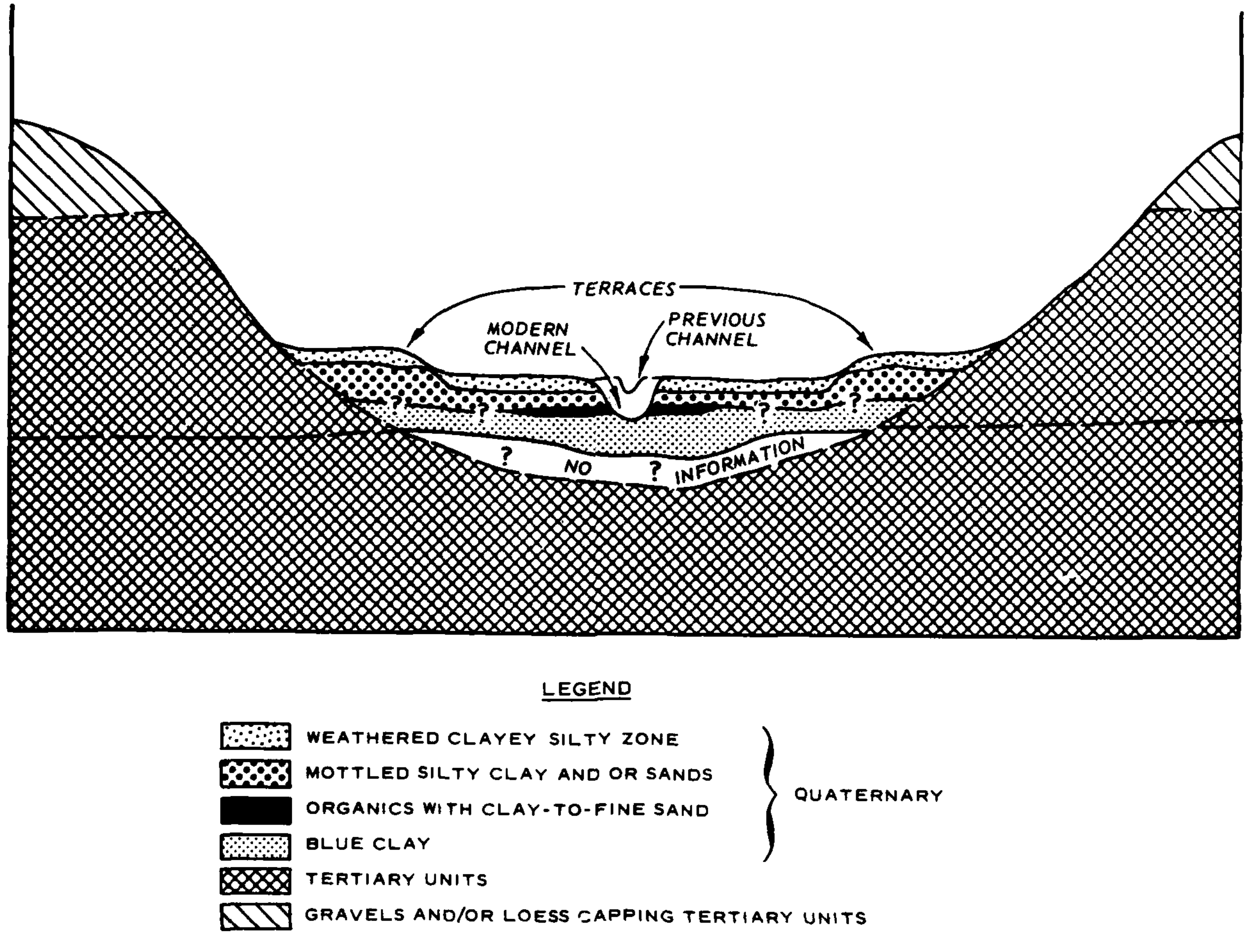

Figure 7. Idealized cross section of an alluvial valley close to the bluff line in the Yazoo River Basin

a. View showing a log in the carbonaceous zone

b. View showing the irregular top surface of the carbonaceous zone and internal structures

Figure 8. Carbonaceous zone

the age of the samples at approximately 10,000 years. Tertiary units are present in streambeds only where the streams have cut into the valley walls. Loess, Citronelle, and terrace gravels are generally located, if present, in upper sections of the streambank or capping the hills.

Soils

40. The parent materials of the soils in the four study areas were a mixture of Tertiary sands, silts, and clays, either in-place or deposited as alluvium in the stream valleys. U. S. Department of Agriculture (USDA) Soil Bulletins describe the soils as having moderate to high dispersion characteristics (Table 2). The ease of dispersion of the soils increases susceptibility to erosion (Huddleston, Bowen, and Ford 1975, Galberry 1963, Scott 1970, and Thomas and Bowen 1967 and 1975).

Geologic and Geomorphic History

41. Now that a brief description of the physiographic and geologic setting has been given and before the geomorphic conditions at the studied site are presented, there is a need to review the geomorphic history of the Yazoo Basin to better understand the significance of the site conditions. The relation between current processes and their evolution, i.e., the geomorphic history, is considered to be both a site and nonsite factor that can provide useful information on fluvial processes (Schumm 1971).

42. As previously indicated, the Yazoo Basin Lowland, or Delta as it is customarily called, is a portion of the Mississippi Alluvial Valley (or Plain) and has been occupied at various times during the Quaternary by the Mississippi River including its distributaries. The Delta, as well as other parts of the Mississippi Alluvial Valley, has been mapped in some detail, and although much remains to be learned, the geologic and geomorphic history of this area is generally reasonably well understood. On the other hand, the geologic and geomorphic history

of the Yazoo Basin Uplands is more poorly understood, particularly with respect to the fluvial history of the upland streams. This lack of knowledge results from the lack of subsurface information. Although details of the Yazoo Basin Uplands are lacking, it is apparent that the history of the upland streams is intimately related to that of the Delta.

43. Surface geologic mapping coupled with subsurface information and limited radiometric dating give data on the Holocene and to a lesser extent the Pleistocene and earlier history of the area. The subsurface information indicates that the oldest alluvial deposits are gravels with sands that lie upon Tertiary strata. These sands and gravels of variable thickness and depth are referred to as the substratum and reflect a period of the evolution of the Delta when the former Mississippi River was braided and was aggrading its valley. The age of substratum deposits is considered to be Pleistocene. However, the actual age at specific locations could be somewhat younger or older. Overlying the substratum is the top stratum, which consists of a lower sand facies and an upper facies representing rather recent stream deposits. The lower sand facies may be gradational with the underlying substratum. The top stratum is predominantly Holocene and locally Pleistocene in age. In the Delta the uppermost fluvial deposits of the top stratum consist of four general types of deposits. These are braided stream, meander belt, backswamp, and alluvial fan deposits. These deposits are shown on the map in Figure 9 and on the cross section in Figure 10 (Kolb et al. 1968).

44. The braided stream deposits are terraces reflecting both Holocene and Pleistocene sedimentation and, as such, are the oldest surfaces in the Delta. Five Mississippi River meander belts are recognized within the Delta, of which the most recent is that occupied by the present river. The backswamp deposits represent areas between meander belts where overbank deposition occurred. The alluvial fans, which are not shown on the map or cross section of Figures 9 and 10, are located along the bluff line and were surfaces of deposition occupied by upland streams as they emerged upon the alluvial valley.

45. The approximate chronology of the Mississippi River

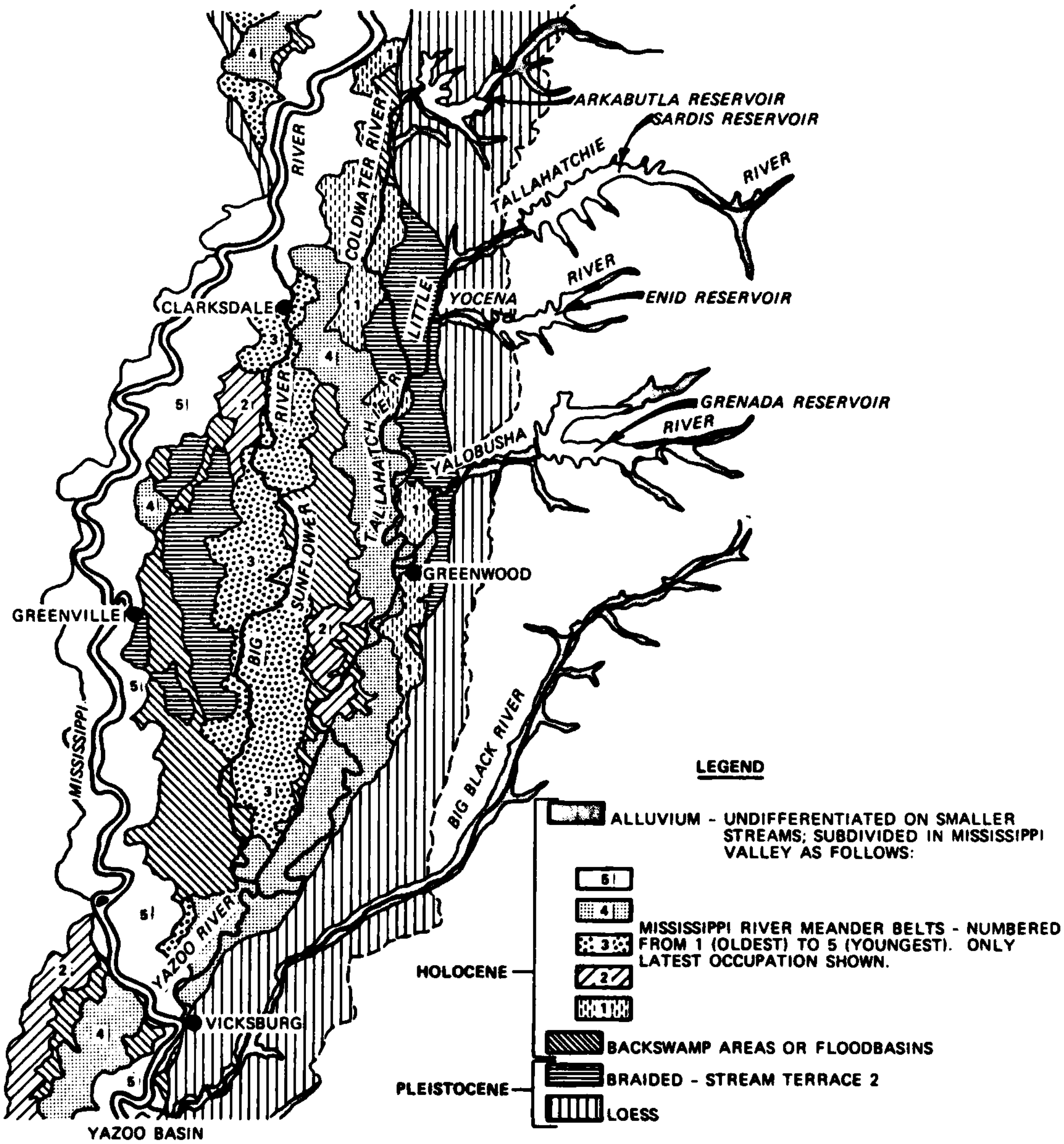

Figure 9. Quaternary geology of the Yazoo Basin (Saucier 1974)

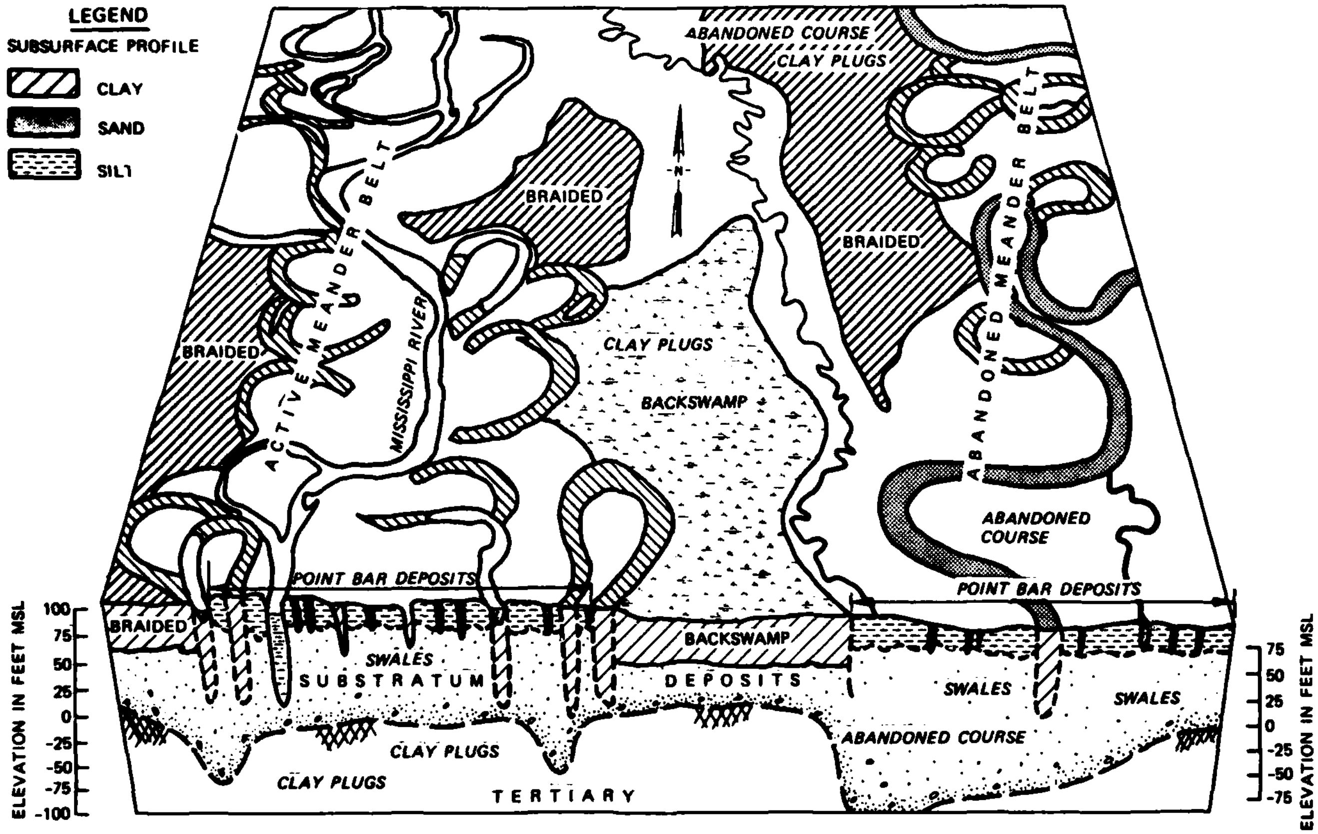

Figure 10. Major environments of deposition in the Delta (Kolb et al. 1976)

meander belts is given below (Saucier 1974):

Meander Belt	Years Before Present
5	0-2,800
4	2,700-4,800
3	4,700-6,000
2	5,900-7,500
1	7,400-9,000

46. The braided stream deposition began prior to 12,000 years before present and continued through 9,500 years before present.

47. With regard to the five identified meander belts, it is important to consider that the abandonment of a particular belt and the occupancy of another may not necessarily have been accomplished simultaneously. That is, divided flow could have occurred between an older and younger belt prior to the abandonment of the older belt. There is evidence that divided flow occurred between belts three and four and that this took place between approximately 4500 and 2500 years ago.

48. The effects on upland tributaries of divided flow, variations in degree of divided flow, and meander belt abandonment in the Delta are generally unknown. It is not possible at this time to relate surface or subsurface features in the upland valleys to events or episodes in the Delta. Current studies at the USDA Sedimentation Laboratory at Oxford, Miss., may ultimately provide some solutions. These studies involved detailed mapping, radiometric dating, and subsurface work in the upland stream valleys and interfluve areas for the purpose of elucidating the evolution of these streams and their response to geomorphic and environmental factors.*

49. It is apparent that the Mississippi River has acted as a local base level for the upland streams and as such has controlled the longitudinal profile of these streams as well as the profiles of any other Delta streams to which the upland streams were tributaries. Both the lateral and vertical movement of the Mississippi River causes

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* Personal communication, Dr. Earl Grissinger, USDA Sedimentation Lab, Oxford, Miss.

changes in the gradient of the Delta and upland tributaries.

50. The response of the Delta streams to vertical base level changes would include aggradation when the base level was raised and degradation when the base level was lowered. The aggrading or degrading conditions established in the Delta would proceed upstream into the uplands.

51. The lateral movement of the Mississippi River by the development of divided flow and the abandonment of meander belts would have resulted in a change in the gradients of these tributaries. Whether the gradients were increased or decreased would depend upon the location of the new meander belt with respect to the bluff line. For example, either the occupancy of a new meander belt or the increase in divided flow of a new meander belt located nearer to the bluff line would result in an increase in the gradient of tributary streams or degradation. On the other hand, the occupancy of a meander belt farther from the bluff line would result in a decrease in the gradient of tributary streams or aggradation. The approximate times of these lateral base level changes may be inferred from the data given in paragraph 45 and from Figure 9 which shows the meander belt locations. These changes are given below:

Meander Belt Change	Direction of Movement	Years Before Present	Effect on Tributary Gradients
1/2 to 3	West	6,000	Decrease
3 to 4	East	4,800	Increase
4 to 5	West	2,800	Decrease

52. The general geomorphic character of the upland valley indicates that the upland streams have responded in the past to processes similar to those described for the Delta. In particular, the evidence for response to base level change is the presence of terraces in these valleys. Generally, two or three low terraces can be seen on large-scale aerial photographs for most valleys. No attempt was made in this study to map these terraces; however, this mapping could provide some insight on valley development and should be accomplished. Another characteristic somewhat related to the terraces is valley size. Ordinarily,

the upland valleys are appreciably larger than the streams meander belts; i.e., the streams are underfit. The presence of terraces and the underfit conditions characterizing the upland valleys could also be attributed to climatic changes occurring regionally as well as to avulsions occurring in the Delta.

Tillatoba Creek

Present channel

53. Streambanks consist predominantly of Quaternary or Holocene clay overlain by mottled silts or silty-clays, with a weathered soil zone less than 1-ft thick at the top. A 1-ft- to 3-ft-thick carbonaceous zone containing logs, wood fragments, leaves, and nuts overlies the clay in most places. Local sections of the streambanks consist of several feet of fine- to medium-grain sand. Loess, Citronelle gravels, and/or the Eocene Zilpha clay are present in the streambanks where the streams have cut into a valley wall. The banks, which are 15 to 20 ft high, are nearly vertical along most of the channels (Figure 11). Streambeds are locally cut into Tertiary and Quaternary clays and sand. Large quantities of sediments are present in the channels along the lower reaches of the North and South Forks.

Channel changes

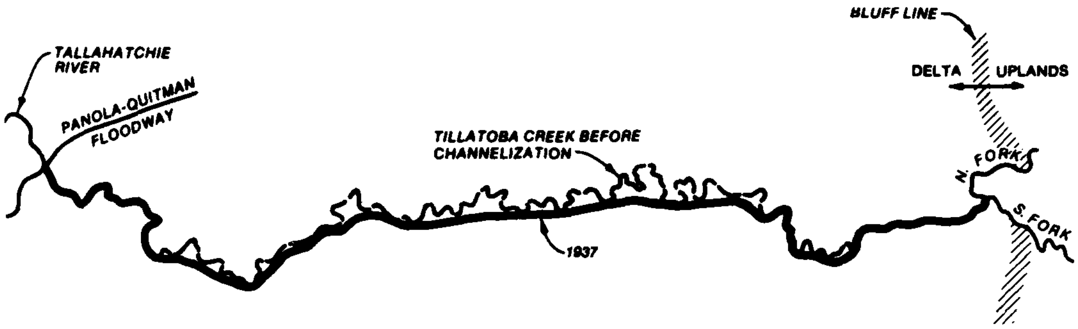
54. Tillatoba Creek Basin is the largest of the four study sites. Tillatoba Creek is located entirely in the Delta flatlands and was channelized in the 1920's (Figure 12). North, Middle, and South Forks are located entirely in the uplands. Middle Fork is a tributary of South Fork and is the only one of the three major upland streams to have been partially channelized.

55. Man-induced changes during the early 1900's, such as land clearing, farming, and channelization of small tributaries, changed the hydaulic geometries in the Tillatoba Creek Basin. The most noticeable change was the large increase in sediment load, which appears to have caused more extensive channel changes in the smaller tributaries. Many of the first-, second-, and third-order streams more than tripled in

a. South Fork

b. Middle Fork

Figure 11. Tillatoba Creek banks



TILLATOBA CREEK

PRE-CHANNELIZATION CHANNEL LENGTH-11.0 MILES
CHANNEL LENGTH-7.8 MILES

Figure 12. Tillatoba Creek before and after channelization

width by 1941, as the large influx of sediments from the gully streams caused erosion of the streambanks. There was no major observable erosion in the larger channels in 1941; however, the generally ragged appearance of all channels in the basin and the entrenched appearance of some of the smaller tributaries indicate that channel erosion was or had been more active than in 1937. Conservation practices, which were started in the 1930's, gradually reduced upland erosion, thereby reducing the sediment load in the streams (Figure 13).

56. Streambed and bank erosion are presently occurring at an excessively rapid rate. Chronological sequences of aerial photographs of several sites along each of the major channels show channel morphology changes as the channel erosion or knickpoint(s) advances upstream.

57. Site T1 is located at the mouth of Tillatoba Creek and includes approximately 1 mile of the channel (Figure 14). This section of Tillatoba Creek was not channelized. Channel width doubled from 1937-79. The increase in width occurred at a uniform rate, rather than having one short period of rapid bank erosion. The smaller meander loops were cut away, while the larger meander loops have not been extensively altered, except for the meander loop at the mouth. This meander loop has been gradually eroded into a very tight loop, which will probably be cut off in the near future.

58. Site T2 is located at the confluence of North and South Forks, 6.8 miles (1957 stream distance) upstream from the mouth of Tillatoba Creek and includes approximately one-half mile of Tillatoba Creek,

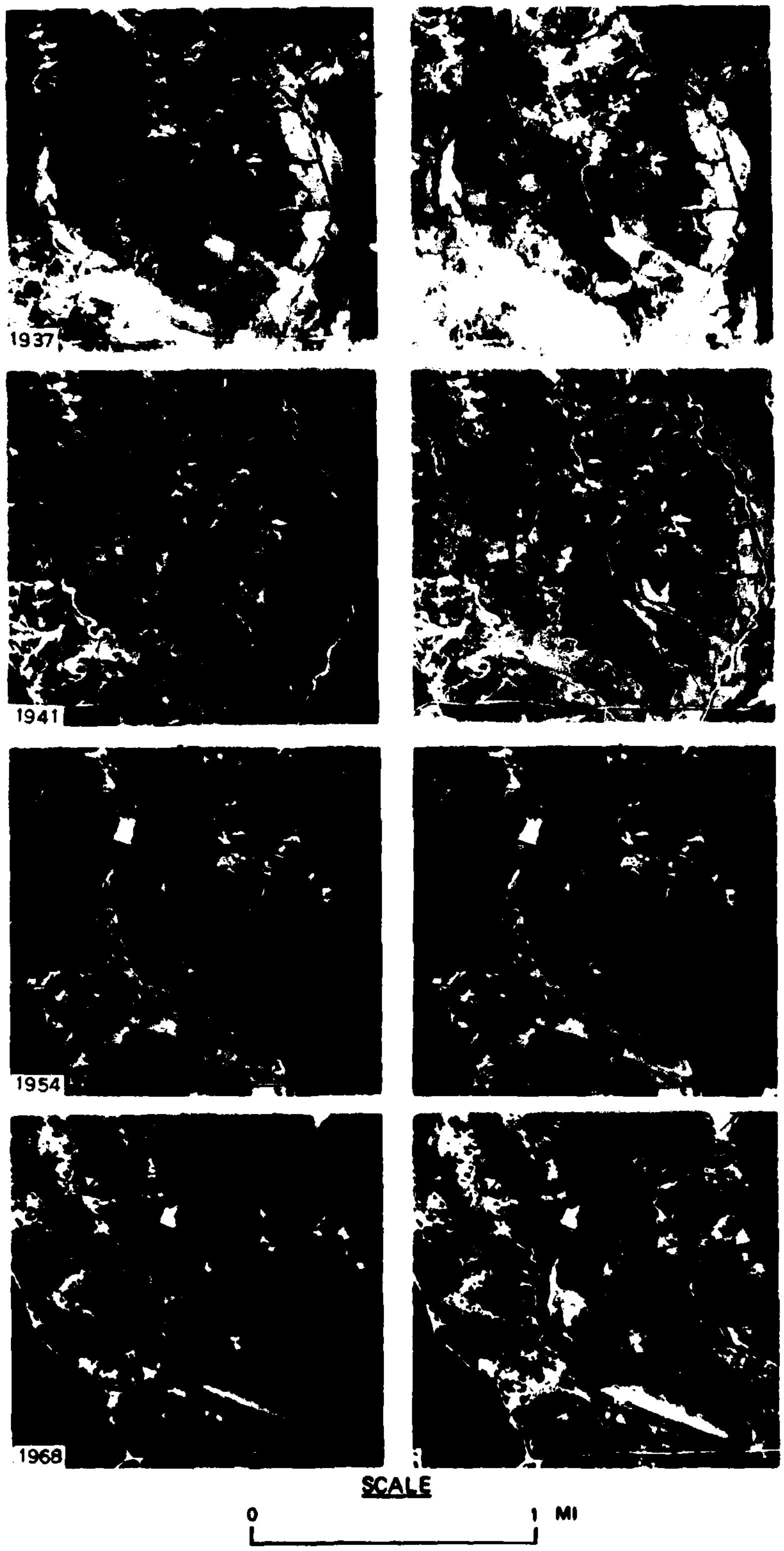


Figure 13. Conservation practices that decrease upland erosion

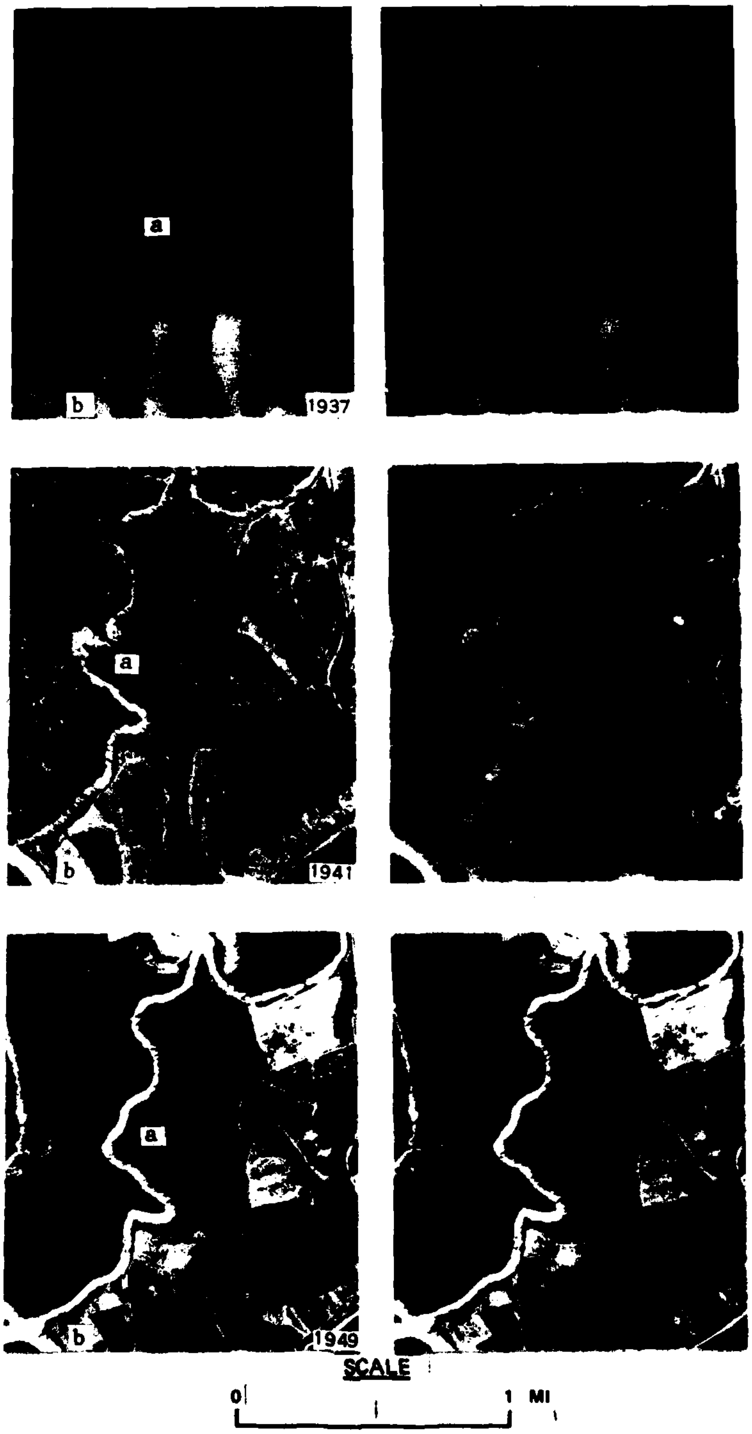


Figure 14. Site T1 on Tillatoba Creek (Symbol "a" designates Tillatoba Creek; "b" is Tallahatchie River, and "c" is the Panola-Quitman Floodway; see 1979 photos.) (Continued)

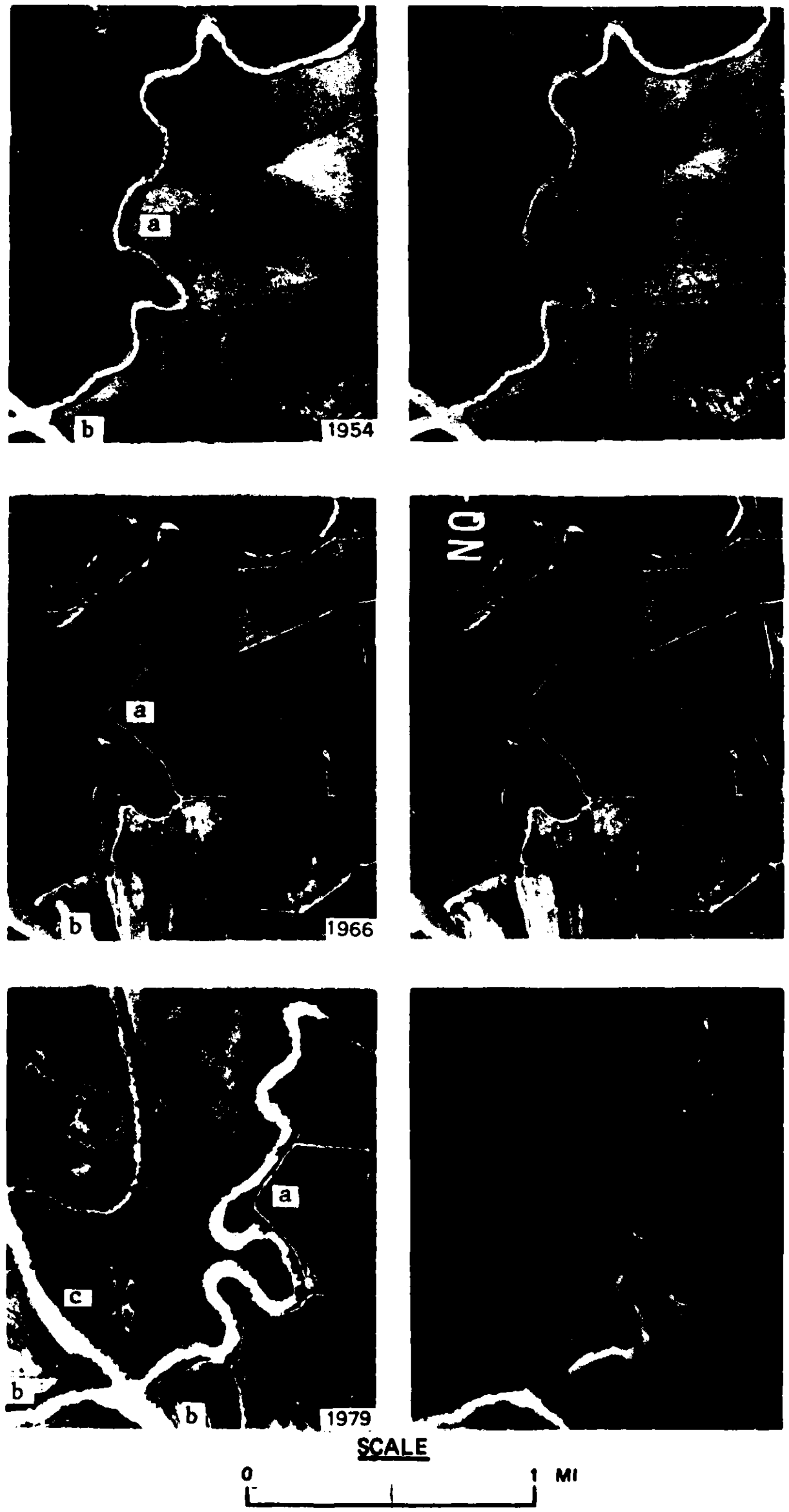


Figure 14. (Concluded)

North Fork, and South Fork (Figure 15). No observable erosion occurred on the vegetation-covered 1937 channels. Tillatoba Creek and a short reach of North and South Forks at the mouths had more than doubled in width by 1941. The banks in this area appeared as raw fresh cuts that were being actively eroded. Frequent slumps and cave-ins in the upper stretch at site T2 indicate bank erosion was very active there in 1941. The channel width of North and South Forks had not increased significantly from 1937 to 1941. The hanging tributaries indicate channel degradation had been or was still active in 1941. Point bars were better developed and more numerous in the lower stretch of site T2.

59. Bank erosion had increased the 1954 channel width of all three channels at site T2 to double that of 1937, and the banks were still eroding in 1954, especially the outside banks of the meanders. Channel widths have continued to increase since 1954. The increases in channel widths since 1954 have not been as extensive as the 1937-54 increases. Isolated stretches of previous streambeds at higher elevations than present streambeds and hanging tributaries indicate the channels have degraded. Point bars were numerous and well developed in all channels from 1954 to present. The thalweg meandered in the wider channels, eroding the banks where it was deflected against the banks by point bars.

60. Site T3 is located on North Fork, 3.9 miles (1962 stream distance) upstream from the mouth of North Fork and includes approximately one-half mile of the channel (Figure 16). The only detectable bank erosion in the 1937 channel was occurring on the outside banks of meander loops. No significant observable changes occurred in channel dimensions by 1941. The generally ragged appearance of the channel indicates the channel had been or was being eroded. The channel width in the lower stretch of site T3 had more than tripled by 1954, and the banks in the upper stretch were being very actively eroded. The extremely rapid rate of bank erosion at T3 can be seen by comparison of the 1941, 1954, 1962, 1966, and 1976 aerial photographs (Figure 16). Bank width increased 283 percent from 1941-76. The wide channels had large, well-developed point bars. The thalweg was meandering in wide sediment-filled channels,

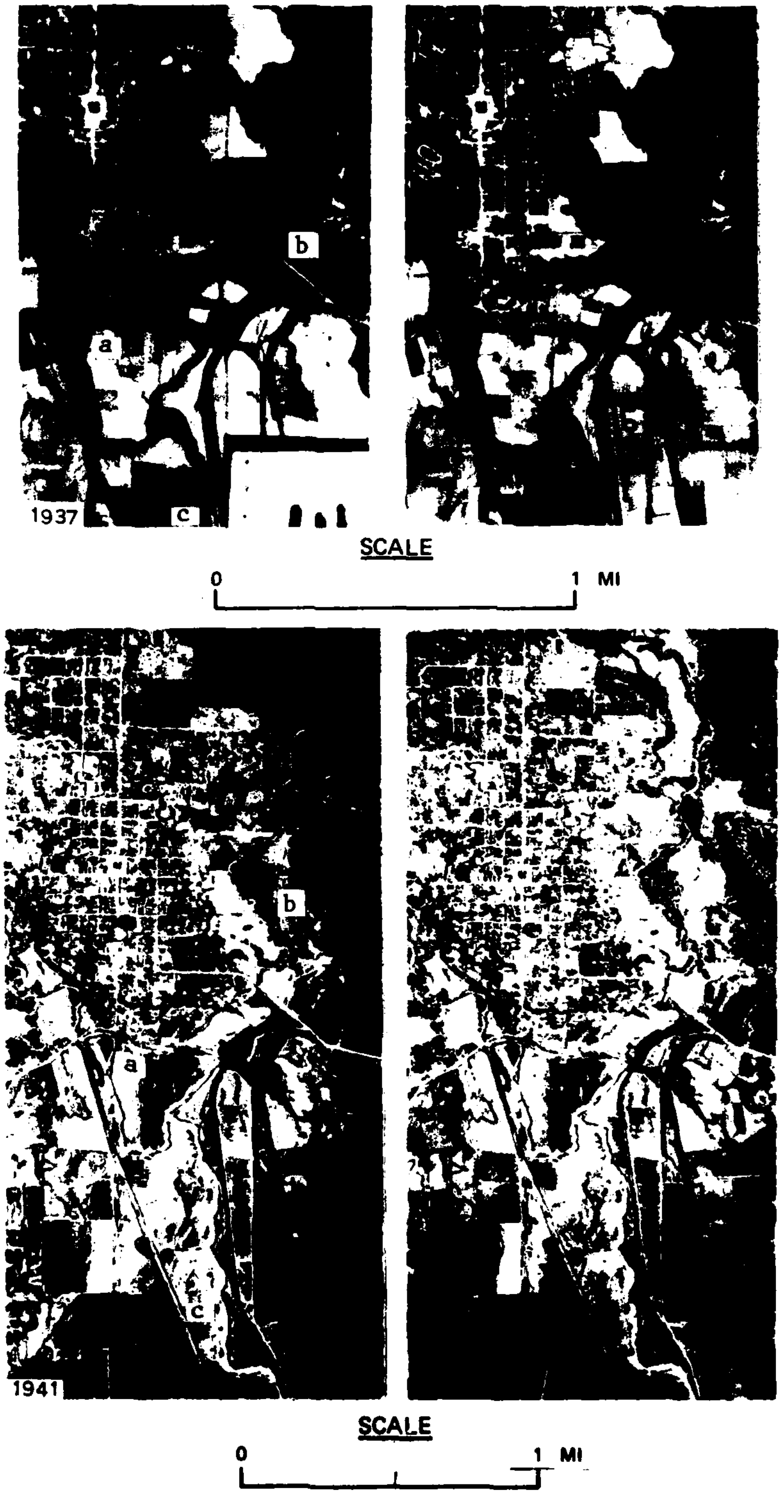


Figure 15. Site T2 in Tillatoba Creek Basin (Symbol "a" designates the North Fork, "b" is South Fork, and "c" is Tillatoba Creek (Sheet 1 of 3)

Figure 15. (Sheet 2 of 3)

Figure 15. (Sheet 3 of 3)

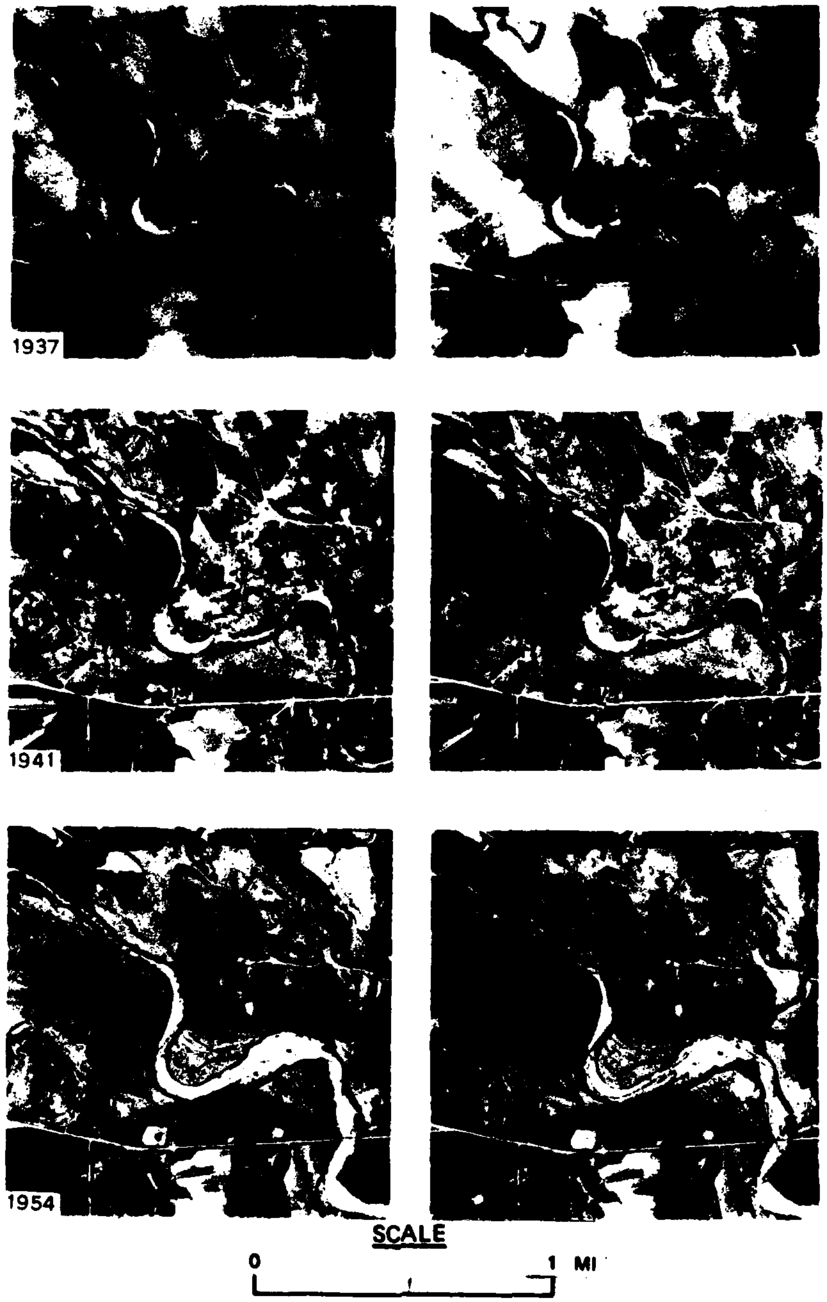


Figure 16. Site T3 in Tillatoba Creek Basin, North Fork (Continued)

Figure 16. (Concluded)

eroding the banks where it was deflected against a bank. Hanging tributaries indicate the channel had degraded.

61. Site T4 is located on North Fork at the mouth of Sandy Creek, 8.3 miles (1962 stream distance) above the mouth of North Fork and includes approximately 1 mile of the North Fork channel (Figure 17). The erosional effects of the large sediment loads from upland erosion were more noticeable on the North Fork channel and its tributaries in the upper reaches of the North Fork Basin. North Fork and Sandy Creek channels appeared entrenched in 1937. The banks were steep and vertical with numerous gullies cutting into them. The smaller drainages had hanging channels. The channel width of North Fork and Sandy Creek decreased from 1937-79. The quantity of sediments in the channels also appears to have decreased with time. The 1937-41 channel appears to have been entrenched in an older channel that was two to three times wider than the 1941 channel. North Fork channel is presently being rapidly eroded approximately 2 miles downstream from site T4 and appears stable 1 mile upstream from T4 (Figure 18).

62. Site T5 is located on South Fork, 5.8 miles (1954 stream distance) upstream from the mouth of South Fork and includes approximately one-half mile of the channel (Figure 19). The 1937 channel was lined with vegetative growth. No observable channel erosion is seen in the photos. The 1941 channel is slightly wider than the 1937 channel. Judging from the rough fresh cut appearance of the banks, bank erosion was very active. Hanging tributaries were being eroded near the tributary mouths. The channel width of South Fork more than doubled from 1941-54. A very significant increase in channel depth occurred. The increase in vegetative debris, absence of point bars, decrease in channel width, rough appearance in the upper stretch of the channel, and irregular shape of the point bars in the lower stretch indicate the upper stretch was being very actively degraded. The meander loop in the lower stretch was cut off by man during the early 1950's. The channel has continued to widen and deepen since 1954, but not as rapidly as during the 1941-54 period. The elevation differences between the bed of the cutoff meander loop and subsequent channel beds indicates the

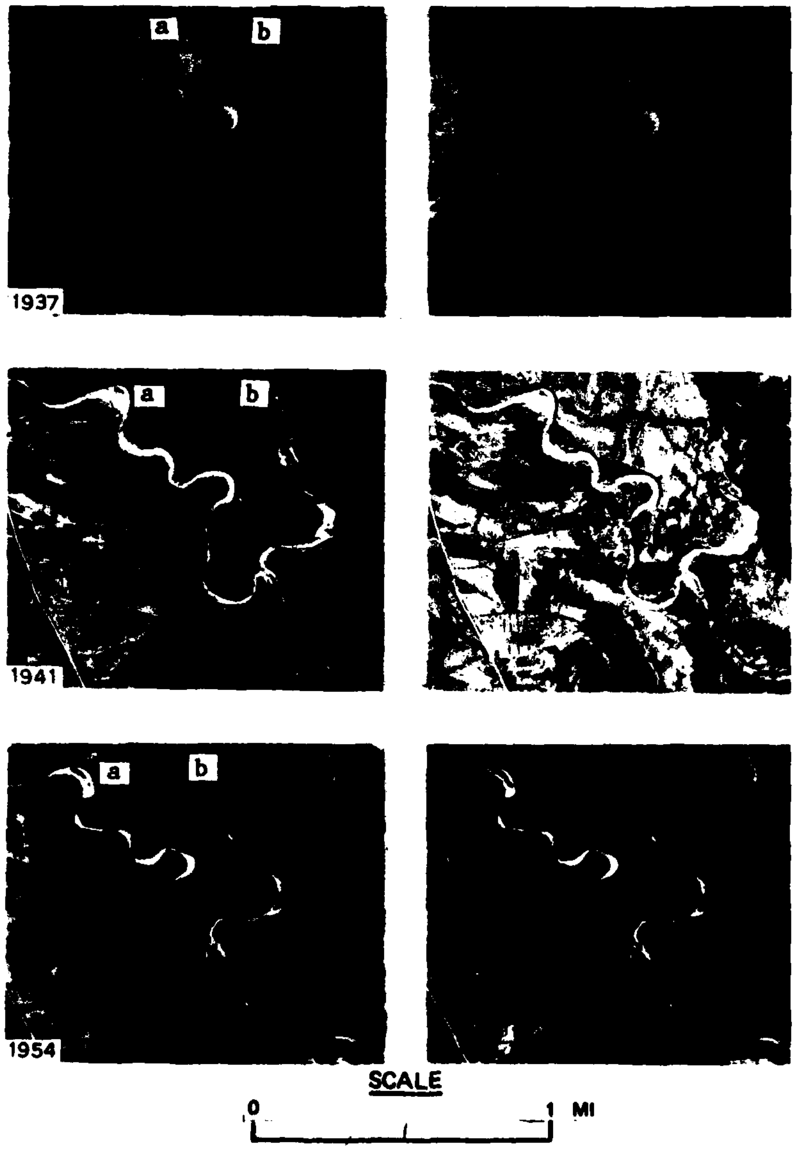


Figure 17. Site T4 in Tillatoba Creek Basin (Symbol "a" designates Sandy Creek, and "b" is North Fork.) (Continued)

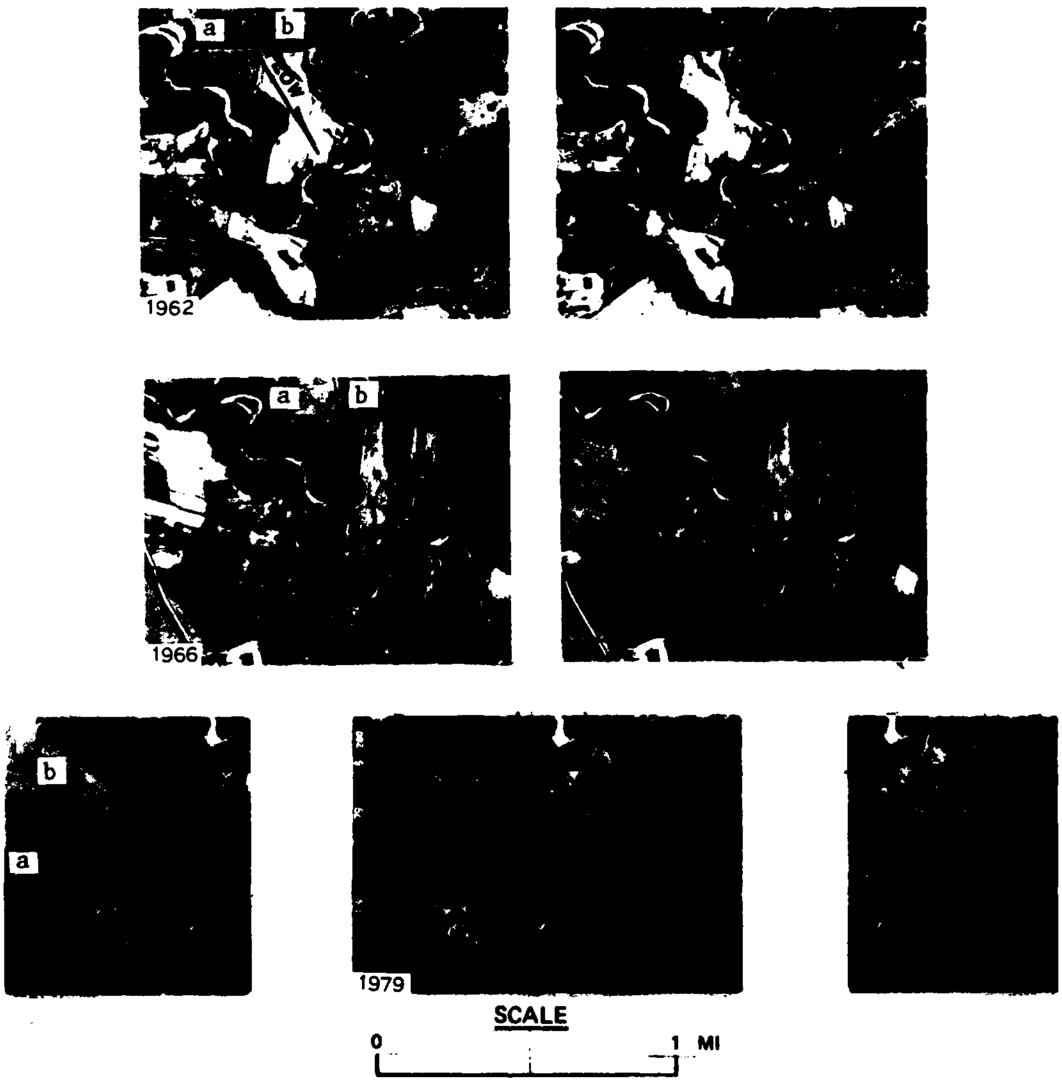


Figure 17. (Concluded)

a. Approximately 1/2 mile downstream from site T4 (Sep 1977)

b. Approximately 1-1/2 miles downstream from site T4 (Sep 1977)

c. Same area as "b" (Feb 1980)

Figure 18. North Fork channel (Symbol "a" is a stable channel, "b" is an unstable channel, and "c" shows several feet of bank erosion that occurred from Sep 1977 to Feb 1980; the lower grade-control structure on North Fork can be seen in the background of "b" and "c.")

Figure 19. Site T5 in Tillatoba Creek Basin, South Fork (Continued)

Figure 19. (Concluded)

channel is degrading. Bank erosion has cut away the meander loops in the channel, thereby shortening the channel.

63. Site T6 is located on South Fork 11.3 miles (1954 stream distance) upstream from the mouth and includes approximately 1.5 miles of the channel (Figure 20). There are no currently observable areas of significant bank erosion in this stretch of channel. A couple of sharp meander loops were cut off by natural erosion between 1941 and 1954. A knickpoint had advanced into the lower stretch of site T6 by 1966. The channel width in this area more than doubled as the knickpoint advanced upstream. The knickpoint had advanced through site T6 by 1979. The 1979 channel width was two to three times the 1954 width. Bank erosion cut away the meander loops, thereby shortening the channel length. Hanging tributaries were rapidly widening as the knickpoint(s) advanced up them.

64. Site T7 is located on Middle Fork 3 miles (1954 stream distance) upstream from the mouth of Middle Fork and includes approximately 1 mile of the channel (Figure 21). The channel upstream from the bridge was channelized prior to 1937. There has been no significant increase in channel width between 1937 and 1977. The roughness of the 1937 and 1941 banks indicates some bank erosion had occurred or was occurring, but no major increase in channel width occurred. There was no observable increase in channel depth from 1937-77. The channel directly below site T7 was being very rapidly eroded in 1977, as a knickpoint advanced upstream (see 1977 photographs in Figure 21).

65. Site T8 is located on Middle Fork 11.5 miles (1954 stream distance) above the mouth and includes approximately one-half mile of the channel (Figure 22). The upper half of Middle Fork was channelized in three different stages: the headward stretch was channelized before 1941; the middle stretch, which includes site T8, in the early 1950's; and the lower stretch in the 1960's. There was no significant observable erosion on the 1937 or 1941 channels. There were numerous large splay deposits scattered across the 1941 floodplain; however, the channel does not appear to have been clogged with sediments. This section of North Fork was channelized in the early 1950's. There was no significant

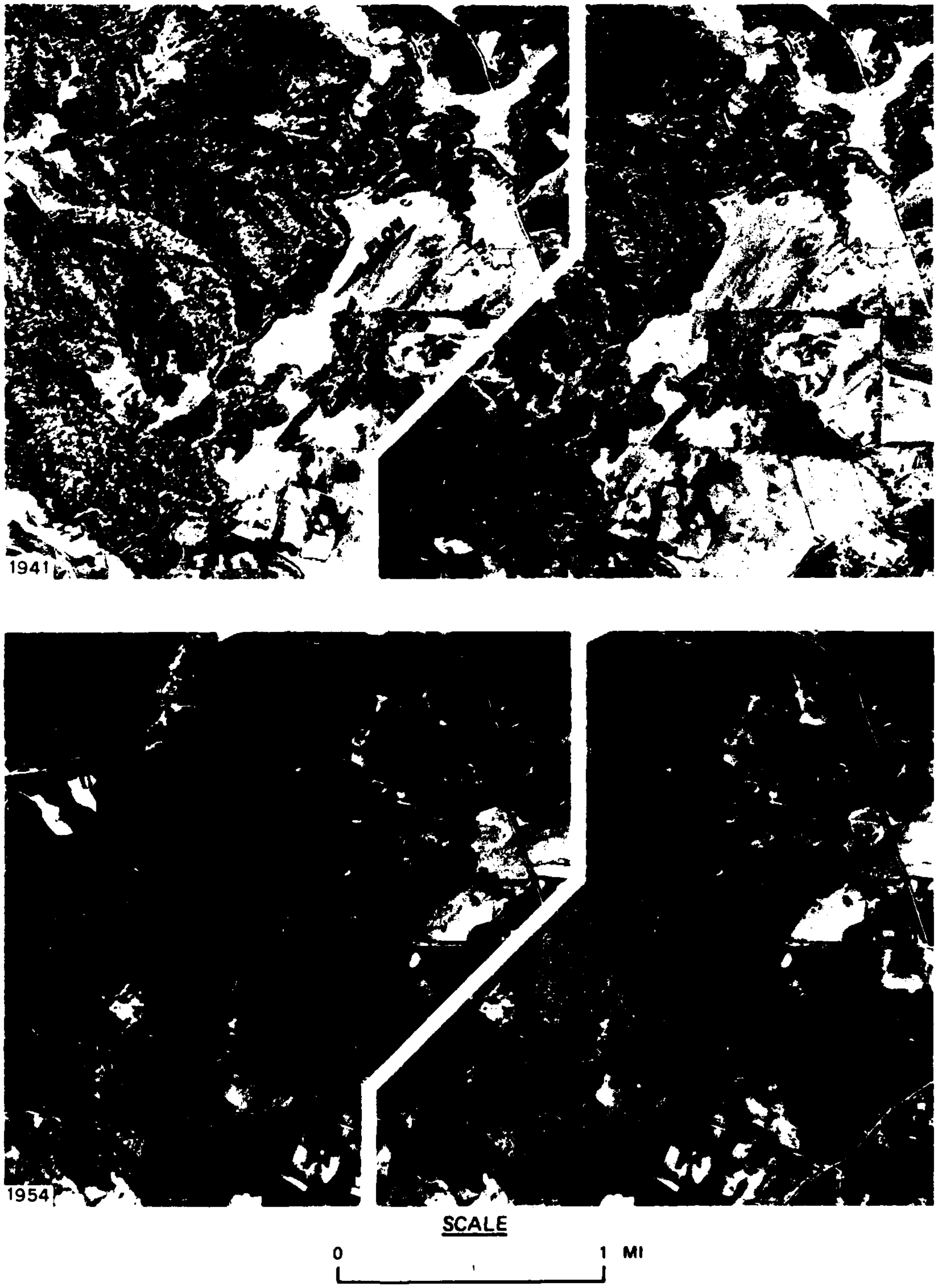


Figure 20. Site T6 in Tillatoba Creek Basin, South Fork (Continued)

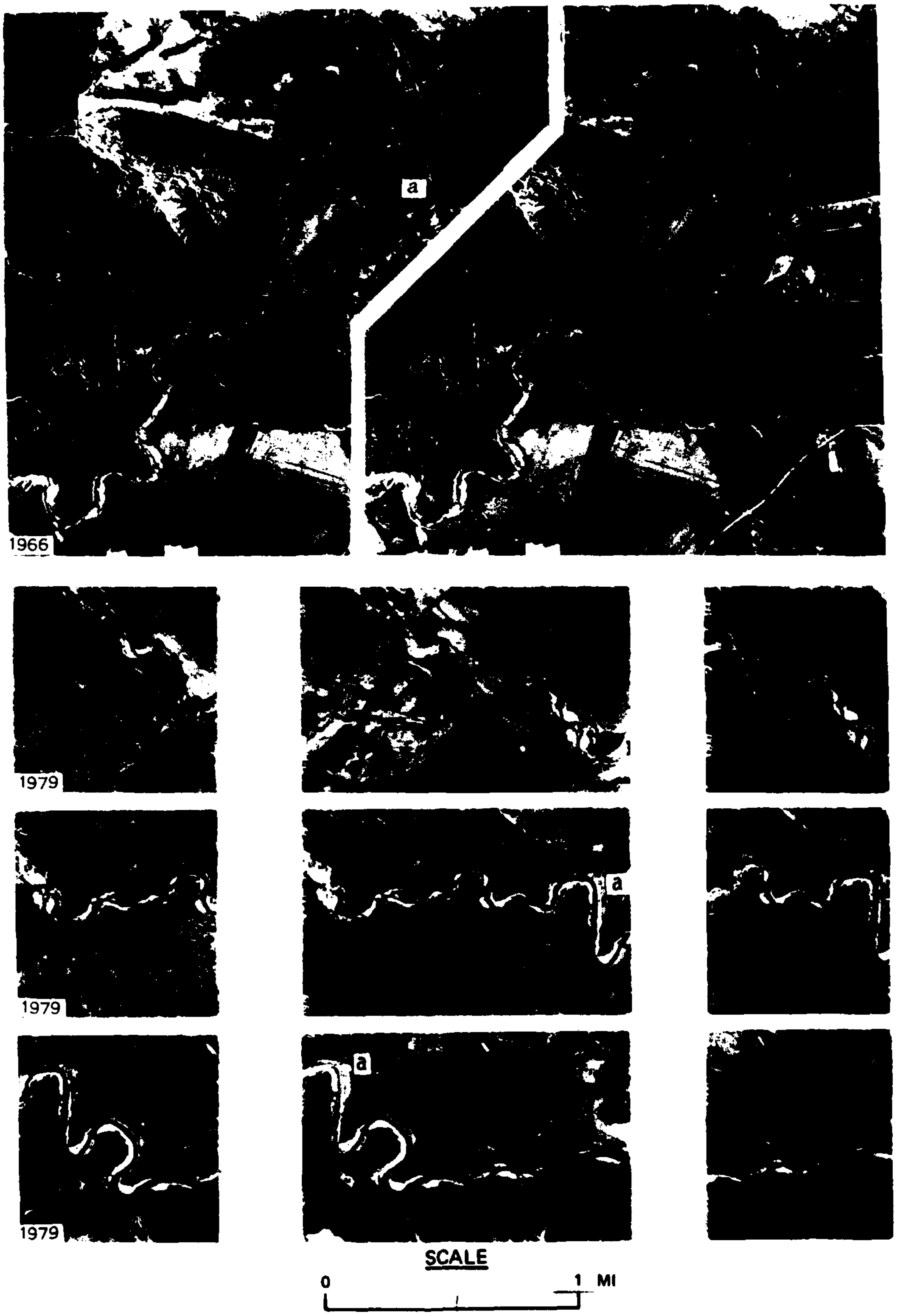


Figure 20. (Concluded)

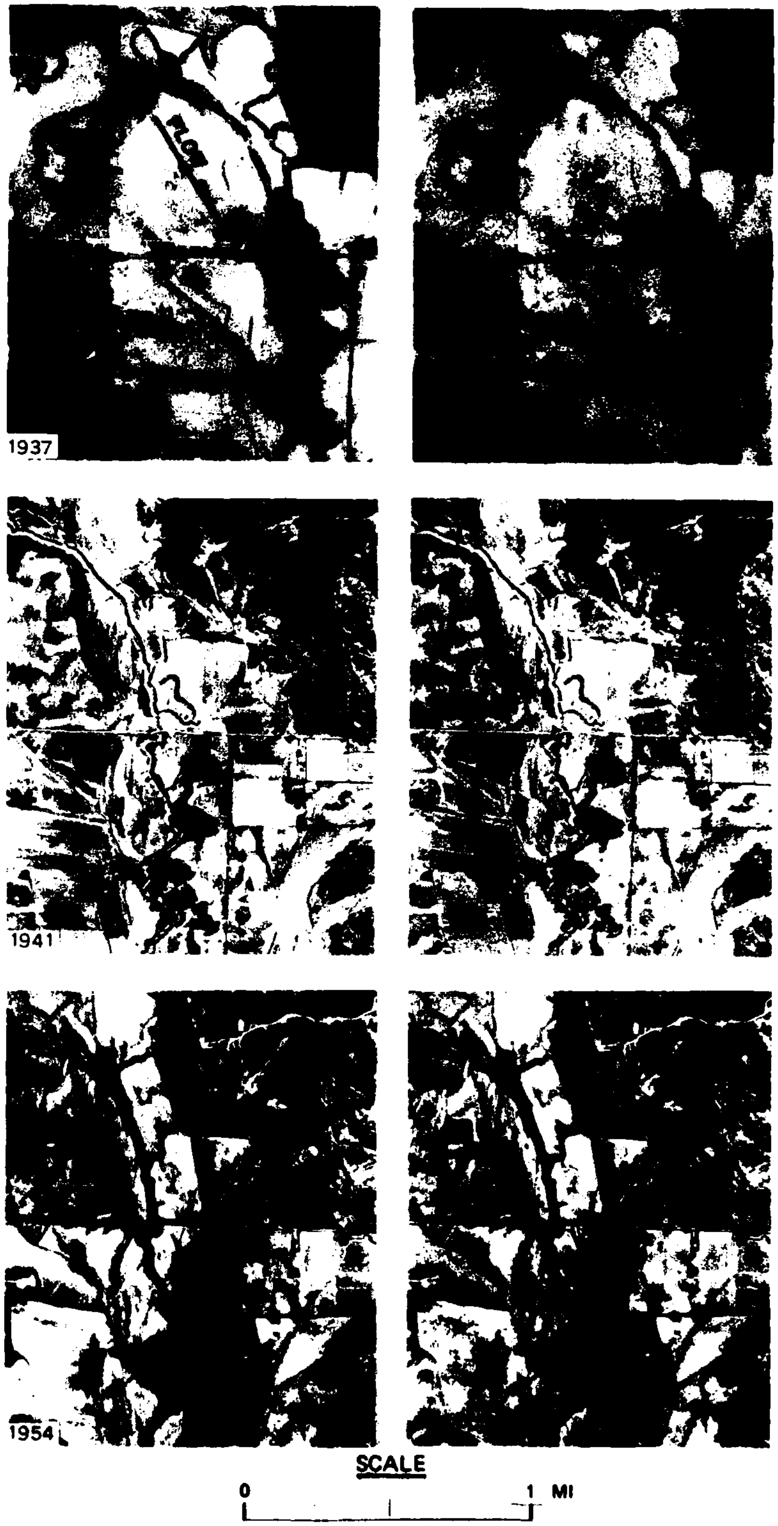


Figure 21. Site T7 in Tillatoba Creek Basin, Middle Fork (Continued)

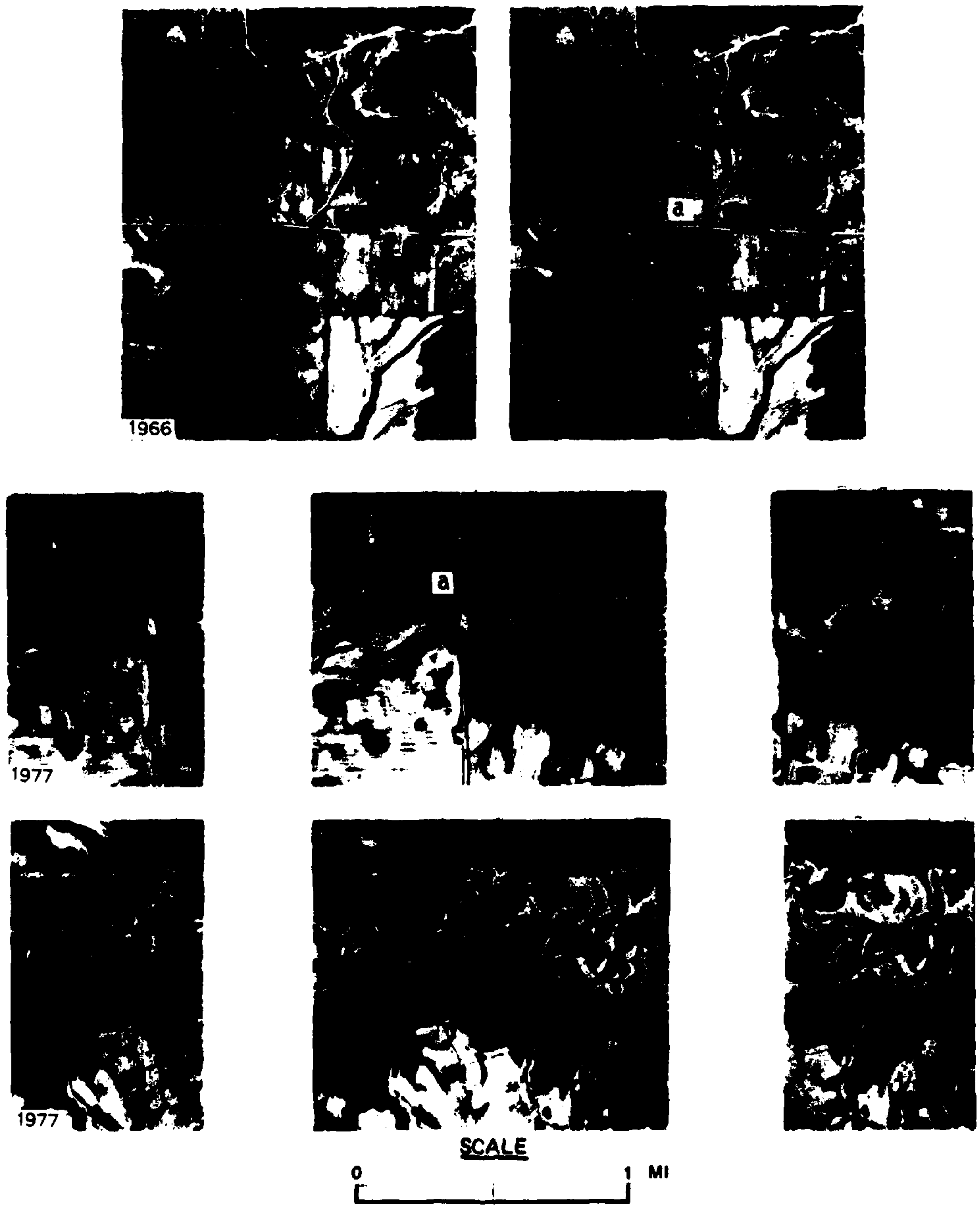


Figure 21. (Concluded)

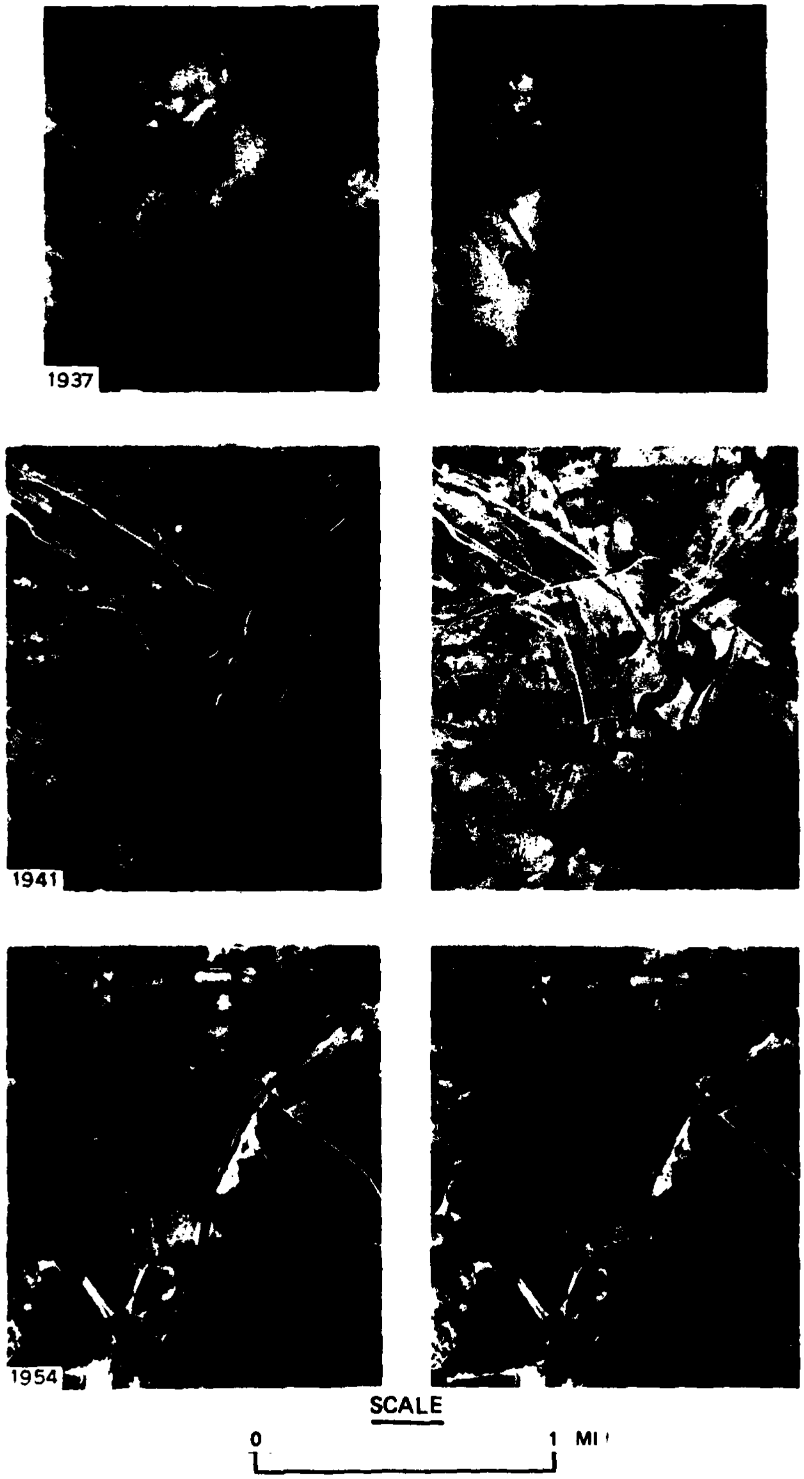


Figure 22. Site T8 in Tillatoba Creek Basin, Middle Fork (Continued)

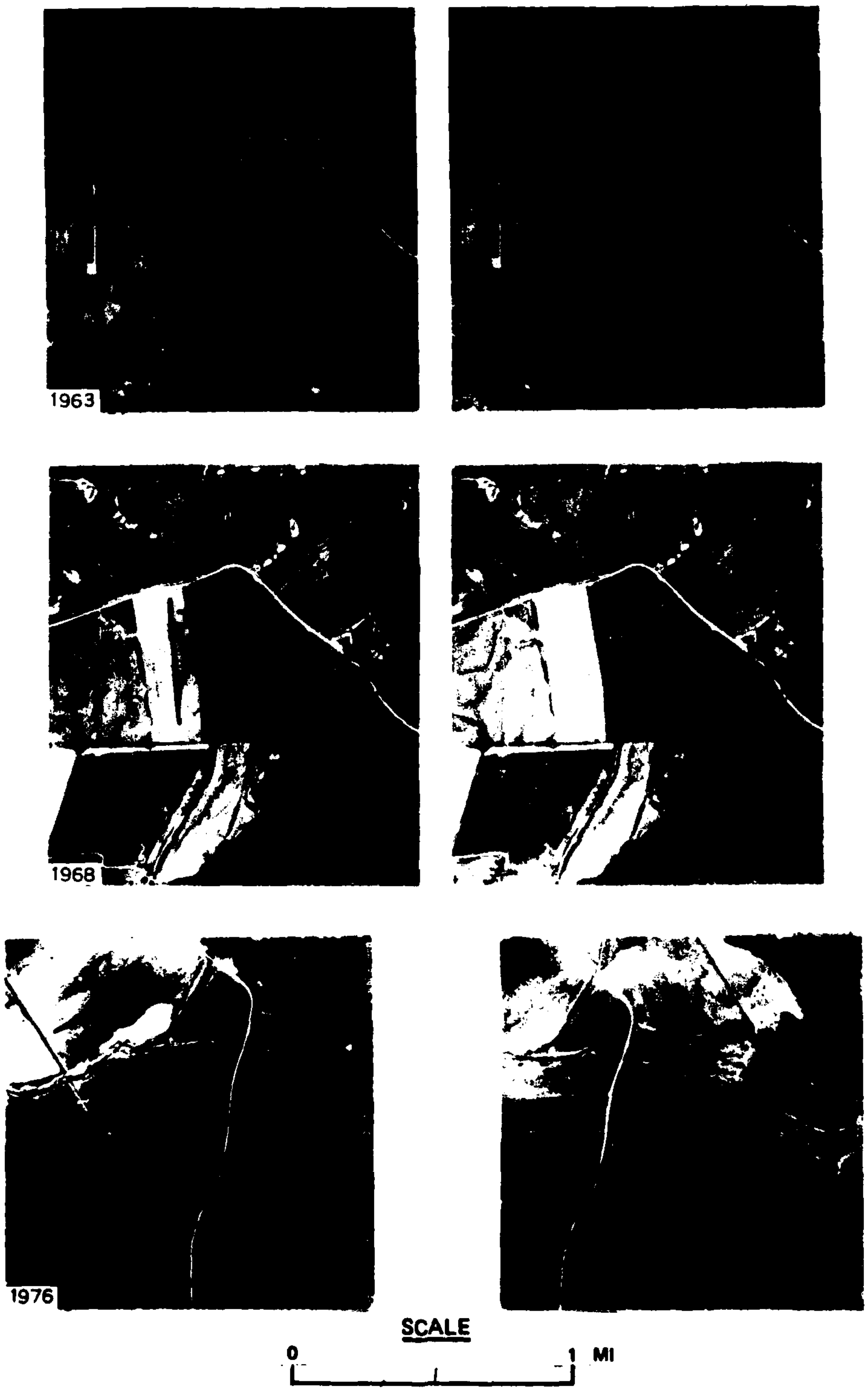


Figure 22. (Concluded) (The 1976 photographs are rotated 90°.)

observable erosion in the channel until 1968, when bank erosion had noticeably widened the lower stretch of the channel. The entire channel in site T8 had nearly doubled in width and degraded several feet by 1976. Figure 23 shows the changes in channel geometry as a knickpoint moved through the channel in 1974-76. Figure 24 shows stereo views of the knickpoint(s) advancing upstream. The knickpoint is cutting into an erosional resistant Tertiary or Quaternary clay. Figure 25 shows a December 1977 and February 1980 view of the waterfall at location c in Figure 24. The waterfall is being held up by this resistant clay. The banks upstream from the waterfall have been eroded as the resistant clay is gradually cut down. A similar waterfall has been formed in the resistant clay directly downstream from the bridge since December 1977 (Figure 26). Note the large blocks of clay caving off at the waterfall. A waterfall approximately 6 ft high formed in the resistant clay at the mouth of the tributary directly downstream from the bridge in Figure 27. Large blocks of the clay are caving off the oversteepened walls of the bank and waterfall. The waterfall on the tributary is an indication of the extensive degradation that has occurred on Middle Fork.

66. Tables 3, 4, 5, and 6 summarize the geomorphic changes on Tillatoba, North Fork Tillatoba, South Fork Tillatoba, and Middle Fork Tillatoba Creeks as observed on the chronological sequences of aerial photographs and from field observations.

67. The only significant channel erosion in the 1937 Tillatoba Creek Basin was in the small upland channels directly associated with active gullying. All of the channels in the 1941 basin appear to have been eroded to some extent. The only extensive erosion of a major channel occurred in Tillatoba Creek. The channel erosion appears to have been advancing upstream on the major upland channels and their tributaries since 1941. The 1954 longitudinal profiles of the major channels are very irregular, especially in the lower reaches (Figure 28). Comparison of the 1954 and 1976 longitudinal profiles shows the channels have degraded as the knickpoint(s) advanced upstream. The irregularity of the 1976 longitudinal profile suggests that the channels are still degrading. The convex upward shape of the longitudinal profile of

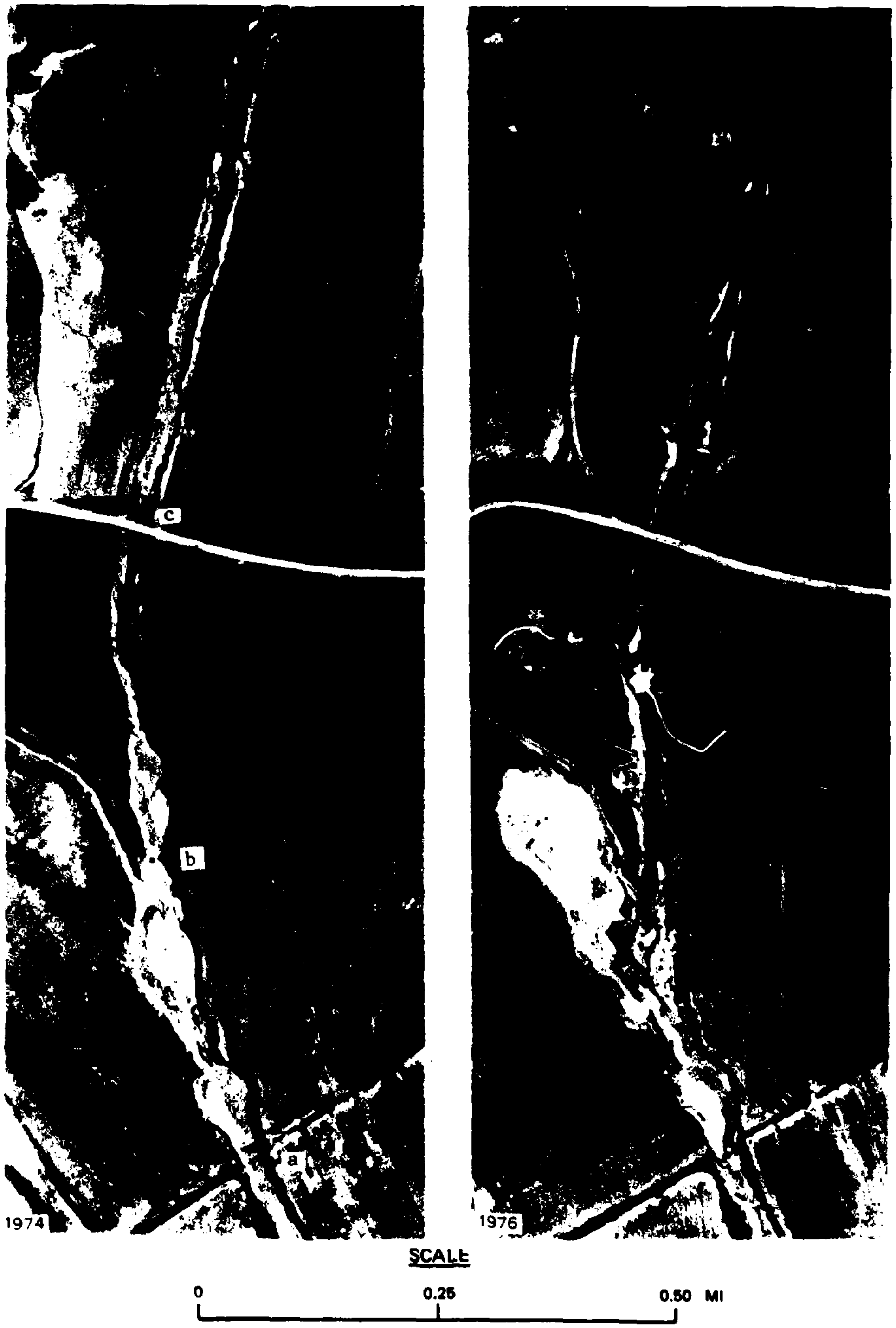


Figure 23. Channel erosion from the upstream movement of a knickpoint at site T8 (See Figure 24 for a chronological sequence of stereo photographs at locations a, b and c. Note the Indian mound to the left of location b is being leveled in the 1976 photographs.)

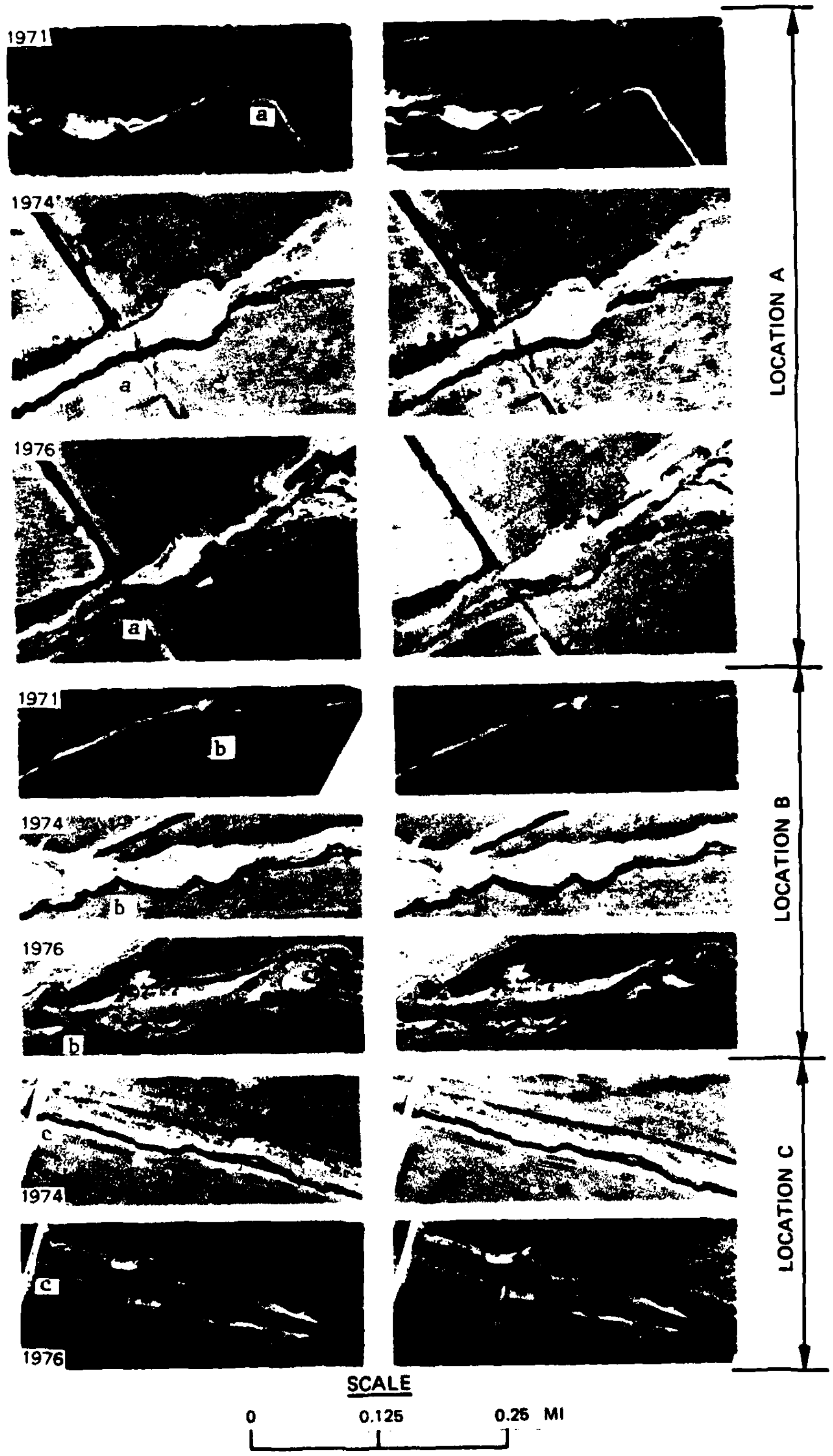


Figure 24. The upstream movement of a knickpoint at site T8 (See Figure 23 for locations a, b and c.)

a. December 1977

b. February 1980

Figure 25. Knickpoint upstream of the bridge at location c in Figure 23

a. Dec 1977, looking downstream from the bridge in Figure 23

b. Feb 1980, same area shown in photo a

Figure 26. Channel degradation downstream of the bridge at location c in Figure 23

Figure 27. Knickpoint at the mouth of the tributary at location b in Figure 23 (Feb 1980)

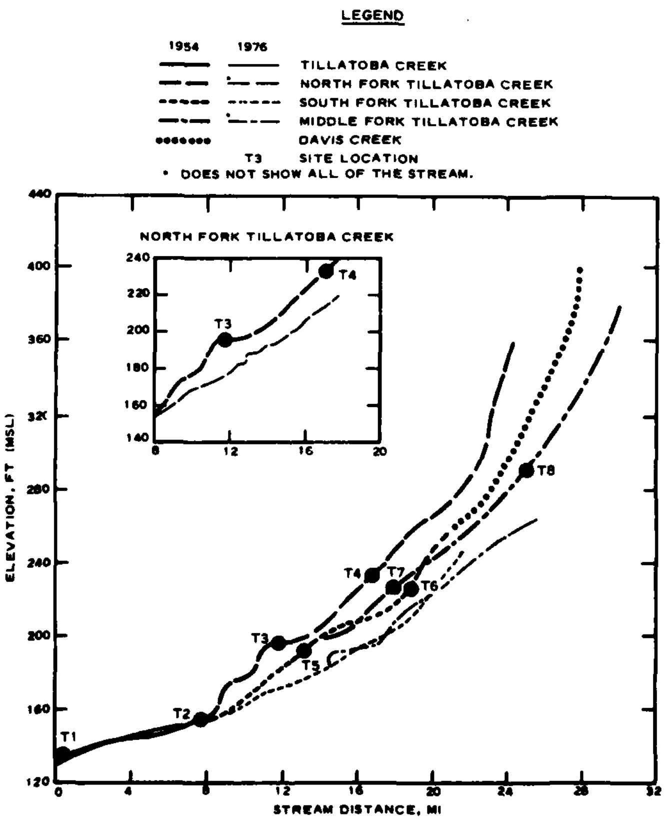


Figure 28. Longitudinal profile of the major streams in the Tillatoba Creek Basin (1954 data from U. S. Geological Survey (USGS) Topographic Maps; 1976 data from survey data; sites T1 through T8 are located on the 1954 profile.)

Tillatoba Creek in 1954 and 1976 indicates that further degradation of the upland streams can be expected. Tillatoba Creek is cutting into an erosion-resistant clay, which is retarding the upstream advance of the knickpoint (Figure 29). The erosion-resistant Quaternary and Tertiary clays form rapids and waterfalls in the stream channels throughout the basin.

68. The upstream movement of the knickpoint(s) has been slower on North Fork than on South Fork. The fact that the South Fork Basin is two and a half times larger than the North Fork Basin and therefore has more flow is one factor that could explain the slower upstream advance of the knickpoint on North Fork. The major factor is that the more erodible alluvial materials are thinner in North Fork Basin than in South Fork Basin and have been cut through, exposing more erosion-resistant Quaternary clays in the lower reaches and Tertiary clays in the vicinity of Little Creek. Figure 30 shows the changes in channel area and length through time. Channel area refers to the planform area of that stretch of channel and reflects the changes in the overall channel width for that entire stretch of channel. Note the extreme bank erosion at site T3. The knickpoint has been hung up on the very

Figure 29. Erosion-resistant clays in the Tillatoba Creek channel

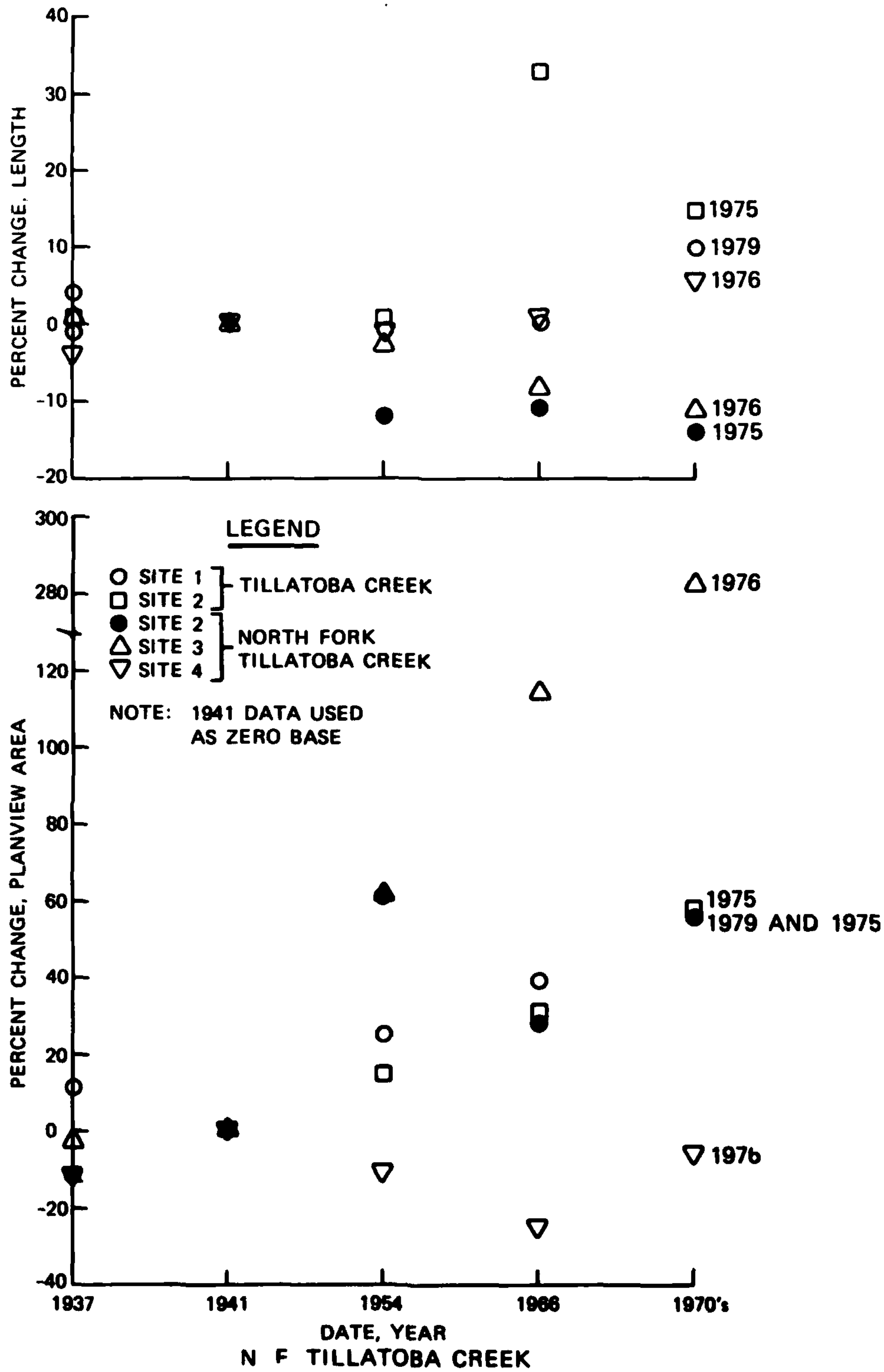


Figure 30. Changes in planform area and channel length of Tillatoba Creek and North Fork

erosion-resistant Zilpha clay (Tertiary) in this area. The prolonged halt of the knickpoint at this point or general area resulted in extensive bank erosion. The 1954 and 1976 longitudinal profiles of North Fork tributaries reflect the upstream rate of movement of the knickpoints on North Fork (Figure 31). The tributaries closer to the mouth of North Fork have been degraded the most.

69. The knickpoint has advanced nearly to the head of South Fork. The knickpoint, as of February 1980, was between Simmons Creek and the head of South Fork, which is formed by the junction of Harper and Davis Creeks (see Figure 3). Figure 32 shows the appearance of the channel in this area. Figure 33 shows the upstream advance of the knickpoint on South Fork. The knickpoint had just passed the junction of Middle and South Forks in April 1954 and the junction of Simmons Creek and South Fork in March 1979. The channel width of South Fork has tripled downstream from the knickpoint, and the channel length has been shortened as bank erosion cut out the small meander loops. Figure 34 shows there has been a decrease in channel length and a corresponding increase in channel area. The increases in channel area at all three sites on South Fork show that bank erosion is very active along the entire channel. Comparison of the 1954 and 1976 longitudinal profiles of Hunter and Simmons Creeks, tributaries of South Fork, shows that channel degradation is very active and quite significant on tributaries at the mouth and head of South Fork (Figure 35).

70. The knickpoint advanced into the lower reach of Middle Fork around 1954. The aerial photos in Figure 21 show the knickpoint was advancing into the lower stretch of site T7 in 1977. Figure 36 shows the channel area has increased at an apparently uniform rate at site T7, while the channel length has slightly increased. The upper reaches of Middle Fork had been channelized by the mid-1960's. The knickpoint(s) advancing through site T8 probably resulted from the channelization rather than from some downstream event on other channels since the knickpoint(s) on South Fork have not yet advanced through the lower reach of Middle Fork.

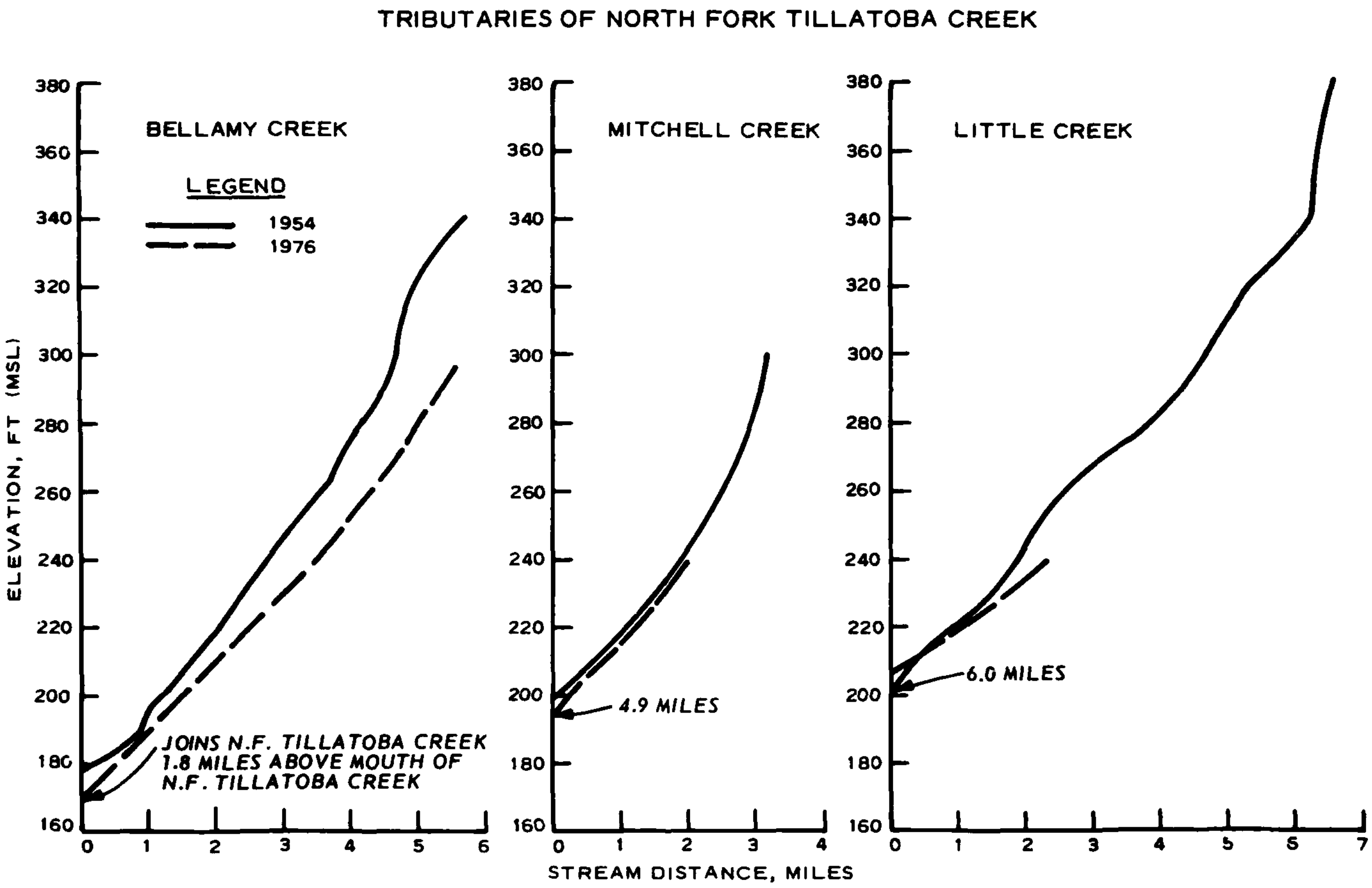


Figure 31. Longitudinal profiles of North Fork tributaries

a. Live trees completely undermined by rapid bank erosion

b. Rapid bank erosion cutting into a soybean field harvested in the fall of 1979

Figure 32. Channel erosion from the upstream movement of a knickpoint on South Fork in Feb 1980

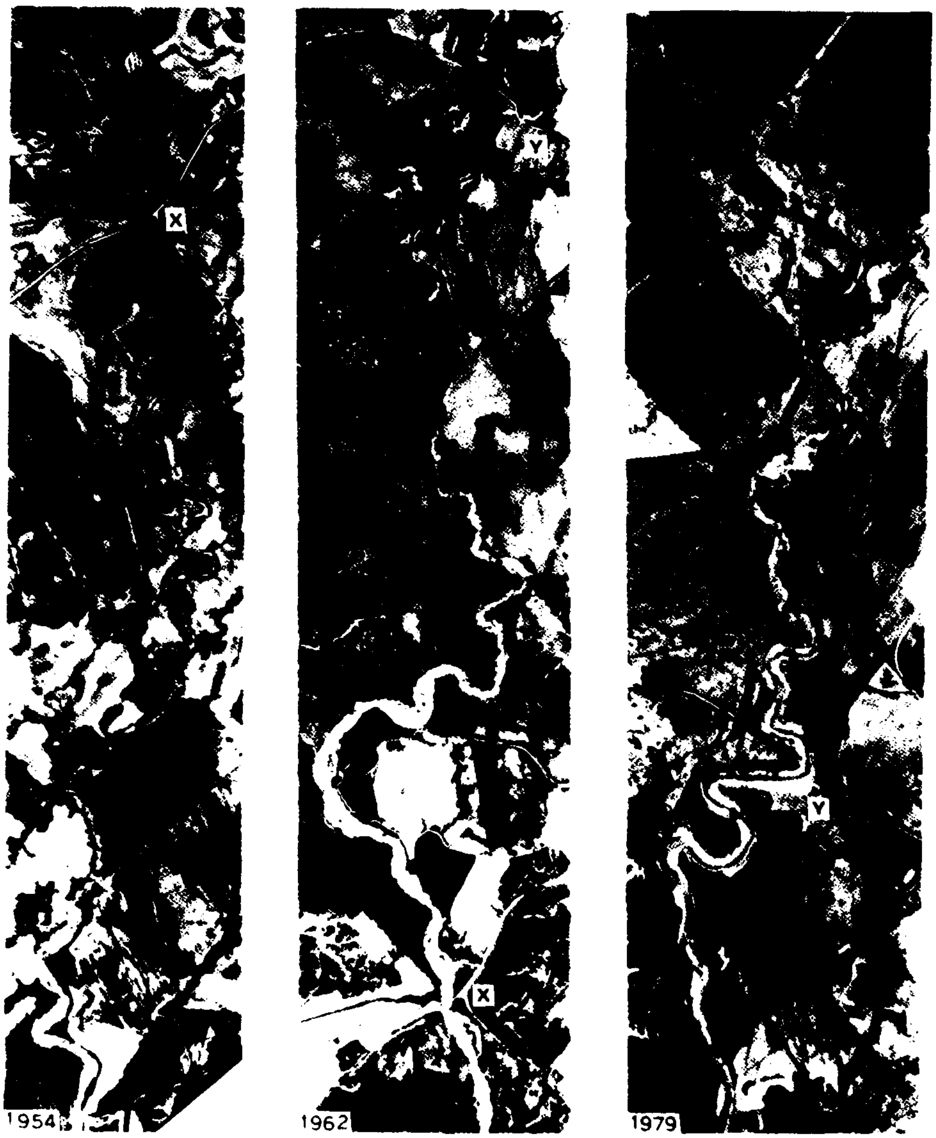


Figure 33. The upstream advance of a knickpoint on South Fork (Symbols "x" and "y" are used to correlate points.)

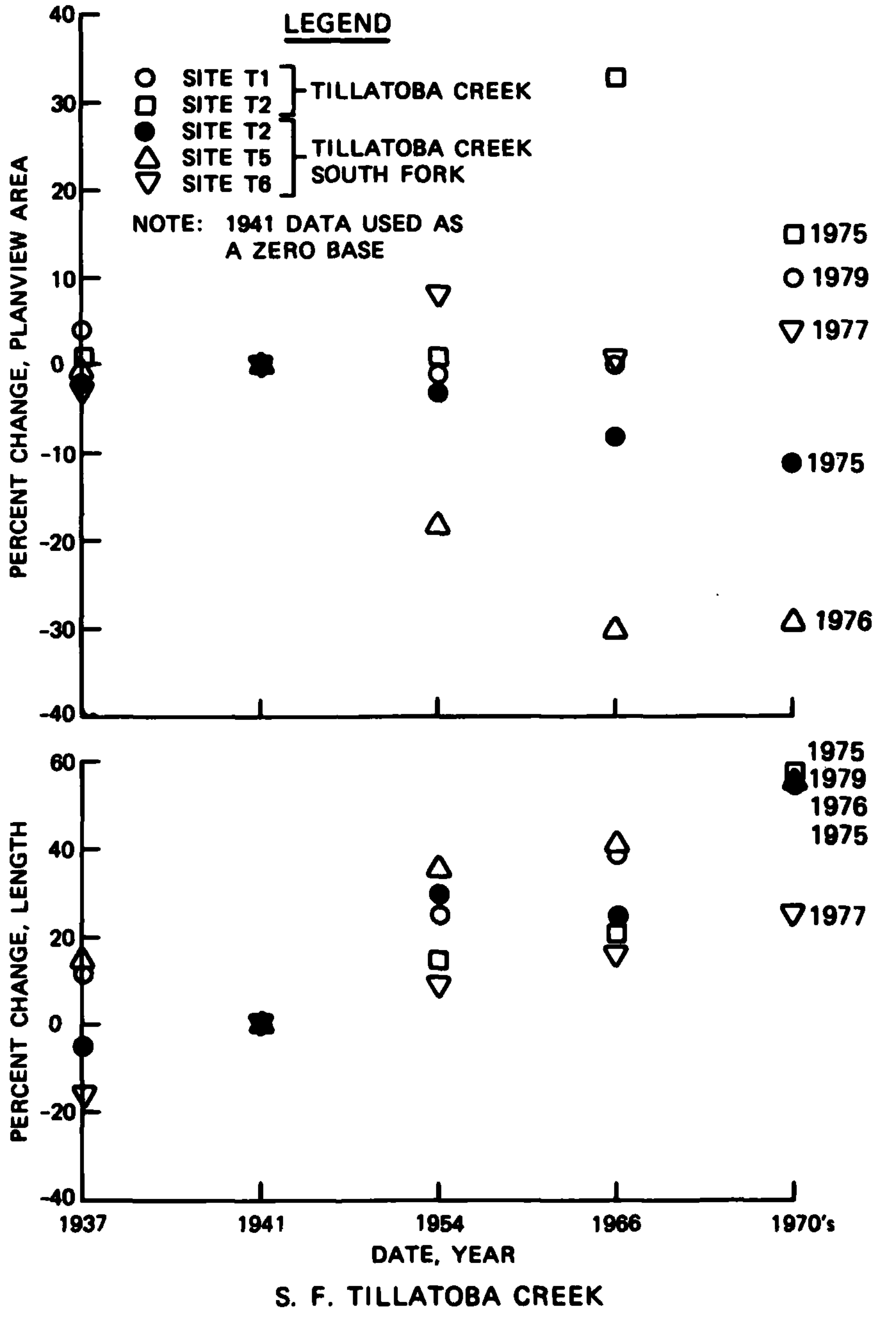


Figure 34. Changes in planform area and channel length of Tillatoba Creek and South Fork

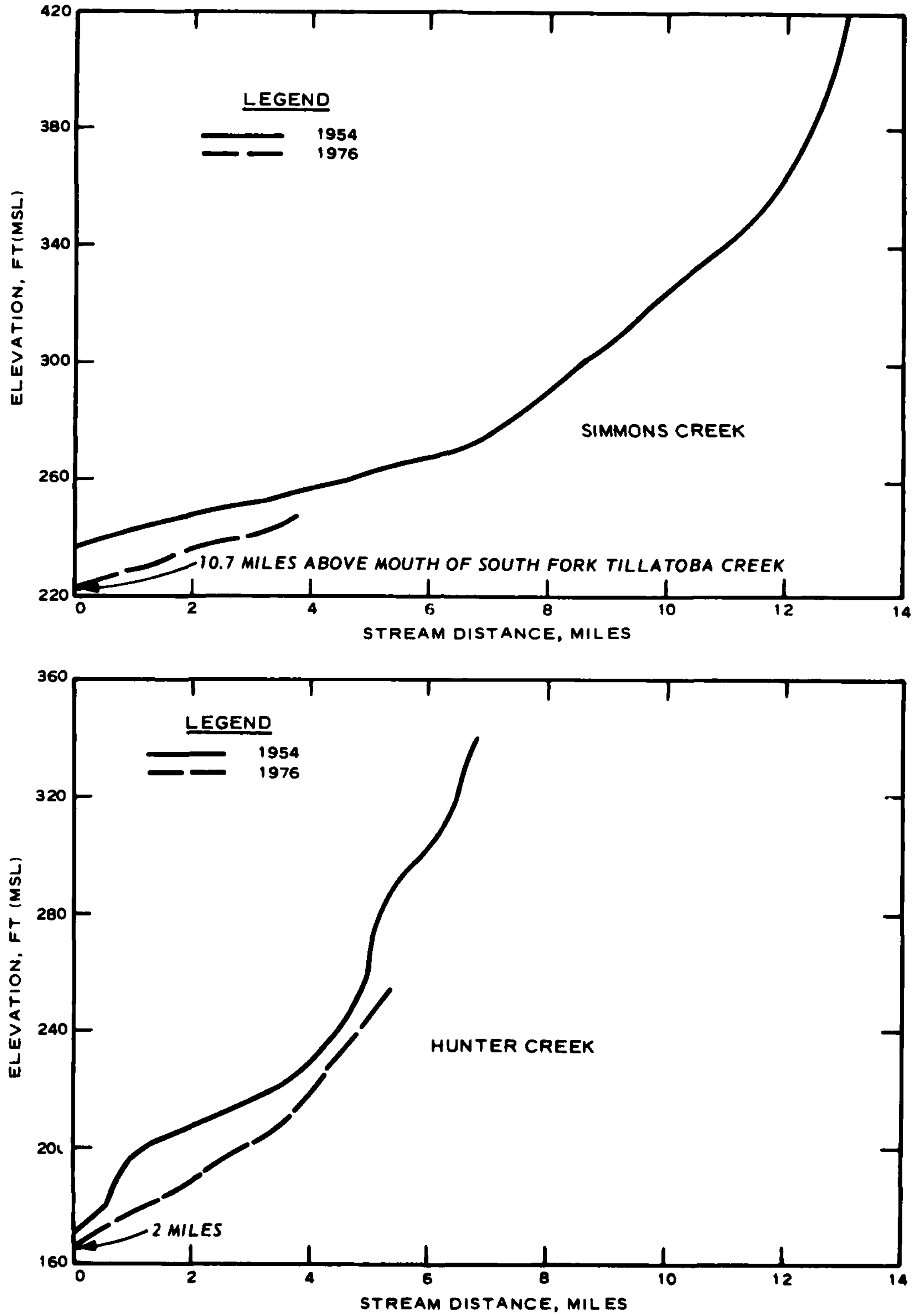


Figure 35. Longitudinal profiles of South Fork tributaries

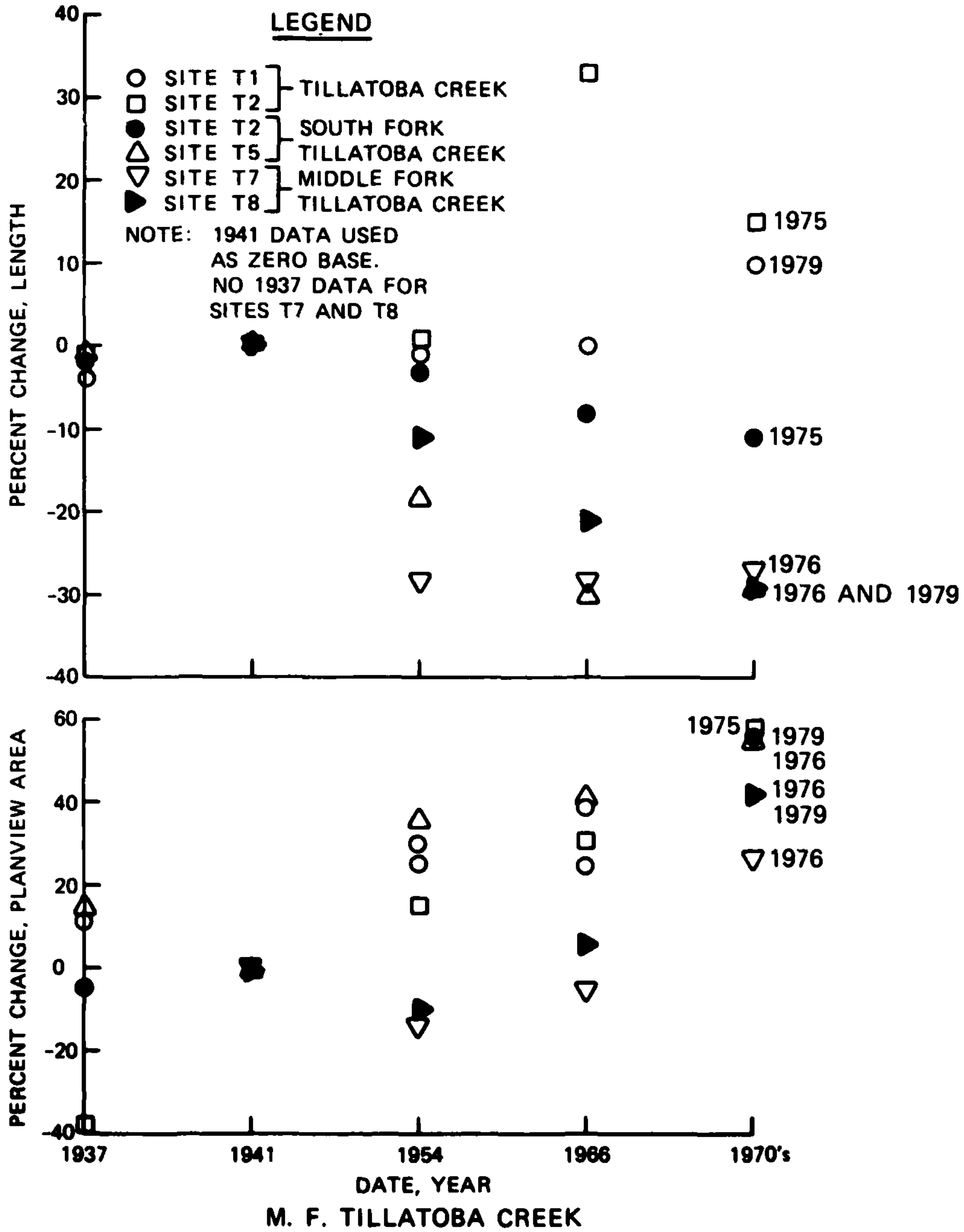


Figure 36. Changes in planform area and channel length of Tillatoba Creek and South and Middle Forks

Perry Creek

Present channel

71. Streambanks consist predominantly of a Quaternary clay overlain by mottled silts or silty-clay. These strata are locally overlain by 5 to 10 ft of fine to medium sand or silty sand. A weathered silty-clayey zone, 1 to 2 ft thick, overlies the sequence. The Quaternary clay, being more resistant to erosion than the sandy-silty materials, forms hard points along the stream course.

72. The present day channel is characterized by vertical or nearly vertical banks, averaging approximately 10 to 15 ft in height. Bank caving or slumping is common along the entire channel (Figure 37). Large quantities of sand are present in the middle and lower reaches. The upper reach is cutting into Quaternary clay and has little or no bedload materials (Figure 38). The overall impression of the stream is that of instability.

Channel changes

73. There has been a very noticeable change in the morphology of Perry Creek in the last 40 years. Channel depth and width have increased, while the length has decreased. A chronological sequence of stereo-aerial photos of four sites along Perry Creek shows the channel changes that occurred.

74. Site P1 is located at the mouth of Perry Creek and includes 1 mile of the channel (Figure 39). Bank erosion has been actively widening the channel since before 1935. The banks are generally vertical with a raw, fresh-cut appearance. The rate of bank erosion or retreat was relatively slow with no noticeable rapid or sudden width increases from 1935-63. Channel width increased less than 20 percent from 1935-63. There was a noticeable increase in channel width at the mouth of Perry Creek in 1963. The width of the lower one-half mile of the channel had increased approximately 50 percent. There were also numerous slumps and cave-ins along this section of channel. Then from 1963-77 the channel width more than doubled.

75. Hanging tributaries and isolated segments of previous

a. Oversteepened bank slumping

b. View showing large volumes of sediments in the channel of the middle and lower reaches

Figure 37. Typical bank erosion on Perry Creek, 1977

a. Upper reach

b. Lower reach; clay exposed in rapids

Figure 38. Erosion-resistant Quaternary clays in Perry Creek, 1977

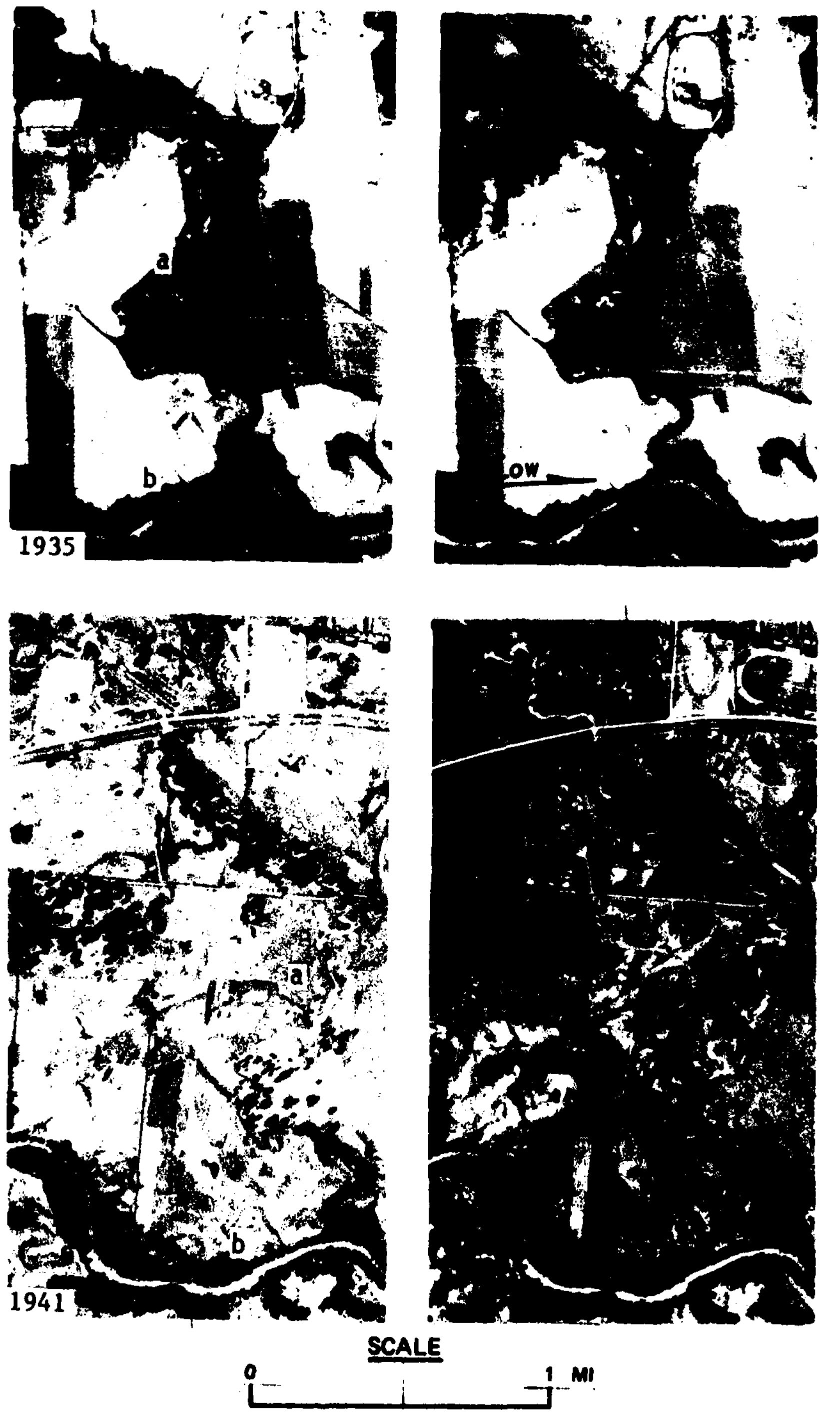


Figure 39. Site P1 on Perry Creek (Symbol "a" designates Perry Creek, and "b" is Batupan Bogue.) (Sheet 1 of 3)

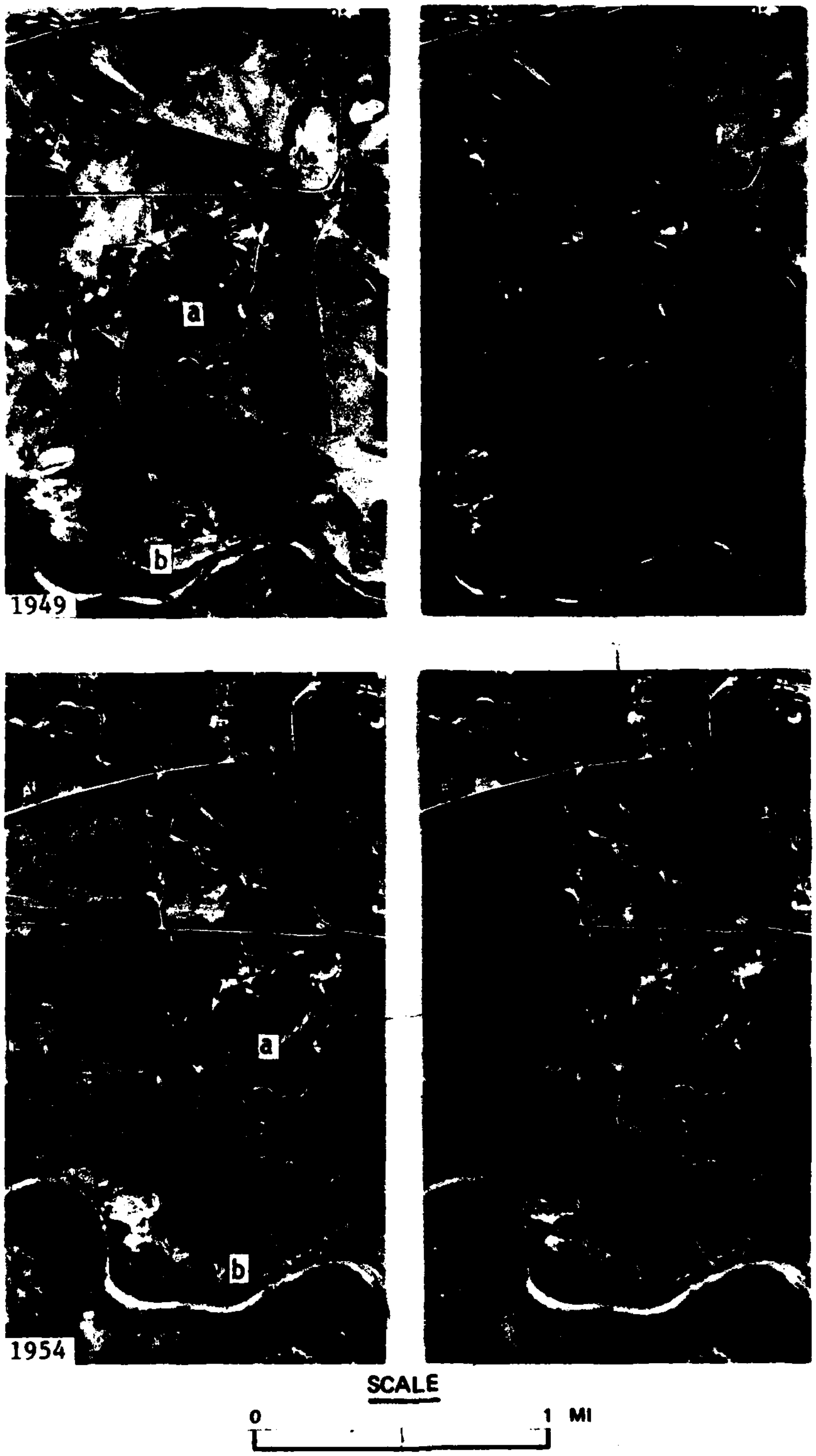


Figure 39. (Sheet 2 of 3)

Figure 39. (Sheet 3 of 3)

streambeds at elevations higher than the present channel in the 1954, 1963, and 1977 streams show that channel degradation had been active since at least the 1950's. Point bars were common in all of the channels. The quantity of sediments in the wide 1977 channel and the numerous middle bars and braided appearance of the thalweg indicate an excess quantity of sediments in the system.

76. Site P2 is located 3.7 miles (1954 stream distance) above the mouth of Perry Creek and includes approximately 1 mile of the channel (Figure 40). The outside banks of the meander loops were actively eroding in 1935 and 1941, but did not appear to have been very active in other areas. The channel width had nearly doubled by 1954. Hanging tributaries and isolated segments of previous streambeds at elevations higher than the 1954 bed indicate the deepening of the channel. The steep, vertical banks had a raw, fresh-cut appearance. Continued bank and bed erosion since 1954 has widened and deepened the channel, but at a much slower rate than during the 1941-54 period. Bank erosion has removed most of the small bends and meander loops and appears to be most active on the outside banks of the larger meander loops.

77. Site P3 is located 5.6 miles (1954 stream distance) above the mouth of Perry Creek and includes approximately 1 mile of the channel (Figure 41). The 1941 channel was lined with vegetative growth. There was no observable erosion in the channel. The vegetative growth along the channel had been removed by 1954, and the channel appeared to be rapidly widening and deepening. The beds of several meander loops, cut off since 1941, were at elevations higher than the 1954 channel bed. By 1954, the lower segment of the channel had nearly doubled in width since 1941 and all of the banks in this site had a fresh-cut appearance. The 1963 channel was two to three times as wide as the 1941 channel and bank erosion still appeared to be very active. Channel depth had also increased. Bank and bed erosion were still very active in the 1977 channel. However, the construction of the Interstate Highway 55 bridge in 1965 had altered the channel erosion above the culvert-type bridge. A more detailed discussion of the effects of the bridge on channel erosion appears later in this section.

Figure 40. Site P2 on Perry Creek (Continued)

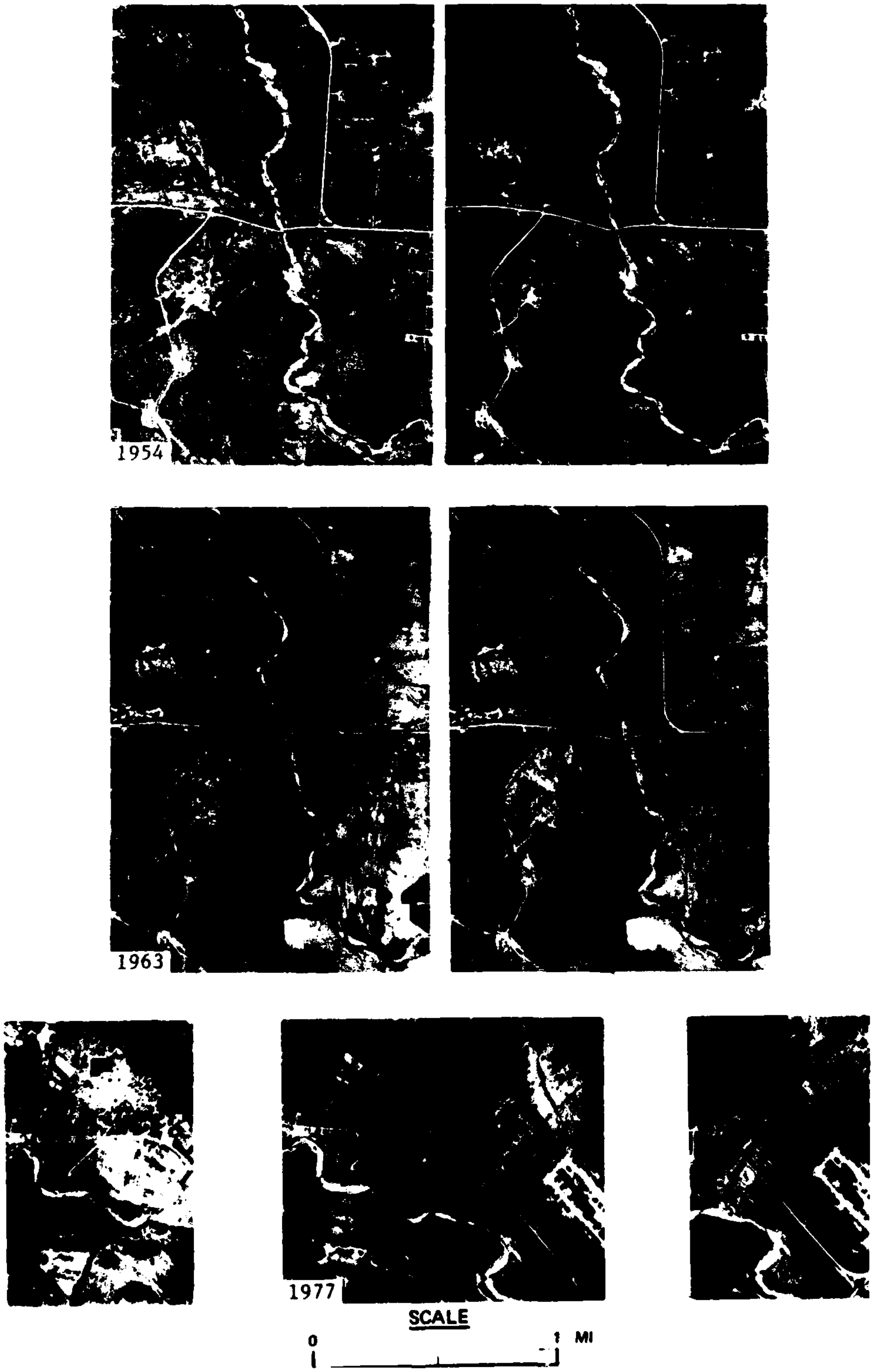


Figure 40. (Concluded) (The 1977 photographs are rotated approximately 45°.)

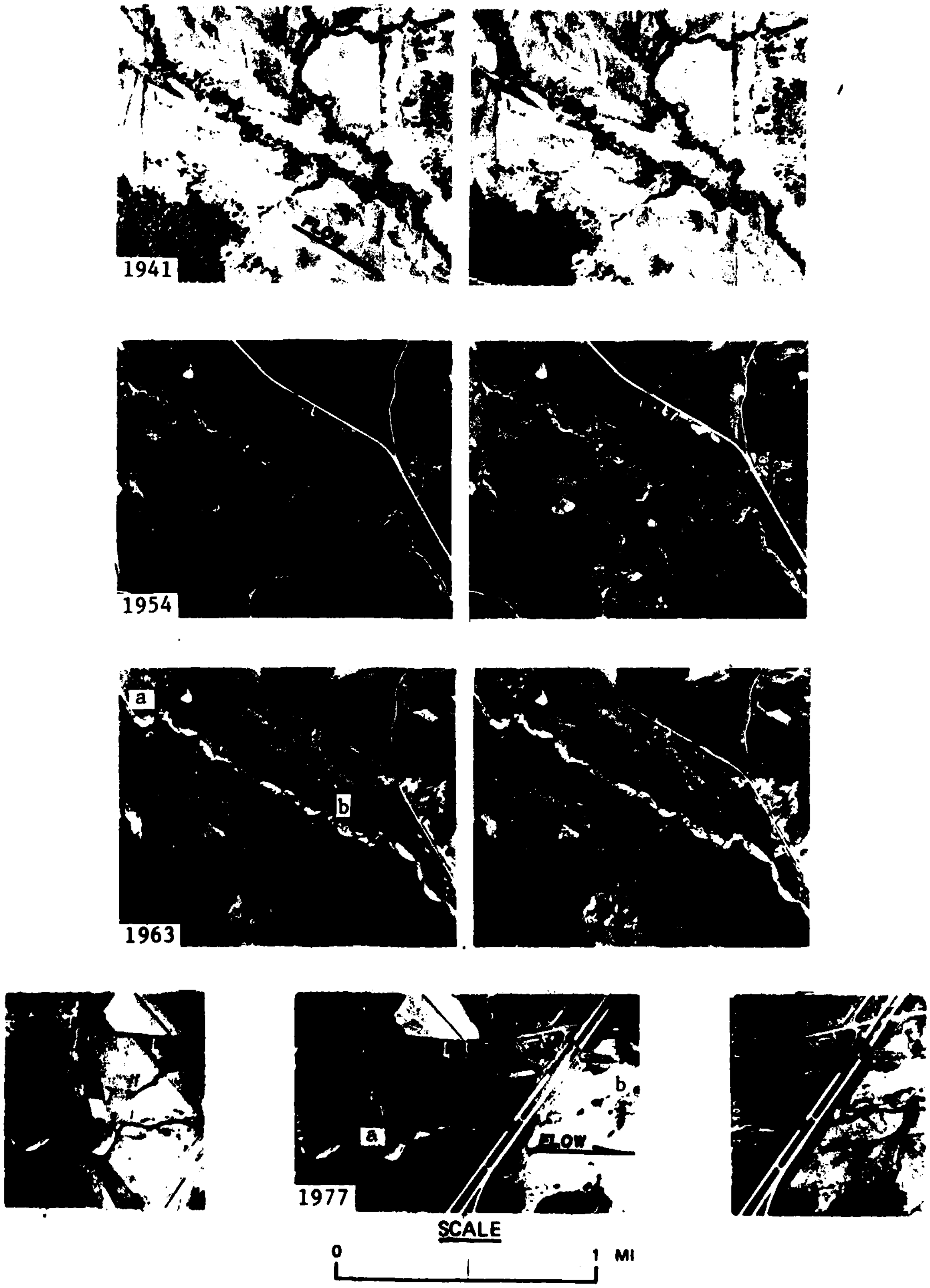


Figure 41. Site P3 on Perry Creek

78. Site P4 is located 6.6 miles (1954 stream distance) above the mouth of Perry Creek and includes approximately one-half mile of the channel (Figure 42). This segment of Perry Creek was channelized prior to 1941. Channel erosion at this site appears to have occurred at a slow, relatively uniform rate since 1941. The most noticeable bank erosion occurred in the upper segment where the meander loops have been slowly straightened as the curves were eroded away. The hanging tributaries show that channel depth has also increased since 1941. The thalweg is presently cutting into Quaternary clays (Figure 38). Channel erosion directly below site P4 has increased channel depth and widths in the same manner seen at site P3.

79. Table 7 is a summary of the geomorphic changes on Perry Creek as observed from the chronological sequences of aerial photographs and from field observations.

80. The chronological sequences of aerial photographs of each of the four sites of Perry Creek show there has been a very significant increase in channel depth and width since 1935 and that these increases have advanced upstream with time. The knickpoint on the 1954 longitudinal profile is located between sites P2 and P3 (Figure 43). Interstate Highway 55 bridge, built at site P3 in 1965, acted as a grade-control structure, preventing any further degradation from advancing past this point after 1965. The prominent knickpoint on the 1977 longitudinal profile shows the effectiveness of this culvert-type bridge as a grade-control structure. The channel downstream from the culvert had degraded 6 to 8 ft by 1977 (Figure 44). The banks are steep with frequent cave-ins, slumps, and undercut trees. The channel directly upstream from the bridge appears stable (Figure 44). Cross sections of Perry Creek show bank erosion has been more extensive downstream from the bridge than upstream (Figure 45).

81. Figure 46 shows the changes in channel area and length at each of the four sites since 1937. There has been a general decrease in channel length at all the sites, except for P4, which has changed very little. Bank erosion cut away the meander loops and bends, thereby straightening and shortening the channel. Figure 47 shows the decreases

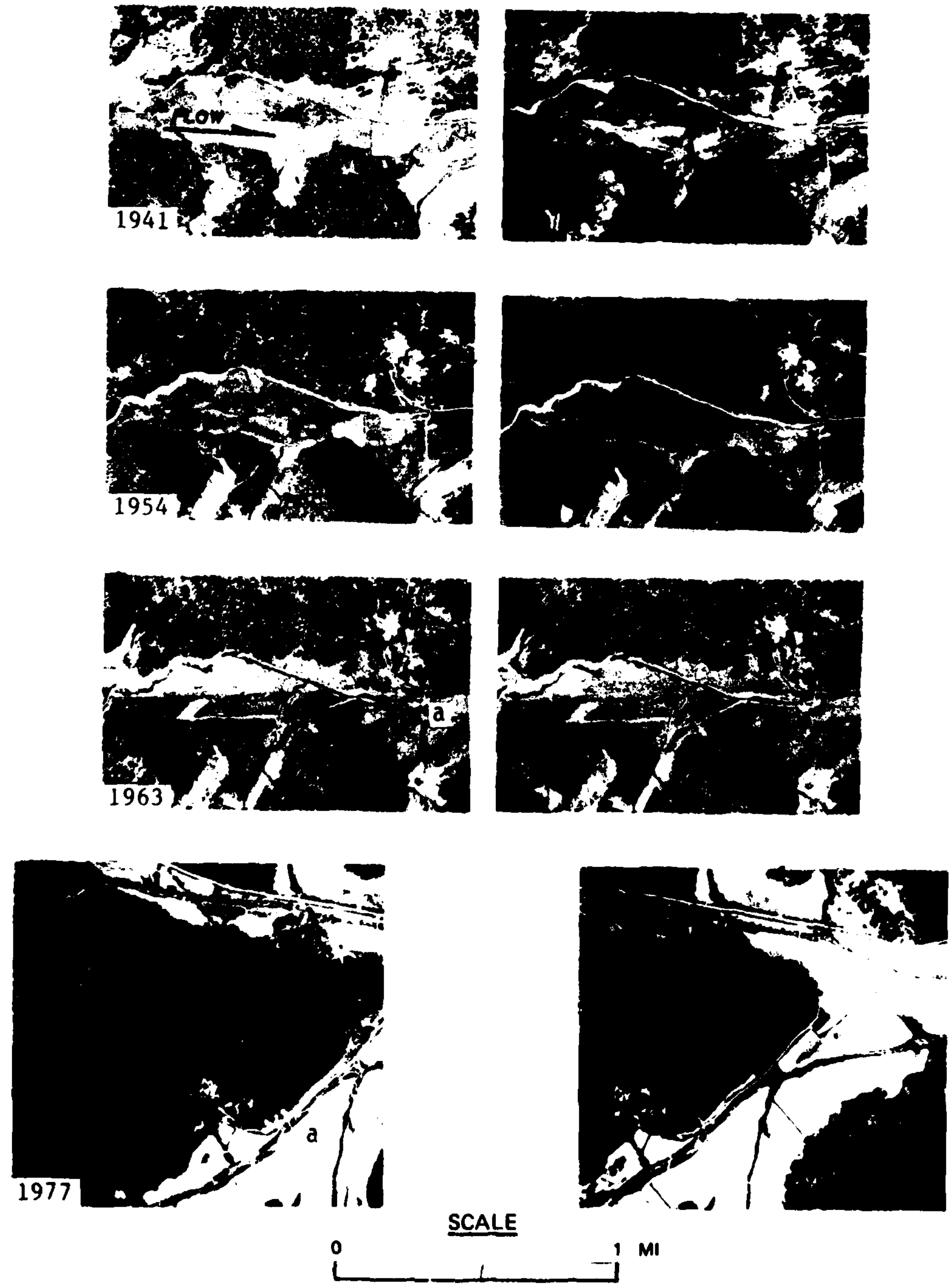


Figure 42. Site P4 on Perry Creek

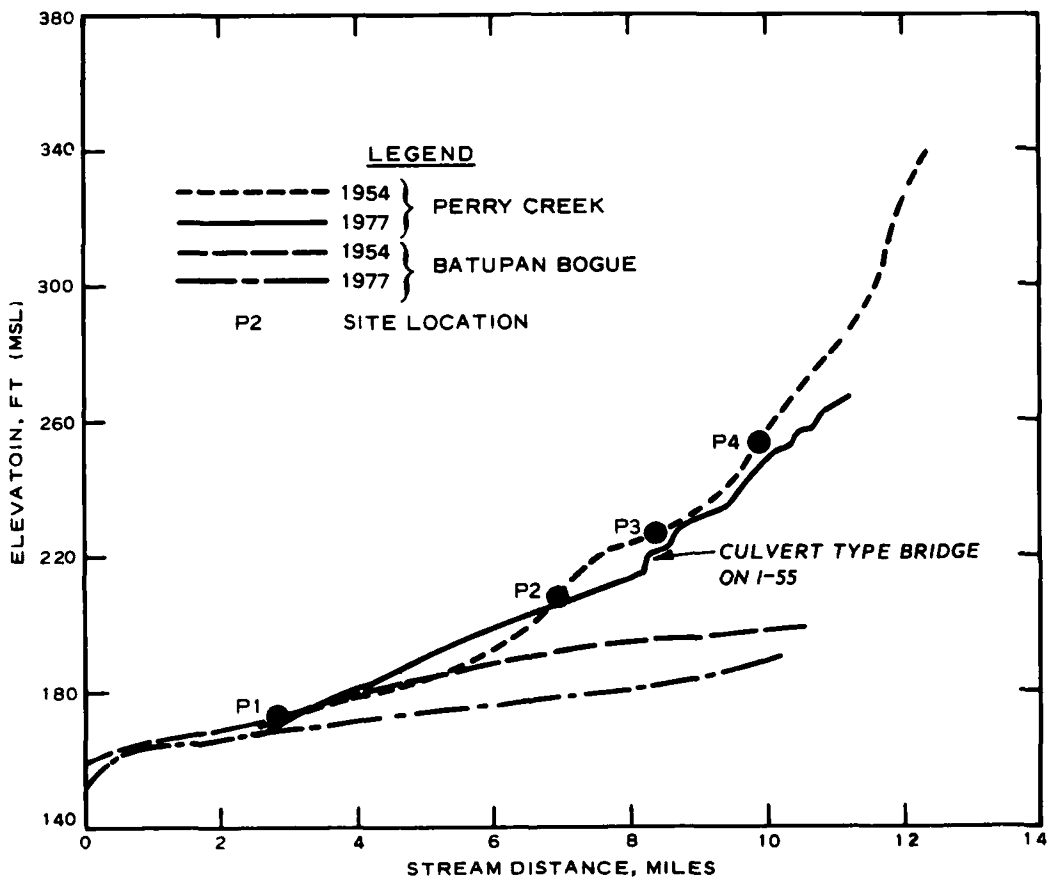
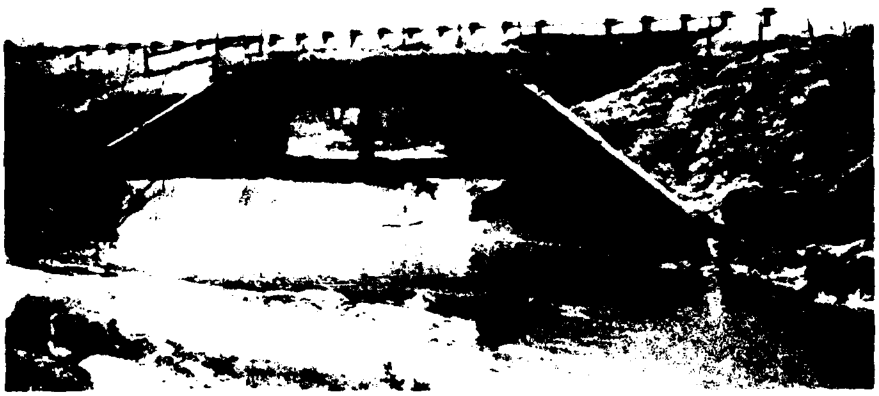


Figure 43. Longituding profiles of Perry Creek and Batupan Bogue (1954 data from USGS Topographic maps; 1977 data from Corps of Engineers survey; sites P1 through P4 are located on the 1954 profile.)

a. Upstream



b. Bridge

c. Downstream

Figure 44. Perry Creek at Interstate Highway 55 bridge

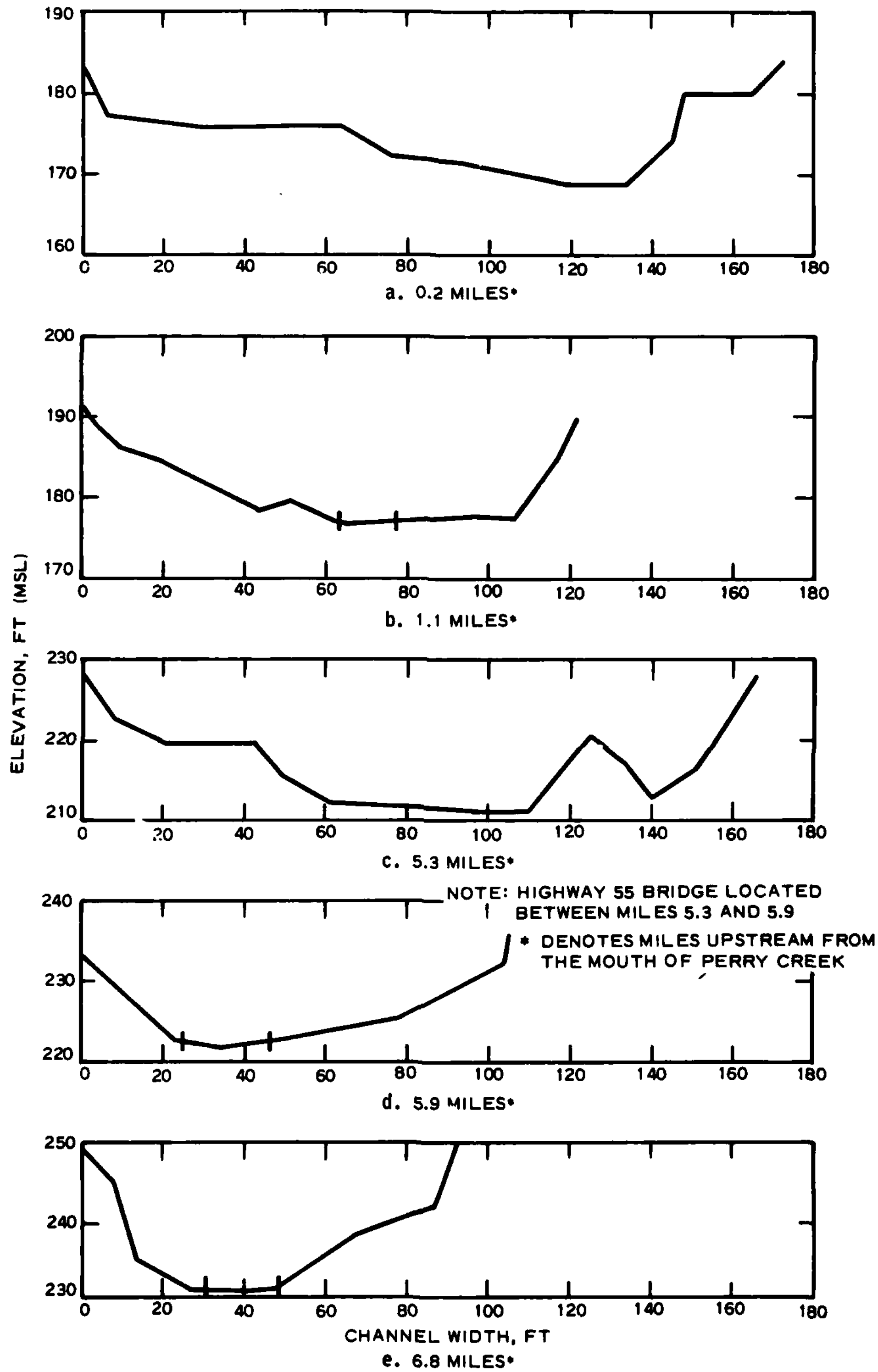


Figure 45. Cross sections of Perry Creek in 1977 (from Corps of Engineers survey data)

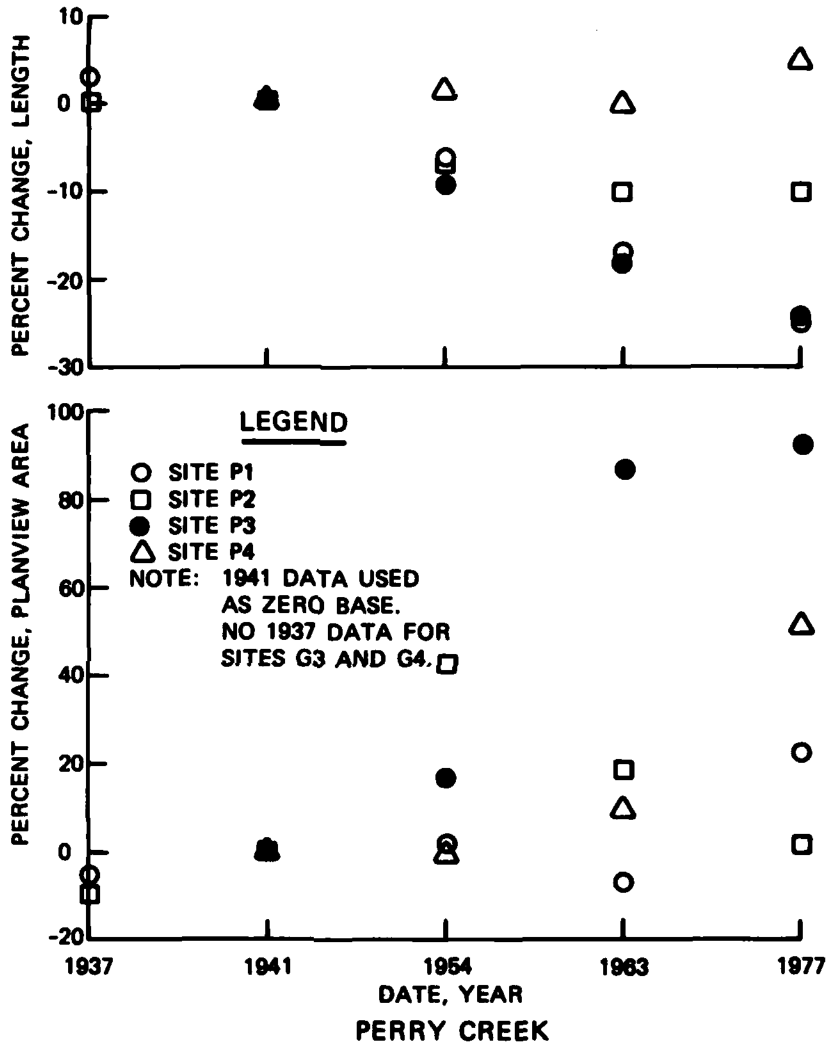
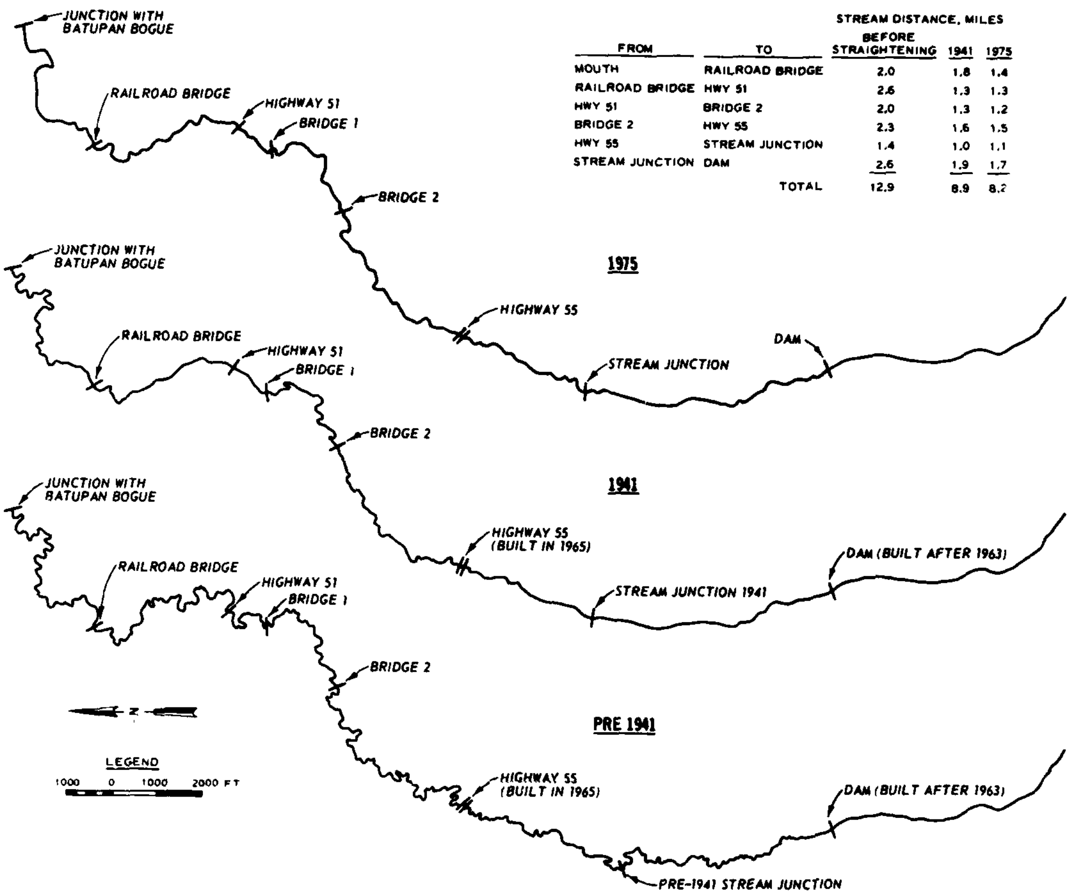


Figure 46. Changes in planform area and channel length of Perry Creek



FROM	TO	STREAM DISTANCE, MILES BEFORE STRAIGHTENING	1941	1975
MOUTH	RAILROAD BRIDGE	2.0	1.8	1.4
RAILROAD BRIDGE	HWY 51	2.6	1.3	1.3
HWY 51	BRIDGE 2	2.0	1.3	1.2
BRIDGE 2	HWY 55	2.3	1.6	1.5
HWY 55	STREAM JUNCTION	1.4	1.0	1.1
STREAM JUNCTION	DAM	2.6	1.9	1.7
	TOTAL	12.9	8.9	8.2

Figure 47. Changes in the channel length of Perry Creek

in channel length from pre-1941-75. Channel area either increased or decreased as the channel was widened. The combination of channel widening and shortening determined whether there was increase in channel area. Channel area increased at site P4 as the length decreased, while just the opposite effect occurred at site P2.

Goodwin Creek

Present channel

82. Goodwin Creek channel is similar to the channels of Perry and Tillatoba Creeks. The bed and banks consist of Quaternary sediments generally composed of a bluish clay or silty clay, which grades upward

into a mottled silty clay, then to a weathered clayey-silty soil weathered zone. Citronelle gravels are present in some of the banks in the upper reaches.

83. The lower three-quarters mile of Goodwin Creek is 75 to 100 ft wide and has steep banks, 20 to 30 ft high (A to B on Figure 4). Channel width from B to C varies from 125 to 450 ft, and the banks are usually steep--10 to 20 ft high. Channel width decreases upstream from C with the widest section being approximately 100 ft wide; however, there is little change in the nature of the banks.

84. The streambed from A to B (Figure 4) is cut into Quaternary clay and has little to no bed-load sediments in the channel (Figure 48). The bed from B to C (Figure 4) is locally cutting into clay; however, there are large quantities of sand and gravel in the channel. The channel above C has a sand and gravel bed. Limonitic ledges, which occur throughout the entire length of Goodwin Creek, form erosion-resistant ledges across the channel in many places (Figure 49).

Channel changes

85. Goodwin Creek is the smallest of the four streams in this study. Most of the land in the basin was under cultivation or was being used as pastureland by 1940. A few gullies had developed on the steeper slopes, but gullying was not a very serious problem in Goodwin Creek Basin. The lower reach of Goodwin Creek was channelized prior to 1940. Chronological sequences of aerial photos of four sites along Goodwin Creek show the channel changes that have occurred since 1940 (Figure 50).

86. Site G1 is located at the mouth of Goodwin Creek and includes one-half mile of Goodwin Creek and one-half mile of Long Creek (Figure 50). This segment of Goodwin Creek was channelized prior to 1940. The prechannelization channel can be seen to the west (left on photo) of the man-made channel. Channel erosion does not appear to have been occurring at a very fast rate from 1940-68. There was a gradual overall increase in channel width during this period. The only noticeable increase in width occurred at the mouth and in the sharper bend. Bank erosion had altered the straight, man-made appearance of the 1940 channel to a more irregular shape by 1968. From a planview, the channel

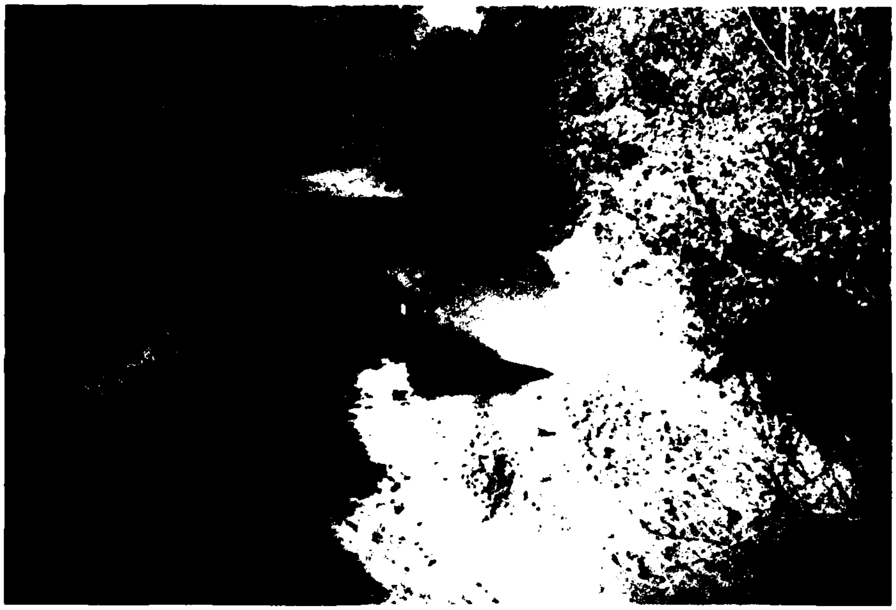


Figure 48. Quaternary clay in the bed of Goodwin Creek, near the mouth

Figure 49. Limonitic ledges in the bed of Goodwin Creek at its mouth

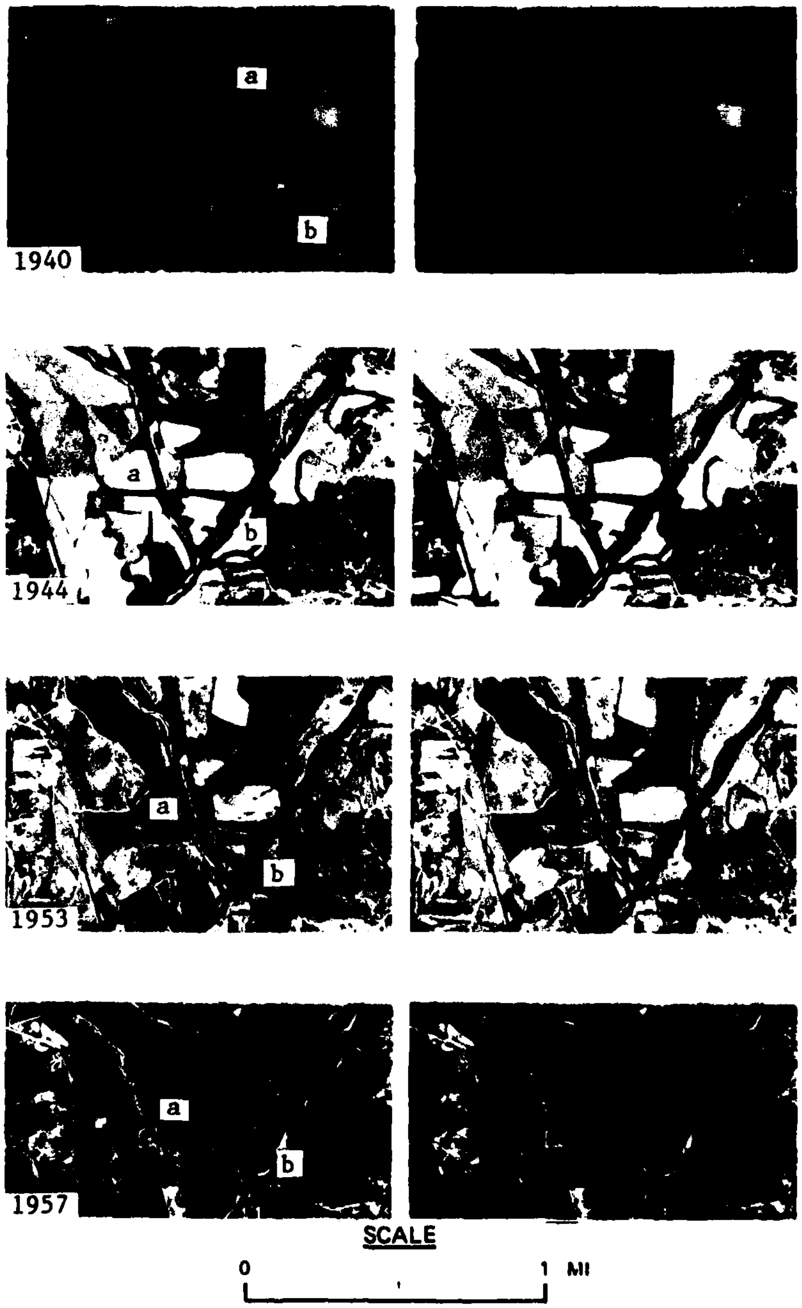


Figure 50. Site G1 on Goodwin Creek (Symbol "a" designates Goodwin Creek, and "b" is Long Creek.) (Continued)

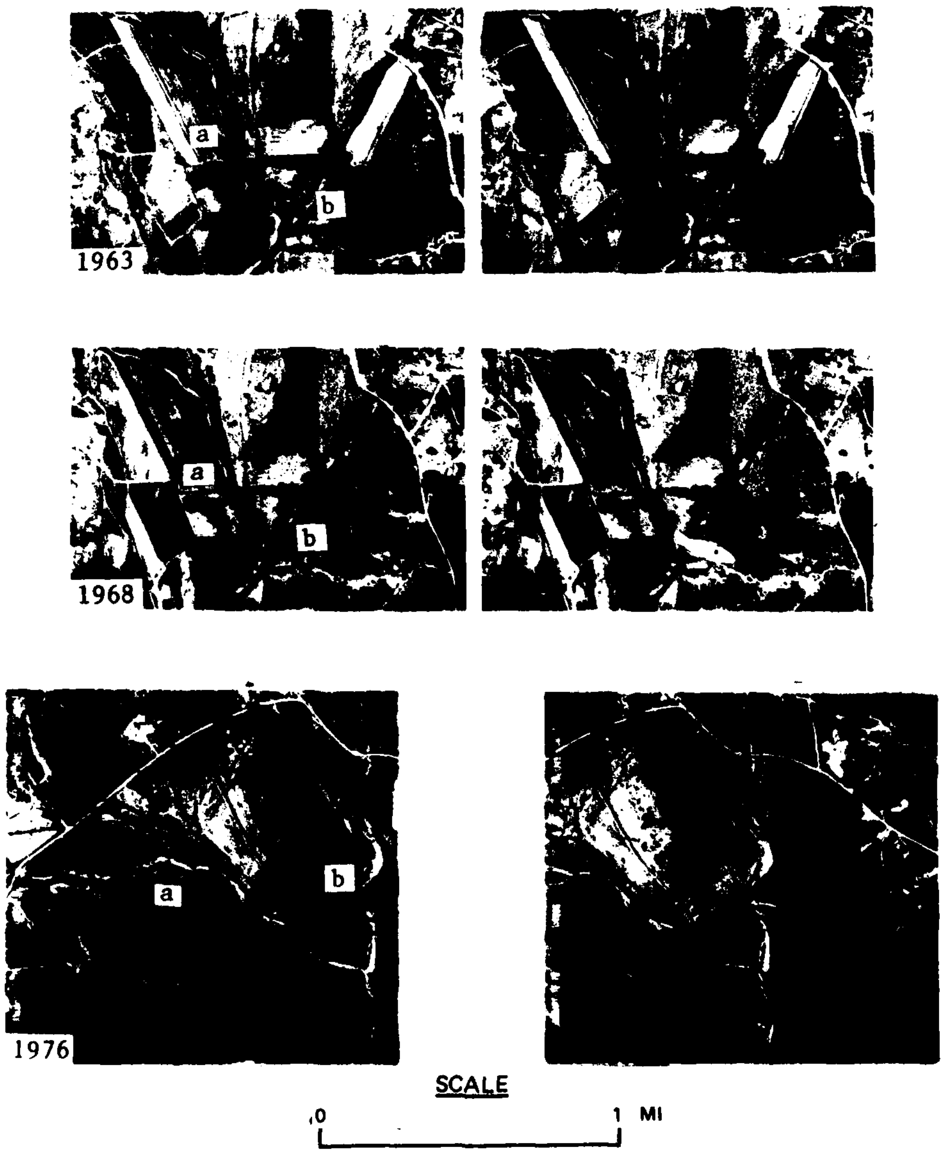


Figure 50. (Concluded)

appeared to be developing a meander pattern.

87. There was a very pronounced increase in channel erosion after 1968. Bank erosion nearly doubled the width of Goodwin and Long Creeks. The banks of both channels were very irregular and ragged with numerous small gullies cutting back into the banks. Channel depth also increased. Both channels had numerous well-developed point bars.

88. Site G2 is located 0.6 miles (1954 stream distance) above the mouth of Goodwin Creek and includes one-half mile of the channel (Figure 51). Channel erosion was not excessively active in this channel segment from 1940-57. There was some bank erosion along the entire stretch, with the most noticeable erosion occurring in the meander loops. Degradation appears to have been very limited or insignificant. There was a sudden increase in bank and bed erosion after 1957. Channel width had doubled by 1978, and the depth had also increased. Point bars were present in the channel throughout this time period (1940-78). Bank erosion was very active in 1978, judging from the raw, ragged appearance of the banks.

89. Site G3 is located 2 miles (1954 stream distance) above the mouth of Goodwin Creek and includes approximately 1 mile of the channel (Figure 52). The channel appeared stable in the 1940 and 1944 photos. There was some vegetative cover and no observable bank erosion. The channel below the bridge had nearly doubled in width by 1953 and had also increased in depth. The width had more than tripled in the meander loops directly downstream from the bridge. The channel directly upstream from the bridge was channelized between 1953 and 1957. Bank erosion downstream from the bridge has continued to erode the meander loops since 1957. The smaller loops have been completely cut away. The thalweg meander has increased as the large meander loop is enlarged by bank erosion (Figure 53). Large point bars have developed and the channel bed has degraded. Clay was exposed in the channel bed in 1978 (Figure 53). The channel banks upstream from the bridge have not been significantly eroded.

90. Site G4 is located 4.6 miles (1954 stream distance) above the mouth of Goodwin Greek and includes three-quarters mile of the channel

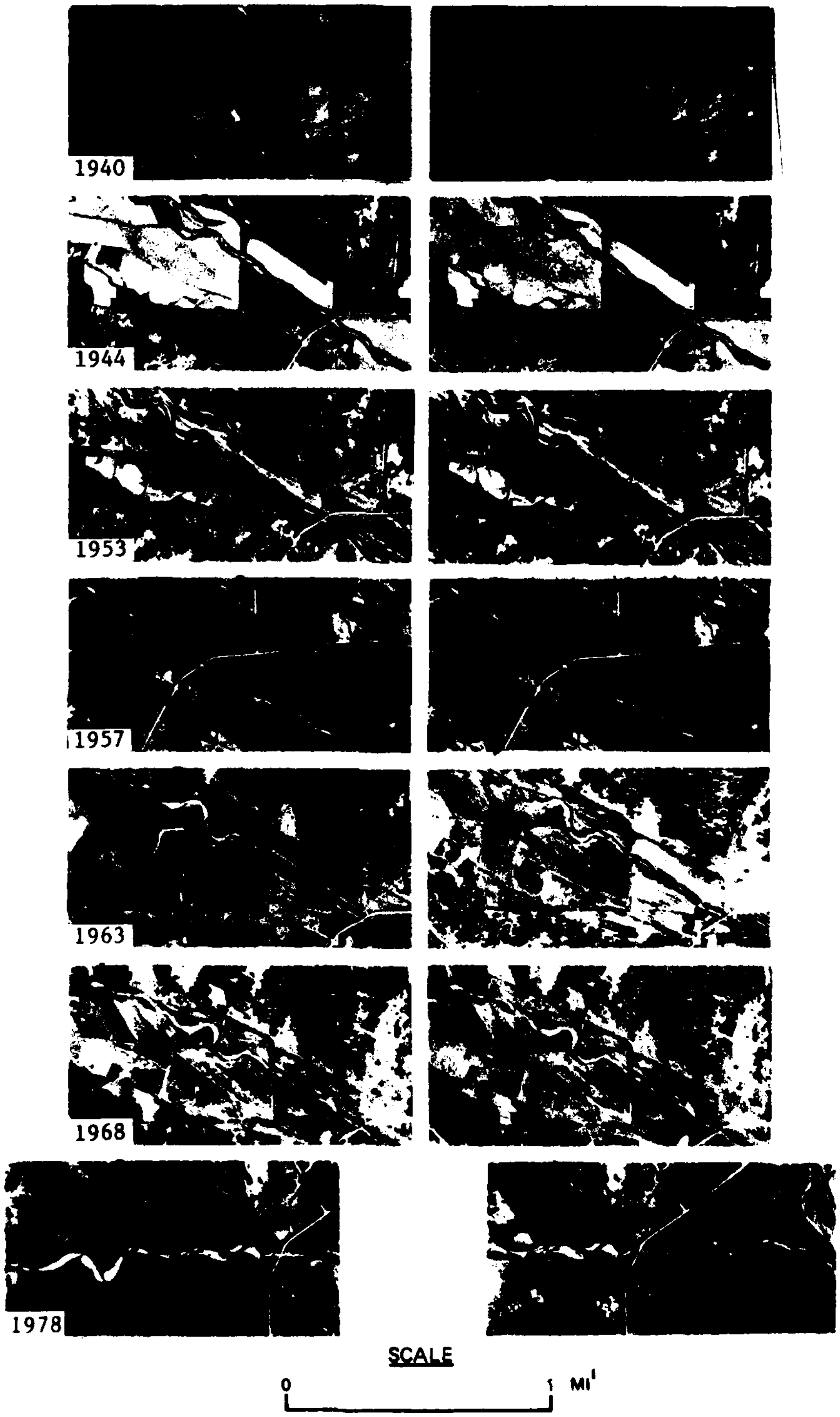


Figure 51. Site G2 on Goodwin Creek

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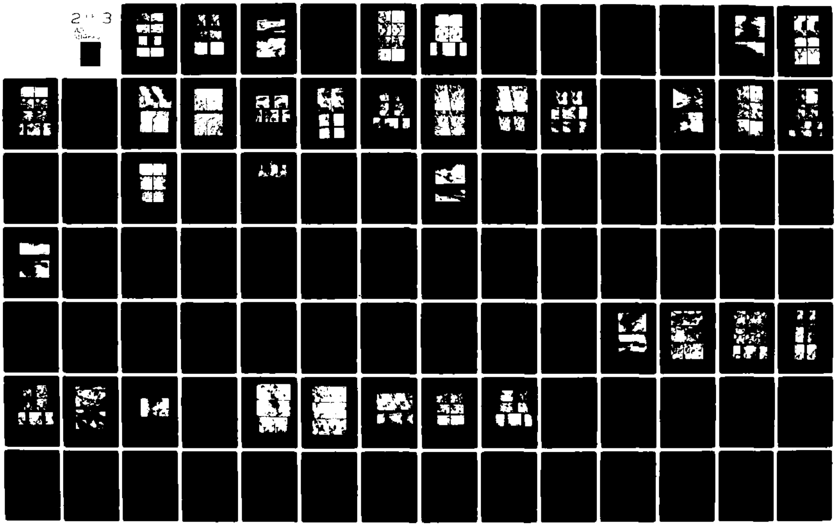

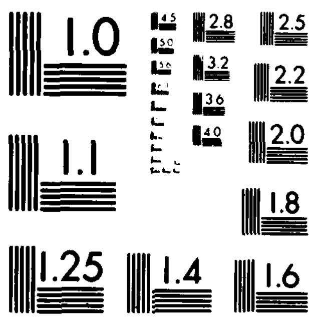

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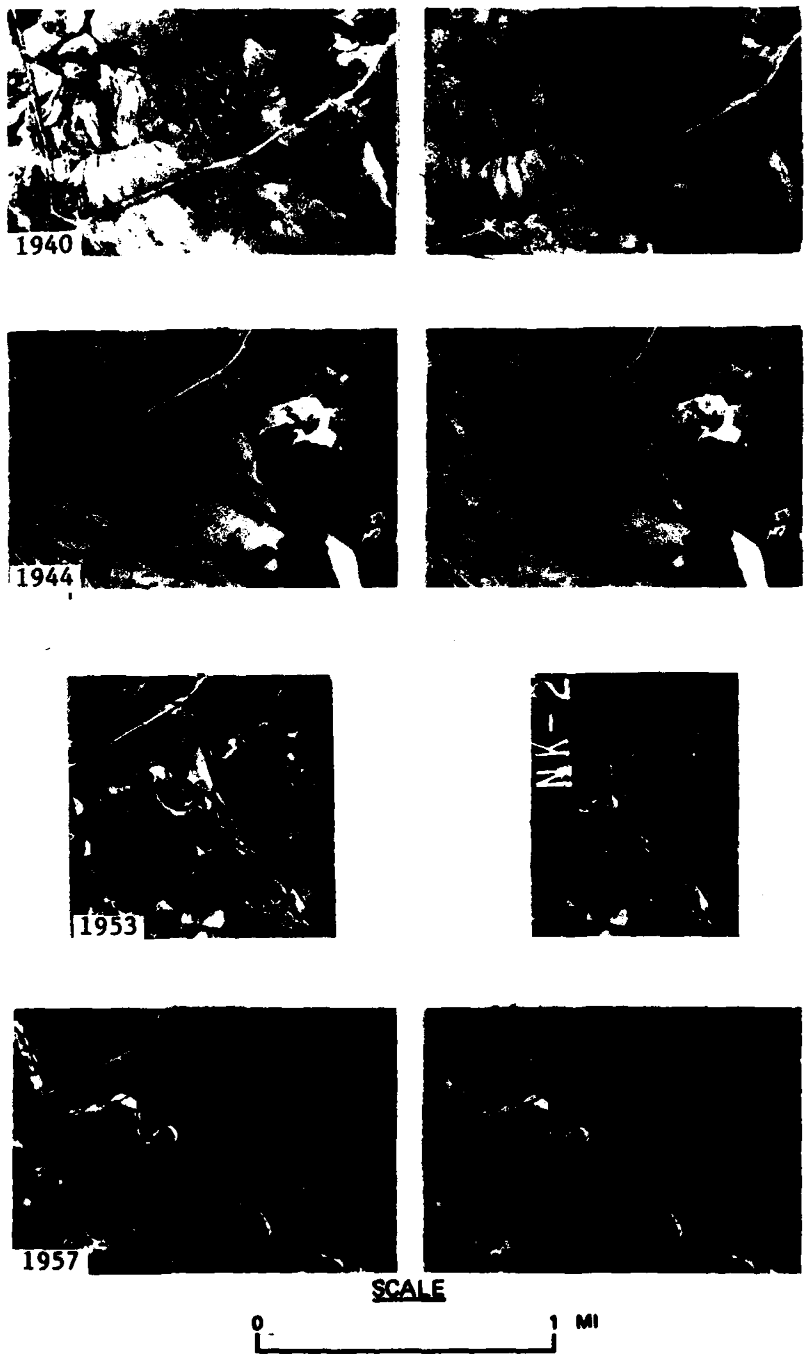


Figure 52. Site G3 on Goodwin Creek (Continued)

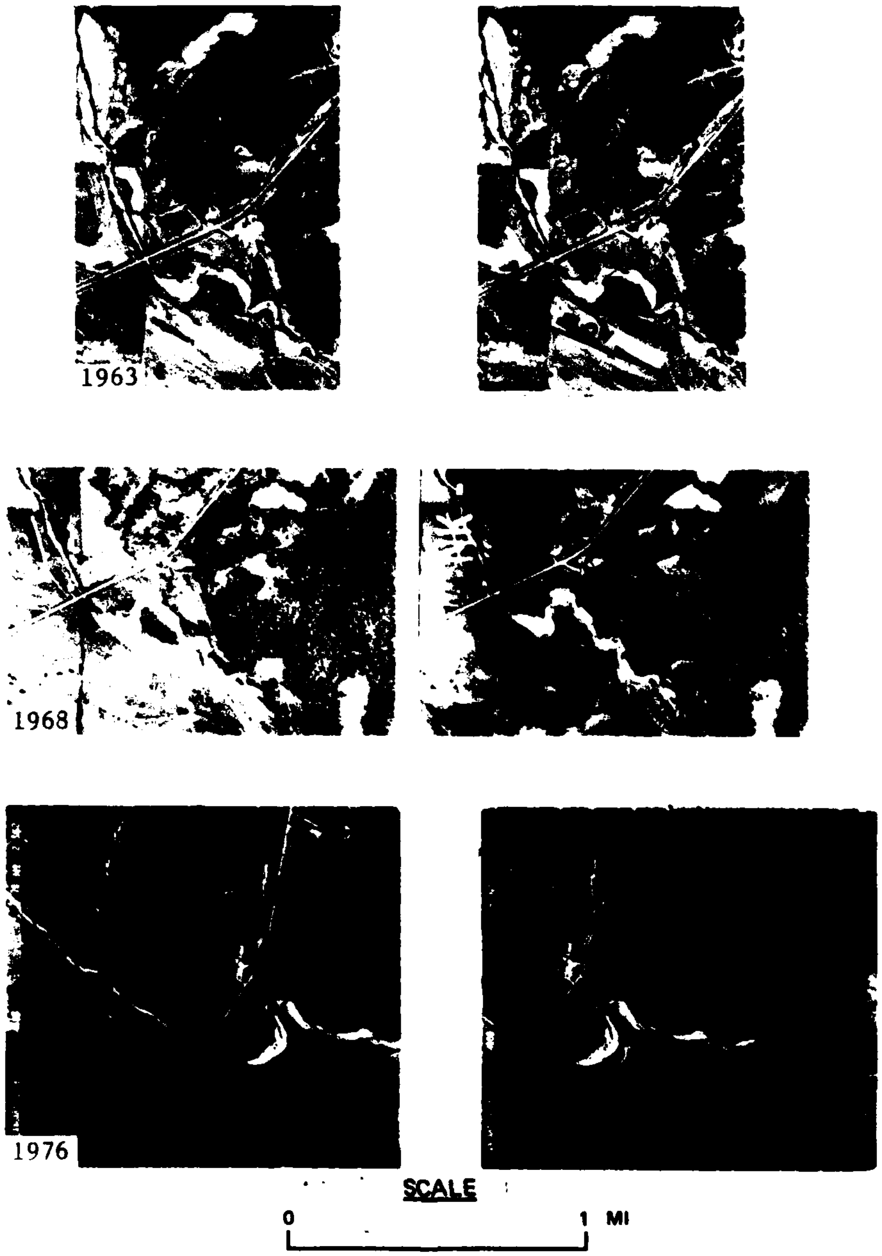


Figure 52. (Concluded)

a. Bank erosion, 1978 (Notice the piping in Unit 1. Unit 2 is a mottled silty-sandy clay. Unit 3 is an erosion-resistant clay. Note the channel feature in Unit 2, right center.)

b. Erosion-resistant clay in the streambed, 1978

Figure 53. Goodwin Creek at site G3

(Figure 54). There was very little gully erosion in Goodwin Creek Basin; however, the gullying that did occur was more prevalent in the upper reach of the basin. The increased sediment load in the streams in this area caused extensive bank erosion on the small first- and second-order streams. The increased sediment load also caused aggradation and very noticeable bank erosion in the upper reach of Goodwin Creek. Bank erosion at site G4 was very active in the 1940's, especially in the meander loops. Continued bank erosion cut off one meander loop prior to 1953. The rate of bank erosion appears to have decreased since 1953. A short section of the upper reach was channelized between 1953-57. Bank erosion could only be detected in a few isolated places in 1978. The channel had degraded some, but this could be from the removal of excess sediments in the channel or from a knickpoint.

91. Table 8 is a summary of the geomorphic changes on Goodwin Creek as observed from the chronological sequences of aerial photographs and from field observations.

92. Channel erosion has increased the overall depth and width of Goodwin Creek since 1940. Comparison of the 1954 and 1977 longitudinal profiles of Goodwin Creek shows that the knickpoint in the lower reaches in 1954 had advanced upstream by 1977 (Figure 55). The irregularity of the 1977 profile indicates degradation was still active in the channel. The irregularities, in many instances, reflect erosion-resistant points (limonitic and clay ledges) that have temporarily halted degradation at that point.

93. Chronological sequences of aerial photographs at each of the four sites on Goodwin Creek show there has been an increase in channel width since 1940. Figure 56 shows the changes in area and length at each of the four sites since 1940. Bank erosion has generally increased the channel area and decreased channel length. The erosion of the meander loop at site G3 has increased the channel area and length. The channelization of site G4 decreased the channel length and temporarily decreased the channel area. Cross sections of the 1977 channel show very wide channels in the lower reach, which corresponds to the increases in channel area (Figure 57). The decrease in channel depths

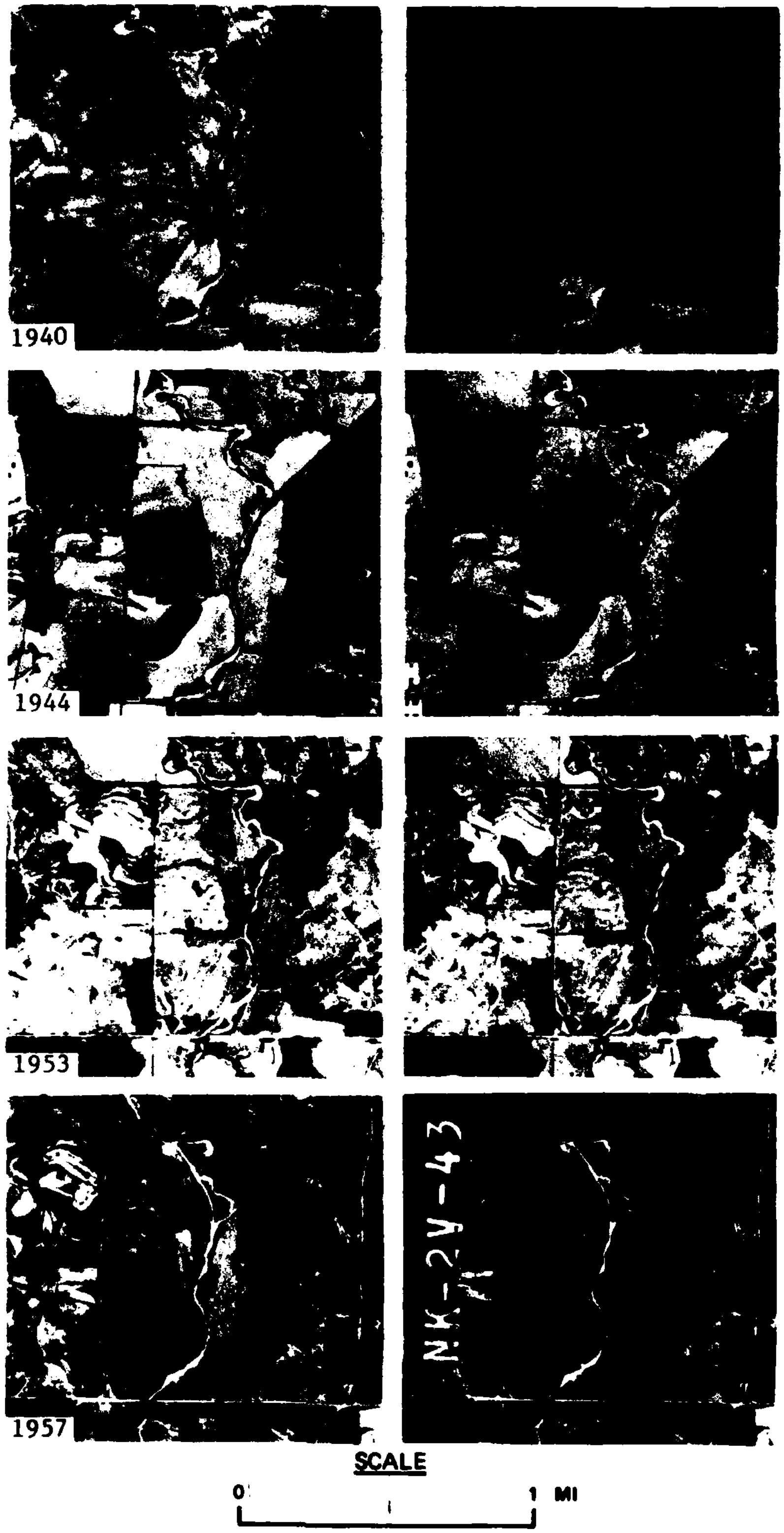


Figure 54. Site G4 on Goodwin Creek (Continued)

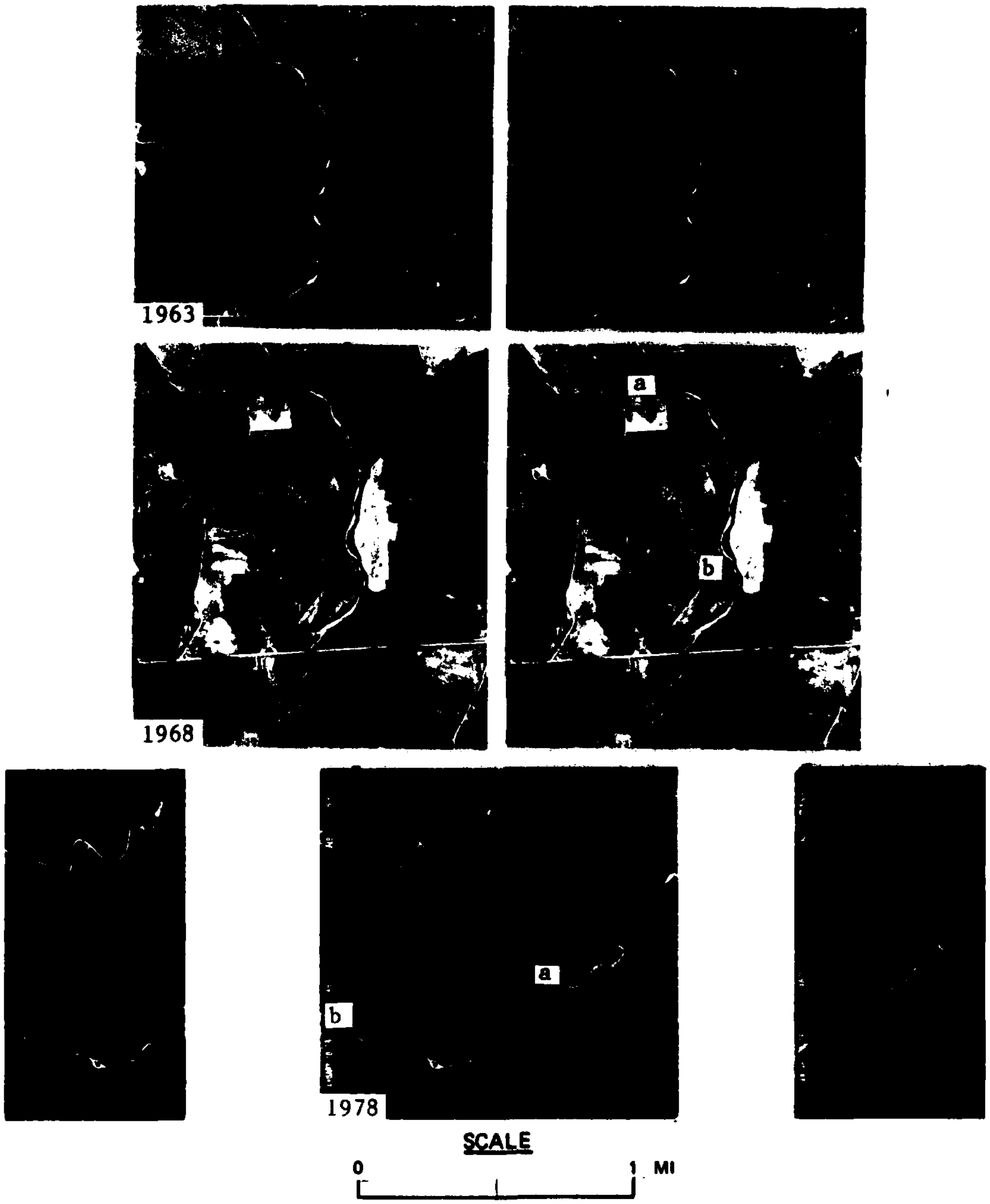


Figure 54. (Concluded)

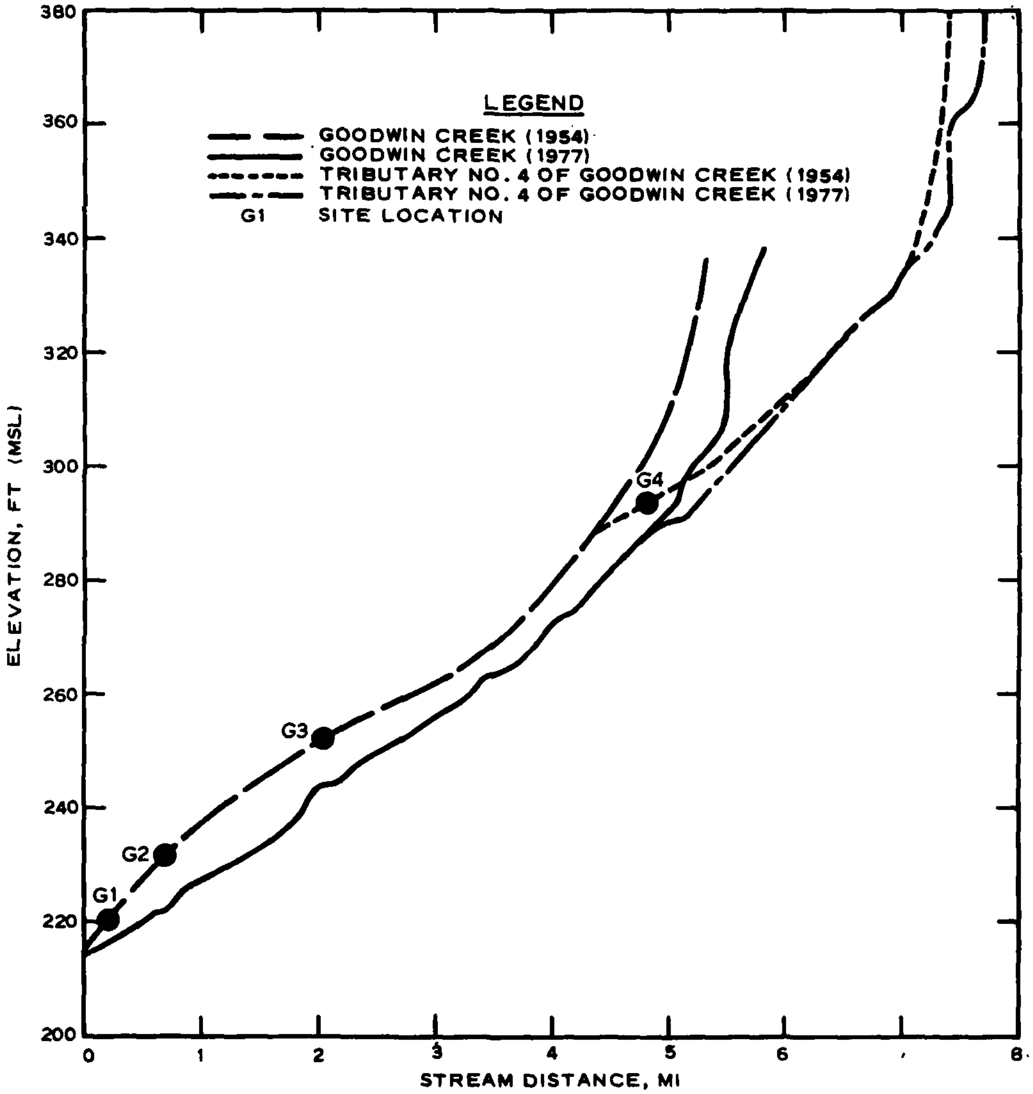


Figure 55. Longitudinal profiles of Goodwin Creek (1954 data from USGS topographic maps, 1977 data from Corps of Engineers survey; sites G1 through G4 are located on the 1954 profiles.)

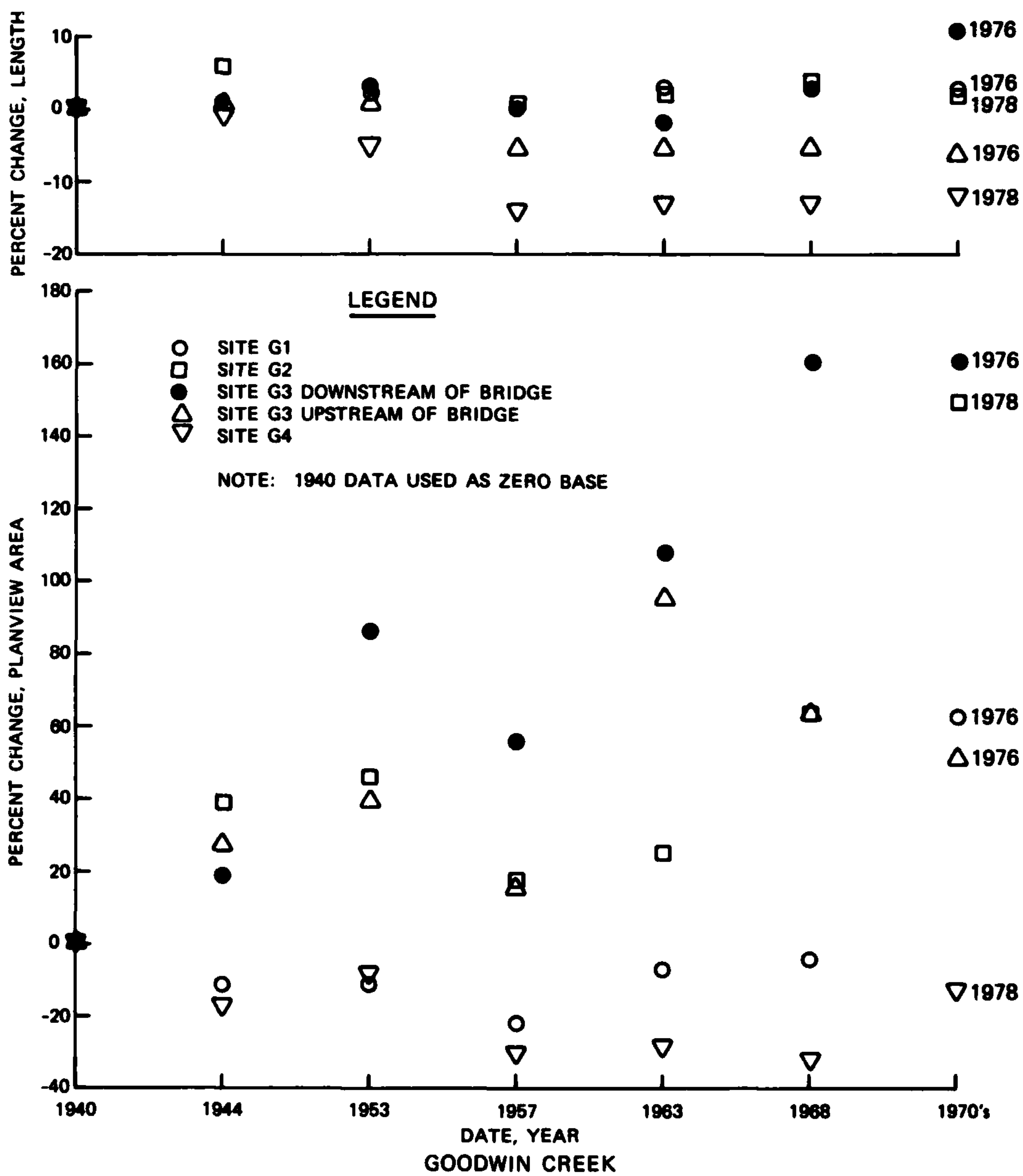


Figure 56. Changes in planform area and channel length of Goodwin Creek

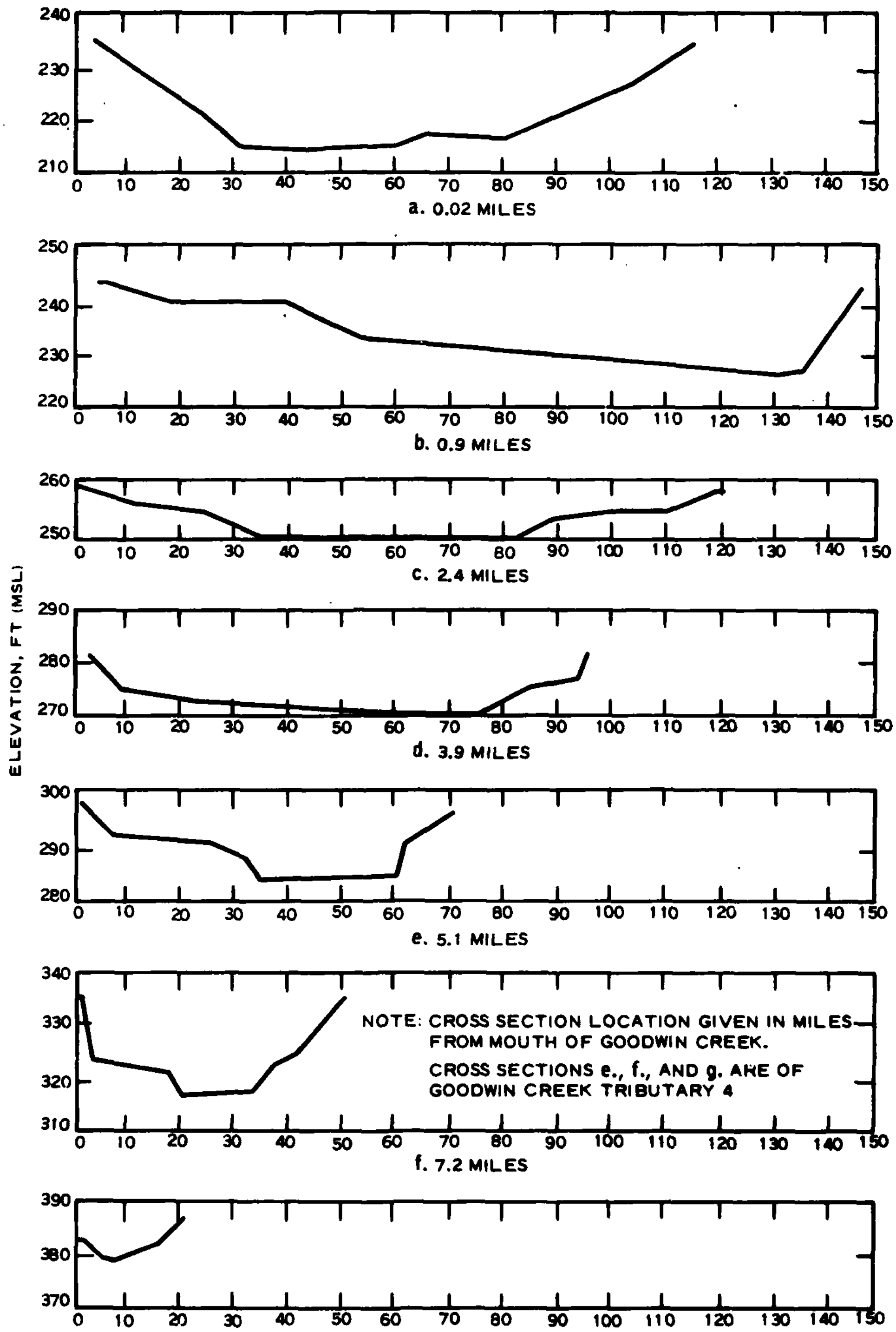


Figure 57. Cross sections of Goodwin Creek in 1977 (from Corps of Engineers survey data)

along with a very significant increase in channel width show the "whipping action" or lateral bank erosion resulting from a knickpoint hung up on erosion-resistant points.

Hotopha Creek

Present channel

94. Hotopha Creek channel is similar to the channels of Perry, Tillatoba, and Goodwin Creeks. The bed and banks consist of Quaternary sediments in the same sequence described in the above-mentioned channels.

95. The modern Hotopha Creek channel is characterized by vertical or nearly vertical banks that are 15 to 20 ft high, frequent cave-ins or slumps, a rapid decrease in bed load in the upstream direction, deposition of relatively large quantities of sediment in the lower reaches of the channel, and Quaternary clays exposed in the bed of the middle and upper reaches of the channel (Figure 58).

Channel changes

96. All of Hotopha Creek, except for the approximate 3.3-mile stretch at its mouth, has been channelized. The channel from A to B on Figure 5 was channelized from 1958-61, and the channel upstream from B was channelized prior to 1935. Chronological sequences of aerial photographs of five sites on Hotopha Creek show the channel changes that occurred prior to and after the 1958-61 channelization.

97. Site H1 is located at the mouth of Hotopha Creek and includes approximately one-half mile of the channel (Figure 59). Vegatative cover lined the 1935 and 1940 channels. There was no observable bank erosion occurring at this time. However, bank erosion appears to have been very active in the 1949 channel. The 1949 banks were steep and fresh-cut, and the meander loops had a sharp V-shaped inside bank, rather than a U-shaped bank. Continued erosion of the banks had removed all of the meander loops, except for the large, gently curving ones, by 1968. The post-1968 channel has a straight channelized appearance. The banks of the meander loops on Little Tallahatchie River have been eroding also.

a. Upper reach

b. Lower reach

Figure 58. Upper and lower reaches of Hotopha Creek

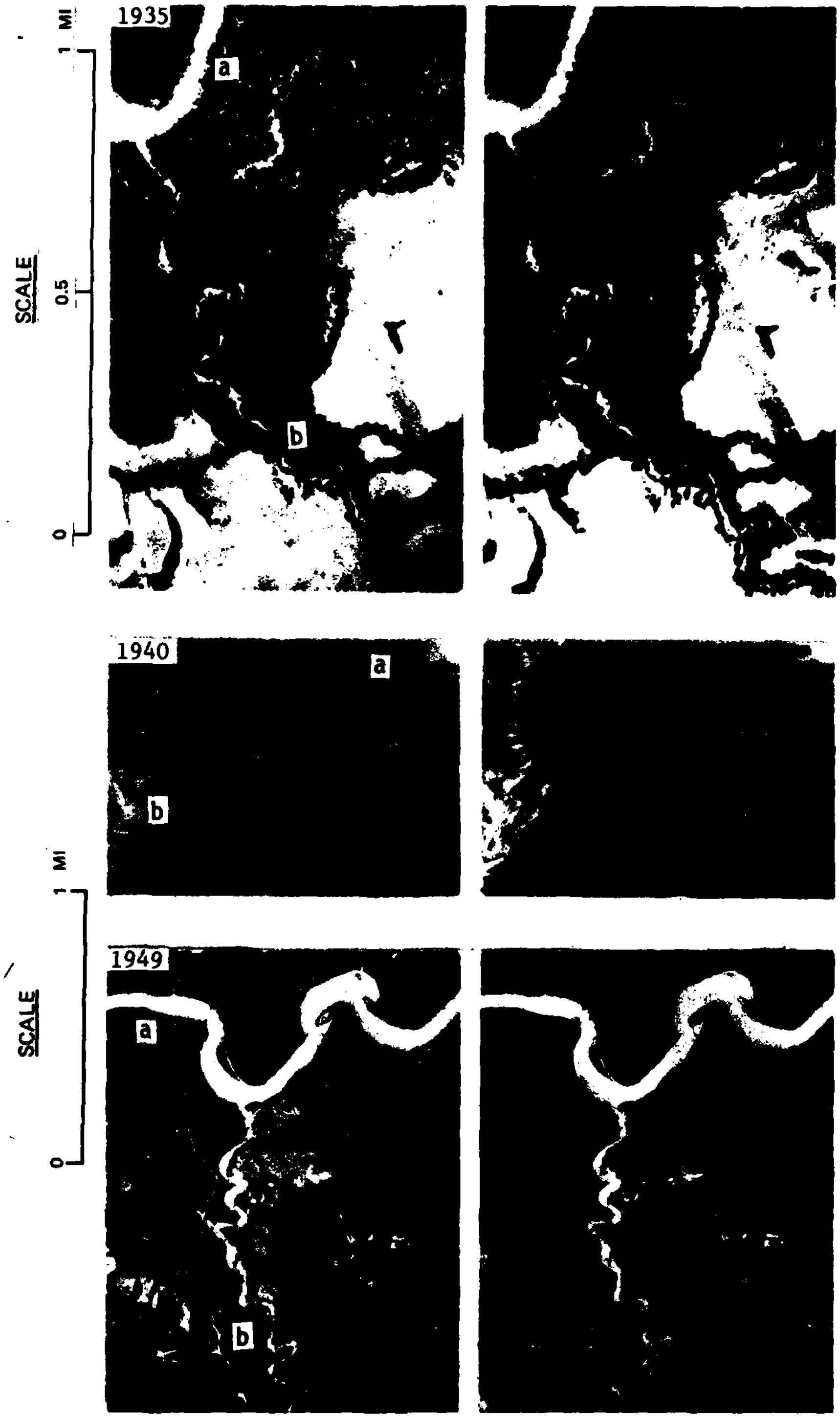


Figure 59. Site H1 on Hotopha Creek (Symbol "a" designates Little Tallahatchie River; "b" is Hotopha Creek.)
(Continued)

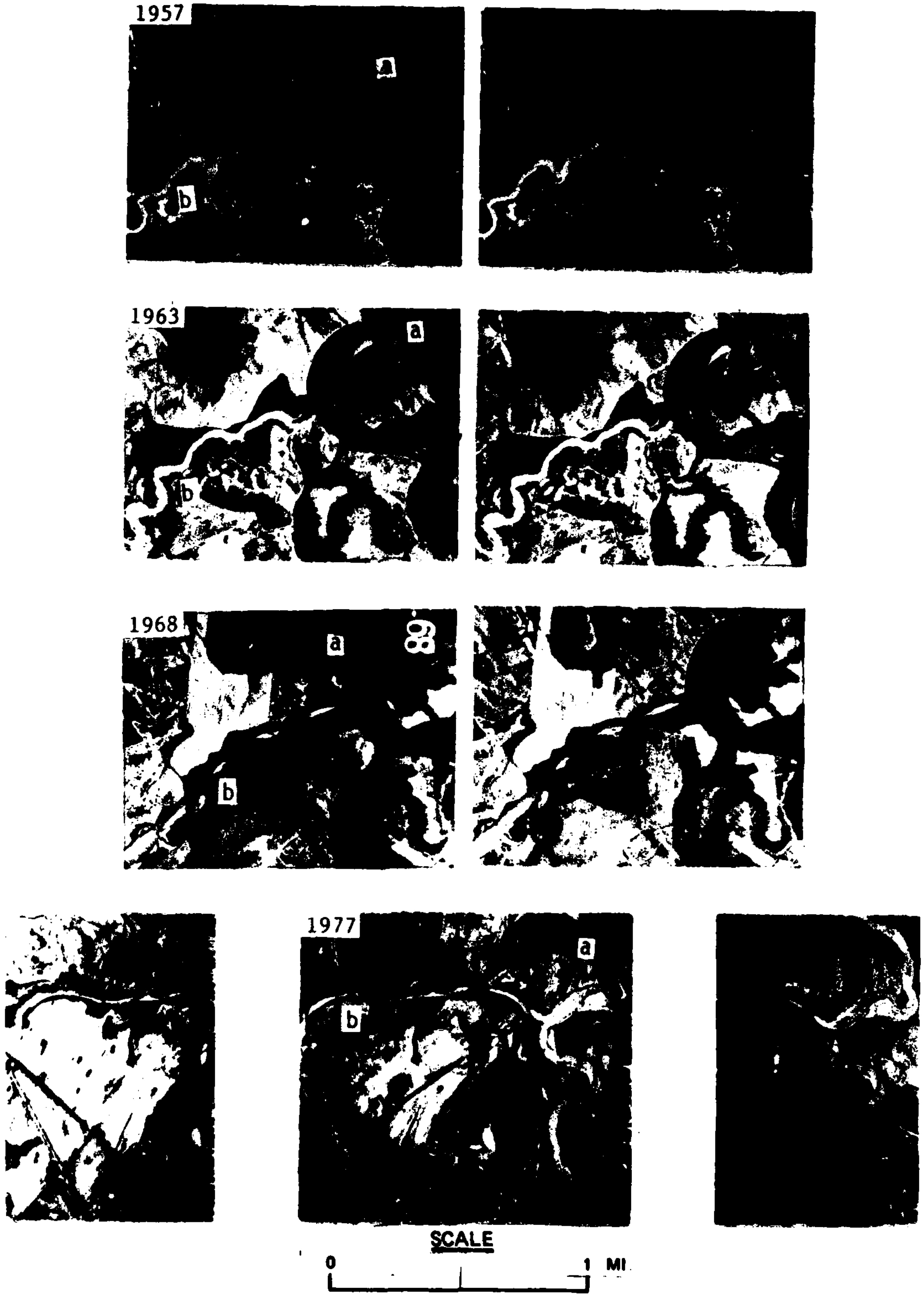


Figure 59. (Concluded)

98. Site H2 is located at the beginning of the 1958-61 channelization, 3.3 miles (1957 stream distance) above the mouth of Hotopha Creek and includes approximately 1.5 miles of the channel (Figure 60). There was no observable bank erosion on this stretch of channel prior to channelization. A 160-ft-wide path along the 3.3-mile stretch that was not channelized was cleared of vegetative growth, stumps, debris, and other obstructions. By 1963, two years after channelization, the unchannelized segment appears to have been rapidly eroded, especially laterally. Channel width had nearly doubled since 1957. Several meander loops had been cut off, and the smaller meander loops had nearly been eroded away. The banks were vertical with fresh-cut appearances. There were large splay deposits at the mouth of the channelized section. Channel width more than tripled from 1957-68. Bank erosion had removed all of the smaller meander loops, giving the 1968 channel a channelized appearance. The cutoff meander loops were higher in elevation than the 1968 channel. Continued bank and bed erosion had widened and deepened the channel by 1977. The large volume of sediments in the 1968 and 1977 channels caused the thalweg to become braided in several places.

99. Site H3 is located 6 miles (1963 stream distance) above the mouth of Hotopha Creek and includes approximately 1 mile of the channel (Figure 61). The only noticeable bank erosion, prior to 1957, occurred at the State Highway 6 bridge, and the localized erosion was probably related to the highway and bridge. A short section of the channel downstream from the bridge was channelized prior to 1935; however, there was no noticeable erosion in the channel through 1957. The post-1961 channelized stream rapidly degraded and eroded its banks. Lateral bank erosion, slumps, cave-ins, and gullying had altered the straight man-made appearance of the 1963 channel by 1977.

100. Site H4 is located 10.5 miles (1963 stream distance) upstream from the mouth of Hotopha Creek and includes approximately 1.5 miles of the channel (Figure 62). This site is at the mouth of the pre-1935 channelization, which extends from approximately 1 mile below the junction of Hotopha and Marcum Creeks to the head of Hotopha Creek. The pre-1935 man-made channel and prechannelization channel appear to be

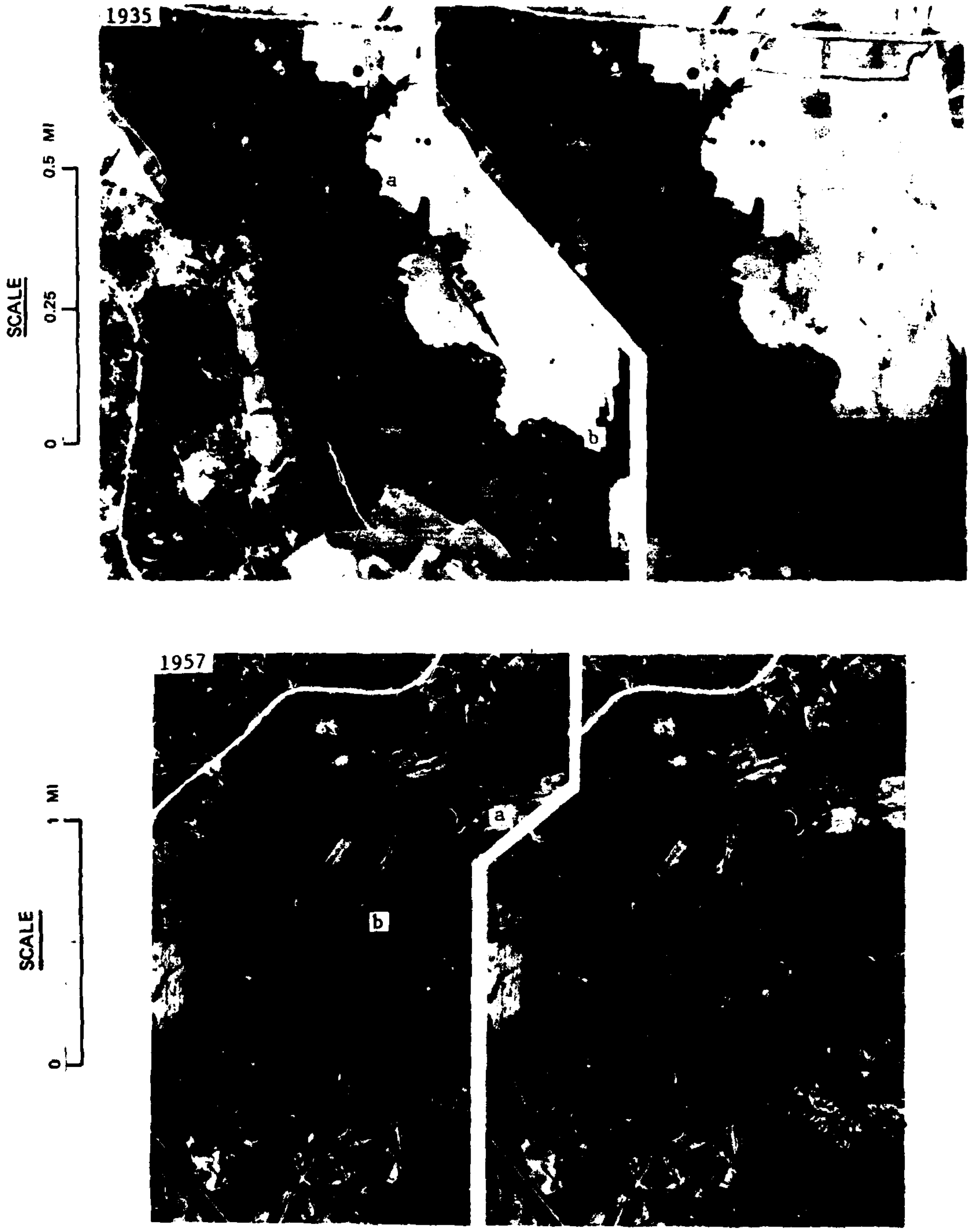
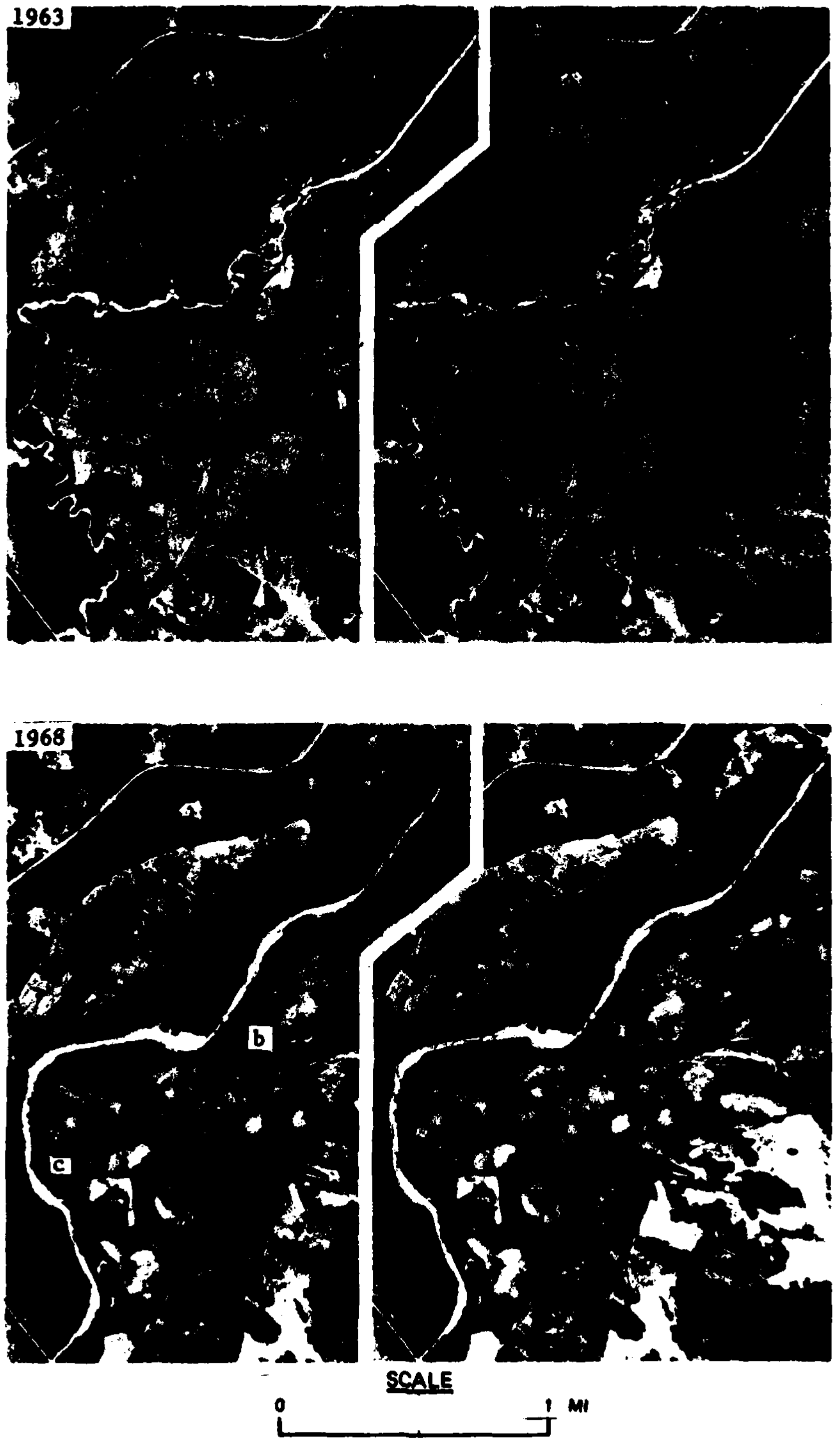


Figure 60. Site H2 on Hotopha Creek (Sheet 1 of 3)



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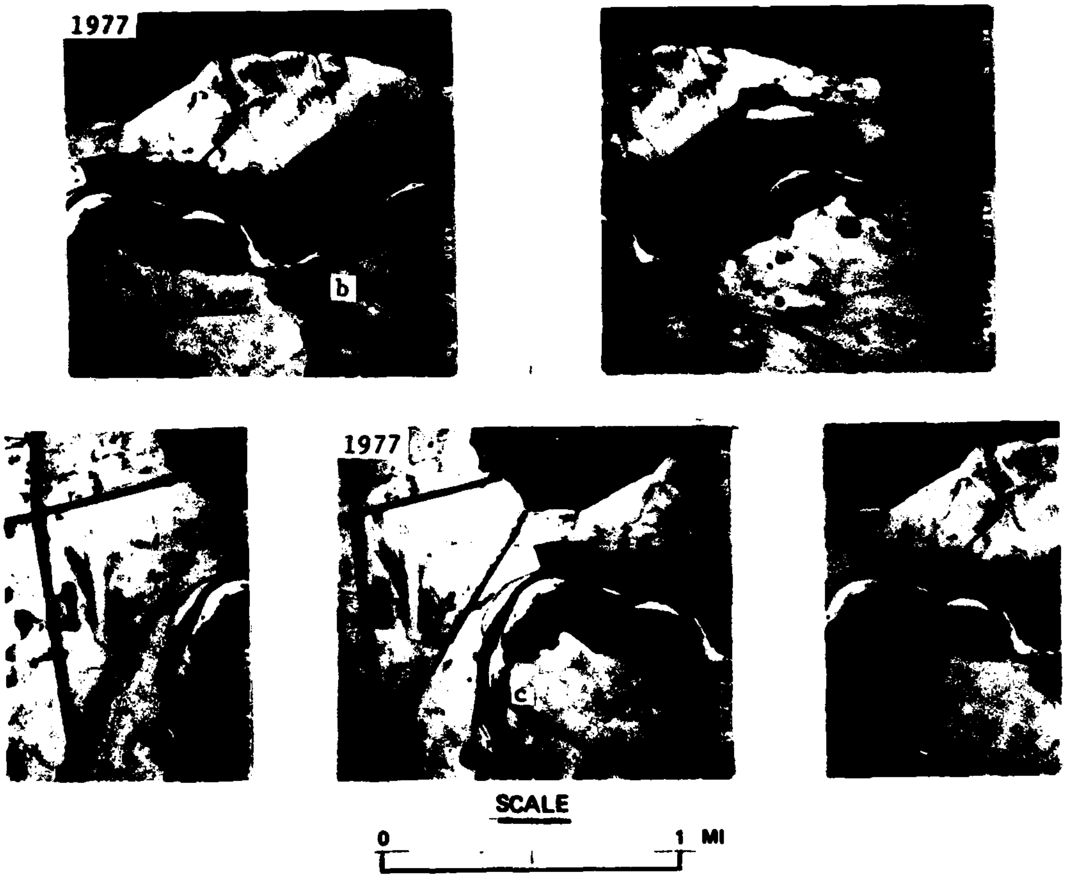


Figure 60. (Sheet 3 of 3)

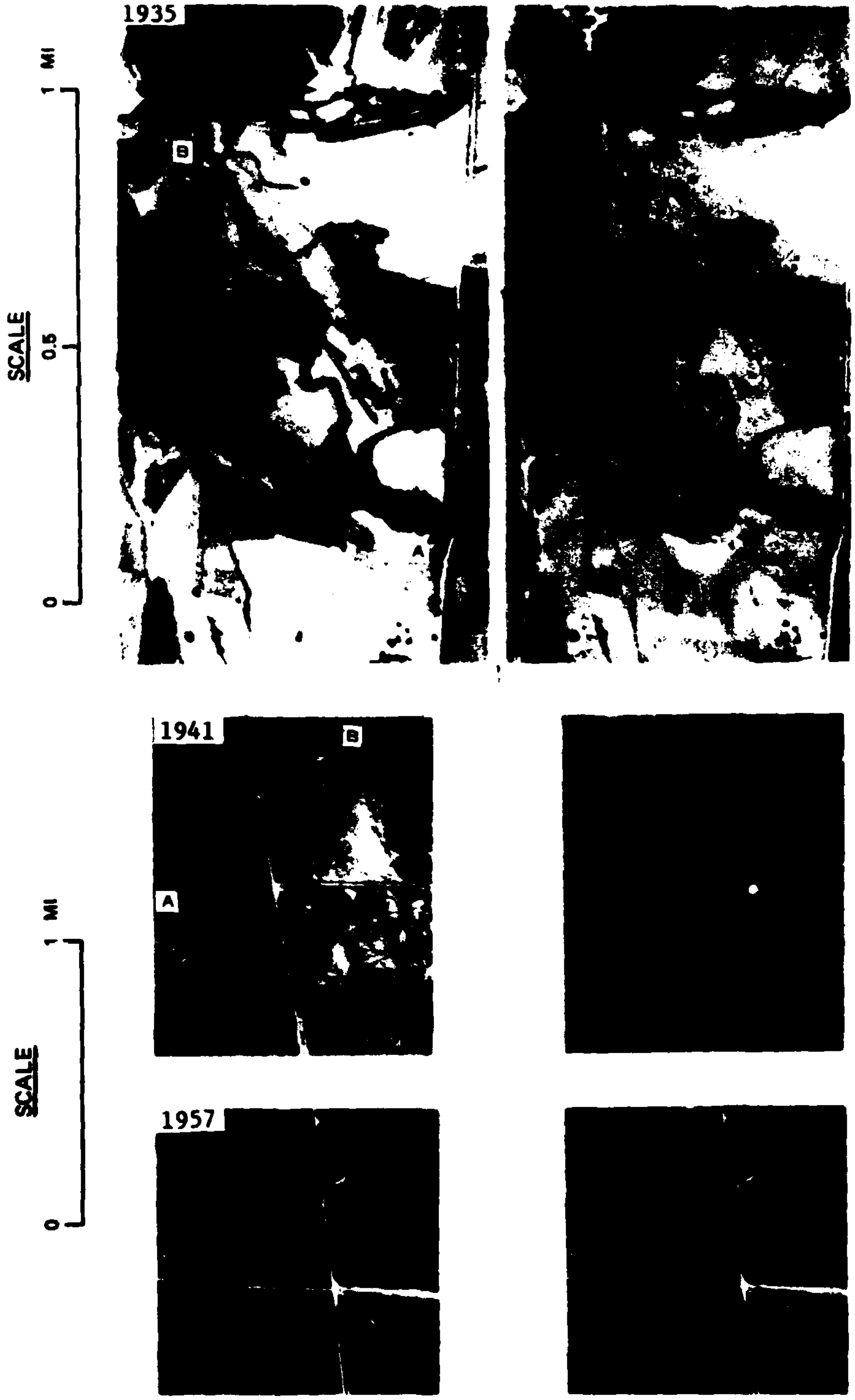
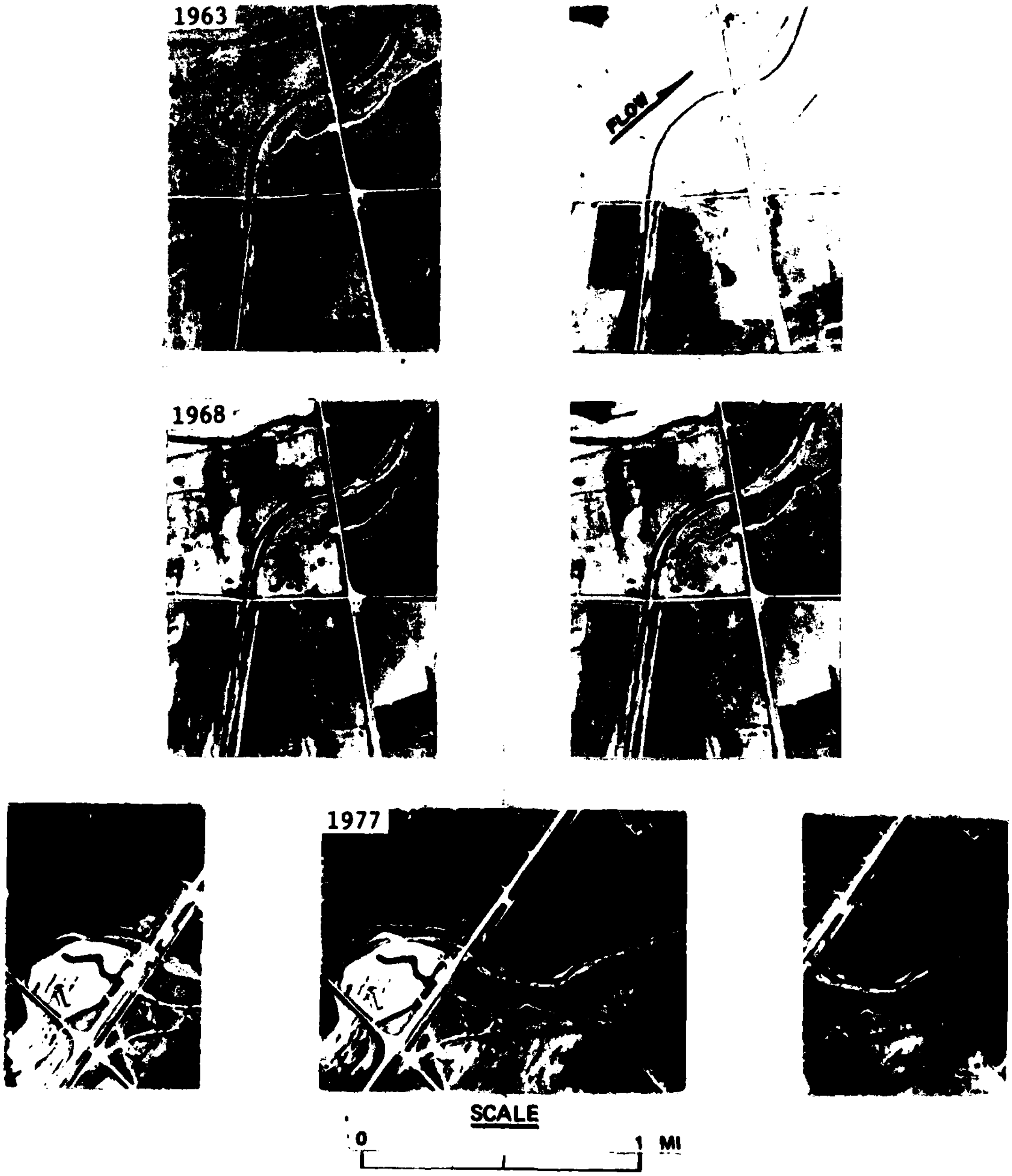


Figure 61. Site H3 on Hotopha Creek (Continued)



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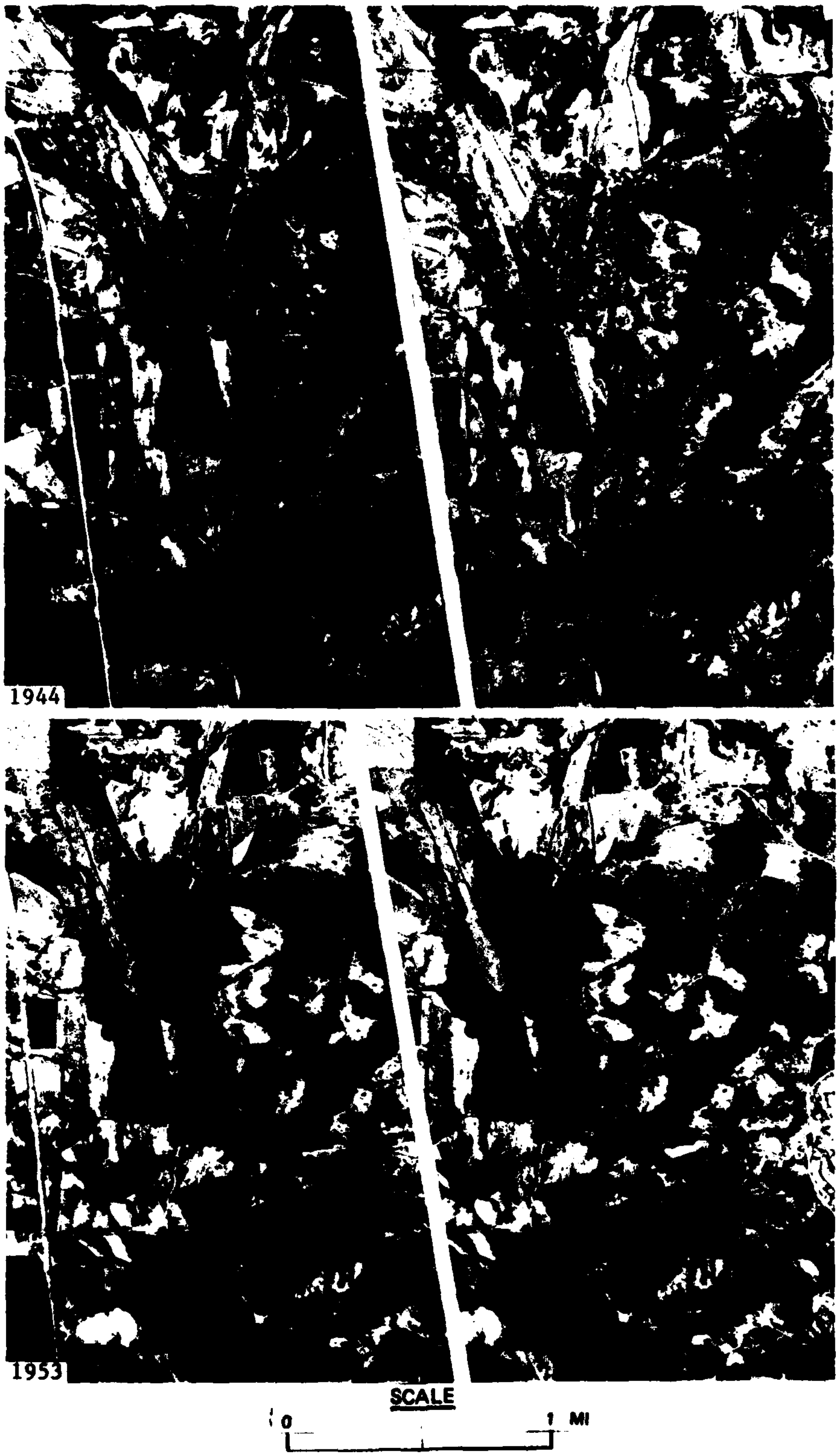


Figure 62. Site H4 on Hotopha Creek (Sheet 1 of 3)

Figure 62. (Sheet 2 of 3)

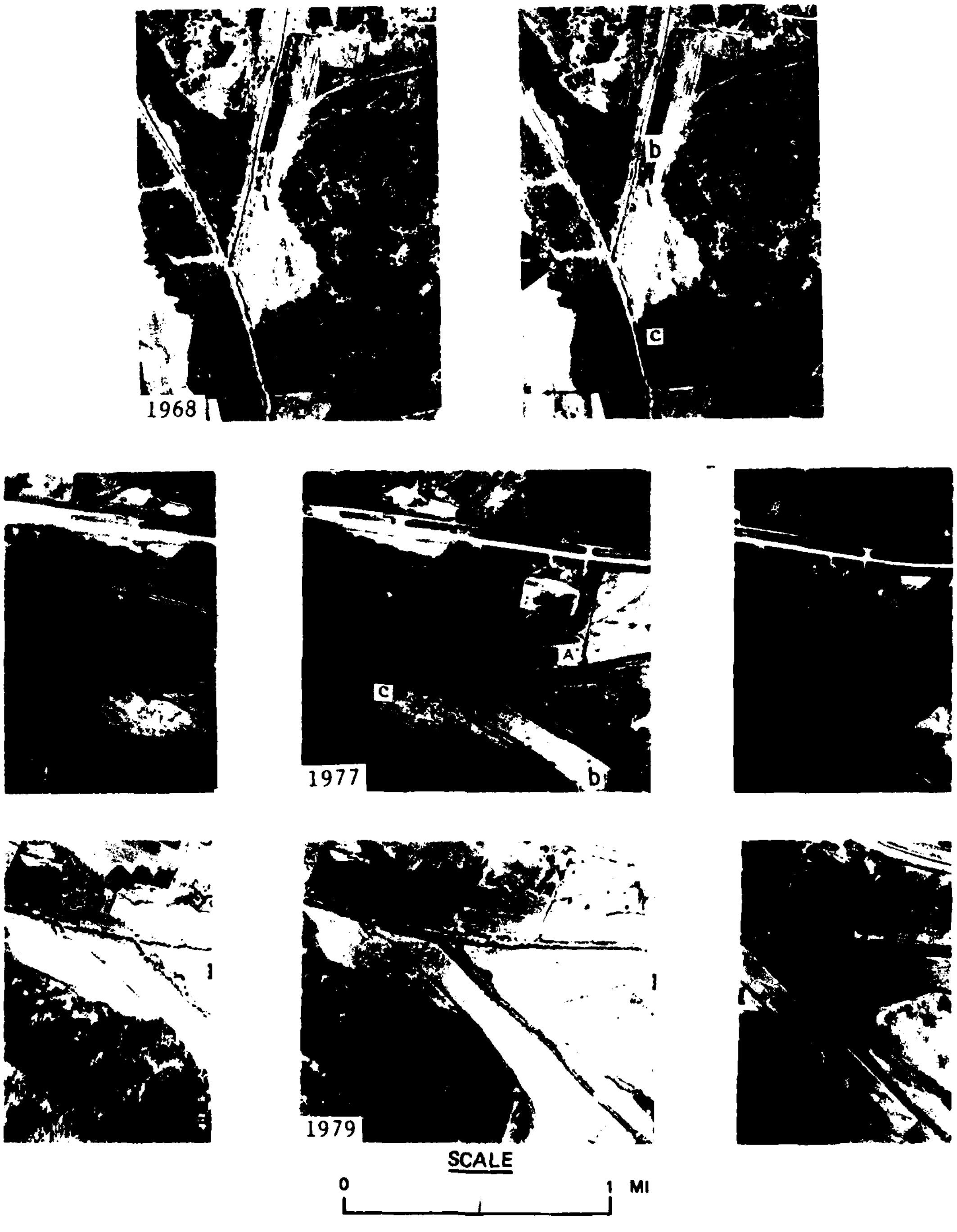


Figure 62. (Sheet 3 of 3)

approximately the same width. Numerous splay deposits along the entire length of the 1953 and 1957 channels in site H4 indicate the channel was clogged with sediments or debris. There was no noticeable change in channel width from 1944-57. The 1958-61 channelization enlarged the channel. Bank erosion quickly altered the straight man-made appearance of the 1963 channel to a more irregular shape by 1968. There was a noticeable increase in channel width below the mouth of Marcum Creek by 1968. Continued channel erosion widened and deepened the channel by 1977. The 4- to 5-ft waterfall at this site in 1977 and 1979 indicates the degree of degradation occurring in the channel (Figure 63).

101. Site H5 is located 11.5 miles (1963 stream distance) upstream from the mouth of Hotopha Creek and includes approximately 1 mile of the channel (Figure 64). This section of Hotopha Creek was channelized prior to 1935. The 1958-61 channelization extended into the lower part of this site. There was no observable, significant erosion in the channel from 1944-57. The channels from 1944-57 appear to have had a sediment-covered bed, while those from 1963 to the present appear to have a clay bed. The degradation at the mouths of the tributaries in 1963 indicates the channel was degrading, which would account for the removal of the sediments in the channel. The tributaries appeared as entrenched channels by 1979. Bank erosion had noticeably increased the channel width of Hotopha Creek in 1979.

102. Table 9 is a summary of the geomorphic changes on Hotopha Creek as observed from the chronological sequences of aerial photographs and from field observations.

103. The only noticeable or significant erosion seen on the pre-channelization photographs (pre-1958) was occurring at the mouth of Hotopha Creek. The 1953 longitudinal profile of Hotopha Creek shows a prominent knickpoint approximately 2 miles upstream from the mouth (Figure 65). The smooth concave downward shape of the rest of the 1953 longitudinal profile indicates no significant degradation was occurring elsewhere in the channel.

104. The 1958-61 channelization shortened the channel length approximately 2.9 miles (Soil Conservation Service (SCS) 1961). The

a. Long view

b. Close-up

Figure 63. Knickpoint at site H4 on Hotopha Creek, 1978 (See symbol "A" on the 1977 photograph in Figures 62 and 65.)

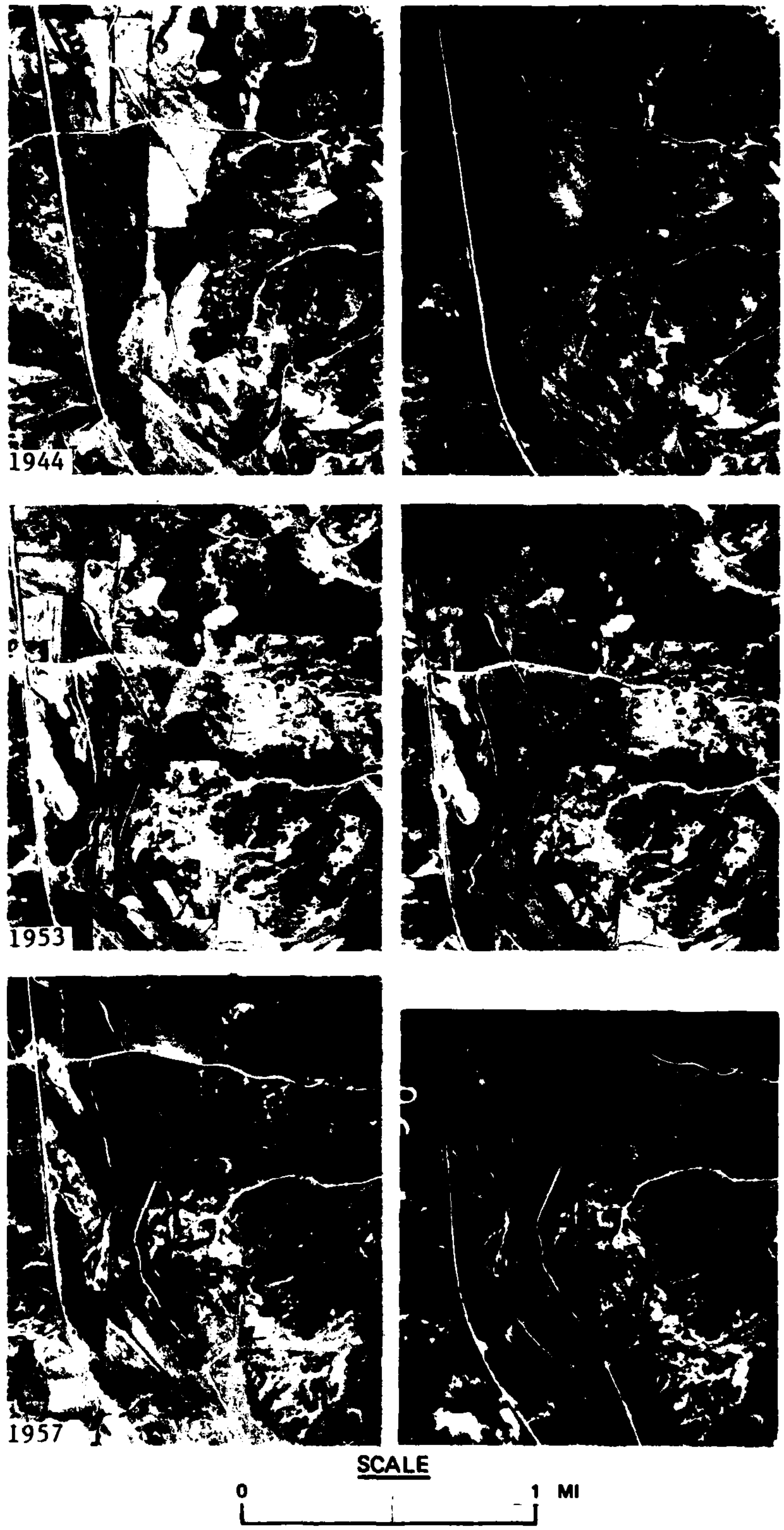


Figure 64. Site H5 on Hotopha Creek (Continued)

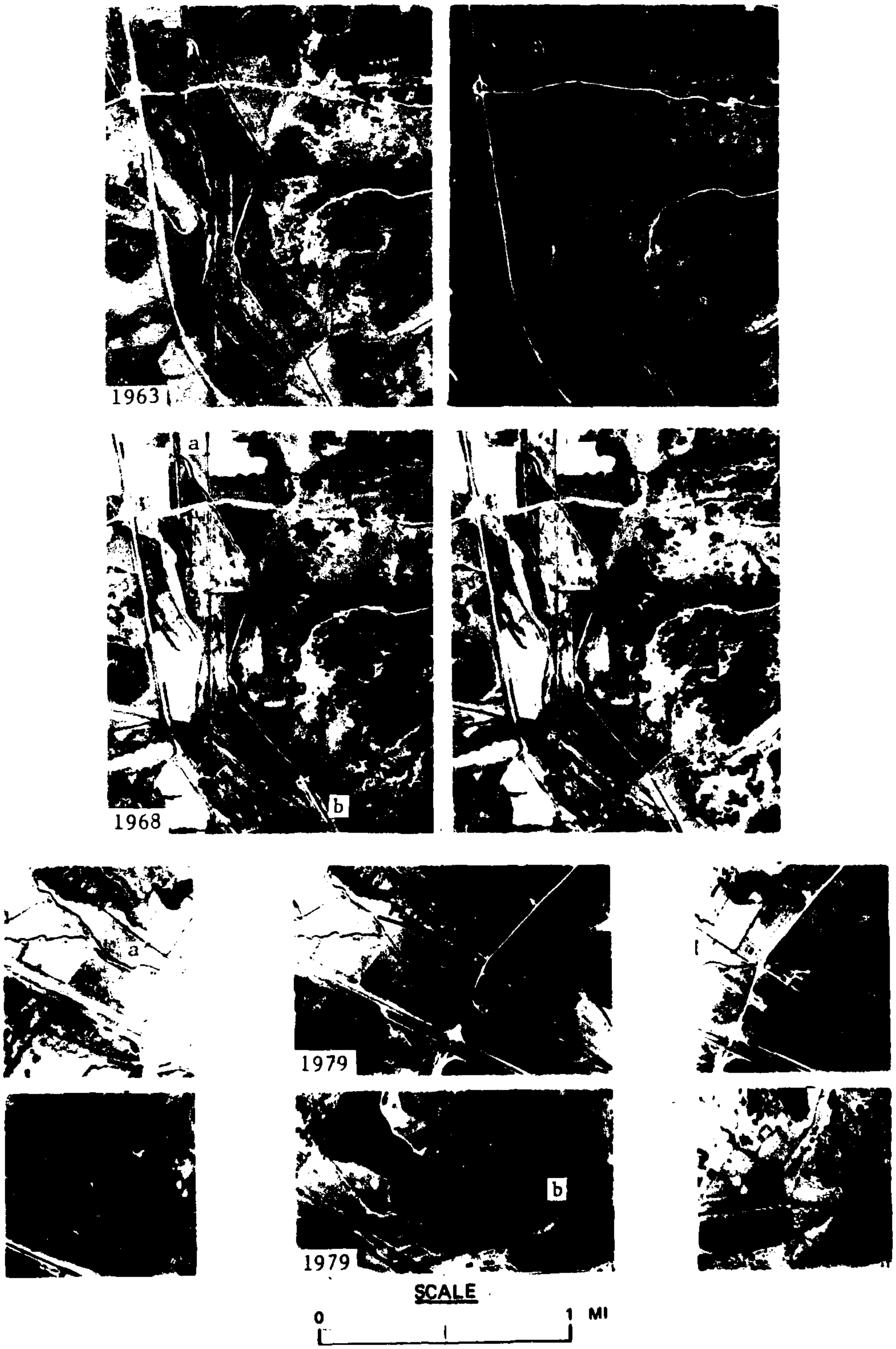


Figure 64. (Concluded)

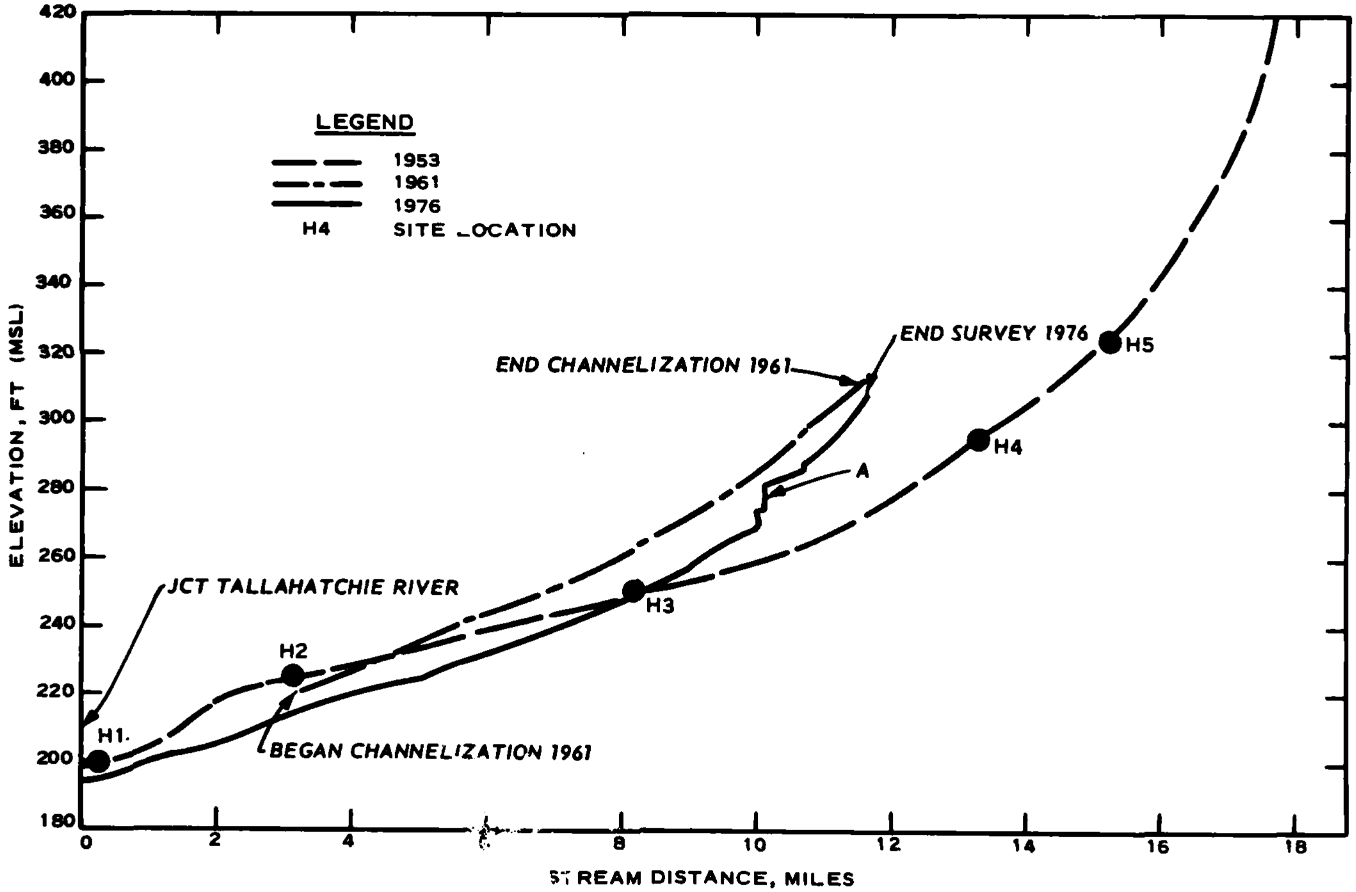


Figure 65. Longitudinal profiles of Hotopha Creek (1953 data from USGS topographical map; 1961 data from SCS survey; 1976 data from Corps of Engineers survey; sites H1 through H5 are located on the 1953 profile; see Figures 62 and 63 for Point A.)

gradient in the channelized stretch was increased from about 7.8 ft/mile to 11.1 ft/mile. A comparison of the 1961 and 1976 longitudinal profiles shows the channel has degraded up to 15 ft (Figure 65). The degradation was caused by the continued upstream advance of the knickpoint shown on the 1953 longitudinal profile and of subsequent knickpoints. The increased gradient in the channelized section probably increased the rate of speed of upstream movement of the knickpoint. Figure 66 shows the stretch of Hotopha Creek between sites H1 and H2. The knickpoint was approaching the lower part of site H2 in 1957. The channel in Figure 66 had nearly tripled in width by 1968.

105. There is a very prominent knickpoint at point A on the 1976 longitudinal profile (Figure 65). The knickpoint is cutting an erosion-resistant clay and has formed a 4- to 5-ft waterfall (Figure 63). The steep, unstable banks resulting from the channel degradation are slumping or caving in. The channel directly downstream from the knickpoint is 6 to 10 ft wider than the channel directly upstream from the knickpoint. Cross sections of the 1961 and 1976 channels show there is a downstream increase in width and an upstream increase in depth (Figure 67). The downstream increase in width results from the slumping and caving of the oversteepened banks and from bank erosion caused by the increased sediment load. The banks are also being eroded by piping (Figure 68).

106. The changes in channel area generally correspond to changes in channel length. Figure 69 shows the changes in channel length and area through time (1940's-1970's). The 1963 data were used as a zero base since channelization (1958-61) significantly altered the channel morphology. Sites H1 and H2 were not channelized in 1958-61; however, the changes in channel morphology of these two sites has been very pronounced. Bank erosion, as seen in Figures 59 and 60, shortened the channel length at both sites. The channel area decreased at H1 and increased at H2. The channel at site H3 decreased 74 percent in length and 23 percent in area from 1940-63; but channel length had not changed since 1963, while the area had increased 39 percent by 1977. Sites H4 and H5 were channelized prior to 1935, and H4 was enlarged in 1958-61.

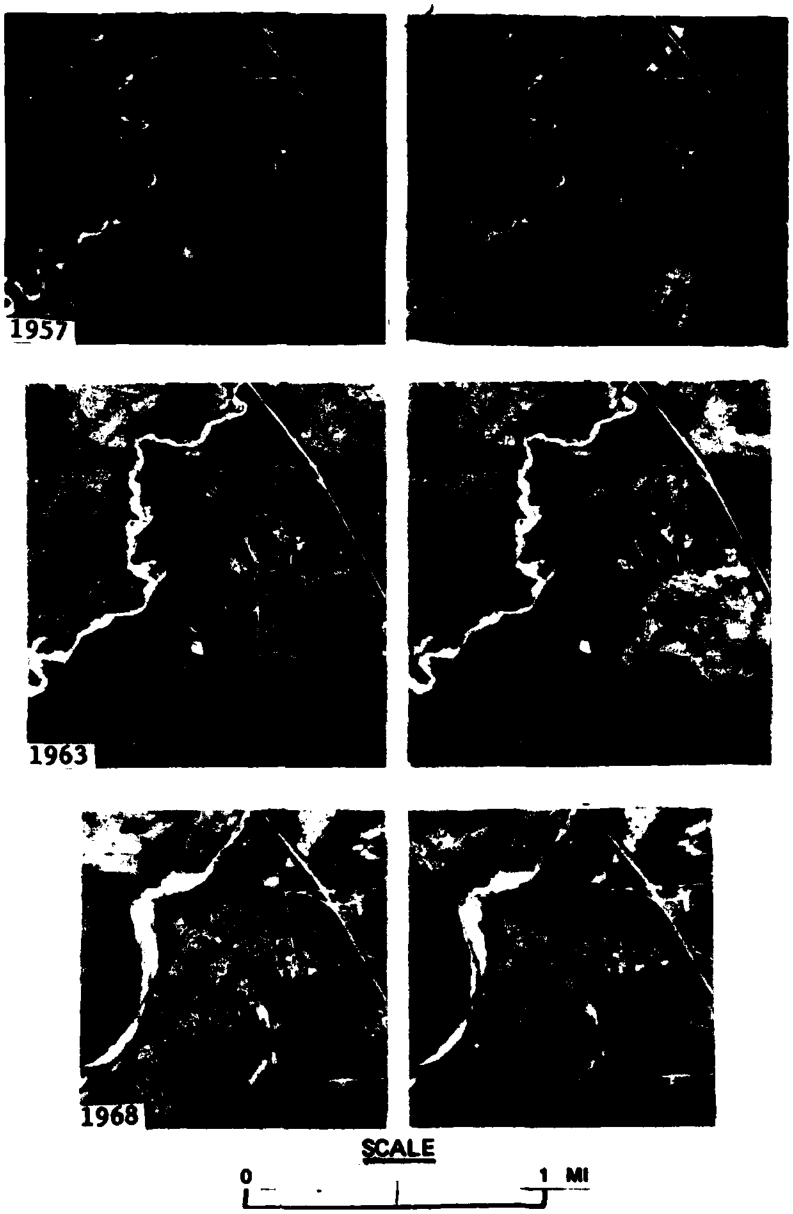
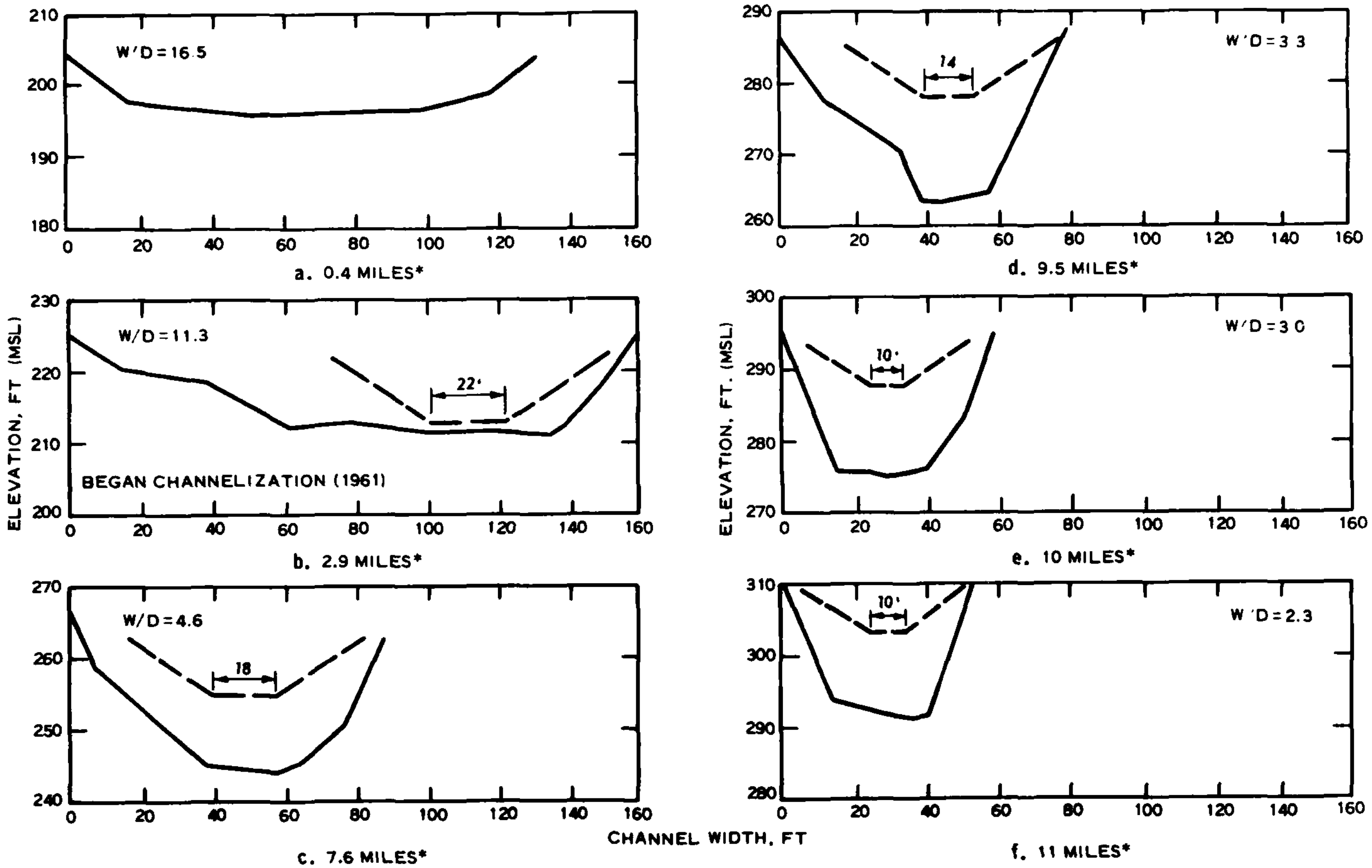


Figure 66. Hotopha Creek between sites H1 and H2 (Site H2 is directly upstream.)



LEGEND

— — CHANNEL, 1961

—— CHANNEL, 1976

* DENOTES MILES UPSTREAM FROM THE MOUTH OF HOTOPHA CREEK

W/D 1976 WIDTH/DEPTH RATIO

NOTE: THE 1961 CHANNELS ARE NOT IN CORRECT LATERAL POSITION WITH REFERENCE TO THE 1976 CHANNEL.

Figure 67. Cross sections of Hotopha Creek in 1976 with 1961 channel superimposed

Figure 68. Erosion of channel banks by piping

There has been no change in channel length at either site since 1940, but the channel areas have increased, especially at H4. The overall trend has been a decrease in channel length and an increase in channel area or width. There have been some temporary decreases in channel area when the channel has been widened, but also shortened, by bank erosion.

Erosion Control Measures

107. Numerous channel erosion control measures are being tested in the Yazoo River Basin to determine the most economical and effective means of reducing or preventing the erosion. As of 1978, 11 demonstration projects had been completed and were being monitored; three projects were being constructed, and at least six more projects were being planned. The projects include transverse and longitudinal dikes, revetment, retards, riprap, the replanting of vegetative cover on banks, and other types of bank cover. Most of the projects have been concerned with the immediate protection and stabilization of eroding banks. At least eight grade-control structures have been built or are being planned to reduce or prevent further channel degradation and

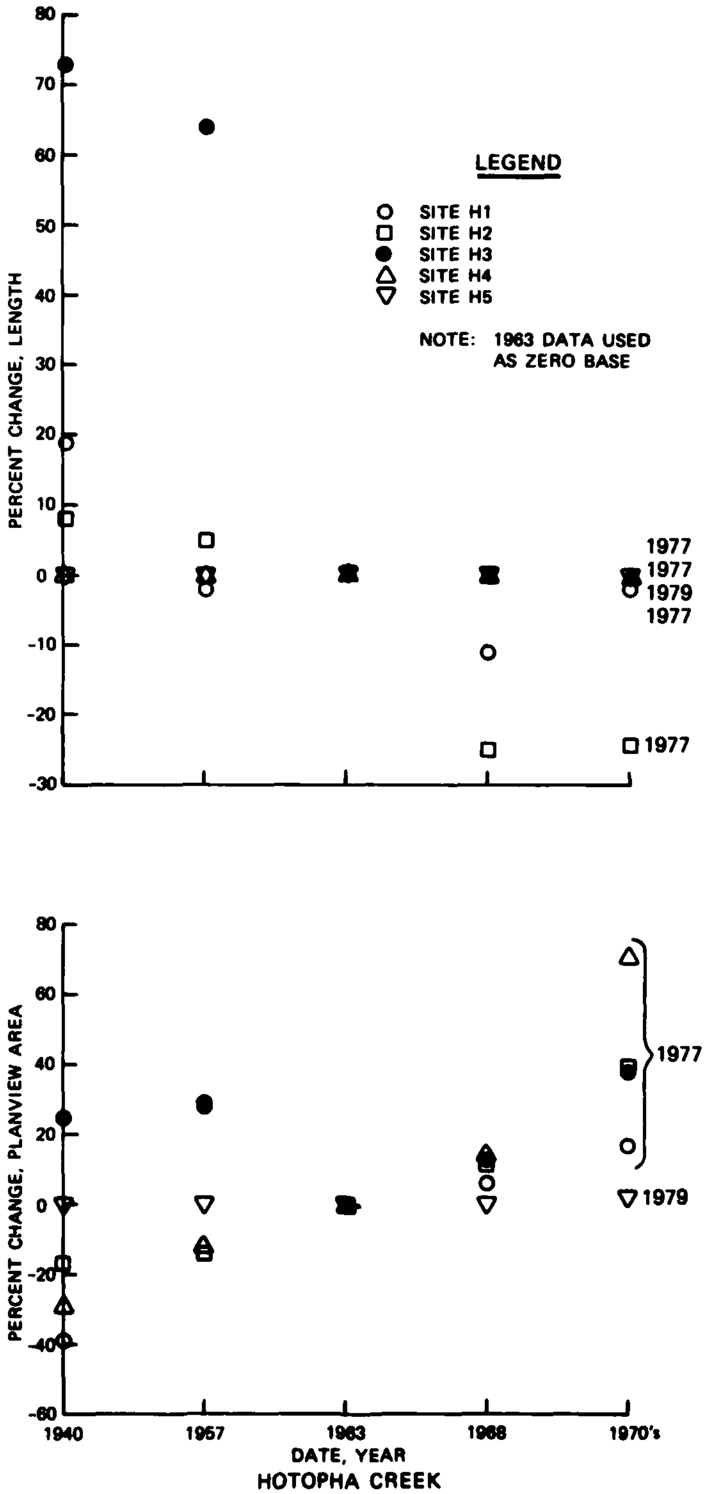


Figure 69. Changes in planform and channel length of Hotopha Creek

accompanying bank erosion. Figure 70 shows two of the grade-control structures constructed in Tillatoba Creek Basin.

108. The effectiveness of the channel erosion control methods has not yet been determined as of this date. The substantial increases observed in channel width as a knickpoint advances upstream, especially where the knickpoint is retarded by erosion-resistant materials, such as clay or a limonitic ledge suggest that there could be problems in maintaining some grade-control structures.

109. In addition to the various channel erosion methods being tested, the following cooperative efforts have been initiated (U. S. Army Corps of Engineers 1978):

- a. A joint venture with the Science and Education Administration--Federal Research, USDA Sedimentation Laboratory at Oxford, Miss., to define and monitor amounts, sources, direction, and time of travel of sediments. This will include complete analysis of the drainage basin morphology, geology, soils, land use, vegetation, basin stratigraphy, hydrology, climatology, and stream hydraulics. Particular emphasis will be in the Goodwin Creek Basin, and the results will be used to determine the performance of selected channel stabilization methods and to determine the influence of grade-control structures on channel stability.
- b. A program to test a wide variety of vegetative controls both on the floodplain and on the beds and banks of the streams has been initiated with the combined efforts of the USDA SCS agronomy teams for an 11-state area.
- c. A complete inventory of SCS bank stabilization efforts for the past two decades. This will include location, type, and purpose of stabilization; results and maintenance; effects on geology and soils; stream and basin hydraulics and hydrology; and land use.
- d. A cooperative agreement with the U. S. Army Engineer Division, North Central, of the Corps of Engineers to use Dr. C. T. Yang's concept of "Unit Stream Power" to develop a more theoretical approach to stream stabilization.

Discussion

110. Generally the results of these historical geomorphic analyses have revealed that during the last 40 years, the studied stream

a. Lower structure in North Fork, 4-ft drop

b. Middle Fork, 13-ft drop

Figure 70. Two grade-control structures in Tillatoba Creek Basin

basins have undergone major, abrupt changes of channel position, drastic changes in sinuosity, increases in channel widths of 200 to 300 percent, and tens of feet of channel deepening. These changes have occurred so quickly and are so extensive in magnitude and distribution that it is unlikely they represent normal stream behavior. Of course, sinuosity change, widening, and deepening are normal fluvial processes that individually (and under certain circumstances collectively) contribute to the evolution of fluvial regimes. However, it will be necessary to consider what conditions, natural or human-initiated, could cause these processes to occur so quickly and over so wide an area. Furthermore, one must consider whether the assumed baseline conditions of 1937 are truly typical.

111. The assumption that the 1937 imagery revealed typical channel abandoment conditions seems acceptable for two reasons. The first reason is the stable development of vegetation along the streambanks, indicating that the stream had not actively shifted position either horizontally or vertically. The second reason is the absence of relatively recent terraces on the floodplain. As previously mentioned, terraces do occur; however, they are predominantly located near the bluff line. If the 1949-80 channel changes were common phenomena during the last 500 years, for example, one would expect to see prominent surface evidence of their occurrence. With respect to terraces, it should be pointed out that the post-1940 degradation has, in fact, resulted in the development of a new floodplain at an elevation of 20 ft or so below the pre-1940 surface, which is now a terrace.

112. The imagery has shown the progressive widening of stream channels. Channel deepening can also be seen on the imagery, but this deepening was not quantified. The evidence on the aerial photographs, including visible knickpoints and hanging tributaries, and field evidence supported the conclusion of active degradation. Having established that both widening and degradation have occurred, one must consider the relations between the two. That is, have both width and depth increased due to increases in both water and sediment discharge, or has increased water discharge initiated deepening which in turn produced

widening due to the instability of channel walls? These two possibilities may be explained by the proportionalities below:

<u>Increased Water and Sediment Discharge</u>

$$W/d \propto Q_s \quad \text{and} \quad d \propto Q$$

or

<u>Increased Water Discharge</u>

$$d \propto Q$$

113. The relations above provide an explanation of the influence of both water and sediment discharge on producing the observable geomorphic conditions. These relations also underscore the need for vertical control. The lack of quantified data on channel degradation and sediment discharge is unfortunate, but perhaps not crucial to the understanding of the processes.

114. The influence of upland-derived sediment discharge may be determined from the imagery analyses. Generally, the observations from aerial photography suggest that excessive sediment discharge may be restricted to the uppermost portions of the basins and are thus primarily affecting the first- and second-order streams. On the other hand, the sediment observed on the lower reaches has been derived primarily from the channel banks by headcutting and subsequent bank erosion. The observations in the field, as well as of the imagery, suggest that the basin streams investigated in this study are not particularly overloaded with sediment. One is more strongly impressed by the amount of degradation than by the accumulations of sediment. This impression is due, in part, to the infrequency of extensively braided reaches. Probably the most conclusive negative evidence is the absence of any apparent downstream progression of sediment fluxes. One should suppose that if both increased water and sediment discharge were occurring, there would be an indication of this progression. These lines of evidence strongly suggest that increased discharge of both water and sediment are not primary contributors to geomorphic change in the Yazoo Basin.

115. The evidence against the significant influence of sediment discharges is generally in accord with the nature of land use within the

uplands, which will be more fully discussed in PART IV. Briefly, improved land use practices in the upland areas over the last 40 or 50 years are believed to have greatly reduced the sediment loads entering these small watersheds.

116. If increased sediment load is not the primary contributory cause of geomorphic change, then increased water discharge may be. There are two primary ways in which water discharge may be increased. The first involves a shorter runoff time for overland flows resulting in higher velocities of flow within the basin. Such conditions could occur by urbanization and paving of large areas and by changes in ground cover. The latter would be a more appropriate consideration in this portion of the Yazoo Basin and might include timber stripping on the hillslope, and floodplains and conversion to grazing. The second way in which water discharge may be increased is by an increase in stream gradient, leading to more peaked hydrographs. For a given reach, the channelization of that reach would increase the reach's slope, and channelization downstream of a given reach would produce a break in slope or knickpoint at the head of the channelized section. Climatic conditions are discussed in PART IV.

117. Generally, the data derived from the imagery provide some indication of how the flow has been increased. The evidence is found in the upstream progression of channel instability. Bank erosion, sediment accumulation, and other changes occur in the lower reaches first and progress upstream accompanying the advance of the knickpoint.

118. The observations and tentative conclusions derived mainly from aerial imagery and which have been given in this part of the report indicate that channelization and related engineering improvements are the primary causes of bank erosion, and agricultural practices are of secondary importance. PART IV describes these agricultural activities.

PART IV: NONSITE FACTORS

119. This Part of the report will address those factors, specifically climate and human activities, that are operating basin-wide or outside of the basin, excluding the geology, soil, hydrology, etc. of the area, which were described in PART III. Tectonism has been suggested as one possible cause of channel erosion in the Yazoo River Basin. There is presently no data to support this idea, so it will not be discussed in this report.

Climate

120. Climate is considered to be a primary cause of streambank erosion only to the extent that it is the driving force behind all hydrologic processes, including the geomorphic development of fluvial systems (Gregory 1976). A systematic change in the magnitude or frequency of climatic events is not considered to be the principal cause of massive and extensive historical bank failure, although extreme climatic change can, by itself, produce a dramatic change in fluvial systems.

121. Average yearly rainfall records for the Yazoo River Basin from 1895-1976 do not show any drastic changes in rainfall patterns (Figure 71) (U. S. Weather Bureau 1895-1976). One apparent change is the recent increase in the number of years of extremely high average rainfall; however, the brevity of the period of record does not provide a basis for identifying any major change. Any stream reaction to changes in channel configuration, vegetative cover in the basin, or other factors influencing a fluvial system are partially controlled by rainfall. The randomly alternating wet and dry periods have not initiated any major channel erosion, but do have strong control on the rate of channel erosion resulting from other causes. For example, extremely wet periods, such as the one from 1944-51, or just one year of abnormally high rainfall, such as in 1932, tend to accelerate the erosional processes initiated by other factors.

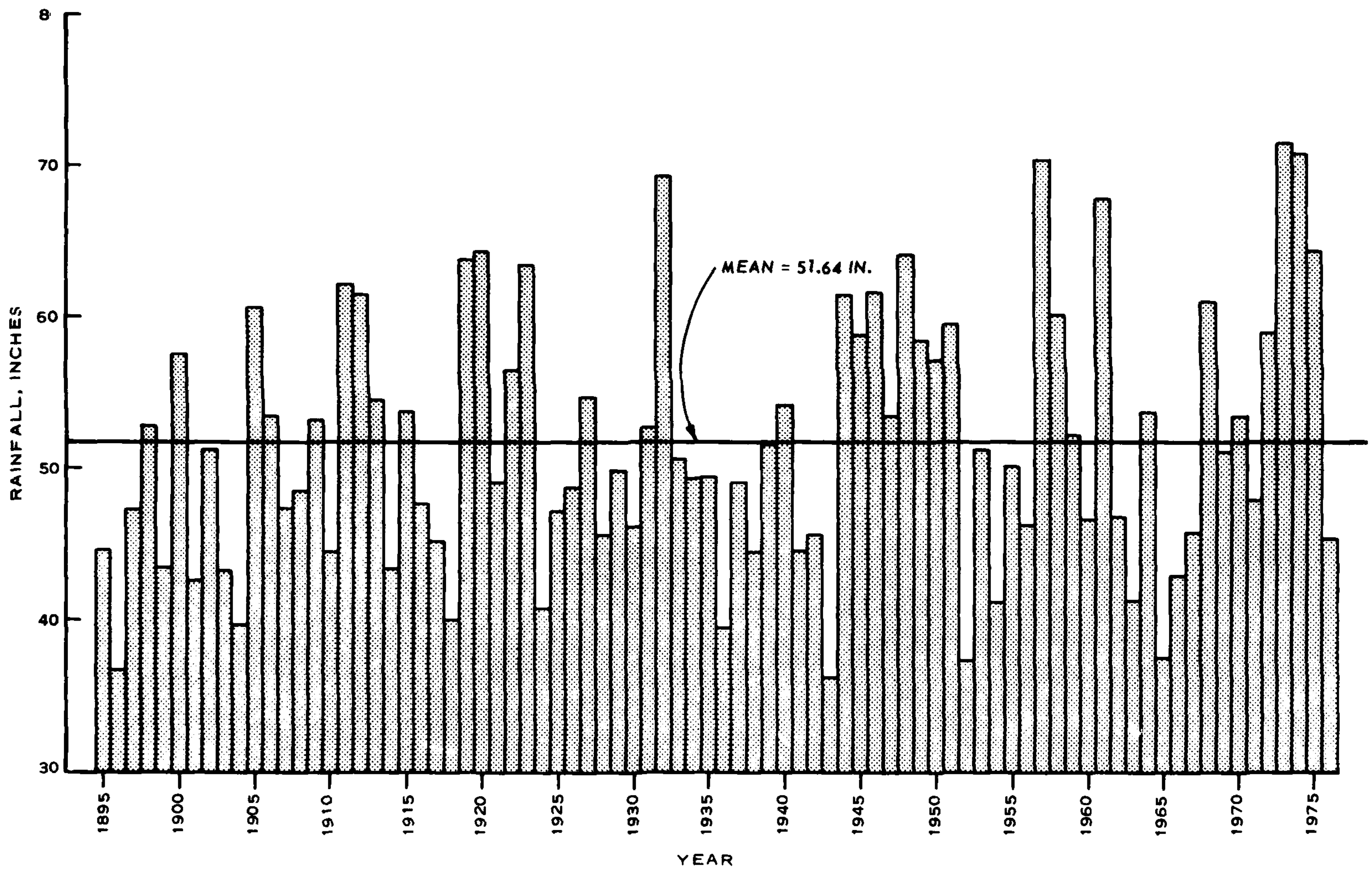


Figure 71. Rainfall averages in the Yazoo River Basin from 1895 to 1976 (U. S. Weather Bureau 1895-1976)

Human Activities

122. The most significant factors contributing to bank erosion in the Yazoo Basin Uplands are human activities. These activities have initiated, and are still contributing to, major changes in the fluvial regimes of the basin's streams. The activities directly and indirectly cause bank instability. An example of direct causes of erosion are removal of bank vegetation; indirect causes, which are probably more significant, include overextensive agriculture leading to high water discharges and high sediment yields, channelization resulting in higher stream gradients and higher velocities, and dams (Bray and Kellerhals 1979).

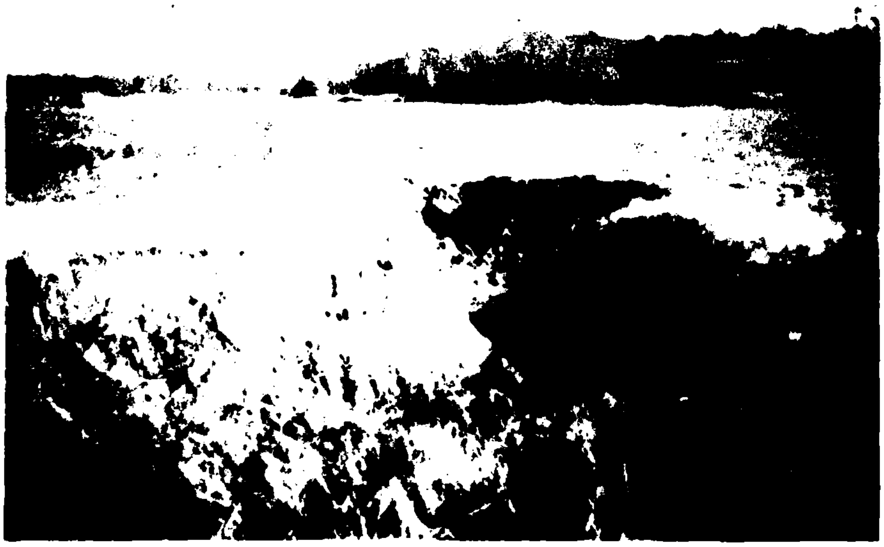
Land use

123. For the purposes of this discussion, land use includes agricultural uses (and related activities) and urbanization. Basically, these two activities may affect hydrologic and geomorphic conditions both locally and regionally by producing changes in water discharges and sediment yields. Urbanization (which generally contributes to increased water discharges) is not a major factor affecting the streams under study and will not be discussed.

124. The effects of agricultural activities on natural fluvial regimes depend principally upon the extent to which these activities are so extensive or poorly conducted that they contribute to erosion. Thus, the clearing of natural vegetation and the cultivation of crops or overintensive grazing of livestock may lead to erosion on the less well-protected surfaces and, as a consequence, to increased runoffs to the basin's streams and also higher sediment loads in these streams (Figure 72).

125. Logging and land clearing for agricultural use has removed most of the natural vegetative cover from the Delta. The chronological sequence of aerial photographs in Figure 14 illustrates how the Delta has been systematically cleared. The flat nature of the Delta required that the drainage systems be improved before much of the land could be used for agricultural purposes. Many of the natural drainage systems

a. Uplands



b. Valley

Figure 72. Upland soil erosion resulting from agricultural practices

were cleaned and enlarged, and canals or drainage ditches were dug. Drainage improvements included 3054 miles of ditches, 320 miles of levees, and 4 pumping plants by 1941 (Olsen and Dunn 1941). The effects of land clearing, farming activities, and improved drainage have been increased water and sediment discharges into the stream systems. The increase in water discharge has been much more significant than the sediment discharge, since the flat nature of the Delta does not lend itself to sheet or gully erosion.

126. Historically, the Yazoo Basin Uplands have indeed been subjected to overextensive agriculture. During the late 1800's and early 1900's logging and land clearing for agricultural purposes removed much of the natural vegetation. This clearing and subsequent cultivation resulted in extensive sheet and gully erosion, increased runoffs, and higher stream flows (Tharp 1933). Although the basin had probably been subjected to repeated flooding prior to the days of land clearing, these resulting higher flows produced more serious and perhaps more frequent flood threats and hazards to agriculture in low-lying areas both in the Yazoo Basin Uplands and in the Delta area downstream.

127. Sheet and gully erosion in the uplands produced large volumes of sediments, which were introduced into the basin's streams. These sediments locally clogged the channels and also locally and particularly in upper reaches of the basin veneered the floodplain itself (Happ, Rittenhouse, and Dobson 1940, Happ 1968). As indicated previously, these channel sediments further aggravated the flood problems. Also, agricultural use of the floodplains was decreased by the nonproductive nature of these sandy and silty sediments. During this period, streambank erosion was probably also a problem due to lowering of channel capacities by the aggradation in the channels. One would suppose that these sediments would restrict and redirect flows, causing bank erosion and channel widening; however, bank erosion was not reported as a major problem in that period. Another effect of these increased sediment loads was to restrict navigation of the larger streams.

128. By the late 1940's upland sheet erosion and gullying had decreased significantly (Figure 13). The decrease was due to improved

land use and the construction of impoundments in the uplands. These impoundments were intended to decrease surface runoff and act as sediment traps, thereby decreasing sediment loads in tributary streams and decreasing flooding.

Channelization

129. Efforts were begun in the late 1800's and early 1900's to improve drainage. These improvements consisted mainly of channelization of basin streams and were made under the auspices of private individuals as well as by government agencies. Between 1888 and 1941 more than 300 drainage districts were organized within the Yazoo Basin to combat the flood problems (Olsen and Dunn 1941). As of 1 January 1941, various organizations had constructed approximately 3563 miles of ditches and 310 miles of levees. However, no systematic procedure was followed in the construction of drainage works, as shown by this statement by Olsen and Dunn (1941): "Big ditches flow into little ditches which empty into unimproved badly congested, winding streams or sluggish bayous."

130. Channelization is an engineering procedure in which the capacity of a slow-moving, meandering stream is increased by cutting off selected tortuous meander loops and by widening and deepening the stream as required. The improved capacity derived from these actions channels high flows along the modified reach, thereby decreasing flooding and possibly improving navigation. Although the alleviation of flood potential is in itself beneficial, adverse geomorphic conditions may also result from channelization. These adverse conditions arise mainly from the shortening of the stream by cutting off meander loops and consequently increasing the slope of the channel. Since the magnitude of the natural (original) slope had developed as a consequence of a given flow and sediment discharge transported through a given channel cross section, a change in slope magnitude will produce a change in some other hydraulic quantity.

131. Proportionalities 4 and 5 (PART II) indicate the direction of these changes. For example, Proportionality 5 predicts that decreasing sinuosity (such as by straightening) must result in a decrease in the ratio of valley slope to sediment discharge. Because the valley

slope is affected mainly by major tectonic processes and will therefore remain essentially constant, there must be an increase in sediment discharge, thus decreasing the ratio of valley slope to sediment discharge. The sediment is thus removed from the channel, resulting in degradation and bank erosion. Knickpoints produced by the change in slope will move upstream to such a point where further downcutting is stopped or at least retarded by the presence of resistant material in the streambed or a new equilibrium is achieved. The upstream movement of knickpoints is called headcutting. Headcutting may, in the same fashion, proceed up upstream tributaries. The processes caused by channelization are shown in the flowchart in Figure 73.

132. Degradation produced by the upstream movement of the knickpoint will also be accompanied by aggradation. Thus, the sediments removed by headcutting will be transported some distance downstream where they will be deposited. These sediments will probably not remain indefinitely at the location of initial sedimentation, but will eventually be moved out and redistributed farther downstream. The net effect of both downstream aggradation and upstream degradation will be the gradual elimination of the knickpoints and a smoothing of the longitudinal profile. Also, bank erosion may be initiated by either degradation or aggradation.

133. The fact that headcutting may be quite active requires that consideration be given to the possible effects of channelization not only at or along the stretch under study, but also many miles downstream or upstream of the site(s) being considered. In PART III, in which the local geomorphology of the sites was described, possible effects of channelization at and along the stream stretches under study were discussed. Therefore, the remainder of this section on human activities will address the influences of the channelization of the streams and rivers downstream from the study sites.

134. Mississippi River. Agricultural practices; urbanization; channelization; and the construction of locks, dams, and levees have altered the hydrologic regime of all the streams in the Mississippi River Basin. Man-made cutoffs on the stretch of the Mississippi River

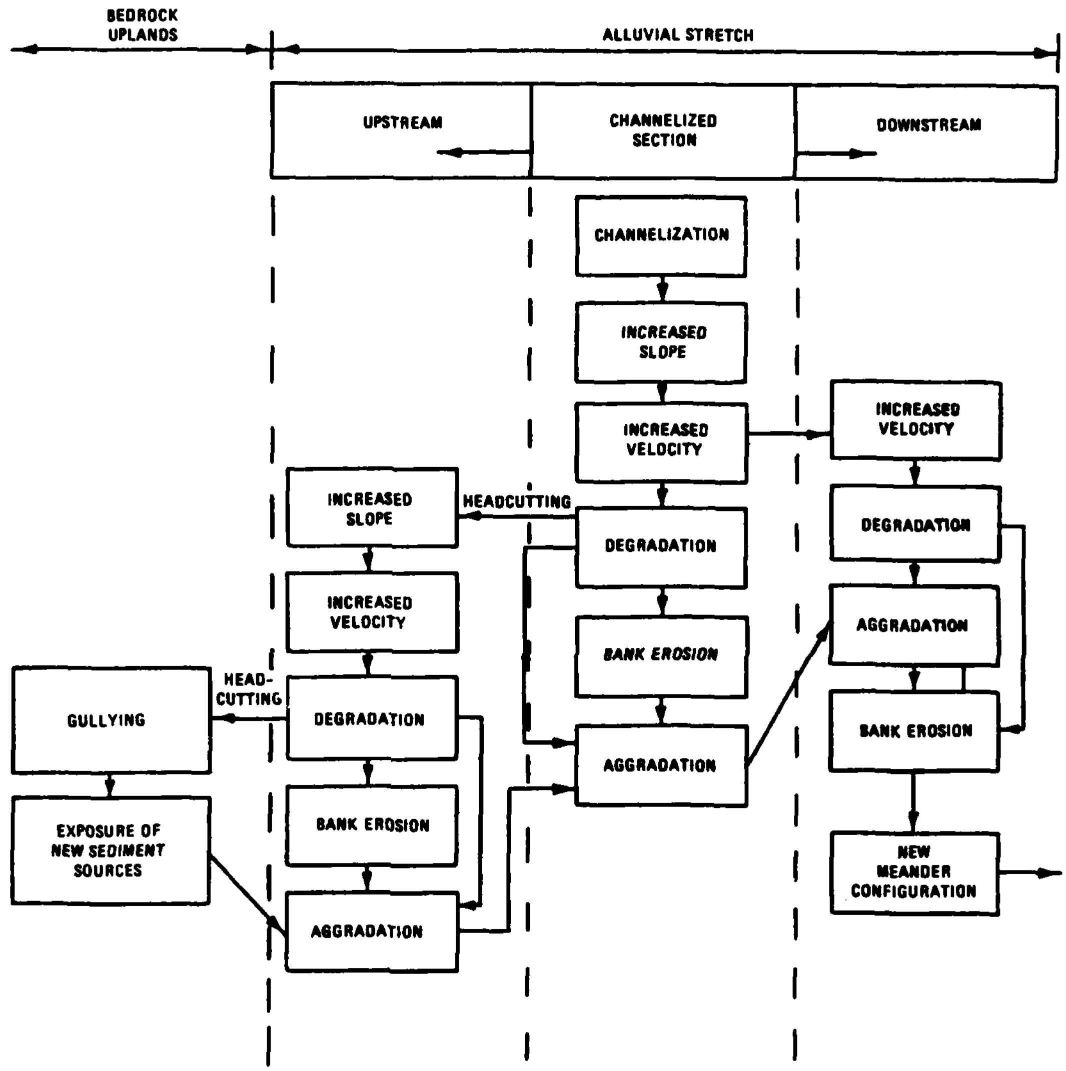
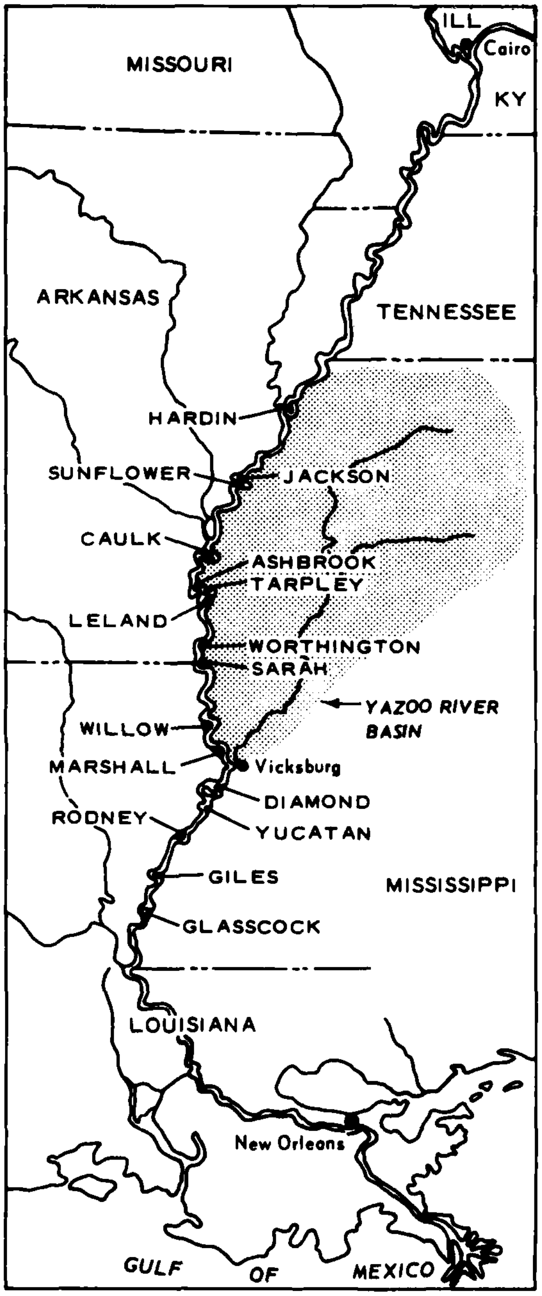


Figure 73. Generalized flowchart showing processes initiated by straightening a section of stream channel

bordering the state of Mississippi have alone shortened the river distance by 151.8 miles (Figure 74) (Mississippi River Commission 1968). Schumm (1971) stated that without knowing a great deal about the problems of this river, one could speculate that the straightening has created severe problems of channel stability. It is impossible to determine how much each individual factor has affected the hydrologic regime, but the collective effects of all factors have influenced channel stability (Winkley 1977). The increasing irregularity of the 1932-75 longitudinal profiles of the Mississippi River from Cairo, Ill., to the Gulf of Mexico shows the instability of this section of the river (Figure 75). As the instability of the major trunk stream, the Mississippi River, is progressively transmitted to smaller tributaries, the effects become more noticeable.

135. Yazoo River Basin--Delta streams. All of the major streams that drain the Yazoo River Basin Uplands have been channelized to some extent. The Yazoo-Tallahatchie-Coldwater River system was shortened approximately 88.2 miles by meander cutoffs constructed between 1921 and 1953 (Table 10). The construction of Pompey Ditch in 1921 shortened the Coldwater River about 24.9 miles, increasing the gradient from approximately 0.7 ft/mile to approximately 1 ft/mile. Channelization of the Yazoo, Tallahatchie, and Coldwater Rivers from 1940-43 shortened their channels about 61.2 miles. The Jonestown Cutoff on the Yazoo River in 1953 further shortened the channel about 2.1 miles. Channelization of the Yazoo-Tallahatchie-Coldwater River system increased the gradient from approximately 0.4 ft/mile to approximately 0.8 ft/mile.

136. The prechannelization and postchannelization longitudinal profiles of the Yazoo-Tallahatchie-Coldwater River system are both very irregular (Figure 76). The irregularities can be attributed to several sources, such as degradation, geologic controls, and aggradation. The increased gradient of the Yazoo-Tallahatchie-Coldwater River system resulting from channelization, increased water discharge resulting from agricultural practices, and the instability of the Mississippi River are some of the factors that could have caused degradation in the Yazoo-Tallahatchie-Coldwater River channels.



NAME OF CUT-OFF	YEAR OPENED	SHORTENING IN MILES
HARDIN	1942	16.9
JACKSON	1941	8.7
SUNFLOWER	1942	10.4
CAULK	1937	15.2
ASHBROOK	1935	11.4
TARPLEY	1935	8.6
LELAND	1933	9.6
WORTHINGTON	1933	4.3
SARAH	1936	5.3
WILLOW	1934	7.7
MARSHALL	1934	4.2
DIAMOND	1933	12.0
YUCATAN	1929	9.8
RODNEY	1936	5.8
GILES	1933	11.1
GLASSCOCK	1933	10.8
TOTAL SHORTENING AT CUT OFFS		151.8

Figure 74. Man-made meander cutoffs on the Mississippi River (Mississippi River Commission 1968)

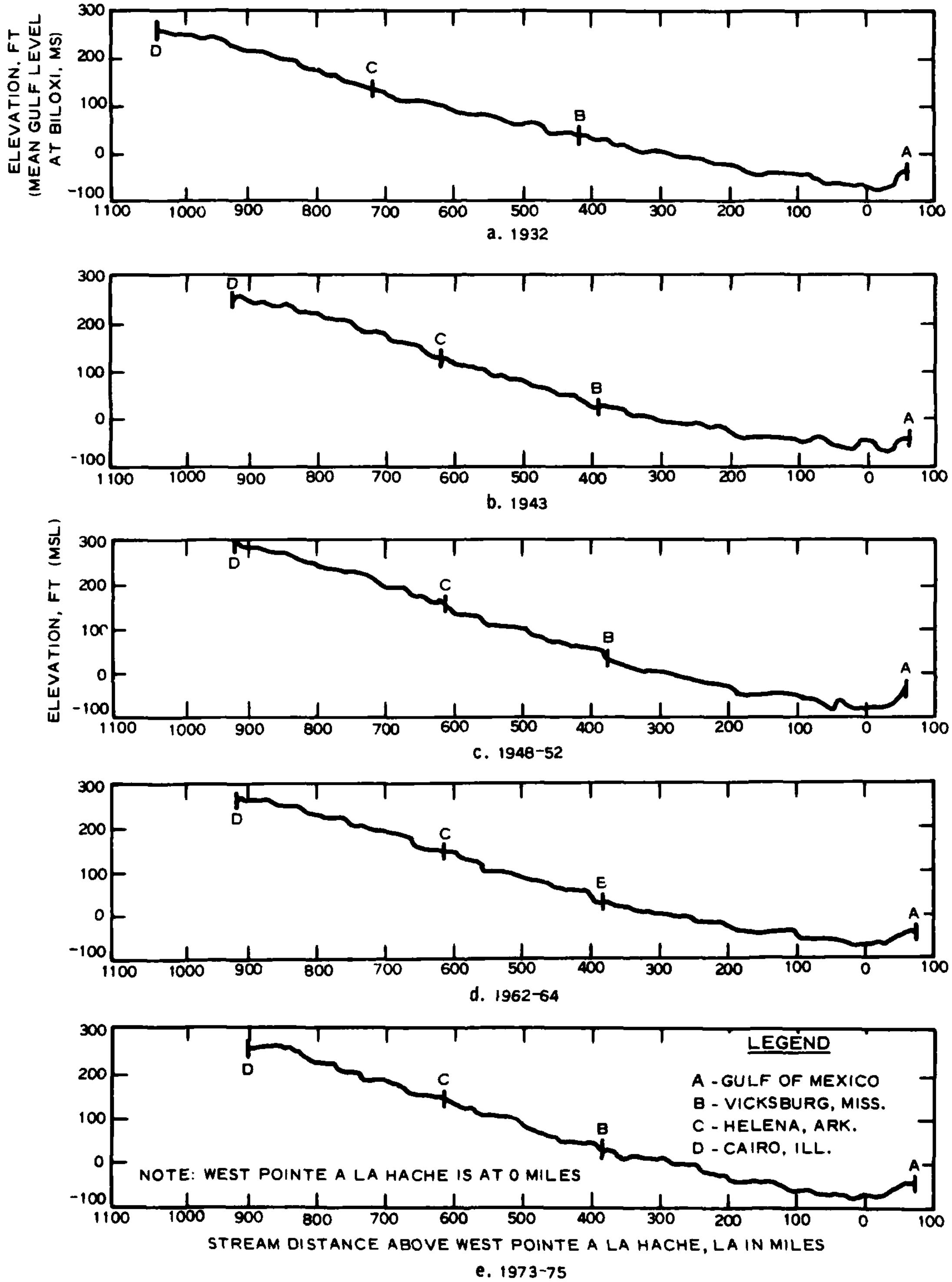


Figure 75. Longitudinal profiles of the Mississippi River (Mississippi River Commission 1937-38, 1942)

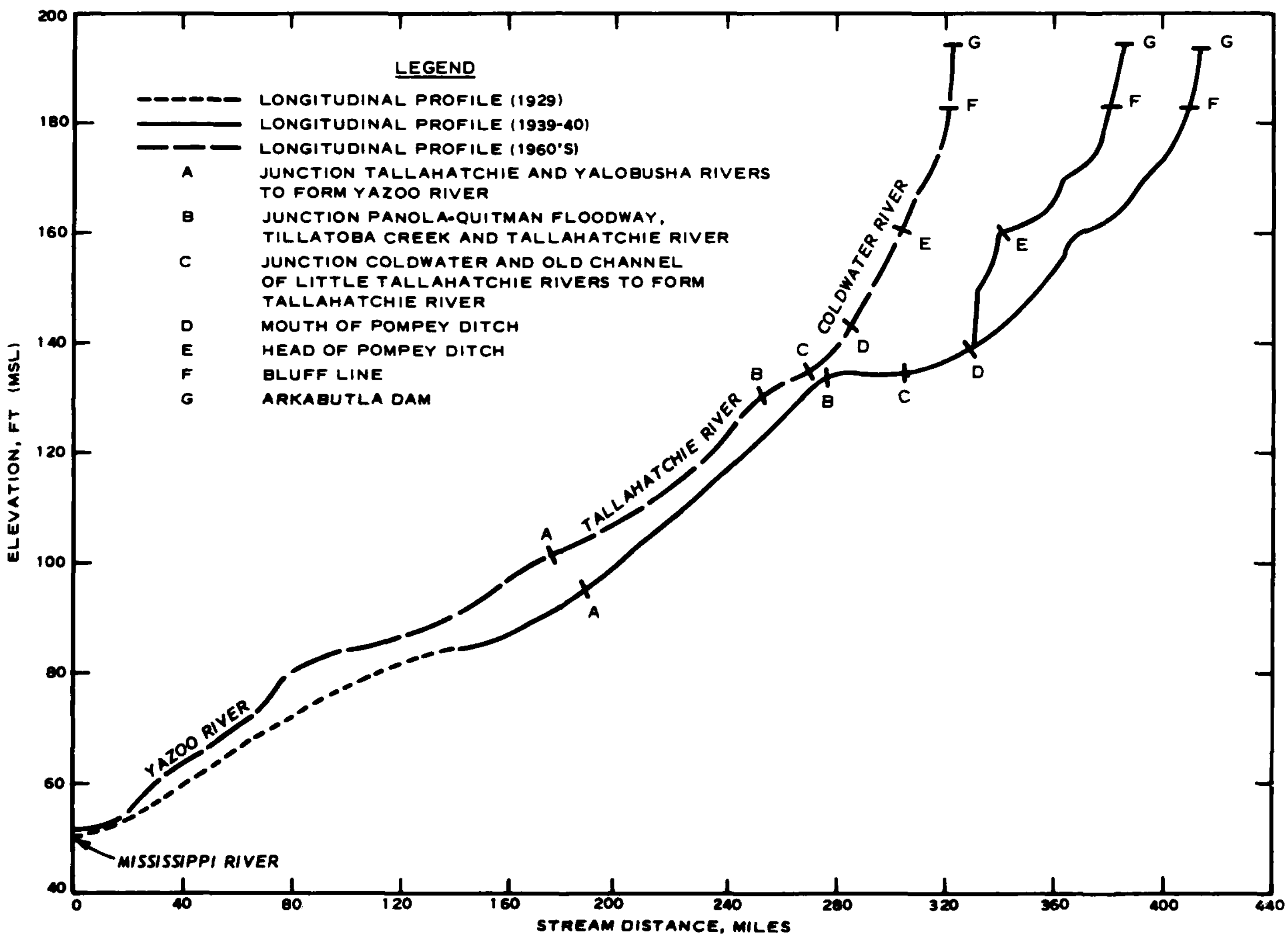


Figure 76. Longitudinal profiles of the Yazoo-Tallahatchie-Coldwater River system (data from USGS topographic maps)

137. The prominent knickpoint at point B in Figure 76 resulted from geologic controls. The lateral extent of the geologic unit can easily be seen on the planview of this section of the river (Figure 77). The channel between elevation 140 and 125 is cutting in ancestral Mississippi River braided stream (Kolb et al. 1968) deposits veneered by clayey backswamp-type deposits. The veneer deposits consist of 10 to 30 ft or erosion-resistant oxidized clay, which grades downward into coarser braided stream materials. The channel in the erosion-resistant clay has a gentler slope and small, tight meanders. The channel above elevation 140 and below elevation 125 is cutting in point bar deposits consisting of sediments ranging from sandy clays to sandy silts (Kolb et al. 1968). The point bar deposits could be from any of the ancestral Mississippi River systems that have occupied that area. The channels in the more easily eroded point bar deposits have steeper slopes and large closed meanders. The effects of the geologic control can still be seen on the 1960's longitudinal profile even after the extensive channelization of this section of Tallahatchie River.

138. Increased sediment loads caused by upland erosion clogged many of the Delta streams during the early 1900's. Olsen and Dunn (1941) reported that many of the important Delta waterways that were once used by steamboats were so filled with sediments from upland land erosion that many were now unusable. The construction of flood control dams on the major upland rivers and the soil conservation practices begun in the 1930's have reduced the sediment loads in the Delta channels.

139. Yazoo River Basin--upland streams. The major rivers draining the uplands have been extensively channelized since the early 1900's. Most of the channelization has been since 1939 and is associated with the construction of flood control dams, which will be discussed later in this report. Since channel alterations below the dams do not affect the channels above the dam and all of the study areas are downstream from the dams, only the channelization below the dams will be discussed.

140. Yocona and Little Tallahatchie Rivers were the only major upland rivers that were extensively channelized prior to 1939. The Panola-Quitman Floodway, constructed in the early 1920's, cut off the

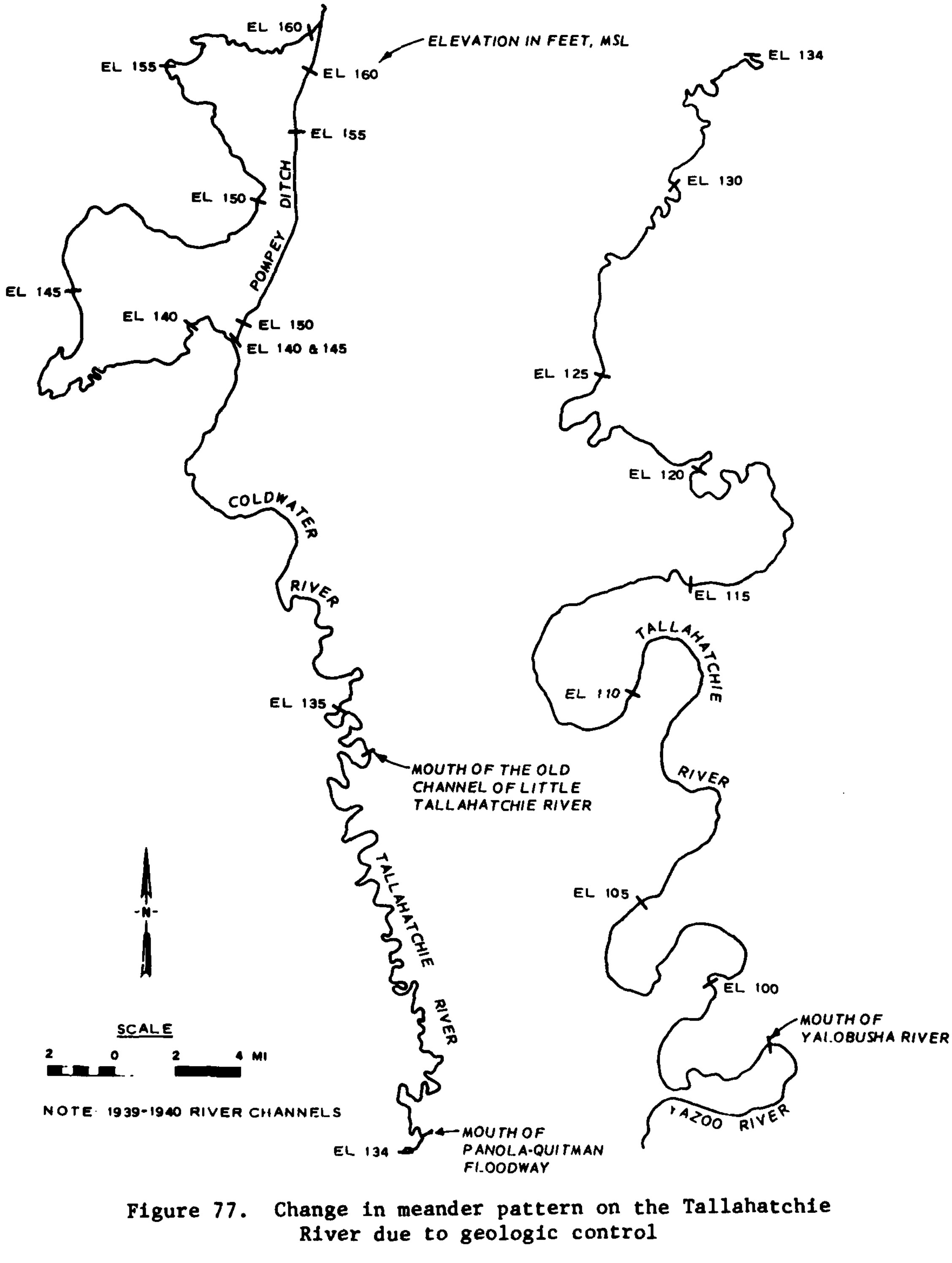


Figure 77. Change in meander pattern on the Tallahatchie River due to geologic control

lower 26.3 miles of Little Tallahatchie River and 11.1 miles of Yocona River (Figure 78). The floodway reduced the stream distance from the head of the floodway to the junction of Tallahatchie River and Tillatoba Creek from approximately 52 miles to 26.3 miles. The 67-mile stretch of Yocona River above the floodway was also channelized in the early 1920's, reducing the stream distance to 45.2 miles. The new Yocona River channel on a grade of about 2.5 ft/mile enlarged rapidly by erosion until its average cross-sectional area had doubled.

141. Little Tallahatchie and Yalobusha Rivers were channelized after the flood control dams were built. Five meander cutoffs were made on Little Tallahatchie River in 1941. The stream distance was shortened approximately 2 miles. Local interests straightened and improved the channels of the Yalobusha and Skuna Rivers and many of their tributaries in the upper basin above Grenada Reservoir in the 1910's and 1920's. Thirty cutoffs, 1 in 1939 and 29 from 1951-54, shortened the Yalobusha River approximately 18 miles between its mouth and Grenada Dam. The gradient was increased from about 0.9 ft/mile to about 1.2 ft/mile. The 1940 and 1954-57 longitudinal profiles of Yalobusha River are convex upwards in the lower reaches of channel, indicating the channel was degrading (Figure 79). The knickpoint at the bluff line had become more exaggerated from 1940-57. The knickpoint appears to be hung up on a hard point, possibly Tertiary bedrock or Quaternary clay. The 1965 longitudinal profile shows that the exaggerated knickpoint is still at the bluff line. The density of the data points for the 1965 longitudinal profile better emphasizes the irregularity of the channel bed.

142. Hotopha, Goodwin, Tillatoba, and Perry Creeks and the streams that connect each of these creeks to their ultimate base level, the Gulf of Mexico, have all been channelized or shortened to some extent. The overall channel shortening amounts to approximately 10.5 to 13.6 percent of the prechannelization channel lengths (Table 11). This reduction in channel length increases the gradient, thereby increasing the flow velocity. The increase in velocity with no apparent increases in sediment load will result in channel degradation. Comparison of prechannelization and postchannelization longitudinal profiles shows

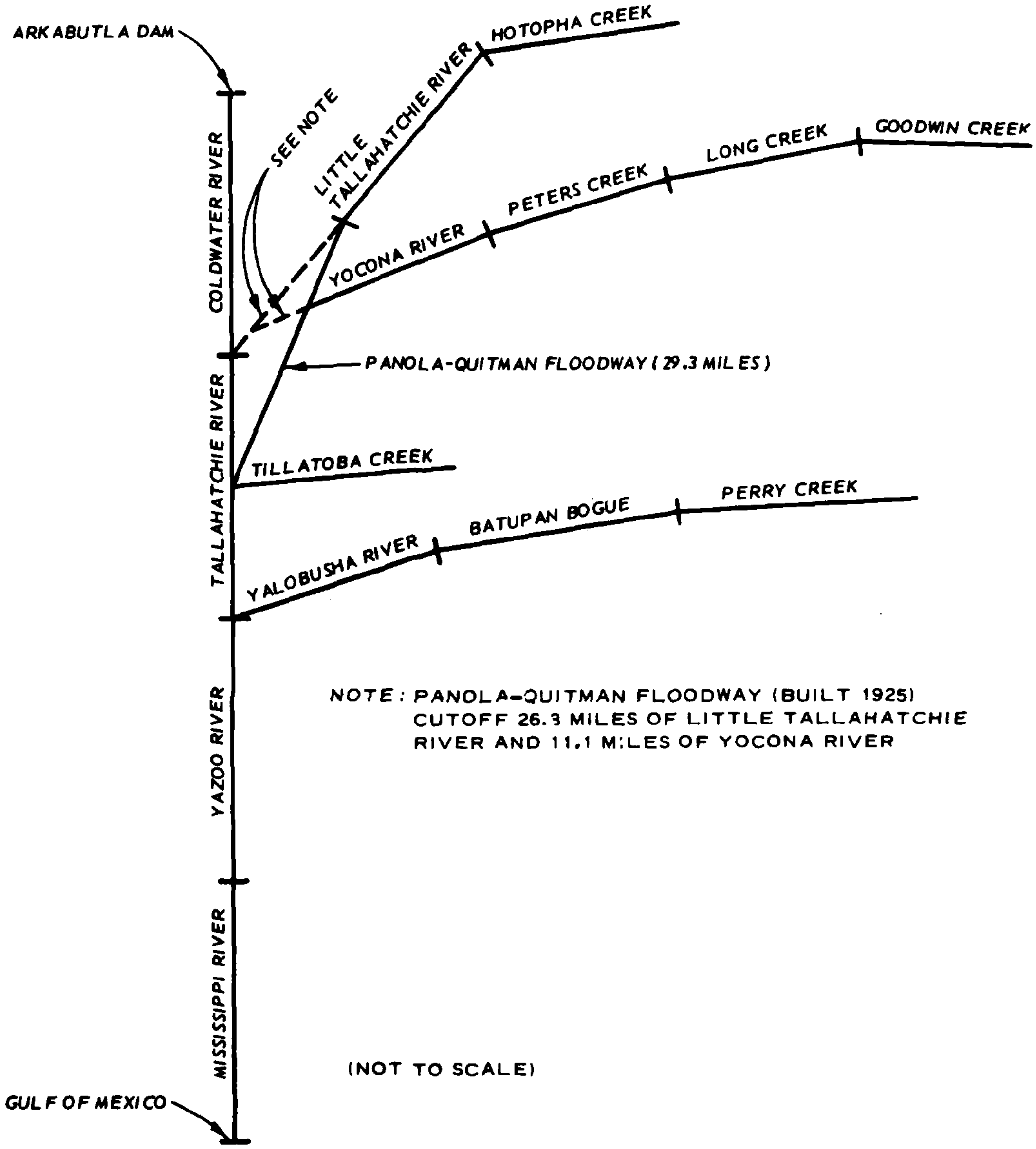


Figure 78. Channel system connecting the four study areas with zero-base level, the Gulf of Mexico

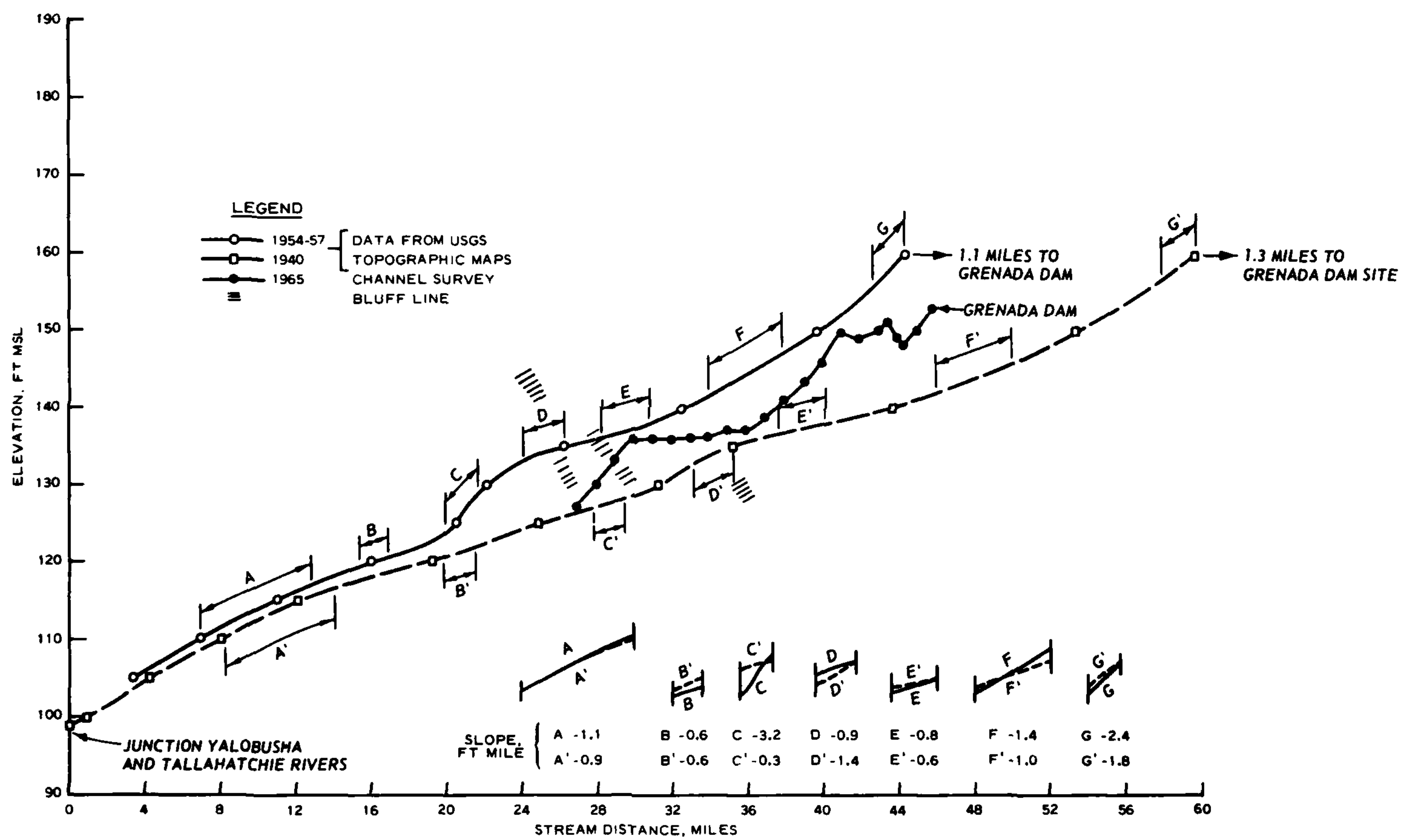


Figure 79. Longitudinal profiles of Yalobusha River

there has been increased channel degradation.

Dams

143. Sites. Four flood control dams have been constructed in the Yazoo Basin Uplands. Three of these structures, shown in the table below, are located in the basins of the four studied streams.

Dam	River	Date Completed	Association with Study Site
Grenada	Yalobusha	1954	2 miles upstream from mouth of Batupan Bogue
Enid	Yocona	1951	7 miles upstream from mouth of Peters Creek
Sardis	Little Tallahatchie	1940	8 miles upstream from mouth of Hotopha Creek

144. Discussion. The construction of a dam on a stream does not necessarily mean that adverse hydrologic or geomorphic conditions will occur. However, there exist significant data that show that adverse conditions are possible and that the effects of dams should always be considered when studying hydrologic or geomorphic phenomena.

145. From the standpoint of hydrology and geomorphology, flood control dams such as the ones under consideration may cause changes in fluvial regimes both upstream and downstream of the dam. These changes are well known and have been summarized by Simmons (1979). Since the streams under study are downstream from the dams, upstream effects will not be considered.

146. Potential downstream changes result from two conditions which the dam imposes on the natural hydrologic and sedimentologic environment. These are: (a) flattening and decreasing flood hydrographs, and (b) the cessation of bottom sediment movement past the dam. The actual geomorphic impact of these two conditions is dependent upon the relative importance of (a) versus (b), size and volume of sediment transported, hydrologic environment, and the actual operation of the dam. Downstream geomorphic changes result when there develops disequilibrium conditions between the regulated flow, sediment movement past the dam, and the size and volume of sediment introduced into the mainstream channel by downstream tributaries.

147. If disequilibrium conditions prevail, two types of geomorphic changes may occur downstream: (a) sedimentation in channel (filling) and (b) degradation or downcutting.

148. Channel filling occurs when downstream tributaries carry more sediments into the mainstream than the regulated flow from the dam can transport. Degradation results from the scouring by the sediment-free water released from the dam. Both of these geomorphic changes may be explained semiquantitatively by examination of the proportionalities described in PART II. Both changes may also result in at least local bank erosion by the mechanisms of widening and degradation, also given in PART II. The impact of dams on the subject streams is given below.

149. Impact of the dams. In considering the downstream effects which Sardis, Enid, and Grenada Dams had on their respective channels, the effects of channelization that occurred prior to or in conjunction with the construction of dams must also be included. The following discussion will not attempt to separate channel erosion caused by channelization or dams. The effects of channelization were given previously.

150. Comparison of the thalwegs (Figures 80-82), channel widths (Figures 80-82), and tailwater rating curves (Figures 83-85) at the time of the dam construction and those several years later shows there has been a general increase in channel depth and width on all three of the streams. Cross sections of Little Tallahatchie, Yocona, and Yalobusha Rivers near the mouths of the study streams or trunk stream of the study streams also show increases in channel depth and width on all three of the major stream (Figures 86-88). The tributaries react to the change in base level of the trunk streams, in this case by degrading.

151. Perry Creek flows into Batupan Bogue approximately 2 miles downstream from the junction of Batupan Bogue and the Yalobusha River. Longitudinal profiles and cross sections show the Yalobusha River has degraded. Figure 88 shows the Yalobusha River degraded 5-6 ft from 1951-53. Batupan Bogue has attempted to degrade in response to the lowering of its base level, which is the Yalobusha River. The 1954 and 1977 longitudinal profiles of Batupan Bogue show a knickpoint at the mouth (see Figure 43). The knickpoint is evidently hung up on a hard

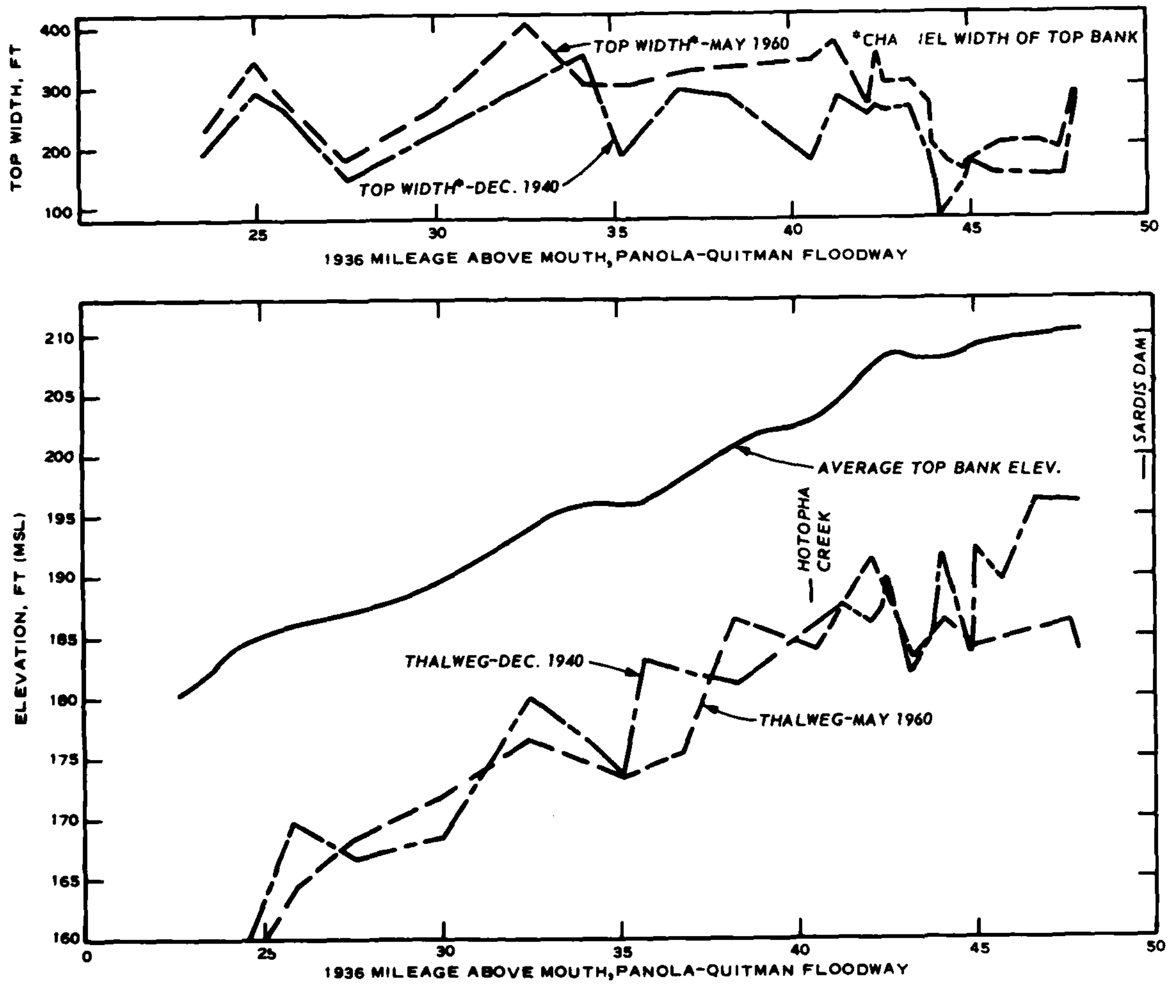


Figure 80. Longitudinal profiles and channel widths of Little Tallahatchie River (U. S. Army Corps of Engineers 1966b)

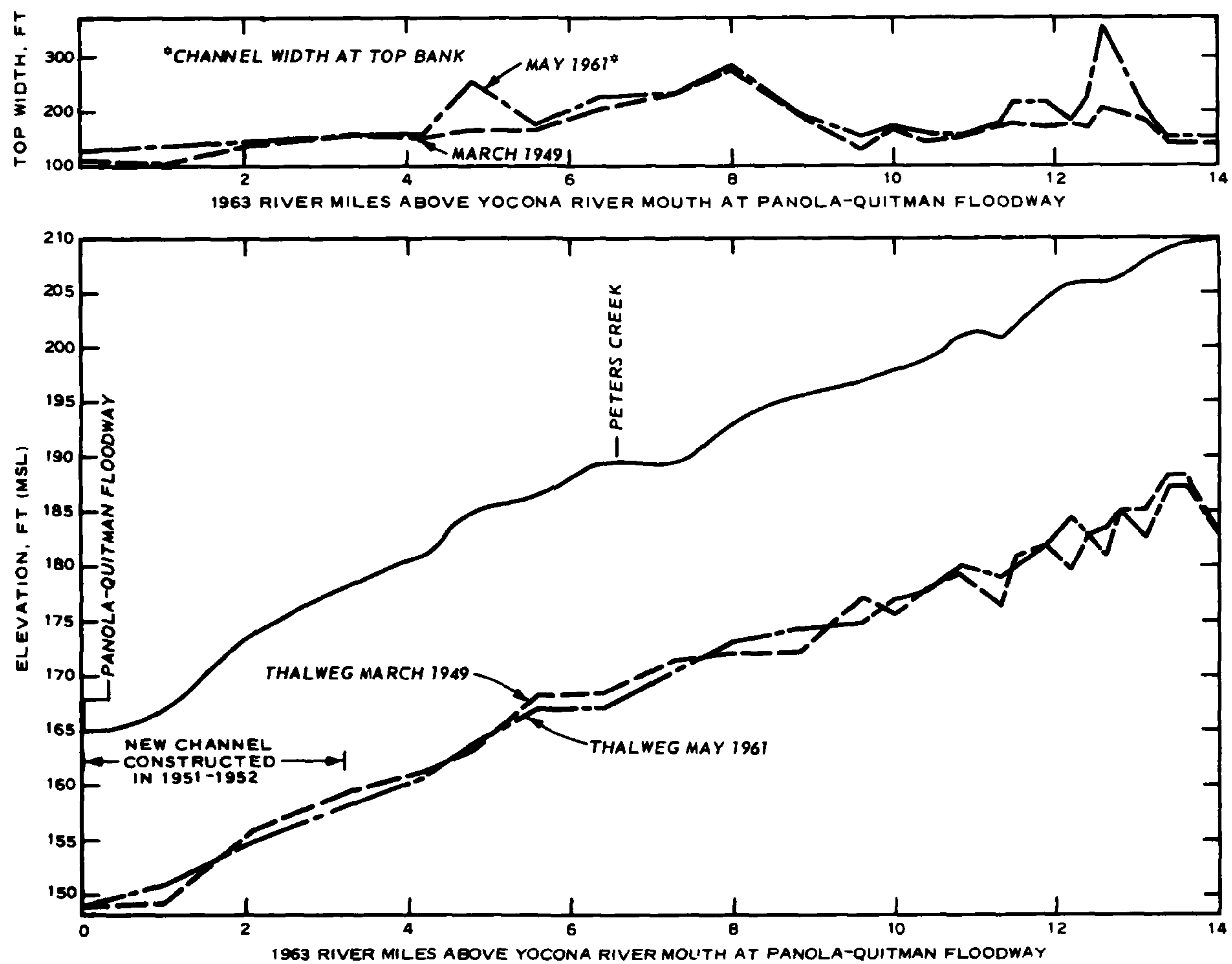


Figure 81. Longitudinal profiles and channel widths of Yocona River (U. S. Army Corps of Engineers 1966a)

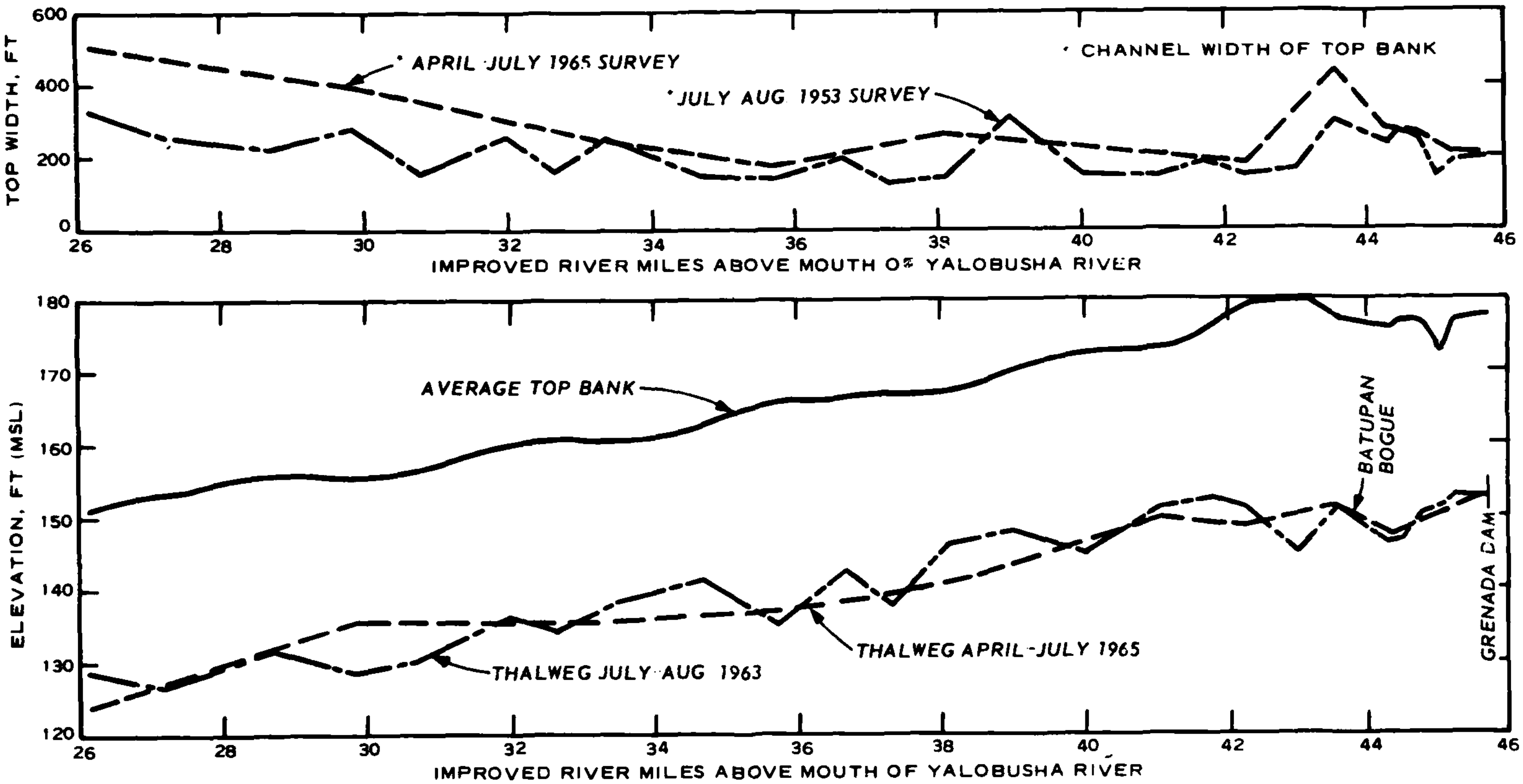


Figure 82. Longitudinal profiles and channel widths of the Yalobusha River (U. S. Army Corps of Engineers 1966c)

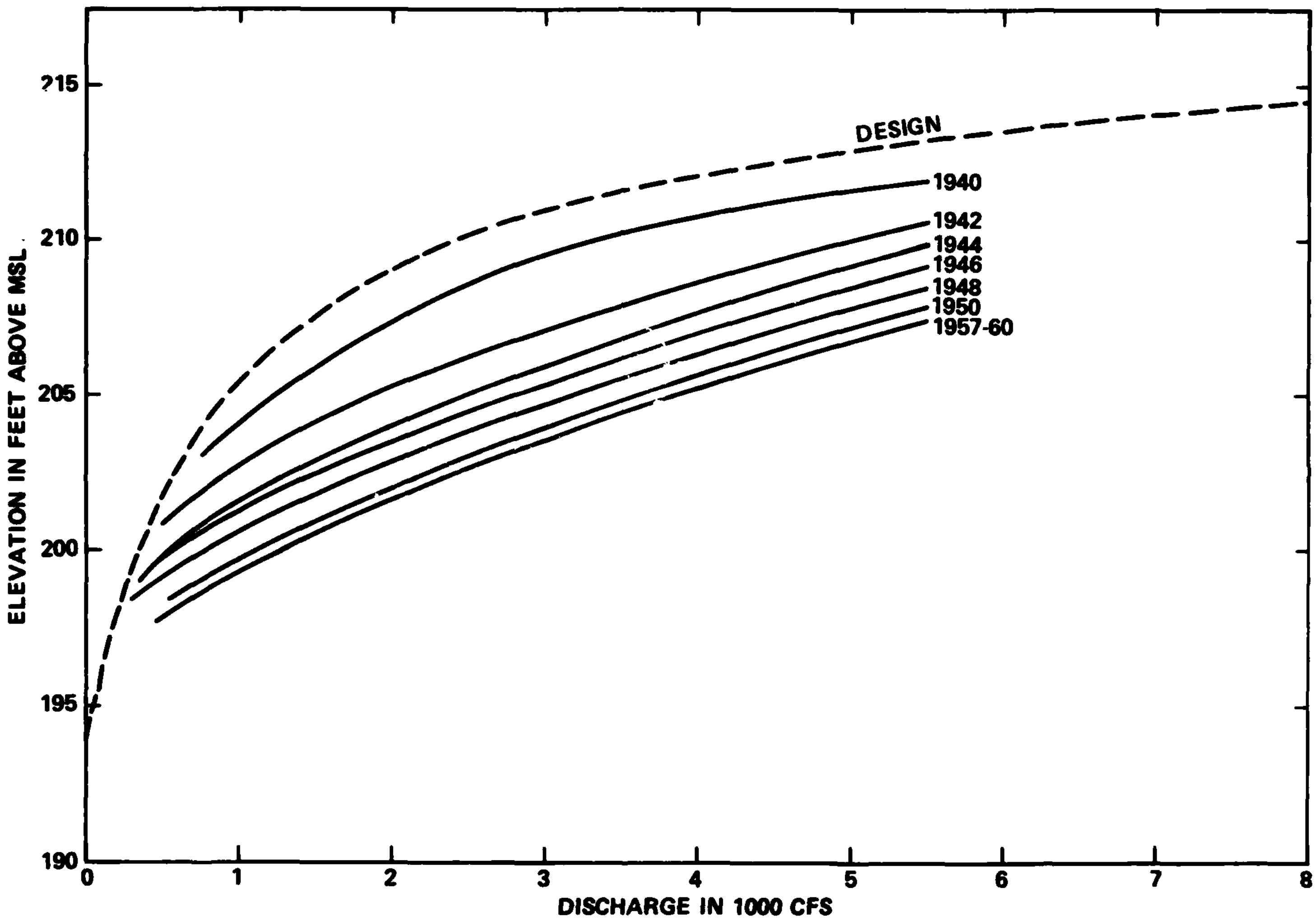


Figure 83. Tailwater rating curve for Little Tallahatchie River (U. S. Army Corps of Engineers 1966b)

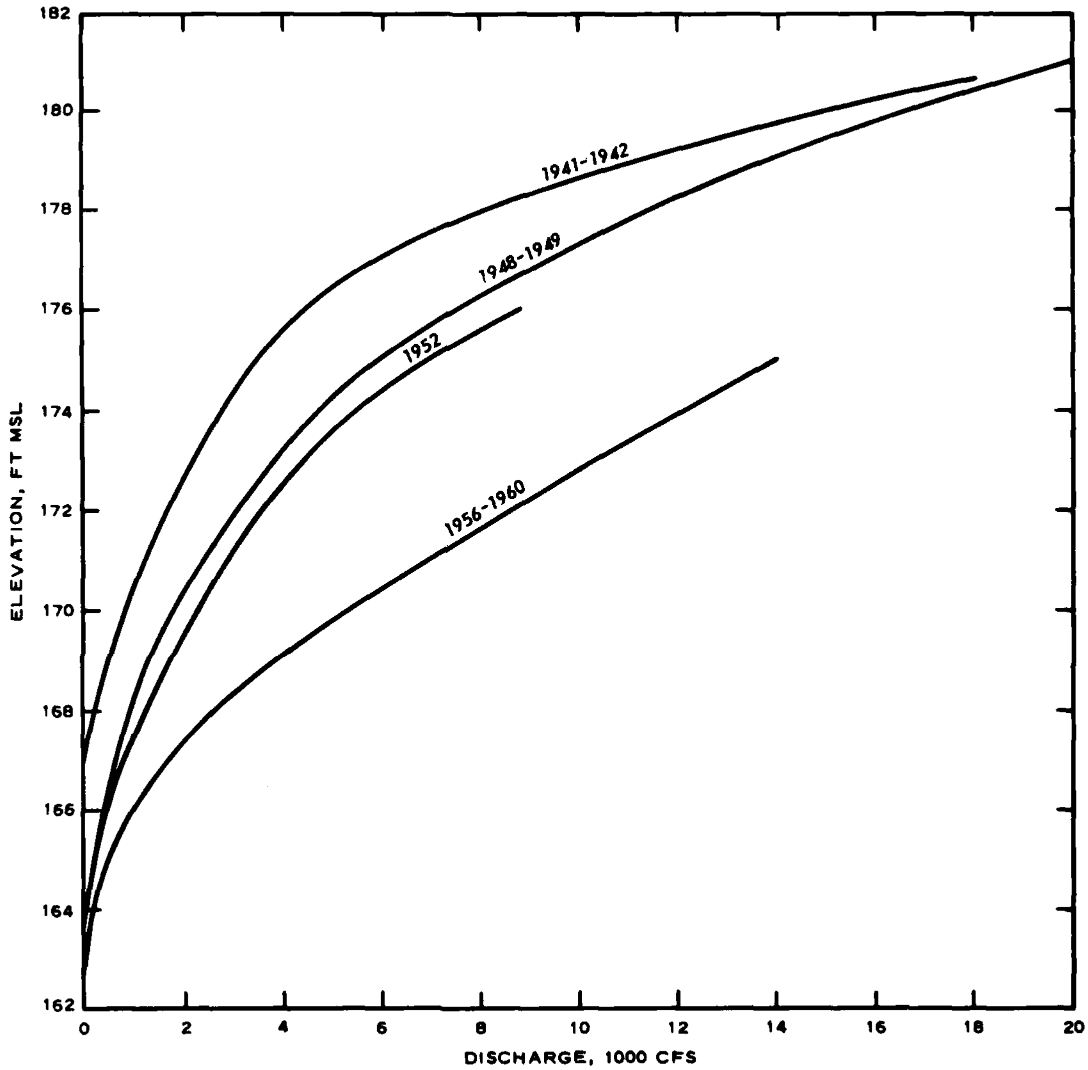


Figure 84. Tailwater rating curve for the Yocona River, approximately 2 miles downstream from the mouth of Peters Creek (U. S. Army Corps of Engineers 1966a)

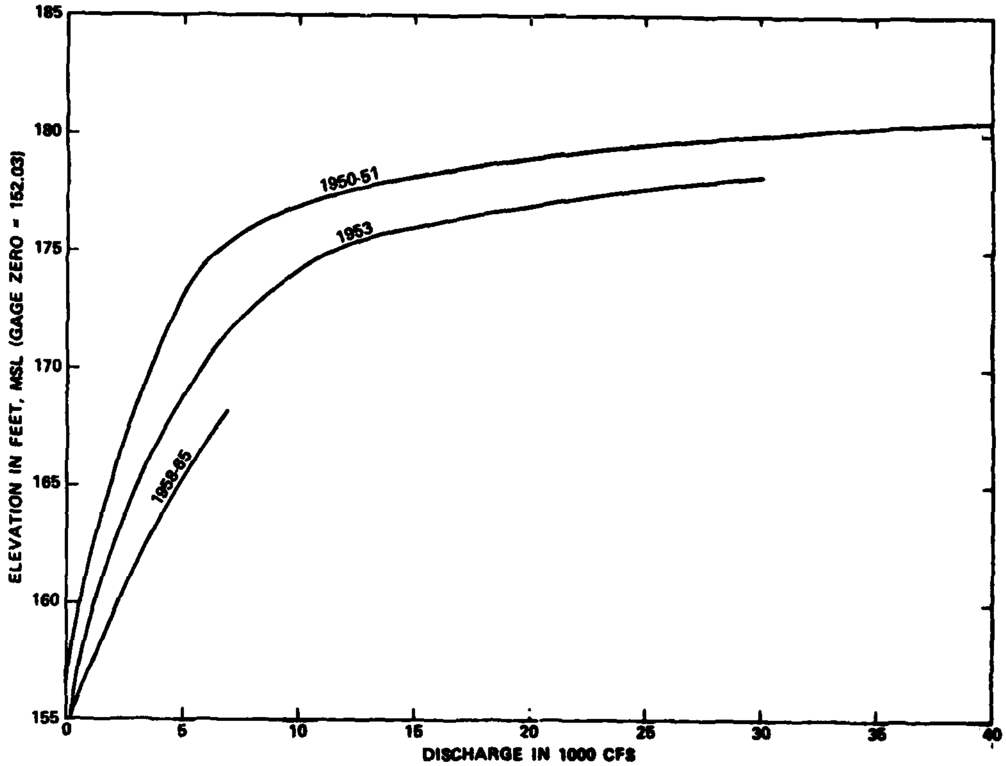


Figure 85. Tailwater rating curve for Yalobusha River, 1 mile downstream from the mouth of Batupan Bogue (U. S. Army Corps of Engineers 1966c)

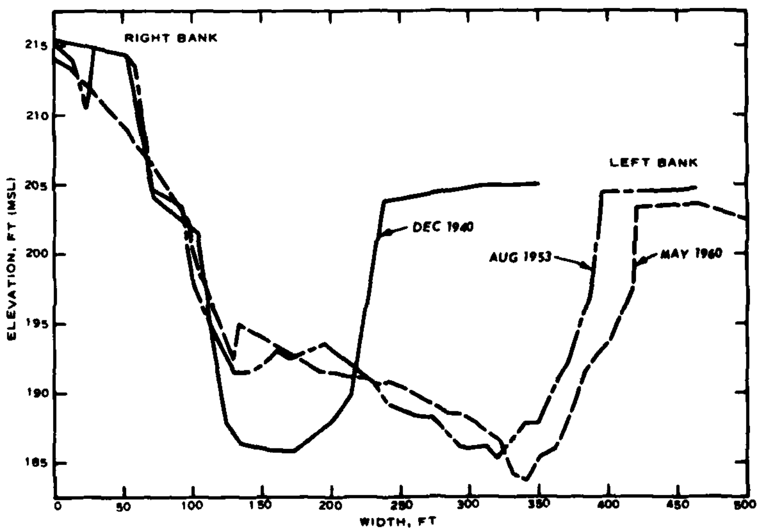


Figure 86. Cross sections of Little Tallahatchie River, approximately 2 miles upstream from the mouth of Hotopha Creek (U. S. Army Corps of Engineers 1966b)

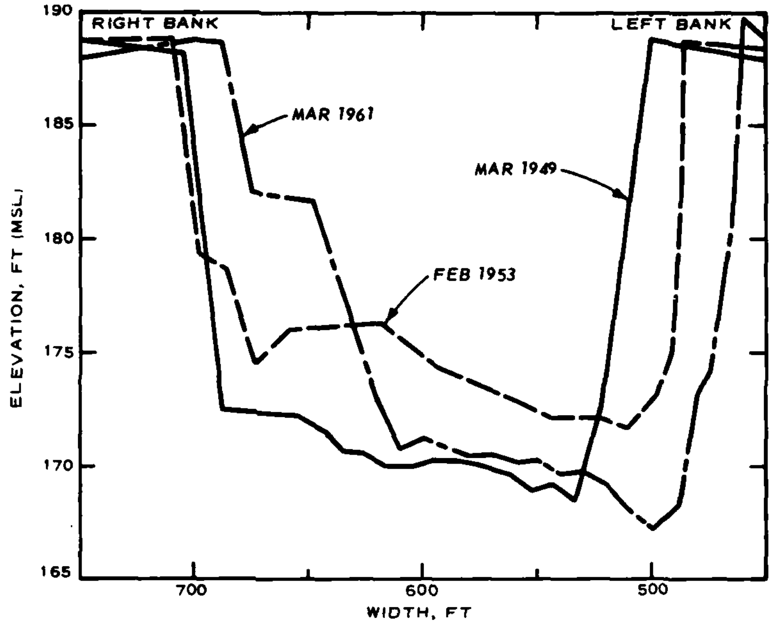


Figure 87. Cross sections of Yocona River directly downstream from the mouth of Peters Creek (U. S. Army Corps of Engineers 1966a)

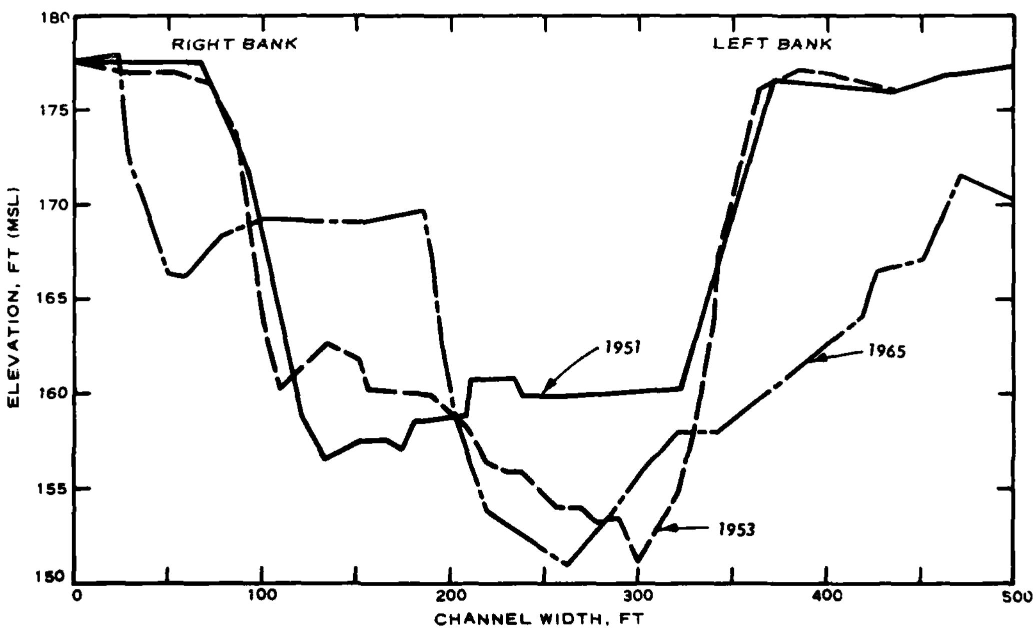


Figure 88. Cross sections of Yalobusha River directly downstream from the mouth of Batupan Bogue (U. S. Army Corps of Engineers 1966c)

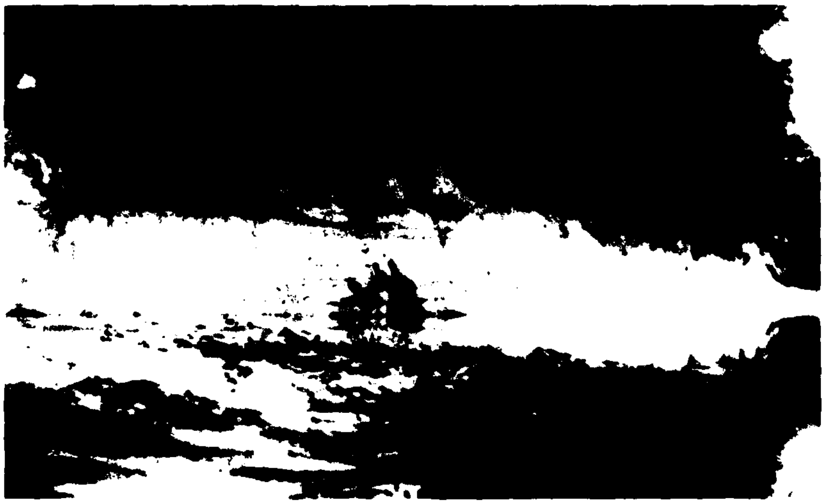
point, probably Tallahatta shale (Figure 89). A chronological sequence of aerial photographs shows the channel erosion, especially bank erosion, that has occurred at the mouth of Batupan Bogue since 1937 (Figure 90). The tributaries of Batupan Bogue, such as Perry Creek, are responding to the degradation of Batupan Bogue by also degrading (Figure 91).

152. The irregularity of the 1954 longitudinal profile of the Goodwin Creek-Long Creek-Peters Creek-Yocona River system indicates the channels may have been degrading (Figure 92). Figure 81 shows the Yocona River has been degrading in some sections while aggrading in other sections from 1949-61. Cross sections of the Yocona River directly below the mouth of Peters Creek show that this section of the Yocona River aggraded from 1949-53 and degraded from 1953-61 (Figure 87). A chronological sequence of aerial photographs at the mouth of Peters Creek shows the channel changes in Peters Creek and Yocona River since 1937 at this site (Figure 93). Both streams were channelized prior to 1937. The narrower, meandering prechannelization channel of Peters Creek and the Yocona River can be seen on the photographs. The most noticeable channel changes are the gradual increase in channel width and sinuosity. The thalweg is meandering in the wide sediment-filled channel. Increased bank erosion at the points where the thalweg is deflected against a bank is widening the channel and simultaneously increasing channel sinuosity.

153. Peters Creek is formed by the junction of Long and Johnson Creeks. Peters Creek and the lower reaches of Long and Johnson Creeks were channelized prior to 1935. A chronological sequence of aerial photographs at the head of Peters Creek shows no major observable channel erosion until 1963 (Figure 94). Note the narrow, meandering prechannelization channels in Figure 94. Channel erosion had doubled the channel width by 1979 and increased the channel depth.

154. The Yocona River degraded approximately 5 ft at the mouth of Peters Creek from 1953-61, and the first observable significant channel erosion at the head of Peters Creek occurred between 1957 and 1963. Since the base level of a tributary is controlled by its trunk stream,

a. View of weathered Tallahatta shale in a road cut



b. Right bank of Batupan Bogue upstream from the bridge in Figure 90, sheets 3 and 4

Figure 89. Tallahatta shale in bank of Batupan Bogue near its mouth

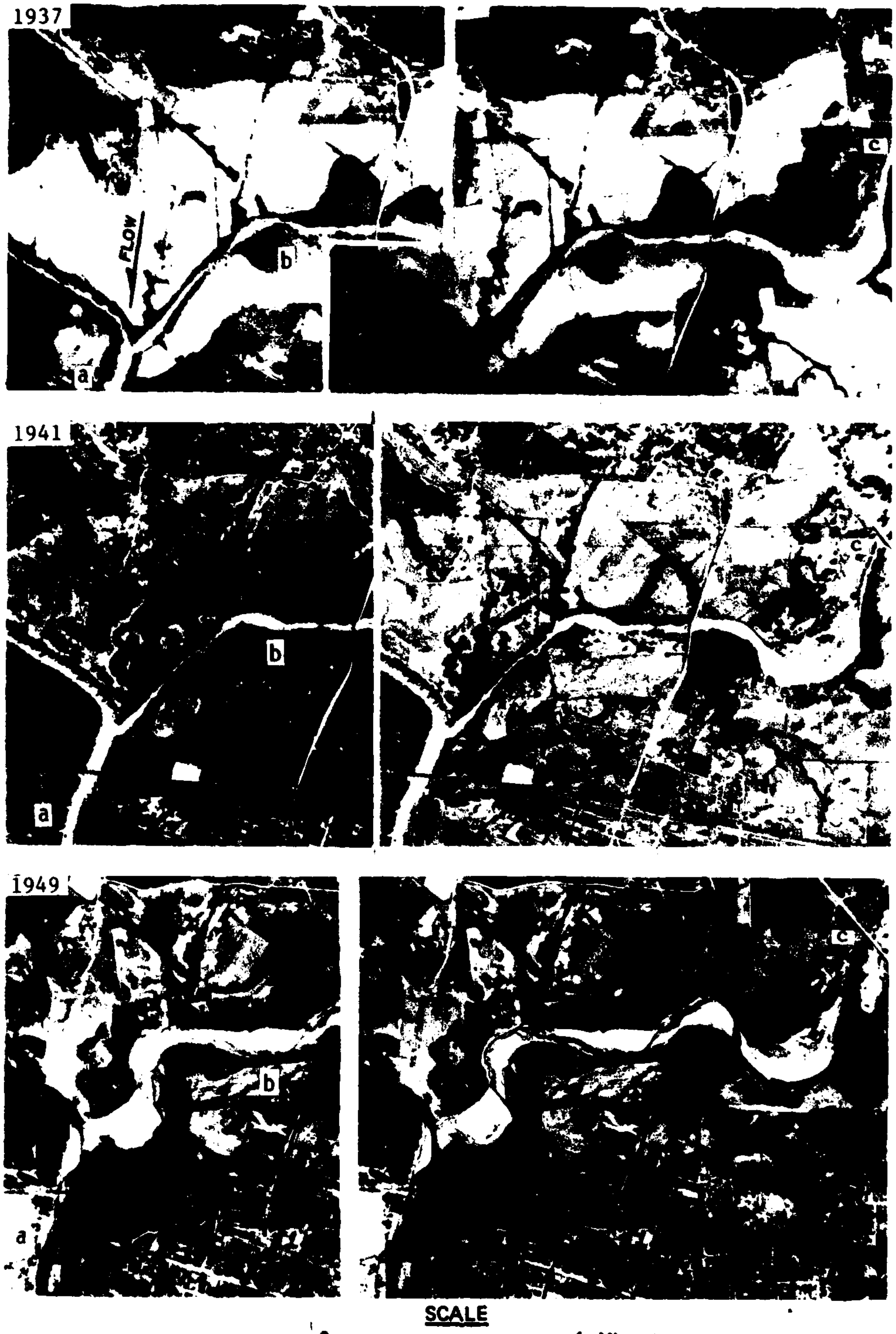


Figure 90. Mouth of Batupan Bogue (Symbol "a" designates Yalobusha River, "b" is Batupan Bogue.) (Sheet 1 of 4)

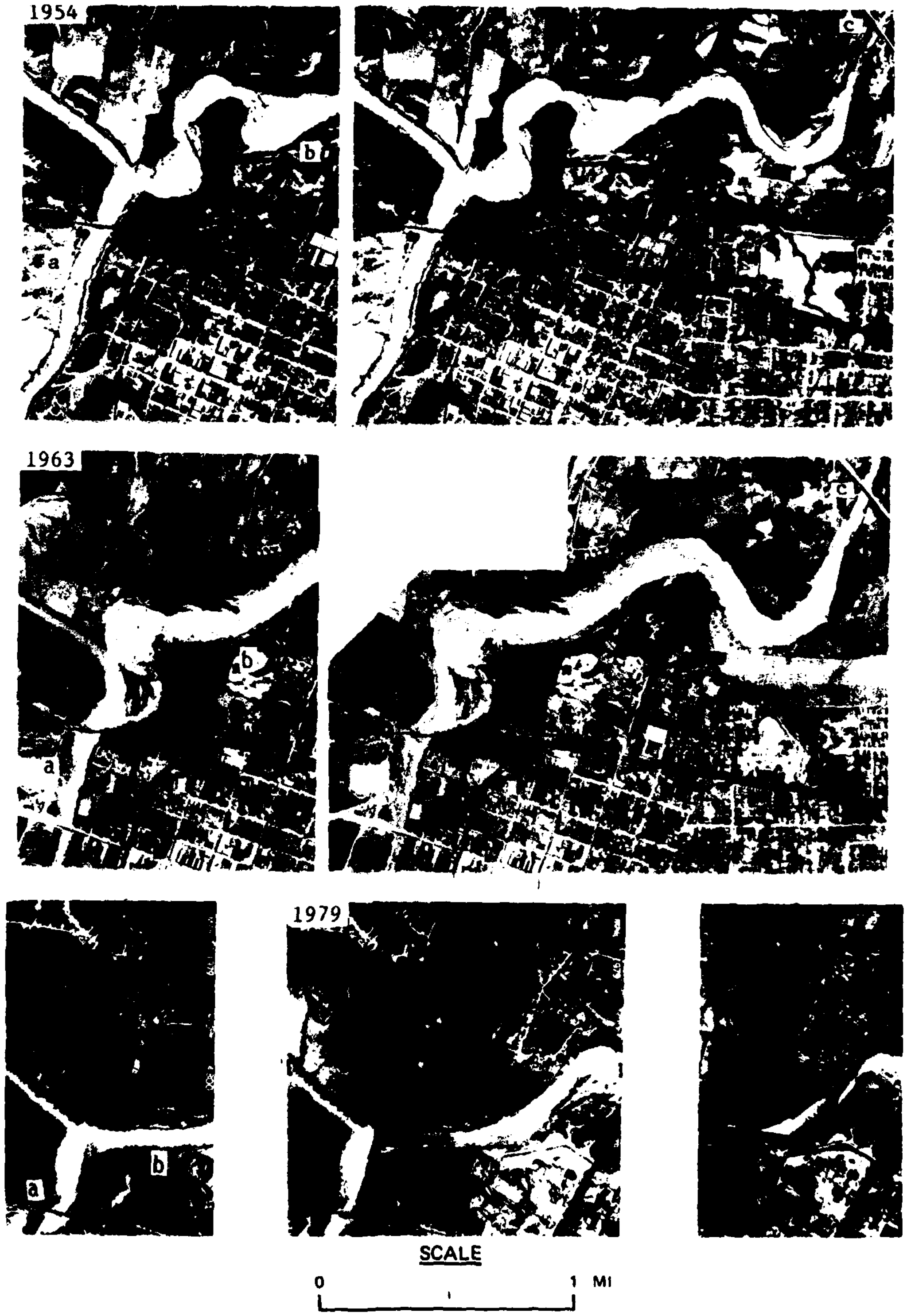


Figure 90. (Sheet 2 of 4)

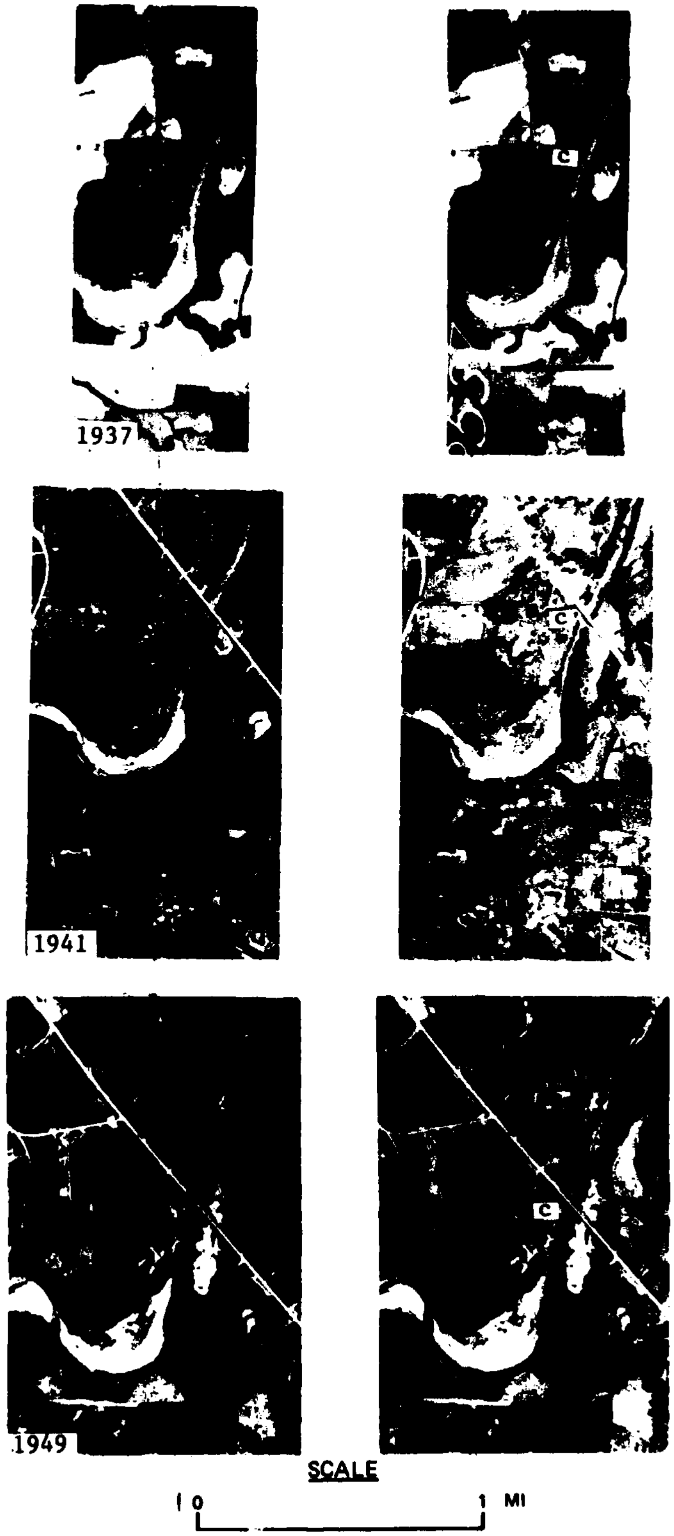


Figure 90. (Sheet 3 of 4)

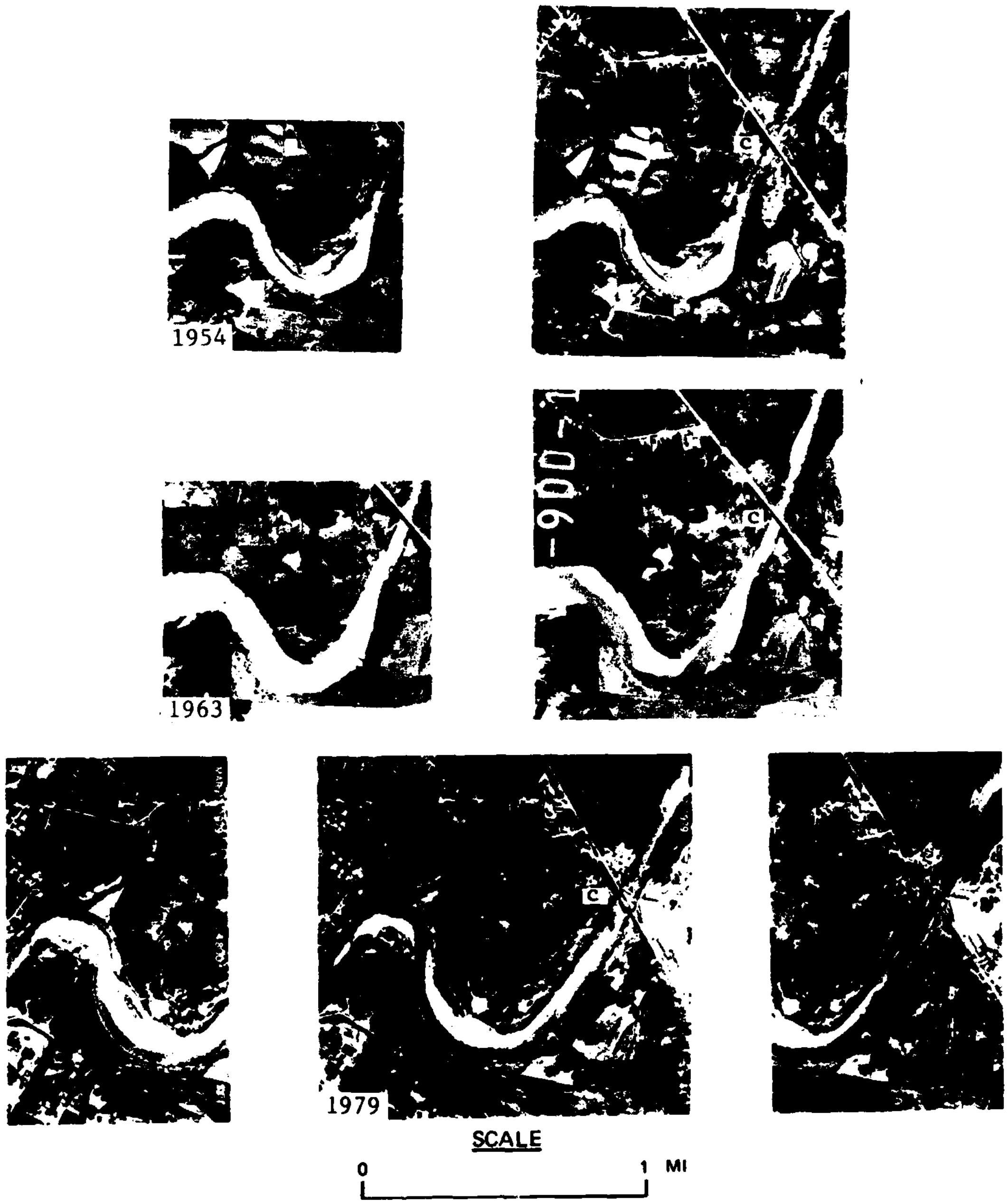
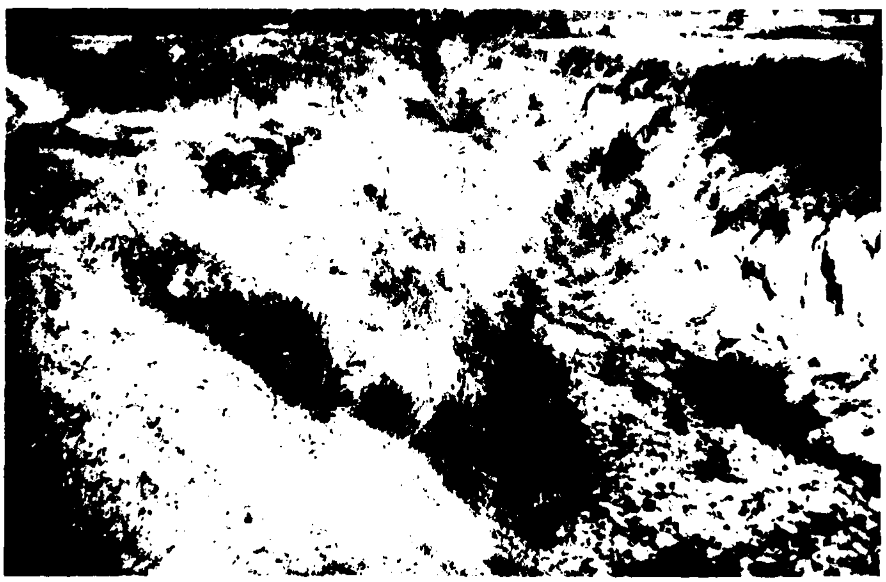


Figure 90. (Sheet 4 of 4)

a. Mouse Creek



b. Mouse Creek directly dowstream of "a"

Figure 91. Channel erosion on Batupan Bogue tributaries in 1977 (Continued)

c. Worsham Creek

Figure 91. (Concluded)

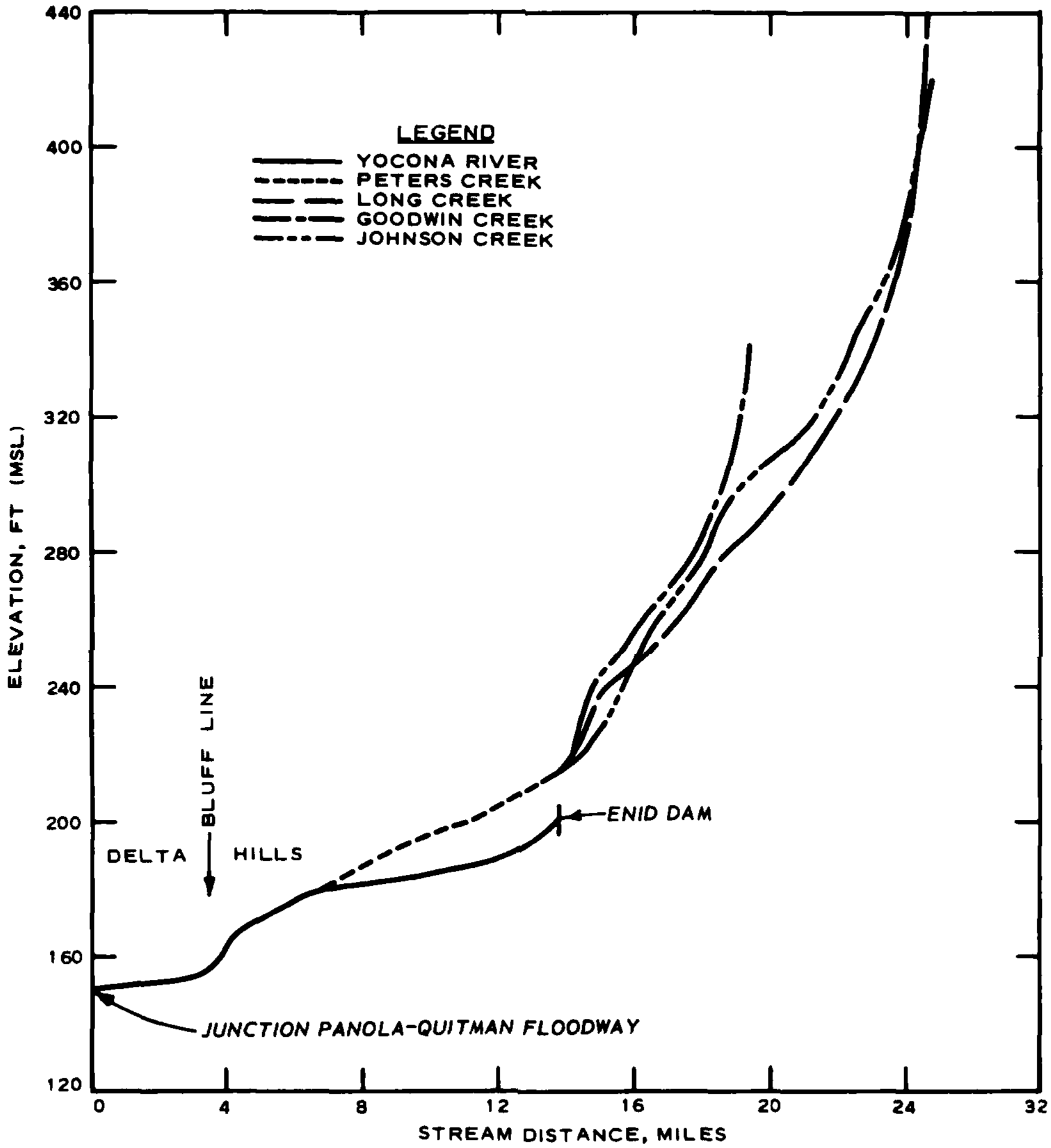


Figure 92. Longitudinal profiles of Goodwin, Long, Johnson, and Peters Creeks and Yocona River

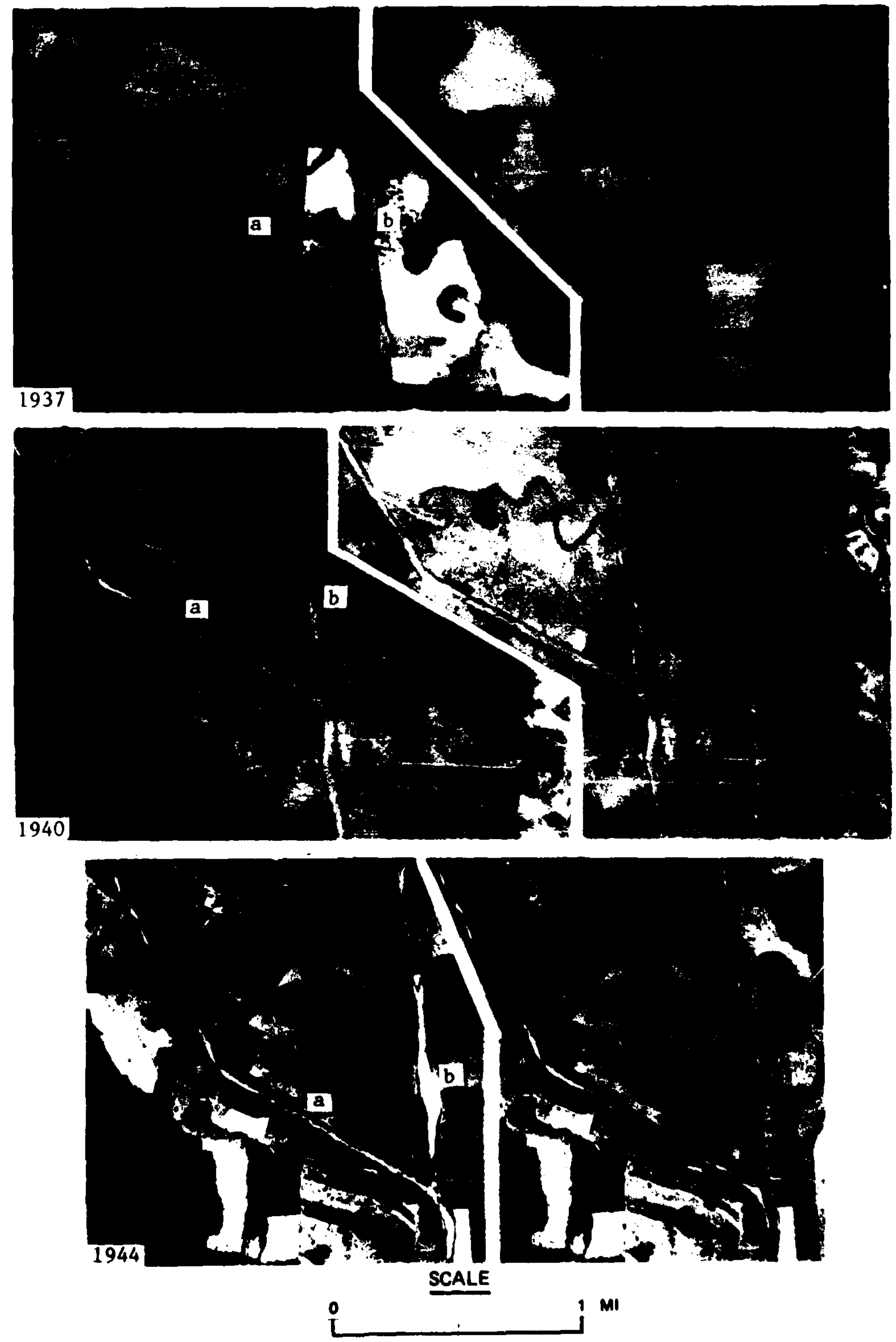


Figure 93. Mouth of Peters Creek (Symbol "a" designates Peters Creek, and "b" is the Yocona River.) (Sheet 1 of 3)

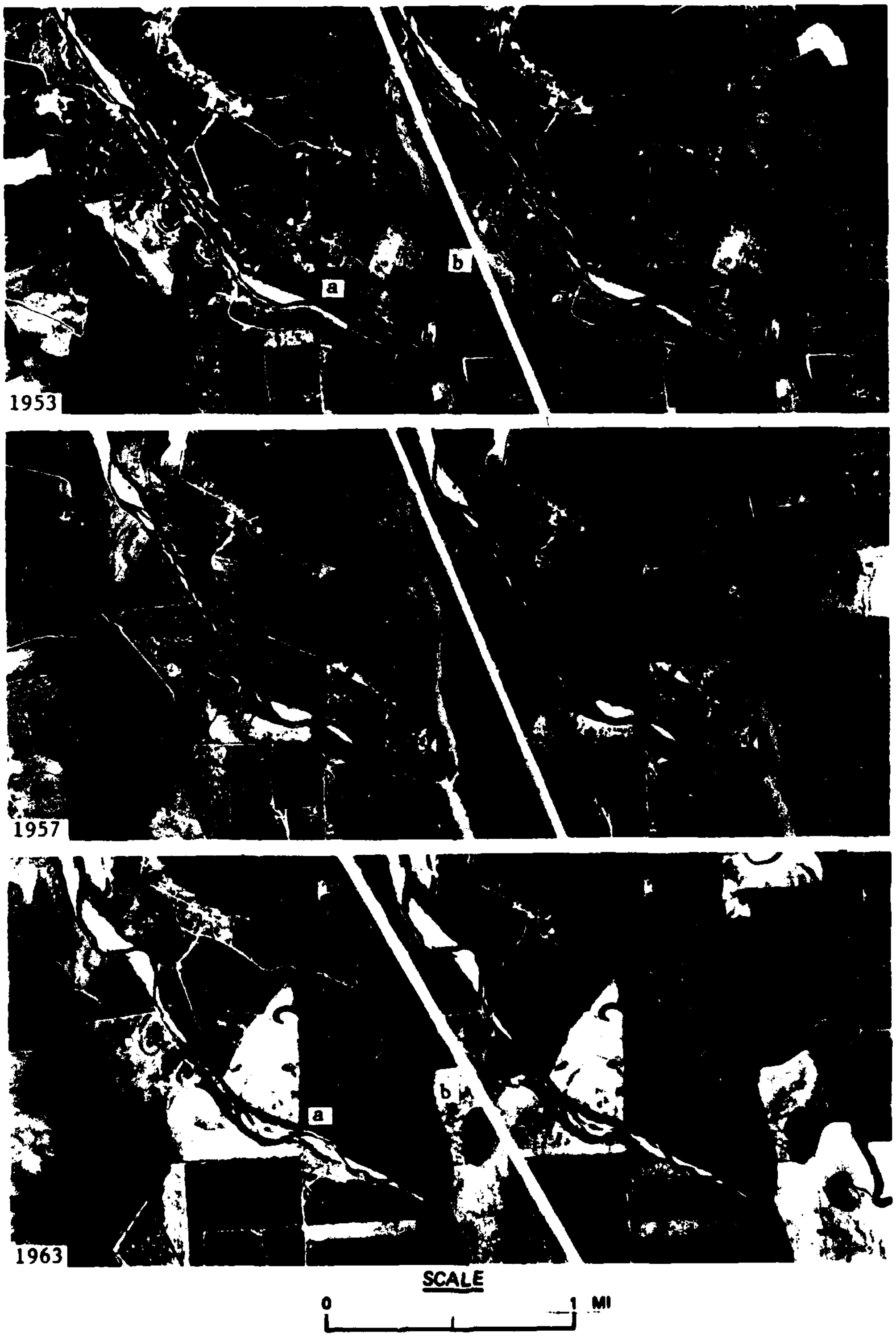


Figure 93. (Sheet 2 of 3)

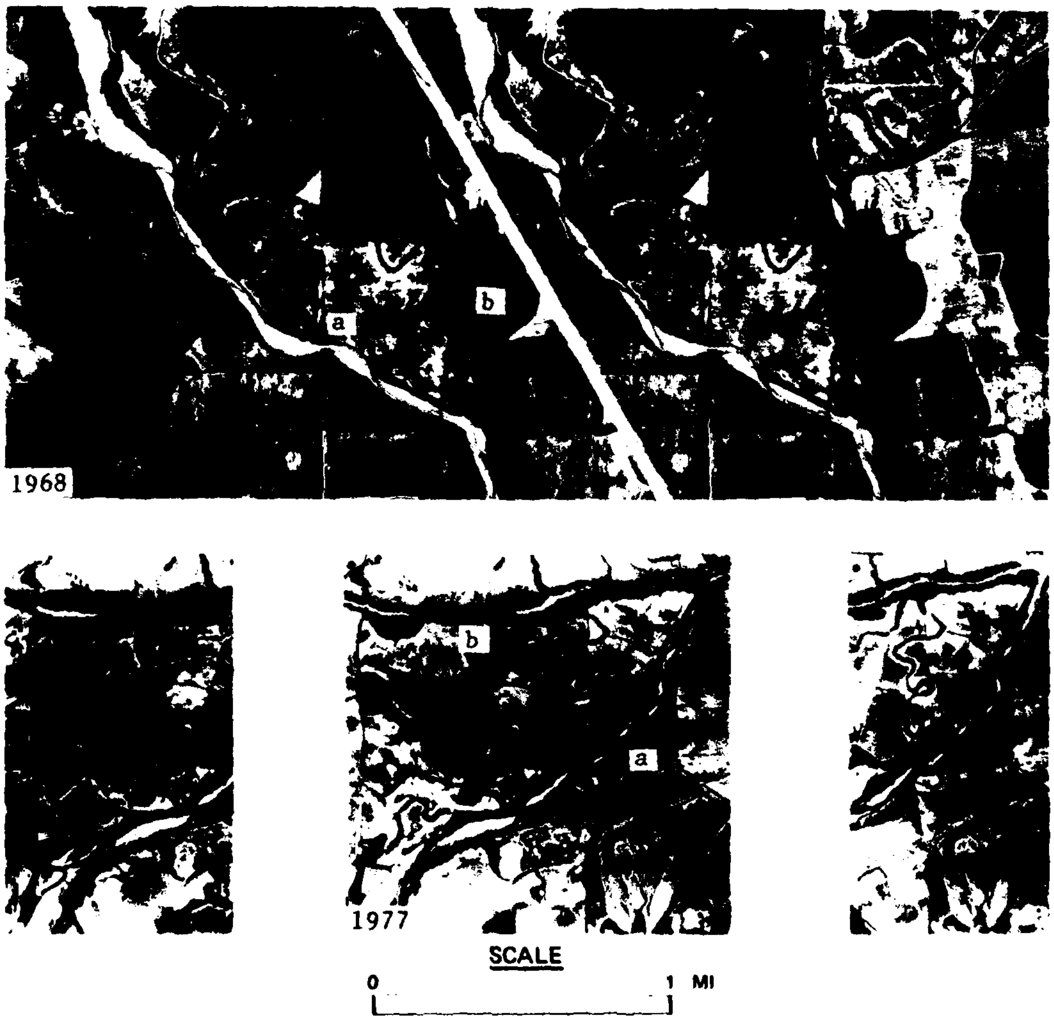


Figure 93. (Sheet 3 of 3)

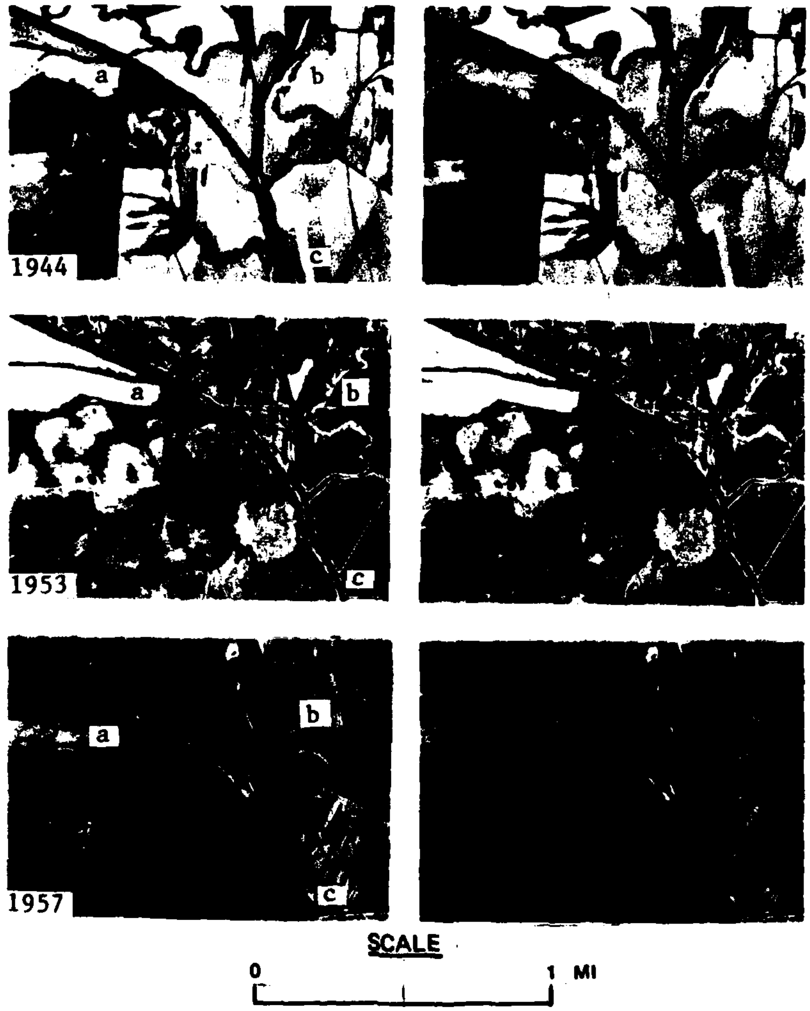


Figure 94. Junction of Long and Johnson Creeks to form Peters Creek (Symbol "a" designates Johnson Creek, "b" is Long Creek, and "c" is Peters Creek.) (Continued)

Figure 94. (Concluded)

it seems logical to assume the degradation at the head of Peters Creek was caused by degradation of the Yocona River and that the degradation has advanced up Long Creek to Goodwin Creek.

155. Schumm (1971) described the reaction a tributary has to the lowering of its base level:

> The average water surface elevation in the main channel acts as the base level for the tributary. It is assumed here that the base level in the main channel has been lowered by a natural change in the river environment or by man-induced change. . . . Applying Eq (5-60), $QS \sim Q_s D_{50}$, to the tributary stream, it can be seen that the increase in the slope S+ must be balanced by an increase in sediment transport $Q+_s$. Thus, under the new imposed condition, the local gradient of the tributary stream is significantly increased. This increased energy gradient induces headcutting and causes a significant increase in water velocities in the tributary stream. This results in bank instability, possible major changes in the geomorphic characteristics of the tributary stream, and increased local scour.

PART V: CONCLUSIONS AND RECOMMENDATIONS

156. Channel erosion is the fluvial reaction to change in the hydraulic and geomorphic conditions that control the fluvial processes. These conditions are, to a great extent, interdependent and are adjusted so that near-equilibrium conditions prevail in most natural stream systems. Any significant change in any one or more of the various conditions and variables will produce changes in the other variables and channel erosion may result.

Conclusions

157. Historical comparative analysis was used to identify significant changes in four selected study areas--Perry, Tillatoba, Goodwin, and Hotopha Creeks--and to detect the mechanisms that produce or could produce these changes. The primary cause of streambank erosion in the study area was human activities (land use, channelization, and dams). Climate is considered a contributory cause only in the sense that it is the major force behind all hydrologic phenomena.

158. Human activities affecting the hydraulic and geomorphic conditions in the study areas can be broken down into six general periods as follows:

- a. The 1800's to the present. Much of the Delta area has been cleared and the drainage systems improved so the land can be used for agricultural purposes. Water and sediment discharge have been increased; however, the increase in water discharge has been much greater than the increase in sediment discharge.
- b. The 1800's and early 1900's. Logging and land clearing for agricultural purposes removed much of the natural vegetative cover in the uplands, thereby increasing runoff and sheet and gully erosion. Stream flow and sediment discharge were increased.
- c. The 1900's to 1940. Many streams were channelized to increase the flow and sediment discharge, thereby reducing flooding conditions and increasing arable land. Channel slopes were increased.
- d. From 1921 to 1953. Man-made cutoffs on the major trunk

streams shortened the channels, thereby increasing channel slopes.

e. The late 1930's to the present. Conservation practices decreased runoff and soil erosion. Flow rate and sediment discharge were reduced.

f. The 1940's and 50's. Dams were constructed on the major streams draining the uplands and the channels below the dams were straightened to some extent. Channel slopes below the dams were increased and sediment-free water was released below the dam.

g. Post-1940. Channelization has increased the gradient of some streams such as Middle Fork, Tillatoba and Hotopha Creeks.

159. Channelization since 1939 has caused the most drastic change in the hydraulic and geomorphic conditions. All of the streams and rivers associated with the Yazoo River Basin have been channelized to some extent. Degradation resulting from the increased channel slopes has and is advancing up each of the channels and their successive tributaries. Headcutting in the Yazoo River Basin streams can usually be associated with degradation on the channel systems connecting them with zero-base level or sea level. The degradation of some of the channels, such as the upper reach of Middle Fork, is associated with alterations or channelization of that particular channel.

160. Water discharge in the Delta streams has been significantly changed by two factors: (a) The water discharge from the Delta area has been significantly increased by agricultural and associated practices while the sediment discharge has only been slightly increased; and (b) the four streams draining approximately 70 percent of the uplands have been dammed, thereby cutting off the sediment discharge (bed load) but continuing the water discharge. The increase in water discharge with a decrease in sediment discharge, combined with the increased gradients resulting from channelization, increases channel degradation.

161. The degradation of the large channels may be only a few feet and not particularly significant or noticeable on that channel. However, this few feet of degradation on the large channels becomes very significant and noticeable when it advances up successively smaller tributaries.

162. Upland erosion, usually resulting from farming activities, was evident to some extent in all four study areas. The increased sediment load introduced into the streams by gullying and sheet erosion did not appear to significantly affect any of the four study areas. The only noticeable bank erosion attributed to the increased sediment load was in the first-, second-, and third-order streams and was more prevalent in headward reaches of the basins. Bank erosion resulting from increased sediment loads was very extensive on some similarly sized streams elsewhere in the Yazoo River Basin. Evidently, the capacity of the major channels in the four study areas to transport the increased diment loads without noticeable erosion of the banks was not exceeded.

Recommendations

163. Efforts to control streambank erosion should be directed toward the control of channel degradation, since present-day bank erosion is usually caused by channel degradation. If the upstream movement of the knickpoints can be arrested or retarded, bank erosion can be more easily controlled or reduced. Present data indicates that all of the major Delta and upland channels downstream from the flood control dams are being degraded to some extent. A more comprehensive collection of historical and modern data could identify the critical areas of channel degradation and the trend of the channel erosion. Grade-control structures could be more effectively located and designed by the combined use of historical and modern data.

164. Farming activities in the uplands have increased in the past few years. Pastureland on the steeper slopes has been converted to cropland, and there has been some land clearing on the steeper slopes for agricultural use. Numerous gullies can be seen on the steeper slopes and in the gentler slopes where the water flow has been concentrated. The increasing sediment and water discharge into the streams will change the hydraulic and geomorphic conditions, which could possibly cause an increase in channel erosion. The effects of the possible increasing water and sediment discharges should be considered and

verified in planning channel erosion measures. Conservation laws or practices to control the upland erosion would be preferable.

165. Past and present agricultural practices in Delta have changed the hydraulic and geomorphic conditions of Delta streams. Continued land clearing and drainage system improvements have increased the water discharge into channels whose gradients have been increased by channelization. Flood control dams have already removed the bed load from the streams draining approximately 70 percent of the uplands, thereby releasing sediment-free water into the channels just before they enter the Delta. The effects of these changes in water and sediment discharge have to be quantified before excessive channel erosion can be effectively controlled.

166. A study of the streams upstream of the flood control dams would help verify whether the excessive channel erosion downstream from the dams was indeed caused by factors downstream of the dams or by some regional factor such as tectonic forces.

167. There appears to be a need for a comprehensive basin study and master plan in order to effectively stop or control excessive channel erosion both locally and basin-wide.

168. Several different agencies and branches within these agencies are presently involved with the control or prevention of channel erosion. The overall effectiveness and success of the streambank erosion project could be enhanced if a more unified or combined approach were used.

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Table 1

Geologic Units in Yazoo River Basin*

Period (Epoch)	Group	Formation	Description
Quaternary (Holocene)	--	Alluvium	Loam, sand, gravel, and clay
Quaternary (Pleistocene)	--	Loess	Grayish to yellowish-brown massive silt
Tertiary (Miocene)	--	Catahoula	Mostly sand and silt with some clay
Tertiary (Oligocene)	Vicksburg	--	Predominantly limestone and marl with some clay and sand
Tertiary (Eocene)	Jackson	Yazoo Clay	Clay containing some sand and marl
		Moodys Branch	Shells embedded in glauconitic clayey quartz sand
Tertiary (Eocene)	Claiborne	Cockfield	Irregularly bedded lignitic clay, sand, and lignite; sparingly glauconitic
		Cook Mountain	Clay with some glauconitic sand
		Kosciusko	Irregularly bedded sand, clay, and some quartzite
		Zilpha	Clay with some glauconitic sand
		Winona	Highly glauconitic clayey sand
		Tallahatta	Predominantly sand, containing claystone and clay lenses; abundant clay stringers
		Neshoba Sand	Fairly coarse, glauconitic sand
Tertiary (Eocene)	--	Wilcox	Irregularly bedded fine to coarse sand with lignitic clay and lignite
Tertiary (Paleocene)	Midway	Naheola	Fine to coarse micaceous sand, kaolin, and bauxitic clay
		Porters Creek	Clay with glauconitic micaceous sand lenses
		Clayton	Upper part - coarsely glauconitic sandy clay and marl
			Lower part - sandy limestone and sand

(Continued)

* Bicker 1969.

Table 1 (Concluded)

Period (Epoch)	Group	Formation	Description
Upper Cretaceous	Selma	Prairie Bluff Chalk	Compact brittle chalk; sandy chalk and calcareous clay
		Owl Creek	Tough blue glauconitic sandy clay
		Ripley	Fine glauconitic sand, clay, and sandy limestone
Citronelle and/or terrace deposits			Gravel, sand, clay; cap hills along western edge of uplands; overlain by loess in many places

Table 2

Brief Description of Soils and Their Estimated Physical Properties*

Stream Basin	Position in Basin	Soil Association	Description	Depth in inches	Unified Classification	Permeability inches/hour	Dispersion
Perry	Near Mouth	Falaya-Collins-Waverly	Well drained to poorly drained silty soils formed in recent alluvium from the Yalobusha River and other streams	0-60	ML or CL	0.20-0.63	Moderate to High
	Lower	Grenada-Calloway	Silty soils that have a fragipan and border floodplains	0-60	ML or CL	Upper 22 inches 0.63-2.00 Lower 38 inches < 0.20	Moderate to High
	Upper 1/2	Providence-Loring-Ruston	Silty and sandy soils on hilly uplands	0-60	ML, CL, or SM	0.20-2.5	Moderate to High
Tillatoba	Lower 1/2 in Delta	Falaya-Collins	Nearly level, poor to well drained soils that are medium textured throughout; formed in silty alluvium on flood plain	0-54	ML or CL	0.63-2.00	High
	Valley	Collins-Falaya	Poor to moderately well drained, nearly level silty soils; formed on floodplain and upland drainageways	0-54	ML or CL	0.63-2.00	High
	Uplands	Memphis-Gullied land	Moderately sloping to very steep, well drained soils that have a fragipan	0-60	ML or CL	0.63-2.0	Moderate to High

(Continued)

* Huddleston, Bowen, and Ford 1975; Galberry 1963; Scott 1970; Thomas and Bowen 1967, 1975.

Table 2 (Concluded)

Stream Basin	Position in Basin	Soil Association	Description	Depth in inches	Unified Classification	Permeability inches/hour	Dispersion
Goodwin	Valley	Collins-Falaya-Grenada-Calloway	Poorly drained and moderately well drained, silty soils in alluvium on nearly level floodplain	0-53	ML or CL	0.8-2.5 some < 0.05	Moderate to High
	Uplands	Loring-Grenada-*Memphis*	Well drained and moderately *well drained*, *gently sloping* to very steep soils in thick loess	0-65	ML or CL	0.8-2.5 some < 0.05	Moderate to High
Hotopha	Valley		all columns same as Goodwin Valley				
	Uplands (lower basin)		all columns same as Goodwin Valley				
	Uplands (upper basin)	Ruston-Providence-Eustis	Excessively drained, steep or very steep soils in sandy Coastal Plain sediments on side slopes, and moderately well drained soils in thin loess on ridges	0-55	ML, CL, SM, or SC	0.8->10.0	Moderate to High

Table 3

Geomorphic Changes in Delta Area of Tillatoba Creek

	Date of Imagery				
Erosion	1937	1941	1954	1960's	1970's*
Bank	Tree lined channel, no detectable erosion	Channel width doubled; banks appear steep and vertical; sharp bends being eroded; banks appear very irregular and rough	Increasing channel width; small meander loops or bends are being eroded	Continued increase in channel width, but at slower rate; small meander loops and bends still being eroded	Continued increase in channel width
Bed	No apparent degradation	Isolated remnants of recent** channel bed indicate degradation has and/or is occurring; small tributary channels are degrading†	Continued degradation has left isolated segments of the previous bed elevated above the present channel	Degradation continuing but at much slower rate	Degradation occurring but at slower rate than in the late 1940's and early 1950's
General	Channel appears stable; no detectable point bars	Point bars common, but more numerous near bluff line	Point bars near bluff line larger and more continuous; fewer point bars near mouth	Thalweg meandering in channel deposits, causing bank erosion	Increased channel length as thalweg meanders resulting in eroding banks

* This period includes data from imagery and field observations.

** Recent - this term, as used in this table, refers to events since 1937.

† The eroded appearance of these channels is like that of modern eroding tributaries seen in the field.

Table 4

Geomorphic Changes in Upland Area of North Fork

Channel Character	Reach	Date of Imagery 1937	1941	1954	1960's	1970's*
Bank erosion	Lower reach	Tree lined channel with no apparent erosion	Noticeable erosion along entire reach, but more pronounced at mouth; steep vertical banks are present	Channel width more than doubled; channel length shortened as bank erosion cut out some meander loops and bends	Outside bank of sharper bends being eroded; reduced rate of bank erosion in other areas	Continued erosion of outside banks of sharp bends, and lesser rate in other areas
	Middle reach	Outside bank of some meander loops being eroded	Noticeable erosion along entire reach, but more noticeable along outside bank of meander loops	Channel width more than doubled in lower stretch; bank erosion increasing in upper stretch since 1941	Channel width more than triple 1937 width in lower stretch; and increased bank erosion in upper stretch	Channel width increasing in lower stretch; major bank erosion was occurring in the vicinity of the junction of North Fork and Little Creek
	Upper reach	Outside bank of meander loops being eroded	Noticeable erosion along entire reach, but more noticeable in meander loops	Bank erosion in some meander loops	Very little detectable on imagery	Very little detectable
	Tributaries	Extensive bank erosion on the smaller streams associated with gully systems, and noticeable erosion on the larger streams; no noticeable erosion on other streams	Increased bank erosion on all streams associated with gullying	Decreased bank erosion on streams associated with gully areas; increased bank erosion at mouths of streams in lower reach	Very little detectable erosion on streams associated with gully areas; increased bank erosion in lower and middle reaches	Very little bank erosion on streams associated with gully areas; increased bank erosion in lower and middle reaches
Degradation	Lower reach	Not detectable	Downcutting at mouth	Knickpoint had advanced through reach; isolated sections of previous bed left at higher elevation than present bed	Continued downcutting but at slower rate; isolated sections of previous beds at higher elevation than present bed	Continued downcutting as in 1960
	Middle reach	Not detectable	Not detectable	Knickpoint in lower stretch; isolated sections of previous bed at elevation higher than present bed	Knickpoint advancing upstream	Knickpoint in vicinity of junction of North Fork and Sandy Creek

(Continued)

* This period includes data from imagery and field observations.

Table 4 (Concluded)

Channel Character	Reach	Date of Imagery 1937	1941	1954	1960's	1970's
	Upper reach	Not detectable	Not detectable	Not detectable	Not detectable	Not detectable
	Tributaries	Channels draining gullies exhibit some degradation	Channels draining gullies and the mouth area	Channels draining directly into North Fork below the knickpoint	Channels draining directly into North Fork below the knickpoint	Channels draining directly into North Fork below the knickpoint
General		Point bars in upper and middle reaches, and in tributaries associated with gully systems	Point bars in upper and middle reaches, mouth area, and tributaries associated with gully systems	Point bars in channel below knickpoint; thalweg meandering in wide channels	Point bars in channel below knickpoint; thalweg developing meander pattern in wide channels	Point bars in channel below knickpoint; thalweg developing meander pattern in wide channels

Table 5

Geomorphic Changes in Upland Area of South Fork

Channel Character	Reach	Date of Imagery				
		1937	1941	1954	1960's	1970's*
Bank erosion	Lower reach	Tree-lined channels with no apparent erosion	Noticeable erosion along entire reach, but more pronounced at mouth	Channel width more than double that of 1937; meander loops and bends cut off by bank erosion, thereby shortening the channel length	Bank erosion in meander loops, but at slower rate than pre-1954	Continued erosion in meander loops as in the 1960's
	Middle reach	Very limited erosion, mainly in meander loops	Noticeable bank erosion along entire reach	Extensive bank erosion in lower stretch, decreasing upstream; width two to three times wider in lower stretch than in 1937; meander loops and bends being straightened by bank erosion	Channel width along entire reach two to three times wider than 1937; continued erosion especially in meander loops	Decreased rate of bank erosion; however, meander loops still being eroded
	Upper reach	Very limited erosion	Noticeable bank erosion along entire reach	Noticeable bank erosion along entire reach, but especially noticeable in meander loops, no great change in width	Extensive bank erosion in lower two-thirds of reach; width two to three times wider than in 1937; meander loops and bends being straightened by bank erosion	Extensive bank erosion along entire reach; width two to three times wider than in 1937
Degradation	Lower reach	No noticeable channel degradation	Lower stretch being degraded	Knickpoint had advanced through entire reach; isolated sections of previous beds left at higher elevation than present bed	Continued downcutting but at slower rate; isolated sections of previous beds at higher elevation than present bed	Degradation occurring, but apparently at much slower rate than previously
	Middle reach	No noticeable channel degradation	Possible degradation but very little if any	Knickpoint in middle stretch of reach; isolated sections of previous channel bed at higher elevation than present bed	Knickpoint had advanced through reach; isolated sections of previous beds at higher elevation than present bed	Degradation occurring, but at much slower rate than previously

(Continued)

* This period includes data from imagery and field observations.

Table 5 (Concluded)

Channel Character	Reach	Date of Imagery: 1937	1941	1954	1960's	1970's
	Upper reach	No noticeable channel degradation	Possible degradation but very little if any	Possible degradation	Knickpoint advanced to middle of upper reach; isolated sections of previous channels at higher elevation than present bed	Knickpoint advanced into Simmons and Davis Creeks; isolated sections of previous channels at higher elevation than present bed
Tributaries	--	Point bars in tributaries associated with gully systems	Point bars at mouth of South Fork, and tributaries associated with gully systems	Tributaries associated with degrading channels are also degrading in lower reaches, and widening; decreased erosion in channels associated with gully systems	Tributaries associated with degrading channels are also degrading and widening; very little erosion in channels associated with gully systems	Tributaries associated with degrading channels are also degrading and widening; no noticeable erosion in channels associated with older gully systems

Table 6

Geomorphic Changes in Upland Area of Middle Fork

Channel Character	Reach	Date of Imagery 1937	1941	1954	1960's	1970's*
Bank erosion	Lower reach	Bank erosion occurring on channelized stretches; no erosion noticeable on other stretches	Noticeable bank erosion on entire reach, but not very extensive	Bank erosion limited to a few meander loops	Limited to few meander loops	Extensive bank erosion in the lower stretch near mouth; channel width more than doubled
	Middle reach	No noticeable bank erosion	Noticeable bank erosion on entire reach, but not very extensive	Bank erosion limited to a few meander loops	Bank erosion on channelized stretch	Bank erosion on channelized stretch
	Upper reach	No noticeable bank erosion	Noticeable bank erosion on entire reach, but not very extensive	Bank erosion in lower stretch of channelized stretch	Bank erosion on channelized stretch	Extensive bank erosion on channelized stretch
Degradation	Lower reach	Not noticeable	Possible downcutting, but very little if any	Some degradation in short channelized stretch	Some degradation in short channelized stretch	Knickpoint advancing up lower stretch
	Middle reach	Not noticeable	Possible downcutting, but very little if any	Channelized stretch degrading	Channelized stretch degrading	Channelized stretch degrading
	Upper reach	Not noticeable	Possible downcutting, but very little if any	Channelized stretch degrading	Channelized stretch degrading	Channelized stretch degrading
Tributaries		Bank erosion in channels associated with gully systems; point bars in eroding channels	Extensive bank and bed erosion in those channels directly associated with gully systems; point bars in above channels	Decreased erosion in channels associated with gully; point bars in eroding channels	Point bars in eroding channels	Point bars below knickpoint at mouth and in channelized stretches

* This period includes data from imagery and field observations.

Table 7

Geomorphic Changes in Perry Creek

Channel Character	Site	Date of Imagery					
		1935	1941	1949	1954	1963	1970's*
Bank Erosion	P1 (mouth)	Noticeable erosion in bends	Erosion along entire channel; but more noticeable on outside bank of bends	Outside banks of some bends appear to be only active areas	Outside bank of some bends	Active erosion in lower 1/2 mile; more limited in in rest of channel	Very active erosion along entire channel
	P2	Noticeable erosion in bends	Very noticeable on outside bank of bend	--	Very active along entire channel; bends and meander loops being straightened	Mostly along outside bank of bends	Active erosion along entire channel but more noticeable in bends
	P3	--	Not detectable, tree-lined channel	--	Active erosion along entire channel	Channel width doubled; bends and meander loops straightened	Active erosion along entire channel, but more extensive below Interstate 55 bridge
	P4	--	Erosion in bends	--	Active along entire stretch but more noticeable in bends	Some erosion in bends	Erosion in bends
Degradation	P1 (mouth)	Possible degradation	Tributaries degrading	Bed of cutoff meander loop at higher elevation than present bed	Continued degradation; tributaries rapidly degrading since 1949	Continued degradation; more pronounced at mouth	Continued degradation; erosion-resistant clays exposed in bed

(Continued)

* Includes field observations.

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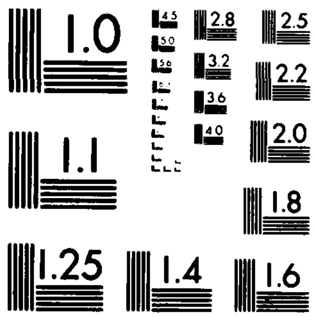

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Table 7 (Concluded)

Channel Character	Site	Date of Imagery 1935	1941	1949	1954	1963	1970's
Degradation	P2	Possible degradation	Tributaries degrading at their mouths	--	Tributaries appear entrenched; isolated remnants of recent channel bed at higher elevation than present bed	Tributaries degrading headward; degradation in Perry, but not as rapid as pre-1954	Continued degradation
	P3	--	Not detectable	--	Rapidly degrading	Continued degradation	Bed downstream from highway cut down 6 to 8 ft since 1965
	P4	--	Possible degradation	--	Tributaries degrading at their mouths	Isolated remnant of former channel bed higher elevation than present bed	Rapid degradation in lower stretch
General	Batupan Bogue gradually increased in depth and width from 1935 to present. Perry Creek responded by also degrading. Knickpoints can be traced upstream in time. Former beds of Perry Creek, at higher elevations than the 1979 bed, can be seen along the relatively wide modern channel.* Figure 39 shows the extensive channel erosion that has occurred at the mouth of Batupan Bogue.						

Table 8

Geomorphic Changes in Goodwin Creek

Channel Character	Site	Date of Imagery			
		1940's	1950's	1960's	1970's*
Bank Erosion	G1 (Mouth)	Some bank erosion where meandering thalweg deflected against bank	Same as 1940's; gradual bar erosion altering straight appearance of channel	Continued gradual erosion of banks; channel shape more irregular	Channel width nearly doubled from 1968 to 1979; channel attempting to reestablish a meandering type channel
	G2	Some erosion on the outside banks of meander loops	Some erosion on the outside banks of meander loops	Increased erosion along entire channel, but more extensive in meander loops	Channel widths doubled since 1968; channel upstream from bridge more extensively eroded
	G3	Some erosion in meander loops	Extensive erosion on outside banks of meander loops	Erosion along entire channel, but very pronounced in meander loops	Continued erosion as in 1960's
	G4	Channel erosion along entire stretch, but more pronounced in meander loops	Some erosion in meander loops	Channel width decreased, no noticeable bank erosion	Some erosion on outside banks of meander loops
Degradation	G1 (Mouth)	Limited downcutting at mouths of tributaries	Not noticeable	Possible degradation	Degradation occurring; erosion resistant clay and limonitic ledges exposed in bed

(Continued)

* This period includes data from imagery and field observations.

Table 8 (Concluded)

Channel Character	Site	Date of Imagery 1940's	1950's	1960's	1970's
Degradation	G2	Downcutting at mouths of tributaries	Tributaries downcutting	Possible degradation	Degradation occurring
	G3	Possible degradation	Channel degrading	Tributaries degrading; isolated segment of former bed at higher elevation than present	Channel degrading; erosion resistant clay in bed
	G4	T[illegible] degrading	Tributaries degrading; bed of meander cutoffs at higher elevation than present bed	Beds of meander cutoffs at higher elevation than present bed	Continued as in 1960's
General	The straight appearance of the channelized section is being gradually altered to a more meandering-type appearance. Erosion-resistant clays and limonitic ledges are exposed in the channel bed throughout the stream.				

Table 9

Geomorphic Changes in Hotopha Creek

Channel Character	Site	Date of Imagery: 1935 - 1941	1957	1958–1961	1963	1968	1970's*
Bank Erosion	H1 (Mouth)	No noticeable bank erosion in 1935 or 1940; channel width doubled from 1940 to 1949	Bank erosion cutting away meander loops and increasing channel width	Hotopha Creek was channelized from ~ 3.3 miles above its mouth to ~ 1 mile above the mouth of Marcum Creek. The channel downstream from the channelization was cleared.	Channel widening and straightening as meander loops cut away	Continued bank erosion, channel has straight channelized appearance	Continued bank erosion
	H2	No noticeable bank erosion in 1935, channel tree-lined	Tree-lined channel, some erosion on outside banks of meander loops		Rapid erosion of cleared banks	Channel width nearly tripled since 1963; straight channelized appearance	Continued bank erosion
	H3	Tree lined channel, no observable bank erosion	Vegetation removed, no observable bank erosion, except at bridge		Some erosion all along channel	Erosion all along channel, but more noticeable downstream from bridge	Extensive bank erosion all along channel
	H4	Mostly tree lined, no observable erosion	Mostly tree lined, no observable erosion		Limited erosion all along channel	Erosion along entire stretch, but more extensive downstream from mouth of Marcum Creek	Extensive bank erosion all along channel
	H5	Very gradual bank erosion along entire stretch of channel			Continued gradual bank erosion along entire stretch, but appears to be occurring at faster rate. This section channelized pre-1935.		
Degradation	H1 (Mouth)	Not noticeable in 1935 or 1940; beds of meander cutoff, and previous channel beds at higher elevation than 1949 bed	Beds of meander cutoffs at higher elevation than 1957 bed		Continued degradation	Continued degradation	Small tributaries have hanging beds; beds of previous channels at higher elevations than 1979 bed

(Continued)

* Includes field observations and data.

Table 9 (Concluded)

Channel Character	Site	Date of Imagery: 1935 - 1941	1957	1958–1961	1963	1968	1970's
Degradation	H2	Not detected	Not detected at H2, however channel degradation is occurring directly downstream from H2	Hotopha Creek was channelized from ~ 3.3 miles above its mouth to ~ 1 mile above the mouth of Marcum Creek. The channel downstream from the channelization was cleared.	Beds of meander cutoffs at successively higher elevations than the 1963, 1968 and 1979 bed		
	H3	Not detected	Not detected		New channel deeper than prechannelization channel	Channel degrading	10 to 12 ft vertical drop in 100 ft on pre-1957 channel
	H4	Not detected	Not detected		New channel deeper than previous channel	Noticeable increase in depth	5 to 6 ft waterfall; drainage channels elevated 8 to 10 ft above 1979 channel
	H5	Not detected	Not detected		Channel depth increased from 1963 to present, tributaries degrading		
General	There are no sediments in the channel of the Middle and Upper reach. The stream is cutting into clay. The lower reach has a wide sediment-covered bed. There is an 8- to 10-ft vertical drop in ~ 100 ft at the present mouth of Deer Creek.						

Table 10

Man-Made Cutoffs on the Yazoo, Tallahatchie, and Coldwater Rivers

River	Name of Cutoff	Year Opened	Shortening in Miles
Yazoo	Jonestown	1953	2.1
	Yazoo City	1940	1.7
	Belle Raire	1940	3.0
	Hard Cash	1941	3.0
	Famolsa	1941	1.9
	Silent Shade	1941	1.4
	Marksville B	1941	0.9
	Sidon	1943	3.7
		Subtotal -	17.7
Tallahatchie	Pecan Point	1943	3.5
	Lower Glendora	1942	1.5
	Upper Glendora	1942	2.2
	Grassy Lake	1940	0.8
	Opossum Bayou	1940	0.9
	Locopolis	1940	1.1
	Tillatoba	1940	1.1
	Oakland Lake	1941	0.4
	Yonkapih	1941	1.4
	Twin Lakes	1941	0.6
	Oxbow	1941	1.8
	White Lake	1941	0.7
	Horseshoe Lake	1941	0.9
	Blue Lake	1941	0.8
	Willow Lake	1941	1.6
	Island Lake	1941	0.8
	Agar Lake	1941	0.8
		Subtotal -	20.9
Coldwater	Campbell White	1941	1.5
	Morning Star	1941	1.9
	Wright School	1941	1.8
	Marks	1941	0.5
	Pompey Ditch	1921	24.9
	Coon Bayou and other cutoffs above Pompey Ditch to Arkabutla Dam	1941-42	19.0
		Subtotal -	49.6
		Total Shortening -	88.2

Table 11

Decreases in Channel Lengths

System	Prechannelization		Present		Change in Length miles	Percent Change
	Date	Length, miles	Date	Length, miles		
Hotopha Creek	pre-1954	17.7	1976	14.8		
Little Tallahatchie River	pre-1925	41.1	1952	14.8		
Panola-Quitman Floodway	--	--	1962-63	29.3		
Tallahatchie River	pre-1941	111.2	1957	77.2		
Yazoo River	pre-1941	188.2	1952	170.5		
Mississippi River	1932	488.2	1976	437.0		
		846.4		743.6	102.8	-12.1
Goodwin Creek	--	--	1976	7.7*		
Long Creek	1937	0.1	1962	1.0		
Peters Creek	1937	11.1	1962	6.4		
Yocona River	1937	21.6	1962	6.8		
Little Tallahatchie River	pre-1941	3.2	1952	--		
Panola-Quitman Floodway	--	--	1962-63	12.3		
Tallahatchie River	pre-1941	111.2	1957	77.2		
Yazoo River	pre-1941	188.2	1952	170.5		
Mississippi River	1932	488.2	1976	437.0		
		823.6		711.2	112.4	-13.6
Tillatoba Creek	pre-1925	11.0**	1976	7.8**		
Tallahatchie River	pre-1941	86.0	1957	77.2		
Yazoo River	pre-1941	188.2	1952	170.5		
Mississippi River	1932	488.2	1976	437.0		
		773.4		692.5	80.9	-10.5

(Continued)

* Not included in total length.

** Length from junction of North and South Forks, Tillatoba Creek.

Table 11 (Concluded)

System	Prechannelization		Present		Change in Length miles	Percent Change
	Date	Length, miles	Date	Length, miles		
Perry Creek	pre-1941	12.9	1976	8.9		
Batupan Bogue	1954	2.7†	1979	2.7†		
Yalobusha River	pre-1940	60.7	1957	43.3		
Yazoo River	pre-1941	188.2	195	170.5		
Mississippi River	1932	488.2	1976	437.0		
		752.7		662.4	90.3	-12.0

† No channelization.

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

Whitten, Charlie B.
  Engineering geology and geomorphology of streambank erosion : Report 2 : Yazoo River Basin Uplands, Mississippi / by Charlie B. Whitten, David M. Patrick (Geotechnical Laboratory, U.S. Army Engineer Waterways Experiment Station). -- Vicksburg, Miss. : The Station ; Springfield, Va. : available from NTIS, 1981.
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  Bibliography: p. 176-178.

  1. Engineering geology. 2. Erosion. 3. Geomorphology. 4. Yazoo River (Miss.) I. Patrick, David M.

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