CHANNEL AND BANK STABILITY OF TWENTYMILE CREEK AT U.S. HIGHWAY 45 NEAR WHEELER, PRENTISS COUNTY, MISSISSIPPI

by D. Phil Turnipseed and K. Van Wilson, Jr.

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CONVERSION FACTORS

For readers who may prefer to use the metric (International System) of units rather than the inch-pound units used herein, the conversion factors are listed below:

Multiply inch-pound unit	by	To obtain metric unit
foot per second (ft/s)	0.3048	meter per second (m/s)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m3/s)
foot (ft)	0.3048	meter (m)
foot per mile (ft/mi)	0.018939	meter per kilometer (m/km)
square foot (ft^2)	0.09290	square meter (m^2)
pounds per square foot (lb/ft^2)	47.88	newtons per square meter (N/m^2)
pounds per cubic foot (lb/ft^3)	157.09	newtons per cubic meter (N/m^3)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)

Mississippi State Highway Department Datum: In this report, elevations are referenced to Mississippi State Highway Department Datum (MSHDD), which is to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929 and referred to in this report as sea level.

DEFINITION OF TERMS

Terms used in this report are defined below.

Angle of internal friction -angle of the plane of contact of soil particles with the horizontal at the point of sliding (shearing); angle whose tangent is the coefficient of friction between the soil particles (Cernica, 1982).

Channel-bed aggradation - filling in of the channel because streamflows are not sufficient to transport the material delivered from upstream channel-bed degradation (Simon and Hupp, 1986b).

Channel-bed degradation -headward erosion of the channel bed usually caused by increases in downstream channel gradient and cross-sectional area by man (Simon and Hupp, 1986b).

Cohesion -attraction of adsorbed water and soil particles that produce a body, which holds together but deforms plastically at varying water contents (Sowers, 1979).

Critical bank height -height of channel bank above which failure can be expected, produced by an increased height (channel-bed degradation) or bank angle (over steepening through erosion) (Thorne and others, 1981).

Dry bulk-unit weight -ratio of the weight of the soil solids to the volume of the soil sample (Das, 1984).

Factor of safety -ratio of the resisting force (shear strength of the soil) to the driving force (weight of the soil). If the resisting force is less than the driving force, the factor of safety is less than 1.0, and therefore, failure occurs (Huang, 1983).

Failure-block width -the measured width of the failure block or the distance between affected stems of woody plants growing in bank material that has failed and fallen down slope and the existing top-bank edge (Hupp, 1987).

Iowa Borehole Shear Test -direct measure of shear strength of fine- to medium-grained soils insitu (from inside a borehole) (Handy, 1981).

Knickpoint -an abrupt change in channel-bed elevation along a reach of channel relative to the upstream or downstream direction.

Moisture content -ratio of the weight of the water present to the weight of the soil solids (Das, 1984).

Planar failure -slides along a surface of rupture whereby the mass progresses down and out along a more or less planar or gently-undulatory surface and has little rotational movement or backward tilting characteristics (Huang, 1983).

Rotational failure -landslide along a surface of rupture that is concave upward. The exposed cracks are concentric in plan and concave toward the direction of movement (Huang, 1983).

Shear strength -capacity of a soil to resist shear; in terms of effective stress, it can be given by the equation:

$$s' = c' + \sigma' \tan \phi'$$

where:

σ' = effective normal stress on plane of shear

c' = cohesion or apparent cohesion of the soil; and

ϕ' = angle of internal friction.

(Das, 1984).

Slough-line angle -angle attained by projecting the slope of failed blocks of soil mass (which represents a temporary angle of stability) to its intersection with the top of channel bank (flood-plain level). It is used to determine short-term (10-20 years) bank widening (Simon and Hupp, 1986a).

Temporary angle of stability -the angle from the horizontal extended from the toe to the top of bank in which that bank at that given height is the most stable. It can be estimated by averaging the existing bank angle with the angle of internal friction of the bank material. (Spangler and Handy, 1973).

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ABSTRACT

The channel of Twentymile Creek at existing U.S. Highway 45 near Wheeler, Mississippi, has degraded about 8 feet and widened about 73 feet since it was channelized in about 1912. No recent (at least since 1968) channel degradation or widening is evident on Twentymile Creek near the proposed U.S. Highway 45 relocation. Botanical evidence indicates that both banks in the vicinity of the proposed relocation are fairly stable, but the removal of mature riparian vegetation from channel banks could result in near-future instability.

Rates of channel gradation and widening--as determined from channel descriptions, discussions with local residents, and botanical evidence along the banks--were used in conjunction with soil properties to estimate probable future channel degradation and widening through the year 2010. No additional channel degradation through the year 2010 is expected at the existing and proposed crossing of Twentymile Creek. At existing U.S. Highway 45, the channel width could increase about 15 feet through the year 2010; at the proposed relocation, the channel width could increase about 20 feet in the next 10 to 20 years if mature riparian vegetation is removed from the channel banks. These projections are based on the assumption that no additional channel modifications and no unusually large and destructive flooding will occur by the year 2010.

INTRODUCTION

The Mississippi State Highway Department proposes to relocate the U.S. Highway 45 crossing of Twentymile Creek near Wheeler, Prentiss County, Mississippi (fig. 1). Because channel degradation and bank sloughing have occurred recently on the lower reaches of Twentymile Creek, the U.S. Geological Survey, in cooperation with the Mississippi State Highway Department, conducted a study of channel and bank stability at the existing U.S. Highway 45 crossing and at the proposed U.S. Highway 45 relocation.

Purpose and Scope

The purpose of this report is to describe the existing channel and bank conditions and present the results of a study to determine the potential for near-future (through the year 2010) degradation and widening for Twentymile Creek at existing U.S. Highway 45 and at the proposed relocation near Wheeler, Mississippi. Past and present channel conditions were determined on the basis of field observations of channel-bed elevations, bank failures, ages and types of trees on the channel banks, and other botanical evidence. The potential for future degradation was estimated using power functions of past channel-bed elevations with time for Twentymile Creek at existing U.S. Highway 45. The potential for future channel widening was estimated using both the potential for future bank failures (based on present channel geometry and the dry-bulk unit weights and shear-strength properties of the bank material) at the proposed relocation and application of power functions of past channel widths with time at existing U.S. Highway 45. This report is the fifth in a series of similiar reports for selected stream crossings in Mississippi.

General Description of Twentymile Creek

Twentymile Creek is located in the Black Belt, East Gulf Coastal Plain physiographic region (Thornbury, 1965). The drainage area of Twentymile Creek at the proposed U.S. Highway 45 relocation is 14.9 mi^2 (square miles), and the length of the channel upstream of the site is about 8.0 mi (miles). Average channel and valley slopes in the vicinity are about 10 and 12 ft/mi (feet per mile), respectively. Although much of Twentymile Creek has been channelized, the reach of the channel in the vicinity of the proposed relocation has not been channelized. Twentymile Creek is crossed by existing U.S. Highway 45 and by a county road about 1,700 ft (feet) and 600 ft, respectively, downstream of the proposed relocation (fig. 1). Twentymile Creek flows into the Tombigbee River 22.1 mi downstream of the proposed relocation (beyond area shown on fig. 1).

The channel of Twentymile Creek in the vicinity of the proposed relocation is composed of a hard, gray chalky sand which extends 4 to 5 ft above the channel bed in both banks. The bed is intermittently overlain with large (1- to 4-ft diameter) limestone boulders; the channel banks average about 18 ft in height.

Channel Modifications to Twentymile Creek

About 1912, the Prentiss County Twenty Mile Drainage District excavated a ditch about 5 mi long, which approximately followed the natural drainage channel of Twentymile Creek from the Prentiss-Lee County line (in the vicinity of State Highway 370) to the vicinity of State Highway 362 (fig. 1), (Mississippi Board of Development, 1940b). At about the same time, the Lee County Twenty Mile Drainage District excavated a ditch about 7.4 mi long, from the Prentiss-Lee County line to the Lee-Itawamba County line (Ramser, 1930), and the Itawamba County Twenty Mile Drainage District channelized the reach of Twentymile Creek from the Lee-Itawamba County line to the mouth (Mississippi Board of Development, 1940a). This downstream reach was channelized again in 1966 by the U.S. Army Corps of Engineers.

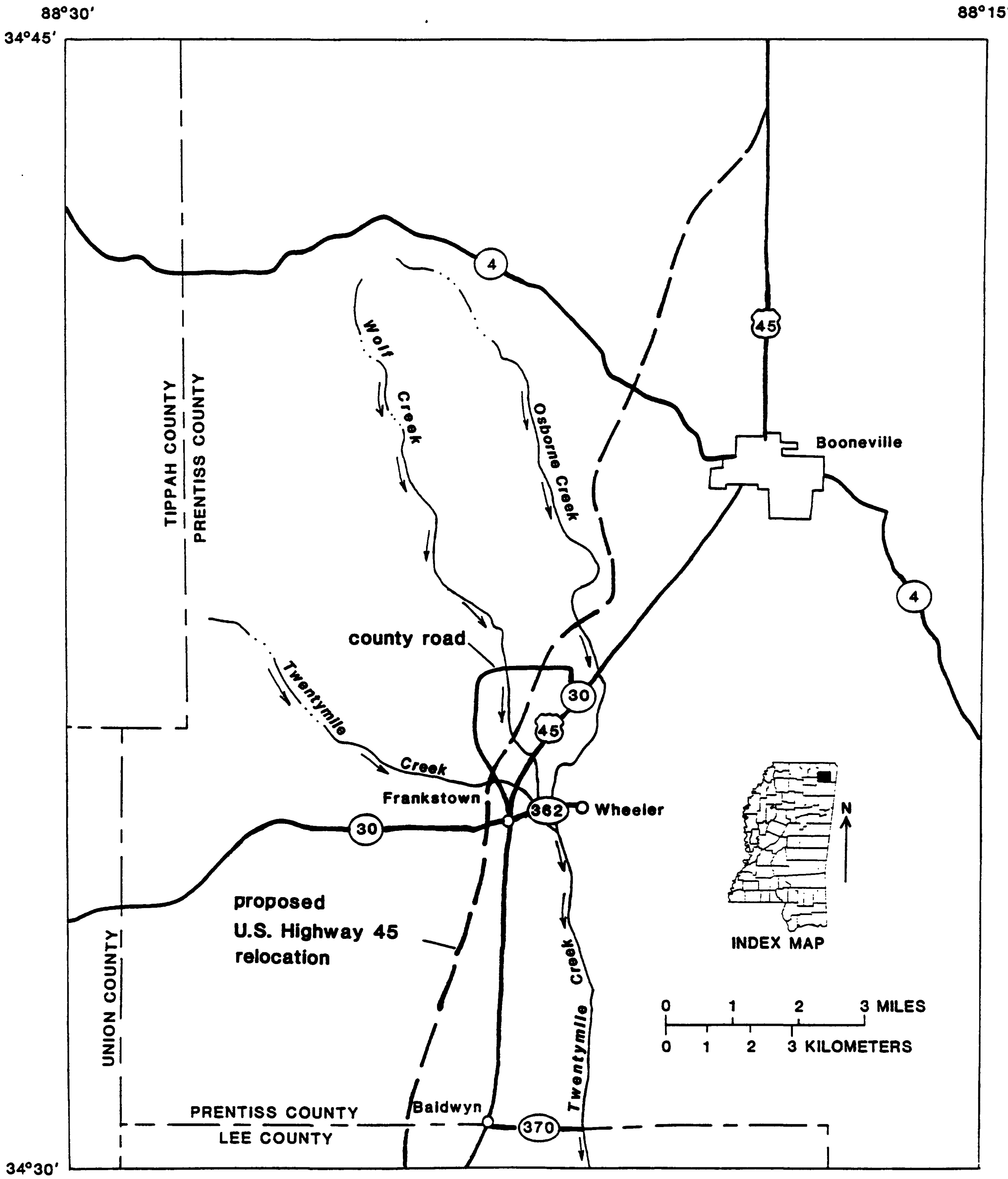

Figure 1.--Location of Twentymile Creek at existing U.S. Highway 45 and proposed U.S. Highway 45 relocation near Wheeler, Mississippi.

A bank-stabilization project was begun by the U.S. Army Corps of Engineers in 1981 to prevent further bank caving and erosion that began shortly after the 1966 channel-modification project was completed in the lower reaches of Twentymile Creek (U.S. Army Corps of Engineers, 1983). Two grade-control structures were installed 11.7 and 19.9 mi upstream from the mouth of Twentymile Creek in 1982. In 1983, grade-control structures were also installed at State Highway 370 (about 5.9 mi downstream from the proposed relocation) and at State Highway 362 (4,200 ft downstream from the proposed relocation). In 1984, grade-control structures were installed at existing U.S. Highway 45 (1,700 ft downstream from the proposed relocation) and at the county road crossing 600 ft downstream from the proposed relocation (D.C. Otto, U.S. Army Corps of Engineers, oral commun., 1988). Willows and reed grass were planted to provide protection along erodible banks in selected areas along Twentymile Creek (U.S. Army Corps of Engineers, 1983). A project to study the effects of the grade-control structures is currently being conducted by the Waterways Experiment Station in Vicksburg, Mississippi (D.C. Otto, U.S. Army Corps of Engineers, oral commun., 1988).

Acknowledgments

The authors are indebted to members of the Mississippi State Highway Department, Hydraulics Division, who provided bridge-inspection records and to members of the Department's Soil Mechanics Laboratory, who assisted in the analysis of soil samples. The authors also acknowledge personnel of the U.S. Army Corps of Engineers who provided channel cross sections and profiles.

CHANNEL-BED STABILITY

Botanical Evidence of Gradation

Trees growing below tops of banks can indicate rates of channel gradation. Trees establish a root collar at the ground surface during germination (Simon and Hupp, 1986a). The thickness of sediment burial or the depth of exhumation relative to the root collar define the degree of aggradation or degradation, respectively. From USGS data files, personnel of the U.S. Geological Survey and the Mississippi State Highway Department determined that by 1979 about 5 ft of degradation had occurred at State Highway 362 (probably by observing exhumation from the root collar of trees growing below bankfull level) and that degradation had nearly ended at State Highway 370 (probably by observing the hard, gray, chalky sand composing the channel bed at the site). In 1983, the U.S. Army Corps of Engineers documented bed degradation in the lower reaches of Twentymile Creek, but in the vicinity of the proposed relocation the hard, compacted nature of the material indicates a stable channel bed.

Gradation Analyses

Channel-gradation processes on an alluvial stream undergoing morphologic change in response to channel modifications generally start at a high rate and diminish with time. Studies of channel-gradation processes on alluvial streams have shown that channel-bed elevation can be expressed as a power function with time (Simon and Hupp, 1986b) in the general form:

$$E = a \cdot t^b \qquad (1)$$

where

- E = elevation of the channel bed, in feet above sea level;
- a = regression constant, indicative of channel-bed elevation prior to the onset of the gradation process in response to channel modification, in feet above sea level;
- t = time, in years since beginning of the gradation process (t = 1 during the first year of channel adjustment); and
- b = regression coefficient indicative of the rate of the gradation process (negative for degradation and positive for aggradation).

Datums other than sea level for channel-bed elevations (E) in equation 1 may be used for convenience (for example, when sea level datum is not readily available at a site), but this will affect values of **a** and **b**. If elevations above the assumed datum are greater than the elevations obtained when referenced to sea level datum, the value of **a** will increase, but the absolute value of **b** will decrease. Conversely, if elevations above the assumed datum are less than the elevations obtained when referenced to sea level datum, the value of **a** will decrease, but the absolute value of **b** will increase. Also, by varying the datum, an imposed logarithmic offset for the log-linear relation will change, thus, in some cases, improving or worsening the log-linear statistical fit of the data points. In previous studies, the effects of channel-bed elevations on gradation trends were analyzed by varying the datum of the study sites; the analysis indicated no significant effects on the gradation estimates (Andrew Simon, U.S. Geological Survey, oral commun., 1988). Elevations in the analyses in this report were referenced to Mississippi State Highway Department Datum, which is to sea level datum.

It is assumed that the general form of equation 1 is applicable for estimating channel-bed degradation in the near future (to the year 2010) on Twentymile Creek. Channel-bed gradation processes in the past are assumed to be representative of those in the near future. This assumption could be negated by additional channel modifications or the occurence of unusually large, destructive flooding, which could alter the ongoing gradation processes.

The channel-bed elevations used in these analyses were obtained from surveys and inspections made by the Mississippi State Highway Department, the U.S. Army Corps of Engineers, the U.S. Department of Agriculture, and the U.S. Geological Survey (table 1). Some minor differences in channel-bed elevations may not be absolutely indicative of actual change. The channel-bed elevations used to analyze gradation were obtained in the vicinity of the proposed relocation and at the existing U.S. Highway 45 bridge; no significant evidence of localized scour was observed. Localized scour at a bridge occurs when flow velocities are increased for a short distance upstream

Table 1.--*Channel-bed elevation and total degradation on Twentymile Creek at existing U.S. Highway 45 near Wheeler, Mississippi*

Year	Channel-bed elevation (feet above Mississippi State Highway Department Datum)	Total degradation since 1936[a] (feet)
1936	338.3	0
1938	330.4	7.9
1954	330.1	8.2
1962	332.7	5.6
1975	334.9	3.4
1980	333.8	4.5
1988	330.3	8.0

[a] Appears to be more representative of what has occurred since about 1912.

and downstream from the bridge. Increased velocities are caused by the cross-sectional area being reduced substantially by bridge-approach embankments, piers, and other obstructions. However, localized scour holes exist immediately downstream from the grade-control structures at existing U.S. Highway 45 (1,700 ft downstream from the proposed relocation) and at the county road crossing 600 ft downstream from the proposed relocation. The scour holes are the result of increased flow velocities produced by the increase in channel gradient through the structures. The scour holes have no significant effect on channel-bed elevations given in table 1 because all of the elevations were obtained prior to the construction of the structures, except the 1988 elevation which was surveyed just upstream from the bridge. The effect of localized scour would be an addition or a subtraction to the ongoing degradation or aggradation processes, respectively, and, therefore, would not be representative of the selected reach of channel studied.

Channel gradation processes on Twentymile Creek at existing U.S. Highway 45 appear to be representative of processes about 1,700 ft upstream at the proposed relocation. At the county road crossing (600 ft downstream from the proposed relocation) channel-bed elevation data were limited to elevations of 333.7, 334.2, and 334.5 ft, obtained in 1968, 1980, and 1988, respectively. These elevations indicated that the channel bed has not degraded during the 21-year period – 1968-88. This agreed with field observations and information from local residents and also the 1938, 1954, and 1988 elevations at existing U.S. Highway 45 (table 1).

Available data from 1936 to 1988 indicate channel-bed degradation totaling about 8 ft on Twentymile Creek at existing U.S. Highway 45 (table 1). However, the difference in the 1936 and 1938 elevations indicates about 8 ft of degradation. The 8 ft of degradation occurring over such a short period of time is unlikely and this difference appears to be more representative of what occurred between 1912 and 1938. Significant variation in the data motivated the use of two possible scenarios to project near-future degradation on Twentymile Creek. The first scenario omitted any aggradation that may have occurred. The minimum channel-bed elevations in 1938, 1954, and 1988 (table 1) were virtually constant during the 51-year period because the channel bed is composed of hard, gray chalky sand, which has prevented further degradation. This scenario projects no further degradation through the year 2010 (fig. 2).

The second scenario was based on the assumption that the March 1955 flood and the May 1983 flood altered the degradation process that began in about 1912 and exposed the hard stratum (present channel bed) at least by 1938. These floods were both known to have been about a 20-year recurrence interval on Twentymile Creek. Therefore, Twentymile Creek underwent degradation from about 1912 to 1938 (when the hard stratum prevented further degradation), aggradation from 1955 to 1983, and degradation from 1983 to 1988. The 1938, 1954, and 1988 elevations were averaged to define the top of the hard stratum. Log-linear regression of channel-bed elevation with time was used to define channel gradation relations from 1955 to 1983 ($E_a = 330.3\ t_a^{+0.00380}$, where t_a is time, in years since 1955) and from 1983 to 1988 ($E_d = 334.6\ t_d^{-0.00722}$, where t_d is time, in years since 1983).

The second scenario projected about 3½ ft of further degradation through the year 2010 (fig. 2). However, the aggraded channel-bed material probably was mostly sand, and the material below the existing channel bed is mostly hard, gray chalky sand, which has prevented further degradation at this site. Therefore, 3½ ft of further degradation by the year 2010 is unlikely.

In summary, the channel bed of Twentymile Creek at existing U.S. Highway 45 has degraded about 8 ft since about 1912. Channel-bed gradation processes at existing U.S. Highway 45 appear to be representative of processes at the proposed relocation. The hard, compacted nature of

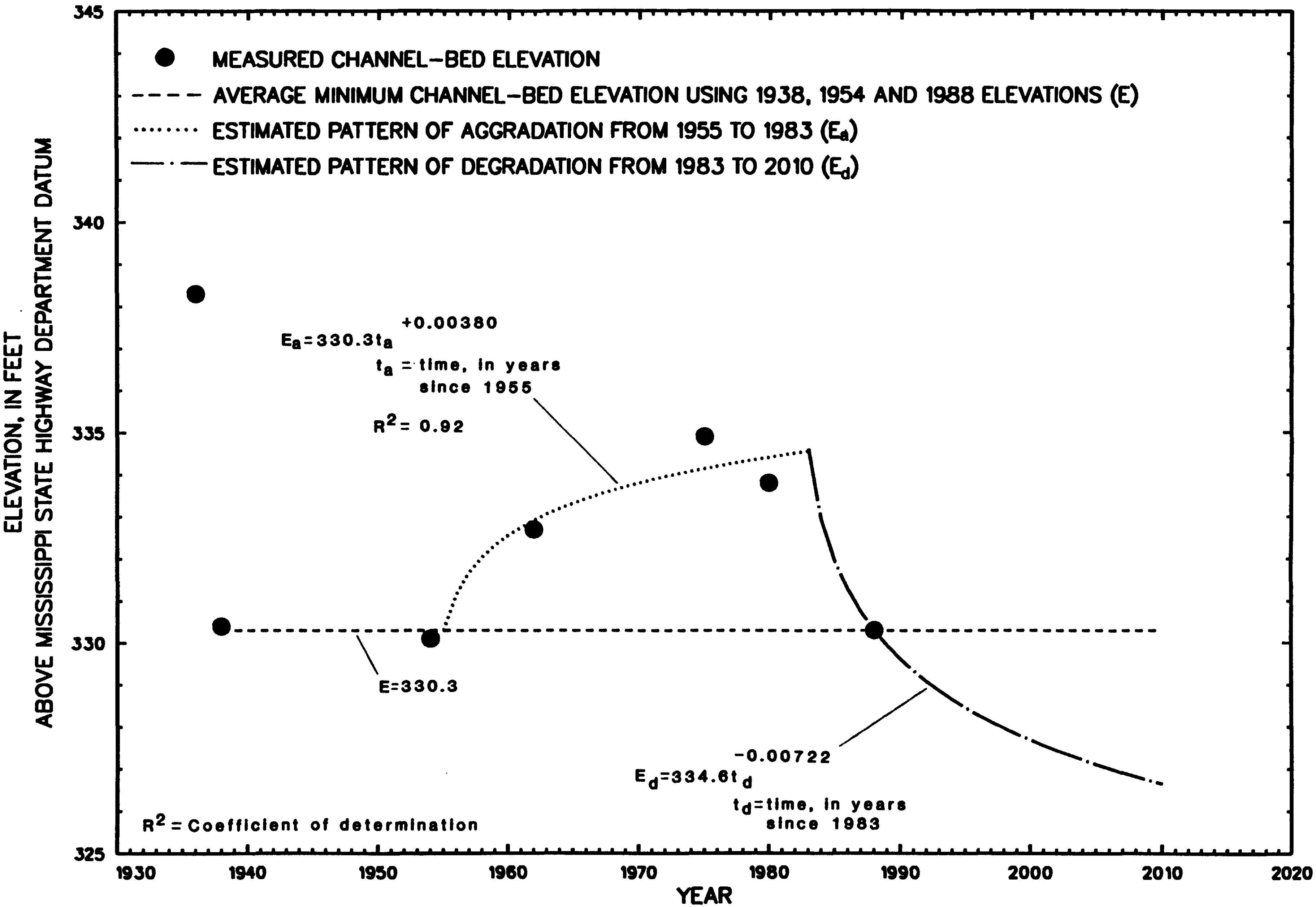

Figure 2.--Estimated patterns of channel-bed gradation processes on Twentymile Creek at existing U.S. Highway 45 near Wheeler, Mississippi.

the soils composing the existing channel bed of Twentymile Creek at both existing U.S. Highway 45 and at the proposed relocation, in combination with grade-control structures that have been installed, indicate no further degradation through the year 2010 could reasonably be expected.

CHANNEL-BANK STABILITY

Botanical Evidence of Widening

Bank failures along unstable reaches may kill, tilt, or scar existing woody plants, and create fresh surfaces upon which plants may become established. Scars and sprouts from parental stems of tilted plants yield accurate dates (within 1 year, often within one season) of bank failures (Hupp, 1987, 1988; Sigafoos, 1964).

Eccentric growth, resulting in anomalous tree-ring series, occurs when the stem is inclined. This type of growth is determined easily from tree cross sections where concentric-ring formation abruptly shifts to the eccentric because ring width is greater in the upslope direction. Eccentric-ring patterns yield highly accurate dates, usually accurate within one season, of tilting. Dating of stems that have established on disturbed surfaces yields minimum ages for the surfaces (Simon and Hupp, 1986a).

Trees growing on bank surfaces along Twentymile Creek in the vicinity of the proposed relocation show some effects of recent bank sloughing in their stem morphology, anatomy, and ages. Botanical data were collected by taking cross sections or increment borings of sprouts from tilted trees and of saplings and mature trees (such as cottonwood, sweet gum, pecan, and willow) to determine their ages and by measuring bank failure-block widths. The ages of mature trees on the channel banks at the proposed relocation were not determined, but some were estimated (based on size) to be about 50 to 75 years old, which is a good indication of stable banks; however, evidence of upper-bank failure on the right (south) bank and mid-bank undercutting on the left (north) bank was observed. Although both banks appear stabilized by existing mature hardwood trees, the sandy composition of the banks indicates that an unstable condition could occur with the cutting and removal of trees. It should be noted that botanical evidence of previous bank failures may have been obscured with time and (or) by succeeding large floods (Simon and Hupp, 1986a).

Stability Analyses

Shear-strength properties of the channel banks were determined on the left (north) bank of Twentymile Creek at the proposed U.S. Highway 45 relocation with the Iowa Borehole Shear Tester[1] (BST) (Handy and Fox, 1967). Dry bulk-unit weight and shear-strength properties of soil obtained at the site are given in table 2. The average moisture content of the soil during testing was about 24 percent.

Shear-strength data obtained using the BST have compared reasonably well with the results of other standard laboratory procedures for the determination of soil strength (Thorne and others, 1981; Wilson and Turnipseed, 1989a). BST results for individual soil strata (except for cohesion of the gray chalky sand) were used in stability analyses. Soil cohesion measured in the field for the gray chalky sand that forms the channel bed of Twentymile Creek in the vicinity of the proposed relocation was zero (table 2). An assumed cohesion of 200 lb/ft^2 (pounds per square foot) was used for the bank-stability analysis (Mississippi State Highway Department Soils Laboratory, oral commun., 1988).

The factor of safety is the ratio of the resisting force (shear-strength of the bank material) to the driving force (weight of the bank material). Therefore, if the resisting force is equal to the driving force then the factor of safety is 1.0. Theoretically, when the factor of safety is less than 1.0, failure

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[1]The use of trade or product names in this report is for identification purposes only, and does not constitute endorsement by the U.S. Geological Survey.

Table 2.--Dry bulk-unit weight and shear-strength properties of soil as determined from borehole tests on the left (north) bank at the proposed U.S. Highway 45 relocation near Wheeler, Mississippi
[ft, feet, lb/ft^2, pounds per square foot, lb/ft^3, pounds per cubic foot]

General soil description	Bore hole depth (ft)	Dry bulk-unit weight (lb/ft^3)	Cohesion (lb/ft^2)	Angle of internal friction (degrees)
Orange-brown silty-sandy clay	0-4.5	94	160	33.1
Orange-brown silty sand	4.5-6.7	102	60	34.1
Light brown sand	6.7-8.0	89	0	32.6
Light brown sand	8.0-11.8	89	0	24.4
Gray chalky sand	11.8-14.1	91	[a]0	26.2

[a] Cohesion of 200 lb/ft^3 was used in the stability analyses.

occurs, when it is greater than 1.0, failure does not occur. This is based on the assumption that all forces have been considered. A factor of safety of at least 1.5 generally is used in design. Factors of safety for bank failures at selected percentages of bank saturation were determined by using the dry bulk-unit weight and shear-strength properties of the bank material at typical cross sections about 300 and 750 ft downstream from the proposed relocation. Computer programs REAME (Rotational Equilibrium Analysis of Multilayered Embankments) and SWASE (Sliding Wedge Analysis of Sidehill Embankments) developed by Huang (1983) were used to perform an iterative search to determine the minimum factor of safety for each percentage of bank saturation analyzed.

Analysis of both planar and rotational bank failures indicated rotational bank failures were more critical. Factors of safety for rotational bank failures ranged from 0.74 to 2.26 at all percentages of saturation tested (table 3). The left (north) bank fails (factor of safety less than 1.0) between 75- and 100-percent bank saturation. The critical rotational-failure surfaces with respective factors of safety for 100-percent bank-saturation conditions for the cross section located 300 ft downstream from the proposed relocation are shown in figure 3. On the right (south) bank, the failure-block width is about 6 ft and on the left (north) bank, failure-block width is about 3 ft. Similar and somewhat wider failure-block widths were observed downstream of the county road crossing near the proposed relocation; however, in the vicinity of the proposed relocation, both banks are presently covered by mature trees (50 to 75 years old) that provide reinforcement to the bank material. The tree-root reinforcement of the channel banks was not accounted for in the analyses, and, therefore, the computed factors of safety probably are lower than the actual values.

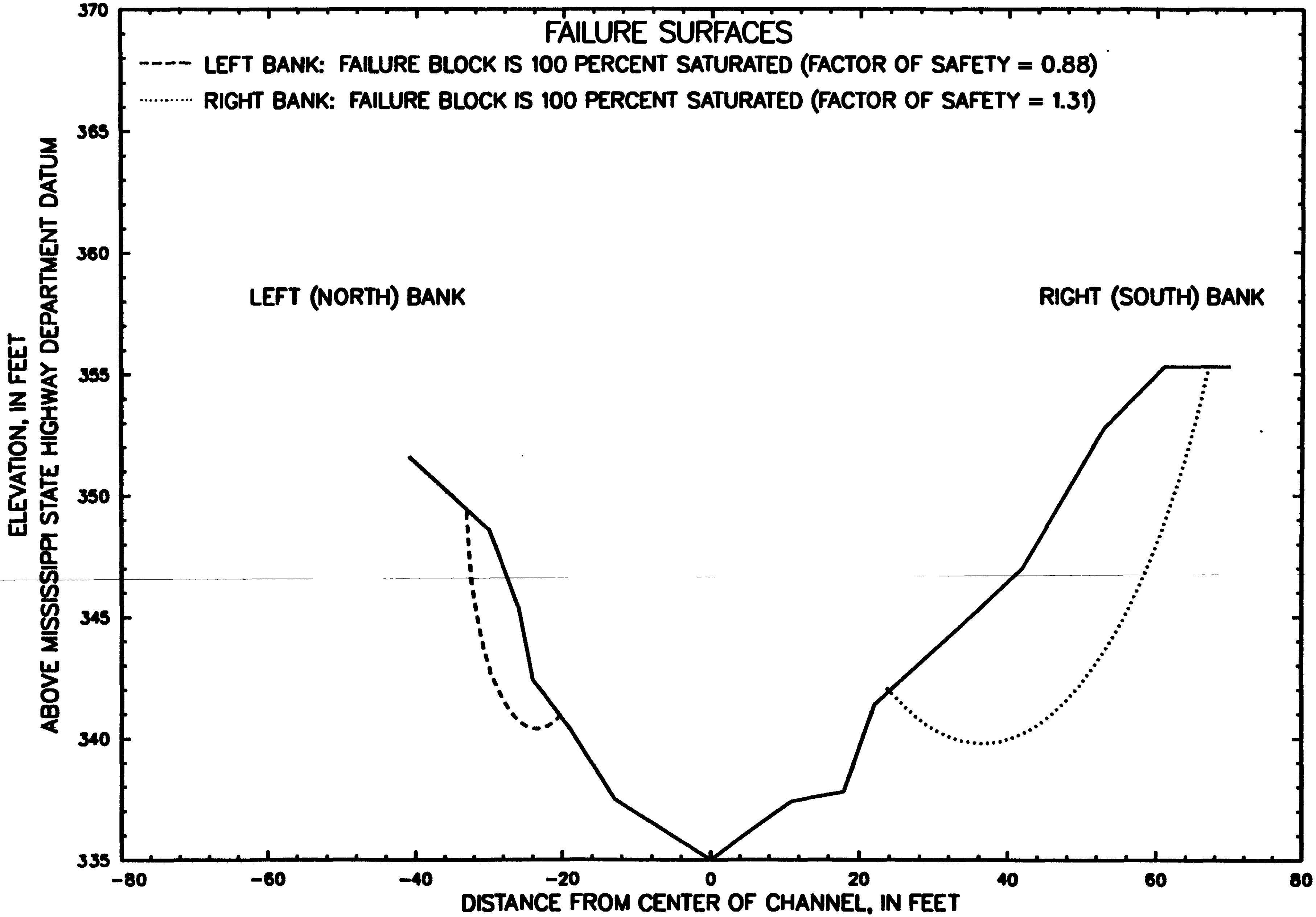

Figure 3.--Cross section showing critical failure surfaces for channel banks on Twentymile Creek 300 feet downstream from the proposed U.S. Highway 45 relocation near Wheeler, Mississippi.

Table 3.--*Factors of safety for rotational bank failures on Twentymile Creek in the vicinity of the proposed U.S. Highway 45 relocation near Wheeler, Mississippi*

Amount of failure block saturated (percent)	Factors of safety Left bank	Factors of safety Right bank	Distance downstream from proposed alignment (feet)
0	1.71	2.12	750
25	1.55	1.91	
50	1.43	1.73	
75	1.25	1.52	
100	0.74	1.28	
0	1.53	2.26	300
25	1.37	2.02	
50	1.20	1.80	
75	1.04	1.55	
100	0.88	1.31	

Widening Analyses

Channel-widening processes on an alluvial stream undergoing morphologic change in response to channel modifications generally start at a high rate and diminish with time. Channel-bed degradation increases bank heights and angles and causes channel widening by mass wasting. Depending on the soil properties of the bank material, some time generally elapses between the beginning of degradation and the beginning of widening. In this report, the time interval is assumed to be negligible because of insufficient data to support any other assumption. Enough channel-width information was available at the existing U.S. Highway 45 crossing of Twentymile Creek to develop power functions of bankfull channel width with time, a technique used by Wilson and Turnipseed (1989b), in the general form:

$$W = c \cdot t^{d} \qquad (2)$$

where

W = bankfull channel width, in feet;

c = regression constant indicative of bankfull channel width prior to the onset of widening processes in response to channel modification, in feet;

t = time, in years since beginning of the widening process ($t = 1$ during the first year of channel adjustment); and

d = regression coefficient indicative of the rate of widening.

Channel-widening processes in the past are assumed to be representative of those in the near future. This assumption could be negated by additional channel modifications or the occurence of unusually large, destructive flooding that could alter ongoing widening processes.

As with channel-bed elevations, the channel widths used in equation 2 were obtained from surveys and inspections made by the Mississippi State Highway Department, the U.S. Army Corps of Engineers, the U.S. Department of Agriculture, and the U.S. Geological Survey (table 4). Some changes in width may not be absolutely indicative of actual change. The bankfull widths were derived from surveys made by different agencies and may not reflect exactly the same location(s). Thus, there are inherent uncertainties in the interpretation of these data.

Table 4.--*Bankfull channel width and total widening on Twentymile Creek in the vicinity of existing U.S. Highway 45 near Wheeler, Mississippi*

Year	Bankfull width (feet)	Total widening since 1912 (feet)
1912	[a]25	0
1936	66	41
1938	60	35
1954	81	56
1975	81	56
1980	85	60
1988	98	73

[a] Design width downstream of site (Ramser, 1930)

Channel-widening processes at existing U.S. Highway 45 do not appear to be representative of processes 1,700 ft upstream at the proposed relocation because of the tree-root reinforcement of the channel banks at the relocation. However, in 1988, the channel at existing U.S. Highway 45 was only about 7 ft wider than at the proposed relocation.

Available channel width data from 1936 to 1988 indicate that the Twentymile Creek channel widened about 32 ft at existing U.S. Highway 45 (table 4). Assuming an initial width of 25 ft [1912 channel-design width for Twentymile Creek downstream of the site (Ramser, 1930)] the channel has widened about 73 ft during the 77-year period. Two possible scenarios were analyzed for this site using the channel-width data to project near-future widening. For the first scenario, a log-linear regression of all available channel widths with respective times was used to define a channel-widening relation ($W = 24.7\ t^{+0.299}$, where t is time, in years since 1912). The first scenario projected no further widening by the year 2010 at existing U.S. Highway 45.

The second scenario was based on the assumption that the March 1955 flood and the May 1983 flood altered the ongoing widening process that began in 1912. Channel-width data (table 4) indicated no significant widening from 1954 to 1980 probably because the possible aggradation period negatively affected the channel-widening on Twentymile Creek. Therefore, Twentymile Creek underwent widening from 1912 to 1955, no widening from 1955 to 1983, and widening from 1983 to 1988. Log-linear regression of channel width with time was used to define a channel-widening relation from 1912 to 1955 ($W_1 = 24.8t^{+0.299}$, where t_1 is time, in years since 1912) and from 1983 to 1988 ($W_3 = 82.0t_3{}^{+0.0995}$, where t_3 is time, in years since 1983). The 1954, 1975, and 1980 channel widths were averaged to define the width ($W_2 = 82$ ft) from 1955 to 1983. The second scenario projected about 15 ft of further widening by the year 2010 at existing U.S. Highway 45 (fig. 4).

Estimates of near-future (10 to 20 years) widening can also be obtained by projecting the streambank slough-line angle on a plotted cross section (Simon and Hupp,

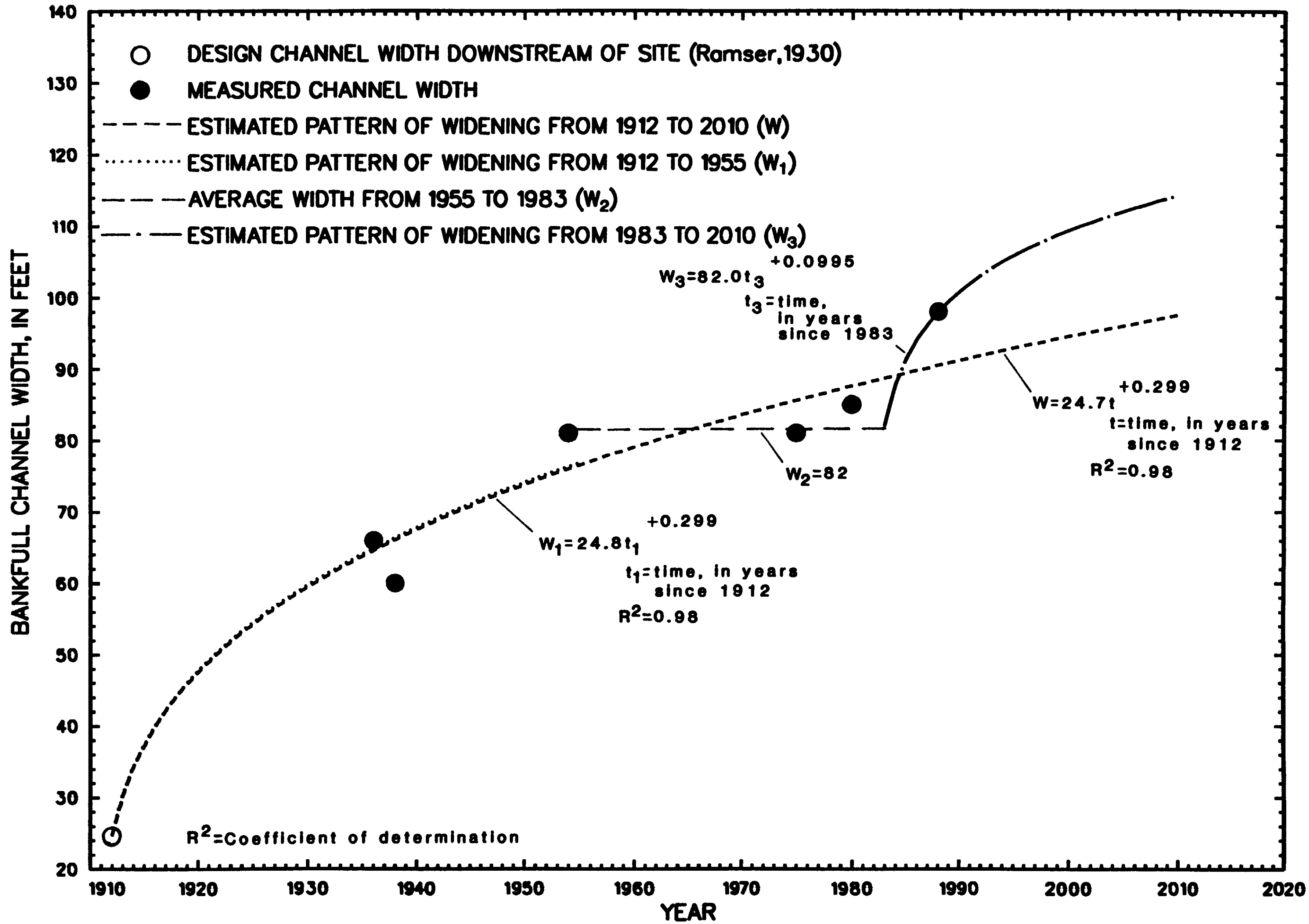

Figure 4.--Estimated patterns of channel widening on Twentymile Creek at existing U.S. Highway 45 near Wheeler, Mississippi.

1986b). Projection of this slough-line angle on the banks was used where conditions were stable and vegetation was well established. On banks where a slough line had not developed, a temporary angle of stability was estimated by averaging the angle of internal friction of the bank material and the existing bank angle, a technique developed by Spangler and Handy (1973). There were no defined slough lines at the channel cross section just upstream of existing U.S. Highway 45, and by extending the temporary angle of stability, no significant additional widening was projected, which agreed with the first scenario. At the proposed relocation, about 15 to 20 ft of additional widening was projected; however, both banks are reinforced by the root systems of mature hardwood trees, which would decrease the amount of additional widening. The sandy composition of the banks indicates an unstable condition could occur with the cutting and removal of trees; therefore, channel width could increase about 20 ft in the next 10 to 20 years.

In summary, the channel at existing U.S. Highway 45 has widened about 73 ft since 1912. Channel-widening processes at existing U.S. Highway 45 do not appear to be representative of processes at the proposed relocation because of tree-root reinforcement of the channel banks at the relocation. At existing U.S. Highway 45, channel width could increase about 15 ft through the year 2010, and, at the proposed relocation, could increase about 20 ft in the next 10 to 20 years with the cutting and removal of trees from the sandy banks.

SUMMARY

The channel of Twentymile Creek at the existing U.S. Highway 45 near Wheeler, Mississippi, has degraded about 8 ft and widened about 73 ft since about 1912; however, at the proposed U.S. Highway 45 relocation, no recent (at least since 1968) degradation or widening is evident. The hard, compacted soils of the channel bed in the vicinity of existing U.S. Highway 45 and proposed U.S. Highway 45 relocation, in combination with grade-control structures that have been installed, indicate no further degradation through the year 2010 is likely. In the vicinity of existing U.S. Highway 45, channel width could increase about 15 ft through the year 2010. In the vicinity of the proposed relocation, both banks are reinforced by existing mature hardwood trees. If these trees are cut and removed, the sandy banks could become unstable and channel width could increase about 20 ft in the next 10 to 20 years. These projections are based on the assumption that no additional channel modifications and no unusually large and destructive flooding will occur by the year 2010.

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