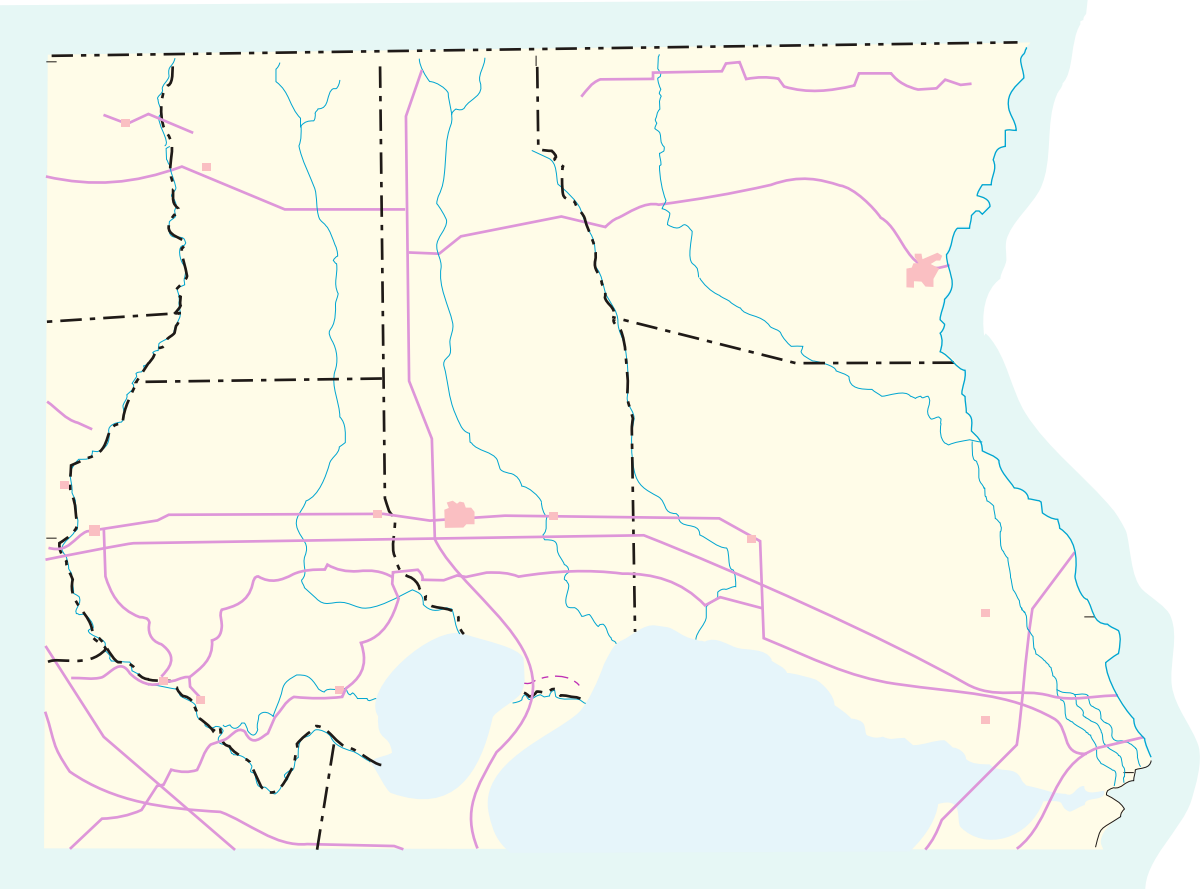
Estimation of Scour and Channel Stability for Selected Highway Crossings of Rivers in the Florida Parishes, Southeastern Louisiana

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
Water Resources Technical Report No. 67B



STATE OF LOUISIANA
DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
PUBLIC WORKS AND FLOOD CONTROL DIRECTORATE
WATER RESOURCES SECTION
in cooperation with the
U.S. GEOLOGICAL SURVEY

1999

STATE OF LOUISIANA

DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

PUBLIC WORKS AND FLOOD CONTROL DIRECTORATE

WATER RESOURCES SECTION

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WATER RESOURCES

TECHNICAL REPORT NO. 67B

Estimation of Scour and Channel Stability for Selected Highway Crossings of Rivers in the Florida Parishes, Southeastern Louisiana

By

J. Josh Gilbert and Paul A. Ensminger

U.S. GEOLOGICAL SURVEY

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CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
foot (ft)	0.3048	meter
foot per second (ft/s)	0.3048	meter per second
foot per mile (ft/mi)	0.1894	meter per kilometer
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
inch per year (in/yr)	25.4	millimeters per year
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer

Sea level: In this report “sea level” refers to the National Geodetic Vertical Datum of 1929--a geodetic 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.

Estimation of Scour and Channel Stability for Selected Highway Crossings of Rivers in the Florida Parishes, Southeastern Louisiana

By J. Josh Gilbert *and* Paul A. Ensminger

ABSTRACT

Maximum pier scour and contraction scour estimates for 22 bridge crossings in Louisiana were estimated using methodologies outlined by the Federal Highway Administration and information in U.S. Geological Survey and Louisiana Department of Transportation and Development (DOTD) files. The selected highway crossings were located over the Amite, Tickfaw, Tangipahoa, Tchefuncte, Bogue Chitto, and Pearl (including distributaries) Rivers.

Of the selected sites along the Amite River, the maximum pier scour of 31 feet was at the Interstate Highway 12 crossing. The Interstate Highway 12 crossings of the Tickfaw, Tangipahoa, and Tchefuncte Rivers had maximum pier scour estimates that ranged from 8 to 28 feet. Louisiana Highway 438 crossing of the Bogue Chitto River had a maximum pier scour of 6 feet. At the Interstate Highway 59 crossings of the Pearl and West Pearl Rivers, the maximum pier scour was approximately 12 feet at both bridges.

At the Interstate Highway 10 crossings of the Pearl, Middle, and West Pearl Rivers, the maximum pier scour ranged from 4 to 35 feet. The Middle Pearl River crossing had contraction scour estimates that were more than five times the magnitude of the pier scour estimates at that site.

The U.S. Highway 90 crossings of the Pearl, East Middle, Middle, West Middle, and West Pearl Rivers had pier scour estimates that ranged from 12 to 33 feet. The higher values are associated with the sites on the east side of the floodplain.

When available, pile tip elevations from DOTD bridge plans are shown with historic and estimated riverbed elevations. The maximum scour estimates exceeded the design pile tip elevation of individual piers at 8 sites.

The periodic hydrographic surveys performed by DOTD provided the basis for evaluating the observed channel stability. The Amite River bridges show no major changes of the channel bottom; however, the Pearl River bridges show major decreases in channel-bed elevations.

INTRODUCTION

The design, construction, and maintenance of highway crossings over rivers and floodplains require a balance of design variables such as bridge and embankment lengths, pier spacing, and pile penetration. The Federal Highway Administration requires that all state highway agencies evaluate bridges in the Federal aid system for scour susceptibility. The U.S. Geological Survey (USGS), in cooperation with the Louisiana Department of Transportation and Development (DOTD), began a study in 1992 to evaluate scour potential and channel stability of selected bridges that cross the Amite, Tickfaw, Tangipahoa, Tchefuncte, Bogue Chitto, and Pearl (including distributaries) Rivers. This study supplements bridge design information with an evaluation of scour potential at 22 selected sites.

Purpose and Scope

This report describes potential scour and channel stability at 22 bridges that cross rivers in East Feliciana, East Baton Rouge, St. Helena, Livingston, Ascension, Tangipahoa, Washington, and St. Tammany Parishes in southeastern Louisiana. Associated hydrologic data are presented. Maximum scour estimates were computed using methods outlined by the Federal Highway Administration. General hydrologic, hydraulic, hydrographic, and bathymetric information for these evaluations was obtained from DOTD, U.S. Army Corps of Engineers (USACE), and from streamflow-gaging station records of the USGS. The 500-year design discharge (Q_{500}) was estimated from streamflow-gaging station records at the site, streamflow-gaging station records transferred to the site, or by a region-of-influence regression model. Contraction scour was estimated for the main channel and overbank areas of the bridge openings. The scour estimated in these areas was added to the scour predicted at the pier locations. The bridge, pier, and pile geometries examined in this report were derived from DOTD bridge plans.

Approach

General hydrologic, topographic, and hydrographic information was assembled from available information in USGS, USACE, or DOTD files. The Q_{500} was determined from statistical analysis of existing streamflow-gaging station records of the stream evaluated, where available. At locations where streamflow data were not available, the Q_{500} estimate from the nearest location on the stream or a region-of-influence regression model (Ensminger, 1998) was used. The distribution of flow within the bridge openings was computed using the one dimensional Water Surface Profile (WSPRO) flow model (Shearman and others, 1986). For all sites in the lower Pearl River Basin, results of previous two-dimensional (2-D) models of the two largest floods of record were used to determine the distribution of flow among multiple openings (Gilbert and Froehlich, 1987).

Estimates of local and contraction scour were based on Federal Highway Administration guidelines presented in Hydraulic Engineering Circulars (HEC) 18 (Richardson and others, 1995) and 20 (Lagasse and others, 1991). In estimation of contraction scour, the average depth in the section or subsection was used. The scour estimate computed from the average depth was applied to the actual depths at pier and abutment locations for determination of the cumulative scour depth. Results of the analysis are presented in tabular format and in a graphical format which is superimposed on the bridge plan information from DOTD. When "left" or "right" bank is used, it refers to the direction as viewed when looking downstream.

At all sites along the Amite River, Q_{500} estimates were compared to Q_{500} estimates developed by the USACE in studies for the Federal Emergency Management Agency (FEMA) (1993) to verify consistency with previous evaluations. At sites on the mainstem of the Amite River, downstream of the diversion canal, values of discharge computed by USACE were used.

Acknowledgments

The assistance of Jack C. Manno, Hydraulics Engineer Administrator, and Fred Cifreo, Hydraulics Engineer Supervisor, of the Louisiana Department of Transportation and Development, and Charles E. Shadie, Hydraulic Engineer, of the U.S. Army Corps of Engineers, New Orleans District, in providing hydrographic survey information on the rivers is gratefully acknowledged.

EVALUATION OF SELECTED HIGHWAY CROSSINGS OF RIVERS

The Florida Parishes in southeastern Louisiana include parts of two surface-water basins: the East Mississippi River Delta Basin, which includes the Amite River and its tributaries and the Tickfaw, Tangipahoa, and Tchefuncte Rivers; and the Pearl River Basin, which includes the Bogue Chitto, Pearl, West Pearl, East Middle, Middle, and West Middle Rivers. The major roadways that cross these rivers include seven State highways (432, 10, 64, 42, 16, 22, and 438), two U.S. highways (190 and 90), and three Interstate highways (12, 59, and 10). The sites evaluated for scour and channel stability at highway crossings of these rivers are listed in table 1 and shown in figure 1.

Table 1. Sites evaluated for scour and channel stability at selected highway crossings of rivers in the Florida Parishes, southeastern Louisiana

Site number (fig.1)	Site name and location	Site number (fig.1)	Site name and location
	East Mississippi River Delta Basin		**Pearl River Basin**
1	Louisiana Highway 432 crossing of the Amite River near Felixville	12	Louisiana Highway 438 crossing of the Bogue Chitto River near Warnerton
2	Louisiana Highway 10 crossing of the Amite River near Darlington	13	Interstate Highway 59 crossing of the Pearl River near Pearl River
3	Louisiana Highway 64 crossing of the Amite River at Magnolia	14	Interstate Highway 59 crossing of the West Pearl River near Pearl River
4	U.S. Highway 190 crossing of the Amite River near Denham Springs	15	Interstate Highway 10 crossing of the Pearl River near Slidell
5	Interstate Highway 12 crossing of the Amite River near Denham Springs	16	Interstate Highway 10 crossing of the Middle Pearl River near Slidell
6	Louisiana Highway 42 crossing of the Amite River at Port Vincent	17	Interstate Highway 10 crossing of the West Pearl River near Slidell
7	Louisiana Highway 16 crossing of the Amite River near French Settlement	18	U.S. Highway 90 crossing of the Pearl River near Slidell
8	Louisiana Highway 22 crossing of the Amite River at Clio	19	U.S. Highway 90 crossing of the East Middle River near Slidell
9	Interstate Highway 12 crossing of the Tickfaw River near Albany	20	U.S.Highway 90 crossing of the Middle River near Slidell
10	Interstate Highway 12 crossing of the Tangipahoa River near Robert	21	U.S. Highway 90 crossing of the West Middle River near Slidell
11	Interstate Highway 12 crossing of the Tchefuncte River near Covington	22	U.S. Highway 90 crossing of the West Pearl River near Slidell

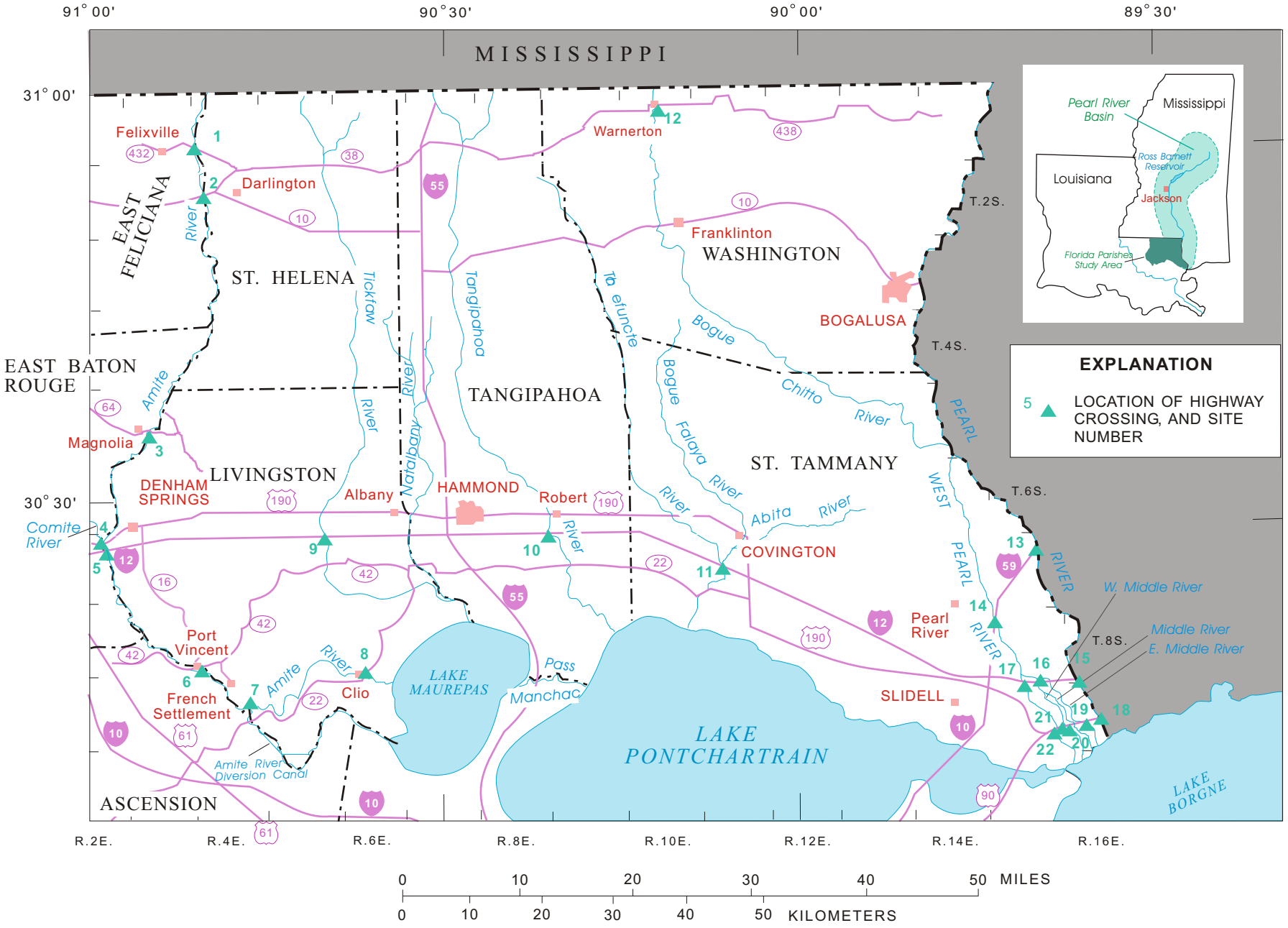


Figure 1. Location of sites evaluated for scour and channel stability at selected highway crossings of rivers in the Florida Parishes, southeastern Louisiana.

East Mississippi River Delta Basin

The Amite River, in the western part of the East Mississippi River Delta Basin, originates in southwestern Mississippi and flows through five parishes (East Feliciana, East Baton Rouge, St. Helena, Livingston, and Ascension) in Louisiana before reaching the mouth of the river at Lake Maurepas (fig. 1). The river is a naturally meandering sand bed stream with a slope that varies from 6 ft/mi in the upland areas to less than 1 ft/mi near the mouth. Water-surface elevations can reflect tidal influence from the receiving water body in the southern parts of the basin. Flood profiles computed by the USACE were supplemented with historic information from USGS files in evaluation of the Q_{500} profile and compared with the USACE estimates to verify agreement with previous studies. Streamflow-gaging stations along the river were evaluated individually to obtain flood statistics. The drainage area at the gaged sites ranged from 580 mi^2 at Darlington to 1,596 mi^2 at Port Vincent. The drainage area of the Amite River at the mouth at Lake Maurepas is 1,819 mi^2. The Q_{500} ranged from 135,900 to 167,300 ft^3/s at the gaged sites above the Amite River diversion canal. The Amite River diversion canal, which diverts flow directly to Lake Maurepas, is located downstream of Port Vincent. At sites near French Settlement and Clio, which are located on the mainstem of the Amite River downstream of the diversion canal, the flow in the river channel was reduced according to the diversion of flow determined by the USACE and the Q_{500} which was 36,200 ft^3/s.

The Lake Pontchartrain-Lake Maurepas basin region of the East Mississippi River Delta Basin in Louisiana is about 70 mi long and 100 mi wide. Lakes Pontchartrain and Maurepas, and the Tickfaw, Tangipahoa, Tchefuncte, and Natalbany Rivers are the principal surface-water bodies in the basin. The slopes of the streams in this area are greater than 10 ft/mi in the northern part, and near 1 ft/mi in the southern part. Water-surface elevations can reflect tidal influences from the receiving water bodies in the southern part of this basin.

Louisiana Highway 432 Crossing of the Amite River near Felixville

The La. Hwy. 432 bridge near Felixville (site 1 in fig. 1) is located approximately 4.6 mi north along the Amite River from La. Hwy. 10 near Darlington (site 2 in fig. 1). The Amite River meanders westward immediately upstream of the bridge and again immediately downstream of the bridge (fig. 2). Flood characteristics near Felixville were established based on information from the gaging station downstream near Darlington, which is located at the La. Hwy. 10 bridge crossing the Amite River and has discharge and stage records dating from 1949. The Q_{500} was determined to be 167,300 ft^3/s using log-Pearson Type III flood frequency estimation analysis as outlined in Bulletin 17B of the Hydrology Subcommittee of the Interagency Advisory Committee on Water Data (USGS, 1982). For the Amite River near Felixville site, the flood estimate (from the site near Darlington) was not adjusted for small reductions in drainage area, resulting in a water-surface elevation of 187.4 ft above sea level at the bridge. The discharge estimates were not adjusted because the difference in drainage area for the gaged and ungaged sites was insignificant compared to the total drainage area. Although the estimates may be biased, they do not indicate scour below the pile tips.

The reach simulated with the WSPRO model for evaluation of the hydraulic conditions at the bridge extends from La. Hwy. 10 to upstream of La. Hwy. 432. The width of the floodplain ranged from approximately 4,860 to 17,000 ft through the modeled reach. The minimum cross-section elevation in the reach modeled was 142.0 ft above sea level. The downstream starting water-surface elevation for hydraulic profile computations, specified immediately upstream of La. Hwy. 10, was 175.1 ft above sea level. The Q_{500} did not overtop the road, and the total flow was apportioned between the main channel opening and a single relief bridge based on the conveyance of each opening.

Photograph source: Louisiana Department of Transportation and Development, June 1992

Figure 2. Aerial photograph of the Louisiana Highway 432 crossing of the Amite River near Felixville.

Pier Scour

The cross section used in this analysis was based on general 1976 data and revised where 1993 data were available (fig. 3). Computed velocities ranged from 5.3 to 17.6 ft/s along the cross section at the bridge (table 2). The greatest pier scour depth estimated was 19.9 ft at DOTD station 117+02.

Table 2. Scour data for Louisiana Highway 432 crossing of the Amite River near Felixville

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 187.4 feet above sea level; K_2, dimensionless correction factor for angle of flow attack; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above sea level)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above sea level)	Pile tip elevation (ft above sea level)
112+52	187.4	Abutment	2.5	1.5	5.6	NA	8.5	179	NA
113+02	174.0	Square	2.5	1.5	5.6	11.1	8.5	154	130
113+52	175.0	Square	2.5	1.5	6.5	11.7	8.5	155	130
114+02	176.0	Square	2.5	1.5	6.5	11.6	8.5	156	130
114+52	177.0	Square	2.5	1.5	5.7	10.8	8.5	158	130
115+02	176.0	Square	2.5	1.5	6.0	11.2	8.5	156	130
115+52	176.0	Square	2.5	1.5	6.0	11.2	8.5	156	130
116+02	175.0	Square	2.5	1.5	6.2	11.4	8.5	155	130
116+52	164.0	Square	2.5	1.5	13.4	17.4	11.0	136	120
117+02	161.0	Square	2.5	1.5	17.6	19.9	11.0	130	120
117+52	164.0	Square	2.5	1.5	16.3	18.9	11.0	134	120
118+02	164.0	Square	2.5	1.5	16.6	19.1	11.0	134	120
118+52	168.0	Square	2.5	1.5	7.7	13.4	9.4	145	130
119+02	172.0	Square	2.5	1.5	7.2	13.0	9.4	150	130
119+52	176.0	Square	2.5	1.5	5.3	10.6	9.4	156	130
120+08	187.4	Abutment	2.5	1.5	5.3	NA	9.4	178	NA

Channel Stability

Elevations at the piers from the limited 1993 cross-section information vary less than 2 feet from the original cross-section information. Although the 1993 information is limited to the main channel area, it documents that the riverbed elevations are not substantially different from the 1976 survey data. The 1976 cross section represents the cross-section geometry when the bridge was constructed.

Contraction and Abutment Scour

Flow through the main channel bridge was subdivided into flow in the main channel, left overbank, and right overbank. The average depth at the bridge is approximately 28 ft for the main channel and 12 ft for the overbanks. For computations of contraction scour in the main channel, the channel is approximately 200 ft in width upstream and approximately 150 ft at the bridge. Contraction scour was computed as 11 ft in the main channel and as approximately 9 ft for the overbanks. In accordance with guidelines presented in HEC 20 (Lagasse and others, 1991), no computations for abutment scour were made due to the presence of spur dikes which prevent scouring at the abutments.

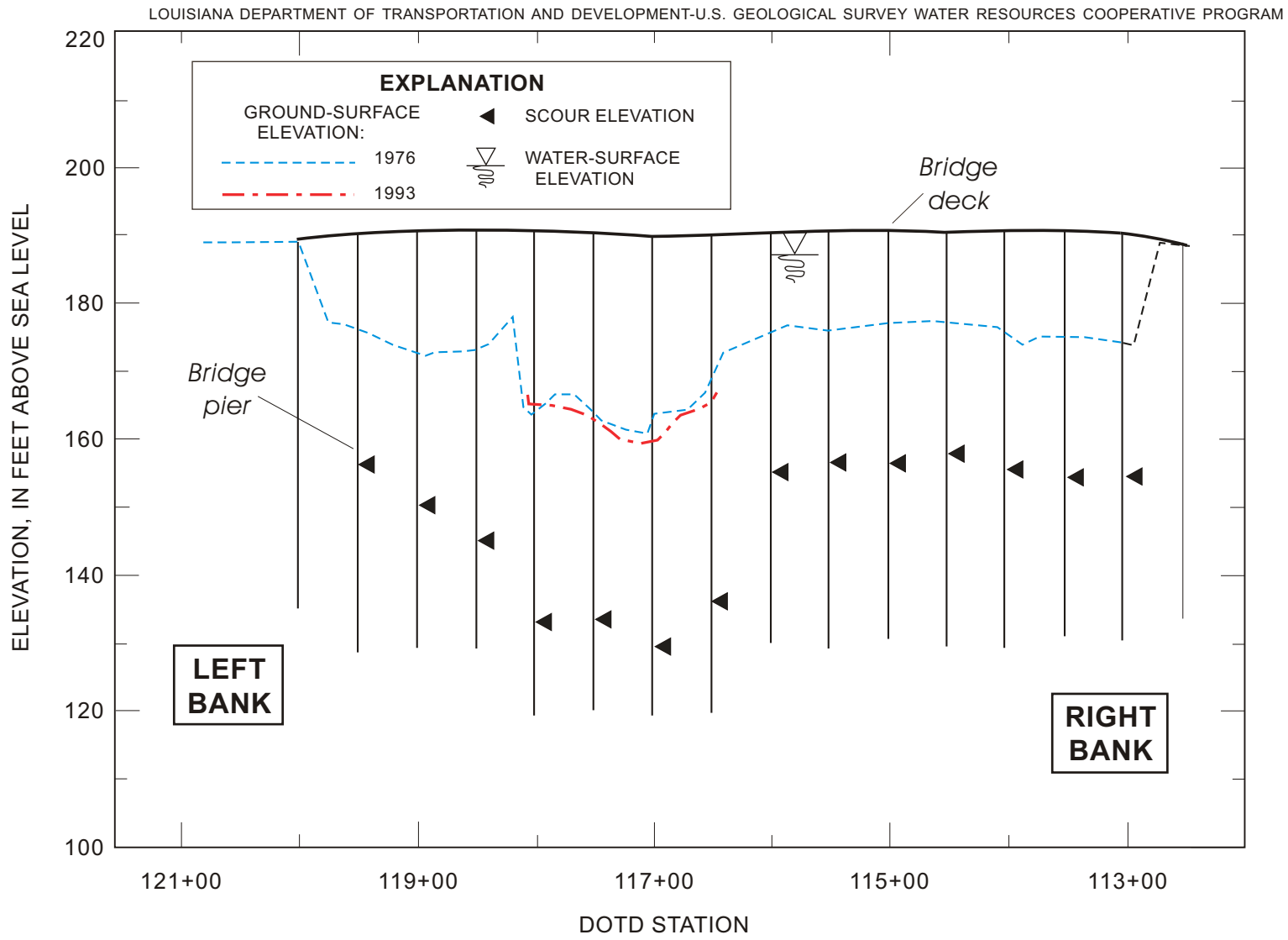


Figure 3. Comparative cross sections and scour estimates at the Louisiana Highway 432 crossing of the Amite River near Felixville.

Louisiana Highway 10 Crossing of the Amite River near Darlington

The La. Hwy. 10 crossing of the Amite River (fig. 4) near Darlington is about 4.6 mi south of the La. Hwy. 432 bridge near Felixville (fig. 1). A USGS gaging station is located at the La. Hwy. 10 bridge crossing. Stage and discharge records are available from 1949 to 1998. The Q_{500} was estimated by the USACE as 161,260 ft^3/s. The log-Pearson Type III flood frequency estimate, based on the gaging records at the site and using the station skew, resulted in a Q_{500} of 167,300 ft^3/s. The discharge based on the site information agrees well with the USACE estimate which was used for the analysis to provide continuity with previous analyses along the Amite River.

The reach modeled for evaluation of the La. Hwy. 10 bridge extends from La. Hwy. 64 to upstream of La. Hwy. 10. The width of the floodplain ranges from 4,860 to 17,050 ft through the reach. The minimum cross-section elevation at La. Hwy. 10 was 141.6 ft above sea level. The water-surface elevation used in scour computations was 174.4 ft above sea level. The highway embankment crossing the flood plain has four relief bridges, and the Q_{500} was distributed among the openings based on the conveyance of the openings and historic flood measurements. The portion of the Q_{500} allocated to the main bridge was 64,050 ft^3/s.

Pier Scour

The cross section (fig. 5) used for this analysis was based on 1990 data, which is the most recent information and documents the lowest thalweg elevation of all data at the site. Computed velocities ranged from 2.4 to 6.7 ft/s along the cross sections of the bridge (table 3). The greatest pier scour depth estimated was 13.5 ft at the pier located at DOTD station 470+75.

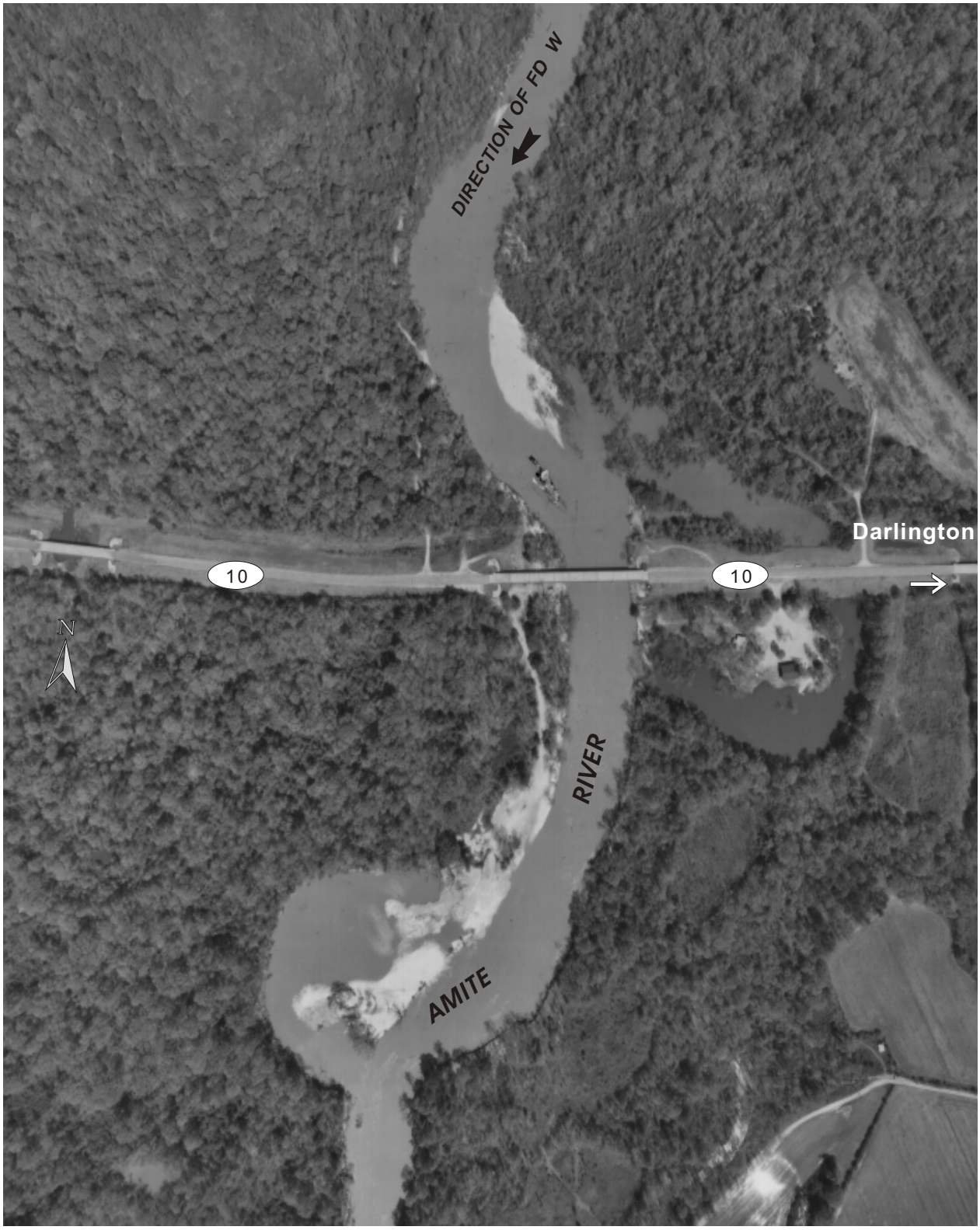
Table 3. Scour data for Louisiana Highway 10 crossing of the Amite River near Darlington

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 174.4 feet above sea level; K_2, dimensionless correction factor for angle of flow attack; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above sea level)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above sea level)	Pile tip elevation (ft above sea level)
467+25	169.6	Abutment	2.5	1.5	2.8	NA	4.8	165	132
467+75	157.0	Square	2.5	1.5	2.8	8.5	4.8	144	122
468+25	156.0	Square	2.5	1.5	3.9	9.9	4.8	141	110
468+75	154.0	Square	2.5	1.5	4.6	10.8	4.8	138	110
469+25	142.0	Square	2.5	1.5	6.0	12.9	3.8	125	110
469+75	142.0	Square	2.5	1.5	6.2	13.1	3.8	125	110
470+25	142.0	Square	2.5	1.5	6.5	13.4	3.8	125	110
470+75	142.0	Square	2.5	1.5	6.7	13.5	3.8	125	110
471+25	142.0	Square	2.5	1.5	5.6	12.5	3.8	126	110
471+75	157.0	Square	2.5	1.5	2.4	8.0	7.3	142	115
472+25	169.6	Abutment	2.5	1.5	2.4	NA	7.3	162	142

Channel Stability

The historical cross sections show the shifting nature of the thalweg at this site, but that the vertical downward movement of the thalweg is limited to approximately 140 ft above sea level. Movement of the river to the left has been mitigated by the installation of riprap material on the left bank near the abutments. Surveys from 1958 to 1990 indicate some horizontal bed dynamics but show no substantial incising.



Photograph source: Louisiana Department of Transportation and Development, March 1983

Figure 4. Aerial photograph of the Louisiana Highway 10 crossing of the Amite River near Darlington.

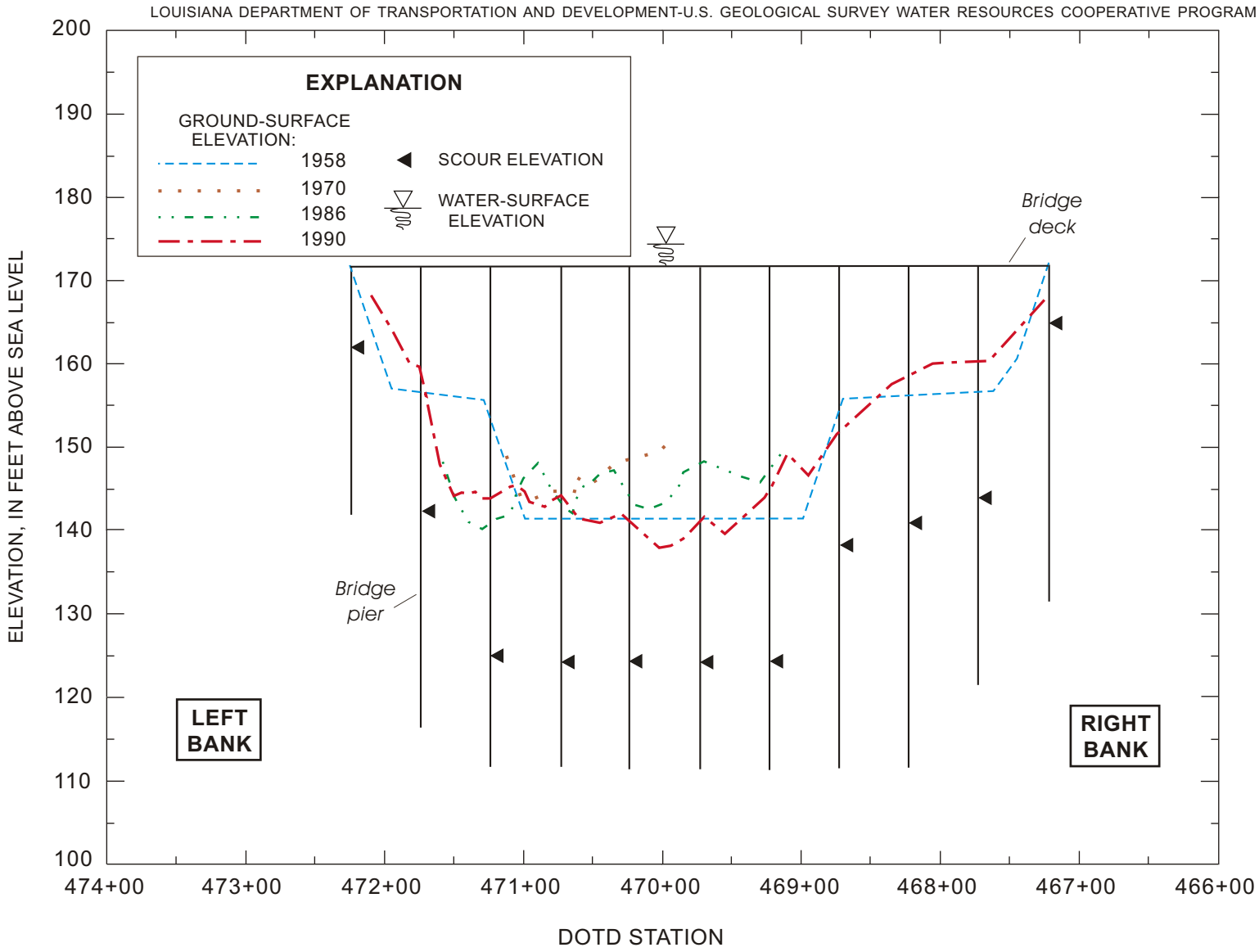


Figure 5. Comparative cross sections and scour estimates at the Louisiana Highway 10 crossing of the Amite River near Darlington.

Contraction and Abutment Scour

The bridge opening was evaluated as three separate parts of channel and overbank areas. The estimated value of contraction scour of 7.3 ft applies to the left overbank, 3.8 ft for the channel area, and 4.8 ft for the right overbank. The abutments are protected with a concrete apron, making abutment scour computations inapplicable.

Louisiana Highway 64 Crossing of the Amite River at Magnolia

The Amite River at Magnolia meanders substantially at the La. Hwy. 64 crossing (fig. 6). A USGS gaging station was located at this site from 1949 to 1983. The Q_{500} log-Pearson Type III flood frequency estimate based on the 35 years of data is 128,100 ft^3/s, with 95 percent confidence limits from 94,140 to 199,120 ft^3/s. The study performed by the USACE estimated the Q_{500} at Magnolia to be 160,230 ft^3/s.

The USACE estimate of 160,230 ft^3/s was used which is within the 95 percent confidence limits of the log-Pearson Type III distribution estimates based on the gage data. This value of discharge is also in agreement with the station analysis upstream at Darlington. The reach modeled for evaluation of scour at the Magnolia bridge extends from 2,630 ft upstream to 6,000 ft downstream of the bridge. The width of the floodplain varies from 16,000 to 25,000 ft through the reach. The minimum cross-section elevation in the reach was 3.4 ft above sea level. The downstream starting water-surface elevation was 46.4 ft, resulting in a water-surface elevation of 57.0 at the bridge.

Pier Scour

The cross sections (fig. 7) used for analysis were based on 1993 data obtained from the DOTD. Computed velocities ranged from 2.6 to 5.7 ft/s along the cross section of the bridge (table 4), with a discharge of 108,860 ft^3/s passing through the main channel bridge. The coefficient K_2 was set at 2.7 to account for the flow approaching the piers at an angle. The greatest pier scour depth estimated was 26.1 ft at the pier located at DOTD station 31+00. Pier scour estimates for the overbank piers ranged from 9 to 12 ft.

Channel Stability

Figures 6 and 7 indicate aggradation of the left bank, erosion of the right bank, and shifting of the thalweg, but show no large scale incising. The cross section measured in 1983 shows the left bank of the main channel had moved approximately 100 ft since 1954. A similar movement of the left bank of the main channel occurred during the period 1983 to 1993. The right bank of the main channel had moved approximately 100 ft during the period 1954 to 1983, but remained unchanged during 1983 to 1993. The right bank may be stabilized in this position, but continued monitoring of the river channel would determine whether that is the case.

Contraction and Abutment Scour

Flow through the main channel bridge was subdivided into flow in the main channel, left overbank, and right overbank. The average depth at the bridge is approximately 30 ft for the main channel and 21 ft for the overbanks. For computations of contraction scour in the main channel, the channel is approximately 480 ft in width upstream and at the bridge. Contraction scour in the main channel was computed as 9.7 ft. Scour on the left and right overbanks was estimated as 1 and 2 ft, respectively. Due to flow over the road, and the concrete armoring at the abutments, scour at the abutments was not estimated.

Photograph source: Louisiana Department of Transportation and Development, February 1982

Figure 6. Aerial photograph of the Louisiana Highway 64 crossing of the Amite River at Magnolia.

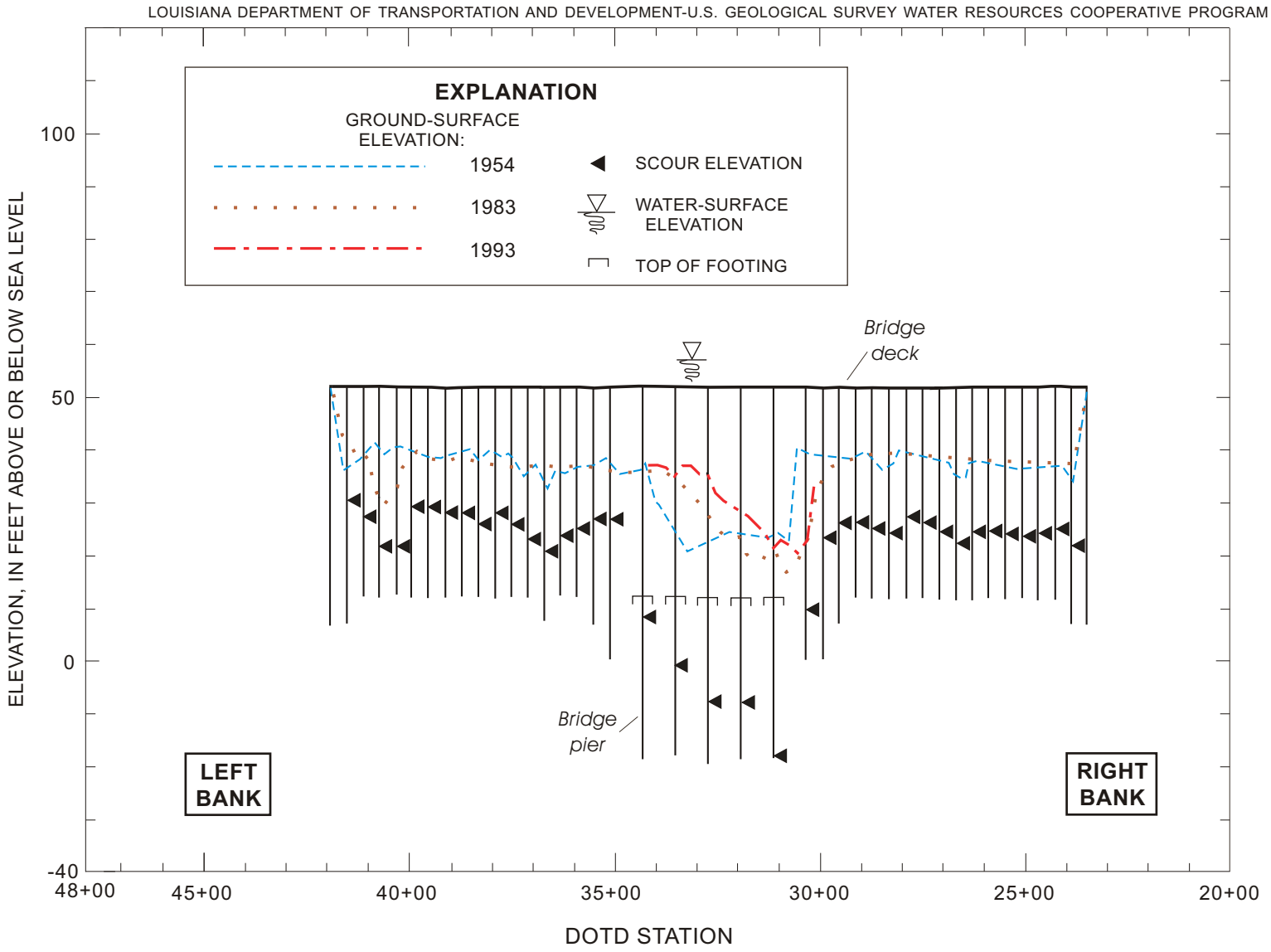


Figure 7. Comparative cross sections and scour estimates at the Louisiana Highway 64 crossing of the Amite River at Magnolia.

Table 4. Scour data for Louisiana Highway 64 crossing of the Amite River at Magnolia

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 57.0 feet above sea level; K_2, dimensionless correction factor for angle of flow attack; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above sea level)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above sea level)	Pile tip elevation (ft above sea level)
23+40	57.0	Abutment	2.7	1.2	3.4	NA	2.0	57	8
23+80	34.0	Square	2.7	1.2	3.4	9.1	2.0	23	8
24+20	37.0	Square	2.7	1.2	3.4	9.0	2.0	26	12
24+60	36.5	Square	2.7	1.2	3.4	9.0	2.0	26	12
25+00	36.0	Square	2.7	1.2	3.6	9.2	2.0	25	12
25+40	36.5	Square	2.7	1.2	3.6	9.2	2.0	25	12
25+80	37.0	Square	2.7	1.2	3.6	9.2	2.0	26	12
26+20	37.0	Square	2.7	1.2	3.8	9.4	2.0	26	12
26+60	35.0	Square	2.7	1.2	3.8	9.5	2.0	23	12
27+00	37.0	Square	2.7	1.2	3.8	9.4	2.0	26	12
27+40	38.0	Square	2.7	1.2	3.1	8.6	2.0	27	12
27+80	39.0	Square	2.7	1.2	3.1	8.5	2.0	28	12
28+20	36.0	Square	2.7	1.2	3.1	8.7	2.0	25	12
28+60	37.0	Square	2.7	1.2	3.1	8.6	2.0	26	12
29+00	38.0	Square	2.7	1.2	3.1	8.6	2.0	27	12
29+40	38.0	Square	2.7	1.2	4.5	10.0	2.0	26	8
29+80	36.0	Square	2.7	1.2	5.3	10.9	2.0	23	0
30+20	24.0	Square	2.7	1.2	5.7	12.0	2.0	10	0
31+00	22.0	Square	2.7	4.0	5.5	26.1	9.7	-14	-18
31+80	28.0	Square	2.7	4.0	5.5	25.4	9.7	-7	-18
32+60	28.0	Square	2.7	4.0	5.4	25.2	9.7	-7	-18
33+40	32.0	Square	2.7	4.0	4.8	23.5	9.7	-1	-18
34+20	36.0	Square	2.7	4.0	3.9	21.0	9.7	5	-18
35+00	37.0	Square	2.7	1.2	3.6	9.2	1.0	27	0
35+40	37.0	Square	2.7	1.2	3.6	9.2	1.0	27	8
35+80	36.0	Square	2.7	1.2	3.8	9.5	1.0	26	12
36+20	35.0	Square	2.7	1.2	3.8	9.5	1.0	24	12
36+60	33.0	Square	2.7	1.2	3.8	9.6	1.0	22	8
37+00	35.0	Square	2.7	1.2	3.8	9.5	1.0	24	12
37+40	37.0	Square	2.7	1.2	3.7	9.3	1.0	27	12
37+80	38.0	Square	2.7	1.2	3.7	9.2	1.0	28	12
38+20	37.0	Square	2.7	1.2	3.7	9.3	1.0	27	12
38+60	38.0	Square	2.7	1.2	2.8	8.2	1.0	29	12
39+00	38.0	Square	2.7	1.2	2.8	8.2	1.0	29	12
39+40	39.0	Square	2.7	1.2	2.8	8.1	1.0	30	12
39+80	39.0	Square	2.7	1.2	2.8	8.1	1.0	30	12
40+20	32.0	Square	2.7	1.2	2.8	8.5	1.0	22	12
40+60	32.0	Square	2.7	1.2	2.8	8.5	1.0	22	12
41+00	37.0	Square	2.7	1.2	2.6	8.0	1.0	28	12
41+40	40.0	Square	2.7	1.2	2.6	7.8	1.0	31	8
41+80	57.0	Abutment	2.7	1.2	2.6	NA	1.0	57	8

U.S. Highway 190 Crossing of the Amite River near Denham Springs, Louisiana

The U.S. Hwy 190 crossing of the Amite River is downstream of the confluence of the Amite and Comite Rivers (fig. 8) resulting in complex and diverse flow dynamics. A USGS gaging station is located at the U.S. Hwy. 190 bridge, which is located 1.5 mi upstream of the I-12 bridge crossing (fig. 1). The Q_{500} was 189,000 ft^3/s. Hydraulic simulations were calibrated to the April 8, 1983, flood of 112,000 ft^3/s with a water-surface elevation of 41.5 ft at U.S. Hwy. 190. The reach modeled for hydraulic evaluation of U.S. Hwy. 190 extends 2,750 ft downstream and 3,322 ft upstream of the bridge. The minimum cross-section elevation in the reach was 0 ft above sea level. This site is the most upstream site on the Amite River that exhibits the hydrodynamic behavior typical of low-sloped coastal streams. The simulation of the Q_{500} resulted in a starting downstream water-surface elevation for the water-surface profile computation of 44.8 ft and a water-surface elevation of 46.1 ft above sea level at U.S. Hwy. 190.

Pier Scour

The cross section used for this analysis was based on information from the USACE and the DOTD. Simulations indicate velocities ranging from 2.1 to 4.1 ft/s along the main channel bridge (table 5). The greatest pier scour depth estimated was 8.4 ft at DOTD station 571+88 (fig. 9).

Table 5. Scour data for U.S. Highway 190 crossing of the Amite River near Denham Springs, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 46.1 feet above sea level; K_2, dimensionless correction factor for angle of flow attack; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above sea level)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above sea level)	Pile tip elevation (ft above sea level)
567+40	45.6	Abutment	1.0	2.0	2.7	NA	5.3	40	-12
568+08	21.0	Square	1.0	2.0	2.7	4.3	5.3	11	-15
568+68	17.0	Square	1.0	2.0	3.5	4.9	5.3	7	-15
569+28	19.0	Square	1.0	2.0	3.4	4.7	5.3	9	-10
569+88	20.0	Square	1.0	2.0	3.3	4.7	5.3	10	-10
570+63	6.0	Square	1.0	3.0	3.5	6.0	5.0	-5	-20
571+88	4.0	Square	1.0	4.5	4.1	8.4	5.0	-9	-20
573+62	4.0	Square	1.0	4.5	2.7	7.0	5.0	-8	-20
574+87	21.0	Square	1.0	3.0	2.9	5.2	4.0	12	-15
575+40	20.0	Square	1.0	2.0	2.1	3.9	4.0	12	-5
576+08	20.0	Square	1.0	2.0	3.4	4.7	4.0	11	-5
576+68	20.0	Square	1.0	2.0	3.6	4.8	4.0	11	-5
577+28	20.0	Square	1.0	2.0	2.8	4.4	4.0	12	-5
577+88	20.0	Square	1.0	2.0	2.9	4.4	4.0	12	-5
578+48	20.0	Square	1.0	2.0	2.9	4.4	4.0	12	-5
579+08	20.0	Square	1.0	2.0	2.8	4.3	4.0	12	-5
579+68	20.0	Square	1.0	2.0	2.8	4.3	4.0	12	-5
580+28	20.0	Square	1.0	2.0	2.7	4.3	4.0	12	0
580+88	20.0	Square	1.0	2.0	2.7	4.3	4.0	12	0
581+48	20.0	Square	1.0	2.0	2.4	4.1	4.0	12	0
582+00	45.6	Abutment	1.0	2.0	2.4	NA	4.0	42	0

Photograph source: Louisiana Department of Transportation and Development, February 1989

Figure 8. Aerial photograph of the U.S. Highway 190 crossing of the Amite River near Denham Springs, Louisiana.

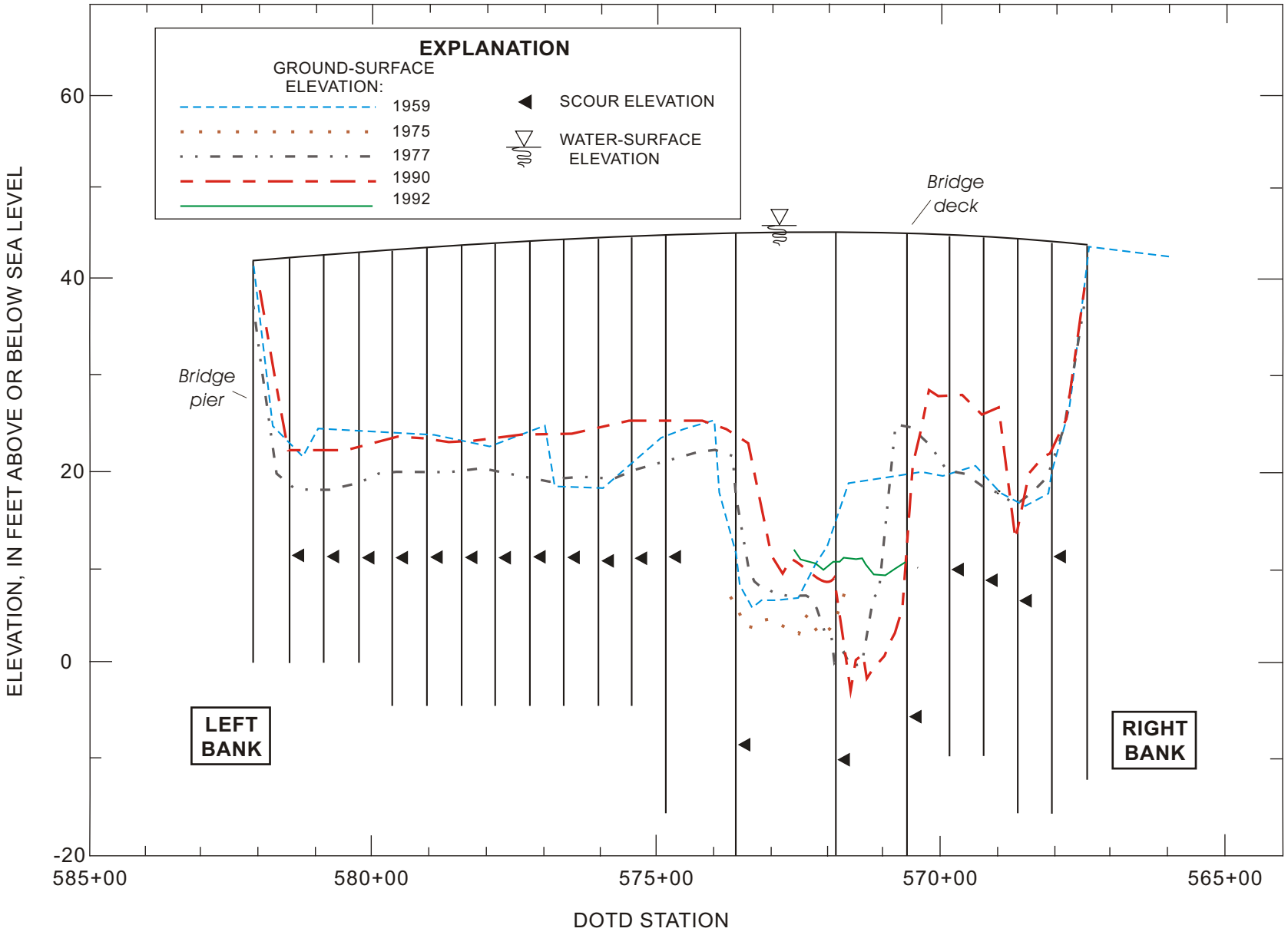


Figure 9. Comparative cross sections and scour estimates at the U.S. Highway 190 crossing of the Amite River near Denham Springs, Louisiana.

Channel Stability

Historical cross sections at the bridge are shown in figure 9. The 1959 data represent the geometry when the bridge was constructed. The cross section measured in 1977 indicates that the main channel had shifted toward the right bank and deepened. Cross sections measured through 1992 generally maintain the new horizontal position. Comparison of these cross sections indicate a vertically dynamic channel bed. From the available historical cross sections, the channel seems to degrade approximately 10 ft periodically, and has the potential to recover as shown by the 1990 and 1992 data. The lower bed elevations were used in scour estimates. This degradation of the right edge of the main channel is in a position that directly involves pile bents at DOTD stations 570+63 and 571+88. The bridge cross section indicated erosion of the right bank. Channel degradation and potential shifting of the thalweg could increase the scour potential at piers on the right bank.

Contraction and Abutment Scour

Flow through the main channel bridge was subdivided into flow in the main channel, left overbank, and right overbank. The average depth at the bridge is approximately 35 ft for the main channel and 25 ft for the overbanks. For computations of contraction scour in the main channel, the channel is approximately 300 ft in width upstream and at the bridge. Due to the amount of flow conveyed by the relief opening and roadway overflow, no contraction scour is indicated in the main channel. Contraction scour estimates for the left and right overbanks at the bridge section were 4.0 and 5.3 ft, respectively. Although the contraction scour computed for the main channel part of the opening was not significant, a value of 5 ft was used based on the contraction scour computed for the overbank areas and the observed mobility of the main channel section. Vegetation on the overbank, which reduces flow velocity in these areas and armors the soil surface, may limit scour on the overbanks. The protection of the abutments with a concrete apron and sack concrete apron increases the resistance to abutment scour.

Interstate Highway 12 Crossing of the Amite River near Denham Springs, Louisiana

A USGS gaging station is located on the Amite River at the U.S. Hwy. 190 bridge crossing (fig. 10). The Interstate Highway 12 (I-12) bridge is located approximately 1.5 mi south of U.S. Hwy. 190 and 15.3 mi north of La. Hwy. 42. The small difference in drainage area between I-12 and U.S. Hwy. 190 crossings provides a reliable 500-year flood estimate at I-12 of 189,000 ft^3/s based on flood records from 1921 to 1993 at U.S. Hwy. 190. The reach modeled for hydraulic evaluation of the I-12 extends from a cross section 1,300 ft downstream to a cross section 1,400 ft upstream of I-12. The minimum channel-bed elevation ranged from -34 ft to 2 ft above sea level in the reach. The downstream starting water-surface elevation was based on calibration of the model at Port Vincent, which is the next highway crossing downstream.

Hydraulic simulations were calibrated to the April 8, 1983, flood of 112,000 ft^3/s and a water-surface elevation of 41.5 ft at U.S. Hwy. 190. This resulted in an elevation of 39.0 ft at I-12. Hydraulic simulation using the Q_{500} resulted in a water-surface elevation of 44.2 ft above sea level at I-12. Flow apportionment at the approach section resulted in approximately 125,000 ft^3/s through the main bridge approach and 64,000 ft^3/s through the overflow approach. Hydraulic simulation of the main channel bridge section indicated that 87,860 ft^3/s flows through the main bridge and 37,365 ft^3/s flows over the road.

Pier Scour

The cross section used for this analysis was based on a DOTD survey of 1990. The bridge piers cross the channel at an angle approximately equal to 15 degrees from the direction of flow; therefore, correction for alignment by setting the factor K_2 equal to 2.5 was applied (table 6). The greatest scour occurs at the main channel pier at DOTD station 860+20, where the estimated pier scour is approximately 31 ft (table 6,

Photograph source: Louisiana Department of Transportation and Development, October 1992

Figure 10. Aerial photograph of the Interstate Highway 12 crossing of the Amite River near Denham Springs, Louisiana.

fig. 11). The final bed elevation at the pier is approximately 18 ft below sea level, which represents the scour elevation including contraction and pier scour estimates. The scour elevation at station 861 + 35 is below the pile tip elevation shown on the original bridge plans. Pier scour at the locations that are in or near the channel, or for piers of greater width, ranged from 21.8 to 31.2 ft. Pier scour at the overbank piers was approximately 9 ft. Simulations indicate velocities range from 1.5 to 4.6 ft/s along the main channel bridge.

Table 6. Scour data for Interstate Highway 12 crossing of the Amite River near Denham Springs, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 44.2 feet above sea level; K_2, dimensionless correction factor for angle of flow attack; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above sea level)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above sea level)	Pile tip elevation (ft above sea level)
855+50	44.2	Abutment	2.5	2.0	1.5	NA	5.5	39	0
856+10	24.0	Square	2.5	2.0	1.5	8.1	5.5	10	-10
856+70	18.0	Square	2.5	2.0	1.5	8.4	5.5	4	-10
857+30	17.0	Square	2.5	7.0	2.1	21.8	5.5	-10	-12
858+45	8.0	Square	2.5	7.0	3.7	28.9	0	-21	-30
860+20	13.0	Square	2.5	7.0	4.6	31.2	0	-18	-25
861+35	19.0	Square	2.5	7.0	4.4	29.9	5.5	-16	-10
861+95	19.0	Square	2.5	2.0	1.9	9.3	5.5	4	-10
862+55	18.0	Square	2.5	2.0	1.9	9.4	5.5	3	-10
863+15	19.0	Square	2.5	2.0	2.0	9.4	5.5	4	-20
863+75	22.0	Square	2.5	7.0	2.0	20.8	5.5	-4	-23
864+35	19.0	Square	2.5	2.0	1.9	9.1	5.5	4	-10
864+95	17.0	Square	2.5	2.0	2.0	9.6	5.5	2	-10
865+55	16.0	Square	2.5	2.0	2.1	9.8	5.5	1	-10
866+15	16.0	Square	2.5	7.0	2.1	22.3	5.5	-12	-10
866+75	16.0	Square	2.5	2.0	2.1	9.7	5.5	1	-10
867+35	16.0	Square	2.5	2.0	1.6	8.7	5.5	2	-10
867+95	19.0	Square	2.5	2.0	1.6	8.6	5.5	5	-10
868+54	44.2	Abutment	2.5	2.0	1.6	NA	5.5	39	-5

Channel Stability

Cross sections at the bridge are shown in figure 11. The 1972 cross section represents the original cross-section geometry when the bridge was constructed. Cross-sections from 1972 to 1990 generally show a stable cross section with no major vertical or lateral movement indicated. A meander of the river upstream of the bridge which may have potential for lateral erosion can be seen on the aerial photograph (fig. 10).

Contraction and Abutment Scour

Flow through the main bridge was subdivided into flow in the main channel, left overbank, and right overbank. The average depth of the channel at the bridge is approximately 39 ft for the main channel and 24 ft for the overbanks. A section of channel 175 ft in width was used to estimate contraction scour in the main channel. The width of the main channel at the bridge is 175 ft. Contraction scour was not indicated in computations for the main channel. Contraction scour on the left and right overbanks was estimated as 7.3 and 6.1 ft, respectively. Abutment scour was not included due to the spur dike characteristics of the width of the embankment and heavy vegetation adjacent to the embankment which may serve to protect the abutment from scouring.

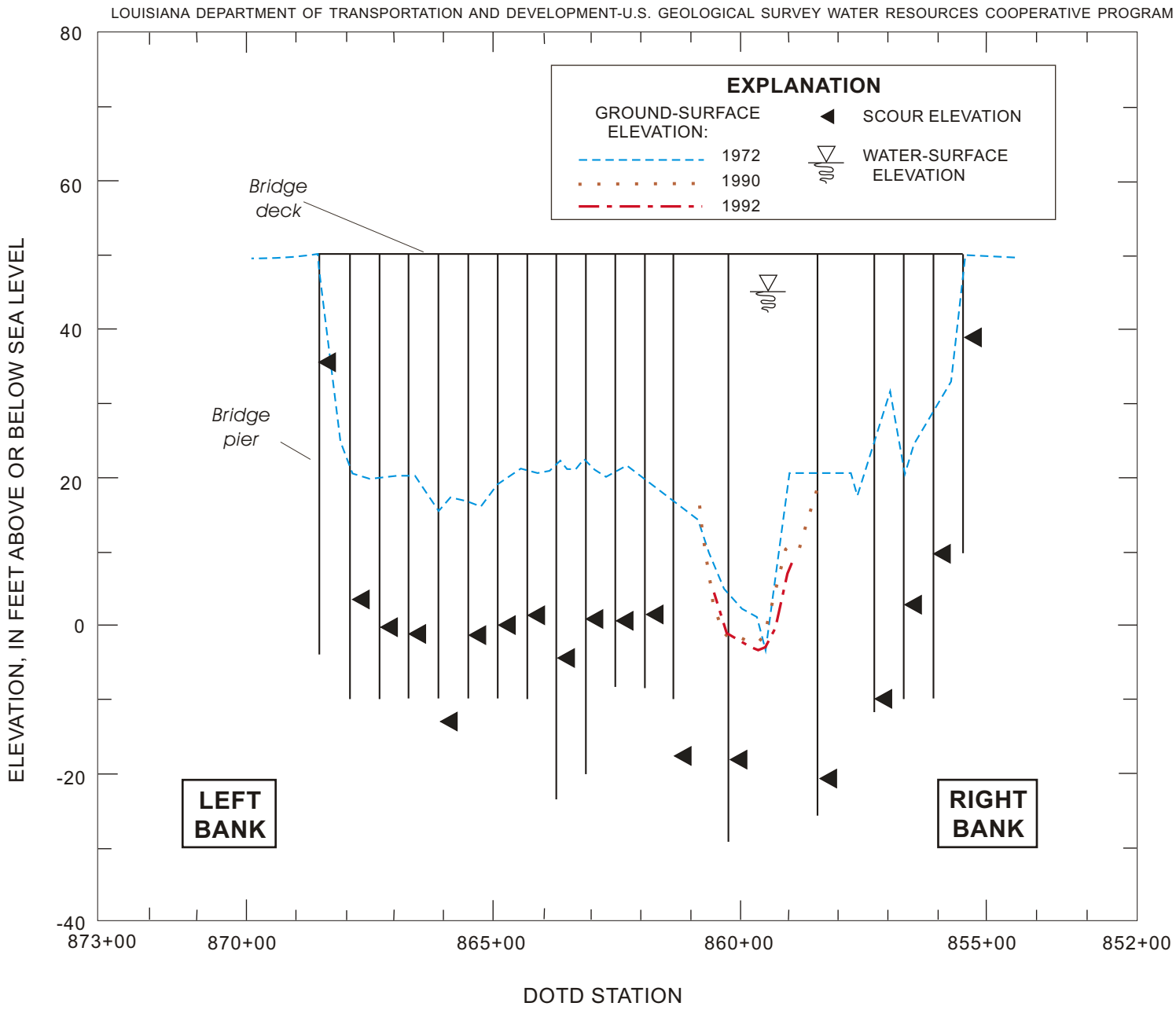


Figure 11. Comparative cross sections and scour estimates at the Interstate Highway 12 crossing of the Amite River near Denham Springs, Louisiana.

Louisiana Highway 42 Crossing of the Amite River at Port Vincent

The La. Hwy. 42 bridge crossing (fig. 12) at Port Vincent is a coastal site, which has very mild channel and water surface slopes. Low slope coastal sites are influenced by tides, winds, and storm surges, all of which affect the stage-discharge relation. Discharge in the coastal area is influenced by tides and winds which could result in backwater effects where flood stage could be increased with little or no change in flood discharge. This site is influenced by backwater and tidal conditions from Lake Maurepas. The overbank areas of the wide floodplain are flat and well vegetated resulting in relatively high resistance to flow.

A USGS gaging station is located on the La. Hwy. 42 bridge crossing the Amite River at Port Vincent. The river stage has been recorded from 1946 to 1994. The maximum stage of record was 14.65 ft above sea level which occurred in 1983. A log-Pearson Type III analysis on the stage data resulted in an estimated Q_{500} stage of 16 ft. For the 40 years of stage record, there are only 9 years of flood-discharge record. The maximum recorded discharge measured during this period was 69,500 ft^3/s in 1990, with a flood stage of 10.91 ft above sea level.

A flood frequency estimate based on the 9 years of data, using log-Pearson Type III analysis and the station skew, indicates a Q_{500} of 136,000 ft^3/s. To validate the estimate at Port Vincent, the flood estimate for U.S. Hwy. 190 at Denham Springs was adjusted to the Port Vincent site based on previous flood measurements at both sites. The resulting flood Q_{500} estimate was 135,890 ft^3/s, which supports the log-Pearson Type III estimate of 136,000 ft^3/s. Flow apportionment to several small relief openings was based on historic flood discharge measurements. A step-backwater analysis resulted in a stage of 17.2 ft for the Q_{500}.

The reach modeled for evaluation of the Port Vincent bridge extends from 0.5 mi north of the Amite River diversion canal to upstream of La. Hwy. 42. The minimum channel-bed elevations of the cross sections ranged from -40.7 to -22.0 ft above sea level. Hydraulic simulations indicate velocities ranging from 2.4 to 8.6 ft/s along the cross section at the bridge.

Pier Scour

The cross section used for this analysis was based on a USGS survey in 1994. The greatest scour depth estimated was 26.3 ft at the pier located at DOTD station 56+56 (fig. 13), which corresponds to a riverbed elevation of -52 ft above sea level. In evaluation of scour potential around the main channel piers, the estimated scour depth was decreased by 5 percent. The 5 percent decrease in estimated scour results from the flow protection provided by the fender system (Abed and Richardson, 1993). Although the fender system is designed to provide pier protection from river traffic, it may also inhibit the development of the vortices that induce scour. Piers at other locations show a scour potential of 9.7 ft or less (table 7).

Channel Stability

Historical cross sections at the bridge are shown in figure 13. The 1960 cross section represents the original cross-section geometry when the bridge was built. The historical cross sections show a lowering of the channel bed. Surveys from 1960 and 1982 indicate initial lowering of the channel bed with additional channel lowering until 1985. From 1985 to 1994, there are indications of relatively stable bed conditions with little degradation. Continued monitoring could be performed at this location to determine if any observed channel changes represent new equilibrium conditions or transient conditions. The minimum channel-bed elevation based on the most recent survey is -38 ft above sea level.

Photograph source: Louisiana Department of Transportation and Development, October 1981

Figure 12. Aerial photograph of the Louisiana Highway 42 crossing of the Amite River at Port Vincent.

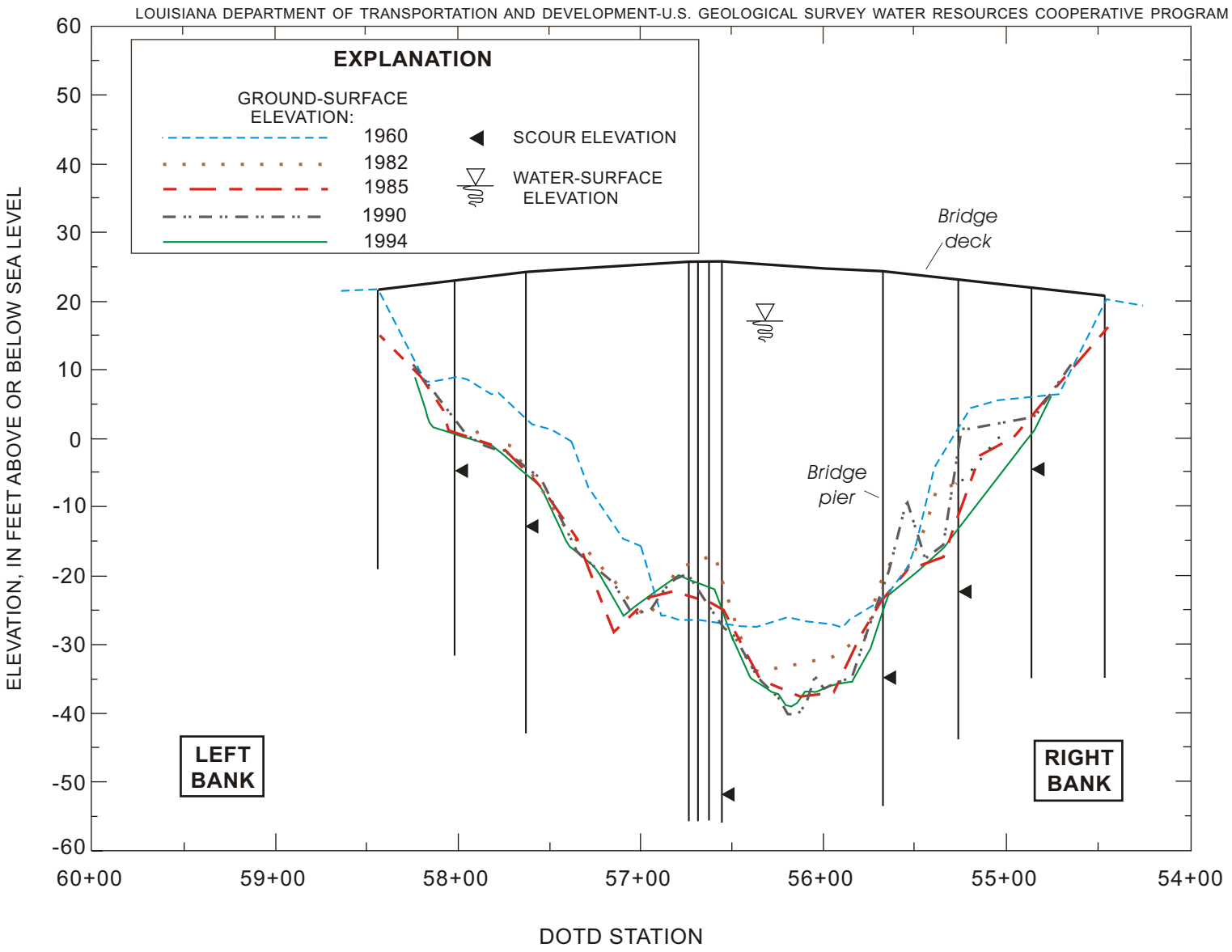


Figure 13. Comparative cross sections and scour estimates at the Louisiana Highway 42 crossing of the Amite River at Port Vincent.

Table 7. Scour data for Louisiana Highway 42 crossing of the Amite River at Port Vincent

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 17.2 feet above sea level; K_2, dimensionless correction factor for angle of flow attack; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans]

DOTD station	Ground elevation (ft above sea level)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above sea level)	Pile tip elevation (ft above sea level)
54+46	17.2	Abutment	1.0	1.6	2.5	6.8	1.6	9	-35
54+86	0	Square	1.0	1.6	2.5	3.5	1.6	-5	-35
55+26	-15.0	Square	1.0	1.6	8.1	6.2	1.6	-23	-45
55+68	-24.0	Square	1.0	3.3	8.2	9.7	1.6	-35	-52
56+56	-24.0	Square	1.0	14.9	8.6	26.3	1.6	-52	-55
57+61	-6.0	Square	1.0	3.3	2.4	5.6	1.6	-13	-42
58+03	0	Square	1.0	1.6	2.4	3.4	1.6	-5	-30
58+43	17.2	Abutment	1.0	1.6	2.4	4.8	1.6	11	-20

Contraction and Abutment Scour

Flow among the main channel and relief bridges was determined based on the conveyance of each opening and from historic discharge measurements. Contraction scour was calculated as 1.6 ft. Due to the flow conveyed by the relief openings and road overflow, abutment scour was estimated as 4.8 ft at the left abutment and 6.8 ft at the right abutment. These estimates may be larger than what may occur because at this water level, the only parts of the embankment that are above the water surface are the immediate area of the approaches.

Louisiana Highway 16 Crossing of the Amite River near French Settlement

The bridge crossing of the Amite River near French Settlement (fig. 14) is at a low slope coastal site that is influenced by conditions at Lake Maurepas. Low slope coastal stations are generally influenced by tides, winds, and storm surges, all of which affect the stage discharge relation. The overbank areas at French Settlement are wide, flat, and heavily vegetated, resulting in increased flood storage capacity and low velocities.

A USGS gaging station recording the river stage was located at the La. Hwy. 16 bridge crossing the Amite River near French Settlement from 1950 to 1978. The maximum stage recorded was 7.40 ft above sea level which occurred in 1977. The resulting frequency analysis of the stage data predicted a 500-year stage (S_{500}) of 10.4 ft above sea level. An evaluation of flood profiles based on peak stages also was made to estimate the flood slope of the statistical Q_{500} peak at 1.15 ft/mi. This flood slope compared with historical flood slopes that range between 0.7 and 0.9 ft/mi.

Between Port Vincent and French Settlement the floodplain continues to flatten and widen which reduces the Q_{500} estimate. The Amite River diversion canal is located between of Port Vincent and French Settlement, and diverts a substantial percentage of flood flows out of the mainstem of the Amite River through the diversion canal and into Lake Maurepas. The magnitude of the Q_{500} at the point of diversion and the percent of flow diverted established by the USACE was accounted for in the analysis of sites near French Settlement and at Clio. The estimated Q_{500} flood is 114,000 ft^3/s, with 63,000 ft^3/s being conveyed by the diversion canal, and 36,200 ft^3/s remaining in Amite River channel. The peak flows do not exactly total because of overbank storage (Chuck Shadie, U.S. Army Corps of Engineers, oral commun., 1994). A flood discharge of 36,200 ft^3/s at the La. Hwy. 16 crossing was apportioned as 23,500 ft^3/s passing through the bridge, and 12,700 ft^3/s over the road.

Photograph source: Louisiana Department of Transportation and Development, January 1977

Figure 14. Aerial photograph of the Louisiana Highway 16 crossing of the Amite River near French Settlement.

Pier Scour

The cross section used for this analysis was based on a 1993 USGS survey (fig. 15). Simulations indicate velocities ranging between 1.1 and 4.0 ft/s at the bridge (table 8). The greatest scour depth estimated was 23.2 ft at the support pilings in the main channel at DOTD station 390+10 (table 8). In evaluation of scour potential around this group of piers, the estimated scour depth was decreased by 5 percent, resulting from the flow protection provided by the fender system. Although the fender system is designed to provide pier protection from boat traffic, it also may provide a measure of protection from scouring (Abed and Richardson, 1993). Scour depth estimates at the piers at DOTD stations 389+11 and 391+10 are less than 10 ft. Pier scour estimates at stations 387 + 50 and 392 + 72 are less than 6 ft. All other piers show scour potential of less than 3 ft.

Channel Stability

At French Settlement, the floodplain is about 11 mi wide with minimum channel-bed elevation of approximately -20 ft. Surveys from 1958 to 1993 (fig. 15) appear stable and show no long-term trend.

Table 8. Scour data for Louisiana Highway 16 crossing of the Amite River near French Settlement

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 10.4 feet above sea level; K_2, dimensionless correction factor for angle of flow attack; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD Station	Ground elevation (ft above sea level)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above sea level)	Pile tip elevation (ft above sea level)
385+23	10.4	Abutment	1.0	6.0	1.1	NA	0	10	-42
385+60	2.0	Square	1.0	1.8	1.1	2.3	0	0	-42
386+30	2.7	Square	1.0	1.8	1.1	2.3	0	0	-39
386+70	3.0	Square	1.0	1.8	1.1	2.3	0	1	-39
387+10	3.7	Square	1.0	1.8	1.2	2.4	0	1	-36
387+50	4.0	Square	1.0	6.0	1.2	5.2	0	-1	-36
387+90	4.2	Square	1.0	1.8	1.2	2.4	0	2	-40
388+30	4.2	Square	1.0	1.8	1.2	2.4	0	2	-45
388+70	4.2	Square	1.0	1.8	1.2	2.4	0	2	-50
389+11	-4.0	Square	1.0	6.0	4.0	9.6	0	-14	-50
390+10	-20.0	Square	1.0	22.0	3.9	23.2	0	-43	-58
391+10	-12.0	Square	1.0	6.0	3.7	9.8	0	-22	-55
391+50	4.0	Square	1.0	1.8	1.1	2.3	0	2	-50
391+99	4.0	Square	1.0	1.8	1.1	2.3	0	2	-45
392+39	3.7	Square	1.0	1.8	1.1	2.3	0	1	-45
392+72	3.5	Square	1.0	6.0	1.1	5.1	0	-2	-42
393+11	3.2	Square	1.0	1.8	1.3	2.6	0	1	-42
393+53	3.0	Square	1.0	1.8	1.3	2.6	0	0	-38
394+00	2.7	Square	1.0	1.8	1.3	2.6	0	0	-39
394+37	2.7	Square	1.0	1.8	1.3	2.6	0	0	-35
394+80	10.4	Abutment	1.0	6.0	1.3	NA	0	10	-30

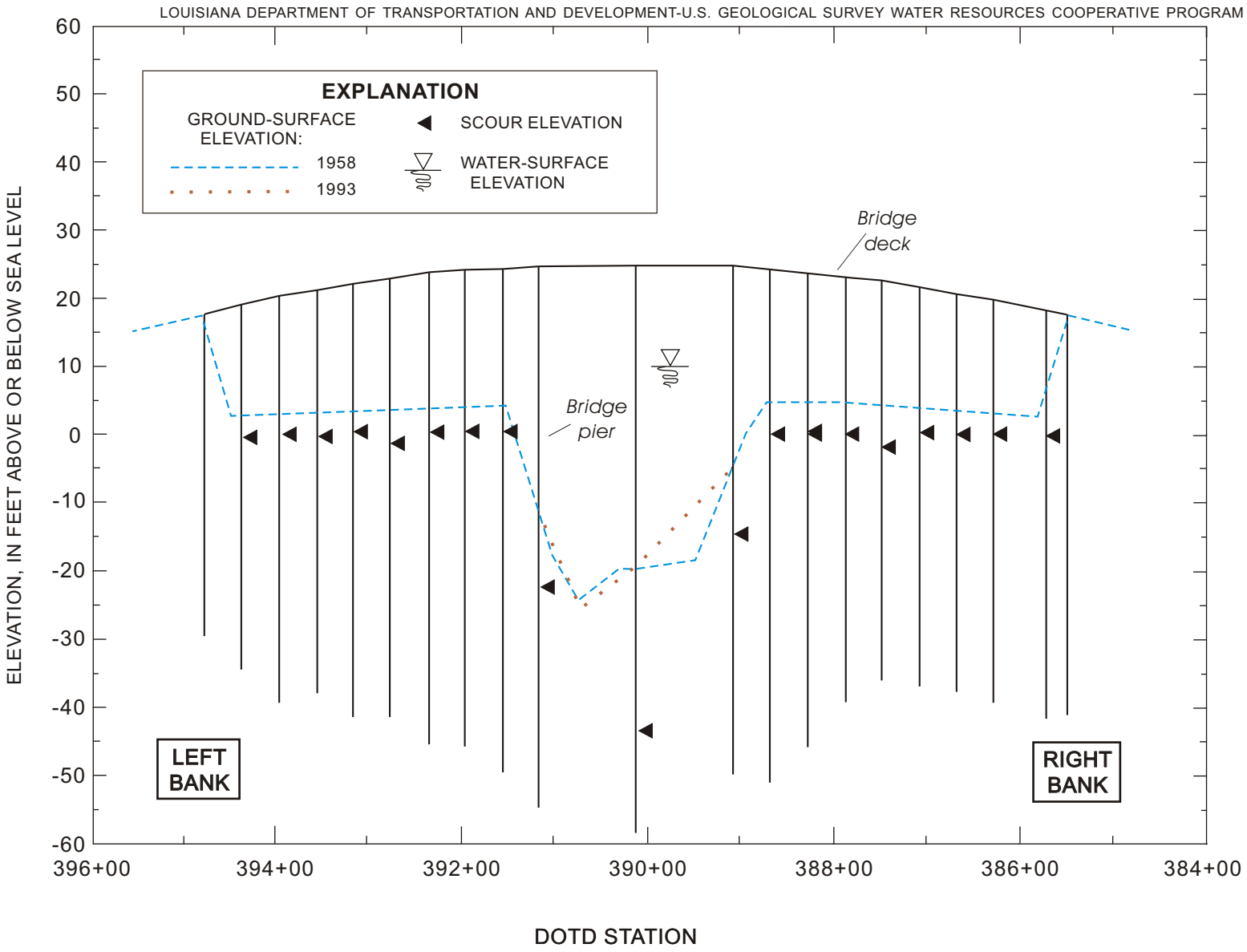


Figure 15. Comparative cross sections and scour estimates at the Louisiana Highway 16 crossing of the Amite River near French Settlement.

Contraction and Abutment Scour

The La. Hwy. 16 crossing of the Amite River was constructed utilizing a low roadway embankment with multiple openings to accommodate floodplain flows. Contraction scour and abutment scour estimates were small due to the amount of flow that is diverted to the relief openings and the amount of road overflow.

Louisiana Highway 22 Crossing of the Amite River at Clio

The bridge crossing of the Amite River (fig. 16) at Clio is a very low sloped coastal site which is influenced by backwater tides, winds, and storm surges from Lake Maurepas. Overbank areas are very flat and well vegetated resulting in a wide flood plain with high resistance to flow. The roadway section at this site is above the floodplain elevation by an amount which prevents overtopping for relatively frequent floods, but becomes overtopped for floods of the 100- to 500-year magnitude. Clio is approximately 3 mi upstream of the mouth of the Amite River and approximately 11 mi east of French Settlement. Stage information at Clio and at Pass Manchac (downstream of Lake Maurepas) was obtained from the USACE. The period of record is from 1988 to 1993 at Clio and from 1956 to 1993 at Pass Manchac. The Clio and Pass Manchac stage data are highly correlated. The stage at Clio is a maximum of 0.2 ft greater than the stage at Pass Manchac. A statistical analysis of the stage data at Pass Manchac indicates a S_{500} stage of approximately 6.8 ft above sea level, which translates to a stage at Clio of approximately 7.0 ft above sea level.

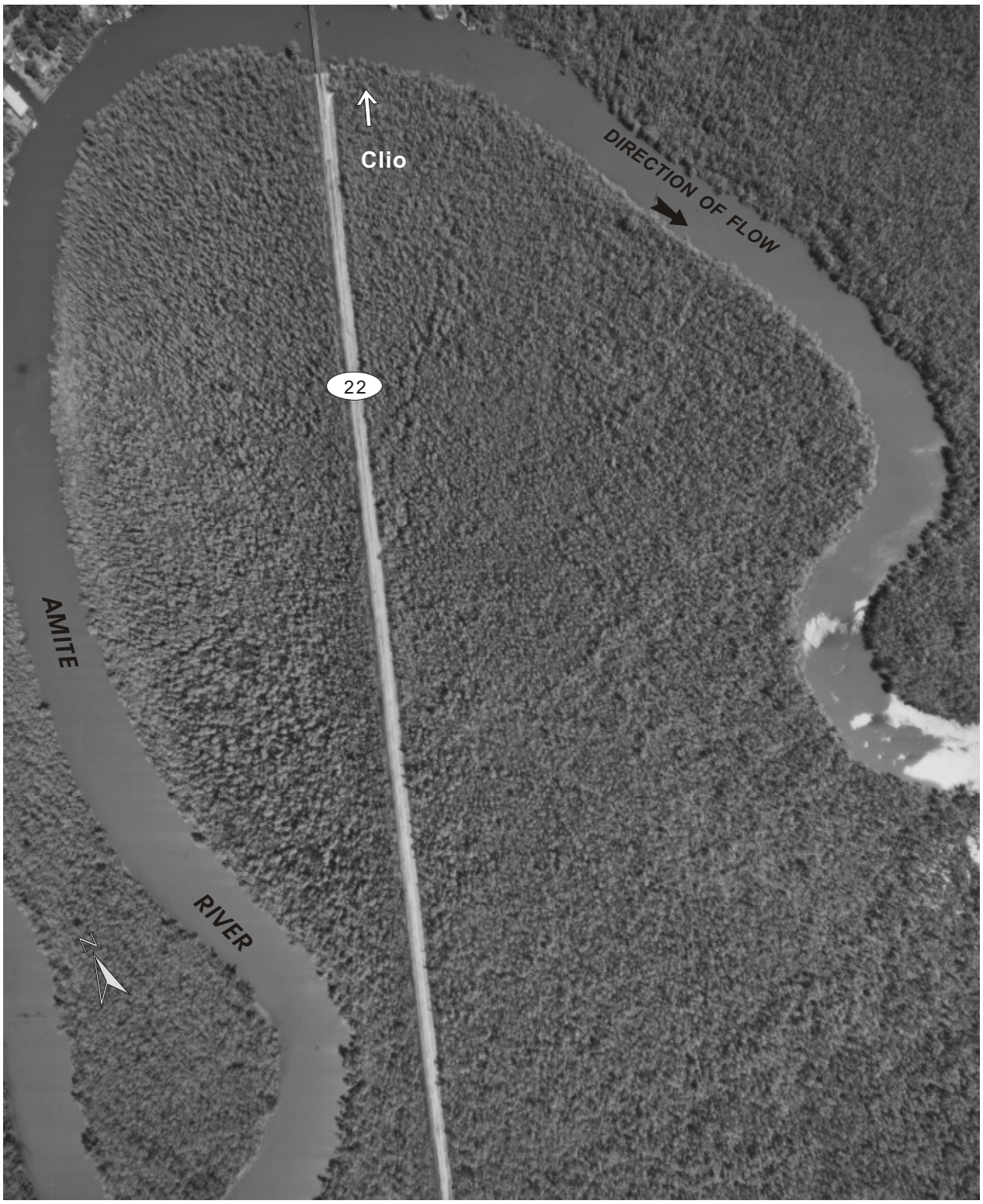
Between Port Vincent and Clio, the floodplain continues to flatten and widen which reduces the Q_{500}. The Amite River diversion canal also reduces the discharge at Clio. The USACE provided both the discharge and flood diversion estimates at the point of diversion. The Q_{500} is 114,000 ft^3/s with 36,200 ft^3/s passing down the Amite River. The flood slope is approximately 1 ft/mi between French Settlement and Port Vincent and approximately 0.25 ft/mi between French Settlement and Clio. After adjusting for slope, the discharge at Clio is approximately 18,100 ft^3/s with 12,400 ft^3/s passing through the bridge and 5,700 ft^3/s flowing over the road.

Pier Scour

The cross section used for analysis was a 1993 cross section measured by the USGS. The greatest pier scour depth estimated was 19.0 ft at the group of piers in the main channel at DOTD station 552+35 (table 9). In evaluation of scour potential, the estimated scour depth was decreased by 5 percent for those piers associated with the fender system. The 5 percent decrease in estimated scour results from the flow protection provided by the fender system. The "width" of the pier group that supports the swinging superstructure of the bridge was estimated using the cumulative widths of the piers in the group. Although the computed value of 19 feet of scour may be exaggerated due to the pier width approximation, it is well above the pile tip elevations indicated on the bridge plans. The piers near the main channel have an estimated pier scour of 2.7 to 6.7 ft. All overbank bents and other piers show pier scour potential of less than 2 ft.

Channel Stability

Cross sections at the bridge are shown in figure 17. Cross sections from surveys from 1971 to 1993 show no substantial changes in the channel geometry. Although the channel is very sinuous along this reach of the river (fig. 16), the channel is stable.



Photograph source: Louisiana Department of Transportation and Development, March 1970

Figure 16. Aerial photograph of the Louisiana Highway 22 crossing of the Amite River at Clio.

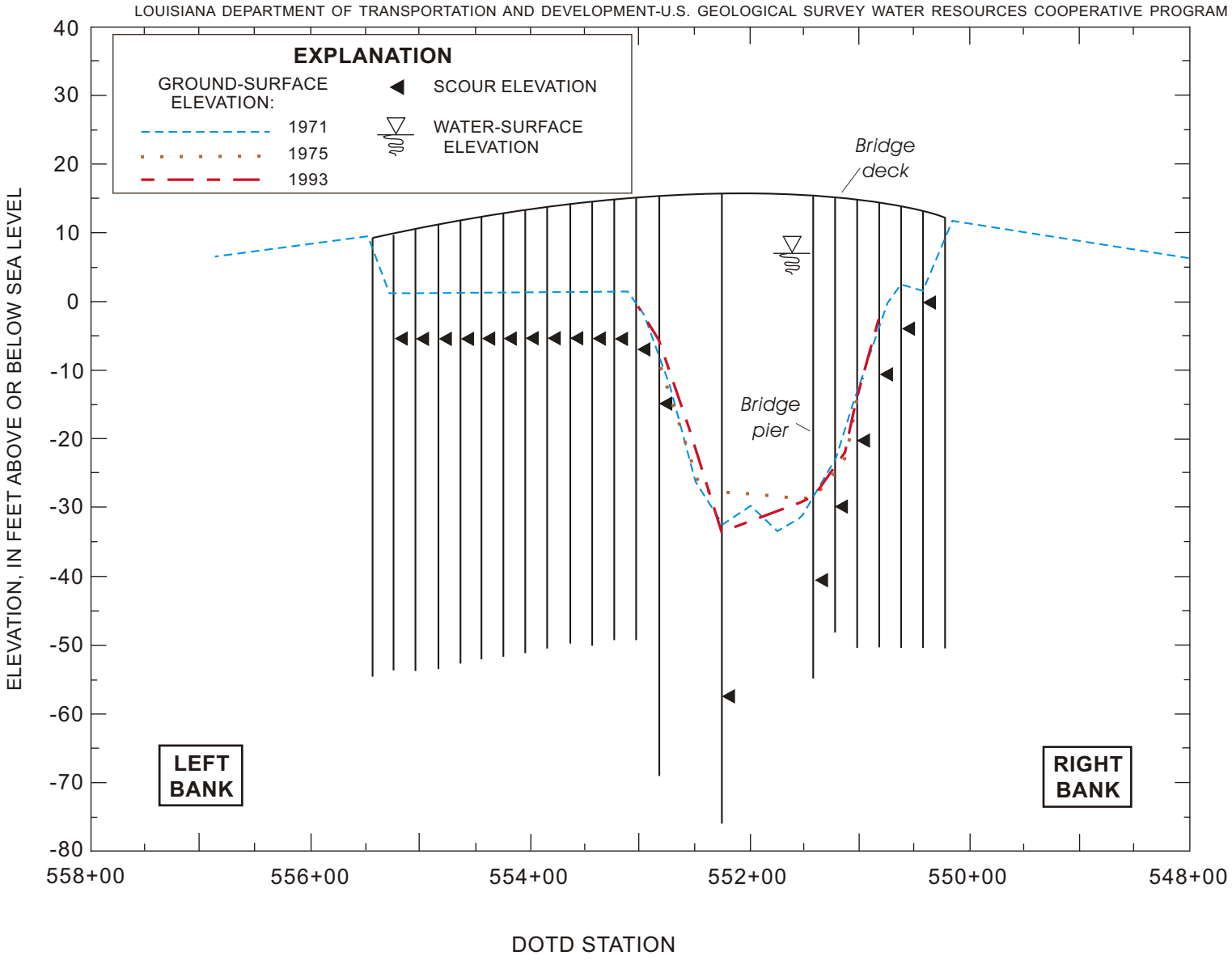


Figure 17. Comparative cross sections and scour estimates at the Louisiana Highway 22 crossing of the Amite River at Clio.

Table 9. Scour data for Louisiana Highway 22 crossing of the Amite River at Clio

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 7.0 feet above sea level; K_2, dimensionless correction factor for angle of flow attack; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above sea level)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above sea level)	Pile tip elevation (ft above sea level)
550+22	7.0	Abutment	1.0	1.8	0.4	NA	4.7	2	-52
550+42	2.0	Square	1.0	1.8	.4	1.4	4.7	-4	-52
550+62	2.5	Square	1.0	1.8	.4	1.4	4.7	-4	-52
550+82	-4.0	Square	1.0	1.8	.4	1.6	4.7	-10	-52
551+02	-14.0	Square	1.0	1.8	.4	1.7	4.7	-20	-52
551+22	-22.0	Square	1.0	1.8	1.2	2.9	4.7	-30	-48
551+45	-28.0	Square	1.0	6.0	1.3	6.7	4.7	-40	-55
552+35	-32.0	Square	1.0	28.0	1.4	19.0	4.7	-56	-75
552+82	-8.0	Square	1.0	6.0	.2	2.7	4.7	-15	-70
553+04	0	Square	1.0	1.8	.2	1.1	4.7	-6	-50
553+24	1.5	Square	1.0	1.8	.2	1.1	5.7	-5	-50
553+44	1.5	Square	1.0	1.8	.2	1.1	5.7	-5	-48
553+64	1.5	Square	1.0	1.8	.2	1.1	5.7	-5	-48
553+84	1.5	Square	1.0	1.8	.2	1.1	5.7	-5	-48
554+04	1.5	Square	1.0	1.8	.2	1.1	5.7	-5	-48
554+24	1.5	Square	1.0	1.8	.2	1.1	5.7	-5	-48
554+44	1.5	Square	1.0	1.8	.2	1.1	5.7	-5	-52
554+64	1.5	Square	1.0	1.8	.2	1.1	5.7	-5	-52
554+84	1.5	Square	1.0	1.8	.2	1.1	5.7	-5	-54
555+04	1.5	Square	1.0	1.8	.2	1.1	5.7	-5	-54
555+24	1.5	Square	1.0	1.8	.2	1.1	5.7	-5	-54
555+44	7.0	Abutment	1.0	1.8	.2	NA	5.7	1	-55

Contraction and Abutment Scour

Flow through the bridge for the Q_{500} was subdivided into flow in the main channel, left overbank, and right overbank. The average depth at the bridge is approximately 26 ft for the main channel and 5 ft for the overbanks. For computations of contraction scour in the main channel, the channel is approximately 260 ft in width upstream and at the bridge. Contraction scour in the bridge opening was computed as 4.7 to 5.7 ft. Computation of abutment scour is not applicable due to the concrete protection of the bed near the abutments.

Interstate Highway 12 Crossing of the Tickfaw River near Albany, Louisiana

Although this site is located on a sinuous sand-bed stream, the reach near the highway crossing (fig. 18) is straight for approximately one bridge length upstream and downstream of the highway crossing.

Photograph source: Louisiana Department of Transportation and Development, October 1992

Figure 18. Aerial photograph of the Interstate Highway 12 crossing of the Tickfaw River near Albany, Louisiana.

A USGS gaging station established in 1941 is located near Albany on U.S. Hwy. 190, 2.2 mi upstream of the I-12 bridge crossing of the Tickfaw River.

No historic discharge records are available for the Tickfaw River south of U.S. Hwy. 190. The I-12 crossing of the Tickfaw River is located in a transition area between the upland and coastal areas of Louisiana and is influenced by backwater from Lake Maurepas. The floodplain is very wide, flat, and generally has dense vegetation. Discharge in the coastal area is influenced by tides and winds which could result in backwater effects where flood stage could be increased with little or no change in flood discharge.

The flood discharge at the I-12 crossing will be less than at U.S. Hwy. 190 due to peak attenuation through increased overbank storage and decreased flood slopes. Based on the change in flood slope, the Q_{500} at I-12 is estimated at 33,710 ft^3/s with an associated stage of 34.4 ft above sea level. Step backwater analysis indicates no road overflow. A log-Pearson Type III analysis of the annual flood peaks resulted in an estimated Q_{500} of 40,600 ft^3/s.

Pier Scour

The cross section used for this analysis was based on a DOTD survey of 1993 (fig. 19). Computed velocities at the bridge cross section range from 2.5 to 7.5 ft/s (table 10). The maximum estimated pier scour was 13.7 ft (table 10) at DOTD station 332+91, which indicates a scour depth (including contraction scour) below the depth of the pile. Based on these estimates, piers at DOTD stations 322+10 and 332+91 may be susceptible to failure due to scouring if no remedial measures are taken.

Table 10. Scour data for Interstate Highway 12 crossing of the Tickfaw River near Albany, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 34.4 feet above sea level; K_2, dimensionless correction factor for angle of flow attack; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above sea level)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above sea level)	Pile tip elevation (ft above sea level)
329+10	40.0	Abutment	1.0	1.8	2.5	NA	6.0	34	10
329+70	26.0	Round	1.0	1.8	2.5	3.0	6.3	17	10
330+30	26.0	Round	1.0	1.8	3.1	3.3	6.3	16	10
330+90	26.0	Round	1.0	7.0	2.8	7.6	6.3	12	8
331+50	26.0	Round	1.0	1.8	5.4	4.2	6.3	16	8
332+10	14.0	Round	1.0	1.8	7.4	5.4	2.5	6	2
332+91	8.0	Round	1.0	7.0	7.5	13.7	2.5	-8	-2
333+50	22.0	Round	1.0	1.8	4.1	3.9	2.5	16	8
334+10	24.0	Round	1.0	1.8	2.9	3.3	6.5	14	10
334+69	40.0	Abutment	1.0	1.8	2.9	NA	6.0	34	6

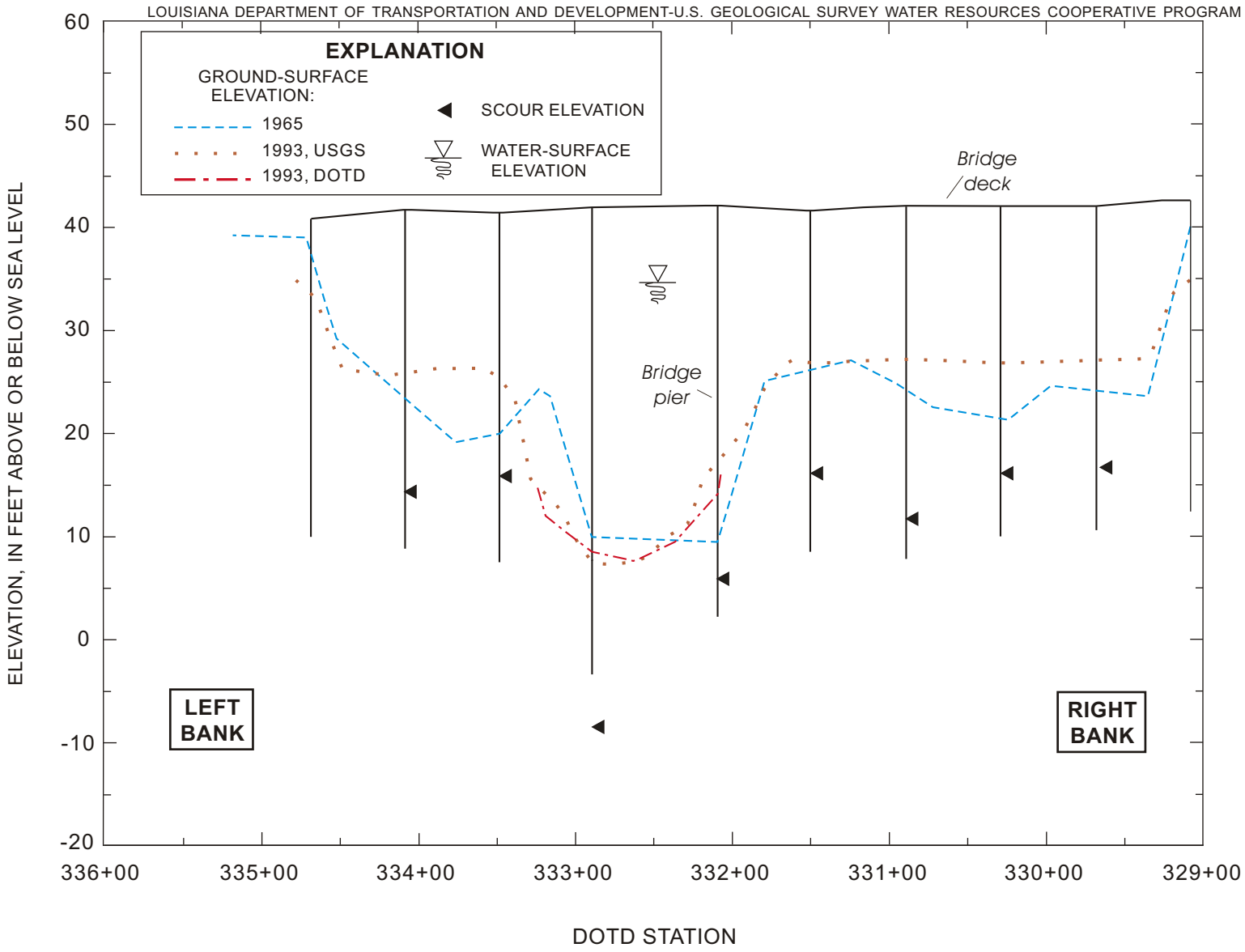


Figure 19. Comparative cross sections and scour estimates at the Interstate Highway 12 crossing of the Tickfaw River near Albany, Louisiana.

Channel Stability

Surveys performed in 1965 and 1993 indicate no instability of the channel. The 1965 cross section represents the original cross-section geometry when the bridge was built, and the information collected in 1993 indicates only minor variations in the channel geometry.

Contraction and Abutment Scour

Flow through the bridge was subdivided into flow in the main channel, left overbank, and right overbank. The average depth at the bridge is approximately 21 ft for the main channel and 9 ft for the overbanks. For computations of contraction scour in the main channel, the channel is approximately 160 ft in width upstream and at the bridge. Contraction scour in the main channel was computed as 2.5 ft. Scour on the left and right overbanks was predicted as 6.3 to 6.5 ft (table 10). Abutment scour computation is not applicable because ground elevations at the abutments are greater than the flood elevation (fig. 19).

Interstate Highway 12 Crossing of the Tangipahoa River near Robert, Louisiana

The Tangipahoa River is a meandering sand-bed stream along its reach near Robert (fig. 20). A USGS gaging station is located near Robert on the U.S. Hwy. 190 bridge, which is located approximately 2 mi upstream of the I-12 bridge crossing of the Tangipahoa. Considering the small difference in drainage area and hydrologic similarity of I-12 and U.S. Hwy. 190 crossings, a Q_{500} estimate based on the streamflow records at U.S. Hwy. 190 is applicable to the I-12 site. The U.S. Hwy. 190 gaging station has a period of record from 1921 to 1994. Flood frequency estimates based on log-Pearson Type III analysis were used for the hydrologic analysis and provided an estimated Q_{500} of 112,500 ft^3/s. The stage associated with the discharge of 112,500 ft^3/s is estimated at 34.5 ft based on the computed stage and discharge characteristics of the site. A frequency analysis of the stage record indicated an S_{500} stage of 34.9 ft, supporting the stage-discharge estimate. Hydraulic simulations from I-12 to U.S. Hwy. 190, resulted in a Q_{500} water-surface elevation of 28.2 ft above sea level at I-12. Based on the conveyances of the main and overflow bridges, 72,700 ft^3/s was apportioned for the main bridge. No road overflow was indicated based on the hydraulic simulations.

Pier Scour

The cross sections (fig. 21) used for this analysis were based on a 1993 DOTD survey. Computations indicate velocities ranging from 3.9 to 9.2 ft/s along the bridge cross section (table 11). The main channel passes through the bridge opening at an angle. The value of K for the main channel piers is l.0 because the piers are aligned with the flow. The maximum pier scour was 7.5 ft at DOTD station 611+32. The resulting bed elevation (including contraction scour estimates) at that station is 11 ft above the pile tip elevation on bridge plans. The estimated scour depth at this location is approximately equal to the pile tip elevation denoted on the bridge plans.

Channel Stability

Cross sections shown in figure 21 indicate slight erosion of the left bank and a shift in the location of the thalweg since 1969. The 1969 cross section represents the original cross-section geometry when the bridge was built. The channel seems to be relatively stable with only minor horizontal changes in the channel section on the left bank after construction.

Photograph source: Louisiana Department of Transportation and Development, October 1992

Figure 20. Aerial photograph of the Interstate Highway 12 crossing of the Tangipahoa River near Robert, Louisiana.

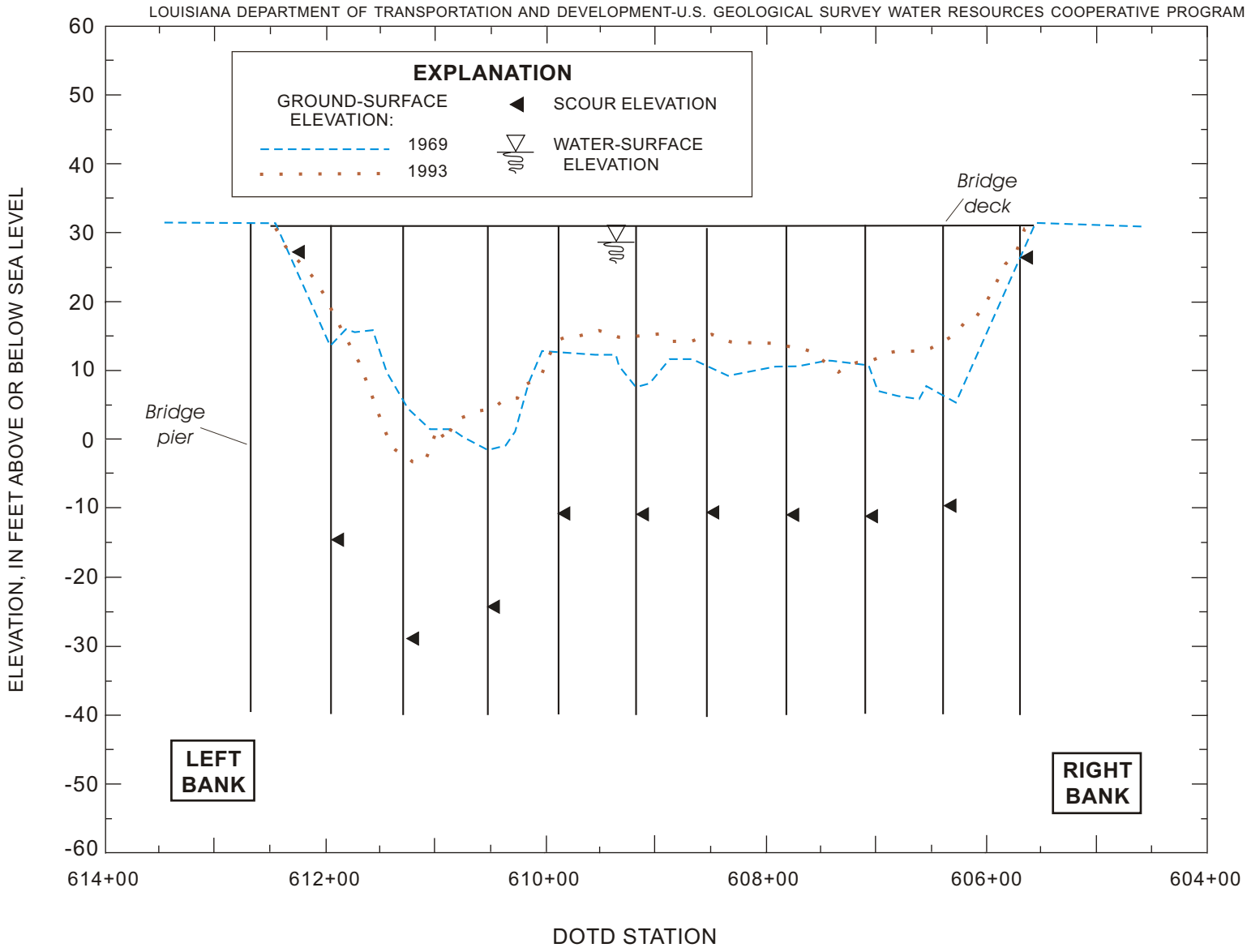


Figure 21. Comparative cross sections and scour estimates at the Interstate Highway 12 crossing of the Tangipahoa River near Robert, Louisiana.

Table 11. Scour data for Interstate Highway 12 crossing of the Tangipahoa River near Robert, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 28.2 feet above sea level; K_2, dimensionless correction factor for angle of flow attack; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above sea level)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above sea level)	Pile tip elevation (ft above sea level)
605+72	28.0	Square	1.0	2.0	3.9	NA	NA	28	-40
606+42	10.0	Square	1.0	2.0	3.9	4.8	14.9	-10	-40
607+12	10.0	Square	1.0	2.0	7.0	6.1	14.9	-11	-40
607+82	10.0	Square	1.0	2.0	6.5	6.0	14.9	-11	-40
608+52	10.0	Square	1.0	2.0	6.0	5.8	14.9	-11	-40
609+22	10.0	Square	1.0	2.0	5.9	5.7	14.9	-11	-40
609+89	10.0	Square	1.0	2.0	5.5	5.5	14.9	-10	-40
610+52	0	Square	1.0	2.0	8.0	6.9	17.5	-24	-40
611+32	-4.0	Square	1.0	2.0	9.2	7.5	17.5	-29	-40
611+95	8.0	Square	1.0	2.0	4.1	5.0	17.5	-14	-40
612+70	28.0	Square	1.0	2.0	4.1	NA	NA	28	-40

Contraction and Abutment Scour

Flow through the bridge was subdivided into flow in the main channel, left overbank, and right overbank. The average depth at the bridge is approximately 25 ft for the main channel and less than 15 ft for the overbanks. For contraction scour in the main channel, the main channel is approximately 175 ft in width at the approach and bridge sections. Contraction scour in the main channel was computed as 17.5 ft. Scour on the left and right overbanks was predicted as 4.3 and 14.9 ft, respectively. The overbanks are vegetated with mature trees and heavy underbrush which extends through the overbank section of the bridge. This vegetation will serve to armor the bed and prevent scouring of the overbank areas. Scour estimates were not necessary at the abutments due to the existing protective spur dikes.

Interstate Highway 12 Crossing of the Tchefuncte River near Covington, Louisiana

The crossing of the Tchefuncte River at I-12 (fig. 22) is immediately downstream of the confluence of the Bogue Falaya and Tchefuncte Rivers and about 2 mi south of the town of Covington. Approximately 1 mile upstream of the confluence of the Bogue Falaya and Tchefuncte Rivers on the Bogue Falaya is the confluence of the Abita River with the Bogue Falaya River. The I-12 crossing is about 5 mi upstream of the mouth at Lake Pontchartrain and is a low sloped coastal site, which can be influenced by winds, tides, and similar backwater conditions. The Q_{500} was approximated using techniques outlined by Ensminger (1998), which resulted in a discharge of 66,443 ft^3/s and a water-surface elevation of 9.8 ft above sea level.

Pier Scour

The cross section (fig. 23) used for this analysis was based a 1993 DOTD survey. The hydraulic simulation indicates velocities ranging from 1.4 to 7.4 ft/s across the stream at the bridge location. The maximum pier scour was 27.8 ft at DOTD station 1336+25 (fig. 23, table 12).

Photograph source: Louisiana Department of Transportation and Development, December 1985

Figure 22. Aerial photograph of the Interstate Highway 12 crossing of the Tchefuncte River near Covington, Louisiana.

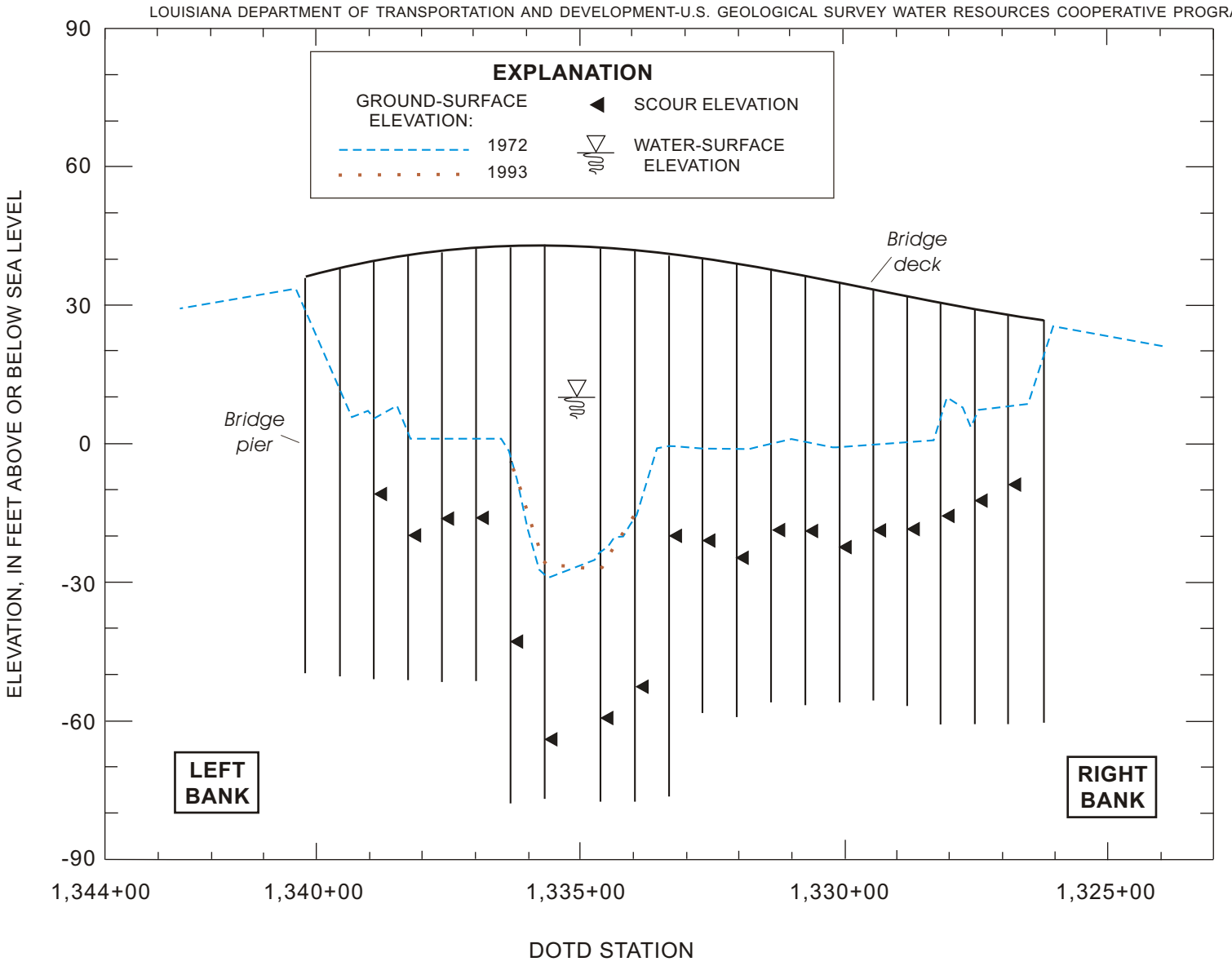


Figure 23. Comparative cross sections and scour estimates at the Interstate Highway 12 crossing of the Tchefuncte River near Covington, Louisiana.

Table 12. Scour data for Interstate Highway 12 crossing of the Tchefuncte River near Covington, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 9.8 feet above sea level; K_2, dimensionless correction factor for angle of flow attack; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above sea level)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above sea level)	Pile tip elevation (ft above sea level)
1326+05	18.0	Abutment	2.5	2.0	NA	NA	NA	NA	-60
1326+69	7.5	Round	2.5	2.0	1.4	5.3	11.5	-9	-60
1327+34	6.0	Round	2.5	2.0	1.4	5.7	11.5	-11	-60
1327+99	6.0	Round	2.5	4.0	1.4	8.9	11.5	-14	-60
1328+64	0	Round	2.5	2.0	1.4	6.4	11.5	-18	-57
1329+29	0	Round	2.5	2.0	1.4	6.4	11.5	-18	-56
1329+94	0	Round	2.5	4.0	1.4	10.1	11.5	-22	-56
1330+59	0	Round	2.5	2.0	2.1	7.7	11.5	-19	-56
1331+24	0	Round	2.5	2.0	2.1	7.7	11.5	-19	-56
1331+89	-1.0	Round	2.5	4.0	2.3	12.7	11.5	-25	-59
1332+54	-1.0	Round	2.5	2.0	2.3	8.1	11.5	-21	-59
1333+19	0	Round	2.5	2.0	2.3	8.0	11.5	-20	-76
1333+84	-15.0	Round	2.5	9.0	2.9	26.5	11.5	-53	-77
1334+49	-24.0	Round	2.5	4.5	6.4	24.8	11.5	-60	-77
1335+60	-29.0	Round	2.5	4.5	7.4	26.9	11.5	-67	-76
1336+25	-4.0	Round	2.5	9.0	3.9	27.8	11.5	-43	-78
1336+90	1.0	Round	2.5	2.0	1.6	6.7	11.5	-17	-52
1337+55	1.0	Round	2.5	2.0	1.6	6.7	11.5	-17	-52
1338+20	3.0	Round	2.5	4.0	1.6	10.2	11.5	-19	-52
1338+85	6.0	Round	2.5	2.0	1.6	6.0	11.5	-12	-52
1339+50	12.0	Round	2.5	2.0	NA	NA	NA	NA	-50
1340+14	30.0	Abutment	2.5	2.0	NA	NA	NA	NA	-50

Channel Stability

Surveys from 1972 to 1993 indicate that the cross section is stable. Cross sections constructed from the surveys at the bridge in 1972 and in 1993 are shown in figure 23. There is no indication from the cross sections shown of any substantial shifting of the channel.

Contraction and Abutment Scour

Evaluation of flow through the bridge as a single contracted section produced greater scour estimates which are presented in this section. The average depth at the bridge is approximately 13 ft, with an opening width of approximately 1,300 ft. Contraction scour at the bridge opening was computed as 11.5 ft. The paved surfaces of the secondary roadways and embankments beneath the bridge near the abutments combined with the wider roadway embankments act similarly to spur dikes in abutment protection. Spur dike structures serve to protect the abutment areas from scouring conditions. Therefore, abutment scour computations are not applicable as per guidelines in HEC 20 (Richardson, 1995).

Pearl River Basin

The Pearl River Basin is approximately 240 mi long and 50 mi wide (fig. 1). The basin drains a large part of Mississippi and part of southeastern Louisiana. The Pearl River originates in northeastern Mississippi, and flows southwestward for 130 mi to the vicinity of Jackson, Mississippi, then southeastward to empty into Lake Borgne. The main channel of the Pearl River has a slope of about 1 ft/mi and varies in width from about 100 to 1,000 ft. The channel meanders within the floodplain and is obstructed in many places by sandbars, brush, and fallen and overhanging trees. The Ross Barnett Reservoir, put into operation in 1961, is just upstream from Jackson, Mississippi, on the Pearl River and is the only major reservoir within the basin. The capacity of the reservoir is not great enough to substantially affect floods of the Q_{500} magnitude (Lee and Arcement, 1981). The Bogue Chitto River is tributary to the Pearl River about 40 mi upstream of the mouth. In the lower reach of the Pearl River, the channel distributes and ultimately forms a system of five channels; the West Pearl River is formed as a distributary channel about 35 mi upstream of the mouth. About 10 mi above the mouth, the Middle River is formed in the floodplain between the Pearl and West Pearl Rivers. The Middle River branches into the West Middle and East Middle Rivers immediately downstream of the Interstate Hwy. 10 (I-10) crossing of the floodplain. About 5 mi above the mouth, and approximately 0.5 mi above U.S. Hwy. 90, the East Middle River branches again forming the East Middle and Middle Rivers.

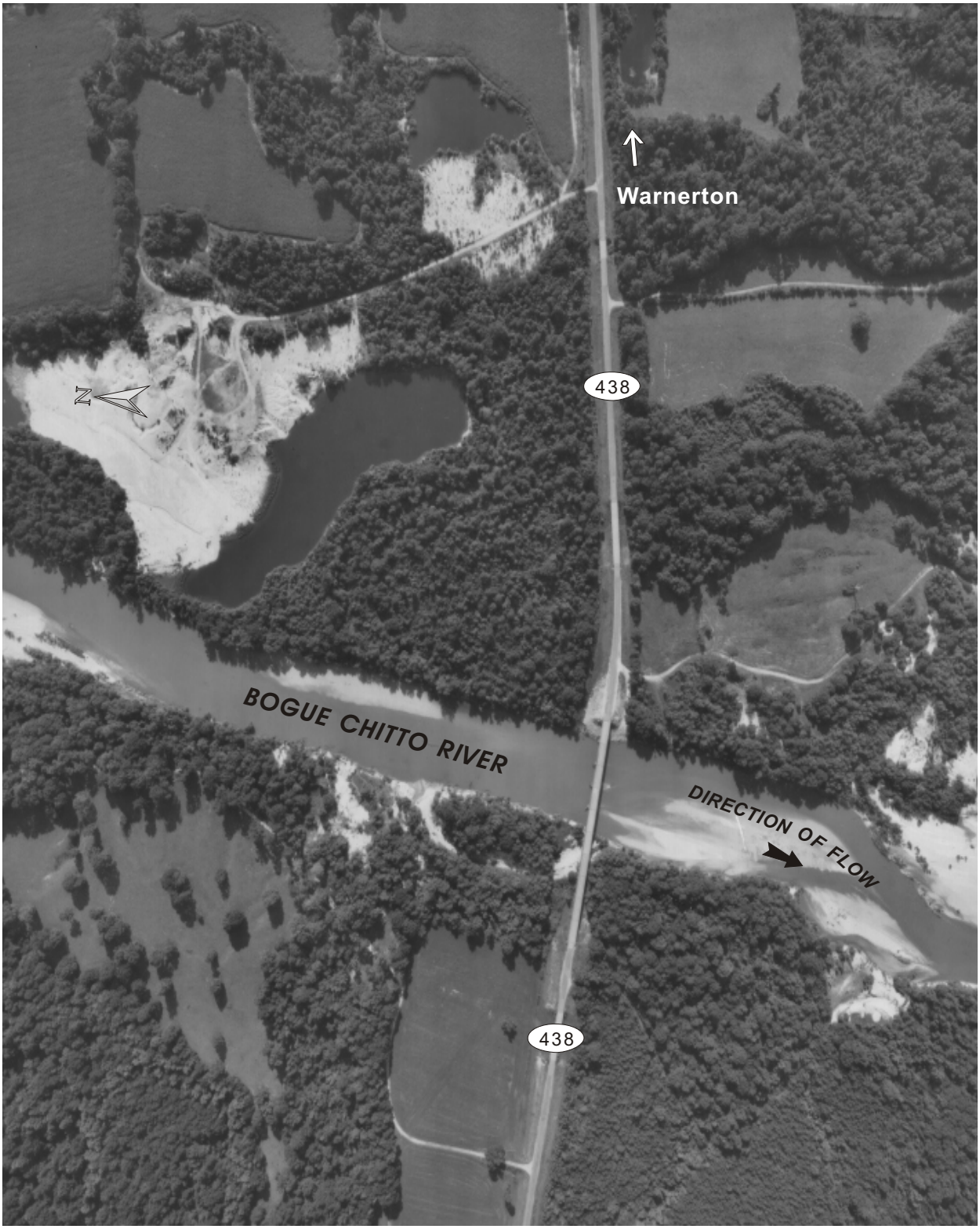
Louisiana Highway 438 Crossing of the Bogue Chitto River near Warnerton

This site, La. Highway 438 crossing of the Bogue Chitto River (fig. 24), has overbank areas consisting of rolling hills and floodplains, which are narrower compared to sites located in the coastal plain. A USGS gaging station on the Bogue Chitto River is located approximately 10.6 mi south at Franklinton. The maximum recorded stage was 148.5 ft above sea level which occurred in 1983, with a discharge of 125,000 ft^3/s.

The log-Pearson Type III estimate of the Q_{500} at Franklinton is 141,740 ft^3/s based on 71 years of record. Procedures as outlined by Lee (1985, p. 26) were used to translate the estimate at the Franklinton gage to the ungaged site at La. Hwy. 438, resulting in a Q_{500} estimate at La. Hwy. 438 of 131,011 ft^3/s.

From the stage-discharge relation at Franklinton, the stage associated with the Q_{500} was 149.5 ft above sea level. The flood slope for the La. Hwy 432-to-Franklinton reach is approximately 4.5 ft/mi. Based on the stage at the gaged site and the flood slope, the elevation associated with the Q_{500} at La. Hwy. 438 is 197.4 ft above sea level. A crest stage gaging station existed on the Bogue Chitto at La. Hwy. 438 from 1959 to 1965. Floods of 1960, 1961, and 1965 had peak information at both the Franklinton and La. Hwy. 438 gages. These historic flood profiles were plotted and compare well with the estimated Q_{500} profile.

The modeled reach for evaluation of La. Hwy. 438 extends from 1,000 ft downstream to 1,000 ft upstream of the bridge crossing. The width of the floodplain at the Q_{500} is approximately 1,300 ft at the bridge.



Photograph source: Louisiana Department of Transportation and Development, June 1990

Figure 24. Aerial photograph of the Louisiana Highway 438 crossing of the Bogue Chitto River near Warnerton.

Pier Scour

The cross section used for this analysis was based on 1993 data obtained by the USGS (fig. 25). Computed velocities range from 3.0 to 9.6 ft/s along the cross section at the bridge; a discharge of 91,700 ft^3/s passes through the bridge. DOTD has extensively armored the left bank and has placed riprap which extends to the pier at station 68 + 99 to stabilize the riverbed. The pile caps of piers at DOTD stations 66+89, 67+59 and 68+23 are located at the surface of the riverbed. Analysis for piers having exposed footings were used to evaluate pier scour at these locations. The maximum scour potential occurred at the piers at DOTD stations 67+59 and 68 + 23, with 5.5 ft of pier scour estimated. Overbank piers have scour potential of 3 ft or less (table 13).

Table 13. Scour data for Louisiana Highway 438 crossing of the Bogue Chitto River near Warnerton

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 197.4 feet above sea level; K_2, dimensionless correction factor for angle of flow attack; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above sea level)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above sea level)	Pile tip elevation (ft above sea level)
63+39	202.0	Abutment	1.0	1.3	3.0	0	0	202	140
64+09	184.0	Square	1.0	1.3	3.1	2.6	3.0	178	142
64+73	178.0	Square	1.0	1.3	3.1	3.0	3.0	172	142
65+43	178.0	Square	1.0	1.3	4.0	3.3	3.0	172	142
66+19	178.0	Square	1.0	1.3	4.2	3.4	3.0	172	138
66+89	173.0	Square	1.0	1.3	8.5	4.6	1.6	167	138
67+59	172.0	Square	1.0	1.3	9.5	5.5	1.6	165	142
68+23	171.0	Square	1.0	1.3	9.3	5.5	1.6	164	142
68+99	183.0	Square	1.0	1.3	9.6	NA	NA	NA	152
69+69	186.0	Square	1.0	1.3	5.7	NA	NA	NA	152
70+38	200.0	Abutment	1.0	1.3	4.0	NA	NA	NA	150

Channel Stability

The 1965 cross section was taken near the time of bridge construction. The historical cross sections that indicate post-construction erosion of the left bank and restoration with armoring riprap are shown in figure 25. The Bogue Chitto River is a braided stream at this location, incising is not indicated, but lateral movement of the channel to the left bank is noted (figs. 24, 25). Surveys from 1965 to 1993 indicate erosion of the left bank, which was mitigated by the installation of riprap for armoring.

Contraction and Abutment Scour

Flow through the bridge was subdivided into flow in the main channel, left overbank, and right overbank. The depth of the channel at the bridge is approximately 25 ft for the main channel and 18 ft for the overbanks. For estimating contraction scour in the main channel, the width was approximately 300 ft at the approach section and at the bridge. Contraction scour in the main channel was computed as 1.6 ft. Scour on the right overbank was estimated as 3.0 ft. The estimate for the left bank is not applicable due to the protective material placed to armor that area. No abutment scour was indicated at this site.

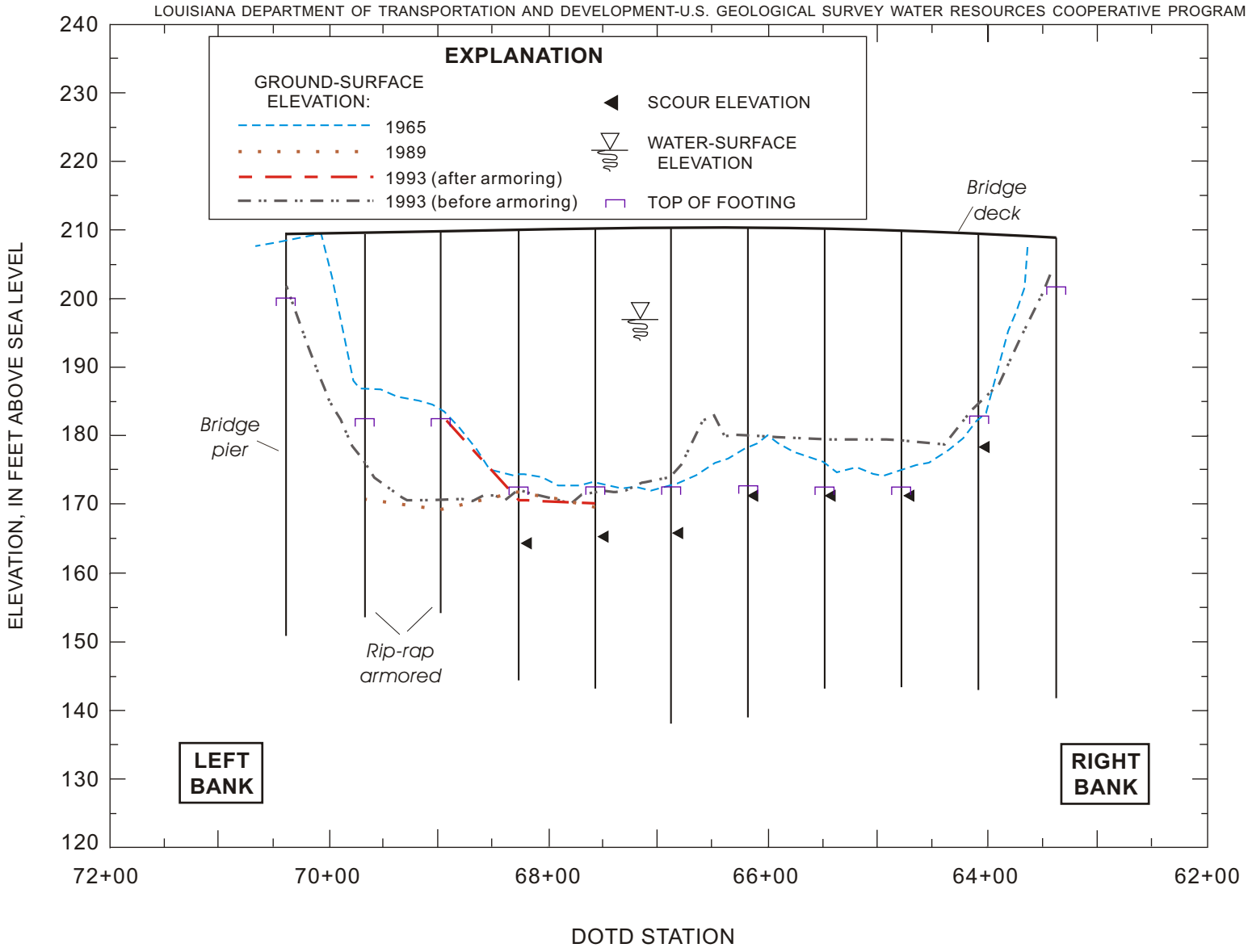


Figure 25. Comparative cross sections and scour estimates at the Louisiana Highway 438 crossing of the Bogue Chitto River near Warnerton.

Interstate Highway 59 Crossings

The I-59 crosses the West Pearl and Pearl Rivers. The Q_{500} of 275,300 ft^3/s was apportioned between the two main bridges and the relief openings using previous discharge measurements. The Pearl River conveyed 33,040 ft^3/s while the West Pearl River was apportioned 165,200 ft^3/s.

Pearl River near Pearl River, Louisiana

The I-59 bridge opening for the Pearl River near Pearl River (fig. 26) is the easternmost opening of the multiple channels at this highway crossing. This channel locally referred to as the East Pearl River is the eastern channel of the Pearl River and West Pearl River distributary located approximately 15 mi upstream of the highway crossing.

Pier Scour

The cross sections used for the analysis of the I-59 crossings were the 1956 pre-construction survey and the 1993 survey performed by DOTD (fig. 27). The water-surface elevation associated with the Q_{500} is approximately 24 ft above sea level. Computed velocities within the bridge opening for the Q_{500} ranged from 3.0 to 8.4 ft/s along the bridge cross section (table 14). The maximum pier scour was 11.4 ft at DOTD station 448+90. Estimated scour at the overbank bents was less than 3 ft.

Table 14. Scour data for Interstate Highway 59 crossing of the Pearl River near Pearl River, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 24.2 feet above sea level; K_2, dimensionless correction factor for angle of flow attack; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above sea level)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above sea level)	Pile tip elevation (ft above sea level)
446+45	32.0	Abutment	NA	NA	NA	NA	9.5	23	NA
446+65	20.0	Round	1.0	1.4	3.0	2.5	9.5	8	-5
446+85	17.0	Round	1.0	1.4	3.0	2.7	9.5	5	-5
447+05	17.0	Round	1.0	1.4	3.0	2.7	9.5	5	-5
447+25	13.0	Round	1.0	3.0	3.0	4.7	9.5	-1	-5
448+00	10.0	Round	1.0	5.0	6.1	9.2	9.5	-9	-15*
448+90	0	Round	1.0	5.0	8.4	11.4	9.5	-21	-15*
449+65	10.0	Round	1.0	3.0	3.5	5.2	9.5	-5	-5
449+85	20.0	Round	1.0	1.4	3.5	2.7	9.5	8	-5
450+05	20.0	Round	1.0	1.4	3.5	2.7	9.5	8	-5
450+25	20.0	Round	1.0	1.4	3.5	2.7	9.5	8	-5
450+65	32.0	Abutment	NA	NA	NA	NA	9.5	23	NA

*Bottom of footing elevation, pile tips extend below footing.

Photograph source: Louisiana Department of Transportation and Development, March 1992

Figure 26. Aerial photograph of the Interstate Highway 59 crossing of the Pearl River near Pearl River, Louisiana.

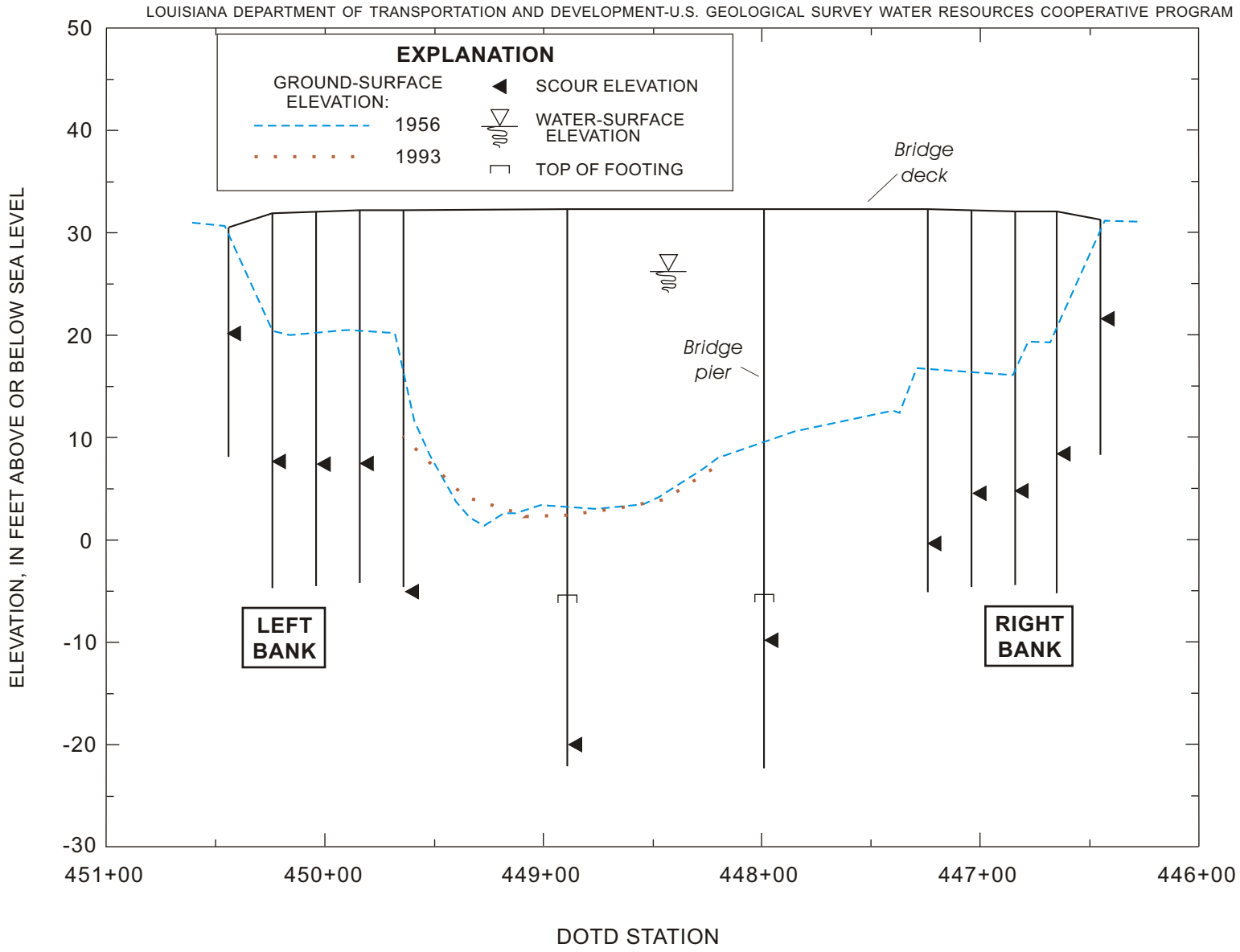


Figure 27. Comparative cross sections and scour estimates at the Interstate Highway 59 crossing of the Pearl River near Pearl River, Louisiana.

Channel Stability

The channels of the lower Pearl River show evidence of minor channels or old meanders, but the reach of the Pearl River near the I-59 bridge is straight. The railroad crossing and embankment which is about 5 channel widths upstream may prevent any major later movements of the main channel (fig. 26). The cross-section information does not indicate any vertical or lateral movement of the channel.

Contraction and Abutment Scour

Flow through the embankment opening was not subdivided into main channel and overbank flow areas. Computed contraction scour based on the opening evaluated as a single section was 9.5 ft.

West Pearl River near Pearl River, Louisiana

The I-59 bridge opening for the West Pearl River (fig. 28) near Pearl River is the westernmost opening for the multiple channels at this highway crossing. This channel is the western channel of the Pearl River and West Pearl River distributary approximately 15 mi upstream of the highway crossing.

Pier Scour

The cross section (fig. 29) used for the scour analysis was the 1988 cross section. The 1980 cross section does show lower bed elevations, but this cross section was taken during the second largest flood of record and represents the scoured condition. The 1988 cross section may still represent a scour condition since the largest flood of record occurred in 1983. Computed velocities at the bridge cross section ranged from 2.1 to 10.0 ft/s. The maximum pier scour was 12.4 ft at DOTD station 68+57 (table 15). The presence of timber fenders near the main piers may reduce the amount of pier scour (Abed and Richardson, 1993).

Channel Stability

The channels of the lower Pearl Rivers show evidence of old meanders and minor channels, one of which passes through the existing embankment opening for the West Pearl Rivers (fig. 28). Although a significant decrease in thalweg elevation has been shown to occur at the main channel during flood flows, no lateral movement has been observed. The embankment for the railroad which is immediately upstream of the highway embankment may serve to maintain the existing horizontal location of the West Pearl River main channel.

Contraction and Abutment Scour

The opening for the West Pearl River was subdivided into main channel and overbank areas for evaluation of contraction scour. The overbank areas had computed scour estimates of 6 to 10 ft. No contraction scour was indicated for the main channel section, which may be due to the cross section which represents a scoured condition. Abutment scour was not computed at this site due to the protective features provided by secondary roadways and paving at the abutments.

Photograph source: Louisiana Department of Transportation and Development, March 1992

Figure 28. Aerial photograph of the Interstate Highway 59 crossing of the West Pearl River near Pearl River, Louisiana.

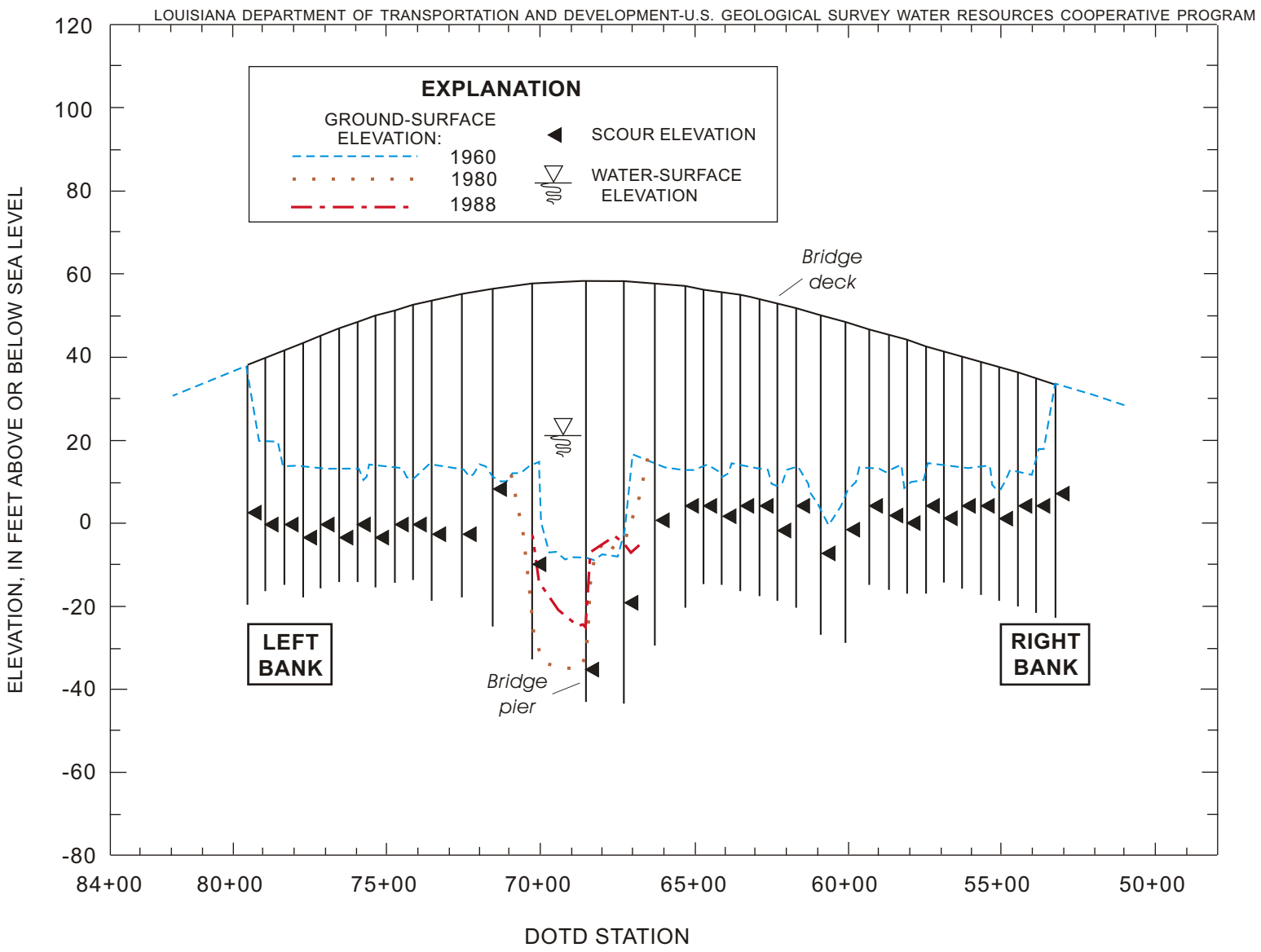


Figure 29. Comparative cross sections and scour estimates at the Interstate Highway 59 crossing of the West Pearl River near Pearl River, Louisiana.

Table 15. Scour data for Interstate Highway 59 crossing of the West Pearl River near Pearl River, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 21.9 feet above sea level; K_2, dimensionless correction factor for angle of flow attack; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above sea level)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above sea level)	Pile tip elevation (ft above sea level)
53+32	13.0	Abutment	NA	NA	NA	NA	6.5	6	-23
53+92	13.0	Round	1.0	2.0	2.2	2.8	6.5	4	-23
54+52	13.0	Round	1.0	2.0	2.2	2.8	6.5	4	-20
55+12	10.0	Round	1.0	2.0	2.2	3.2	6.5	0	-20
55+72	13.0	Round	1.0	2.0	2.2	2.8	6.5	4	-18
56+32	13.0	Round	1.0	2.0	2.2	2.8	6.5	4	-18
56+92	13.0	Round	1.0	4.0	2.2	4.4	6.5	2	-18
57+52	13.0	Round	1.0	2.0	2.2	2.8	6.5	4	-18
58+12	10.0	Round	1.0	2.0	2.2	3.2	6.5	0	-18
58+72	13.0	Round	1.0	4.0	2.2	4.4	6.5	2	-18
59+32	13.0	Round	1.0	2.0	2.2	2.8	6.5	4	-18
60+12	10.0	Round	1.0	4.0	2.2	5.0	6.5	2	-30
60+92	0	Round	1.0	4.0	2.2	5.5	6.5	-12	-28
61+72	13.0	Round	1.0	2.0	2.2	2.8	6.5	4	-21
62+32	10.0	Round	1.0	4.0	2.2	5.0	6.5	2	-18
62+90	13.0	Round	1.0	2.0	2.2	2.8	6.5	4	-18
63+52	13.0	Round	1.0	2.0	2.1	2.8	6.5	4	-16
64+12	13.0	Round	1.0	4.0	2.1	4.4	6.5	2	-15
64+72	13.0	Round	1.0	2.0	2.1	2.8	6.5	4	-15
65+32	13.0	Round	1.0	2.0	2.1	2.8	6.5	4	-21
66+32	13.0	Round	1.0	4.0	2.1	4.4	6.5	2	-30
67+32	-10.0	Round	1.0	4.5	6.1	9.4	0	-19	-45
68+57	-25.0	Round	1.0	4.5	10.0	12.4	0	-36	-45
70+32	-5.0	Round	1.0	4.5	2.6	6.4	0	-11	-33
71+57	13.0	Round	1.0	4.5	2.6	5.2	0	-8	-25
72+57	13.0	Round	1.0	4.0	2.6	4.8	9.7	-2	-18
73+57	13.0	Round	1.0	2.0	2.6	3.0	9.7	0	-18
74+17	11.0	Round	1.0	2.0	2.6	3.2	9.7	-2	-18
74+77	13.0	Round	1.0	4.0	2.6	4.8	9.7	-2	-18
75+37	13.0	Round	1.0	2.0	2.6	3.0	9.7	0	-18
75+97	13.0	Round	1.0	2.0	2.6	3.0	9.7	0	18
76+57	13.0	Round	1.0	4.0	2.6	4.8	9.7	-2	18
77+17	13.0	Round	1.0	2.0	2.6	3.0	9.7	0	18
77+77	13.0	Round	1.0	4.0	2.6	4.8	9.7	-2	18
78+32	13.0	Round	1.0	2.0	2.6	3.0	9.7	0	-15
78+97	13.0	Round	1.0	2.0	2.6	3.0	9.7	0	-17
79+57	13.0	Abutment	NA	NA	NA	NA	9.7	3	-20

Interstate Highway 10 Crossings

The Q_{500} of 275,300 cfs was distributed among the openings for the Pearl, Middle, West Pearl Rivers, and roadway overflow. The Pearl River was apportioned 146,460 ft^3/s, the Middle River 37,720 ft^3/s, the West Pearl River 49,280 ft^3/s, and road overflow was apportioned 41,840 ft^3/s. The cross-section information used for the scour analysis was based on the cross-section data collected in 1980 by the USGS and by data collected in 1965 and 1993 by DOTD.

Pearl River near Slidell, Louisiana

The bridge opening for the Pearl River in the I-10 embankment is the most eastern opening for the multiple channels at this highway crossing. This channel, locally referred to as the East Pearl River, is the eastern channel of the Pearl River and West Pearl River distributary that is located approximately 19 mi upstream of the highway crossing. Wastehouse Bayou, which is a channel formed within the floodplain, is tributary to the Pearl River immediately upstream of the highway crossing. Between the connection with Wastehouse Bayou and the highway crossing, the Pearl River completes a 90 degree bend to the left (fig. 30).

Pier Scour

The greatest scour occurs at the wider main channel piers at DOTD stations 372+07 and 373+72 where the predicted scour is approximately 35 ft (table 16, fig. 31). Pier scour at the piers that are near but not in the channel ranged from approximately 3.8 to 10.3 ft. The estimated pier scour depth at the overbank piers was approximately 2 ft. There are large timber fenders protecting the two center channel piers. The presence of these fenders may serve to reduce the amount of pier scour for those piers (Abed and Richardson, 1993).

Channel Stability

The channel in the floodplain shows evidence of naturally occurring old meanders and some which were cut off by man. The floodplain is heavily vegetated with mature trees and underbrush which provides some control in maintaining the orientation of the channel upstream of the bridge. The timber fender structures at the bridge (fig. 30) may also serve to align the flow through the bridge and reduce tendencies for lateral migration. The historical cross-section information at the bridge does not indicate any lateral movement of the channel, but does show some lowering of the channel bed. The 1965 survey was measured by DOTD before bridge construction. The 1980 cross section measured by USGS shows that the main channel has scoured resulting in a reduction of the minimum bed elevation of over 20 ft. This lowering of the channel bed may have been the cumulative effect of contraction scour from the floods of 1980 and 1983.

Contraction and Abutment Scour

Flow through the bridge was subdivided into flow in the main channel, left overbank, and right overbank. No scour was indicated in the overbank areas. The 1965 geometry was pre-construction and also prior to the 1980 and 1983 floods which had recurrence intervals of greater than 50 and greater than 200 years respectively. Contraction scour in the main channel was computed based on the geometry of 1980 although it may already reflect scoured conditions. The computed scour elevations are similar to the elevations observed during the record flood peak in 1983. Flow in the main channel upstream of the bridge was defined as a section representing the bank-full width of the channel. The main channel had an average depth of 42 ft and a computed scour of 15.7 ft. This site provides some physical credibility to the prediction equations, although overbank scour predictions do not match the observed data. Visual inspections at the site after the 1983 flood peak (200-year) did not indicate overbank scouring. The presence of mature underbrush vegetation may have provided some scour protection in the overbank areas. No abutment scour was indicated at this site due to roadway overtopping.

Photograph source: Louisiana Department of Transportation and Development, March 1992

Figure 30. Aerial photograph of the Interstate Highway 10 crossing of the Pearl River near Slidell, Louisiana.

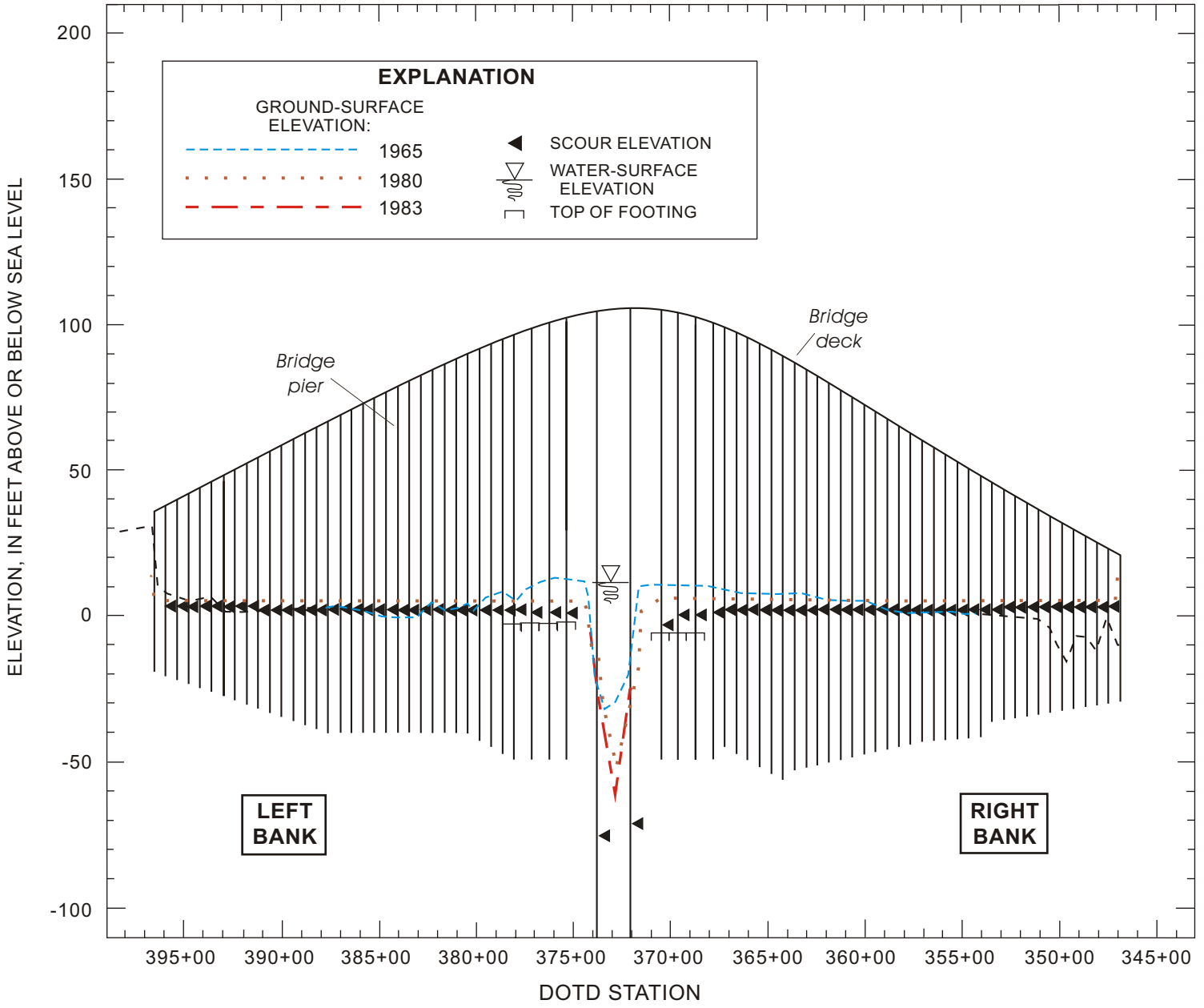


Figure 31. Comparative cross sections and scour estimates at the Interstate Highway 10 crossing of the Pearl River near Slidell, Louisiana.

Table 16. Scour data for Interstate Highway 10 crossing of the Pearl River near Slidell, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 12.5 feet above sea level; K_2, dimensionless correction factor for angle of flow attack; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above sea level)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above sea level)	Pile tip elevation (ft above sea level)
346+76	5.0	Abutment	1.0	1.5	0.9	NA	0	5	-30
347+38	5.0	Square	1.0	2.0	.9	1.9	0	3	-30
347+99	5.0	Square	1.0	2.0	.9	1.9	0	3	-31
348+58	5.0	Square	1.0	2.0	.9	1.9	0	3	-31
349+18	5.0	Square	1.0	2.0	.9	1.9	0	3	-32
349+78	5.0	Square	1.0	2.0	.9	1.9	0	3	-32
350+38	5.0	Square	1.0	2.0	.9	1.9	0	3	-33
350+98	5.0	Square	1.0	2.0	.9	1.9	0	3	-33
351+58	5.0	Square	1.0	2.0	.9	1.9	0	3	-34
352+18	5.0	Square	1.0	2.0	.9	1.9	0	3	-34
352+78	5.0	Square	1.0	2.0	.9	1.9	0	3	-35
353+38	5.0	Square	1.0	2.0	.9	1.9	0	3	-35
353+98	5.0	Square	1.0	3.0	.9	2.4	0	3	-35
354+58	5.0	Square	1.0	3.0	.9	2.4	0	3	-35
355+18	5.0	Square	1.0	3.0	.9	2.4	0	3	-40
355+78	5.0	Square	1.0	3.0	.9	2.4	0	3	-40
356+38	5.0	Square	1.0	3.0	.9	2.4	0	3	-40
356+98	5.0	Square	1.0	3.0	.9	2.4	0	3	-40
357+58	5.0	Square	1.0	3.0	.9	2.4	0	3	-40
358+18	5.0	Square	1.0	3.0	.9	2.4	0	3	-42
358+78	5.0	Square	1.0	3.0	.9	2.4	0	3	-44
359+38	5.0	Square	1.0	3.0	.9	2.4	0	3	-46
359+98	5.0	Square	1.0	3.0	.9	2.4	0	3	-48
360+58	5.0	Square	1.0	3.0	.9	2.4	0	3	-49
361+18	5.0	Square	1.0	3.0	.9	2.4	0	3	-50
361+78	5.0	Square	1.0	3.0	.9	2.4	0	3	-51
362+38	5.0	Square	1.0	3.0	.9	2.4	0	3	-52
362+98	5.0	Square	1.0	3.0	.9	2.4	0	3	-53
363+58	5.0	Square	1.0	3.0	.9	2.4	0	3	-54
364+18	5.0	Square	1.0	3.0	.9	2.4	0	3	-55
364+78	5.0	Square	1.0	3.0	.9	2.4	0	3	-52
365+38	5.0	Square	1.0	3.0	.9	2.4	0	3	-49
365+98	5.0	Square	1.0	3.0	.9	2.4	0	3	-46
366+58	5.0	Square	1.0	3.0	.9	2.4	0	3	-43
367+18	5.0	Square	1.0	3.0	.9	2.4	0	3	-40
367+78	5.0	Square	1.0	6.0	.9	3.8	0	1	-50
368+47	5.0	Square	1.0	6.0	2.0	5.4	0	0	-50
369+58	5.0	Square	1.0	6.0	2.0	5.4	0	0	-50
370+48	5.0	Square	1.0	6.0	9.0	10.3	0	-5	-50
372+07	-21.0	Square	1.0	26.0	10.4	34.7	15.7	-71	-110

Table 16. Scour data for Interstate Highway 10 crossing of the Pearl River near Slidell, Louisiana—Continued

DOTD station	Ground elevation (ft above sea level)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above sea level)	Pile tip elevation (ft above sea level)
373+72	-24.0	Square	1.0	26.0	10.3	34.9	15.7	-75	-110
375+31	5.0	Square	1.0	6.0	0.9	3.8	0	1	-50
376+21	5.0	Square	1.0	6.0	.9	3.8	0	1	-50
377+11	5.0	Square	1.0	6.0	.9	3.8	0	1	-50
378+01	5.0	Square	1.0	6.0	.9	3.8	0	1	-50
378+61	5.0	Square	1.0	3.0	.9	2.4	0	3	-48
379+21	5.0	Square	1.0	3.0	.9	2.4	0	3	-46
379+81	5.0	Square	1.0	3.0	.9	2.4	0	3	-44
380+41	5.0	Square	1.0	3.0	.9	2.4	0	3	-42
381+01	5.0	Square	1.0	3.0	.9	2.4	0	3	-40
381+61	5.0	Square	1.0	3.0	.9	2.4	0	3	-40
382+81	5.0	Square	1.0	3.0	.9	2.4	0	3	-40
383+41	5.0	Square	1.0	3.0	.9	2.4	0	3	-40
384+01	5.0	Square	1.0	3.0	.9	2.4	0	3	-40
384+61	5.0	Square	1.0	3.0	.9	2.4	0	3	-40
385+21	5.0	Square	1.0	3.0	.9	2.4	0	3	-40
385+81	5.0	Square	1.0	3.0	.9	2.4	0	3	-40
386+41	5.0	Square	1.0	3.0	.9	2.4	0	3	-40
387+01	5.0	Square	1.0	3.0	.9	2.4	0	3	-40
387+61	5.0	Square	1.0	3.0	.9	2.4	0	3	-40
388+21	5.0	Square	1.0	3.0	.9	2.4	0	3	-38
388+81	5.0	Square	1.0	3.0	.9	2.4	0	3	-36
389+41	5.0	Square	1.0	3.0	.9	2.4	0	3	-34
390+01	5.0	Square	1.0	3.0	.9	2.4	0	3	-32
390+61	5.0	Square	1.0	3.0	.9	2.4	0	3	-32
391+21	5.0	Square	1.0	3.0	.9	2.4	0	3	-30
391+81	5.0	Square	1.0	3.0	.9	2.4	0	3	-30
392+41	5.0	Square	1.0	2.0	.9	1.9	0	3	-28
393+01	5.0	Square	1.0	2.0	.9	1.9	0	3	-26
393+61	5.0	Square	1.0	2.0	.9	1.9	0	3	-26
394+21	5.0	Square	1.0	2.0	.9	1.9	0	3	-24
394+81	5.0	Square	1.0	2.0	.9	1.9	0	3	-23
395+41	5.0	Square	1.0	2.0	.9	1.9	0	3	-22
396+01	5.0	Square	1.0	2.0	.9	1.9	0	3	-21
396+63	5.0	Abutment	1.0	2.0	.9	NA	0	5	-20

Middle Pearl River near Slidell, Louisiana

The bridge opening for the Middle Pearl River in the I-10 embankment is located approximately midway between the openings for the Pearl and West Pearl Rivers. The Middle Pearl River is formed as a distributary of the West Pearl River approximately 2 mi upstream of the I-10 highway embankment. The channel is meandrous and crosses the highway at an angle (fig. 32).

Pier Scour

Although the bridge crossed the channel at an angle, the pile bents are aligned with the flow. The simulation of the Q_{500} produced velocities ranging from approximately 2 to 7 ft/s at the bridge with a water-surface elevation of approximately 12 ft above sea level. The greatest pier scour occurs at the overbank pier near the main channel at DOTD station 298+39, where the predicted pier scour is approximately 4 ft (table 17, fig. 33). Scour at the three main piers that are in the channel and at the overbank piers was approximately 3 ft. The bed elevation resulting from pier and contraction scour is less than the pile tip elevation from the bridge plans. Some degree of failure was experienced during the 1983 (200-year) flood at this site and remedial work was completed. Although scour estimates show bed elevations below the pile tip elevation, the "as-built" pile tip elevations of the remedial work is not shown in figure 33.

Table 17. Scour data for Interstate Highway 10 crossing of the Middle Pearl River near Slidell, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 12.0 feet above sea level; K_2, dimensionless correction factor for angle of flow attack; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above sea level)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above sea level)	Pile tip elevation (ft above sea level)
294+87	15.0	Abutment	NA	NA	NA	NA	9.0	-6	-40
295+59	5.0	Square	1.0	2.0	2.2	2.7	9.0	-7	-40
296+29	5.0	Square	1.0	2.0	2.2	2.7	9.0	-7	-40
296+99	5.0	Square	1.0	2.0	2.1	2.7	9.0	-7	-40
297+69	5.0	Square	1.0	2.0	4.6	3.7	9.0	-8	-40
298+39	-5.0	Square	1.0	2.0	6.8	4.4	9.0	-16	-40
299+09	-20.0	Square	1.0	2.0	1.9	3.1	31.0	-54	-40
299+79	-23.0	Square	1.0	2.0	1.8	3.1	31.0	-57	-40
300+49	-18.0	Square	1.0	2.0	1.8	3.0	31.0	-52	-40
301+19	-5.0	Square	1.0	2.0	2.1	2.7	6.0	-14	-40
301+89	5.0	Square	1.0	2.0	2.1	2.7	6.0	-4	-40
302+61	20.0	Abutment	NA	NA	NA	NA	6.0	-1	-40

Channel Stability

The Middle Pearl River is shallow at its origin and increases in depth until it passes through the I-10 bridge. The cross-section information at the bridge does not indicate any lateral movement of the channel. Increases in depth are indicated from the cross section taken before construction (1932) and after construction (1980); depth has remained stable since 1980.

Photograph source: Louisiana Department of Transportation and Development, March 1992

Figure 32. Aerial photograph of the Interstate Highway 10 crossing of the Middle Pearl River near Slidell, Louisiana.

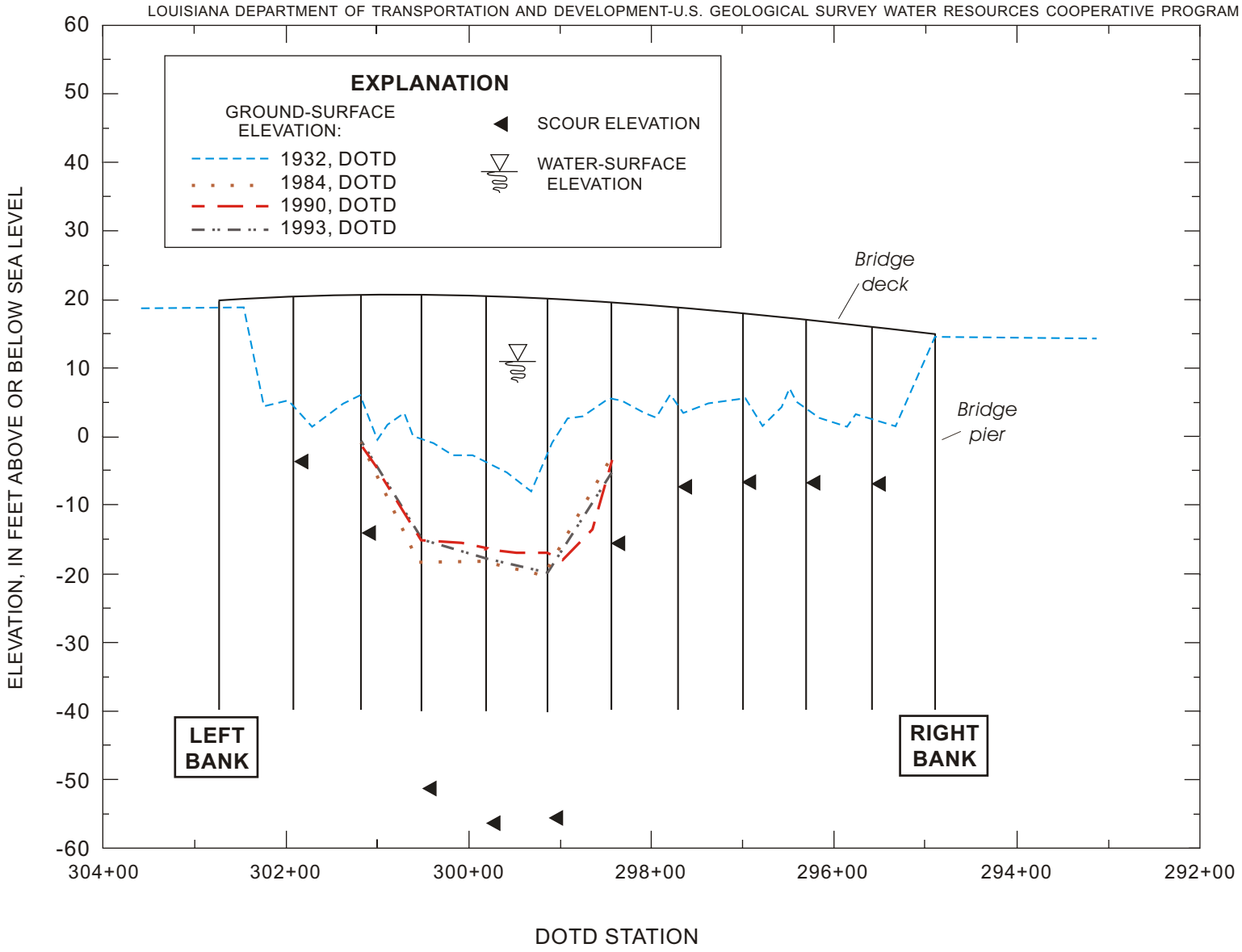


Figure 33. Comparative cross sections and scour estimates at the Interstate Highway 10 crossing of the Middle Pearl River near Slidell, Louisiana.

Contraction and Abutment Scour

Flow through the bridge was subdivided into flow in the main channel, left overbank, and right overbank. The average depth of the channel increases just downstream of I-10. Contraction scour in the main channel was computed based on the geometry of 1990. Contraction scour estimates were more than five times the magnitude of pier scour estimates at this site. For contraction scour computation, the flow in the main channel upstream was defined as a section of the channel and floodplain equal in width to the bridge opening at the roadway. The scour computation based on this channel and floodplain section was applied only to the main channel part of the bridge sections. The main channel had an average depth of 12 ft and a computed scour of 31 ft. Scour on the left and right overbanks was estimated as 6 and 9 ft, respectively. The greatest contraction scour for the I-10 crossings of the Pearl River was estimated at this site. Inspection of the site after the 1983 flood did not reveal significant scouring of the overbank areas. The overbanks are well vegetated which may reduce scour potential in the overbanks. Abutment scour computations are not applicable when spur dikes or other protective measures are in place.

West Pearl River near Slidell, Louisiana

The bridge opening for the West Pearl River in the I-10 embankment is the most western opening for the multiple channels at this highway crossing. This channel is the western channel of the Pearl River and West Pearl River distributary that is located approximately 19 mi upstream of the I-10 crossing. The channel meanders (fig. 34) in the floodplain and shows evidence of old meanders and minor channels. The channel is straight for several channel widths upstream of the bridge, but bends to the east then west within one floodplain width upstream of the highway crossing.

Pier Scour

Simulations of the Q_{500} produced velocities ranging from approximately 1 to 6 ft/s within the bridge opening and a water-surface elevation of approximately 13 ft above sea level at the bridge. The greatest scour occurs at the wider main channel piers at DOTD stations 177+55 and 179+00, where the predicted scour is approximately 15 ft (table 18, fig. 35). The final predicted bed elevation including contraction scour at the piers is -34 and -30 ft above sea level, respectively. The scour predicted at this site agrees with both cross sections taken after the major floods of 1980 and 1983, providing some field verification of the maximum scour computations. Timber fenders protect the two center main channel piers from the river traffic. The presence of these structures may tend to reduce pier scour at those locations (Abed and Richardson, 1993). Estimated scour depth at the overbank piers was approximately 2 ft.

Channel Stability

The cross-section information at the bridge does not indicate any lateral movement of the channel. The timber fenders may serve to align the flow through the bridge, reducing any tendencies for lateral movement (fig. 34). There has been some concern in the past of the existence of scoured areas of the channel immediately downstream of the bridge, and that those increased depths could migrate upstream to the bridge. Some speculation to the cause of the deepening is due to the flow jet which may form during flood flows, eroding material from the river bottom immediately downstream of the bridge. Monitoring the depth and position of this hole downstream of the bridge may prove to be beneficial.

Photograph source: Louisiana Department of Transportation and Development, March 1992

Figure 34. Aerial photograph of the Interstate Highway 10 crossing of the West Pearl River near Slidell, Louisiana.

Table 18. Scour data for Interstate Highway 10 crossing of the West Pearl River near Slidell, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 12.7 feet above sea level; K_2, dimensionless correction factor for angle of flow attack; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above sea level)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above sea level)	Pile tip elevation (ft above sea level)
166+90	4.0	Abutment	1.1	2	0.8	NA	0	4	-30
167+50	4.0	Square	1.1	2	.8	1.8	0	2	-30
168+20	4.0	Square	1.1	2	.8	1.8	0	2	-30
168+90	4.0	Square	1.1	2	.8	1.8	0	2	-30
169+55	4.0	Square	1.1	4	.8	2.8	0	1	-30
170+22	4.0	Square	1.1	2	.8	1.8	0	2	-30
170+88	4.0	Square	1.1	2	.8	1.8	0	2	-30
171+55	4.0	Square	1.1	2	.8	1.8	0	2	-30
172+20	4.0	Square	1.1	4	.8	2.8	0	1	-30
172+90	5.0	Square	1.1	2	.8	1.8	0	3	-30
173+55	5.0	Square	1.1	2	.8	1.8	0	3	-30
174+20	5.0	Square	1.1	2	.8	1.8	0	3	-30
174+90	5.0	Square	1.1	4	.8	2.8	0	2	-30
175+50	5.0	Square	1.1	2	.8	1.8	0	3	-30
176+20	5.0	Square	1.1	2	3.9	3.5	0	2	-40
176+90	5.0	Square	1.1	2	3.9	3.5	0	2	-40
177+55	-8.0	Square	1.1	4	6.0	15.6	10.4	-34	-40
179+00	-5.0	Square	1.1	4	6.0	15.2	10.4	-30	-40
179+65	5.0	Square	1.1	2	4.7	3.8	0.6	1	-40
180+30	5.0	Square	1.1	2	4.7	3.8	.6	1	-40
181+00	5.0	Square	1.1	2	1.0	2.0	.6	2	-30
181+65	4.0	Square	1.1	4	1.0	3.1	.6	0	-30
182+30	4.0	Square	1.1	2	1.0	2.0	.6	1	-30
183+00	3.0	Square	1.1	2	1.0	2.0	.6	0	-30
183+65	3.0	Square	1.1	2	1.0	2.0	.6	0	-30
184+35	3.0	Square	1.1	2	1.0	2.0	.6	0	-30
185+00	2.0	Square	1.1	2	1.0	2.0	.6	-1	-30
185+65	2.0	Square	1.1	2	1.0	2.0	.6	-1	-30
186+35	2.0	Square	1.1	2	1.0	2.0	.6	-1	-30
187+00	2.0	Square	1.1	4	1.0	3.2	.6	-2	-30
187+65	2.0	Square	1.1	2	1.0	2.0	.6	-1	-30
188+30	2.0	Square	1.1	2	1.0	2.0	.6	-1	-30
189+00	2.0	Abutment	1.1	2	1.0	NA	.6	-2	-30

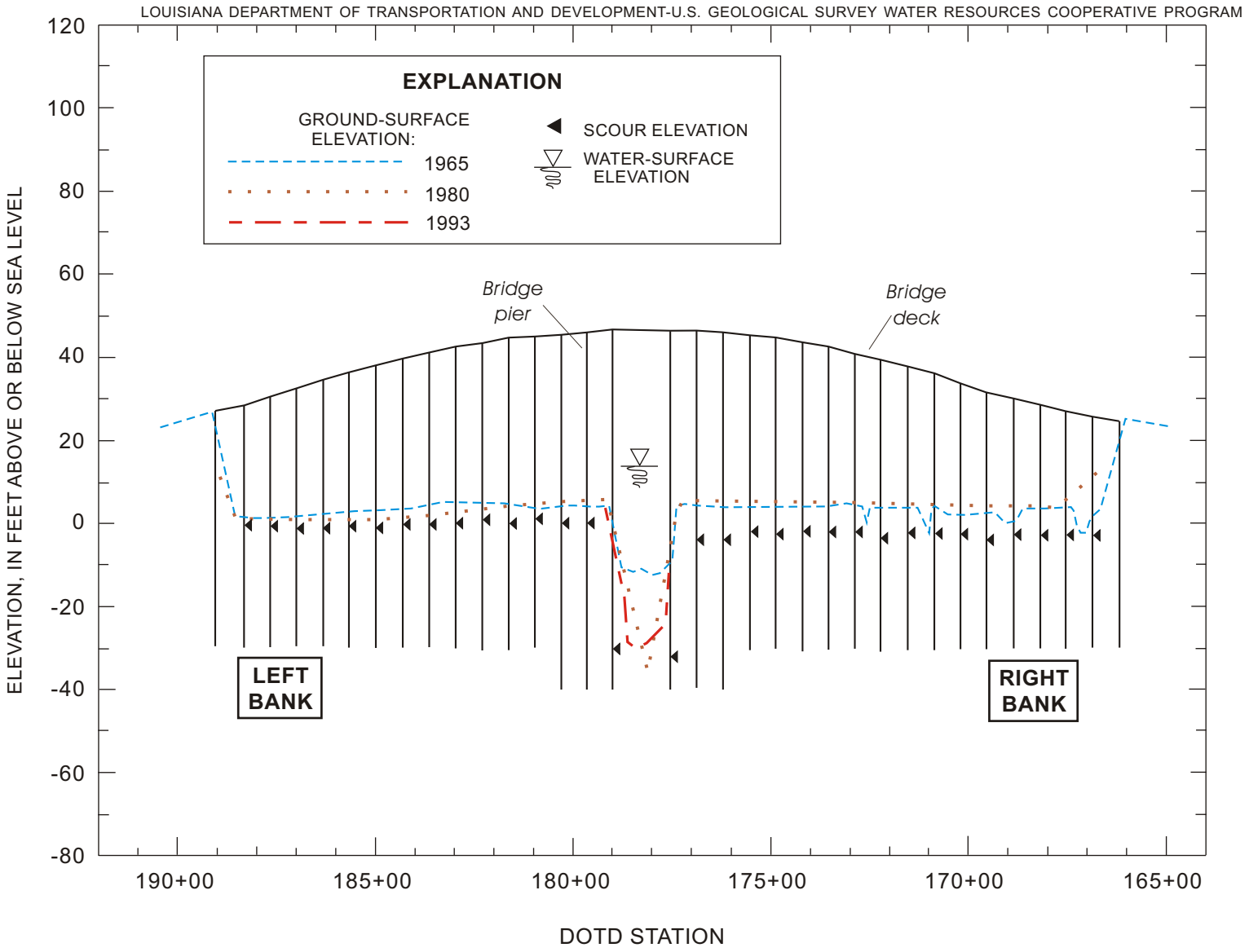


Figure 35. Comparative cross sections and scour estimates at the Interstate Highway 10 crossing of the West Pearl River near Slidell, Louisiana.

Contraction and Abutment Scour

Flow through the bridge was subdivided into flow in the main channel, left overbank, and right overbank. The 1965 geometry represents the pre-construction geometry, prior to the 1980 and 1983 floods. Contraction scour in the main channel was computed based on the geometry of 1980. Flow in the main channel upstream of the bridge was defined as a section representing the bank-full width of the channel. The main channel had a computed scour of 10 ft. The recent cross sections and the predicted cross section do not agree exactly in the main channel, but both are approximately twice the depth of the 1965 background data. The similarity of the predicted condition and the observed scoured cross section at this site provides some physical credibility to the prediction equations. Less than one foot of scour was predicted in the overbank areas. The overbanks are also well vegetated which reduces scour potential. Abutment scour was not indicated at this site due to roadway overtopping.

U.S. Highway 90 Crossings

The U.S. Hwy. 90 embankment of the lower Pearl River Basin spans over 4 mi of the river floodplain system. There are five openings in the embankment for the channels of the Pearl, East Middle, Middle, West Middle, and West Pearl Rivers. The elevation of the roadway embankment is approximately 8 ft above sea level and floodplain elevations range from 1 to 2 ft above sea level. An elevation of 1 ft above sea level was used in the overbank sections of all five bridge openings.

The Q_{500} of 275,000 cfs was distributed among the openings and roadway overflow based on 2-D flow model results (Gilbert and Froehlich, 1987). The Pearl River was apportioned approximately 102,000 ft^3/s, the East Middle River 33,000 ft^3/s, the Middle River 41,000 ft^3/s, the West Middle River 50,000 ft^3/s, the West Pearl River 33,000 ft^3/s, and road overflow was apportioned 16,000 ft^3/s. The cross-section information used for the scour analysis was based on the data collected in 1980 by the USGS and by data collected in 1965 and 1993 by DOTD.

Pearl River near Slidell, Louisiana

The opening for the Pearl River in the U.S. Hwy. 90 embankment (fig. 36) is the eastern-most bridge opening for the Pearl River system. The Pearl River has no substantial tributaries or distributaries in the reach between the I-10 embankment and the U.S. Hwy. 90 embankment. The bridge is located downstream of a mild curve to the right and upstream of a mild curve to the left.

Pier Scour

Simulation of the Q_{500} indicated velocities ranging from approximately 2 to 8 ft/s and a water-surface elevation of approximately 6 ft above sea level at the bridge. The piers located at DOTD stations 516+55 and 518+00 have timber fenders protecting the piers from river traffic (table 19). The bridge and piers cross the channel at an angle slightly greater than 15 degrees; the correction factor for alignment, K_2, was specified as 1.5 except for piers adjacent to the fenders. The presence of the fender structures may also have an effect of reducing pier scour at that location (Abed and Richardson, 1993). These fenders may tend to align the flow with the pile bents; therefore, the correction factor for angle of attack was specified as 1.0. The greatest scour occurs at the main channel pier at DOTD station 516+55 where the predicted pier scour is 33 ft. (table 19, fig. 37). Scour at the four other main piers that are in or near the channel ranged from 9 to 24 ft. Estimated scour depth at the overbank piers was approximately 1.3 ft.

Photograph source: Louisiana Department of Transportation and Development, December 1971

Figure 36. Aerial photograph of the U.S. Highway 90 crossing of the Pearl River near Slidell, Louisiana.

Table 19. Scour data for U.S. Highway 90 crossing of the Pearl River near Slidell, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 6.0 feet above sea level; K_2, dimensionless correction factor for angle of flow attack; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above sea level)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above sea level)	Pile tip elevation (ft above sea level)
511+70	1.0	Abutment	NA	NA	NA	NA	1.3	0	-24
512+00	1.0	Square	1.5	1.5	2.5	3.8	1.3	-4	-24
512+30	1.0	Square	1.5	1.5	2.5	3.8	1.3	-4	-24
512+60	1.0	Square	1.5	1.5	2.5	3.8	1.3	-4	-24
512+90	1.0	Square	1.5	1.5	2.5	3.8	1.3	-4	-24
513+10	1.0	Square	1.5	1.5	2.5	3.8	1.3	-4	-24
513+40	1.0	Square	1.5	1.5	2.5	3.8	1.3	-4	-24
513+70	0	Round	1.5	6.0	3.0	10.2	1.3	-12	-52
515+10	-30.0	Round	1.5	8.0	7.8	24.0	0.3	-54	-56
516+55	-25.0	Round	1.0	28.0	6.7	33.0	.3	-58	-56
518+00	-20.0	Round	1.0	8.0	2.7	9.6	.3	-30	-56
519+40	0	Round	1.5	6.0	2.7	9.8	.3	-10	-54
519+70	1.0	Square	1.5	1.5	1.9	3.3	1.3	-4	-24
519+90	1.0	Square	1.5	1.5	1.9	3.3	1.3	-4	-24
520+25	1.0	Square	1.5	1.5	1.9	3.3	1.3	-4	-24
520+50	1.0	Square	1.5	1.5	1.9	3.3	1.3	-4	-24
520+80	1.0	Square	1.5	1.5	1.9	3.3	1.3	-4	-24
521+10	1.0	Square	1.5	1.5	1.9	3.3	1.3	-4	-24
521+40	1.0	Abutment	NA	NA	NA	NA	1.3	0	-24

Channel Stability

The left edge of the floodplain is approximately 1,000 ft from the left edge of the low water channel. To the right of the right edge of the low water channel lies the majority of the floodplain with the other named channels. The cross-section information at the bridge does not indicate any lateral movement of the channel. Lowering of the channel-bed elevation by 5 to 10 ft is indicated by comparison of the 1932 (pre-construction) cross section and the 1980 (post construction) cross section. No significant change in the channel bed is indicated by comparison of the 1980 and 1994 cross sections.

Contraction and Abutment Scour

Flow through the bridge was subdivided into flow in the main channel, left overbank, and right overbank. The average depth of the channel at the bridge is approximately 25 ft for the main channel and 5 ft for the overbanks. The width of the main channel at the opening is 572 ft. Contraction scour in the main channel was computed as less than one foot. Scour on the left and right overbanks was estimated as 1.3 ft. The overbanks are vegetated with marsh grasses which may provide some resistance to scouring.

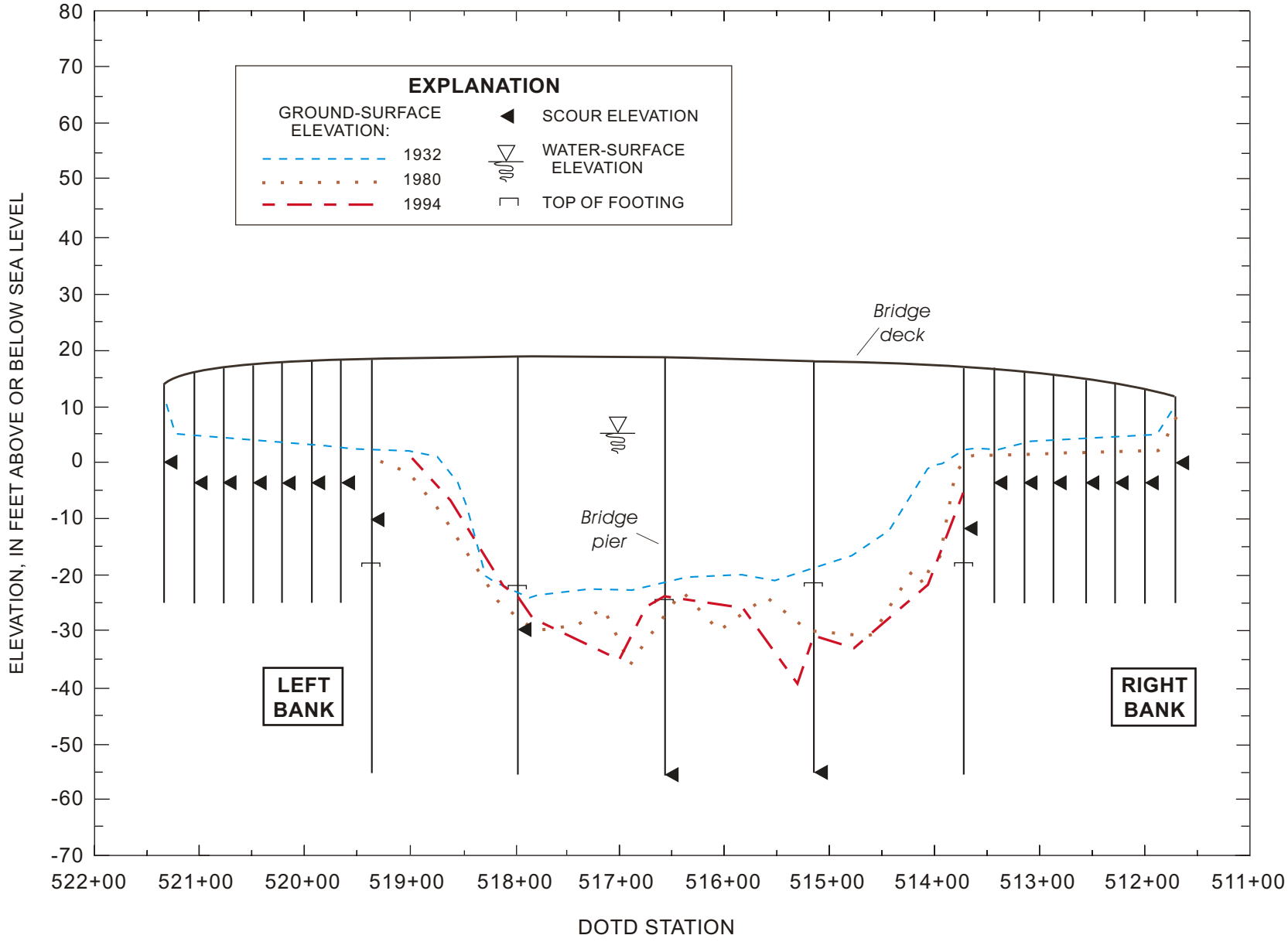


Figure 37. Comparative cross sections and scour estimates at the U.S. Highway 90 crossing of the Pearl River near Slidell, Louisiana.

East Middle River near Slidell, Louisiana

The East Middle River is formed as a distributary of the Middle River half a mile upstream of the U.S. Hwy. 90 embankment. This is the second bridge opening (east to west) of the U.S. Hwy. 90 crossing of the Pearl River system. Upstream of the bridge, a pool is approximately four bridge widths long and three bridge widths wide, which connects with two small channels (fig. 38) which may be distributary or tributary in nature depending on flow conditions. The channel bends to the left upon exiting this pool.

Pier Scour

Simulation of the Q_{500} indicated velocities ranging from approximately 2 to 8 ft/s and a water-surface elevation of approximately 6.5 ft above sea level. The bridge piers are at an angle of 35 degrees with the channel; therefore, the correction for alignment, K_2, was 2.0. The greatest pier scour is approximately 27 ft and occurs at the main channel pier at DOTD station 470+60 (table 20, fig. 39). Pier scour at the three other main piers that are in or near the channel ranged from 13 to 25 ft. Estimated scour depth at the overbank piers was approximately 4 ft. Bed elevation estimates which include contraction scour show elevations that are below the pile tip as indicated on the bridge plans.

Table 20. Scour data for U.S. Highway 90 crossing of the East Middle River near Slidell, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 6.5 feet above sea level; K_2, dimensionless correction factor for angle of flow attack; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above sea level)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above sea level)	Pile tip elevation (ft above sea level)
468+08	1.0	Abutment	2.0	NA	1.9	0	4.3	-3	-20
468+35	1.0	Square	2.0	1.5	1.9	4.5	4.3	-8	-20
468+65	1.0	Square	2.0	1.5	1.9	4.5	4.3	-8	-20
468+95	1.0	Square	2.0	1.5	1.9	4.5	4.3	-8	-20
469+20	1.0	Square	2.0	1.5	1.9	4.5	4.3	-8	-20
469+50	1.0	Square	2.0	1.5	1.9	4.5	4.3	-8	-20
469+80	0	Round	2.0	6.0	3.0	13.8	4.3	-18	-54
470+60	-28.0	Round	2.0	6.0	7.8	26.9	12.3	-67	-56
471+40	-30.0	Round	2.0	6.0	6.7	25.0	12.3	-67	-56
472+20	0	Round	2.0	6.0	2.7	13.2	4.3	-18	-54
472+50	1.0	Square	2.0	1.5	1.9	4.5	4.3	-8	-20
472+80	1.0	Square	2.0	1.5	1.9	4.5	4.3	-8	-20
473+10	1.0	Square	2.0	1.5	1.9	4.5	4.3	-8	-20
473+40	1.0	Square	2.0	1.5	1.9	4.5	4.3	-8	-20
473+80	1.0	Square	2.0	1.5	1.9	4.5	4.3	-8	-20
473+91	1.0	Abutment	NA	NA	1.9	0	4.3	-3	-20

Photograph source: Louisiana Department of Transportation and Development, December 1971

Figure 38. Aerial photograph of the U.S. Highway 90 crossing of the East Middle River near Slidell, Louisiana.

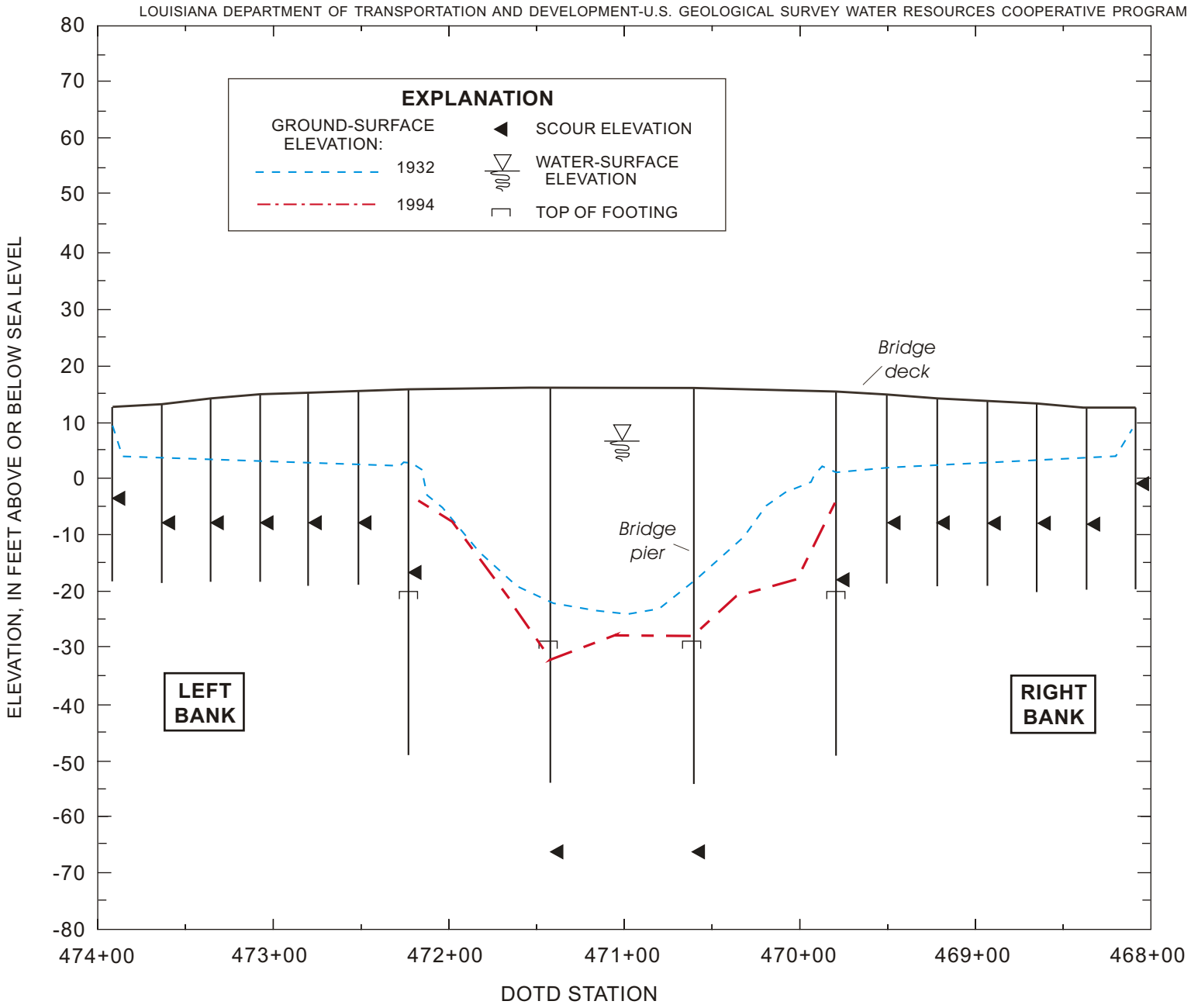


Figure 39. Comparative cross sections and scour estimates at the U.S. Highway 90 crossing of the East Middle River near Slidell, Louisiana.

Channel Stability

Although the bridge crossing is located at a bend to the left in the channel, the cross-section information at the bridge does not indicate any significant lateral movement of the channel. Inspection of the site after the 1983 flood did not indicate substantial scouring of the overbanks.

Contraction and Abutment Scour

Flow through the bridge was subdivided into flow in the main channel, left overbank, and right overbank. The average depth of the channel at the bridge is approximately 22 ft for the main channel and 5 ft for the overbanks. For contraction scour estimates in the main channel, the flow in the main channel upstream was defined as a section of channel, approximately 200 ft in width. The width of the main channel at the opening is 200 ft. Contraction scour in the main channel was computed as 12 ft. Scour on the left and right overbanks was predicted as approximately 4 ft. The overbanks are vegetated with marsh grasses which may reduce the scour potential on the overbanks. Inspection of the site after the 1983 flood did not indicate significant scouring of the overbanks.

Middle River near Slidell, Louisiana

The Middle River is formed as a distributary of the West Pearl River approximately 2 mi upstream of the I-10 embankment. This is the third (east to west) bridge opening for the U.S. Hwy. 90 crossing of the Pearl River system. The channel curves mildly to the right upstream of the bridge and then mildly to the left immediately downstream of the bridge (fig. 40).

Pier Scour

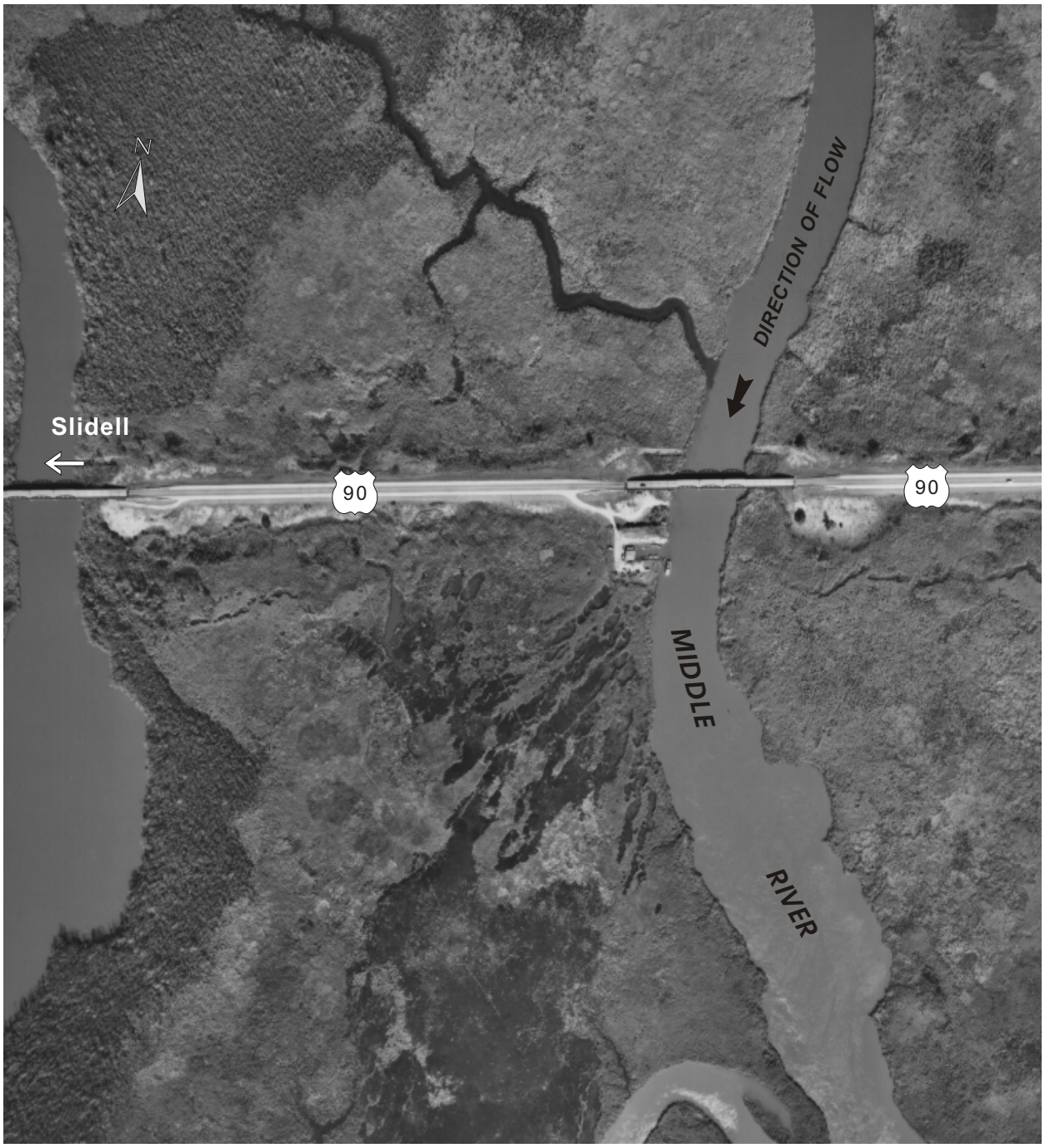
Simulation of the Q_{500} indicated velocities ranging from approximately 1 to 6 ft/s and a water-surface elevation of approximately 6.5 ft above sea level at the bridge. The bridge piers are skewed to the channel at an angle less than 15 degrees; therefore, no correction for alignment was applied. The greatest predicted pier scour is approximately 12.4 ft and occurs at the main channel pier at DOTD station 440+35 (table 21, fig. 41). Scour at the three other main piers that are in or near the channel ranged from approximately 6 to 10 ft. Estimated scour depth at the overbank piers was approximately 2 ft.

Channel Stability

The cross-section information at the bridge does not indicate any significant lateral movement of the channel. Comparison of the 1932 (pre-construction) and the 1994 (post-construction) cross sections indicates a lowering of the channel bed of approximately 10 ft. This is most likely the channel response to embankment construction as is noted in the other openings in this embankment.

Contraction and Abutment Scour

Flow through the bridge was subdivided into flow in the main channel, left overbank, and right overbank. The average depth of the channel at the bridge is approximately 33 ft for the main channel and 5 ft for the overbanks. For contraction scour estimates in the main channel, the flow in the main channel upstream was defined as a section of channel, approximately 250 ft in width. The width of the main channel at the opening is 242 ft. Contraction scour in the main channel was computed as 5.4 ft. Scour on the left and right overbanks was predicted as 1.6 and 1.1 ft, respectively. The overbanks are vegetated with marsh grasses which may reduce the scour potential in the overbank areas. No abutment scour was indicated.



Photograph source: Louisiana Department of Transportation and Development, December 1971

Figure 40. Aerial photograph of the U.S. Highway 90 crossing of the Middle River near Slidell, Louisiana.

Table 21. Scour data for U.S.Highway 90 crossing of the Middle River near Slidell, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 6.5 feet above sea level; K_2, dimensionless correction factor for angle of flow attack; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above sea level)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above sea level)	Pile tip elevation (ft above sea level)
437+10	1.0	Abutment	1.0	NA	1.2	NA	1.1	0	-20
437+28	1.0	Square	1.0	1.5	1.2	1.8	1.1	-2	-20
437+58	1.0	Square	1.0	1.5	1.2	1.8	1.1	-2	-20
437+86	1.0	Square	1.0	1.5	1.2	1.8	1.1	-2	-20
438+14	1.0	Square	1.0	1.5	1.2	1.8	1.1	-2	-20
438+42	1.0	Square	1.0	1.5	1.2	1.8	1.1	-2	-20
438+72	0	Round	1.0	6.0	3.0	6.9	5.4	-12	-54
439+52	-37.0	Round	1.0	6.0	4.1	10.2	5.4	-53	-56
440+35	-35.0	Round	1.0	6.0	6.5	12.4	5.4	-53	-56
441+15	0	Round	1.0	6.0	3.0	6.9	1.6	-8	-52
441+45	1.0	Square	1.0	1.5	1.4	2.0	1.6	-3	-20
441+72	1.0	Square	1.0	1.5	1.4	2.0	1.6	-3	-20
442+00	1.0	Square	1.0	1.5	1.4	2.0	1.6	-3	-20
442+25	1.0	Square	1.0	1.5	1.4	2.0	1.6	-3	-20
442+58	1.0	Square	1.0	1.5	1.4	2.0	1.6	-3	-20
442+84	1.0	Abutment	1.0	NA	1.4	NA	1.6	-1	-20

West Middle River near Slidell, Louisiana

The West Middle River is formed as a distributary of the Middle River approximately one-half mi downstream of the I-10 embankment. There are no substantial or named tributaries or distributaries of this channel in the reach between I-10 and U.S. Hwy. 90; however, the low-water channels of the West Middle River and the Middle River are joined approximately one-half mi upstream of the U.S. Hwy. 90 embankment. This is the fourth (east to west) opening for the U.S. Hwy. 90 crossing of the Pearl River system. The main channel completes a 90 degree bend to the right about two bridge widths upstream of the highway crossing, and is straight when passing through the bridge opening (fig. 42).

Pier Scour

Simulation of the Q_{500} indicated velocities ranging from approximately 2 to 8 ft/s and a water-surface elevation of approximately 6.5 ft above sea level. The bridge piers are skewed to the channel at an angle less than 15 degrees; therefore, no correction for alignment was applied. The greatest predicted pier scour is approximately 15 ft at the main channel pier at DOTD station 417+20 (table 22, fig. 43). Scour at the three other main piers that are in or near the channel ranged approximately from 4 to 13 ft. Estimated scour depth at the overbank piers was approximately 2 ft.

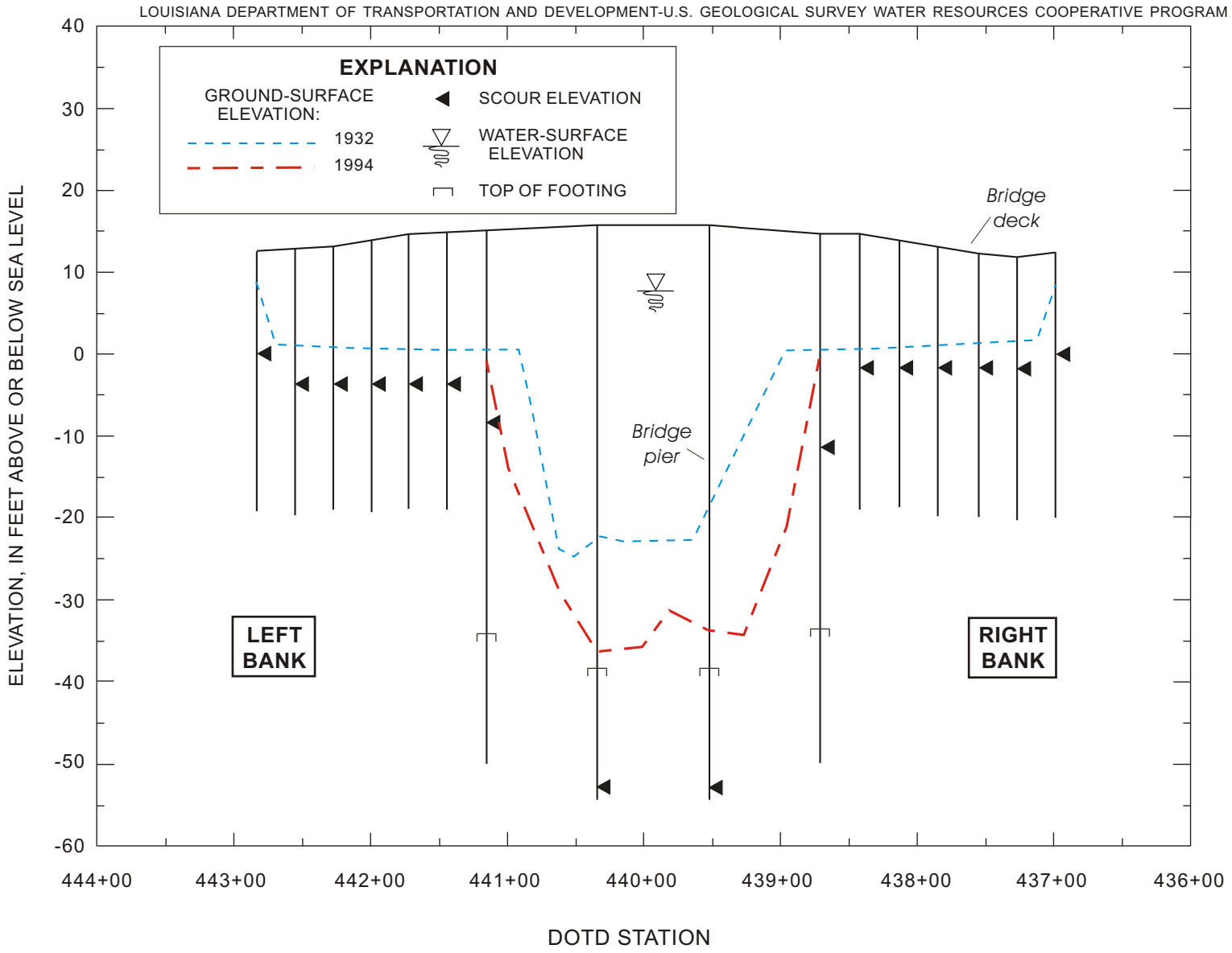
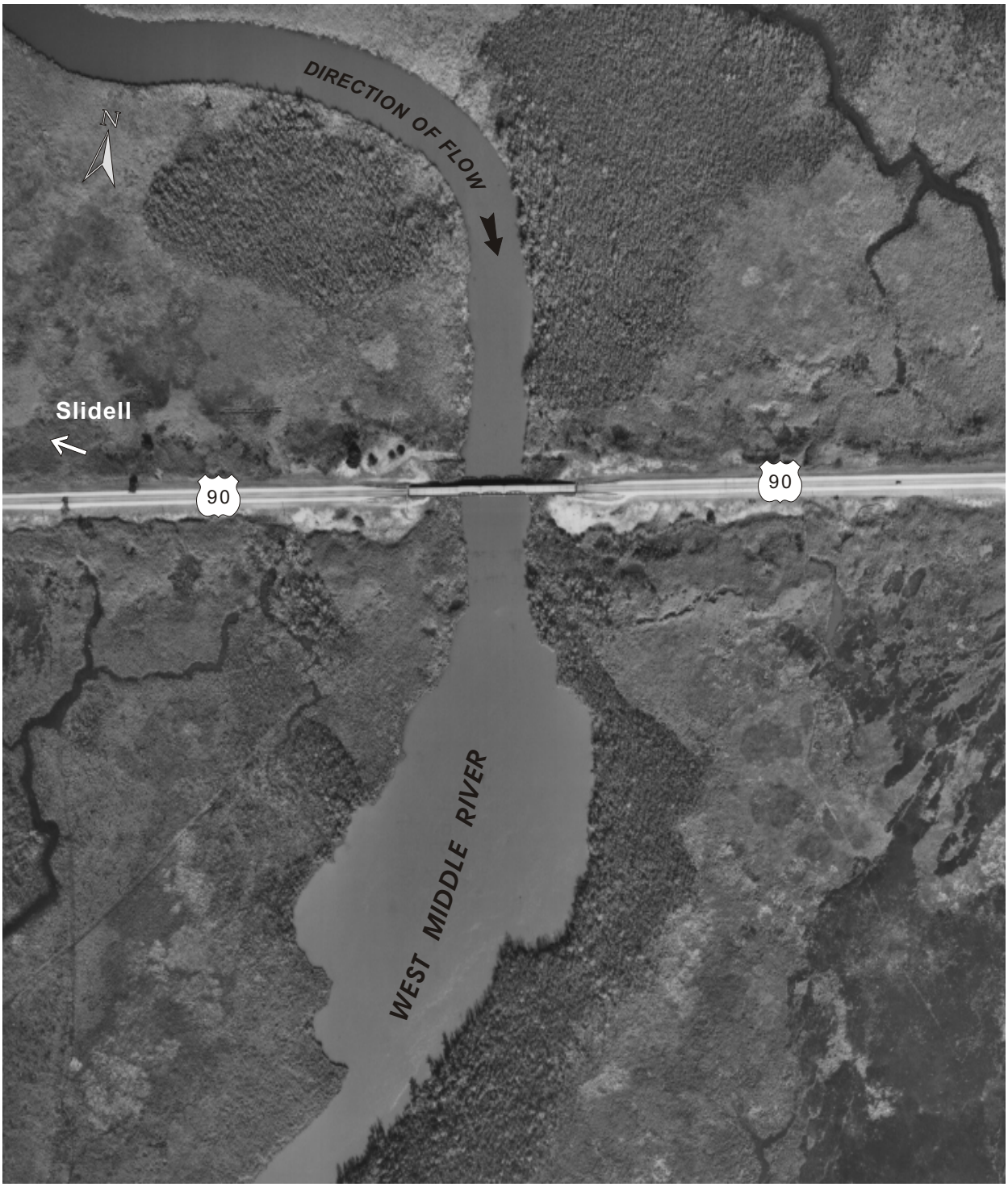


Figure 41. Comparative cross sections and scour estimates at the U.S. Highway 90 crossing of the Middle River near Slidell, Louisiana.



Photograph source: Louisiana Department of Transportation and Development, December 1978

Figure 42. Aerial photograph of the U.S. Highway 90 crossing of the West Middle River near Slidell, Louisiana.

Table 22. Scour data for U.S. Highway 90 crossing of the West Middle River near Slidell, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 6.5 feet above sea level; K_2, dimensionless correction factor for angle of flow attack; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above sea level)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above sea level)	Pile tip elevation (ft above sea level)
413+87	1.0	Abutment	1.0	NA	1.8	NA	3.7	-3	-20
414+15	1.0	Square	1.0	1.5	1.8	2.2	3.7	-5	-20
414+40	1.0	Square	1.0	1.5	1.8	2.2	3.7	-5	-20
414+70	1.0	Square	1.0	1.5	1.8	2.2	3.7	-5	-20
415+00	1.0	Square	1.0	1.5	1.8	2.2	3.7	-5	-20
415+30	1.0	Square	1.0	1.5	1.8	2.2	3.7	-5	-20
415+55	-3.0	Square	1.0	5.5	6.1	4.0	11.8	-19	-52
416+35	-24.0	Square	1.0	8.0	7.4	12.0	11.8	-48	-58
417+20	-23.0	Square	1.0	8.0	7.8	15.0	11.8	-50	-58
418+00	-11.0	Square	1.0	5.5	6.6	13.0	11.8	-36	-56
418+30	1.0	Square	1.0	1.5	2.0	2.3	3.7	-5	-20
418+55	1.0	Square	1.0	1.5	2.0	2.3	3.7	-5	-20
418+85	1.0	Square	1.0	1.5	2.0	2.3	3.7	-5	-20
419+15	1.0	Square	1.0	1.5	2.0	2.3	3.7	-5	-20
419+40	1.0	Square	1.0	1.5	2.0	2.8	3.7	-5	-20
419+68	1.0	Abutment	1.0	NA	2.0	NA	3.7	-3	-20

Channel Stability

A pool about one bridge width downstream of the highway crossing is approximately three bridge widths long and two bridge widths wide. It is unlikely that this downstream pool would cause any changes in the cross section at the bridge that are related to contraction scour. It is more likely that the pool area provides conditions for turbulent losses to fully develop and dissipate any flow jet caused by the contraction at the bridge. The cross-section information at the bridge does not indicate any lateral movement of the channel, but does show some widening that may have been initiated at the time of construction.

Contraction and Abutment Scour

Flow through the bridge was subdivided into flow in the main channel, left overbank, and right overbank. The average depth of the channel at the bridge is approximately 25 ft for the main channel and 5 ft for the overbanks. For contraction scour estimates in the main channel, the main channel upstream was defined as a section of channel approximately 220 ft in width. The width of the main channel at the opening is 275 ft. Contraction scour in the main channel was computed as approximately 12 ft. Scour on the left and right overbanks was predicted as approximately 4 ft. The overbanks are vegetated with marsh grasses which may reduce the scour potential in these areas of the bridge. No abutment scour was indicated.

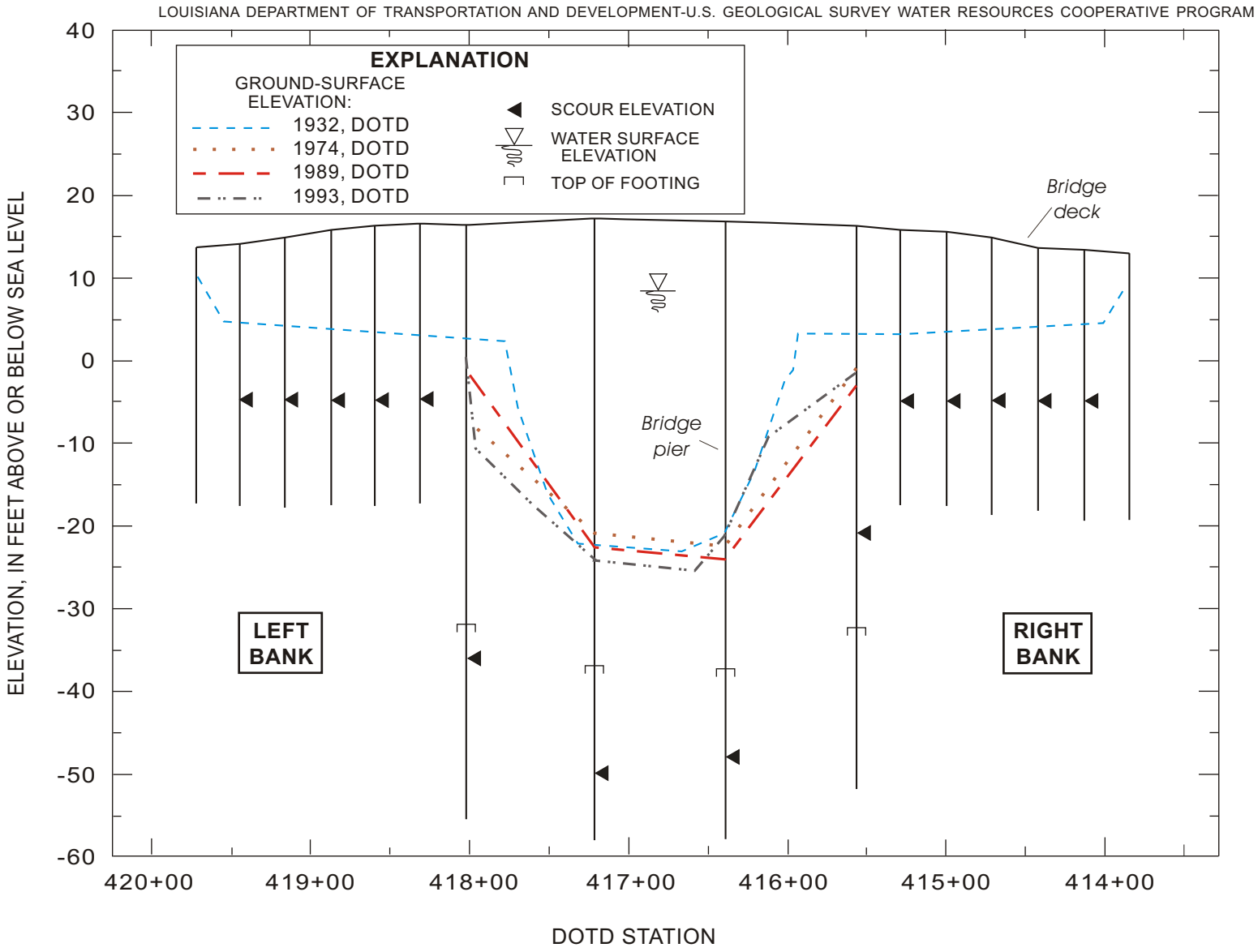


Figure 43. Comparative cross sections and scour estimates at the U.S. Highway 90 crossing of the West Middle River near Slidell, Louisiana.

West Pearl River near Slidell, Louisiana

The West Pearl River is formed as a distributary of the Pearl River approximately 24 mi upstream of the U.S. Hwy. 90 embankment (upstream of both the I-10 and I-59 embankments). The only significant distributary of this reach of the river is the formation of the Middle River approximately 7 mi upstream of the U.S. Hwy. 90 embankment (2 mi upstream of the I-10 embankment). The channel curves sharply to the left immediately downstream of the bridge; upstream of the bridge there is a mild curve to the left (fig. 44).

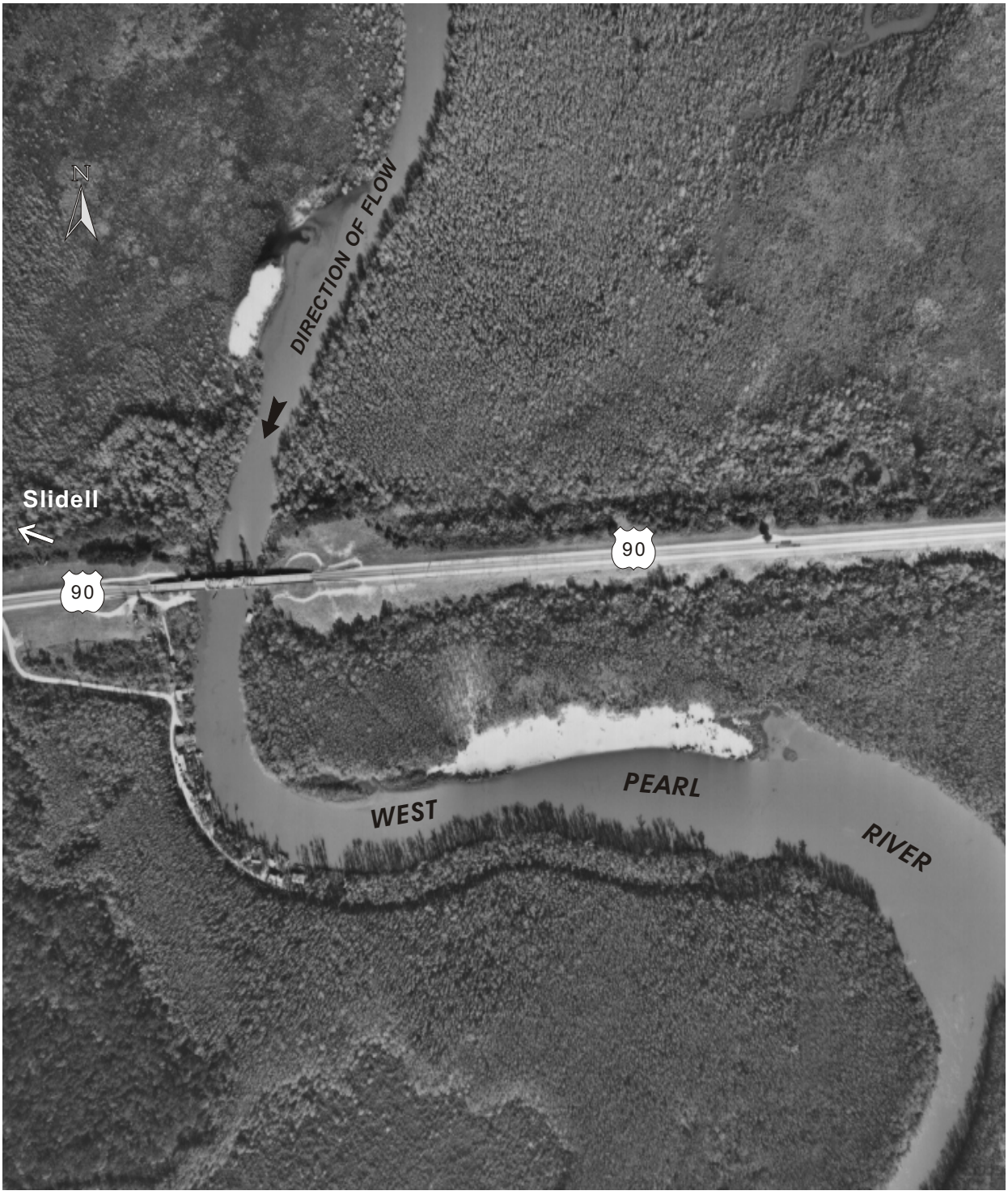
Pier Scour

Simulation of the Q_{500} indicated velocities ranging from approximately 2 to 6 ft/s and a water-surface elevation of approximately 7.5 ft above sea level. The bridge piers are not skewed to the channel at an angle greater than 15 degrees; therefore, no correction for alignment was applied. There are timber fenders protecting the main channel piers from river traffic. The effect of these fenders may tend to align the flow with the pile bents. The presence of the fender structures may also have an effect of reducing pier scour at that location (Abed and Richardson, 1993). The greatest predicted pier scour is approximately 13.3 ft and occurs at the main channel pier at DOTD station 344+48 (table 23, fig. 45). Scour at the three other main piers that are in or near the channel ranged from 7.9 to 11.3 ft. Estimated scour depth at the overbank piers was approximately 2 ft.

Table 23. Scour data for U.S. Highway 90 crossing of the West Pearl River near Slidell, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 7.5 feet above sea level; K_2, dimensionless correction factor for angle of flow attack; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above sea level)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above sea level)	Pile tip elevation (ft above sea level)
341+06	10.0	Abutment	1.0	NA	1.7	NA	4.3	-1	-20
341+35	3.0	Square	1.0	1.5	1.7	2.1	4.3	-3	-20
341+63	3.0	Square	1.0	1.5	1.7	2.1	4.3	-3	-20
341+90	3.0	Square	1.0	1.5	1.7	2.1	4.3	-3	-20
342+18	3.0	Square	1.0	1.5	1.7	2.1	4.3	-3	-20
342+45	3.0	Square	1.0	1.5	1.7	2.1	4.3	-3	-20
342+74	3.0	Square	1.0	1.5	1.7	2.1	4.3	-3	-20
343+05	-9.0	Square	1.0	5.5	3.5	7.9	6.4	-23	-44
343+35	-8.0	Square	1.0	8.0	4.7	11.3	6.4	-26	-52
344+48	-19.0	Square	1.0	8.0	5.7	13.3	6.4	-39	-52
344+80	-10.0	Square	1.0	5.5	4.9	9.2	6.4	-26	-44
345+18	3.0	Square	1.0	1.5	1.7	2.1	3.9	-3	-20
345+38	3.0	Square	1.0	1.5	1.6	2.0	3.9	-3	-20
345+65	3.0	Square	1.0	1.5	1.6	2.0	3.9	-3	-20
345+92	3.0	Square	1.0	2.0	1.6	2.5	3.9	-3	-20
346+20	3.0	Square	1.0	2.0	1.6	2.5	3.9	-3	-20
346+50	3.0	Square	1.0	2.0	1.6	2.5	3.9	-3	-20
346+76	10.0	Abutment	1.0	NA	1.6	NA	3.9	-1	-20



Photograph source: Louisiana Department of Transportation and Development, December 1971

Figure 44. Aerial photograph of the U.S. Highway 90 crossing of the West Pearl River near Slidell, Louisiana.

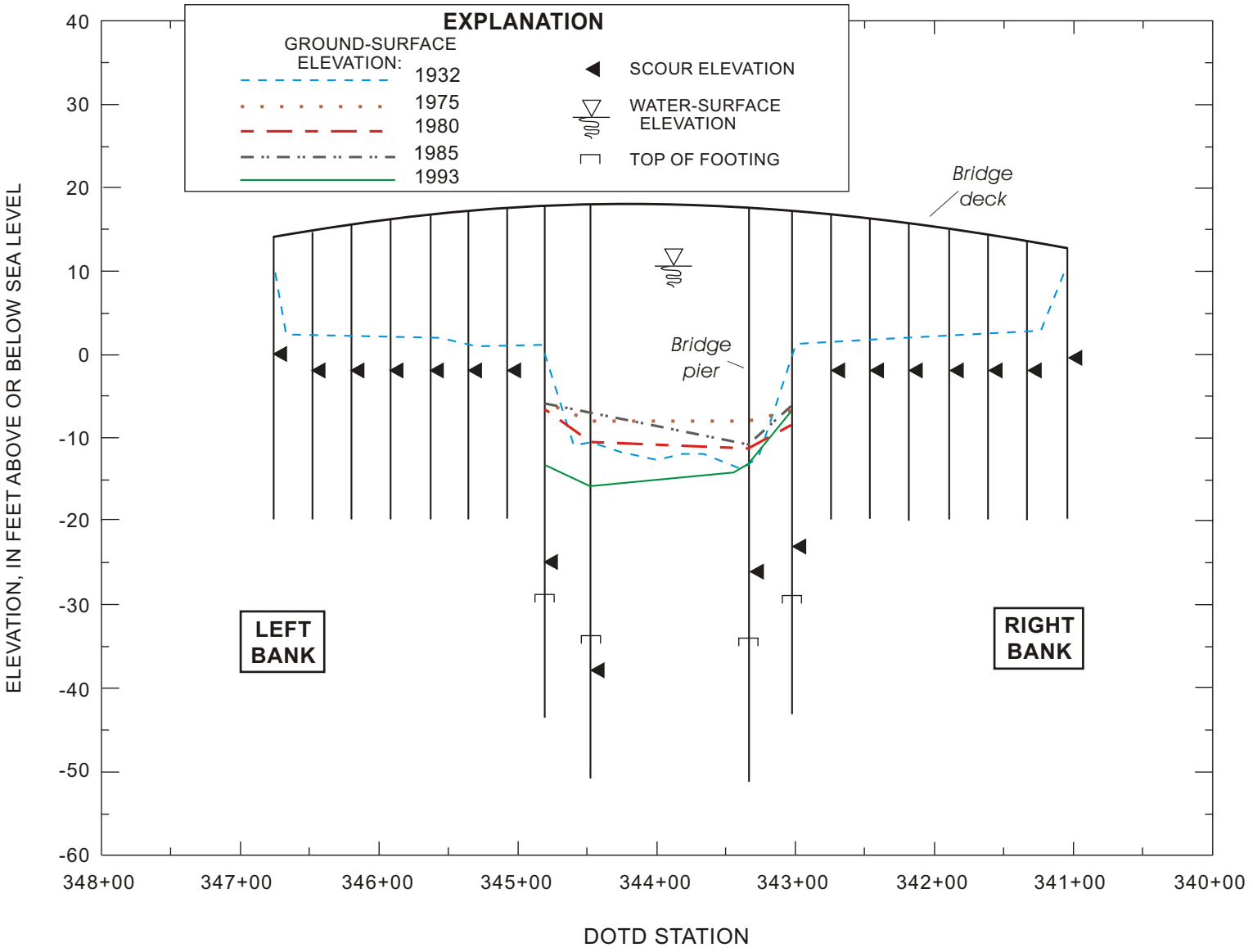


Figure 45. Comparative cross sections and scour estimates at the U.S. Highway 90 crossing of the West Pearl River near Slidell, Louisiana.

Channel Stability

The cross-section information at the bridge does not indicate any lateral movement of the channel. The timber fender structures at the bridge may serve to help align the flow through the structure and limit lateral migration of the channel (fig. 44). The bed elevation has changed by approximately 5 ft, both above and below the original (pre-construction) cross section. The most recent cross section indicates a lowering of approximately 5 ft in some locations.

Contraction and Abutment Scour

Flow through the bridge was subdivided into flow in the main channel, left overbank, and right overbank. The average depth of the channel at the bridge is approximately 22 ft for the main channel and 4.5 ft for the overbanks. For contraction scour estimates in the main channel, the flow in the main channel upstream was defined as a section of channel, approximately 200 ft in width. The width of the main channel at the bridge is 210 ft. Contraction scour in the main channel was computed as 6.4 ft. Scour on the left and right overbanks was predicted as 3.9 and 4.3 ft, respectively. The overbanks are vegetated with marsh grasses which may reduce scour potential in the overbank areas. No abutment scour was indicated.

SUMMARY

The results of maximum scour estimates are presented for 22 sites located in East Feliciana, East Baton Rouge, St. Helena, Livingston, Ascension, Tangipahoa, Washington, and St. Tammany Parishes in southeastern Louisiana, which consists of two surface-water basins: the East Mississippi River Delta Basin, which includes the Amite, Tickfaw, Tangipahoa, and Tchefuncte Rivers; and the Pearl River Basin, which includes the Bogue Chitto, Pearl, West Pearl, East Middle, Middle, and West Middle Rivers. The major roadways that cross these rivers include seven State highways (432, 10, 64, 42, 16, 22, and 438), two U.S. highways (190 and 90), and three Interstate highways (12, 59, and 10).

Maximum scour estimates were computed using methodologies outlined by the Federal Highway Administration. Contraction scour was estimated for the main channel and overbank areas of the bridge openings. The contraction scour estimated in these areas was added to the pier scour estimated at the pier locations. General hydrologic, hydraulic, hydrographic, and bathymetric information for these evaluations was obtained from U.S. Geological Survey and Louisiana Department of Transportation and Development (DOTD) files of periodic hydrographic surveys and from streamflow-gaging station records. The 500-year design discharge was estimated from streamflow-gaging station records at the site, streamflow-gaging station records transferred to the site, or by a region of influence regression model. The distribution of flow within the bridge openings was computed using the one dimensional Water Surface Profile (WSPRO) flow model.

Of the selected sites along the Amite River, the maximum pier scour estimate of 31 feet was at the Interstate Highway 12 crossing. The Interstate Highway 12 crossing of the Tickfaw, Tangipahoa, and Tchefuncte Rivers had maximum pier scour estimates that ranged from 8 to 28 feet. The Louisiana Highway 438 crossing of the Bogue Chitto River had a maximum pier scour of 6 feet. At the Interstate Highway 59 crossings of the Pearl and West Pearl Rivers, the maximum pier scour was approximately 12 feet at both bridges.

Indication of contraction scour from hydrographic surveys performed after a major flood passage was exceptional at Pearl River and West Pearl River at Interstate Highway 10. At the Interstate Highway 10 crossings of the Pearl, Middle, and West Pearl Rivers, the maximum pier scour ranged from 4 to 35 feet. The Middle Pearl River crossing had contraction scour estimates that were more than five times the magnitude of the pier scour estimates at that site. These sites have bed materials of sand/silt size and characteristics. Scour estimates at these sites compare well with the post-flood riverbed elevations, providing some field verification of the maximum scour computations.

The U.S. Highway 90 crossings of the Pearl, East Middle, Middle, West Middle, and West Pearl Rivers had pier scour estimates that ranged from 12 to 33 feet. The higher values are associated with the sites on the east side of the floodplain.

When available, pile tip elevations from DOTD bridge plans are shown with historic and estimated riverbed elevations. The maximum scour estimates exceeded the design pile tip elevation of individual piers at 8 sites.

The periodic hydrographic surveys performed by DOTD provided the basis for evaluating the observed channel stability. The Amite River bridges show no major changes of the channel bottom; however, the Pearl River bridges show major decreases in channel-bed elevations.

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