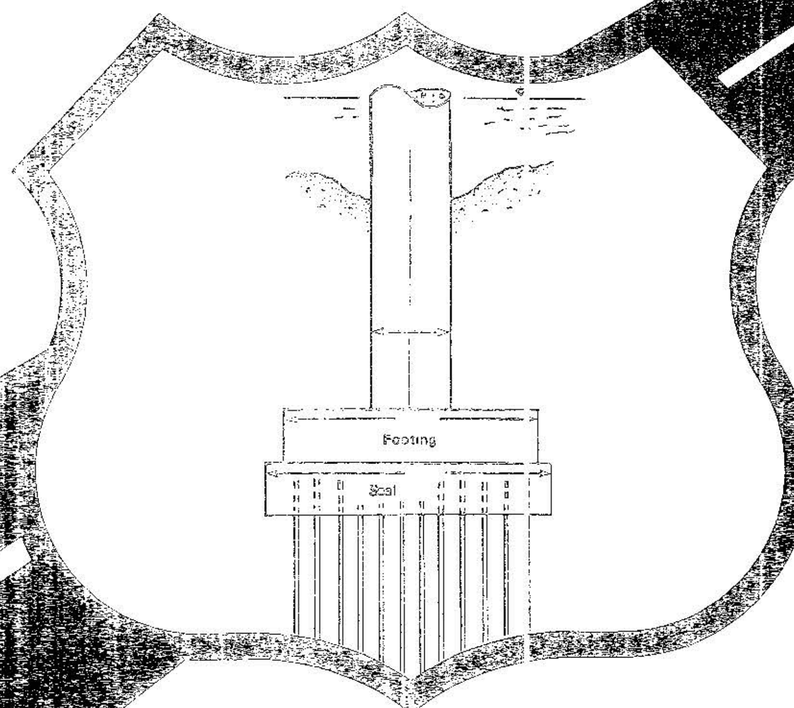
Report No. FHWA-RD-79-105

SCOUR AT BRIDGE PIERS - FIELD DATA FROM LOUISIANA FILES

January 1980
Final Report



Prepared for
FEDERAL HIGHWAY ADMINISTRATION
Offices of Research & Development
Environmental Division
Washington, D.C. 20590

Foreword

This report describes the analysis of field pier scour data extracted from files maintained by the Louisiana hydrologic survey team. This analysis is a relatively low cost effort to augment the sparse set of prototype scour data.

Research in bridge scour is included in the Federally Coordinated Program of Highway Research and Development as part of Task 1 of Project 5H "Protection of the Highway from Hazards Attributed to Flooding." Dr. Roy E. Trent is the Project Manager.

This research was conducted by Dr. Fred Chang of Tye Engineering in Fairfax, Virginia, for the Federal Highway Administration, Office of Research under P.O. 8-3-0129.

Sufficient copies of this report are being distributed to provide a minimum of one copy to each FHWA regional office, a separate copy directly to each regional hydraulics engineer, one copy to each division office, and one copy to each State highway agency. Direct distribution is being made to the division offices.

Charles F. Scheffey
Director, Office of Research
Federal Highway Administration

NOTICE

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16. Abstract

Data from a total of 17 occurrences of scour at seven bridge sites in Louisiana were collected, covering the following ranges: Pier width, 3.4 - 10.4 m; flow depth, 1.7 - 19.5 m; flow velocity, 0.46 - 1.8 m/s; Froude number, 0.067 - 0.189; scour depth, 3.4 - 10.4 m, and bed material median diameter, 0.008 - 0.06 mm. An analysis of the relative scour depth with respect to relative flow depth for flows with Froude numbers about 0.1 shows that the scour depth increases rapidly with an increase in flow depth when the relative flow depth is less than 0.5. The rate of increase then slows down to approach a constant value of 0.8 maximum as the relative flow depth approaches 1.3 and may tend to decrease very slightly as the relative flow depth increases further. For the data where the Froude numbers were about 0.1, Shen's formula II(2) yields the best agreement. Three of the other popular formulas - Laursen's, Shen's formula I and Neill's approximation of Laursen's design curve - tend to overpredict the scour, and three formulas - Ingles-Poona's, Ahmad's and Chitale's - tend to underpredict the scour for these low Froude numbers.

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The cooperation given by the Louisiana Office of Highways in compiling scour data is very much appreciated. Technical assistance was provided by William Jack, Jr. and J. B. Esnard, Jr. The U.S. Geological Survey at Baton Rouge, Louisiana, and at Jackson, Mississippi, and the Army Corps of Engineers (New Oreleans District and Vicksburg District) assisted in compiling the hydraulic data. This project was intiated and coordinated by J. Sterling Jones of the Federal Highway Administration; his helpful advice is gratefully acknowledged.

I. INTRODUCTION

A number of formulas presently available to predict scour depth at bridge piers were developed either empirically or semi-empirically based mostly on small-scale laboratory data. Their validity has been acclaimed as certain within the range of the data used for deriving the formulas. However, when these formulas are compared with each other, a broad scatter can be observed. Because of this and also because of general feelings among practicing engineers that the verification of these formulas with field data has not been adequate, there exists considerable doubt and reluctance in applying them in practice. Therefore, this study undertook to collect field data and to compare these with the conventional formulas in order to provide a basis for judgment and confidence in their application.

II. DATA

Scour data for this study were collected from existing files rather than directly from field measurements. Files from the Mississippi Department of Highways and from the Louisiana Department of Transportation were scanned in search of usable scour data. The Louisiana files were found to contain adequate details to make a meaningful analysis of the data. Bed material samples were then collected and hydrologic data was assembled for those sites that had adequate scour data on file.

The Louisiana Department of Transportation deploys a hydrologic survey team which routinely conducts riverbed surveys at approximately 90 bridges as part of the bridge inspection program. The survey team attaches a fathometer to a boat to make continuous records of bed elevations at several cross sections up to 60 m upstream and downstream from the bridge. From these measurements, the riverbed contour can be mapped. To ensure the safety of the survey crew, however, the surveys are generally conducted after the high water has receded, and thus the scour data obtainable from these surveys, unfortunately, cover only low-flow ranges.

Seven bridges where the channel approaches are fairly straight and uniform for about one kilometer or more were selected for this study. The location of these bridges are shown in Figure 1.

Study Sites

Site 1: This 230-m, 2-span bridge is on the Red River at Bossier City, Louisiana, on the extension of 70th Street. The bridge is supported with three rounded-nose rectangular piers with spread footings founded on piles. The bridge is in a uniform and very slightly curved channel.

Site 2: This bridge is on the Red River at Highway LA-6 at Grand Ecore, Louisiana. Although the bridge is located downstream of a 60-degree bend, the reach of 1.6 km from the bend to the bridge is fairly straight and uniform. The bridge measures about 220 m and is supported with two rounded-nose rectangular piers of which only one pier (Pier 2) is generally in the flow.

Site 3: This bridge located near Boyce, Louisiana, on the Red River at

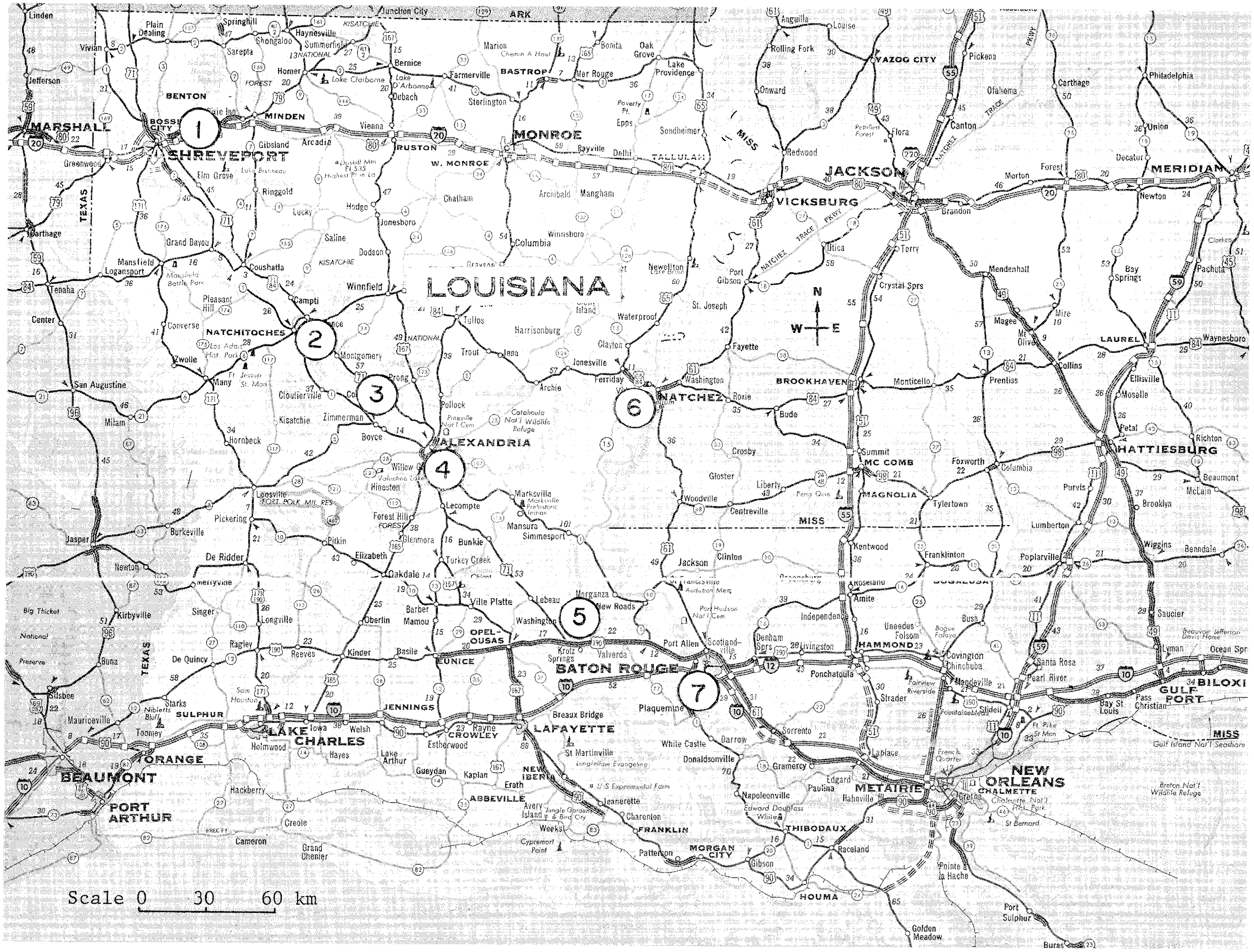


Figure 1 Location Map of Bridge Sites

Highway LA-8 is supported with three piers, of which the center pier has a cylindrical shape with a diameter of 8 meters. The other two piers are composed of a set of smaller circular piers with a 3-m diameter. Scour was observed only at the center pier. The bridge is about 1.2 km downstream of a 150-degree bend and in a uniform reach. Although the bridge is about 20 degrees skew with the channel, it was chosen for this study because the piers are cylindrical and the scour around the piers is not affected by the flow direction.

Site 4: This bridge is on the Red River at Highway LA-3026, Alexandria, Louisiana. The channel is uniform and very straight, 1.3 km upstream and 2.7 km downstream from the bridge. Two rounded-nose rectangular piers support the bridge; one of these is at the edge of the main flow and no measurable scour was observed.

Site 5: This 450-m bridge is on the Atchafalaya River, Highway U.S. 190 at Krotz Springs, Louisiana. The river is fairly straight and uniform from 2 km upstream to 1 km downstream of the bridge. Three equal bridge spans rest on two lenticular piers at midstream and on two abutments at the end of the bridge. The piers are built on large caissons with a diameter of 18 m and a depth of 26 m.

Site 6: This 1120-m bridge is located near Natchez, Louisiana, on the Mississippi River at Highway U.S. 65. Four rectangular piers are set very deep to reach solid blue sand clay. The bridge is on a straight reach approximately 1.5 km downstream of a 45-degree bend.

Site 7: This bridge is located at Baton Rouge, Louisiana, on the Mississippi River at Highway U.S. 190. It is about 1 km long and is supported by six rounded-nose rectangular piers, of which only two piers (No. 3 and No. 4) are normally in the water. Due to a rather short straight reach of less than 1 km between a sharp bend of about 110 degrees and the bridge, the flow at the bridge is slightly skewed. Still, this site was chosen because the data are clear and the pier size is relatively large.

Flow Conditions

Flow conditions at the study sites were estimated directly or indirectly from stage and discharge records taken at the U.S. Corps of Engineers gaging stations located nearby. These stations include:

(a) Red River at Shreveport, Louisiana — Stage and discharge

(b) Red River at Alexandria, Louisiana—Stage and discharge

(c) Atchafalaya River at Krotz Springs, Louisiana — Stage

(d) Atchafalaya River at Simmesport, Louisiana —Stage and discharge

(e) Mississippi River at Natchez, Louisiana — Stage and discharge

(f) Mississippi River at Tarbert Landing, Mississippi (125 km upstream of Baton Rouge, Louisiana) — Stage and discharge

(g) Mississippi River at Baton Rouge, Louisiana — Stage

For the Red River Bridge (Site 1) at Bossier City, the discharge was estimated from the data at Shreveport 2 miles west of Bossier City. No gaging stations are located near the Red River Bridge (Site 2) at Grand Ecore; thus the flow conditions are unknown for this site. The gage in the

Red River at Boyce (Site 3) was inoperative during the period when the riverbed survey was made, so the discharge data at Alexandria (about 16 km downstream of Boyce) was used for this site. For the Red River Bridge at Alexandria (Site 4), the discharge records of the U.S. Army Corps, Alexandria gaging station, were used. Because the gaging station in the Atchafalaya River at Krotz Springs (Site 5) recorded only the stages, the discharges at this site were determined from the discharge taken at Simmesport about 50 km upstream of Krotz Springs. Between these stations, no confluence contributes an appreciable amount of flow to the river. The discharge of the Mississippi River at Natchez (Site 6) was read directly from the records at the Natchez gaging station. For the Mississippi River Bridge at Baton Rouge (Site 7), the discharge was assumed to be the same as at Tarbert Landing 125 km upstream. During the period under consideration, the flow in the river was quite steady; thus the estimated discharge at this site is considered reasonable.

River Cross Sections

The original records of the riverbed surveys at the seven selected sites are replotted for a clearer presentation. These figures are given in the Appendix. Contour lines for the riverbed elevation were inserted in the figures to show the shape of the scour hole and to determine the direction of local flow at the piers. Also included in the figures are the pier dimensions, the structure of the subsurface soil layers at the piers, and the water surface elevation when the survey was made.

Bed Materials

Three or more bed material samples were taken at each of six points for each site. Sampling points were at the water edge on both sides of the river directly under the bridge and 60 m upstream and downstream. Samples were taken with a core sampler to a depth of 15 cm. Mechanical analyses were made by soil engineers of the Louisiana Office of Highways. The results of the analyses are plotted in Figure 2. Samples were taken during very low water periods so that they do represent bed materials during higher water when the scour measurements were taken.

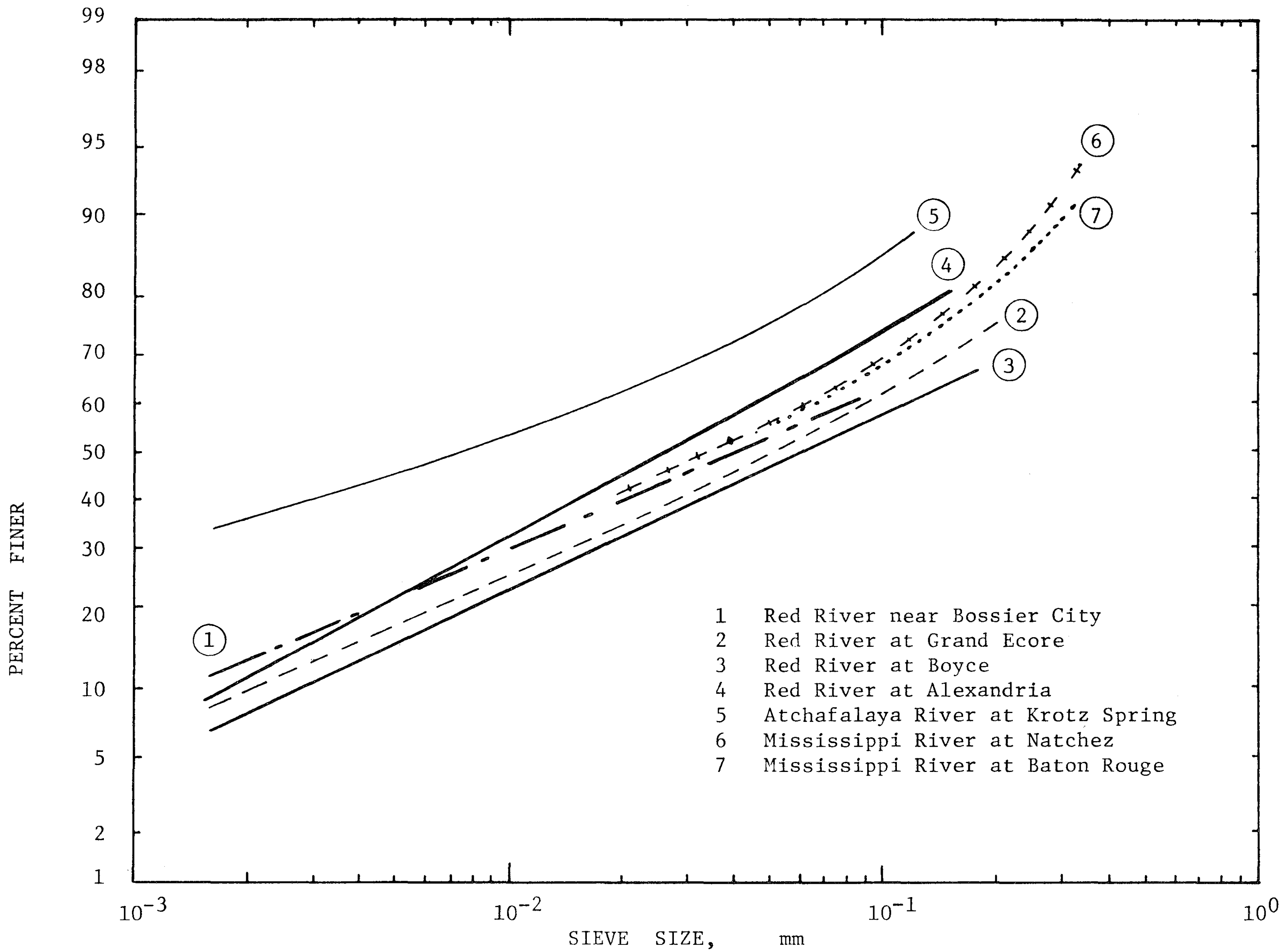


Figure 2 Size Distribution of Bed Materials

III. ANALYSIS OF RESULTS

A summary of the basic data is compiled in Table 1. In Column 1, the first numeral represents the site number and the second numeral the sequence of the data taken at that site. The mean velocity of flow was obtained by dividing the discharge by the cross-sectional area of the flow at 60 m upstream of the bridge. Mean depth was calculated by dividing the cross-sectional area by the channel width at the water surface.

The local flow velocity was estimated in accordance with Manning's formula by assuming the ratio of local velocity to the mean velocity equal to the two-thirdth power of the ratio of the local flow depth to the mean depth. The local depth used in this estimation is the approach depth directly upstream of the pier as measured at the cross section approximately at or less than 30 m upstream. The approach angles of the local flow toward the piers were determined from a study of the contour lines of the riverbed elevation presented in the figures in the Appendix.

The fall velocities of the bed materials were calculated by using Stokes' law for 15.6°C water temperature. For this temperature, the fall velocity, ω, can be expressed by $\omega = 8020\ d^2$ cm/s, where d is the diameter of the particle in cm.

The parameters used in the analysis and comparison with the conventional scour formulas are computed and summarized in Table 2. The projected (or effective) width, b, of the pier was estimated graphically. First, a plan view of the pier was drawn to proper scale and two tangential lines having

TABLE 1

SUMMARY OF SCOUR DATA

Data Number	Description of Pier			Flow Condition (Mean)			Local Flow Condition			Scour	Bed Material			Name of River and Location
	Type	Width B in m	Length L in m	Discharge Q in cms	Velocity V_m in m/s	Depth y_m in m	Velocity V_o in m/s	Depth y_o in m	Approach Angle in deg.	Depth d_s in m	Classification	Median Diameter d_{50}, mm	Fall Velocity in cm/s	
1 -1	Rounded Nose Rectangular	3.7	18.3	850	0.81	2.18	0.69	1.7	0	3.4	Loam	0.043	0.148	Red River near Bossier City *
1 -2		↓	↓	↓	↓	↓	1.09	3.4	0	7.3		↓	↓	
2 -1		4.9	12.8	–	–	1.67	–	1.8	0	4.0	Sandy Loam	0.053	0.225	Red River at Grand Ecore
2 -2		↓	↓	–	–	3.29	–	4.6	0	4.6		↓	↓	
3 -1	Circular Cylinder	7.3	7.3	218	0.37	3.48	0.46	4.9	0	3.7	Sandy Loam	0.06	0.289	Red River at Boyce
3 -2		↓	↓	306	0.52	3.41	0.61	4.3	0	4.3		↓	↓	
4 -1	Rounded Nose Rectangular	13.0	38.0	295	0.53	3.92	0.55	4.1	5	7.3	Silty Loam	0.027	0.058	Red River at Alexandria
4 -2		↓	↓	227	0.53	2.92	0.66	3.4	15	6.8		↓	↓	
4 -3		↓	↓	912	1.12	5.14	1.16	5.4	20	8.5		↓	↓	
5 -1	Lenticular	9.8	12.5	3740	0.80	12.6	0.73	11.0	5	4.3	Silty Clay	0.008	0.005	Atchafalaya River at Krotz Spring **
5 -2		↓	↓	↓	↓	↓	0.81	12.8	30	8.2		↓	↓	
5 -3		↓	↓	6940	1.16	15.1	1.17	15.2	15	4.6		↓	↓	
5 -4		↓	↓	↓	↓	↓	↓	↓	25	7.9		↓	↓	
5 -5		↓	↓	4390	0.89	13.0	0.82	11.6	15	4.0		↓	↓	
5 -6		↓	↓	↓	↓	↓	0.91	13.4	25	7.6				

Data Number: first digit = Site No.; second digit = Event No.

TABLE 1

SUMMARY OF SCOUR DATA (continued)

Data Number	Description of Pier			Flow Condition (Mean)			Local Flow Condition			Scour	Bed Material			Name of River and Location
	Type	Width B in m	Length L in m	Discharge Q in cms	Velocity V_m in m/s	Depth y_m in m	Velocity V_o in m/s	Depth y_o in m	Approach Angle in deg.	Depth d_s in m	Classification	Median Diameter d_{50}, mm	Fall Velocity in cm/s	
6 -1	Rectangular	9.4	19.5	9150	1.14	9.9	1.80	19.5	0	6.1	Silty Loam	0.036	0.104	Mississippi River at Natchez ***
7 -1	Rounded Nose Rectangular	19.5	38.0	5890	0.70	12.2	0.66	11.3	15	10.4	Silty Loam	0.036	0.104	Mississippi River at Baton Rouge

* Friction Slopes for Red River range from 0.98 - 1.0 X 10^{-4} (use 1.0X10^{-4})
** Friction Slopes for Atchafalaya River range from 2.23 - 3.76 X 10^{-5} (use 2.23 X 10^{-5})
*** Friction Slope for Mississippi River was 2.5 X 10^{-5}

Note: Friction Slopes were determined from gage readings at two successive gaging stations in the vicinity of the sites.

TABLE 2 PARAMETERS USED IN COMPARATIVE ANALYSIS

Data Number	B in m	ϕ in degree	b in m	y_o in m	d_s in m	y_o/b	d_s/b	Froude Number	Slope, S X 10^5	y_m in m	τ / τ_c*
1 -1	3.7	0	3.7	1.7	3.4	0.459	0.919	0.168	10	2.18	14.5
	↓	↓	↓	3.4	7.3	0.919	1.973	0.189	↓	↓	↓
2 -1	4.9	↓	4.9	1.8	4.0	0.367	0.816	-	↓	1.67	11.1
-2	↓	↓	↓	4.6	4.6	0.939	0.939	-	↓	3.29	21.9
3 -1	7.3	↓	7.3	4.9	3.7	0.671	0.507	0.067	↓	3.48	23.2
-2	↓	↓	↓	4.3	4.3	0.589	0.589	0.094	↓	3.41	22.7
4 -1	13.0	5	15.0	4.1	7.3	0.273	0.487	0.086	↓	3.92	26.1
-2	↓	15	19.5	3.4	6.8	0.174	0.349	0.105	↓	2.92	19.5
-3	↓	20	21.5	5.4	8.5	0.251	0.395	0.159	↓	5.14	34.3
5 -1	9.8	5	9.8	11.0	4.3	1.122	0.439	0.070	2.23	12.6	18.7
-2	↓	30	10.0	12.8	8.2	1.280	0.820	0.072	↓	↓	↓
-3	↓	15	9.8	15.2	4.6	1.550	0.469	0.095	↓	15.1	22.4
-4	↓	25	10.0	15.2	7.9	1.520	0.790	0.095	↓	↓	↓
-5	↓	15	9.8	11.6	4.0	1.184	0.408	0.077	↓	13.0	19.3
-6	↓	25	10.0	13.4	7.6	1.340	0.760	0.079	↓	↓	↓
6 -1	9.4	0	9.4	19.5	6.1	2.074	0.649	0.130	2.5	9.9	16.5
7 -1	19.5	15	24.2	11.3	10.4	0.467	0.430	0.063	2.5	12.2	20.3

* Critical shear stresses range from 0.0015 to 0.0016 gr/cm^2 (use 0.0015 gr/cm^2).
The values were determined from Shields Curve.
$\tau = \gamma y_m S$

the approach angle, ϕ, were drawn from the furthest corners of the pier. The projected width of the pier was then determined by measuring the perpendicular distance between the tangential lines. The Froude numbers given in this table were based on the local flow conditions and not on the mean flow condition. The relative flow depth and the relative scour depth are expressed in terms of the projected pier width. Relative scour depth, d_s/b, is plotted against relative flow depth, y_0/b, in Figure 3, with the Froude number, Fr, as the third variable. The relative scour depths are smaller than unity except for one data point at the Red River Bridge near Bossier City (Data No. 1-2) where the Froude number of the flow was relatively high. For the two data points at the Red River Bridge at Grand Ecore, the Froude number could not be determined due to the lack of discharge data. Because of the relatively narrow range of the Froude numbers (from 0.067 to 0.197), the effect of Froude number on scour depth did not stand out clearly. However, a general increase of scour depth is shown as the Froude number increases.

For $y_0/b < 0.5$, scour tends to increase with flow depth. The rate of increase becomes milder for $0.5 < y_0/b < 1.0$ and finally approaches a constant maximum before showing a slightly decreasing trend for very large y_0/b. The data with Froude numbers between 0.067 and 0.13 were grouped and replotted in Figure 4 to demonstrate this point clearly. The relative depth of scour increases rapidly for $y_0/b < 0.5$ and approaches a maximum value of about 0.8 when y_0/b is 1.3 or larger. A decreasing trend may be indicated when y_0/b is about 2.

The presently available and popular scour formulas selected by Anderson [1] have been plotted in Figures 4 and 5 for comparison with the data and are

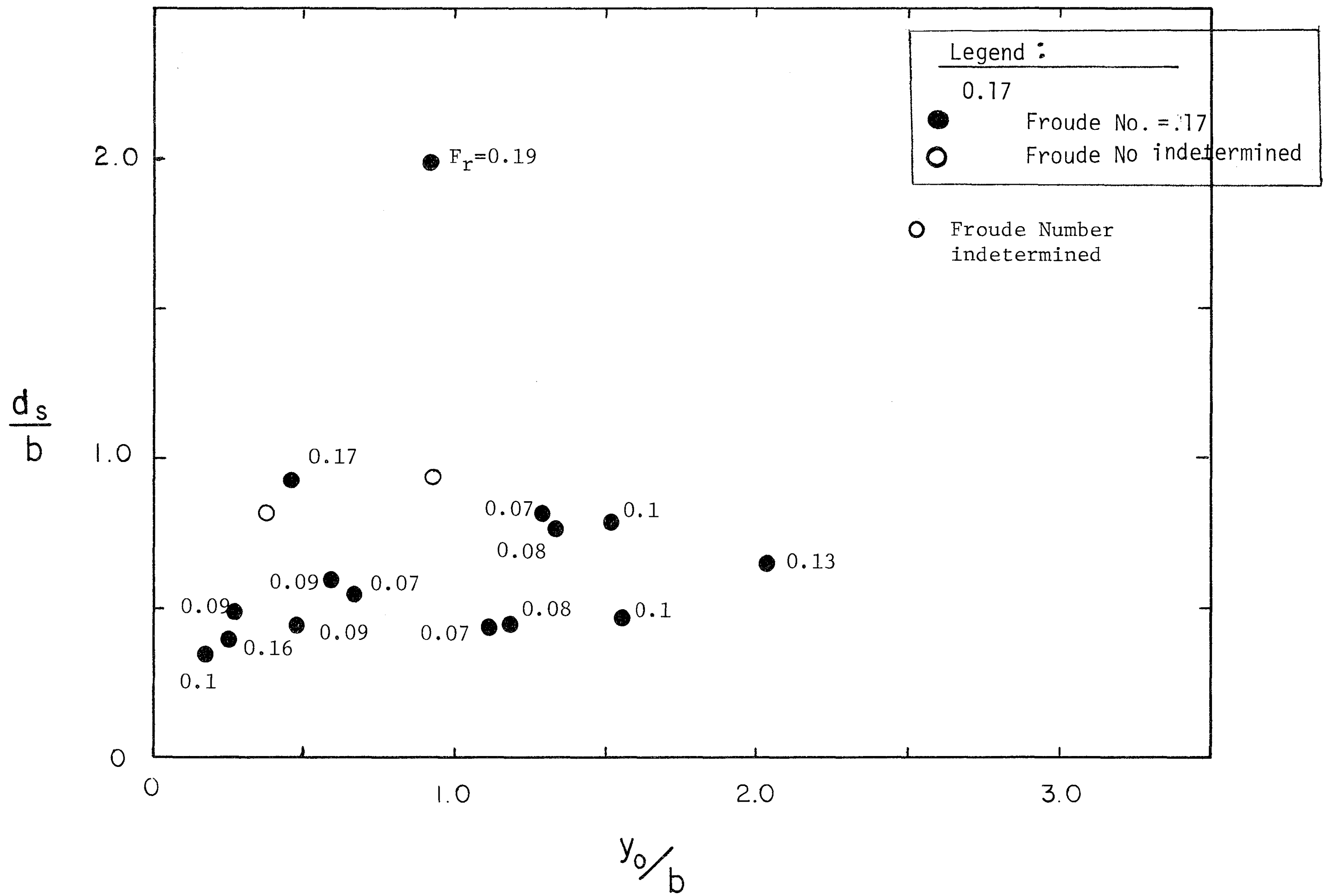


Figure 3 Relative Scour Depth vs. Relative Flow Depth

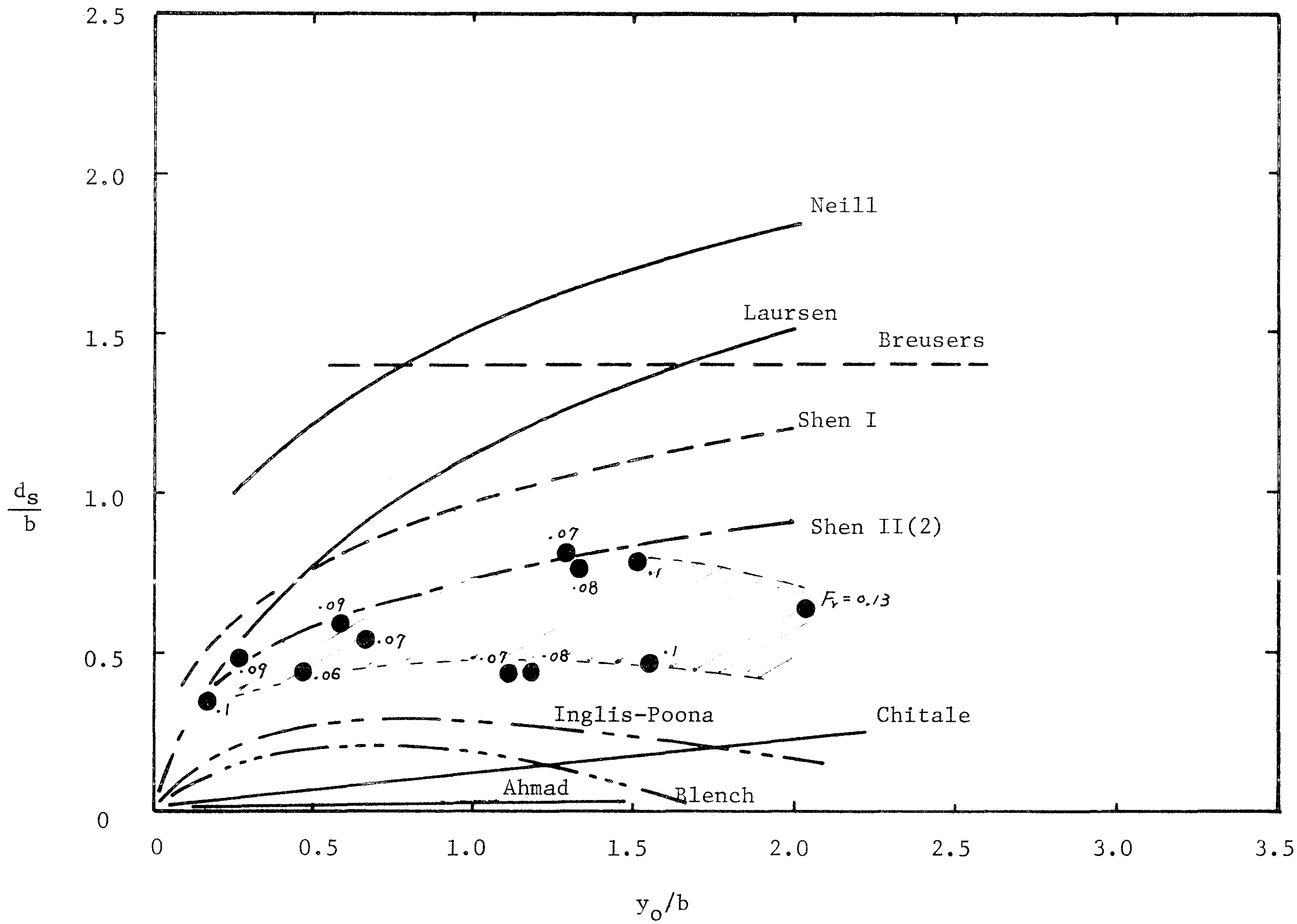


Figure 4 Comparison of Data with Scour Formulas for $F_r = 0.1$

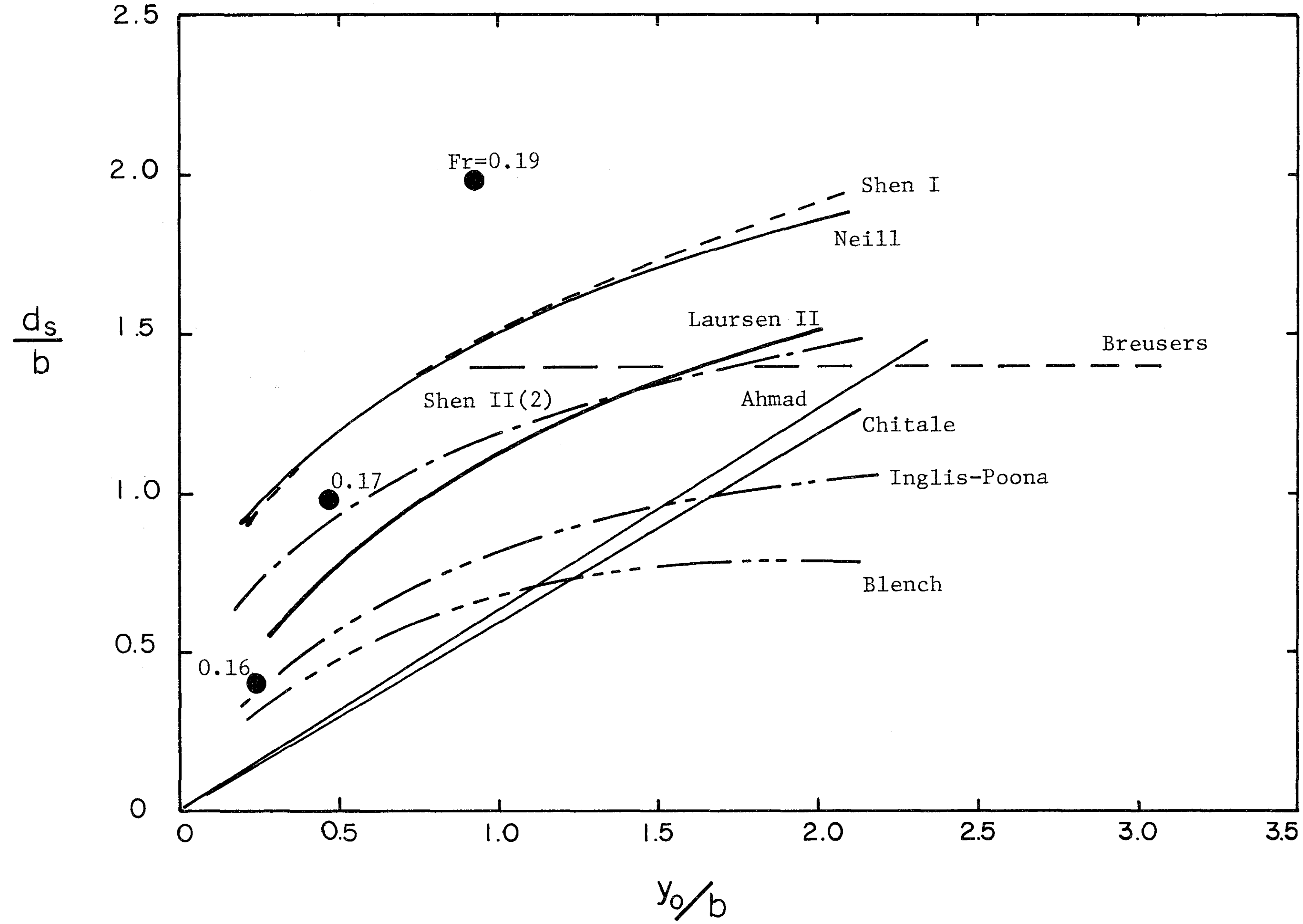


Figure 5 Comparison of Data with Scour Formulas for $F_r = 0.2$

listed in Table 3 for convenience. Shen's formula II(2) follows the upper limit of the data scatter quite closely. Both Laursen's and Shen's formula I give even higher values, with Laursen's formula becoming more divergent for increasing y_0/b. Relative scour depth calculated from Neill's formula is about double the actual value below $y_0/b = 1.5$. Breusers' formula yields a constant almost twice the maximum value of the data; thus it is most inaccurate at low values of y_0/b. Inglis-Poona's formula gives about one-half of the value of the data; however, the curve follows the general trend of the minimum points of the data scatter. Blench's formula yields values even lower than Inglis-Poona's, though it follows the same trend. Ahmad's and Chitale's formulas underestimate the scour by a large factor, especially at values of y_0/b less than 1.0 and show practically no correlation with the data.

TABLE 3 SCOUR FORMULAS

1. Ahmad:

$$\frac{d_s}{b} = \frac{y_o}{b}(4.77\ F^{2/3} - 1)$$

2. Blench:

$$\frac{d_s}{b} = 3.72\ F^{1/2}\left(\frac{y_o}{b}\right)^{3/4} - \frac{y_o}{b} \qquad d_g = 1.0\ \text{mm}$$

3. Breusers:

$$\frac{d_s}{b} = 1.4$$

4. Chitale:

$$\frac{d_s}{b} = \frac{y_o}{b}\left(-5.49\ F^2 + 6.65\ F - 0.51 \right)$$

5. Inglis-Poona:

$$\frac{d_s}{b} = 4.05\ \left(\frac{y_o}{b}\right)^{3/4} F^{1/2} - \frac{y_o}{b}$$

6. Laursen II:

$$\frac{b}{y_o} = 5.5\ \frac{d_s}{y_o}\left(\frac{1}{11.5}\ \frac{d_s}{y_o} + 1\right)^{1.7} - 1$$

7. Neill:

$$\frac{d_s}{b} = 1.5\ \left(\frac{y_o}{b}\right)^{0.3}$$

8. Shen I:

$$\frac{d_s}{b} = 4.43\ F^{2/3}\left(\frac{y_o}{b}\right)^{1/3}$$

9. Shen II(2):

$$\frac{d_s}{b} = 3.4\ F^{2/3}\ \left(\frac{y_o}{b}\right)^{1/3}$$

IV. SUMMARY AND CONCLUSIONS

The data utilized in this study were collected at seven bridge sites in the Red River, the Achafalaya River and the Mississippi River in Louisiana. The ranges of the important parameters are:

Effective pier width	3.4 - 10.4 m
Flow depth	1.7 - 19.5 m
Flow velocity	0.46 - 1.8 m/s
Froude number	0.067 - 0.189
Scour depth	3.4 - 10.4 m
Bed material diameter	0.008 - 0.06 mm

The effect of Froude number on scour depth was not clearly indicated. However, scour depth showed an increasing trend as the Froude number increased.

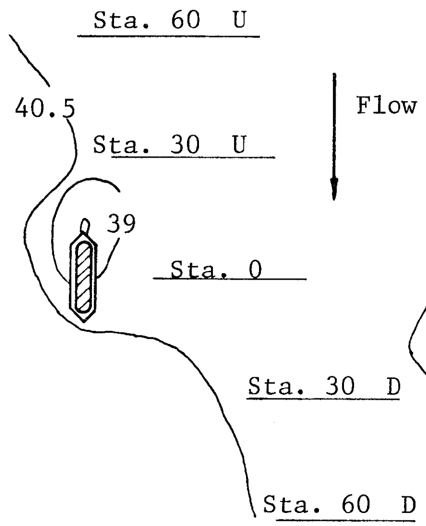
For low flows with a Froude number between 0.067 and 0.13, the relative scour depth increased with an increase in relative flow depth for a relative flow depth less than 0.5. The relative scour depth approached a constant value of about 0.8 maximum with a relative flow depth around 1.3. Past this point, a very slight decreasing trend may be assumed from the scatter of the limited data available. In this range, Shen's formula II(2) shows the best fit with the data, especially along the line of maximum scour. Laursen's formula and Shen's formula I yield values that are much higher, with Neill's formula consistently about twice as high as the actual data. Breusers' formula (a constant) gives the relative scour depth equal to 1.4 which is extremely inaccurate at low values of relative flow depth.

REFERENCE

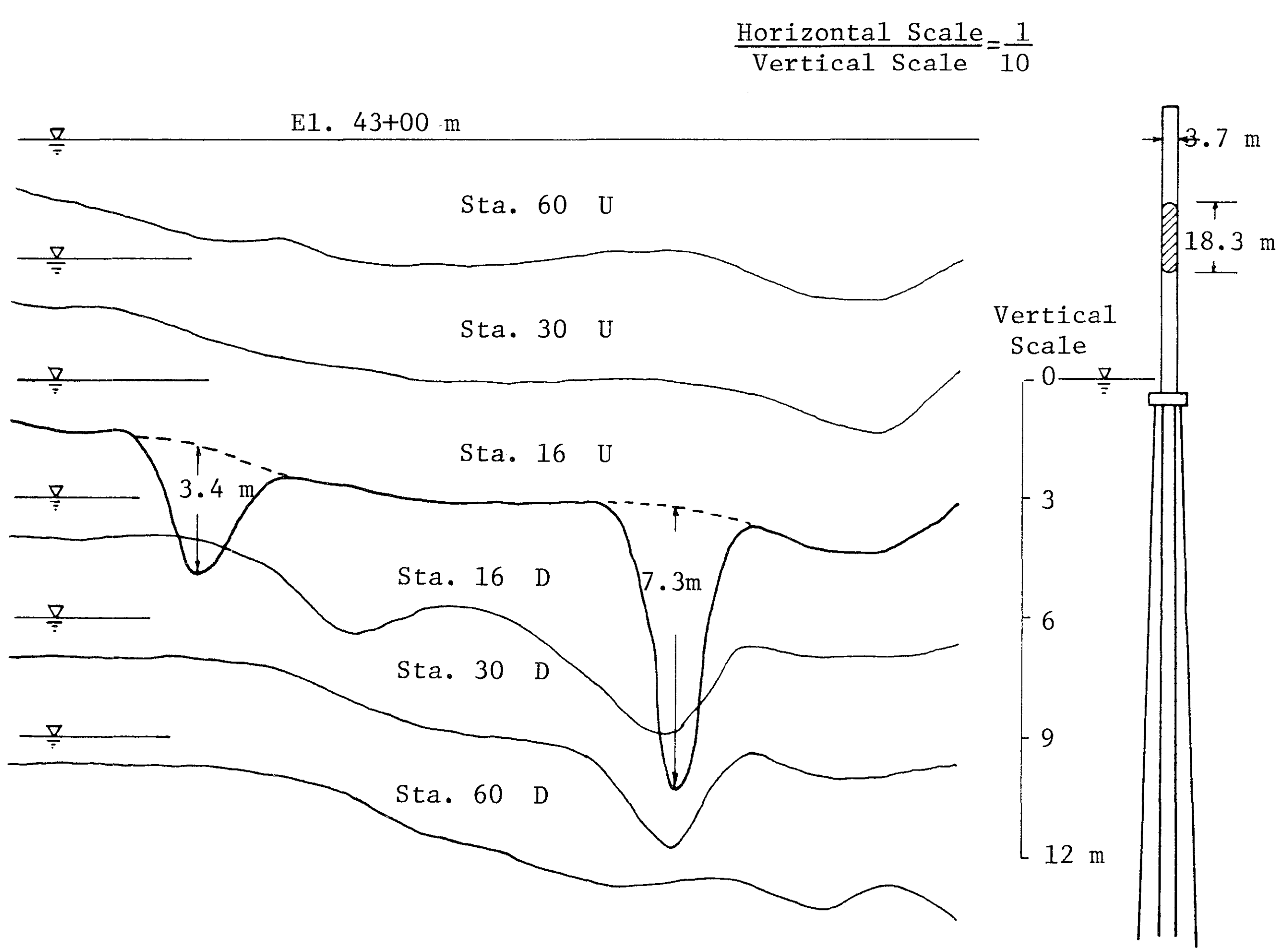
1. Anderson, A.G., "Scour at Bridge Waterways - A Review," Report No. FHWA-RD-75-89, Federal Highway Administration, Washington, 1974, p. 29.

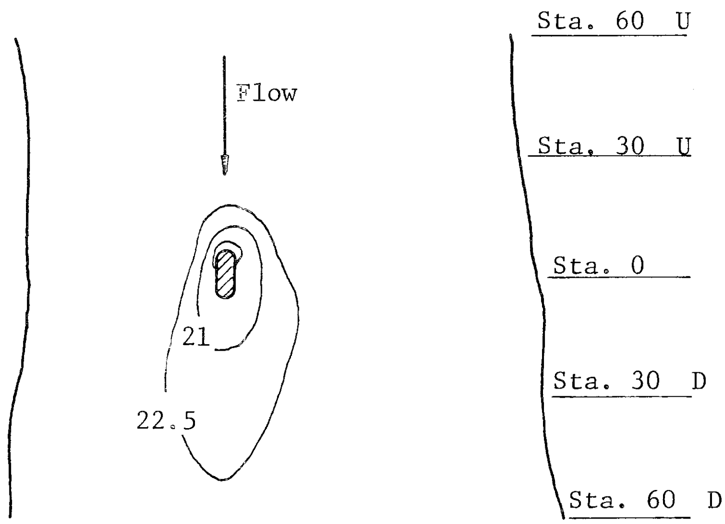
APPENDIX

Profiles of Riverbeds and Contours of Scour Holes

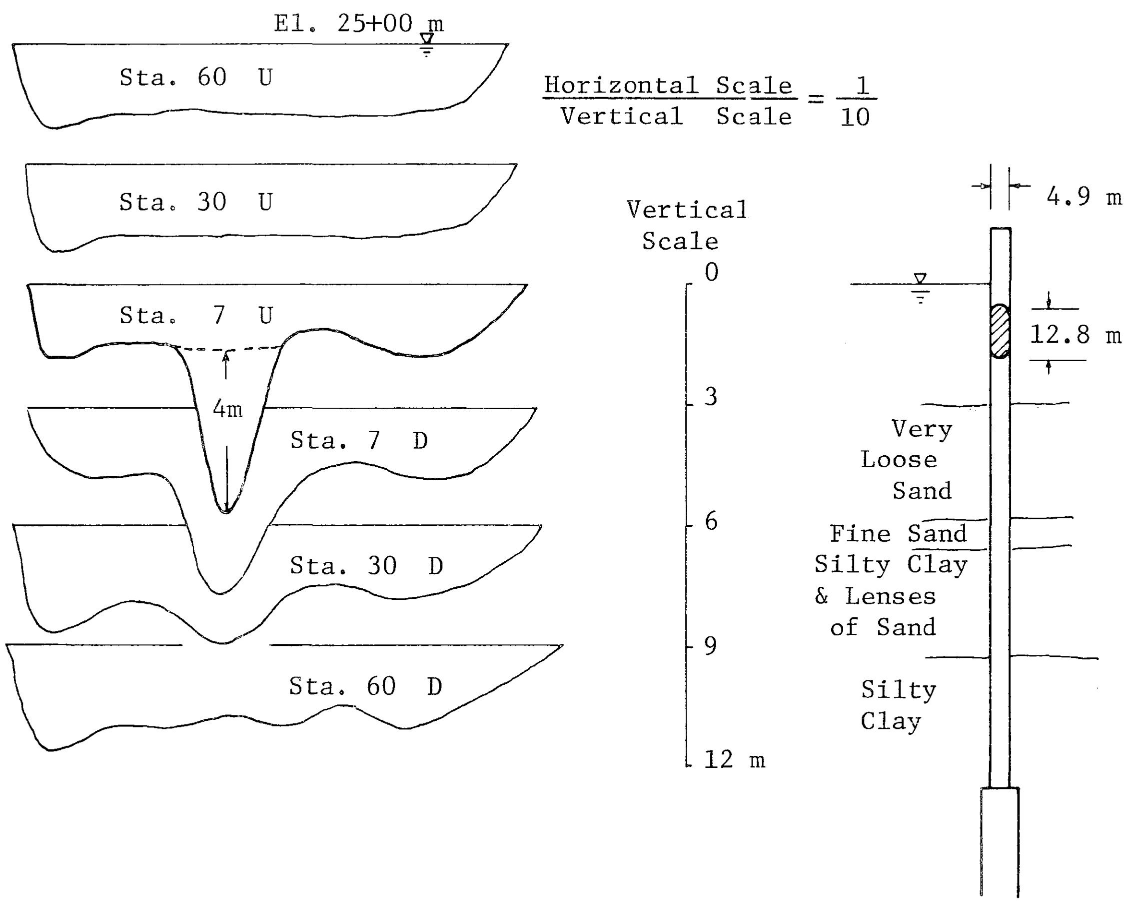


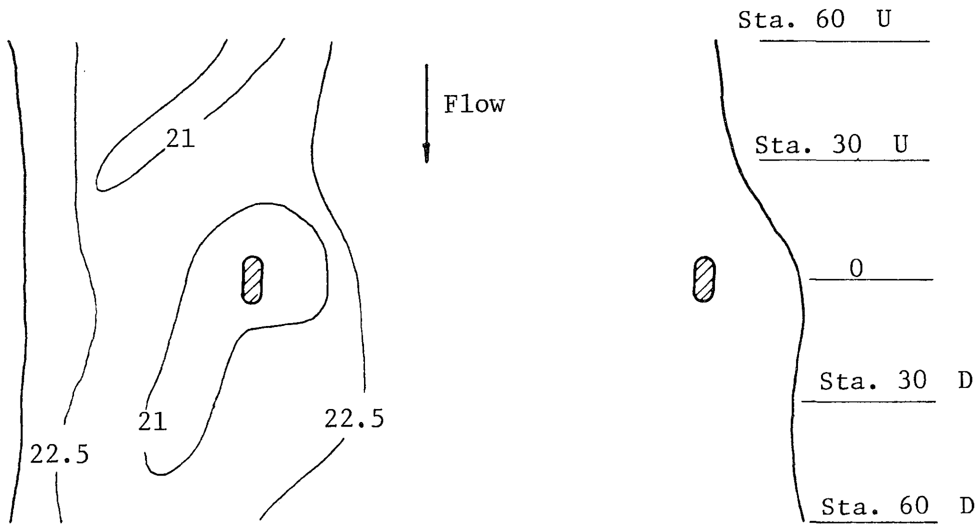
Riverbed Profile at
Bridge on Red River
at 70th Street Ext.
in Bossier City, La.
on 14 March, 1978
(Data No. 1-1 & 1-2)



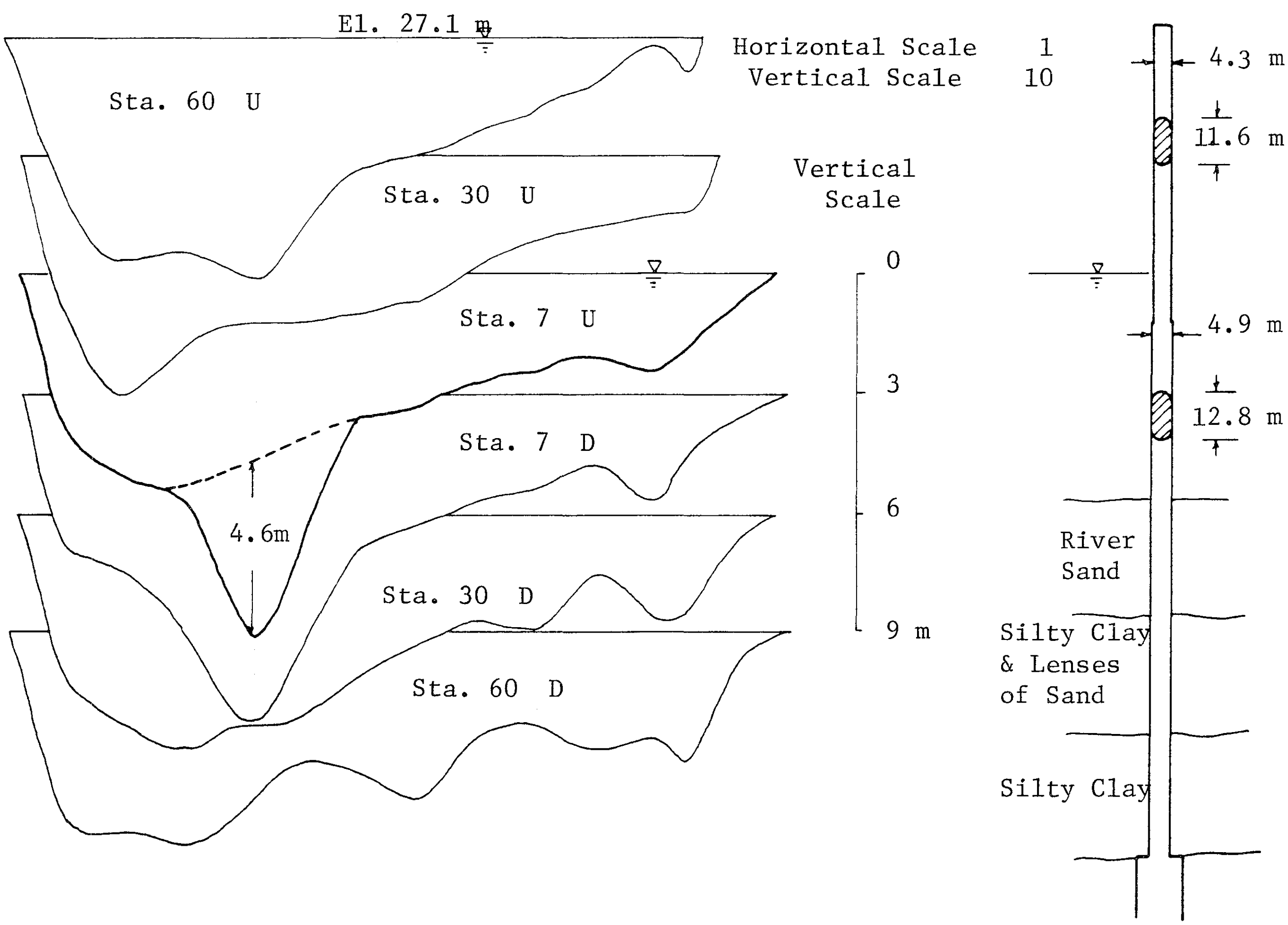


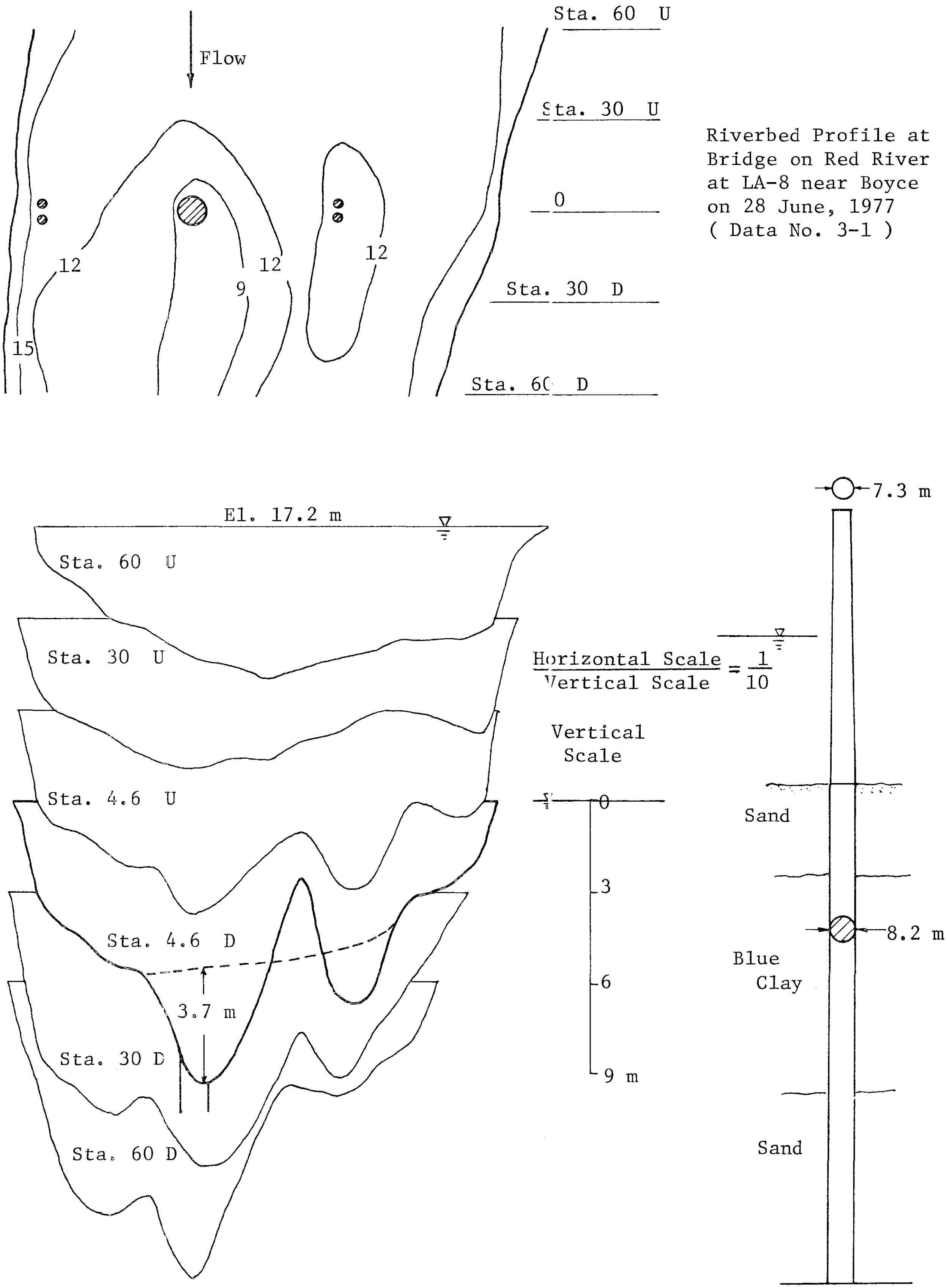
Riverbed Profile at Bridge on Red River at LA-6 near Grand Ecore on 27 December, 1977 (Data No. 2-1)



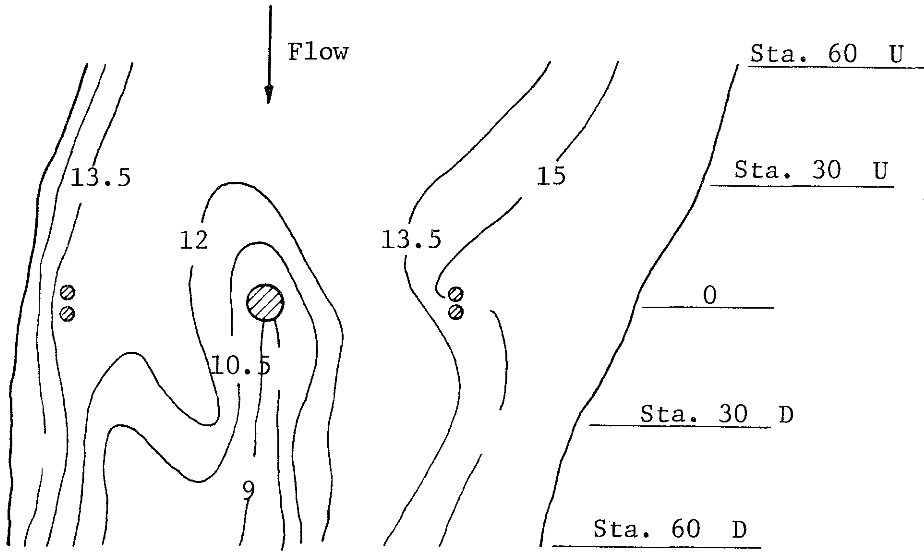


Riverbed Profile at Bridge on Red River at LA-6 near Grand Ecore on 16 June, 1978(Data No. 2-2)

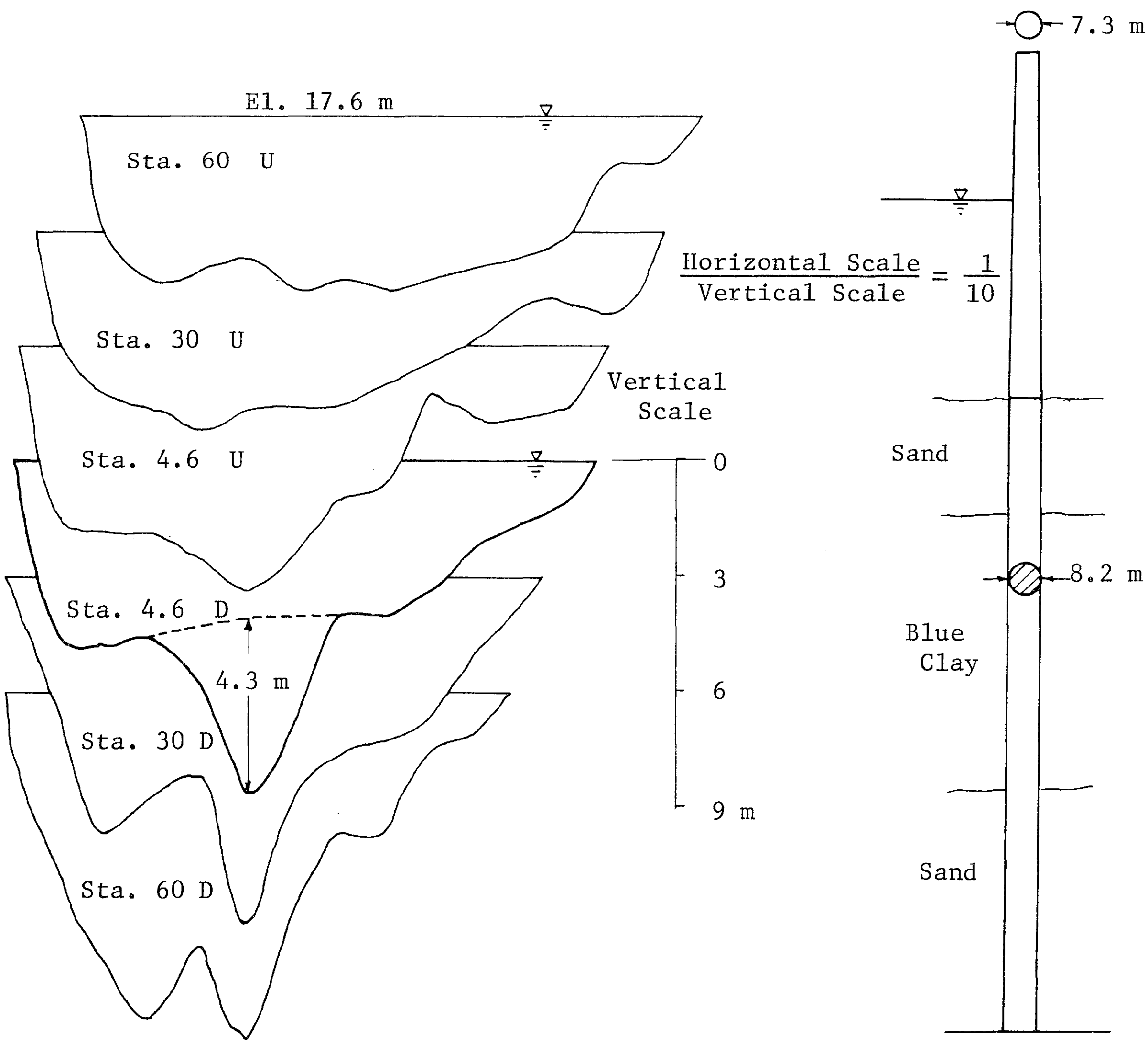


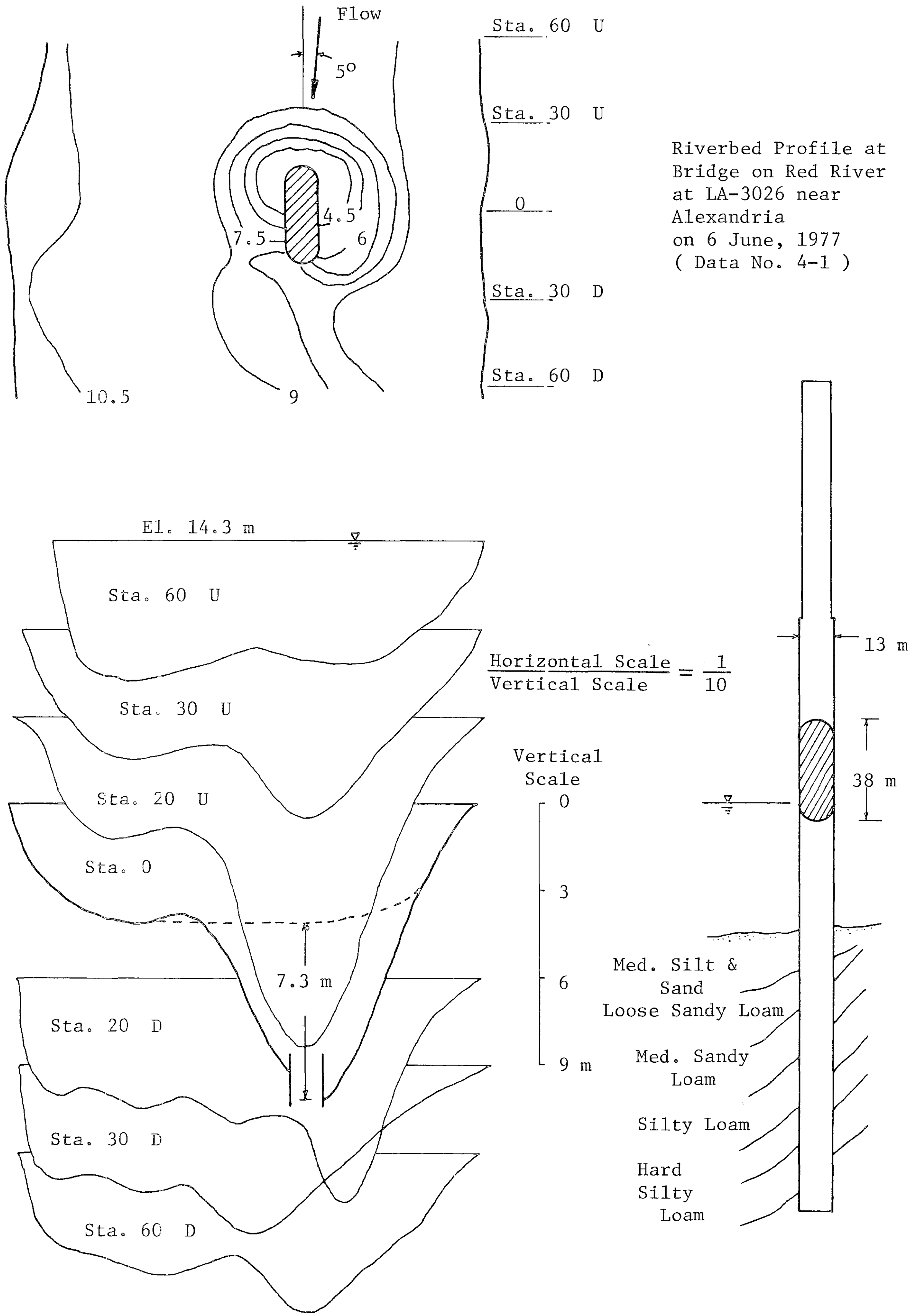


Riverbed Profile at Bridge on Red River at LA-8 near Boyce on 28 June, 1977 (Data No. 3-1)



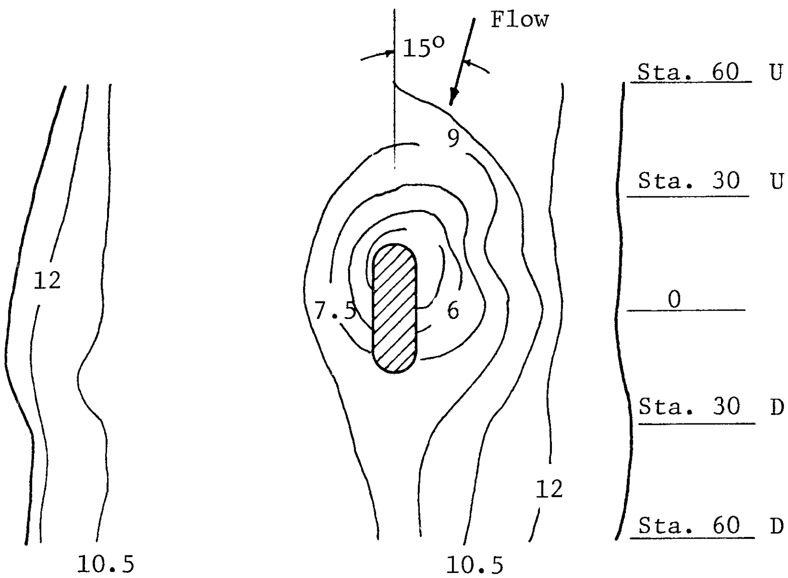
Riverbed Profile at
Bridge on Red River
at LA-8 near Boyce
on 6 June, 1978
(Data No. 3-2)

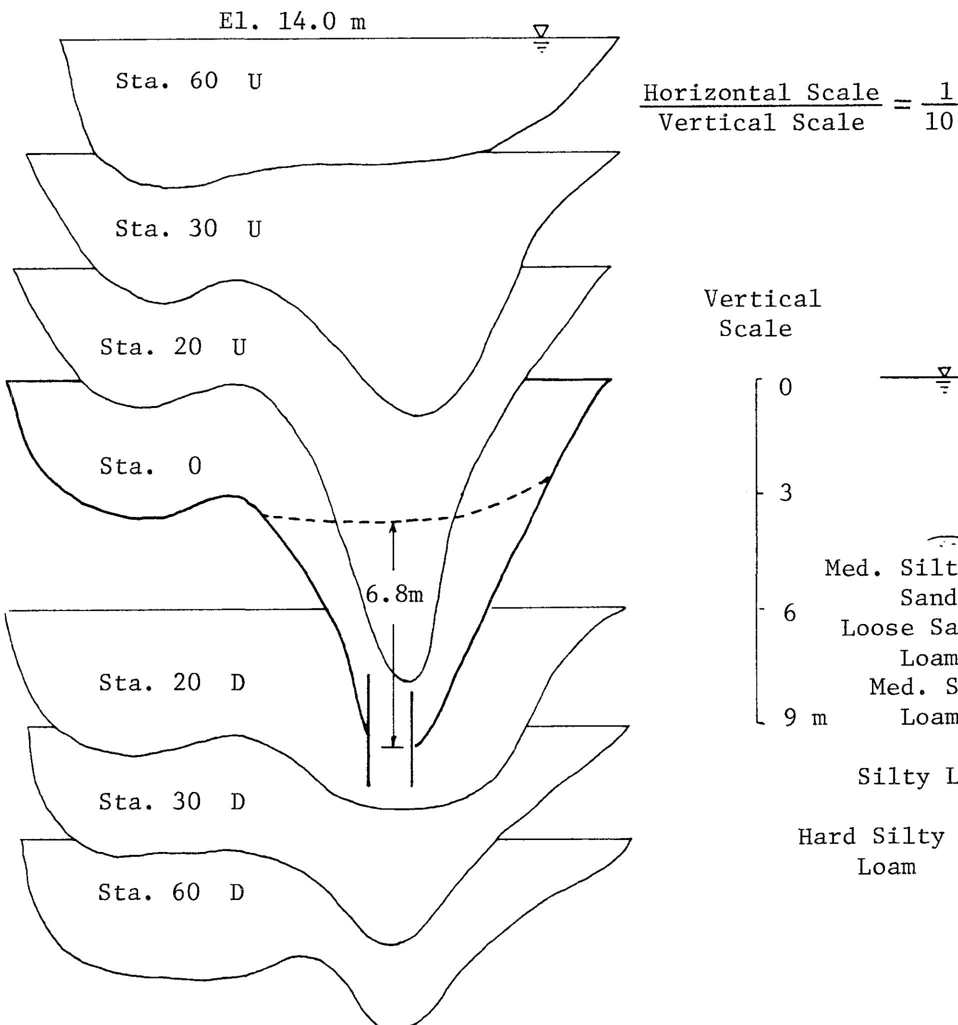


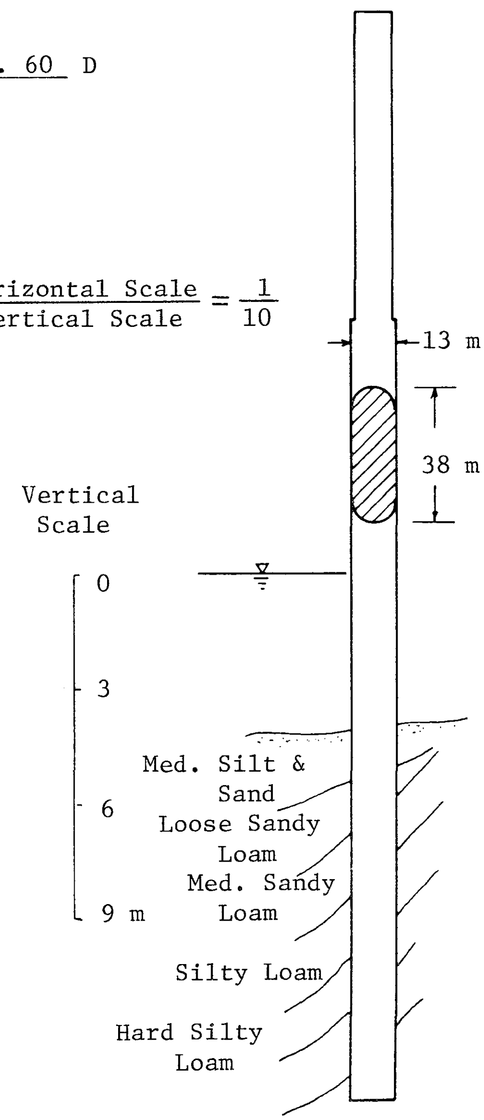


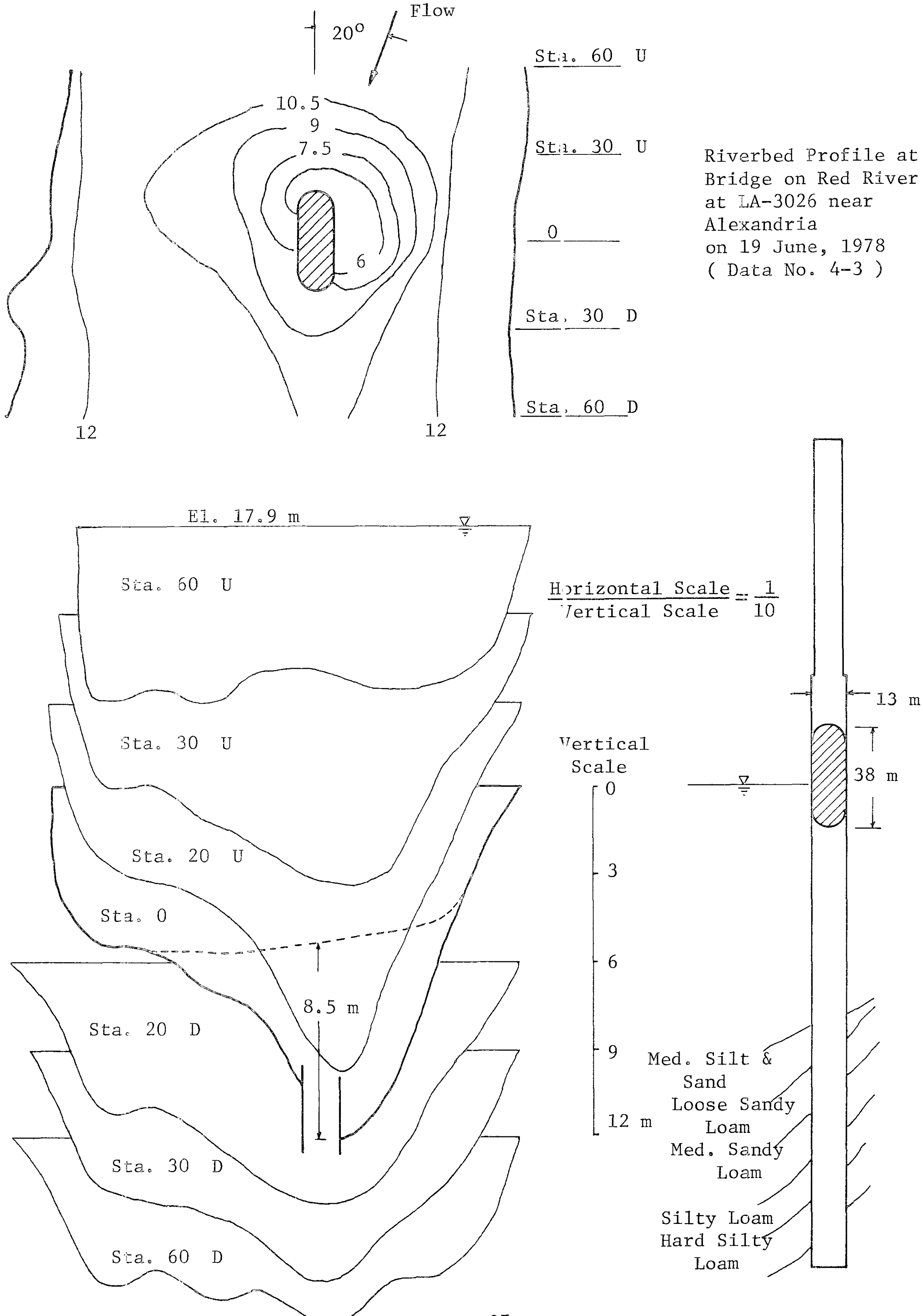
Riverbed Profile at Bridge on Red River at LA-3026 near Alexandria on 6 June, 1977 (Data No. 4-1)

Riverbed Profile at
Bridge on Red River
at LA-3026 near
Alexandria
on 21 November, 1977
(Data No. 4-2)

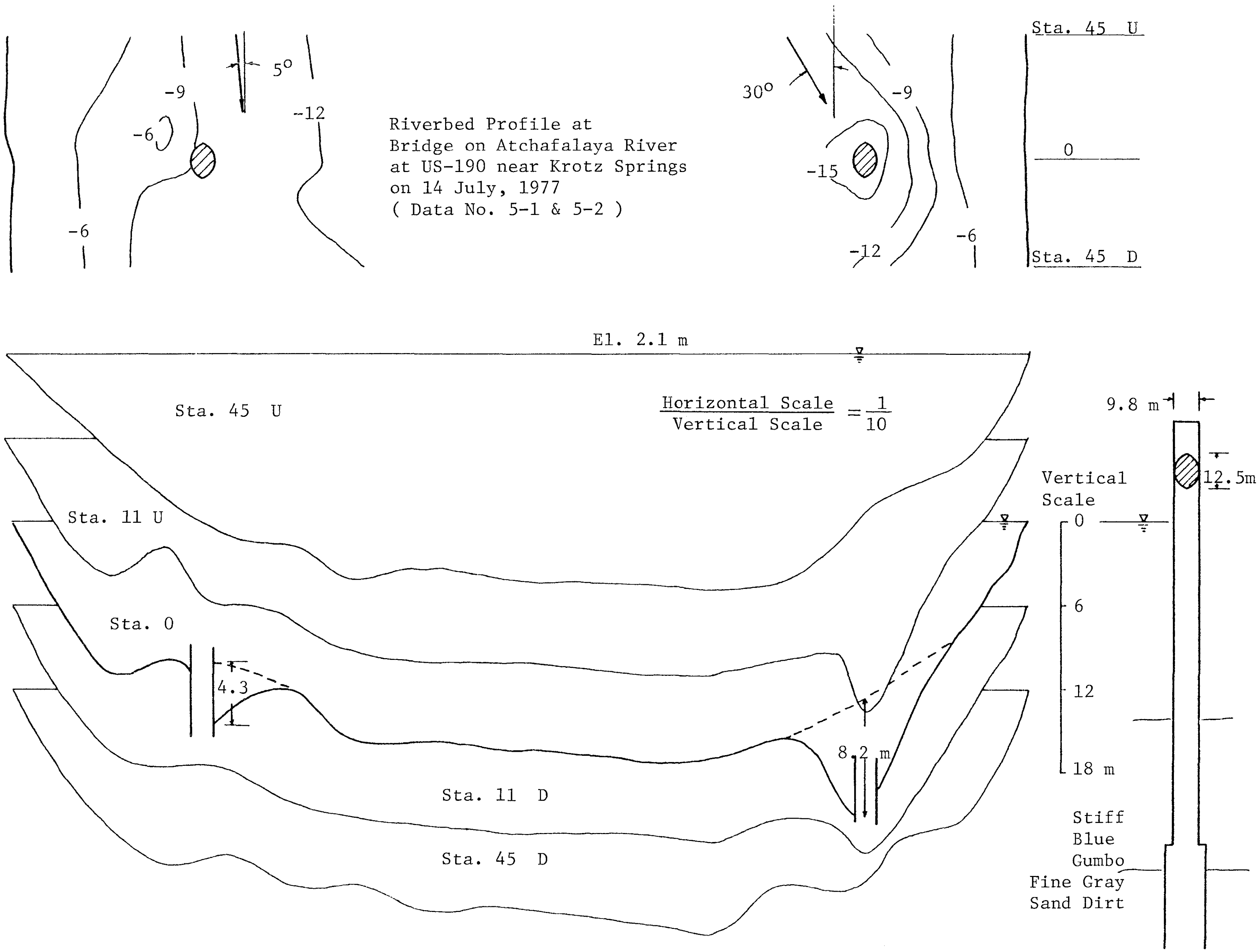


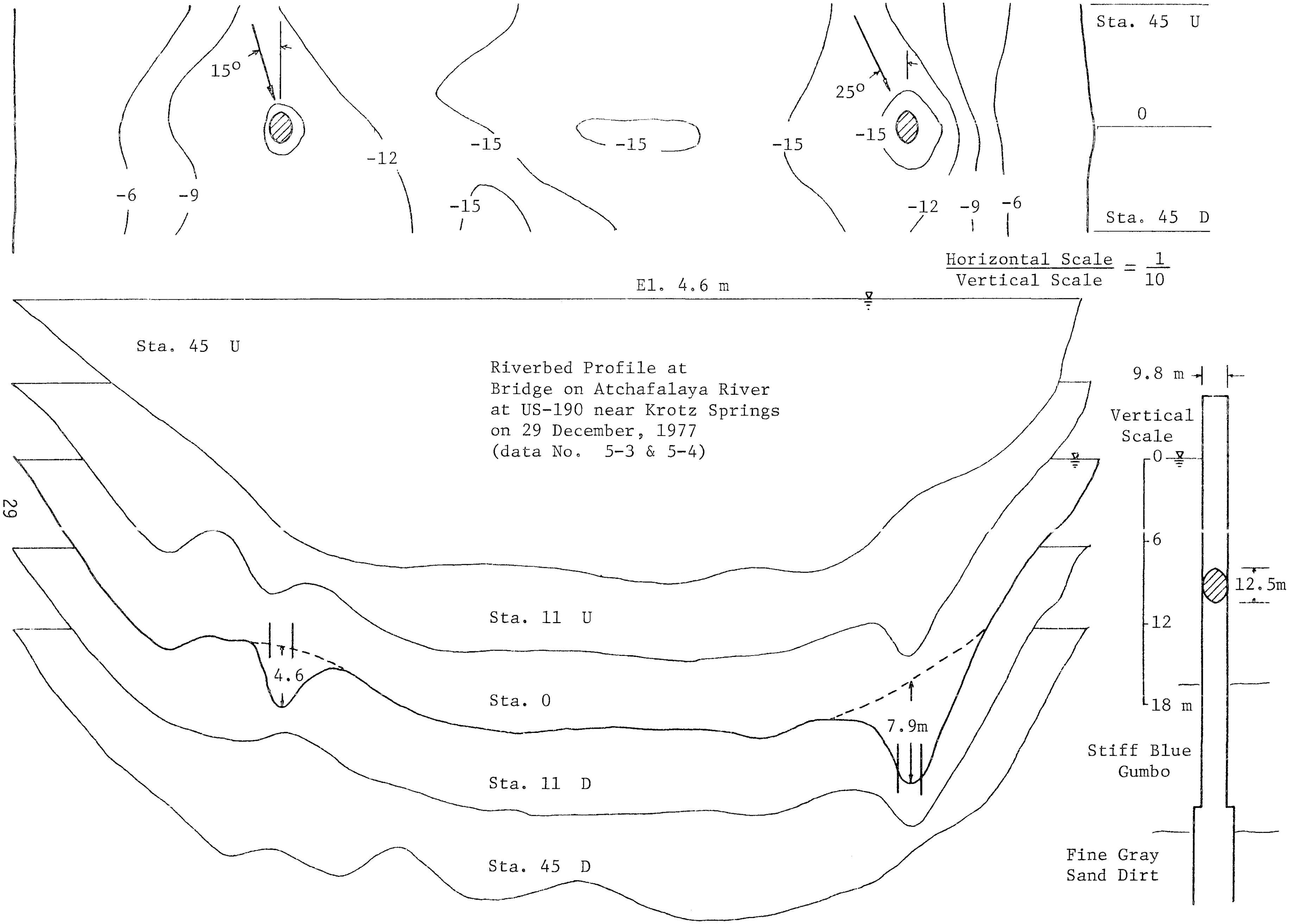


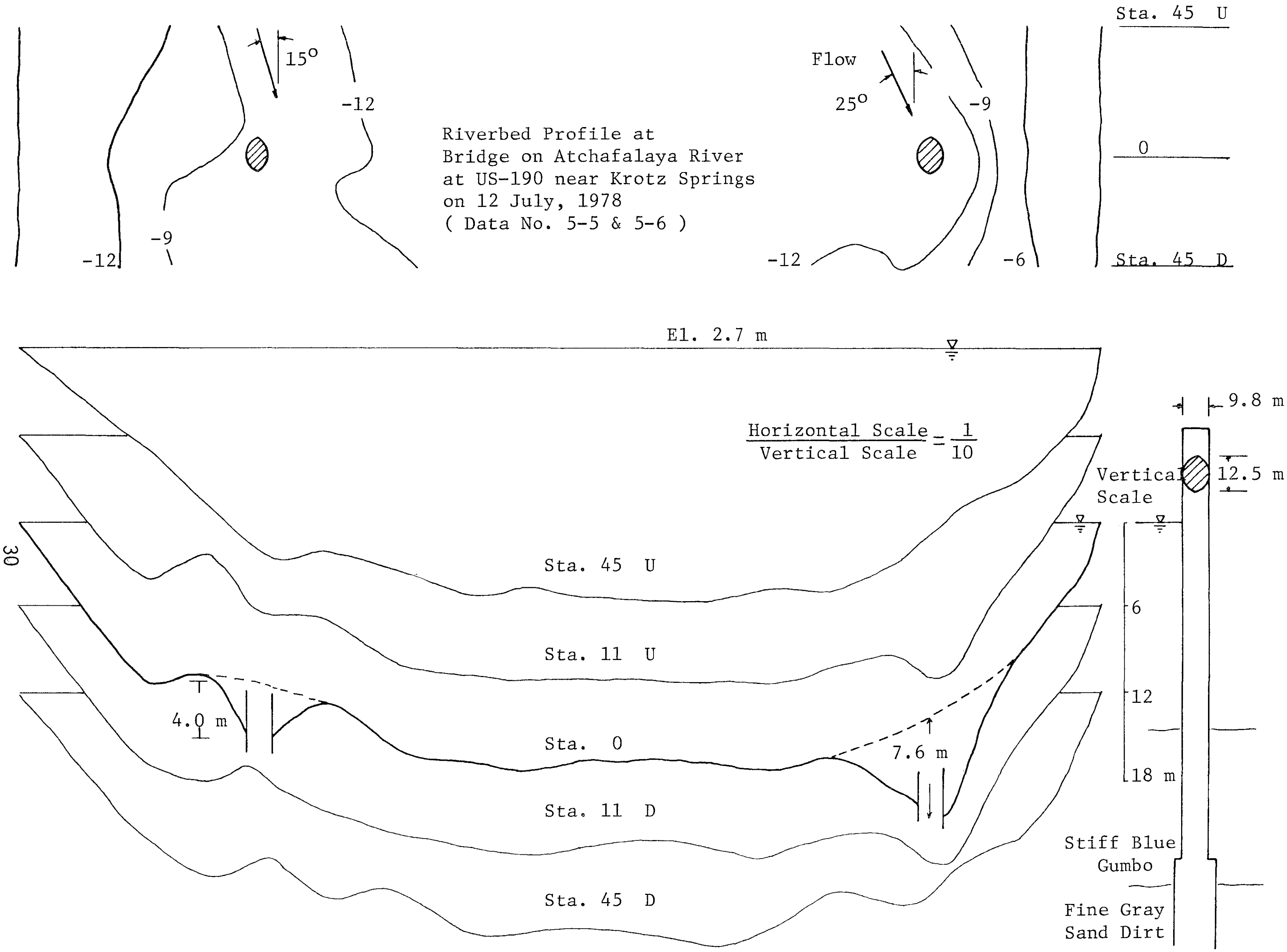


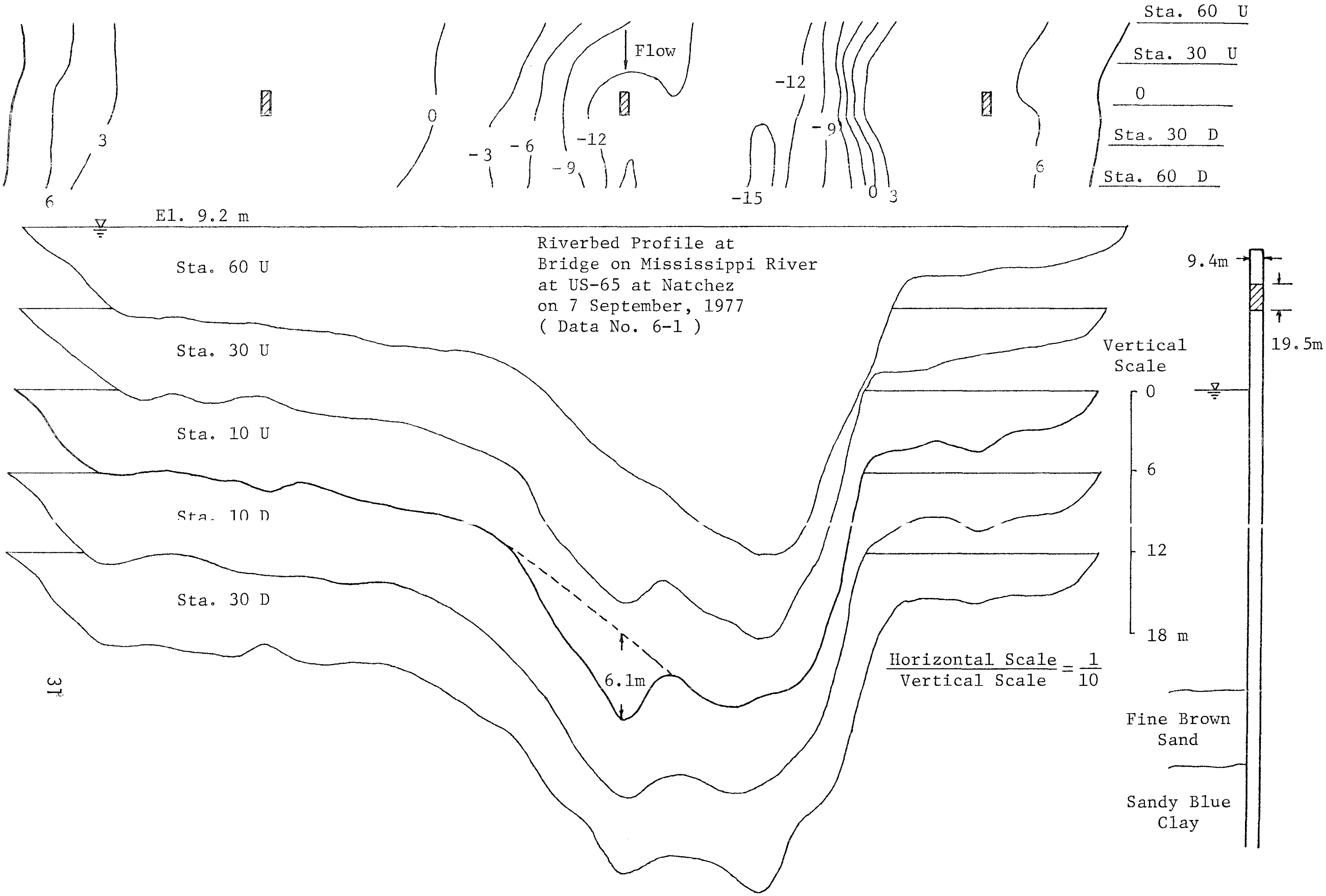


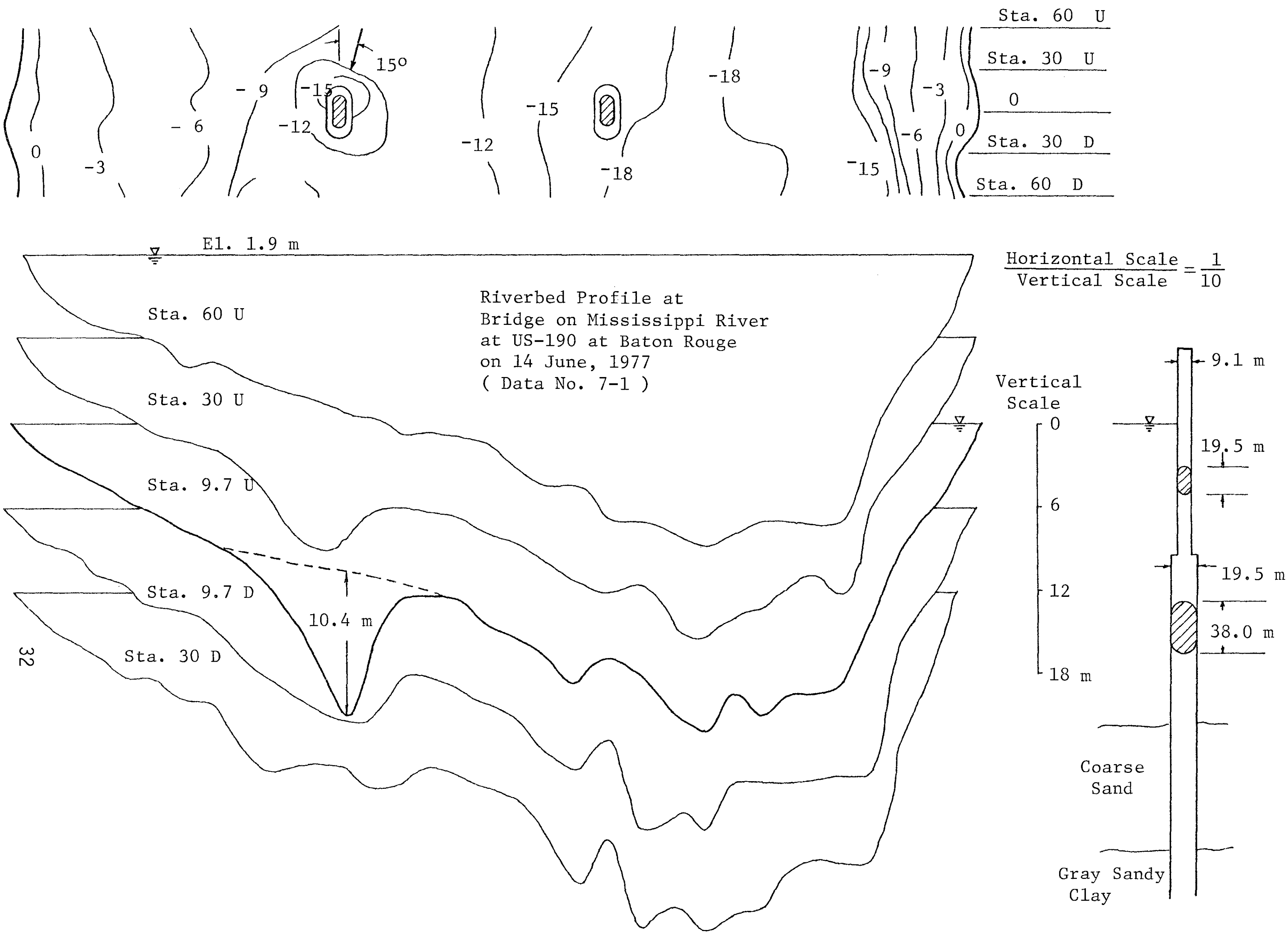
Riverbed Profile at
Bridge on Red River
at LA-3026 near
Alexandria
on 19 June, 1978
(Data No. 4-3)


Riverbed Profile at
Bridge on Atchafalaya River
at US-190 near Krotz Springs
on 14 July, 1977
(Data No. 5-1 & 5-2)
5°
-9
-12
-6
-6
30°
-9
-15
-12
-6
Sta. 45 U
0
Sta. 45 D
El. 2.1 m
Horizontal Scale / Vertical Scale = 1/10
Sta. 45 U
Sta. 11 U
Sta. 0
4.3
8.2 m
Sta. 11 D
Sta. 45 D
9.8 m
12.5m
Vertical Scale
0
6
12
18 m
Stiff Blue Gumbo
Fine Gray Sand Dirt


Sta. 45 U
0
Sta. 45 D
15°
25°
-6
-9
-12
-15
-15
-15
-15
-15
-15
-12
-9
-6
Horizontal Scale / Vertical Scale = 1/10
El. 4.6 m
Sta. 45 U
Riverbed Profile at
Bridge on Atchafalaya River
at US-190 near Krotz Springs
on 29 December, 1977
(data No. 5-3 & 5-4)
Sta. 11 U
4.6
Sta. 0
7.9m
Sta. 11 D
Sta. 45 D
9.8 m
Vertical
Scale
0
6
12
18 m
12.5m
Stiff Blue
Gumbo
Fine Gray
Sand Dirt


Riverbed Profile at
Bridge on Atchafalaya River
at US-190 near Krotz Springs
on 12 July, 1978
(Data No. 5-5 & 5-6)
15°
Flow
25°
-12
-9
-12
-9
-12
-9
-6
Sta. 45 U
0
Sta. 45 D
El. 2.7 m
Horizontal Scale / Vertical Scale = 1/10
Sta. 45 U
Sta. 11 U
Sta. 0
Sta. 11 D
Sta. 45 D
4.0 m
7.6 m
9.8 m
12.5 m
Vertical Scale
6
12
18 m
Stiff Blue Gumbo
Fine Gray Sand Dirt


Flow
Sta. 60 U
Sta. 30 U
0
Sta. 30 D
Sta. 60 D
0
3
6
-3
-6
-9
-12
-12
-9
-15
0
3
6
El. 9.2 m
Riverbed Profile at
Bridge on Mississippi River
at US-65 at Natchez
on 7 September, 1977
(Data No. 6-1)
Sta. 60 U
Sta. 30 U
Sta. 10 U
Sta. 10 D
Sta. 30 D
6.1m
Vertical
Scale
0
6
12
18 m
Horizontal Scale / Vertical Scale = 1/10
9.4m
19.5m
Fine Brown
Sand
Sandy Blue
Clay



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FEDERALLY COORDINATED PROGRAM OF HIGHWAY RESEARCH AND DEVELOPMENT (FCP)

The Offices of Research and Development of the Federal Highway Administration are responsible for a broad program of research with resources including its own staff, contract programs, and a Federal-Aid program which is conducted by or through the State highway departments and which also finances the National Cooperative Highway Research Program managed by the Transportation Research Board. The Federally Coordinated Program of Highway Research and Development (FCP) is a carefully selected group of projects aimed at urgent, national problems, which concentrates these resources on these problems to obtain timely solutions. Virtually all of the available funds and staff resources are a part of the FCP, together with as much of the Federal-aid research funds of the States and the NCHRP resources as the States agree to devote to these projects.*

FCP Category Descriptions

1. Improved Highway Design and Operation for Safety

Safety R&D addresses problems connected with the responsibilities of the Federal Highway Administration under the Highway Safety Act and includes investigation of appropriate design standards, roadside hardware, signing, and physical and scientific data for the formulation of improved safety regulations.

2. Reduction of Traffic Congestion and Improved Operational Efficiency

Traffic R&D is concerned with increasing the operational efficiency of existing highways by advancing technology, by improving designs for existing as well as new facilities, and by keeping the demand-capacity relationship in better balance through traffic management techniques such as bus and carpool preferential treatment, motorist information, and rerouting of traffic.

3. Environmental Considerations in Highway Design, Location, Construction, and Operation

Environmental R&D is directed toward identifying and evaluating highway elements which affect the quality of the human environment. The ultimate goals are reduction of adverse highway and traffic impacts, and protection and enhancement of the environment.

4. Improved Materials Utilization and Durability

Materials R&D is concerned with expanding the knowledge of materials properties and technology to fully utilize available naturally occurring materials, to develop extender or substitute materials for materials in short supply, and to devise procedures for converting industrial and other wastes into useful highway products. These activities are all directed toward the common goals of lowering the cost of highway construction and extending the period of maintenance-free operation.

5. Improved Design to Reduce Costs, Extend Life Expectancy, and Insure Structural Safety

Structural R&D is concerned with furthering the latest technological advances in structural designs, fabrication processes, and construction techniques, to provide safe, efficient highways at reasonable cost.

6. Prototype Development and Implementation of Research

This category is concerned with developing and transferring research and technology into practice, or, as it has been commonly identified, "technology transfer."

7. Improved Technology for Highway Maintenance

Maintenance R&D objectives include the development and application of new technology to improve management, to augment the utilization of resources, and to increase operational efficiency and safety in the maintenance of highway facilities.

* The complete 7-volume official statement of the FCP is available from the National Technical Information Service (NTIS), Springfield, Virginia 22161 (Order No. PB 242057, price $45 postpaid). Single copies of the introductory volume are obtainable without charge from Program Analysis (HRD-2), Offices of Research and Development, Federal Highway Administration, Washington, D.C. 20590.