ATLAS HA-608

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

BACKWATER AT BRIDGES AND DENSELY WOODED FLOOD PLAINS, PEA CREEK NEAR LOUISVILLE, ALABAMA

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Prepared in cooperation with the
DEPARTMENT OF TRANSPORTATION
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and the
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HYDROLOGIC INVESTIGATIONS ATLAS
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INTRODUCTION

New techniques for predicting water-surface profiles, needed in the design of economical, structurally sound, and environmentally compatible stream crossings, are under investigation. The investigation has accelerated with the advent of digital computers capable of analyzing large quantities of data. Among the techniques is the development of two-dimensional (2-D) digital models. Field data are essential for development and evaluation of these techniques for predicting water-surface profiles. This atlas is one of a series that provide a wide range of field data.

Since 1969 the U.S. Geological Survey has been collecting backwater data where wide, densely vegetated flood plains are crossed by highway embankments and single-opening bridges. This work was done in cooperation with the Federal Highway Administration Department of Transportation, the Alabama State Highway Department, the Louisiana Department of Transportation and Development, and the Mississippi State Highway Department. The objective of this cooperative project is to present the data in a format conducive to the development of improved models for predicting hydraulic responses of flow at highway crossings of streams in complex hydrologic and geographic settings.

Backwater data were obtained at 22 sites for 35 floods; that is, 11 sites had 1 flood each; 9 sites, 2 floods each; and 2 sites, 3 floods each. Analysis of data (Schneider and others, 1976) showed that backwater and discharge at these sites computed by methods presently in use, would be inaccurate. The floodflow data are unique in the range and detail in which information was collected and provide a base for evaluating digital models relating to open-channel flow.

The data sites (fig. 1) are listed below. This atlas shows flood data obtained on Pea Creek near Louisville, Alabama, one of the 22 sites.

HYDROLOGIC INVESTIGATIONS ATLAS NUMBER

ALABAMA	
Buckhorn Creek near Shiloh	HA-607
Pea Creek near Louisville	608
Poley Creek near Sanford	609
Yellow River near Sanford	610
Whitewater Creek near Tarentum	611
LOUISIANA	
Alexander Creek near St. Francisville	HA-600*
Beaver Creek near Kentwood	601
Comite River near Olive Branch	602
Cypress Creek near Downsville	603*
Flagon Bayou near Libuse	604
Little Bayou de Loutre near Truxno	605*
Tenmile Creek near Elizabeth	606
MISSISSIPPI	
Bogue Chitto near Johnston Station	HA-591
Bogue Chitto near Summit	592
Coldwater River near Red Banks	593*
Lobutcha Creek at Zama	594
Okatoma Creek east of Magee	595
Okatoma Creek near Magee	596
Tallahala Creek at Waldrup	590
Thompson Creek near Clara	597*
West Fork Amite River near Liberty	598*
Yockanookany River near Thomastown	599*

*In press

DESCRIPTION OF DATA
TYPE OF DATA

Data collected at all study sites consist of (1) depths, velocities, and discharges measured through the bridge openings, and (2) peak water-surface elevations along the highway embankment and along cross sections. A minimum of seven valley cross sections were surveyed at approximately one valley-width intervals in the vicinity of the bridge at each site. Locations of the cross sections were aligned perpendicularly to the assumed direction of flow. Cross sections were extended to intersect the edge of the valley at equal water-surface elevations. Surveying procedures described in the U.S. Geological Survey Techniques of Water-Resources Investigations series (Matthai, 1967; Benson and Dalrymple, 1967) were followed.

HIGH-WATER MARKS

Water-surface elevations were determined from high-water marks identified along the cross sections and the edges of the valley after each flood. During peak discharge measurements, water-surface elevations were marked with standard surveying stakes along the upstream and downstream sides of the highway embankment. For some floods additional high-water marks were identified in the valley adjacent to the bridge to define in detail the water surface in the approach and exit reaches.

BRIDGE GEOMETRY

Detailed bridge geometry was obtained at each site. The bridge cross section was surveyed at the most contracted section. Piers, spur dikes, wingwalls, abutment slopes, and other pertinent geometry were measured.

MANNING'S ROUGHNESS COEFFICIENT

Schneider and others (1976) used composite Manning's roughness coefficient values *n* where frequent changes in roughness occurred. In their study, composite values of *n* were verified by matching step backwater computations of the water surface with actual water-surface profiles for measured discharges. The range of *n* values used in this report is based on values used by Schneider and others (1976). Roughness varies from open fields to dense forests.

Roughness values or ranges of roughness values in different parts of the flood plain are shown on the maps. The values shown are based on water depth. The high value is the value where water depth is less than 0.6 meter and the low value applies where water depth is greater than 1.0 meter. A linear relation of roughness to water depth is assumed for water depths between 0.6 and 1.0 meter.

PRESENTATION OF DATA

The data are presented on topographic maps enlarged from standard 1:24,000 or 1:62,500 scale U.S. Geological Survey topographic maps which comply with National Map Accuracy Standards. Accuracy limitations of the base maps are retained in the enlargements. Although positions may be scaled closely on the enlargements, they are not defined with greater accuracy than positions on the base maps.

Ground elevations are placed adjacent to solid squares. Elevations of floodmarks are indicated by numerical values adjacent to solid triangles. Floodmark elevations for separate floods are shown on separate sheets. Bridge geometry and road-embankment dimensions are shown with brief notations of pier spacing and configuration.

In addition to the data points shown on the maps, discharge measurements of selected floods, plots of cross sections, and velocity distribution diagrams are shown. Cross-section elevations are tabulated to define stream channels and flood-plain features in greater detail. Each cross section is referred to a zero station established at the extreme left edge (facing downstream) of the valley.

DATUM

All elevations presented in this report are referred to National Geodetic Vertical Datum of 1929 (NGVD).

FLOOD FREQUENCY

Flood-frequency relations are presented graphically. Techniques for deriving flood-frequency relations are those described by the U.S. Water Resources Council (1977), and by Hains (1973).

INTERNATIONAL SYSTEM OF UNITS (SI)

The International System of Units (SI) is used throughout this report. All data were measured in the U.S. customary units and converted to SI units. Ground elevations which were originally determined to the nearest tenth of a foot are rounded to the nearest 0.01 meter. Water-surface elevations which were surveyed to hundredths of a foot are rounded to millimeters. The same criteria apply to all other dimensions, except contour elevations which are shown to the nearest tenth of a meter.

The following factors may be used to convert SI units to the U.S. customary units

MULTIPLY SI UNITS	*BY*	*TO OBTAIN U.S. CUSTOMARY UNITS*
	LENGTH	
Meter (m)	3.281	Feet (ft)
	AREA	
Square meter (m^2)	10.76	Square feet (ft^2)
	VOLUME	
Cubic meter (m^3)	35.31	Cubic feet (ft^3)
	VELOCITY	
Meter per second (m/s)	3.281	Feet per second (ft/s)
	FLOW RATE	
Cubic meter per second (m^3/s)	35.31	Cubic feet per second (ft^3/s)

DATA FOR PEA CREEK NEAR LOUISVILLE, ALABAMA

Data for Pea Creek near Louisville, Ala., obtained in a 2-kilometer reach crossed about midway by a Barbour County road, are presented on three sheets (fig. 2). Sheet 1 contains tables showing cross-section data (table 1) and discharge data (table 2). An aerial view of the reach in the vicinity of the bridge is shown in figure 3. Relative magnitudes of the floods are shown on the frequency curve (fig. 4).

The locations of representative ground elevations are shown on sheet 2. These are points of significant changes in cross-section elevations and alinement of the axis. Stationing along cross sections was projected along straight lines perpendicular to the flow. Plots of the cross sections are graphic presentations of the tabular data.

Bridge geometry and road embankments are shown on sheet 2 as they existed at the time of the flood. The cross section surveyed at the downstream side of the bridge is tabulated on sheet 1. The cross section shown for velocity distribution was obtained by sounding from the upstream side of the bridge during the discharge measurement.

Data for the flood of December 21, 1972, on Pea Creek are presented. Seven valley cross sections were surveyed after this flood (sheet 2).

Manning's roughness coefficient values and the 1972 flood boundaries are shown on sheets 2 and 3.

FLOOD OF DECEMBER 21, 1972

Peak water-surface elevations, measured cross section, and velocities for the flood of December 21, 1972, are shown on sheet 3. The flood crested at an elevation of 109.225 meters at the reference point located on the downstream bridge curb 15 meters from the left abutment. The measured peak discharge was 50.4 cubic meters per second. A discharge of 8.30 cubic meters per second was measured two days later on the recession at an elevation of 108.442 meters at the reference point (table 2). The recurrence interval of the peak discharge is 2 years (Hains, 1973). See figure 4.

SUMMARY

Floodflow data that will provide a base for evaluating digital models relating to open-channel flow were obtained at 22 sites on streams in Alabama, Louisiana, and Mississippi. Thirty-five floods were measured. Analysis of the data indicated that backwater and discharges computed by standard indirect methods currently in use would be inaccurate where densely vegetated flood plains are crossed by highway embankments and single-opening bridges. This atlas presents flood information at the site on Pea Creek near Louisville, Ala. Water depths, velocities, and discharges through bridge openings on Pea Creek near Louisville, Ala., for the flood of December 21, 1972, were measured, together with peak water-surface elevations along embankments and along cross sections. Manning's roughness coefficient values in different parts of the flood plain are shown on maps, and flood-frequency relations are shown on graphs.

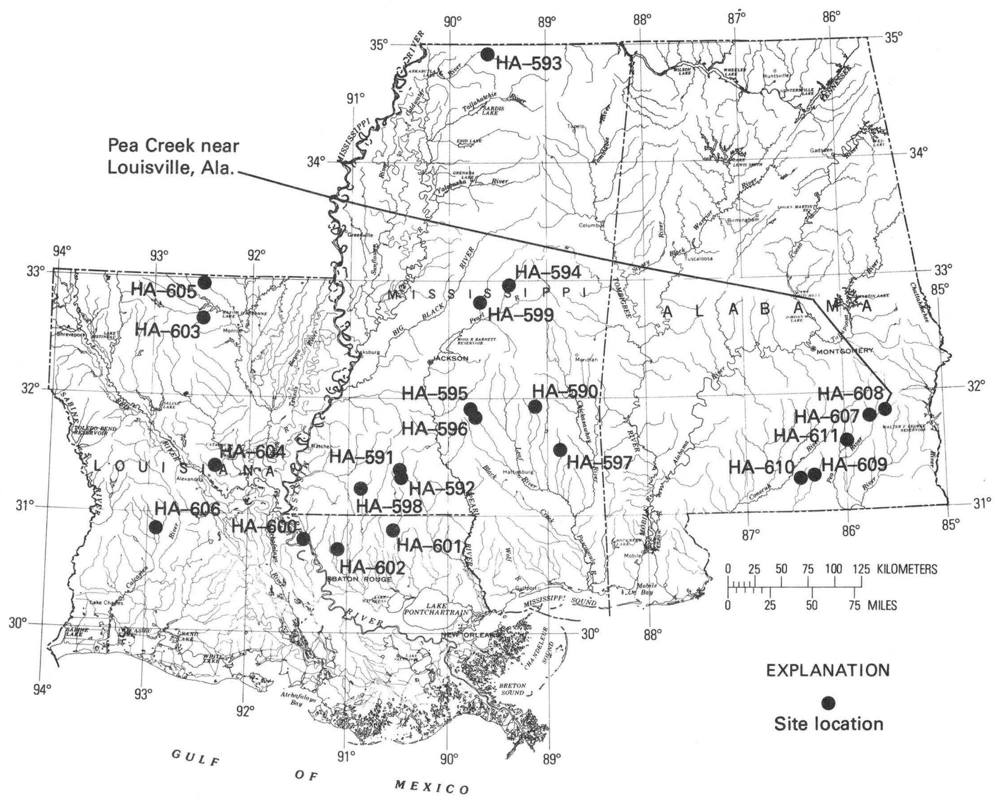

FIGURE 1.—INDEX MAP OF STUDY SITES IN THE BRIDGE BACKWATER INVESTIGATION PROJECT, ALABAMA, LOUISIANA, AND MISSISSIPPI.

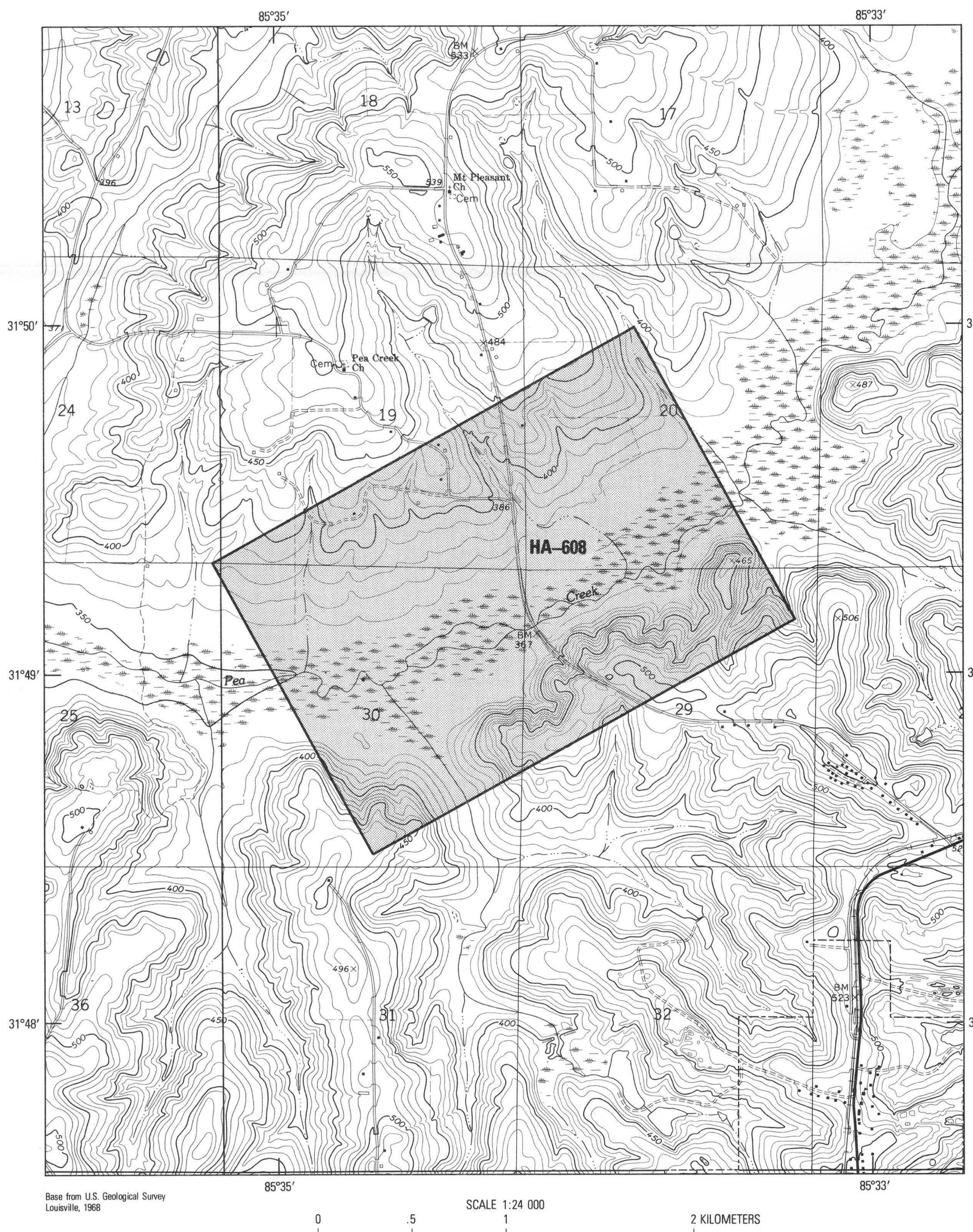

FIGURE 2—INDEX MAP OF STUDY REACH, PEA CREEK NEAR LOUISVILLE, ALABAMA

FIGURE 3—AERIAL VIEW LOOKING UPSTREAM IN VICINITY OF BRIDGE ON BARBOUR COUNTY ROAD, PEA CREEK NEAR LOUISVILLE, ALABAMA

ADDITIONAL INFORMATION

Other information pertaining to floods in Alabama, Louisiana, and Mississippi may be obtained at the offices of the U.S. Geological Survey listed below:

U.S. Geological Survey
Room 202, Oil and Gas Board Building (P.O. Box V)
University, Alabama 35486

U.S. Geological Survey
6554 Florida Boulevard (P.O. Box 66492)
Baton Rouge, Louisiana 70896

U.S. Geological Survey
430 Bounds Street
Jackson, Mississippi 39206

SELECTED REFERENCES

Barnes, H. H., Jr., 1967, Roughness characteristics of natural channels: U.S. Geol. Survey Water Supply Paper 1849, 213 p.

Benson, M. A., and Dalrymple, T., 1967, General field and office procedures for indirect discharge measurements: U.S. Geol. Survey Techniques Water-Resources Inv., book 3, Chap. A1, 30 p.

Bradley, J. N., 1970, Hydraulics of bridge waterways: Federal Highway Admin., Hydraulic Design Ser. No. 1, 111 p.

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Hains, C. F., 1973, Floods in Alabama, magnitude and frequency: Alabama Highway Dept., 37 p.

Hedman, E. R., 1964, Effects of spur dikes on flow through constrictions: Am. Soc. Civil Engineers Proc., Jour. Hydraulics Div., v. 91, no. HY4, July 1965, p. 155–165.

Matthai, H. F., 1967, Measurement of peak discharge at width contractions by indirect methods: U.S. Geol. Survey Techniques Water-Resources Inv., book 3, chap. A4, 44 p.

Neely, B. L., Jr., 1976, Floods in Louisiana, magnitude and frequency, 3d ed.: Louisiana Dept. Highways, 340 p.

Schneider, V. R., Board, J. W., Colson, B. E., Lee, F. N., and Druffel, L., 1976, Computation of backwater and discharge at width constrictions of heavily vegetated flood plains: U.S. Geol. Survey Water-Resources Inv. 76–129, 64 p.

U.S. Water Resources Council, 1977, Guidelines for determining flood flow frequency: Washington, D.C., U.S. Water Resources Council Bull. 17A, 163 p.

TABLE 1—VALLEY CROSS-SECTION DATA FOR PEA CREEK NEAR LOUISVILLE, ALA. ZERO STATION IS AT THE LEFT EDGE OF THE VALLEY (FACING DOWNSTREAM).

CROSS SECTION 1

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	108.86
36	107.55
38	107.34
46	106.88
68	106.88
77	106.94
109	106.94
123	106.97
150	107.06
163	106.82
185	106.94
201	107.06
204	106.91
207	105.54
211	105.36
213	105.05
215	105.78
217	106.88
247	106.21
255	106.30
261	106.18
264	106.91
269	107.06
290	107.03
307	106.94
319	106.94
326	107.37
340	107.03
356	107.37
360	107.49
361	107.55
366	107.80

CROSS SECTION 2

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	109.32
27	108.47
37	108.31
91	108.16
119	108.07
120	108.01
123	107.34
125	107.06
128	106.73
131	105.94
135	106.76
137	107.34
137	107.58
147	107.52
161	107.37
176	107.31
180	107.40
192	107.28
205	107.31
228	107.40
235	107.31
237	107.00
238	107.31
255	107.46
283	107.31
287	107.00
290	107.34
311	107.31
341	107.25
351	107.43
361	107.40
373	107.22
374	107.40
400	107.46
409	107.43
418	107.52
422	107.19
443	107.55
472	107.61
484	107.64
493	107.77
503	108.01
505	108.07
518	108.59

CROSS SECTION 3

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	109.93
37	108.47
48	108.10
77	107.92
110	108.10
150	108.01
208	108.01
210	105.57
213	106.27
215	107.03
216	107.95
218	108.25
244	107.46
262	108.04
279	108.01
287	108.04
293	108.34
294	108.22
311	108.19
321	108.22
327	107.98
335	108.25
340	108.22
348	108.13
359	108.10
367	108.04
373	108.25
376	108.04
395	108.10
402	108.13
408	108.22
421	108.25
428	108.19
461	108.07
478	108.13
494	108.25
504	108.50
531	109.32
549	109.93

CROSS SECTION 4

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	111.85
2	109.01
3	108.92
9	108.71
34	108.44
37	108.41
38	106.58
44	106.58
46	108.07
69	108.37
87	107.61

CROSS SECTION 4 (Cont.)

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
101	108.50
128	108.53
195	108.80
213	108.68
235	108.71
259	108.65
274	108.74
293	109.01
320	109.38
381	110.23

CROSS SECTION 5

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	111.15
26	109.47
33	109.05
39	108.95
46	108.89
50	108.41
62	108.22
68	108.13
77	108.19
87	107.98
92	108.34
94	107.83
98	107.31
106	107.52
109	108.34
127	108.22
145	108.47
157	108.44
194	108.22
241	108.50
269	108.83
285	108.86
301	108.89
344	109.53
377	109.99
481	111.45

CROSS SECTION 6

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	109.93
30	109.32
61	109.01
76	108.86
152	108.95
197	109.01
201	108.25
206	109.01
221	109.14
259	109.17
293	109.08
314	109.08
329	109.23
343	109.14
366	109.17
379	109.50
387	109.93
430	110.36
453	110.48
524	111.00

CROSS SECTION 7

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	112.22
3	111.30
9	110.36
15	109.93
27	109.29
44	109.62
71	109.65
87	109.56
88	109.20
91	109.56
125	108.74
137	108.04
146	109.56
163	109.84
166	108.47
183	109.38
204	110.08
247	110.17
265	110.11
308	110.08
331	110.36
376	110.90
396	112.03

BRIDGE SECTION

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	112.49
0	111.51
1	111.48
3	110.33
5	109.20
6	108.56
9	108.22
11	108.07
12	107.95
12	107.77
14	106.94
15	107.28
17	107.31
18	106.76
20	106.61
21	106.67
23	106.85
24	107.25
26	107.58
27	107.64
29	107.77
30	108.07
30	108.19
34	108.34
37	108.41
40	108.25
43	108.22
44	108.07
46	107.55
47	107.46
49	108.04
52	108.25
55	108.04
58	108.13
61	108.31
64	107.89
67	107.00
68	106.76
69	106.76
70	107.70
72	108.07
73	109.20
76	110.81
77	110.84
77	111.76

TABLE 2—DISCHARGE MEASUREMENTS DECEMBER 21 AND DECEMBER 23, 1972, PEA CREEK NEAR LOUISVILLE, ALABAMA. ZERO STATION IS AT THE EDGE OF THE LEFT ABUTMENT (FACING DOWNSTREAM).

DISCHARGE MEASUREMENT DECEMBER 21, 1972, PEA CREEK NEAR LOUISVILLE, ALA. (WATER-SURFACE ELEVATION=109.225 METERS) TOTAL DISCHARGE=50.4 CUBIC METERS PER SECOND

STATION (METERS)	DEPTH (METERS)	ANGLE (DEGREES)	OBSERVATION DEPTH[1]	VELOCITY (METERS PER SECOND)
5.2	0.0	0	0.0	0.0
6.1	0.52	16	1.0	0.728
9.1	0.88	0	0.6	0.838
10.7	0.98	0	0.6	0.762
12.2	1.25	0	0.2	0.957
			0.8	0.875
13.7	1.98	0	0.2	1.091
			0.8	0.384
15.2	1.40	0	0.2	0.860
			0.8	1.216
16.8	1.46	0	0.2	1.140
			0.8	0.728
18.3	2.35	0	0.2	0.978
			0.8	0.393
19.8	1.92	0	0.2	0.914
			0.8	0.354
21.3	2.07	0	0.2	0.893
			0.8	0.125
22.9	1.71	0	0.2	0.671
			0.8	0.210
24.4	1.68	0	0.2	0.494
			0.8	0.244
27.4	1.52	0	0.2	0.442
			0.8	0.204
30.5	0.98	0	0.6	0.204
33.5	0.98	0	0.6	0.283
36.6	0.85	0	0.6	0.226
39.6	0.73	0	0.6	0.198
42.7	0.88	0	0.6	0.290
45.7	1.92	0	0.2	0.838
			0.8	0.482
48.8	1.13	0	0.6	0.780
51.8	1.07	11	0.6	0.713
54.9	1.16	16	0.6	0.305
57.9	0.91	14	0.6	0.671
61.0	0.76	14	0.6	0.518
64.0	1.37	14	0.2	1.006
			0.8	0.369
67.1	1.98	14	0.2	0.780
			0.8	0.283

[1]Observation depth is the ratio of the velocity – observation depth to the total depth at the station.

DISCHARGE MEASUREMENT DECEMBER 23, 1972, PEA CREEK NEAR LOUISVILLE, ALA. (WATER-SURFACE ELEVATION=108.442 METERS) TOTAL DISCHARGE=8.30 CUBIC METERS PER SECOND

STATION (METERS)	DEPTH (METERS)	ANGLE (DEGREES)	OBSERVATION DEPTH[1]	VELOCITY (METERS PER SECOND)
10.7	0.0	0	0.0	0.0
11.6	1.16	0	0.2	0.055
			0.8	0.116
12.2	1.52	0	0.2	0.250
			0.8	0.152
12.8	1.74	0	0.2	0.338
			0.8	0.250
13.4	1.89	0	0.2	0.223
			0.8	0.256
14.0	1.83	0	0.2	0.491
			0.8	0.268
14.6	1.86	0	0.2	0.393
			0.8	0.338
15.2	1.98	0	0.2	0.421
			0.8	0.390
15.8	1.98	0	0.2	0.411
			0.8	0.402
16.5	2.04	0	0.2	0.421
			0.8	0.448
17.1	1.68	0	0.2	0.061
			0.8	0.198
17.7	1.40	0	0.2	0.046
			0.8	0.055
18.3	0.52	0	0.6	0.043
21.3	0.37	0	0.6	0.198
24.4	0.24	0	0.4	0.338
27.4	0.79	0	0.2	0.268
			0.8	0.223
30.5	0.94	0	0.2	0.277
			0.8	0.143
35.1	0.18	0	0.0	0.079
39.6	0.37	0	0.5	0.168
42.7	0.24	0	0.4	0.104
45.7	0.91	0	0.2	0.283
			0.8	0.235
51.8	0.45	0	0.6	0.101
54.9	0.55	0	0.6	0.235
57.9	0.61	0	0.6	0.152
61.0	0.55	0	0.6	0.125
64.0	0.30	0	0.5	0.244

[1] Observation depth is the ratio of the velocity-observation depth to the total depth at the station.

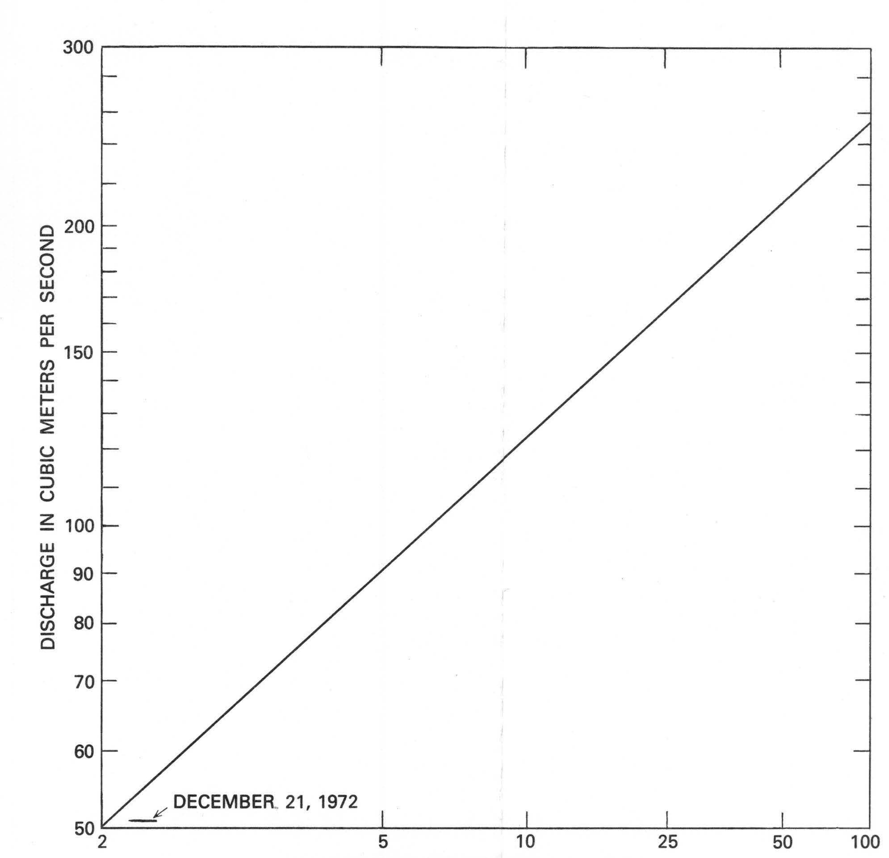

FIGURE 4—FREQUENCY OF FLOODS, PEA CREEK NEAR LOUISVILLE, ALABAMA

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