DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

BACKWATER AT BRIDGES AND DENSELY WOODED FLOOD PLAINS, WHITEWATER CREEK NEAR TARENTUM, ALABAMA

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Prepared in cooperation with the
DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
and the
ALABAMA STATE HIGHWAY DEPARTMENT

HYDROLOGIC INVESTIGATIONS ATLAS
Published by the U.S. Geological Survey, 1979
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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 Whitewater Creek near Tarentum, Ala., 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 alined 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 value where 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 represented on topograhic maps enlarged from standard 1:24,000 (or 1:62,500) scale 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 derived using techniques described in "Floods in Alabama" (C. F. Hains, 1973) are presented graphically.

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 WHITEWATER CREEK NEAR TARENTUM, ALABAMA

Data for Whitewater Creek near Tarentum, Ala., obtained in a 3-kilometer reach crossed about midway by a Pike 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 downstream from 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. Stationing along cross sections was projected along straight lines perpendicular to the flow. These points of significant changes in cross-section elevations and alinement of the axis. 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 floods. The cross section surveyed at the downstream side of the bridge is tabulated. 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 March 2, 1972, on Whitewater Creek are presented. Ten valley cross sections were surveyed after the flood (sheet 2).

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

FLOOD OF MARCH 2, 1972

Peak water-surface elevations, measured cross section, and velocities for the flood of March 2, 1972, are shown on sheet 3. The flood crested at an elevation of 85.832 meters at the reference point located on the downstream guardrail 129 meters from the left abutment. The peak discharge of 158 cubic meters per second was measured at the crest and is shown in table 2. Discharges of 121 and 51.3 cubic meters per second were measured on the recession at elevations of 85.670 and 84.140 meters, respectively (table 2). The measured cross sections and velocity distributions are shown. The recurrence interval of the flood is 6 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 Whitewater Creek near Tarentum, Ala. Water depths, velocities, and discharges through bridge openings on Whitewater Creek near Tarentum, Ala., for the flood of March 2, 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 a graph.

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

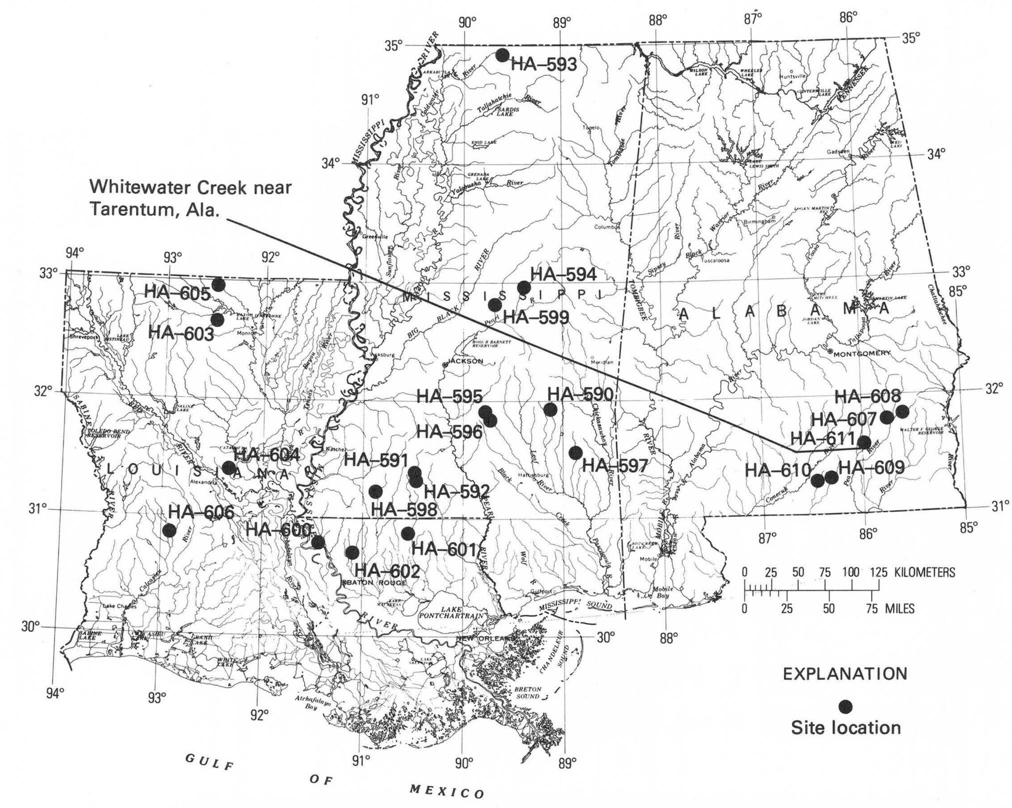

FIGURE 1.—INDEX MAP OF STUDY SITES IN THE BRIDGE BACKWATER INVESTIGATION PROJECT, ALABAMA, LOUISIANA, AND MISSISSIPPI.

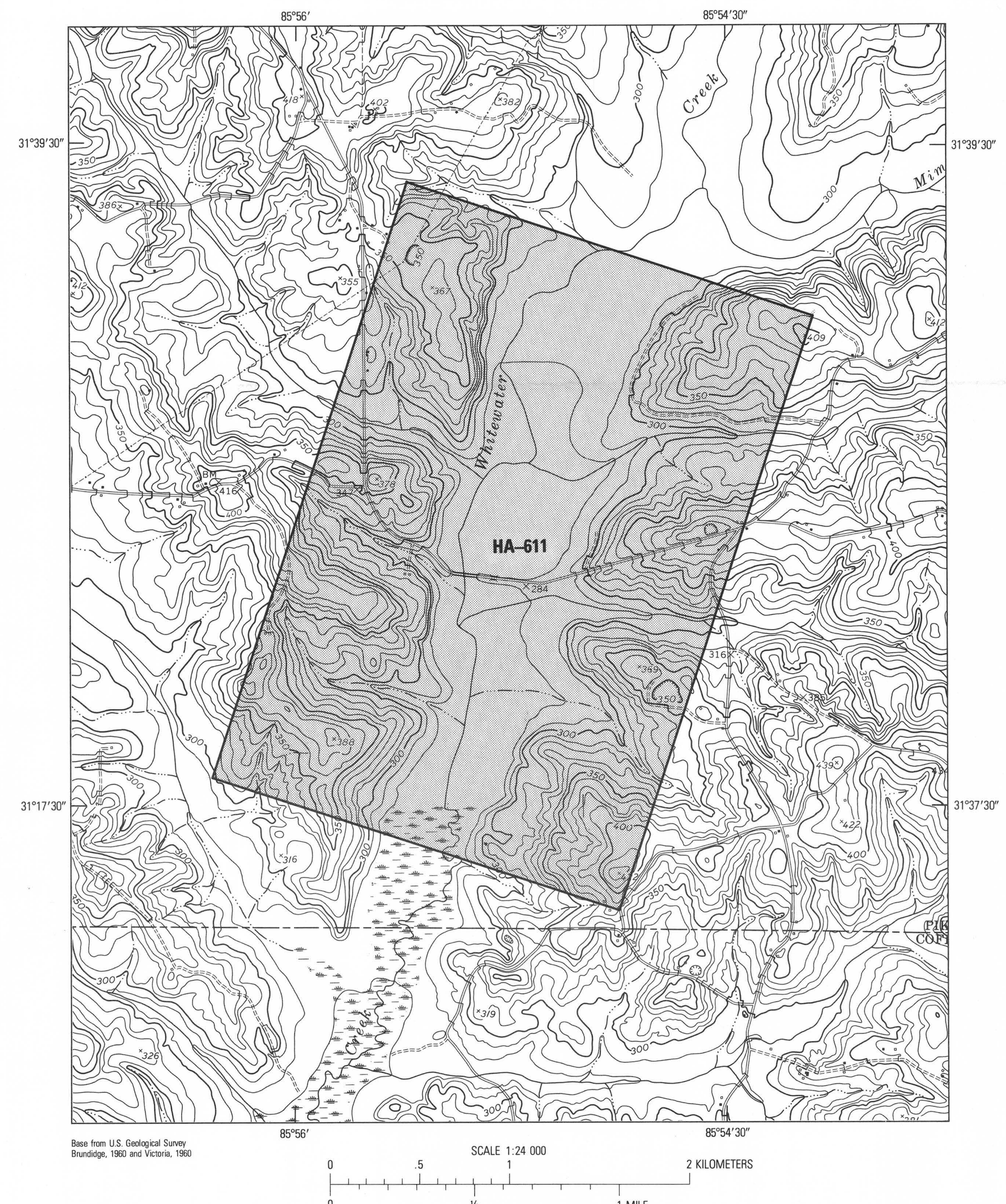

FIGURE 2—INDEX MAP SHOWING STUDY REACH, WHITEWATER CREEK NEAR TARENTUM, ALA.

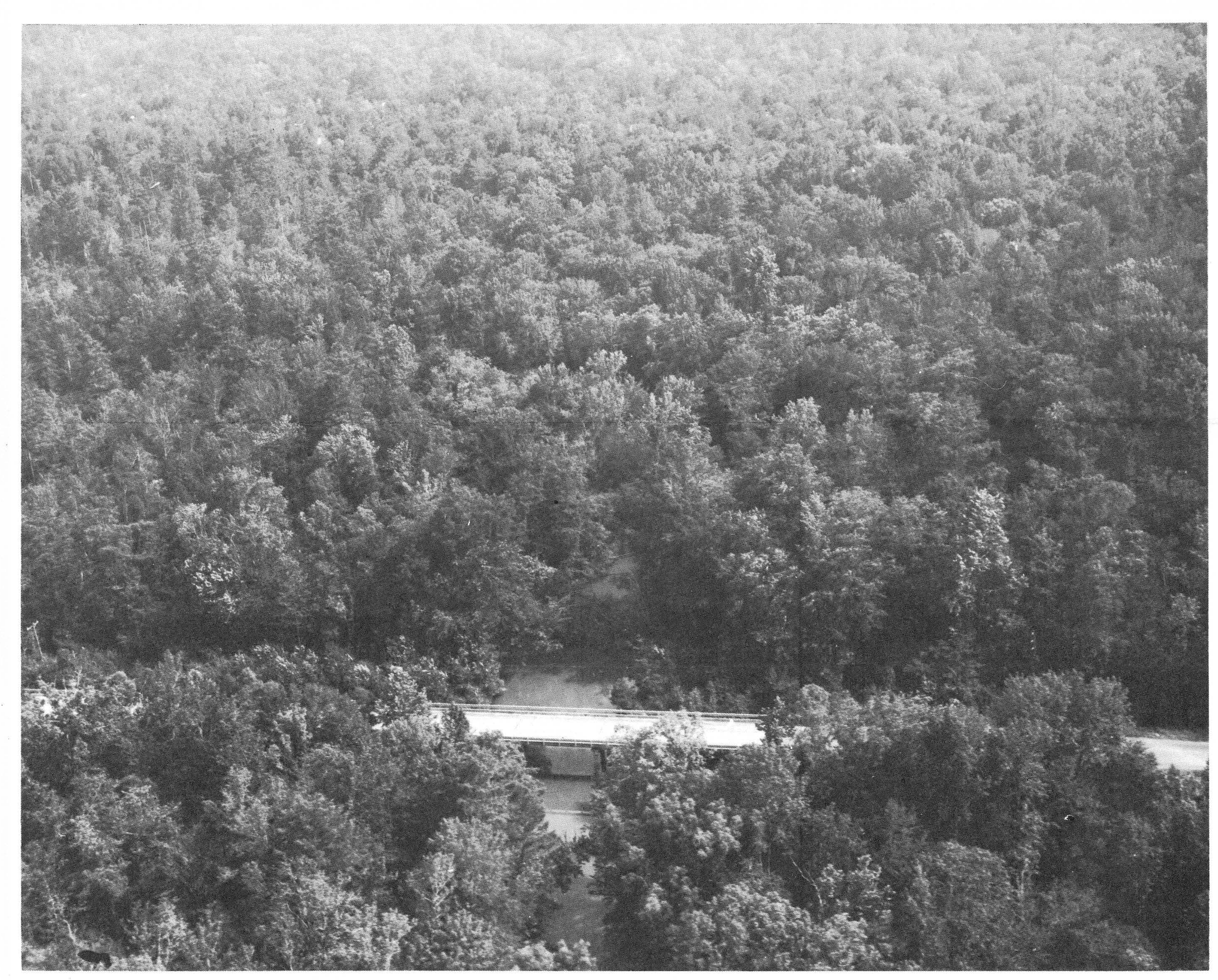

FIGURE 3—AERIAL VIEW LOOKING DOWNSTREAM IN THE VICINITY OF THE BRIDGE ON PIKE COUNTY ROAD, WHITEWATER CREEK NEAR TARENTUM, ALA.

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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.

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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.

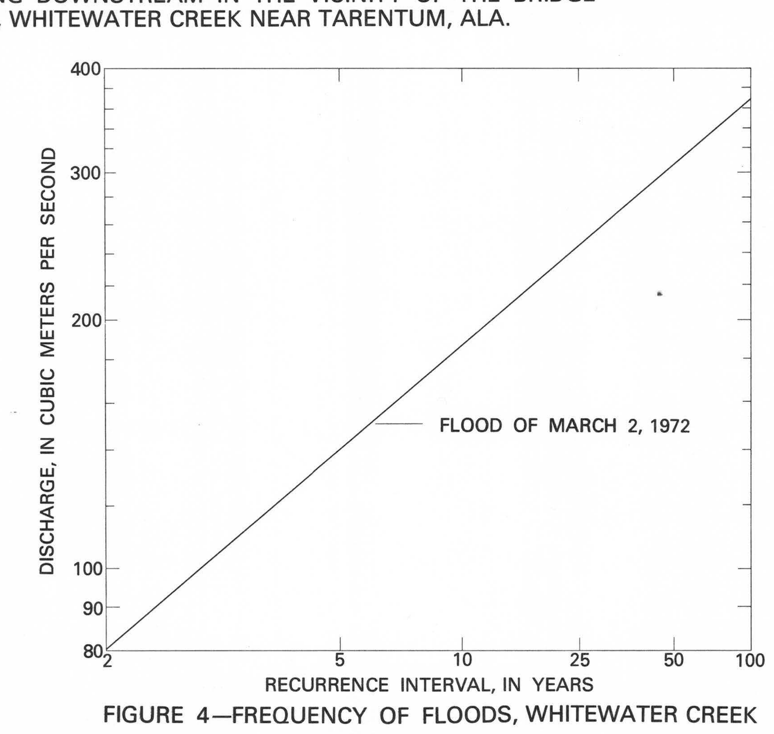

FIGURE 4—FREQUENCY OF FLOODS, WHITEWATER CREEK NEAR TARENTUM, ALA.

TABLE 1—VALLEY CROSS SECTION DATA FOR WHITEWATER CREEK NEAR TARENTUM, ALABAMA. ZERO STATION IS AT THE LEFT EDGE OF THE VALLEY (FACING DOWNSTREAM).

CROSS SECTION 1

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	84.49
1	84.18
20	83.45
48	83.24
55	82.84
56	83.21
71	82.99
74	82.81
85	82.60
89	83.05
97	83.15
145	82.84
150	81.38
156	83.36
166	82.87
168	82.11
169	81.96
169	82.87
212	83.33
213	82.87
218	82.90
219	83.45
260	83.27
268	83.05
270	82.08
272	82.05
274	83.05
415	83.57
476	83.76
491	84.27

CROSS SECTION 2

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	86.08
7	84.91
16	84.42
55	83.73
65	83.68
103	83.43
115	83.59
164	83.63
179	83.52
198	83.45
205	83.44
216	83.69
229	83.87
255	83.42
262	83.43
278	83.65
301	83.66
322	84.06
325	82.69
326	81.67
327	81.74
332	82.09
335	82.55
338	82.68
351	83.93
362	83.74
372	84.35
374	84.62
430	84.79
477	84.36
515	84.97

CROSS SECTION 3

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	86.86
3	86.29
15	84.98
69	83.88
122	83.94
143	83.88
169	83.91
189	83.94
232	84.27
236	83.94
280	83.91
292	83.97
343	83.88
361	83.73
366	83.30
370	83.73
408	83.69
410	82.66
425	82.78
427	83.69
427	83.76
459	84.18
469	83.88
492	83.91
493	82.84
495	82.84
497	83.91
509	84.43
520	84.52
543	84.61
559	84.55
561	85.62
570	86.68
571	86.86

CROSS SECTION 4

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	86.86
43	85.19
53	84.43
155	84.43
204	84.49
226	84.30
236	84.09
253	84.37
283	84.12
288	83.79
299	84.30
314	84.03
338	84.00
354	84.18
357	82.93
358	82.93
360	82.69
367	84.18
369	84.49
422	84.15
430	84.37
442	83.88
463	84.52
491	84.24
492	83.82
494	83.73
497	84.52
506	84.43
521	84.00
539	84.43
541	83.82
552	84.46
575	84.49
587	85.46
610	87.47

CROSS SECTION 5

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	86.86
23	85.80
27	85.40
40	84.73
61	84.88
82	85.10
88	84.64
107	84.73
116	84.52
151	84.40
165	84.06
192	84.18
201	84.37
210	84.58
241	84.37
247	83.63
274	84.46
280	83.60
283	84.73
290	84.21
299	84.58
319	84.73
320	84.34
322	83.42
328	82.99
335	82.63
337	84.34
344	84.61
375	84.27
396	84.52
418	84.32
430	84.30
433	84.43
436	84.21
485	85.62

CROSS SECTION 6

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	87.47
61	85.58
67	85.40
91	85.25
122	85.31
192	84.79
216	85.22
223	84.15
256	84.88
302	84.18
308	84.79
338	84.09
351	84.76
372	84.12
378	83.94
387	84.55
390	83.45
393	84.55
402	84.55
418	84.52
419	83.05
427	82.99
430	84.52
433	85.04
482	84.88
491	84.43
527	84.85
536	85.16
546	85.71
549	86.65

BRIDGE SECTION

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	87.38
0	86.68
4	85.95
4	85.25
6	85.07
12	84.88
19	84.12
24	84.58
31	84.34
34	84.49
37	84.27
46	84.58
65	84.58
67	83.73
69	83.94
72	84.40
76	84.73
87	84.55
93	84.43
110	84.58
122	84.12
124	83.05
128	81.74
130	80.98
131	82.23
133	82.63
140	84.24
146	83.91
149	84.37
151	85.95
151	87.38

CROSS SECTION 7

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	87.78
24	86.68
94	86.29
101	85.19
174	84.85
195	84.88
244	84.94
317	85.07
421	84.94
472	84.88
500	84.49
591	84.76
622	84.94
640	82.99
658	83.05
661	84.58
664	85.04
695	84.67
701	85.04
738	86.16
750	86.80

CROSS SECTION 8

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	87.66
25	86.47
37	85.71
70	85.34
98	85.46
172	85.49
223	85.37
271	85.34
275	85.16
280	83.69
285	83.51
294	85.16
319	85.43
350	85.37
377	85.55
394	85.55
421	85.83
455	85.83
490	86.29
494	86.59
503	87.66

CROSS SECTION 9

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	88.39
15	86.93
27	86.22
29	85.89
53	85.80
97	85.98
112	85.74
169	86.07
259	85.83
300	86.10
327	85.77
401	85.80
415	85.95
434	85.62
451	85.68
485	85.31
497	85.74
511	85.37
515	85.16
521	85.55
528	85.71
539	85.22
541	85.58
551	85.46
556	84.73
562	85.46
607	85.25
630	85.68
666	85.34
669	84.24
675	83.94
676	85.31
719	86.71
732	87.17

CROSS SECTION 10

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	88.51
52	87.78
91	87.66
152	87.47
183	86.74
294	86.56
380	86.62
383	86.29
390	86.22
396	86.68
468	86.50
507	86.65
515	86.16
522	86.10
528	86.59
589	86.47
614	86.41
617	84.61
629	86.41
767	86.56
787	86.32
788	86.80
847	87.17
879	87.20
887	87.50
896	87.72
908	89.30

TABLE 2—DISCHARGE MEASUREMENTS MARCH 2 AND 3, 1972, WHITEWATER CREEK NEAR TARENTUM, ALA. ZERO STATION IS AT THE EDGE OF THE LEFT ABUTMENT (FACING DOWNSTREAM).

DISCHARGE MEASUREMENT MARCH 2, 1972, WHITEWATER CREEK NEAR TARENTUM, ALA. (WATER-SURFACE ELEVATION=85.832 METERS) TOTAL DISCHARGE=158 CUBIC METERS PER SECOND

STATION (METERS)	DEPTH (METERS)	ANGLE (DEGREES)	OBSERVATION DEPTH[1]	VELOCITY (METERS PER SECOND)
3.0	0.0	0	0.0	0.0
6.1	0.70	16	0.6	0.332
12.2	0.88	14	0.6	0.472
18.3	1.74	11	0.2	0.805
			0.8	0.893
24.4	1.22	0	0.2	1.091
			0.8	0.433
30.5	1.31	0	0.2	0.936
			0.8	0.472
36.6	1.31	0	0.2	0.509
			0.8	0.802
42.7	1.07	0	0.2	0.701
			0.8	0.518
48.8	1.22	0	0.2	0.549
			0.8	0.244
54.9	1.10	0	0.2	0.875
			0.8	0.701
61.0	1.10	0	0.2	0.713
			0.8	0.101
67.1	1.92	0	0.2	1.305
			0.8	1.244
70.1	1.62	0	0.2	1.216
			0.8	0.936
73.2	1.19	0	0.2	0.893
			0.8	0.332
79.2	1.22	0	0.2	0.378
			0.8	0.332
85.3	1.16	0	0.2	0.402
			0.8	0.229
91.4	1.28	0	0.2	0.378
			0.8	0.296
97.5	1.31	0	0.2	0.838
			0.8	0.302
103.6	1.25	0	0.2	0.762
			0.8	0.311
106.7	1.25	0	0.2	1.116
			0.8	0.838
109.7	1.25	0	0.2	1.140
			0.8	0.354
112.8	1.22	0	0.2	0.302
115.8	1.16	0	0.6	0.195
118.9	1.49	0	0.2	0.244
			0.8	0.219
121.9	1.71	0	0.2	0.061
			0.8	0.125
125.0	2.68	0	0.2	0.152
			0.8	0.655
128.0	3.96	11	0.2	1.670
			0.8	1.420
131.1	3.90	11	0.2	1.963
			0.8	1.725
134.1	3.08	11	0.2	1.484
			0.8	0.957
137.2	1.89	11	0.2	0.411
			0.8	0.838
140.2	1.58	11	0.2	0.936
			0.8	0.165
143.3	1.71	11	0.2	0.747
			0.8	0.250
146.3	1.83	19	0.2	0.856
			0.8	0.671
149.4	1.34	23	0.2	1.189
			0.8	0.415
150.3	0.0	0	0.0	0.0

DISCHARGE MEASUREMENT MARCH 2, 1972, WHITEWATER CREEK NEAR TARENTUM, ALA. (WATER-SURFACE ELEVATION=85.670 METERS) TOTAL DISCHARGE=121 CUBIC METERS PER SECOND

STATION (METERS)	DEPTH (METERS)	ANGLE (DEGREES)	OBSERVATION DEPTH[1]	VELOCITY (METERS PER SECOND)
3.4	0.0	0	0.0	0.0
6.1	0.55	16	0.6	0.137
12.2	0.73	16	0.6	0.226
18.3	1.58	14	0.2	0.597
			0.8	0.655
24.4	1.07	11	0.6	0.549
30.5	1.19	0	0.6	0.393
36.6	1.19	0	0.6	0.805
42.7	1.04	0	0.6	0.347
48.8	1.07	0	0.6	0.625
54.9	0.91	0	0.0	0.655
61.0	0.94	0	0.6	0.332
57.1	1.77	0	0.2	1.305
			0.8	1.164
70.1	1.55	0	0.2	1.140
			0.8	1.049
73.2	0.91	0	0.6	0.561
79.2	1.01	0	0.6	0.266
85.3	1.07	0	0.6	0.332
91.4	1.07	0	0.6	0.290
97.5	1.13	0	0.6	0.390
103.6	1.10	0	0.6	0.186
109.7	1.10	0	0.6	0.585
116.8	1.22	0	0.6	0.216
121.9	1.46	0	0.2	0.073
			0.8	0.110
125.0	2.50	0	0.2	0.226
			0.8	0.713
128.0	3.66	0	0.2	1.518
			0.8	1.451
131.1	3.78	0	0.2	1.887
			0.8	0.799
134.1	2.59	0	0.2	1.164
			0.8	1.274
137.2	1.65	0	0.2	0.198
			0.8	0.539
140.2	1.40	0	0.2	0.799
			0.8	0.152
143.3	1.55	11	0.2	0.838
			0.8	0.226
146.3	1.80	23	0.2	0.786
			0.8	0.506
149.4	1.25	29	0.6	0.866
151.5	0.0	0	0.0	0.0

DISCHARGE MEASUREMENT MARCH 3, 1972, WHITEWATER CREEK NEAR TARENTUM, ALA. (WATER-SURFACE ELEVATION=85.140 METERS) TOTAL DISCHARGE=51.3 CUBIC METERS PER SECOND

STATION (METERS)	DEPTH (METERS)	ANGLE (DEGREES)	OBSERVATION DEPTH[1]	VELOCITY (METERS PER SECOND)
8.1	0.0	0	0.0	0.0
12.2	0.30	16	0.0	0.146
18.3	1.04	16	0.6	0.799
24.4	0.45	11	0.6	0.317
30.5	0.61	11	0.6	0.674
36.6	0.76	0	0.6	0.561
42.7	0.46	0	0.6	0.162
48.8	0.46	0	0.6	0.341
54.9	0.40	0	0.6	0.393
61.0	0.40	0	0.6	0.223
67.1	1.13	0	0.6	0.780
73.2	0.37	0	0.6	0.323
79.2	0.46	0	0.6	0.168
85.3	0.46	0	0.6	0.146
91.4	0.52	0	0.6	0.155
97.5	0.58	0	0.6	0.442
103.6	0.49	0	0.6	0.250
109.7	0.55	0	0.6	0.165
115.8	0.55	0	0.6	0.030
121.9	0.79	0	0.6	0.046
125.0	2.01	0	0.2	0.323
			0.8	0.482
126.5	2.59	0	0.2	0.838
			0.8	0.643
128.0	3.23	0	0.2	0.957
			0.8	0.765
129.5	3.05	0	0.2	1.116
			0.8	0.820
131.1	2.74	0	0.2	1.244
			0.8	0.820
132.6	2.44	0	0.2	1.006
			0.8	0.875
134.1	2.04	11	0.2	0.747
			0.8	0.561
137.2	1.01	14	0.6	0.107
140.2	0.85	16	0.6	0.146
146.3	1.07	16	0.6	0.256
150.6	0.0	0	0.0	0.0

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

INTERIOR—GEOLOGICAL SURVEY, RESTON, VA.—1979—W79009

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