

FLOODFLOW CHARACTERISTICS OF CURRENT RIVER AT ARKANSAS
STATE HIGHWAY 328 NEAR REYNO, ARKANSAS

By R. C. Gilstrap and Braxtel L. Neely, Jr.

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CONVERSION FACTORS

For use of readers who prefer to use metric units, conversion factors for terms used in this report are listed below:

<u>Multiply</u>	<u>By</u>	<u>To obtain</u>
foot (ft)	0.3048	meter (m)
cubic foot per second (ft ³ /s)	0.02832	cubic meter per second (m ³ /s)
mile (mi)	1.609	kilometer (km)
square mile (mi ²)	2.590	square kilometer (km ²)

National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, called NGVD of 1929, is referred to as sea level in this report.

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HIGHWAY 328 NEAR REYNO, ARKANSAS

by R. C. Gilstrap and Braxtel L. Neely, Jr.

ABSTRACT

Arkansas State Highway 328 in Randolph County crosses Current River about 1.5 miles northwest of Reyno, Arkansas. A main channel bridge with a relief bridge on each side, five culverts, and a bridge on the west side of the valley were the existing flow structures prior to a December 1982 flood. After the December 1982 flood, 34 additional culverts were installed along the highway.

The flood of December 3, 1982, which had a computed peak discharge of 85,300 cubic feet per second and a recurrence interval of about 8 years, caused considerable damage to the highway being reconstructed. The flood of April 1985, which had a discharge of 48,000 cubic feet per second and a recurrence interval of about 2 years, also caused damage to fill areas of the reconstructed highway. A hydraulic analysis was conducted for the 5-, 10-, 25-, 50- and 100-year flood and the floods of December 1982 and April 1985 to determine the river stages before and after Highway 328 was reconstructed. Results of the study indicate that the water surface along the upstream side of the highway for all floods was higher than what the natural water surface would be, whereas the water surface along the downstream side of the highway was lower than natural. The natural water surface is the water surface prior to the existence of a highway. The study indicates that installation of the 34 additional pipe culverts would have reduced water-surface elevations less than 0.1 foot during the December 1982 flood.

INTRODUCTION

The Arkansas State Highway and Transportation Department reconstructed about 8 miles of Arkansas State Highway 328 in Randolph County near Reyno, Arkansas in 1982. About 3.5 miles of the highway construction (from highway station 428+00 to highway station 253+00) lies in the flood plain on the west bank of the Current River. In December 1982 a Current River flood caused considerable damage to Highway 328 where water overtopped the highway in four places.

The drainage structures across Current River existing in December 1982 consisted of four bridges and five culvert installations. When the December 1982 flood occurred, the Highway Department was reconstructing Highway 328 by placing fill on the flood plain to elevate the highway above natural ground. The December 1982 flood caused considerable damage to the nearly completed highway reconstruction. In an effort to reduce future flood damage, the Arkansas Highway Department subsequently installed 34 additional pipe culverts between stations 304+10 and 419+97. However, in April 1985, a flood again overtopped the highway and damaged the highway fill in several places.

In 1983, the U.S. Geological Survey in cooperation with the Arkansas State Highway and Transportation Department initiated a study to determine the hydraulic effects of the additional 34 pipe culverts installed along Highway 328 after the December 1982 flood. This report describes the results of the hydraulic analyses and the effects of various highway conditions at Highway 328 on the stage of flood flows in the Current River. The plan and profile sheets for the highway, bridges, and the valley cross sections were furnished by the Arkansas State Highway and Transportation Department. All elevations in this report are at sea level.

DESCRIPTION OF THE AREA

Arkansas State Highway 328 crosses Current River normal to flow about 1.5 miles west of Reyno, Arkansas in Randolph County (fig. 1). The main channel of Current River is spanned by a main bridge with relief bridges on each side. Five groups of overflow culverts and an overflow bridge are located to the west of the main river channel over a distance of about 3 miles. Both banks of Current River and the banks of two tributaries (Winnington Creek and Briar Creek) on the west side of the flood plain are wooded. The flood plain, which is composed of sandy loam, is in cultivation. Most of the flood plain is above 280 feet in elevation. The Current River flows south to Highway 328 and then flows southwest. Upstream from Highway 328 to the mouth of Little Black River, the stream has a slope of about 1.2 feet per mile. Several residential houses, farm buildings, and storage tanks are located along the segment of Highway 328 affected by the reconstruction. The drainage area of Current River at this site is 2,595 square miles.

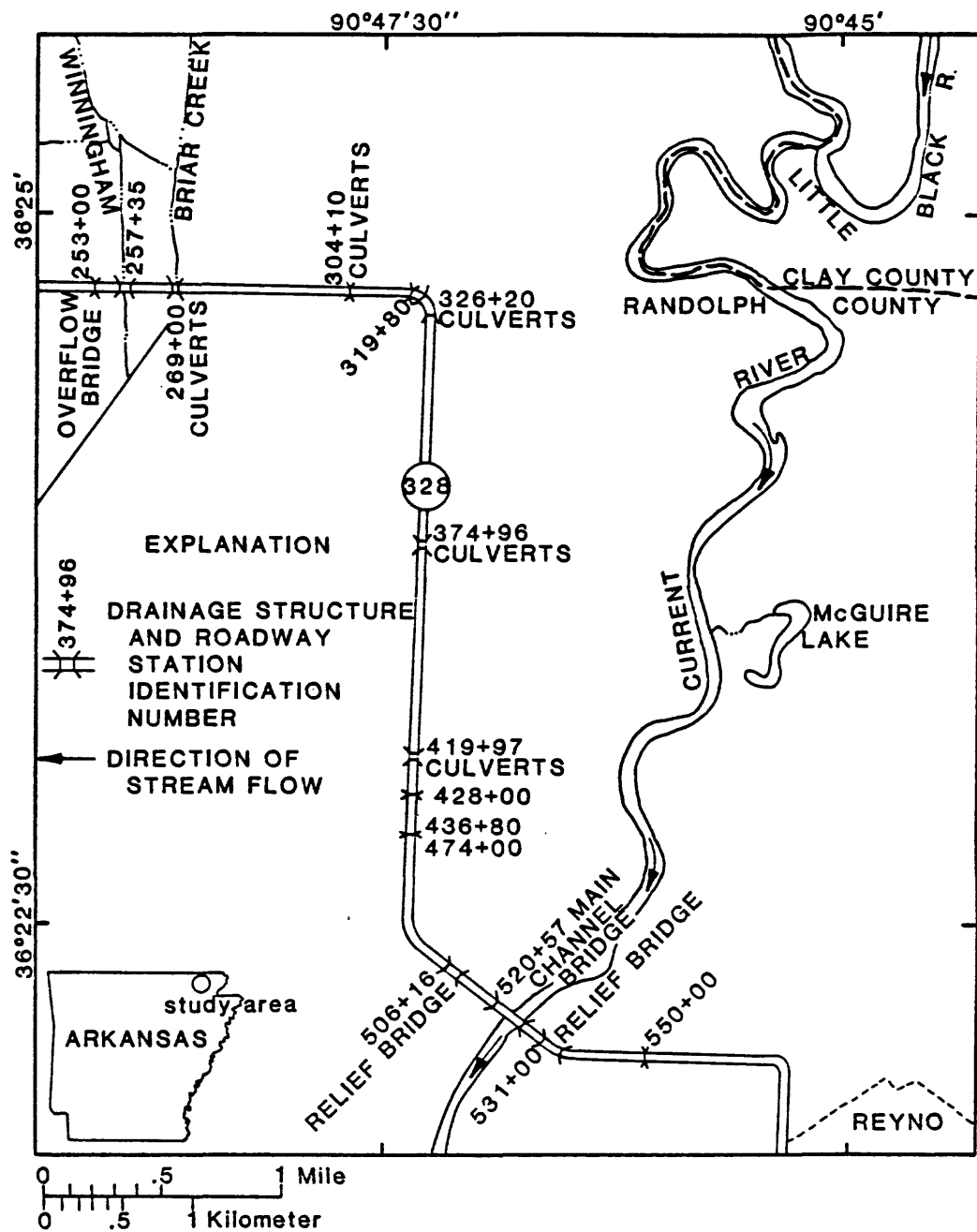


Figure 1.--Location of study area.

DRAINAGE STRUCTURES AT STATE HIGHWAY 328

Starting at the west (right) side of the valley, the drainage structures are as follows:

<u>Highway station</u>	<u>Drainage structure</u>
257+10 to 257+60	50-foot bridge
269+55 to 270+05	Five 10x5x47-foot reinforced concrete box culverts
304+10	Two 6x3x38-foot reinforced concrete box culverts
326+20	4x3x41-foot reinforced concrete box culvert
374+96	Three 6x3x41-foot reinforced concrete box culverts
419+97	Two 30-inch x 40-foot reinforced concrete pipe culverts
504+36 to 507+96	360-foot reinforced concrete slab bridge
516+95 to 524+19	724-foot I-beam bridge
528+90 to 533+10	420-foot reinforced concrete slab bridge

In addition to these drainage structures, the following 34 pipe culverts were added after the December 1982 flood:

<u>Highway station</u>	<u>Drainage structure</u>
304+10	Four 3x38-foot corrugated metal pipe culverts with flared end sections - two on each side of existing culvert installation.
326+20	Four 3x40-foot corrugated metal pipe culverts with flared end sections - two on each side of existing culvert installation.
374+96	Four 3x40-foot corrugated metal pipe culverts with flared end sections - two on each side of existing culvert installation.
419+97	Two 30-inch x 40-foot corrugated metal pipe culverts with flared end sections - one on each side of existing culvert installation.
305+00 to 377+00	Twenty 2x30-foot corrugated metal pipe culverts with flared end sections were installed at various stations.

HISTORY OF FLOODS

From 1919 to 1956, the U.S. Army Corps of Engineers collected records of stage and discharge about 9 miles downstream from the study area on Current River near Biggers, Arkansas. The highest peak stage during this period was 272.8 feet on March 15, 1935. Since 1919, the U.S. Geological Survey has collected records of stage and discharge about 30 miles upstream from the study area on Current River near Doniphan, Missouri. The highest peak during this period of record occurred December 3, 1982 and had a peak discharge of 122,000 ft³/s. This peak was exceeded by the historic flood of March 1904 which had an estimated peak discharge of 130,000 ft³/s. The 100-year flood on Current River at Doniphan is 103,000 ft³/s. At Highway 328, the Current River flood of December 1982 had a computed peak discharge of 85,300 ft³/s at an unconfined water-surface elevation of 282.7 feet at the downstream side of the main channel bridge across Current River. This discharge was computed by the contracted opening method. The rain that caused the December 1982 flood averaged about 11 inches upstream from Doniphan, Missouri, whereas the rain downstream from Doniphan was about 4 inches. The flood wave attenuated as it moved downstream from Doniphan and the peak discharge at the study site was considerably less than the peak discharge at Doniphan. Figure 2 shows the relation of stage to discharge for Current River at Highway 328. During the December 1982 flood, the low members of the main channel bridge and the relief bridges on each side of the main channel bridge were well above high water, but the 50-foot bridge and the five groups of culverts on the west flood plain were submerged.

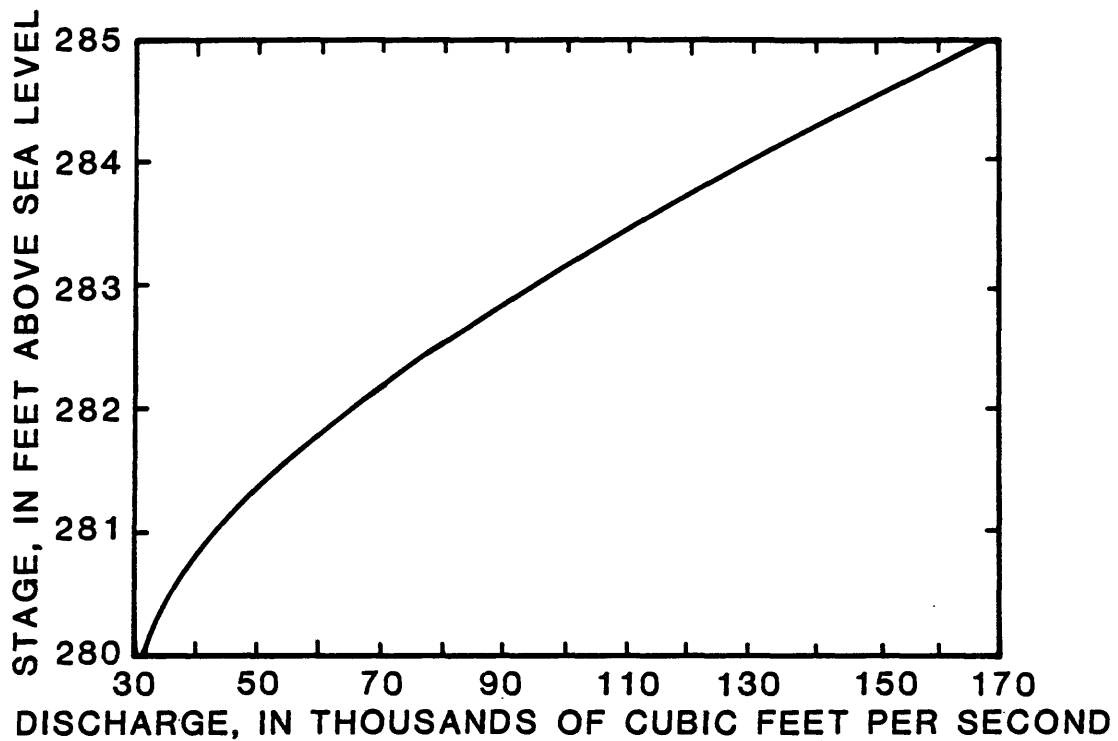
FLOOD-FLOW CHARACTERISTICS

According to Patterson (1971) the 50-year flood would have a discharge of 141,000 ft³/s. The unconfined elevation corresponding to this discharge is 284.3 feet. The 100-year flood discharge of 169,000 ft³/s was determined by extending the discharge-frequency curve above the 50-year discharge. The unconfined elevation of the 100-year flood is 285.0 feet. Figure 3 shows the magnitude and frequency of floods from the 2-year flood to 100-year flood. The flood of December 1982 had a recurrence interval of about 8 years. The April 1985 peak discharge was 48,000 ft³/s, which has a recurrence interval of about 2 years.

Figure 4 is a stage graph for the March 1935 flood on Current River near Biggers, Arkansas, which has been modified by adding 12.2 feet to reference datum so that the stages on this graph correspond to the stages at Highway 328 about 9 miles upstream. The peak of this graph is approximately equal to that of a 100-year peak. Using this graph as a guide and an elevation of 279 feet as the bankfull stage at Highway 328, it is estimated that bankfull stage will be exceeded for a period of about 13 days during the 100-year flood.

Figure 5 shows the four bridges, five groups of culverts, a valley cross section, and the distribution of flow at Highway 328 for existing and natural conditions for the December 1982 flood. The distribution of flow for natural conditions was determined by conveyance in the natural flood plain with adjustments being made for angularity of flow.

Figure 6 shows the four flow-over-road sections, the December 1982 high-water profile, and the profile of the center line of the highway.



EXPLANATION

Q_i = Discharge for i -year recurrence interval at given river stage.

Q_{1982} = Discharge for December 1982 flood.

Q_{1985} = Discharge for April 1985 flood.

Q_2 = 46,300 ft³/s at 281.2 feet.

Q_5 = 73,000 ft³/s at 282.3 feet.

Q_{10} = 92,000 ft³/s at 282.9 feet.

Q_{25} = 118,000 ft³/s at 283.7 feet.

Q_{50} = 141,000 ft³/s at 284.3 feet.

Q_{100} = 169,000 ft³/s at 285.0 feet.

Q_{1982} = 85,300 ft³/s at 282.7 feet.

Q_{1985} = 48,000 ft³/s at 281.3 feet.

Figure 2.--Stage-discharge relation for Current River at downstream side of main channel bridge at State Highway 328.

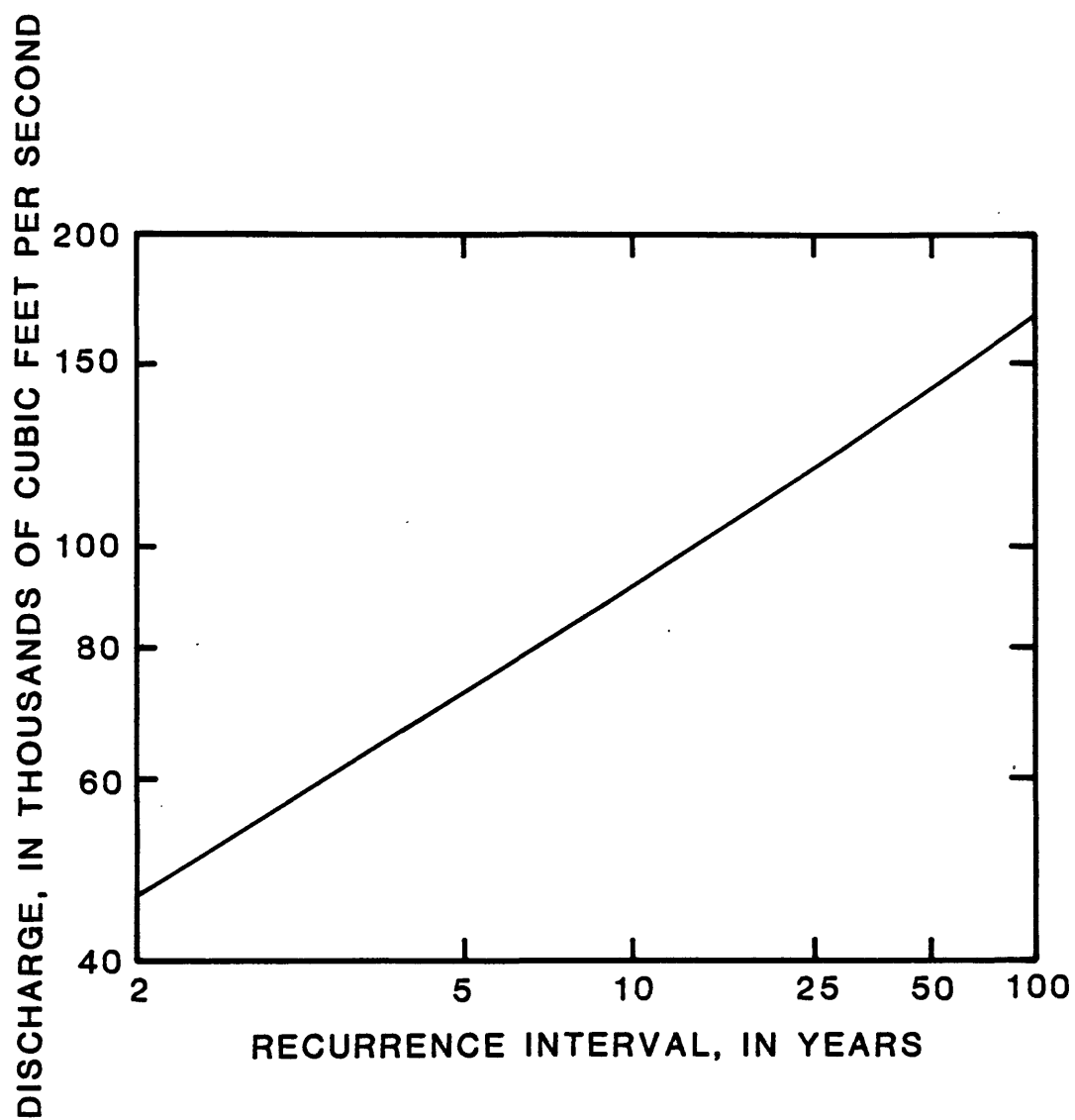


Figure 3.--Discharge-frequency relation for Current River at State Highway 328.

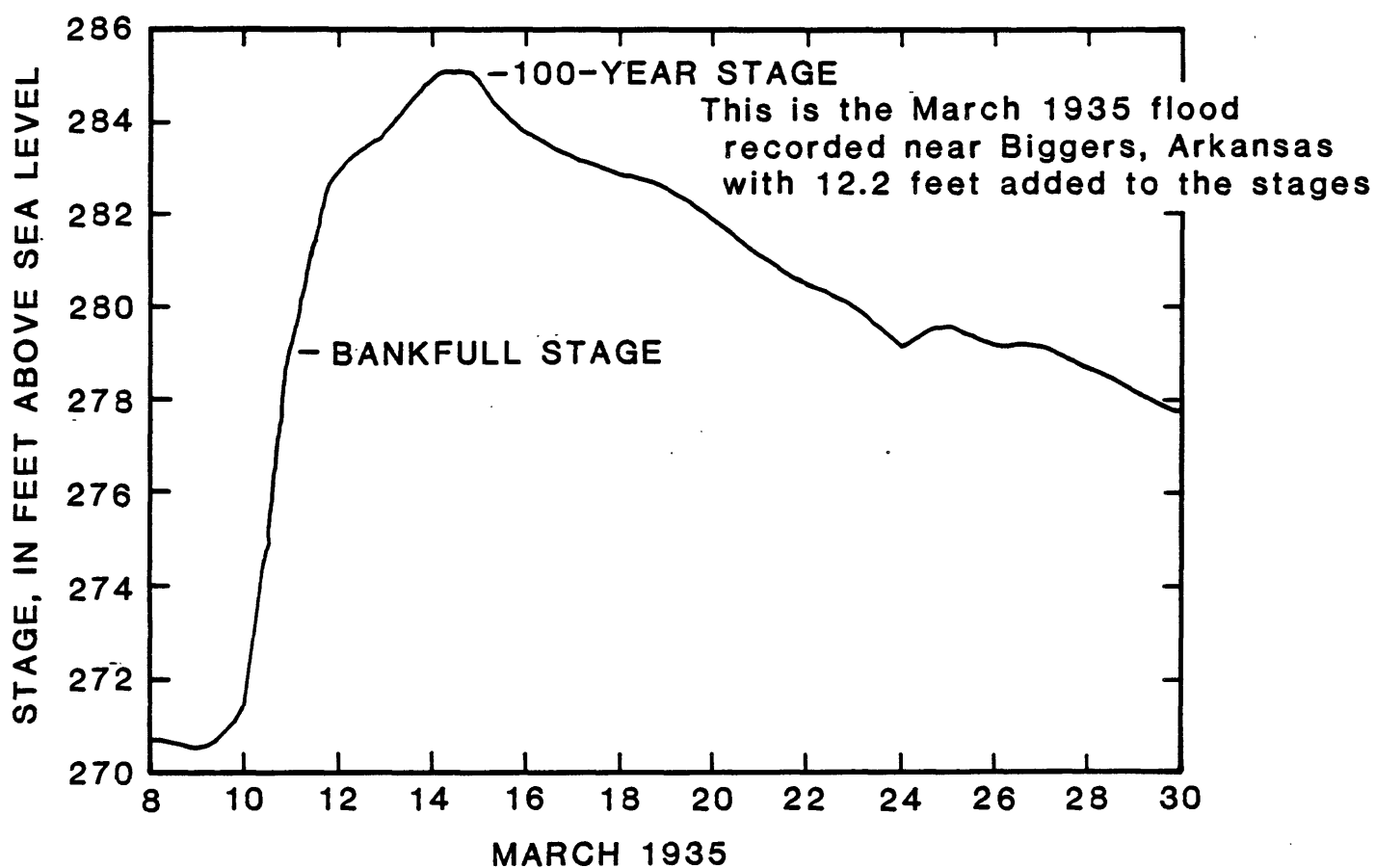


Figure 4.--Estimated stage at Current River near Reyno for the 100-year flood.

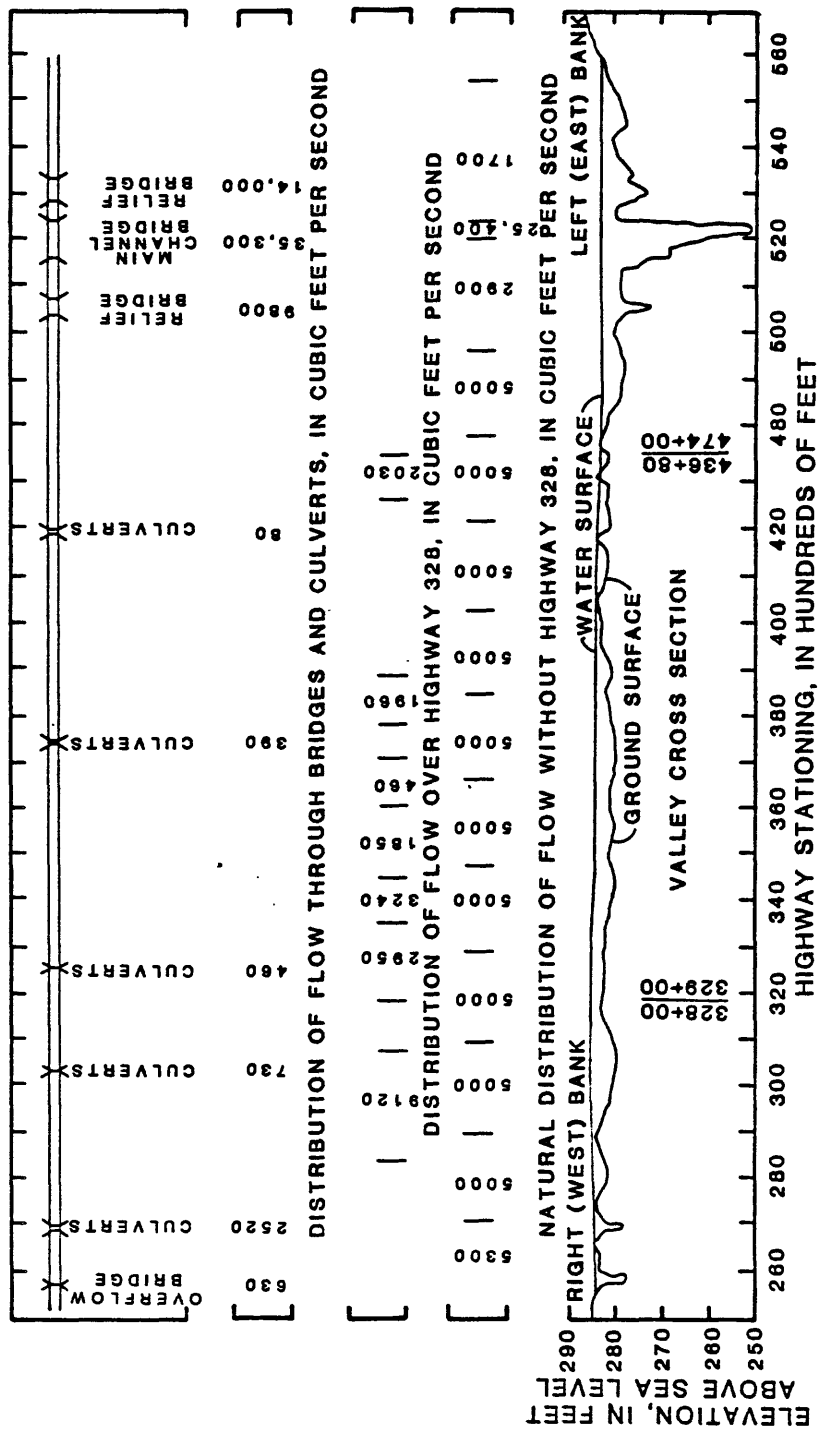


Figure 5.--Valley cross section, location of four bridges and five culverts, and distribution of flow for the December 1982 flood.

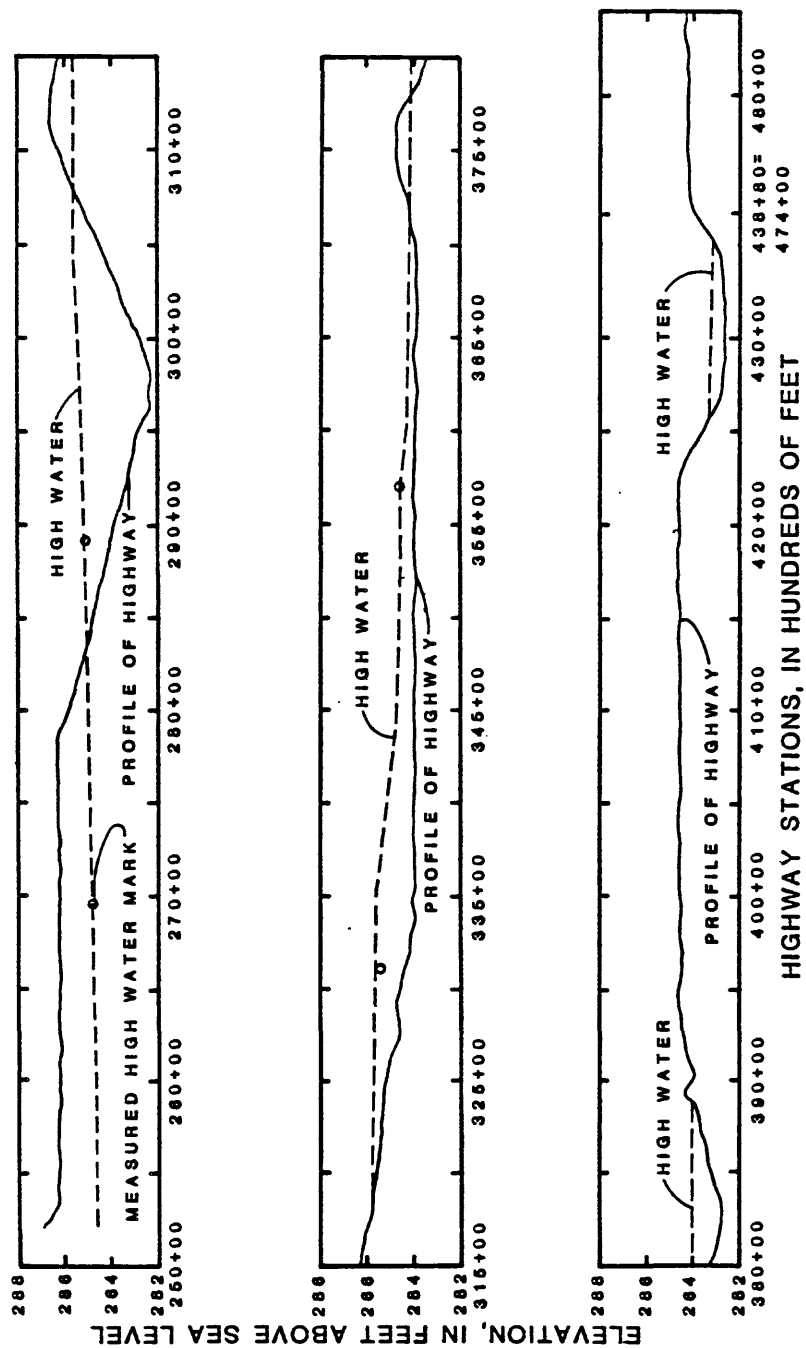


Figure 6.--Upstream high-water profile of December 1982 flood showing flow over the highway.

WATER-SURFACE PROFILES

During overbank flooding, water from Current River flows south-southwest through bridges and culverts along State Highway 328 (fig. 1). During high floods, water overtops Highway 328. Water-surface profiles along the upstream and downstream sides of Highway 328 were computed by the step-backwater method. The discharges used in developing the profiles were adjusted when water would flow from the upstream side of the highway to the downstream side. The initial water-surface elevation at the most downstream cross sections of both profiles was equal to the natural elevation on the flood plain at the main channel bridge. The cross sections for both profiles had common ending point directly across the highway from each other. Water-surface profiles were computed for the 5-, 10-, 25-, 50-, and 100-year floods and for the December 1982 and April 1985 floods. Profiles were computed for five conditions; (1) natural, without highway, (2) before construction with highway at natural ground elevation, (3) after construction with 34 culverts in place (existing conditions), (4) after construction but without 34 culverts, and (5) assuming highway grade raised 1 foot above the 25-year flood under present conditions. The results of these profiles are shown in table 1. In general, the highway retards the flow and causes the water surface along the upstream side of the highway to be higher than it would be under unconfined flow conditions; the water surface along the downstream side of the highway to be lower. From table 1, the upstream water surface for existing highway conditions during the December 1982 flood at station 326+20, which is near the bend in the highway, is 1.24 feet (285.73-284.49) higher than the natural unconfined water-surface elevation and the downstream water-surface elevation is 1.02 feet (284.49-283.47) lower than natural unconfined water-surface elevation. The addition of the 34 culverts lowers the upstream water surface less than 0.1 feet during the December 1982 flood.

Table 2 shows flood elevations and discharges for the December 1982 flood and the 100-, 50-, and 25-year floods for the main channel bridge and the two relief bridges crossing Current River.

SUMMARY

The Current River flood of December 3, 1982 had a peak discharge of 85,300 ft³/s and a recurrence interval of about 8 years. The duration of the out-of-bank flow for the 100-year flood event at Highway 328 is about 13 days.

The upstream water surface for the December 1982 flood at station 326+20 was 1.24 feet higher than the natural unconfined water-surface elevation; the downstream water-surface elevation was 1.02 feet lower.

The hydraulic effects of the 34 pipe culverts for various highway conditions were studied. The addition of 34 pipe culverts from highway station 304+10 to 419+97 along Highway 328 would have lowered the upstream water-surface elevation less than 0.1 foot during the December 1982 flood.

Table 1.—Summary of flood elevations at Current River along State Highway 328

Highway station	Flood	Natural	Water-surface elevations (feet above sea level)							
			Before construction		After construction		Assuming highway grade raised 1 foot above 25-year flood		After construction without 34 culverts	
			Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream
304+10	Ded 1982	284.52	283.92	283.91	285.60	283.50	286.91	282.96	285.62	283.48
	Apr 1985	282.99	282.30	282.29	284.00	281.92	284.17	282.20	284.03	281.92
	100-year	286.73	286.20	286.06	287.10	286.04	289.21	285.01	287.12	286.04
	50-year	286.13	285.56	285.44	286.70	285.32	288.65	284.32	286.71	285.31
	25-year	285.47	284.99	284.88	286.20	284.61	288.14	283.76	286.20	284.60
	10-year	284.72	284.21	284.12	285.70	283.72	287.22	283.11	285.71	283.72
	5-year	284.10	283.57	283.50	285.10	282.98	286.13	282.70	285.12	282.96
326+20	Dec 1982	284.49	285.08	283.90	285.73	283.47	286.39	282.90	285.75	283.46
	Apr 1985	282.99	283.46	282.29	284.18	281.65	284.18	281.66	284.21	281.64
	100-year	286.69	287.43	286.04	287.47	286.02	289.35	285.01	287.48	286.01
	50-year	286.09	286.79	285.43	286.96	285.30	288.46	284.32	286.97	285.29
	25-year	285.43	286.23	284.87	286.53	284.59	287.72	283.75	286.53	284.59
	10-year	284.69	285.34	284.11	285.91	283.70	286.75	283.07	285.92	283.70
	5-year	284.06	284.62	283.49	285.35	282.94	285.69	282.59	285.37	282.92
335+00	Dec 1982	284.33	284.91	283.85	285.61	283.38	286.29	282.85	285.63	283.37
	Apr 1985	282.74	283.14	282.28	284.02	281.48	284.01	281.49	284.05	281.45
	100-year	286.55	287.30	285.96	287.34	285.93	289.26	285.01	287.36	285.92
	50-year	285.96	286.66	285.35	286.84	285.21	288.36	284.32	286.85	285.21
	25-year	285.27	286.10	284.79	286.41	284.51	287.63	283.73	286.41	284.50
	10-year	284.53	285.16	284.05	285.79	283.62	286.65	283.03	285.79	283.61
	5-year	283.89	284.42	283.44	285.22	282.84	285.57	282.50	285.24	282.83
345+00	Dec 1982	283.92	283.93	283.73	284.77	283.26	285.43	282.80	284.78	283.25
	Apr 1985	282.40	282.48	282.22	283.27	281.37	283.26	281.37	283.30	281.34
	100-year	286.20	286.60	285.83	286.63	285.82	288.81	285.01	286.65	285.81
	50-year	285.57	285.82	285.22	286.05	285.10	287.86	284.32	286.05	285.09
	25-year	284.87	285.01	284.66	285.48	284.39	287.07	283.72	285.49	284.38
	10-year	284.11	284.16	283.93	284.92	283.50	285.97	283.00	284.93	283.50
	5-year	283.46	283.49	283.34	284.38	282.72	284.72	282.43	284.40	282.71
360+00	Dec 1982	283.42	283.53	283.44	284.29	283.02	284.86	282.74	284.31	283.02
	Apr 1985	282.00	282.16	282.00	282.88	281.31	282.88	281.31	282.92	281.29
	100-year	285.78	286.03	285.61	286.04	285.60	288.18	285.01	286.07	285.60
	50-year	285.07	285.25	284.97	285.43	284.88	287.18	284.32	285.44	284.87
	25-year	284.44	284.55	284.39	284.94	284.17	286.38	283.70	284.95	284.16
	10-year	283.64	283.74	283.65	284.42	283.27	285.26	282.95	284.43	283.26
	5-year	282.96	283.12	283.04	283.92	282.50	284.22	282.34	283.93	282.49
373+00	Dec 1982	283.37	283.48	283.28	284.18	282.93	284.71	282.73	284.19	282.92
	Apr 1985	282.00	282.11	281.87	282.80	281.29	282.80	281.29	282.83	281.27
	100-year	285.64	285.87	285.49	285.87	285.48	287.84	285.01	285.90	285.48
	50-year	284.96	285.11	284.84	285.25	284.76	286.89	284.32	285.26	284.76
	25-year	284.35	284.47	284.25	284.82	284.06	286.13	283.70	284.83	284.05
	10-year	283.59	283.68	283.49	284.29	283.17	285.01	282.93	284.31	283.17
	5-year	282.96	283.07	283.13	283.81	282.43	284.10	282.31	283.82	282.42
388+00	Dec 1982	283.22	283.37	283.13	284.02	282.86	284.52	282.72	284.04	282.86
	Apr 1985	281.81	281.98	281.74	282.61	281.28	282.61	281.28	282.64	281.27
	100-year	285.51	285.77	285.35	285.77	285.35	287.64	285.01	285.79	285.34
	50-year	284.82	285.02	284.69	285.15	284.64	286.67	284.32	285.15	284.64
	25-year	284.21	284.37	284.10	284.69	283.96	285.94	283.70	284.69	283.96
	10-year	283.44	283.57	283.34	284.14	283.10	284.83	282.93	284.15	283.10
	5-year	282.80	282.97	282.73	283.64	282.38	283.91	282.29	283.65	282.37
420+00	Dec 1982	282.92	282.99	282.85	283.40	282.76	283.69	282.70	283.41	282.75
	Apr 1985	281.49	281.57	281.41	281.91	281.26	281.91	281.26	281.94	281.26
	100-year	285.23	285.36	285.14	285.35	285.14	286.60	285.01	285.37	285.14
	50-year	284.54	284.63	284.46	284.68	284.44	285.63	284.32	284.68	284.44
	25-year	283.92	283.99	283.85	284.13	283.80	285.02	283.70	284.12	283.80
	10-year	283.14	283.19	283.07	283.50	282.98	283.97	282.92	283.51	282.98
	5-year	282.52	282.60	282.43	282.95	282.30	283.15	282.27	282.96	282.30
437+00	Dec 1982	282.81	282.80	282.77	283.03	282.73	283.04	282.70	283.03	282.72
	Apr 1985	281.36	281.35	281.32	281.44	281.26	281.44	281.26	281.44	281.26
	100-year	285.12	285.16	285.08	285.15	285.08	285.76	285.01	285.16	285.07
	50-year	284.43	284.45	284.39	284.46	284.38	284.75	284.32	284.46	284.38
	25-year	283.81	283.82	283.77	283.85	283.75	284.27	283.70	283.87	283.75
	10-year	283.03	283.01	282.99	283.12	282.95	283.29	282.92	283.13	282.95
	5-year	282.38	282.40	282.34	282.48	282.28	282.54	282.27	282.48	282.28

Table 2.--Summary of flood elevations and discharges in Current River
on State Highway 328 at main bridge and two relief bridges

Drainage structure	Discharge (cubic feet per second)	Area (square feet)	Mean velocity (feet per second)	Water-surface elevations (feet above sea level)	
				Upstream	Downstream
Flood of December 1982					
360 feet relief bridge at highway station 504+36 to 507+96	9,820	2,430	4.0	282.9	282.3
Main channel bridge at highway station 516+95 to 524+19	35,300	11,964	3.0	282.9	282.7
420 feet relief bridge at highway station 528+90 to 533+10	14,000	3,678	3.8	282.9	282.3
100-year flood					
360 feet relief bridge at highway station 504+36 to 507+96	5,160	3,400	1.5	285.1	285.0
Main channel bridge at highway station 516+95 to 524+19	40,000	13,630	2.9	285.1	285.0
420 feet relief bridge at highway station 528+90 to 533+10-	25,100	4,810	5.2	285.1	285.0
50-year flood					
360 feet relief bridge at highway station 504+36 to 507+96	4,800	3,150	1.5	284.4	284.3
Main channel bridge at highway station 516+95 to 524+19	38,500	13,120	2.9	284.4	284.3
420 feet relief bridge at highway station 528+90 to 533+10	20,600	4,518	4.6	284.4	284.3

Table 2.--Summary of flood elevations and discharges in Current River
on State Highway 328 at main bridge and two relief bridges--Continued

Drainage structure	Discharge (cubic feet per second)	Area (square feet)	Mean velocity (feet per second)	Water-surface elevations (feet above sea level)	
				Upstream	Downstream
25-year flood					
360 feet relief bridge at highway station 504+36 to 507+96	5,000	2,930	1.7	283.8	283.7
Main channel bridge at highway station 516+95 to 524+19	39,900	12,690	3.1	283.8	283.7
420 feet relief bridge at highway station 528+90 to 533+10	18,000	4,270	4.2	283.8	283.7

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- Patterson, J. L., 1971, Floods in Arkansas, magnitude and frequency characteristics through 1968: Arkansas Geological Commission Water Resources Circular 11, 246 p.