Summary of Floods in the United States During 1965

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1850-E

Prepared in cooperation with Federal, State, and local agencies

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By J. O. ROSTVEDT *and others*

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SUMMARY OF FLOODS IN THE UNITED STATES DURING 1965

By J. O. ROSTVEDT and others

ABSTRACT

This report describes the most outstanding floods in the United States during 1965. The four most damaging floods during the year, by order of decreasing magnitude, were in the South Platte River basin, Colorado (June), the upper Mississippi River basin (March–May), the Arkansas River basin in Colorado, Kansas, and New Mexico (June), and northwestern Missouri (July).

The floods of June in the South Platte River basin were the most damaging in the history of the area. Previous record high discharges on many tributaries were exceeded, sometimes several fold. Six lives were lost, and damage amounted to about $500 million, of which about 75 percent was in the Denver metropolitan area.

Floods in two separate periods during March–May in the upper Mississippi River basin were the most devastating in the history of an area which comprises parts of Minnesota, Wisconsin, Iowa, Illinois, and Missouri. Flood damage was about $160 million, and 15 lives were lost.

Flood discharges in the Arkansas River basin in Colorado, Kansas, and New Mexico in June were particularly outstanding for their great magnitude, often many times greater than previous maximum discharges. Flood damage was about $60 million, and 16 lives were lost.

Torrential rains in July on the Missouri River tributaries caused outstanding floods in a large area extending from the Iowa-Missouri State line on the north to the Blackwater River basin on the south and to the Grand River basin on the east. Flood damage amounted to $24 million, and nine lives were lost.

About $11 million damage resulted in each of two areas in southern California and in Arizona and New Mexico in November and December. Eleven deaths resulted from the floods in California.

More than $7 million damage occurred from floods of April–May in the Red River of the North basin in northwestern Minnesota.

In addition to the floods mentioned above, 23 others of lesser magnitude are considered important enough to be included in this annual summary.

INTRODUCTION

This report summarizes information on outstanding floods in the United States during 1965. The floods reported were unusual hydrologic events in which large areas were affected, great damage resulted, or record-high discharges or stages occurred and for which sufficient data were available for the preparation of a report.

In U.S. Geological Survey Water-Supply Paper 1850, four chapters—1850–A, "Floods of March–May 1965 in Upper Mississippi River Basin" (Anderson and Burmeister, 1970); 1850–B, Floods of June 1965 in South Platte River Basin, Colorado (Matthai, 1969); 1850–C, "Floods of November 1965 to January 1966 in Gila River Basin of Arizona and New Mexico and in Adjacent Basins in Arizona" (Aldridge, 1970); 1850–D, "Floods of June 1965 in Arkansas River Basin, Colorado, Kansas, and New Mexico" (Snites and Larimer, 1970)—are special reports that describe floods in detail in their respective areas. The areas for which flood reports have been prepared for 1965 are shown in figure 1. The areas discussed in chapters A–D are indicated by a stippled pattern, and other areas discussed in this summary chapter are shown by a line pattern. The months in which the floods occurred are shown; the map thereby gives both the location and the time distribution of floods during the year.

A flood may be defined as any abnormally high streamflow that overtops natural or artificial banks of a stream; a great number of these events occur that are unreported every year in the United States. Each flood in this report was selected as an outstanding or relatively rare event. A rare flood is not necessarily an impressive flood, but it is one whose probability of being duplicated at any one site is small. A rare flood in an isolated area or in a sparsely inhabited area could possibly be a more outstanding hydrologic event than a much publicized flood in a developed area.

Many variable factors of meteorology and physiography in inumerable combinations cause floods of all degrees of severity. Some meteorological factors influencing floods are the form, the amount, and the intensity of precipitation; moisture condition of the soil before the storm; the temperature, which may cause frozen soil or may determine the rate of snowmelt; and the direction of the storm movement. The principal physiographic features of a basin that determine floodflows are: drainage area, altitude, geology, shape, slope, aspect, and vegetative cover. With the exception of vegetative cover, which varies seasonally, the physiographic features are fixed for any given area. The combination of the magnitude and intensity of meteorologic phenomena, antecedent moisture conditions, and the effect of inherent physiographic features on runoff determines what the magnitude of a flood will be.

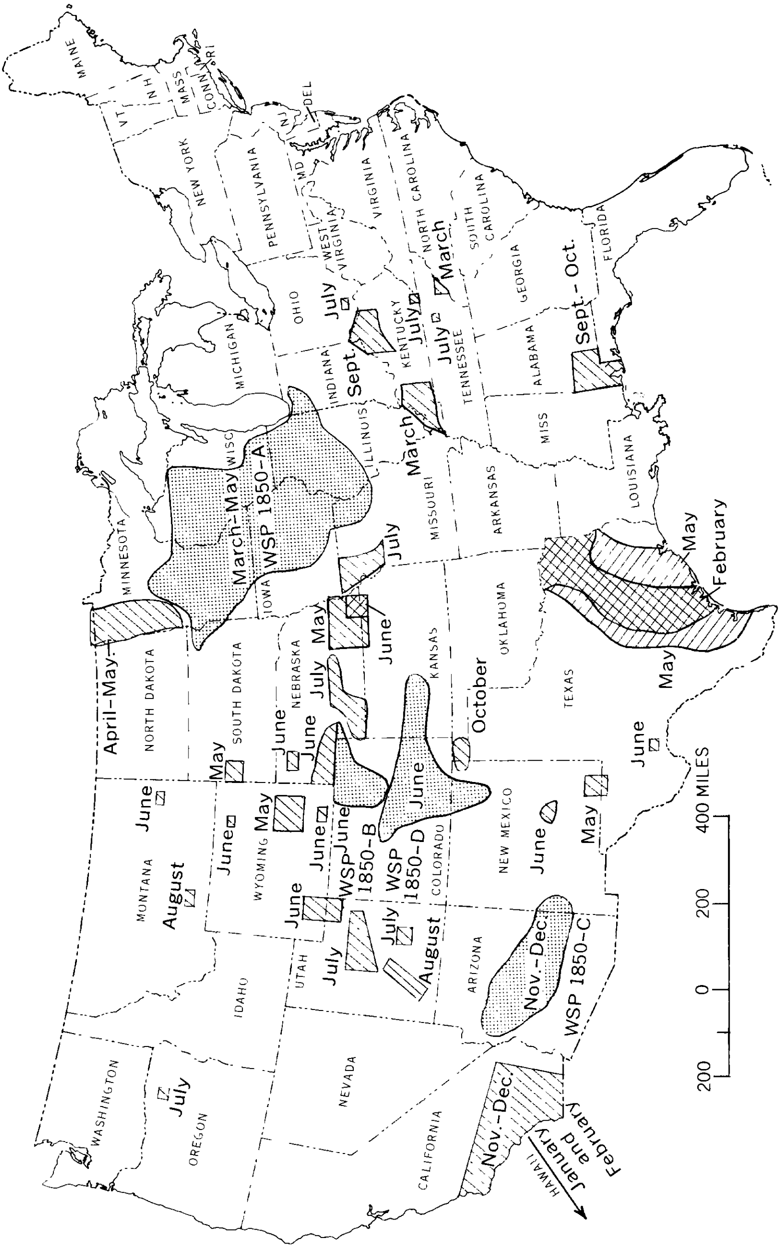

FIGURE 1.—Areas and months of occurrence of floods in 1965 for which reports are included in this summary. Stippled pattern indicates the areas for which special reports have been prepared.

According to U.S. Weather Bureau data, losses from floods in the United States during 1965 ($788 million) were 1.2 times those in 1964 ($652 million) and 4.5 times those in 1963 ($176 million). The 1965 flood losses were the highest since those of $995 million in 1955 and were about 2.3 times the national annual average of $340 million, based on the 10-year period 1951–60, adjusted to the 1960 price index.

The number of lives lost due to floods in 1965 was 119 compared with 100 in 1964 and 39 in 1963 and was considerably greater than the national annual average of 80 lives lost during the 41-year period, 1925–65.

Many of the flood reports give the amount of rainfall and the duration of the storm causing the flood. Recurrence intervals of these storms may be determined from the U.S. Weather Bureau (1961) or from a simplified set of isopluvial maps and charts contained in a report by Rostvedt (1965).

Continuing investigation of surface-water resources in the areas covered by this report is performed by the U.S. Geological Survey in cooperation with State agencies, the U.S. Army Corps of Engineers, the U.S. Bureau of Reclamation, and other Federal or local agencies. Some data were obtained from Weather Bureau publications.

Collection of data, computations, and most of the text were made by the district offices in whose district the floods occurred.

DETERMINATION OF FLOOD STAGES AND DISCHARGES

Data of peak stages and peak discharges at discharge stations in this report are those which are obtained and compiled in regular procedure of surface-water investigation by the Geological Survey.

The usual method of determining stream discharges at a gaging station is the application of a stage-discharge relation to a known stage. The relation at a station is usually defined by current-meter measurements through as much of the range of stage as possible. If the peak discharge at a station is above the range of the computed stage-discharge relation, short extensions may be made to the graph of relation by logarithmic extrapolation, by velocity-area studies, or by use of other measurable hydraulic factors.

Peak discharges that are greatly above the range of the stage-discharge relation at gaging stations and peak discharges at miscellaneous sites (which have no defined stage-discharge relation) are generally determined by various types of indirect measurements. During major floods, adverse conditions often make it impossible to obtain current-meter measurements at some sites. Peak discharges are then measured, after the flood has subsided, by indirect methods based on detailed surveys of selected channel reaches. A general description of the indirect methods used by the Geological Survey is given by Corbett and others (1943), Johnson (1936), and Dalrymple and others (1937). More detailed information concerning the latest techniques is available in recent reports by Kindsvater and others (1953), Bodhaine (1963), and Tracy (1957).

EXPLANATION OF DATA

The floods are described in chronological order. Because the type and the amount of information differ for the floods, no consistent form can be used to report the events.

The data for each flood include: a description of the storm, the flood, and the flood damage; a map of the flood area showing flood-determination points and, for some storms, precipitation stations or isohyets; rainfall amounts and intensities; and peak stages and discharges of the streams affected. When considerable rainfall data are available, they are presented in tabular form and show daily or storm totals. When sufficient data are available to determine the pattern and distribution of rainfall, and isohyetal map may be shown.

A summary table of peak stages and discharges is given for each flood unless the number of stations in the report is small, and then the information is included in the text description. In the summary table the first column under maximum floods gives the period of known floods prior to the 1965 floods. This period does not necessarily correspond to that of gaging-station operation, but the period may extend back to an earlier date. More than one period of known floods is shown for some stations. A period is shown whenever it can be associated with a maximum stage, even though the corresponding discharge may not be known. A second shorter period of floods is then given in which maximums of both discharge and stage are known.

The second column under maximum floods shows the year in which the maximum stage or discharge occurred, within the period of known floods, prior to the 1965 flood being reported. The third column gives the date of the peak stage or discharge of the 1965 flood.

The last column gives the recurrence interval for the 1965 peak discharge. The recurrence interval is the average interval, in years, in which a flood of a given magnitude (the 1965 peak) will be equaled or exceeded once as an annual maximum. A flood having a recurrence interval of 20 years can be expected to occur, on the average, once in 20 years, or it is one that has a 5-percent chance of occurring in any year. The recurrence intervals in the tables were obtained from Geological Survey reports on flood magnitude and frequency. In nearly all flood-frequency reports used, the data limit the determination of recurrence intervals to 50 years. In a few reports the limit is less than 50 years. The severity of a flood whose recurrence interval exceeds the limit of determination is expressed as the ratio of its peak discharge to the discharge of the flood that has a recurrence interval equal to the limits of determination.

SUMMARY OF FLOODS

FLOODS OF JANUARY AND FEBRUARY IN HAWAII

After STUART H. HOFFARD (1965)

Damaging floods occurred in January and February in four islands—Kauai, Maui, Oahu, and Molokai. Two weather fronts invaded Kauai on January 5–6 and January 9–10. On January 5–6 the rainfall was relatively uniform over the island, and every rain gage registered more than 2 inches of rain; 3.5 inches was common along the southern coast, and between 4 and 5 inches of rain fell in several areas. Most of the rain on January 9–10 fell in 7 hours, and at some places the intensity was greater than 2 inches per hour. The total rainfall of January 9–10 was greater than that of January 5–6 except in an area from Wailua to Makahuena Point. Rainfall at many gages exceeded 4 inches and at several gages exceeded 6 inches. Rainfall was heaviest in a small area on the southern coast near Hanapepe—Makaweli received 7.77 inches of rain, and Eleele received 6.32 inches. In northern Kauai, Wainiha had 4.86 inches of rain, and Kilauea Plantation had 3.95 inches.

The rains of January 5–6 caused high stages in the Wailua, Hanapepe, and intermediate basins (fig. 2) but no flooding. The heavy rains of January 9–10 sent water pouring over the highway at six places between Kalaheo and Waimea. Runoff from Hanapepe Height flooded a section of Hanapepe behind the new levee on the west bank of the Hanapepe River. Heavy crop damage occurred in the Hanapepe-Waimea area. Flood damage in the Kalaheo-Waimea area was $12,000 to public property and $158,000 to private property. Although rainfall and runoff were intense on Kauai, no record peak discharge occurred at any gaging station with 10 or more years of record (table 1).

On January 23 heavy rains fell along the east coast of Maui, from Paakea where 8.12 inches fell, southeastward to Hana where 7.85 inches fell, and to Hanahuli where 8.46 inches fell (fig. 3). At Kaupo Ranch, 4.52 inches fell at an altitude of 500 feet, and 7 inches fell at an altitude of 3,570 feet.

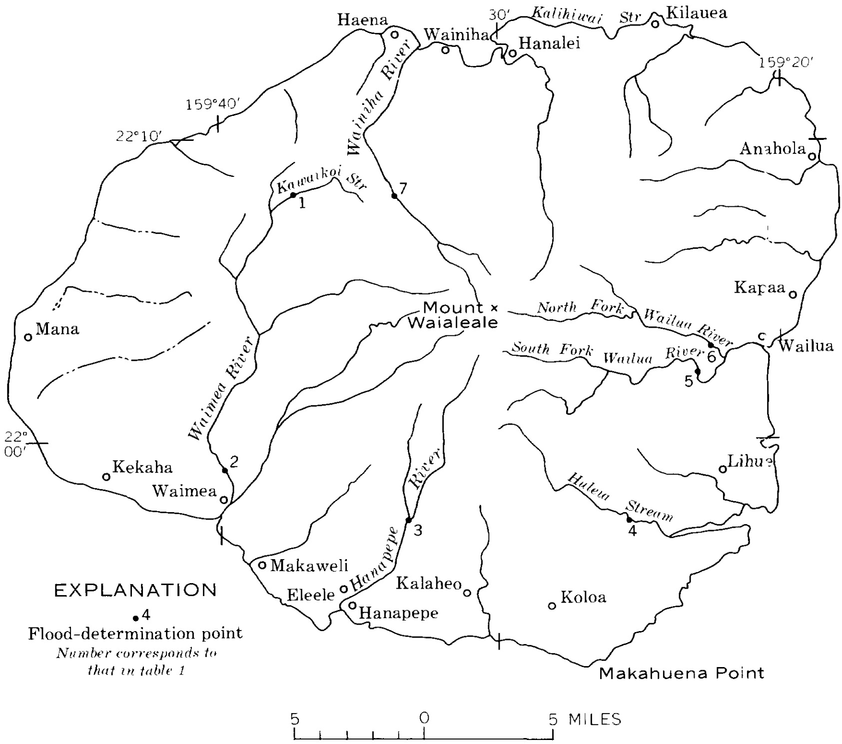

FIGURE 2.—Location of flood-determination points, floods of January 5–9 in Kauai, Hawaii.

TABLE 1.—*Flood stages and discharges, January in Kauai, Hawaii*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before January 1965: Period	Known before January 1965: Year	Peaks of January 1965	Gage height (feet)	Discharge (cfs)
1	Kawaikoi Stream near Waimea	4.1	1909–16, 1919–64.	1916		15.2	10,700
					10	7.42	1,760
2	Waimea River near Waimea	57.8	1910–19, 1943–64.	1949		19.3	37,100
					10	12.36	13,300
3	Hanapepe River below Manuahi Stream near Eleele.	18.8	1917–21, 1926–64.	1963		14.87	39,000
					5	7.58	6,480
					10	6.83	4,980
4	Huleia Stream near Lihue	17.6	1912–16, 1962–64.	1963		19.82	13,200
					10	16.02	7,120
5	South Fork Wailua River near Lihue	22.4	1911–64	1963		22.9	87,300
					5	16.23	11,100
6	North Fork Wailua River near Kapaa	18.7	1952–64	1955		19.88	53,200
					5	7.50	4,950
7	Wainiha River near Hanalei	10.2	1952–64	1956		14.1	40,000
					9	5.64	4,870

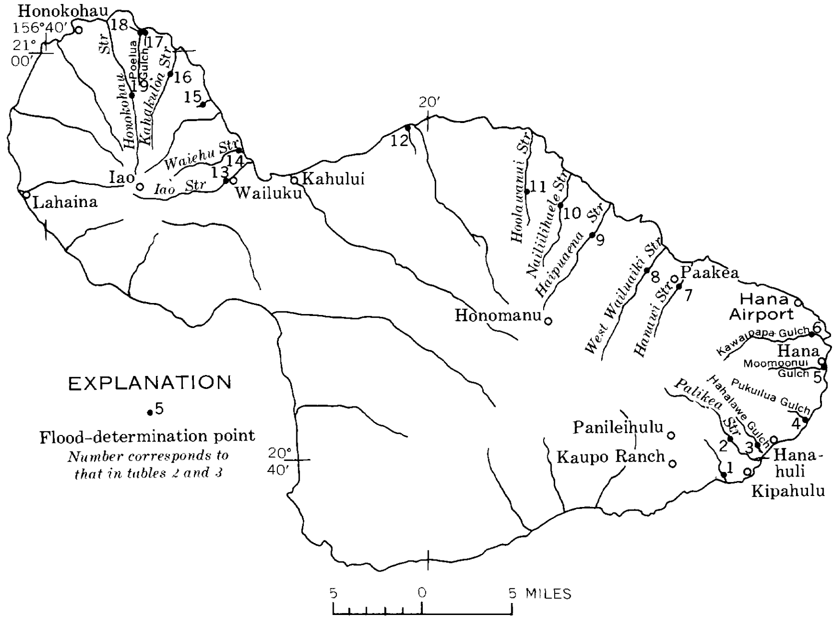

FIGURE 3.—Location of flood-determination points, floods of January and February in Maui, Hawaii.

Runoff from the storm of January 23 was intense in a small area. The peak discharge in Palikea Stream near Kipahulu (sta. 2) was the maximum discharge in 38 years of record (table 2). A highway bridge over Lelekea Stream between Kaupo and Kipahulu was washed out. Runoff from fields crossed a highway at Hana and caused slight damage by flooding the lobby and some rooms of the Hana Hotel.

Torrential rains of 10 or more inches fell in about 8 hours on February 3–4 along the windward coast and slopes in eastern Maui and in the mountains of western Maui (fig. 3). Total rainfall exceeded previous 24-hour maximums at several rain gages; a total of more than 12 inches fell at Hana Airport. The greatest recorded total for the storm was 16.94 inches at Paakea. More than 20 inches may have fallen near Honomanu and at other places at altitudes of 1,500–2,000 feet. Rainfall totals exceeded 12 inches in the mountains in western Maui. On the leeward side at Lahaina, 0.81 inch of rain fell.

Peak discharges (table 3) in Kawaipapa (sta. 6) and Moomoonui (sta. 5) Gulches were slightly higher than they had been on January 23, and runoff in the Kipahulu area was very low. Damage in the Hana area was limited to eroded pastureland, damaged fences, and washed-out roads. Numerous landslides occurred between Hana and central Maui. Sections of Wailuku were flooded for the first time in 50 years. Total damage in Hana and central Maui from the floods of February 3–5 was $45,000.

TABLE 2.—*Flood stages and discharges, January, in Maui, Hawaii*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before January 1965, Period	Maximum floods: Known before January 1965, Year	Maximum floods: January 1965	Maximum floods: Gage height (feet)	Maximum floods: Discharge (cfs)
1	Kukuiula Gulch near Kipahulu	0.76	1964–65	1964		3.70	650
					23	5.11	1,560
2	Palikea Stream below diversion dam near Kipahulu.	6.29	1927–29, 1931–65.	1955		17.5	15,000
					23	18.3	16,100
3	Hahalawe Gulch near Kipahulu	.43	1927–37, 1938–65.	1937		15.74	3,560
					23	4.80	1,450
4	Pukuilua Gulch near Hana	.48	1963–65	1963		6.70	466
					23	9.30	788
5	Moomoonui Gulch at Hana	.90	1963–65	1963		9.16	467
					23	14.25	1,740
7	Hanawi Stream near Nahiku	3.49	1914–16, 1922–65.	1916		11.6	5,570
					23	10.28	4,130
8	West Wailuaiki Stream near Keanae	3.66	1914–17, 1921–65.	1923		13.5	6,960
					23	8.75	2,960

TABLE 3.—*Flood stages and discharges, February, in Maui, Hawaii*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before February 1965, Period	Maximum floods: Known before February 1965, Year	Maximum floods: February 1965	Maximum floods: Gage height (feet)	Maximum floods: Discharge (cfs)
5	Moomoonui Gulch at Hana	0.90	1963–65	1963		9.16	467
					4	14.46	2,070
6	Kawaipapa Gulch at Hana	5.83					
					3	9.59	10,200
7	Hanawi Stream near Nahiku	3.49	1914–16, 1922–65.	1916		11.6	5,570
					3	5.90	1,440
8	West Wailuaiki Stream near Keanae	3.66	1914–17, 1922–65.	1923		13.5	6,960
					3	8.50	2,750
9	Haipuaena Stream above Spreckles ditch near Huelo.	1.16	1914–65	1940		6.91	2,710
					3	6.19	1,360
10	Nailiilihaele Stream near Huelo	3.58	1914–65	1930		10.74	6,410
					4	8.07	2,610
11	Hoolawanui Stream near Huelo	1.34	1911–65	1950		5.94	5,010
					4	4.57	2,400
12	Unnamed gulch at Maliko Bay	.43	1963–65	1963		2.53	28
					4	2.74	32
13	Iao Stream at Wailuku	8.24	1950–65	1950		6.21	7,540
					5	5.06	3,280
14	Waiehu Stream at Waiehu	4.52			4		1,760
15	Unnamed gulch at Maluhia Camp	.12			4	4.07	37
16	Kahakuloa Stream near Honokohau	3.47	1940–42, 1948–65.	1942		[1] 7.02	3,080
					4	8.47	1,590
17	Owaluhi Gulch near Kahakuloa	.20			4	7.83	53
18	Poelua Gulch near Kahakuloa	1.18			4	14.3	1,080
19	Honokohau Stream near Honokohau	4.11	1913–20, 1922–65.	1942		8.40	3,740
					4	5.26	1,030

[1] At control then in use.

The storm of February 3–4 that struck Maui also caused heavy rains in Oahu on the windward slopes of the Koolau Range between Punaluu and Kahaluu (fig. 4). At Waiahole, 2.6 inches of rain fell in a series of showers on February 3. In the first 4 hours of February 4, 7 inches of rain fell, and by 0800 hours 11.5 inches had fallen. The total storm precipitation at Waiahole was 18.17 inches, and at Kahana it was 18.50 inches—both stations are at an elevation of about 800 feet. Estimates from storage gages between the two stations suggest that storm totals may have reached 24 inches. Rainfall during a 24-hour period near the shore in the Kailua area was about 2 inches, and the amount increased rapidly inland. Rainfall west of the Koolau Range decreased rapidly and was about 1 inch in the western part of Oahu.

Some of the most intense rates of runoff (table 4) ever recorded on windward Oahu occurred on February 4. Makawao Stream (sta. 17) reached a stage 3 feet higher and a peak discharge 2.8 times as great as recorded previously. A hydrograph of the brief but intense discharge is shown in figure 5. Streams in the Manoa and Palolo valleys crested at the highest stages recorded since 1921.

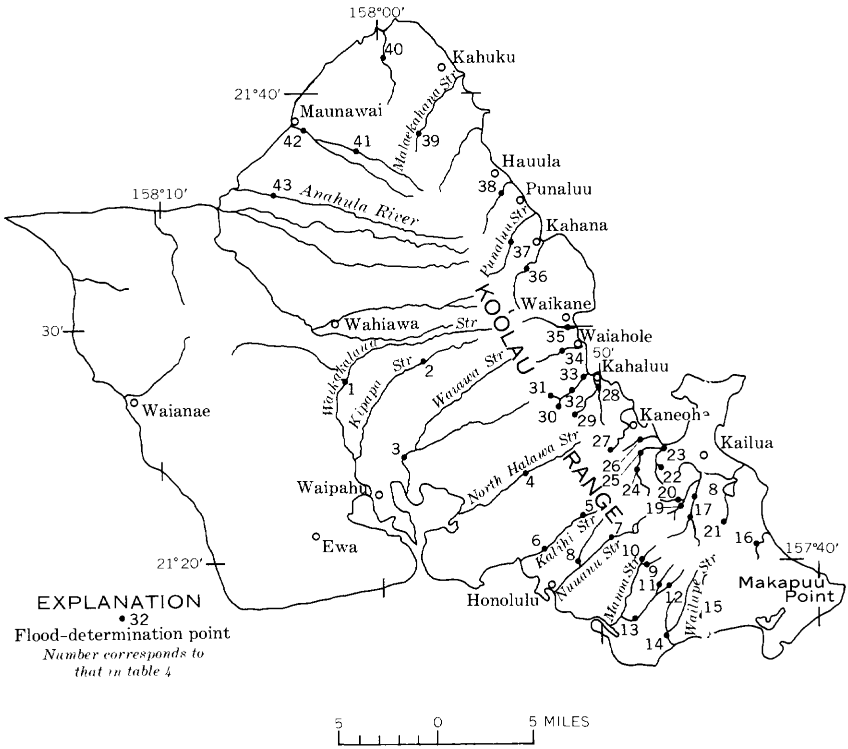

FIGURE 4.—Location of flood-determination points, floods of February in Oahu, Hawaii.

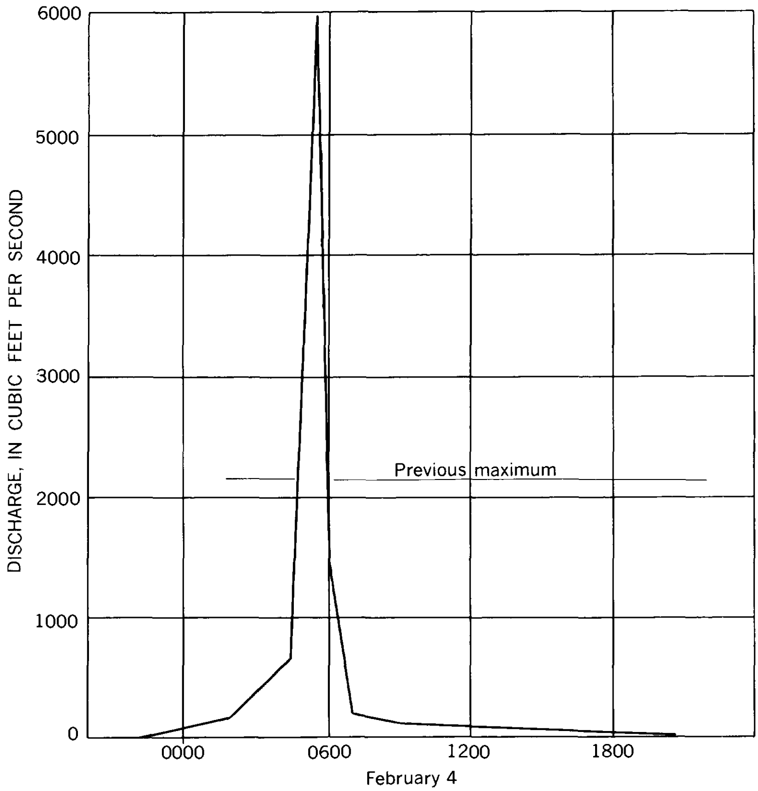

FIGURE 5.—Discharge of Makawao Stream near Kailua, Oahu, Hawaii, February 4.

TABLE 4.—*Flood stages and discharges, February, in Oahu, Hawaii*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before February 1965: Period	Maximum floods: Known before February 1965: Year	Maximum floods: February 1965	Maximum floods: Gage height (feet)	Maximum floods: Discharge (cfs)
1	Waikakalaua Stream near Wahiawa	6.96	1958–65	1963		16.50	4,830
					4	11.55	1,420
2	Kipapa Stream near Wahiawa	4.29	1957–65	1963		12.29	5,680
					4	9.60	2,480
3	Waiawa Stream near Pearl City	26.4	1953–65	1954		19.27	16,900
					4	15.37	10,400
4	North Halawa Stream near Aiea	3.45	1929–33, 1953–65.	1932		13.36	6,650
					4	12.13	2,230
5	Kalihi Stream near Honolulu	2.61	1914, 1917–65.	1930		13.81	12,400
					4	10.0	2,320
6	Kalihi Stream at Kalihi	5.18	1960–65	1960		8.0	6,350
					4	8.02	5,910
7	Nuuanu Stream below reservoir 2 wasteway near Honolulu.	3.35	1918–65	1921		8.74	6,990
					4	5.09	851
8	Waolani Stream at Honolulu	1.28	1958–65	1963		6.14	2,500
					4	2.90	712

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TABLE 4.—*Flood stages and discharges, February, in Oahu, Hawaii*—Continued

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before February 1965: Period	Year	February 1965	Gage height (feet)	Discharge (cfs)
9	Waiakeakua Stream at Honolulu	1.06	1913–21, 1927–65.	1921		10.4	3,090
					4	6.06	2,540
10	Waihi Stream at Honolulu	1.14	1915, 1917–21, 1927–65.	1921		10.4	3,250
					4	6.16	2,860
11	Pukele Stream near Honolulu	1.18	1927–65	1930		7.75	2,600
					4	6.58	1,370
12	Waiomao Stream near Honolulu	1.04	1927–65	1930		6.27	1,550
					4	5.28	724
13	Palolo Stream near Honolulu	3.63	1953–65	1958		5.33	3,250
					4	4.42	2,010
14	Waialaenui Gulch at Honolulu	1.75	1958–65	1958		7.58	2,010
					4	9.26	1,020
15	Wailupe Gulch at Aina Haina	2.35	1958–65	1958		7.20	2,170
					4	4.69	1,470
16	Inoaole Stream at Waimanalo	1.21	1958–65	1958		6.00	665
					4	5.34	557
17	Makawao Stream near Kailua	2.04	1958–65	1958		9.08	2,140
					4	12.41	6,000
18	Maunawili Stream above Kailua Rd. near Kailua.	5.34	1958–65	1958		11.08	2,550
					4	15.62	9,690
19	Kahanaiki Stream near Kailua	.79			4		1,370
20	Kahanaiki Stream tributary near Kailua.	.39			4		661
21	Kaelepulu Stream tributary at Kailua.	.16	1963–65	1963		6.40	370
					4	4.89	233
22	Kawa Stream tributary at Kaneohe	.24			4		877
23	Kawa Stream at Kaneohe	1.19			4		4,510
24	Kamooalii Stream above Luluku St. at Kaneohe.	3.87			4		6,460
25	Kamooalii Stream at Kaneohe	4.38	1958–65	1958		8.3	6,610
					4		6,200
26	Keaahala Stream at Kamehameha Highway at Kaneohe.	.62	1958–65	1958		8.18	1,780
					4	7.21	1,390
27	Haiku Stream near Heeia	.97	1914–18, 1940–65.	1951		5.39	3,160
					4	3.88	1,290
28	Ahuimanu Stream near Kahaluu	2.16	1963–65	1963		10.8	3,000
					4	11.44	6,000
29	Kahaluu Stream near Heeia	.28	1936–65	1963		3.42	477
					4	8.46	1,730
30	South Fork Waihee Stream near Heeia	.03	1963–65	1963		3.25	162
					4	3.74	238
31	North Fork Waihee Stream near Heeia	.03	1963–65	1963		2.64	170
					4	3.38	376
32	Waihee Stream at alt 260 ft near Heeia	.31	1962–65	1963		4.91	515
					4	6.12	1,700
33	Waihee Stream near Heeia	.93	1938–65	1963		6.06	1,560
					4	8.72	5,110
34	Waiahole Stream at alt 250 ft near Waiahole.	.99	1956–65	1963		4.80	2,230
					4	4.77	2,090
35	Waikane Stream at alt 75 ft at Waikane	2.22	1960–65	1963		9.46	4,560
					4	10.76	8,800
36	Kahana Stream at alt 30 ft near Kahana.	3.74	1959–65	1963		8.10	5,430
					4	7.18	4,120
37	Punaluu Stream near Punaluu	2.78	1954–65	1961		6.06	2,970
					4	6.06	2,970
38	Kaluanui Stream at alt 30 ft near Hauula.	2.12	1958–65	1963		5.16	2,470
					4	5.40	2,790
39	Malaekahana Stream near Laie	.64	1964–65	1964		5.54	500
					5	5.29	422
40	Oio Stream near Kahuku	2.13	1958–65	1963		6.54	1,070
					4	3.98	523
41	Kamananui Stream at Pupukea Military Rd. near Maunawai.	3.13	1964–65	1964		7.50	1,020
					4	8.23	1,310
42	Kamananui Stream at Maunawai	9.79	1958–65	1963		7.92	3,450
					4	7.65	3,030
43	Anahula River near Haleiwa	13.5	1958–65	1958		9.77	3,870
					4	9.37	3,640

From the Maunawili basin (sta. 18) toward Kaneohe the rate of runoff decreased. The peak discharges for streams in the Heeia basin were equivalent to 3-year floods. However, thunderstorms in Kahaluu Valley caused peak discharges that were three times as large as the previous maximums on two streams in more than 30 years of record.

The greatest damage from the February floods on Oahu occurred in the Kaneohe and Kahaluu areas. About 30 homes were severely damaged in Kaneohe from flooding on Kamooalii Stream above the Luluku Street culvert (sta. 24). Two persons were drowned, and property damage was about $340,000. In the Kahaluu area about 300 acres were inundated, and the flooding damaged homes, automobiles, and crops. A store owner stated that the depth of water in his store was greater than that from any other flood in 15 years. The U.S. Soil Conservation Service estimated the flood damage in the Kahaluu area at $240,000.

The storm of early February brought heavy rain to Molokai (fig. 6). Showers began at 1930 hours on February 2, became more intense at 1500 hours on February 3, and ended at about 2300 hours—most of the rain fell in an 8-hour period. In the western one-third of the island only a few rain gages caught more than 2 inches of rain, and several caught less than half an inch. More than 3 inches fell above the 1,000-foot elevation on the western slopes in eastern Molokai, and at one gage at 1,450-foot elevation, the rainfall was estimated at 4.6 inches. The greatest rainfall reading was 9.03 inches at Puuohuku, about one-half of its mean annual rainfall, and at Mapulehu, the only gage on the southeastern coast, the reading was 5.89 inches.

Floods occurred in a few streams in eastern Molokai (table 5). The peak stage at Halawa Stream near Halawa (sta. 1) was over the top of the gage shelter, and the peak discharge was more than two times the

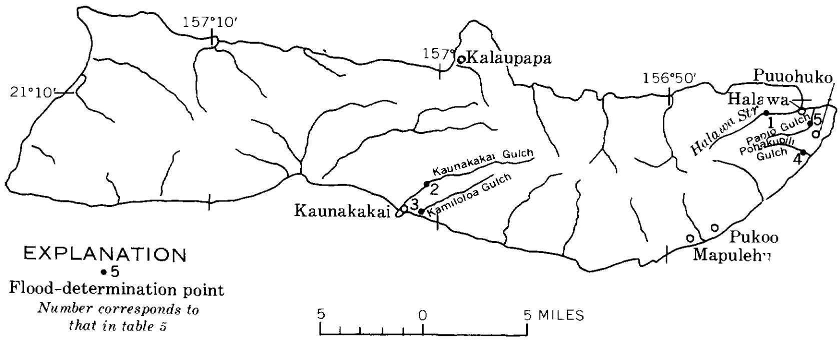

FIGURE 6.—Location of flood-determination points, floods of February in Molokai, Hawaii.

previous maximum in 48 years of record. The peak discharge (26,900 cfs) on Halawa Stream was the highest for this size drainage area (4.62 sq. mi.) ever measured in the Hawaiian Islands. Flood damage amounted to about $36,000.

TABLE 5.—*Flood stages and discharges, January, in Molokai, Hawaii*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before January 1965 — Period	Known before January 1965 — Year	January 1965	Gage height (feet)	Discharge (cfs)
1	Halawa Stream near Halawa	4.62	1918–32, 1938–65.	1961		13.6	10,900
					4	19.91	26,900
2	Kaunakakai Gulch at Kaunakakai	6.57	1950–65	1961		9.30	3,060
					4	4.58	441
3	Kamiloloa Gulch at Kaunakakai	3.24			4	5.30	212
4	Pohakupili Gulch near Halawa	.48	1964–65	1964		6.41	140
					4	7.56	419
5	Papio Gulch at Halawa	.94	1964–65	1964		4.60	309
					4	7.15	1,140

FLOODS OF FEBRUARY AND MAY IN EASTERN TEXAS

By LEO G. STEARNS

General rains of 3–4 inches in east-central Texas (fig. 7) in February made it one of the wettest Februarys in recent years. A peak discharge of 8,050 cfs on February 9 from a 69-sq mi basin of Cuthand Creek near Bogata (sta. 3), in the Red River basin, was the greatest since at least 1950. In the Sulphur River basin, North Sulphur River near Cooper (sta. 1), had a peak discharge of 48,000 cfs on February 9, the highest since at least 1915, and South Sulphur River near Cooper (sta. 2) peaked at 25,000 cfs on February 10, the highest discharge since at least 1942. On February 10, Lake Tawakoni on Sabine River near Wills Point (sta. 4; drainage area 756 sq mi) spilled for the first time since impoundment began on October 7, 1960.

During May, streamflow was high in the same region but in a slightly larger area than that during the February storms (fig. 7). The middle Brazos River basin had rains of up to 10 inches on May 16 and 17, which caused flooding on major tributary streams. Flood damage in the Nolan Creek and Elm Creek basins amounted to an estimated $1.2 million to property and crops mostly around Belton and Killeen. Cowhouse Creek near Pidcoke (sta. 5) had a peak discharge of 63,800 cfs on May 16, second highest stage since at least 1882. Lampasas River at Youngsport (sta. 6) peaked at 87,900 cfs on May 17, which was its greatest discharge in 41 years of record; on the same day Little River near Little River (sta. 7) had a peak discharge of 79,600 cfs. Many low-lying areas near the Little River were inundated, and in an area near Cameron the water was 8 feet above flood stage.

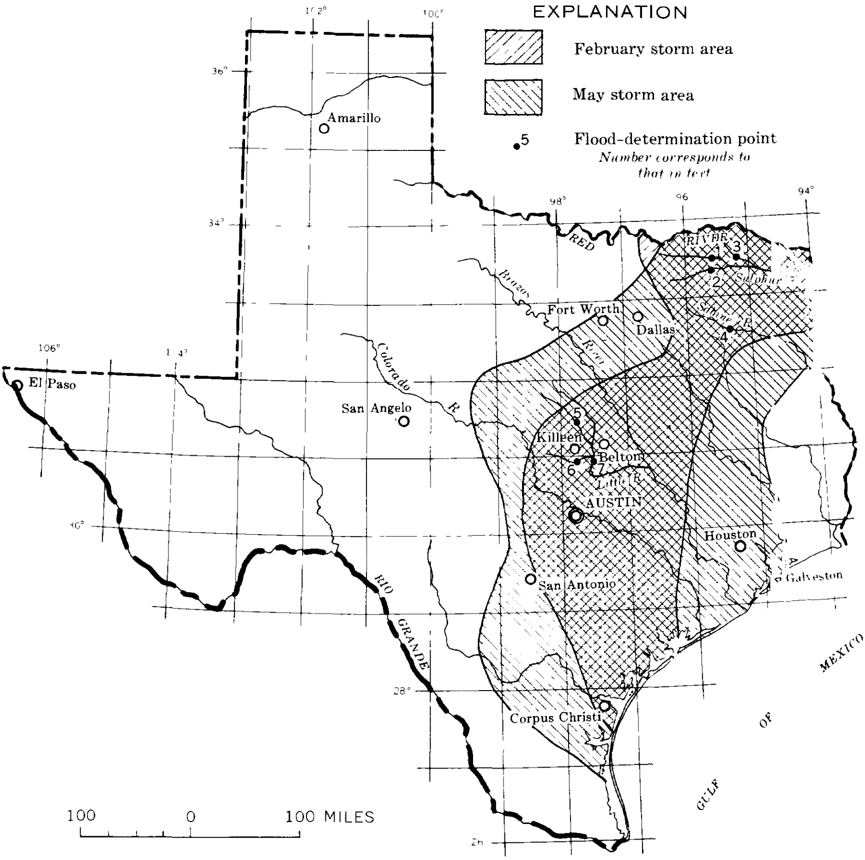

FIGURE 7.—Location of flood-determination points, floods of February and May in eastern Texas.

On May 18, torrential rains exceeding 6 inches in some areas flooded parts of San Antonio. Several usually small streams exceeded their boundaries and caused property damage estimated at $1 million. Two persons were drowned, and 14 were injured.

FLOODS OF MARCH 26 IN SEVIER COUNTY, TENN.

By WILLIAM J. RANDOLPH

Heavy rains on March 25–26 caused major flooding in Sevier County particularly in the town of Sevierville. Sevierville is between two major forks of the Little Pigeon River (fig. 8), which drains a part of the Tennessee side of the Great Smoky Mountains where the mean annual rainfall is about 70 inches.

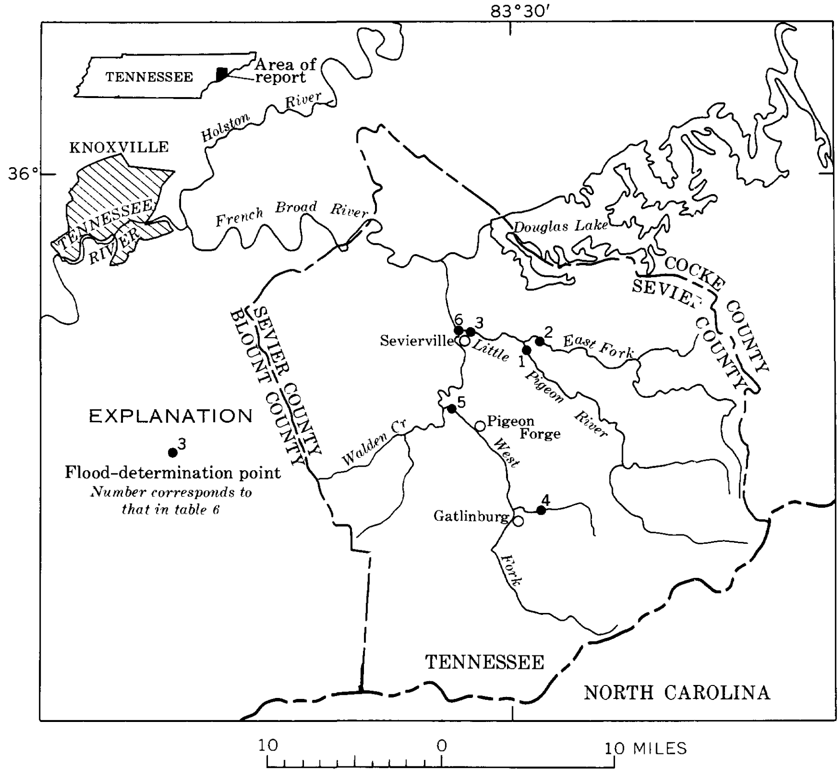

FIGURE 8.—Location of flood-determination points, floods of March 26 in Sevier County, Tenn.

Rainfall over the Little Pigeon River basin ranged from 4.3 to 6.0 inches during the 2-day period March 25–26. This amount would not ordinarily cause a major flood in this area, but the timing of the two storms caused runoff that was exceptionally high with respect to the amount of total rainfall. Heavy rain on March 25 saturated the ground and filled the channels to bankfull stages, so that the ratio of runoff to the heavy rains of the following day was high.

The resulting flood on Little Pigeon River at Sevierville (sta. 6) was the fourth highest since 1867 and was the highest since 1896. The irregular distribution of floods on the Little Pigeon River is illustrated by the following data: The three greatest known floods (1867, 1875, and 1896) occurred in the 19th century. Since 1921 the four floods that had stages within 2 feet of the 1965 crest occurred in the preceding 9 years.

Peak stages were determined at one gaging station and at five crest-stage partial-record stations. The peak discharges determined at three of the stations were relatively large (table 6). For the station where the peak discharge is unknown, the peak stage was the maximum in a period of record of 7 years.

In the town of Sevierville, more than 200 families were evacuated, and most of the business places were flooded. Damage was estimated at more than $1 million.

TABLE 6.—*Flood stages and discharges in the Tennessee River basin, March 26, in Sevier County, Tenn.*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before March 1965: Period	Year	March 1965	Gage height (feet)	Discharge: Cfs	Recurrence interval (years)
1	Little Pigeon River near Sevierville.	110	1954–65	1963		16.94	14,900	
					26	17.42	15,700	[1] 1.09
2	East Fork Little Pigeon River near Sevierville.	64.1	1954–65	1963		19.28	7,950	
					26	19.14	7,880	26
3	Little Pigeon River above West Fork at Sevierville.	201	1954–65	1963		16.98	23,500	
					26	17.09	24,100	50
4	Hog Pen Branch near Gatlinburg.	.61	1959–65	1961		2.29	(2)	
					26	3.41	(2)	
5	West Fork Little Pigeon River near Pigeon Forge.	76.2	1946–49, 1954–65.	1963		11.01	7,370	
					26	11.86	8,800	25
6	Little Pigeon River at Sevierville.	353	1867–1965	1875		18	55,000	
					26	16.09	41,000	[1] 1.11

[1] Ratio of peak discharge to 50-year flood.
[2] Unknown.

FLOODS OF MARCH 29–31 IN WESTERN KENTUCKY

By C. H. HANNUM

Most of the March rainfall in western Kentucky fell in two storms that passed over the area between March 24 and March 29. The first storm of 2-day duration, March 25–26, caused little or no flooding, but it established antecedent conditions for the second storm. The second storm was of 1-day duration, and rainfall ranged from 1.6 to 5.6 inches over the area. Severe flooding occurred on some streams in the storm area (fig. 9). The heaviest rainfall occurred in the vicinity of Mayfield. The Weather Bureau precipitation gage at Mayfield caught 4.18 inches of rain on March 29, and the two Geological Survey recording rain gages in the Perry Creek basin measured 5.55 and 5.60 inches of rain. The rain gages in the Perry Creek basin showed that all the rain of the second storm fell between 1800 hours on March 28 and 0700 hours on March 29. Most of the rain fell between 0200 hours and 0400 hours on March 29. Figure 9 shows the combined rainfall for the two storms in the period March 24–29.

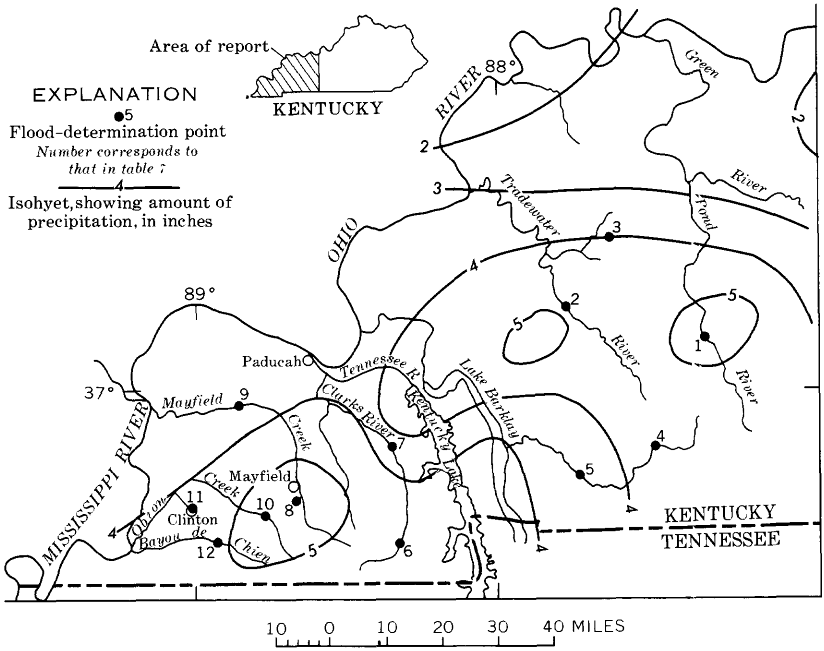

FIGURE 9.—Location of flood-determination points and isohyets for March 24–29, floods of March 29–31 in western Kentucky

Less rain fell in other areas of western Kentucky from the second storm, although the total rainfall in some areas approached that reported by the Weather Bureau station at Mayfield. The most severe flooding occurred on streams having small drainage basins in areas where the rainfall intensity was great. For example, Town Branch at Clinton (sta. 11; drainage area, 1.40 sq mi) had a peak discharge of 512 cfs per sq mi and Perry Creek near Mayfield (sta. 8; drainage area, 1.72 sq mi) had a peak discharge of 1,080 cfs per sq mi, whereas Obion Creek at Pryorsburg (sta. 10; drainage area, 36.8 sq mi) had a discharge of 135 cfs per sq mi. The peak discharge on Obion Creek at Pryorsburg has a recurrence interval of 42 years. Rose Creek at Nebo (sta. 3; drainage area, 2.10 sq mi) had a peak discharge of 296 cfs per sq mi, whereas East Fork Pond River near Apex (sta. 1; drainage area, 194 sq mi) had a peak discharge of 63 cfs per sq mi.

Table 7 lists gaging stations in the storm area, their drainage area, stages and discharges of previous maximum floods, and stages and discharges for the floods of March 29–31.

TABLE 7.—*Flood stages and discharges, March 29–31, in western Kentucky*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before March 1965 — Period	Known before March 1965 — Year	March 1965	Gage height (feet)	Discharge — Cfs	Discharge — Recurrence interval (years)
	Green River basin							
1	East Fork Pond River near Apex.	194	1937, 1940–65.	1957		20.70	21,800	
					29	18.33	12,400	10
	Tradewater River basin							
2	Tradewater River at Olney	255	1937, 1940–65.	1937		19.27	17,000	
					31	16.18	5,050	3
3	Rose Creek at Nebo	2.10	1951–65	1957		7.46	1,230	
					29	6.72	622	[1]
	Cumberland River basin							
4	South Fork Little River at Hopkinsville.	46.5	1937–65	1957		21.51	9,350	
					29	15.37	2,960	3
5	Little River near Cadiz	244	1940–65	1951		21.00	14,200	
					29	15.50	6,050	2
	Tennessee River basin							
6	East Fork Clarks River at Murray.	89.7	1951–65	1952, 1957		15.20	32,300	
					29	12.25	6,850	25
7	East Fork Clarks River near Benton.	227	1937–65	1937		17.8	[1]	
			1938–65	1957		17.10	36,000	
					30	14.20	10,300	7
	Mayfield Creek basin							
8	Perry Creek near Mayfield	1.72	1952–65	1952		10.3	[1]	
			1953–65	1955,			846	
				1957		7.66		
					29	7.76	1,870	[1]
9	Mayfield Creek at Lovelaceville.	212	1937–65	1937		21.1	19,800	
					31	18.73	6,660	2
	Obion Creek basin							
10	Obion Creek at Pryorsburg	36.8	1949	1949		13.0	[1]	
			1951–65	1957		12.60	5,330	
					29	12.82	4,970	42
11	Town Branch at Clinton	1.40			29		719	[1]
	Bayou du Chien basin							
12	Bayou du Chien near Clinton.	68.7	1939–65	1951		15.0	6,880	
					30	14.28	3,860	2

[1] Unknown.

FLOODS OF MARCH–MAY IN THE UPPER MISSISSIPPI RIVER BASIN

Floods of March–May in the upper Mississippi River basin were the most devasting in the history of the area. Five States—Minnesota. Wisconsin, Iowa, Illinois, and Missouri—were affected (fig. 10). Peak stages on the Mississippi River were higher than previous maximums of record throughout the 680-mile reach from Fort Ripley, Minn., to Saverton, Mo., and were from 3 to 4 feet higher than previous maximums from the mouth of the Minnesota River at St. Paul, Minn., to Muscatine, Iowa. Record-breaking floods occurred on the Minnesota River and its tributaries from Mankato to the mouth and on many other Mississippi River tributaries in Minnesota and Wisconsin.

A significant feature of the flood was the great volume of runoff. The Mississippi River remained above flood stage for almost a month. In the Mississippi River from Royalton, Minn. (25 miles south of Fort Ripley), to the mouth of the Missouri River and in the Minnesota River from Mankato to the mouth, the volume of runoff was more than 25 percent greater than that of any previously recorded flood.

Flooding occurred in most of the upper Mississippi River basin during two separate periods almost a month apart. During the first period, in early March, floods occurred in southeastern Minnesota, northeast-

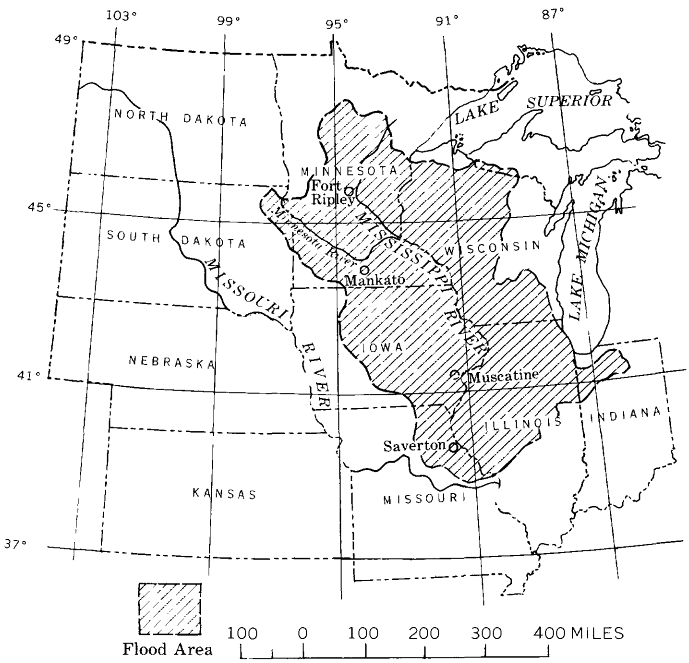

FIGURE 10.—Flood area, March–May in the upper Mississippi River basin.

ern Iowa, and southwestern Wisconsin. Warm temperatures in late February and early March melted the winter accumulation of snow. The runoff from snowmelt and from rainfall, which exceeded 2 inches in the first 3 days of March, caused severe flooding in the Zumbro and Root River basins in Minnesota and in the Cedar River basin in Minnesota and Iowa.

During the second flood period, from early April and into May, floods occurred in the entire upper Mississippi River basin. They were caused by the rapid melting of the winter accumulation of snow in northern Minnesota and Wisconsin and of the March accumulation of snow in northern Iowa, southern Minnesota, and Wisconsin. The water equivalent of snow ranged up to 11 inches. Warm temperatures moved northward into Minnesota during the last days in March, and nighttime temperatures remained above freezing. Up to 3 inches of rainfall in early April accelerated the snowmelt and increased runoff. A severely cold winter had caused deep frost penetration, and consequently much of the rain and snowmelt ran off. Many of the streams in the second flood period were the same as were involved in the first flood period.

Fifteen lives were lost, and over 700 persons were injured from the floods and associated events. Property damage was estimated at $160 million.

These floods are described in detail by Anderson and Burmeister (1970). The report summarizes peak stages and discharges at 333 sites and presents the previous maximum at sites when such data are available. Recurrence intervals are tabulated for many sites. Flood damages are discussed, and damage figures are tabulated.

FLOODS OF APRIL IN THE LITTLE SIOUX RIVER BASIN, IOWA

After HARLAN H. SCHWOB (1966)

A combination of snowmelt and rain in northwestern Iowa in early April caused severe flooding in the Little Sioux River basin (fig. 11). This flood was the greatest of record along the lower part of the Little Sioux River.

Conditions leading to the severity of the flood were heavy snowfall, deep frost penetration, and a sudden rise of temperature accompanied by rain. A snow survey during March 26–29 showed a water equivalent of 6–8 inches at Spirit Lake, 2–3 inches in the area from Spencer to Cherokee, and less than 1 inch in the southern part of the basin. Warmer temperatures and rainfall of about 2 inches in the basin above Cherokee during April 3–6 accelerated the melting. The frozen ground prevented infiltration, and the resulting runoff produced maximum discharge of record in the Little Sioux River downstream from Gillett Grove.

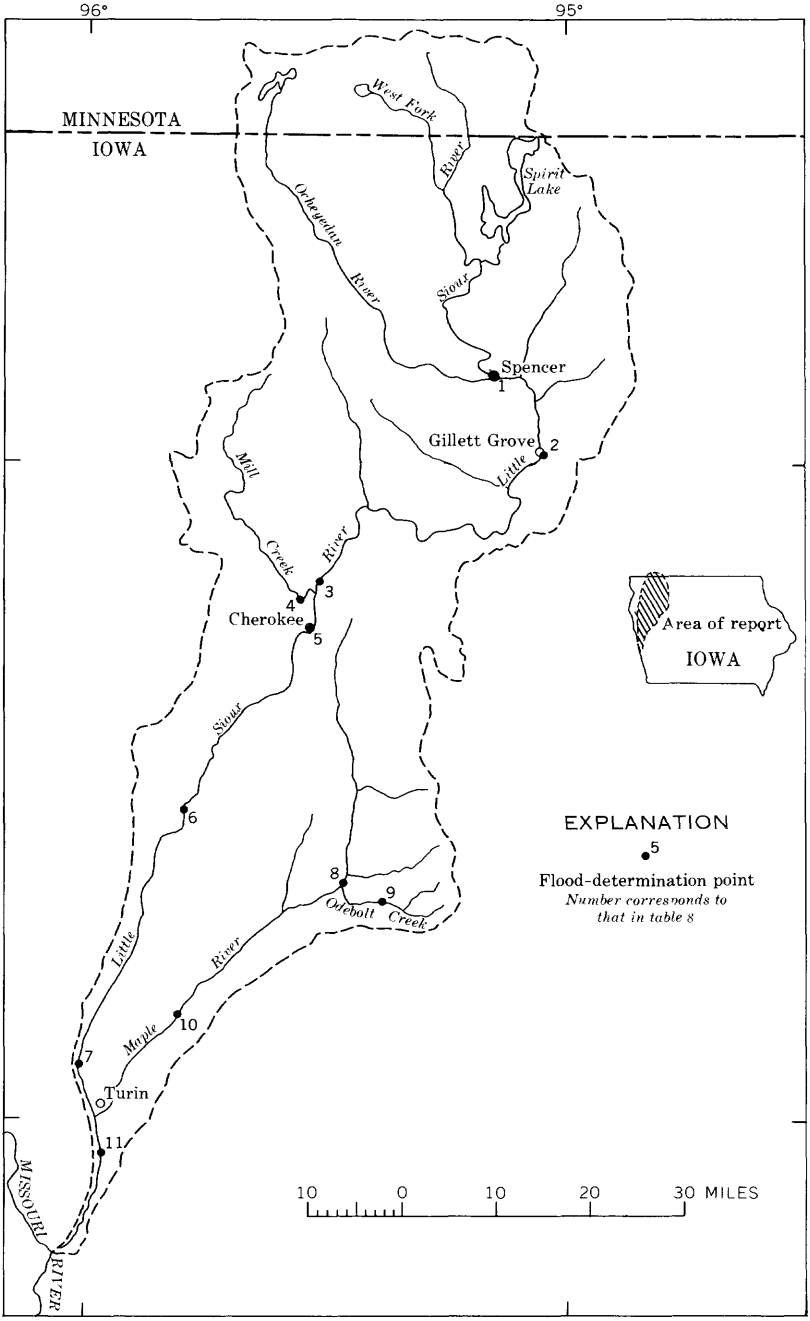

FIGURE 11.—Location of flood-determination points, floods of April in the Little Sioux River basin, Iowa.

The discharge in the Little Sioux River was high in the entire length of the river (table 8). However, the intensity of the discharge decreased considerably at the extreme lower part (see sta. 11) because the discharge contributed by more than 700 sq mi of the Maple River basin was of very low magnitude.

Considerable flood damage occurred in urban areas along the Little Sioux River. The Corps of Engineers estimated the damage at Cherokee to have been $666,000.

TABLE 8.—*Flood stages and discharges, April, in the Little Sioux River basin, Iowa*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before April 1965: Period	Known before April 1965: Year	April 1965	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence interval (years)
1	Little Sioux River at Spencer.	990	1937-42, 1953.	1953		20.20	30,000	
					6	17.37	16,700	[1]1.37
2	Little Sioux River at Gillett Grove.	1,334	1953, 1959-65.	1953		17.87	24,000	
					7	18.67	20,200	[1]1.30
3	Little Sioux River near Cherokee.	1,861	1953	1953		17.48	21,400	
					6	18.83	26,800	[1]1.52
4	Mill Creek near Cherokee	292			6	13.37	10,400	[1]1.48
5	Little Sioux River at Cherokee.	2,182	1891-1965	1891		25.7	(2)	
					6	27.1	33,700	[1]1.72
6	Little Sioux River at Correctionville.	2,500	1891	1891		29.34	(2)	
			1919-25, 1929-32, 1937-65.	1954		23.36	20,900	
					7	25.86	29,800	[1]1.47
7	Little Sioux River near Kennebec.	2,738	1940-65	1954		[3]26.63		
				1962			19,000	
					8	26.50	29,700	[1]1.45
8	Maple River near Ida Grove	364	1954	1954		16.70	(2)	
					1	14.70	8,000	4
9	Odebolt Creek near Arthur	39.3	1951, 1958-65.	1962		13.78	5,200	
					3	11.14	1,360	<2
10	Maple River at Mapleton	669	1942-65	1950		22.1		
				1954			15,600	
					1	12.14	9,240	2
11	Little Sioux River near Turin.	3,526	1959-65	1962		23.97	24,400	
					8	26.05	27,100	

[1] Ratio of peak discharge to 50-year flood.
[2] Unknown.
[3] Before levee broke in vicinity of gage.

FLOODS OF APRIL–MAY IN NORTHWESTERN MINNESOTA

By D. W. ERICSON

Rains during the snowmelt period augmented overland runoff and caused severe flooding in the Red River of the North basin in Minnesota during April and May (fig. 12). Other antecedent conditions contributed to the high runoff. Frost penetration was deeper than usual because of abnormally low temperatures and relatively light snow cover during most of the winter. Only in March was precipitation

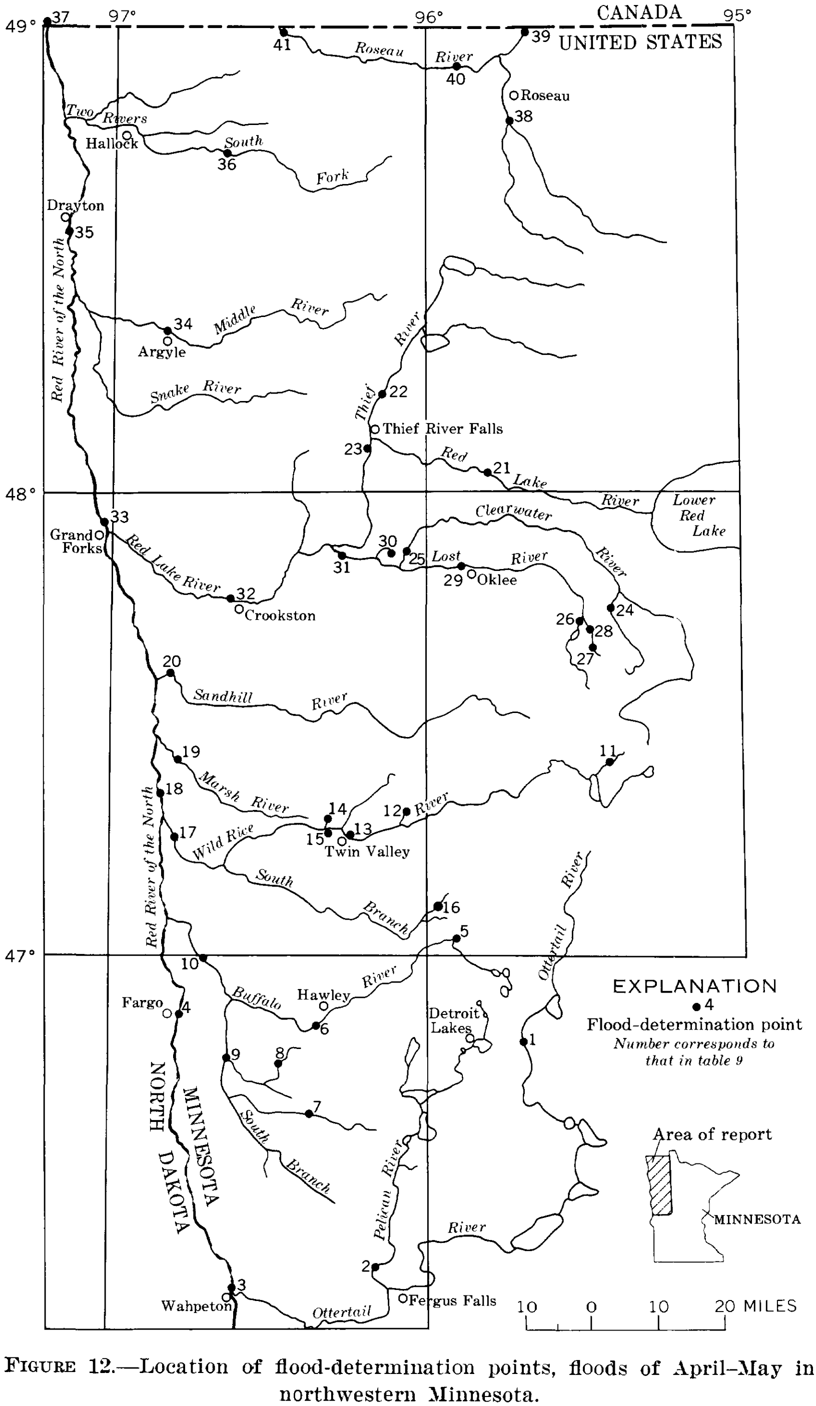

FIGURE 12.—Location of flood-determination points, floods of April–May in northwestern Minnesota.

above normal, and then it was confined primarily to the eastern part of the area. The water equivalent of the snowpack on March 30 ranged from 0.5 inch near the western boundary of Minnesota to more than 3 inches in the eastern part of the basin.

Temperatures remained below freezing during the last 2 weeks in March, and minimum subzero temperatures occurred over most of the area on March 16–26. Most of the snowpack melted from March 31 to April 5 as daytime temperatures approached 40°F and nighttime minimum temperatures were near freezing. A storm on April 5–6 brought 1–2 inches of rain mixed with snow over most of the area. Runoff increased rapidly, particularly in the southern part, and some of the smaller tributaries crested by April 6. On April 10–11, a second storm deposited 1–2 inches of rain over the central part. By this time the rains and warm temperatures had melted all the snow cover except for that in the extreme northwestern corner of Minnesota where 1–4 inches still remained on the ground. The additional runoff from the rains of April 10–11 caused peaks to occur on most tributaries by April 14.

Peak stages and discharges for 41 sites are listed in table 9. Recurrence intervals have been computed for peaks at most gaging stations using data from Patterson (1968). Recurrence intervals can not be assigned to peaks at crest-stage gage sites because flood-frequency relations have not been determined for such small drainage basins.

TABLE 9.—*Flood stages and discharges in Red River of the North basin, April–May, in northwestern Minnesota*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before April 1965: Period	Year	April–May 1965	Gage height (feet)	Discharge: Cfs	Recurrence interval (years)
1	Ottertail River near Detroit Lakes, Minn.	270	1937–65	1943			371	
				1950		[1] 6.96		
					Apr. 6	[1] 4.83	233	2
2	Pelican River near Fergus Falls, Minn.	482	1909–12	1943			756	
			1942–65	1950		[1] 8.60		
					Apr. 6	[1] 6.73		
					Apr. 9		551	5
3	Red River of the North at Wahpeton, N. Dak.	4,010	1897–1965	1897		17 0	(2)	
			1942–65	1952		14.99	7,130	
					Apr. 11	14.34	5,690	8
4	Red River of the North at Fargo, N. Dak.	6,800	1897–1965	1897		[3] 40.1	(2)	
			1901–65	1952		[4] 28.79	16,300	
					Apr. 15	30.5	11,400	18
5	Buffalo River near Callaway, Minn.	49.9	1960–65	1962		13.35	370	
					Apr. 10	[1] 16.12	245	(2)
6	Buffalo River near Hawley, Minn.	322	1921–65	1921		11.3	(2)	
			1945–65	1955		9.31	1,590	
					Apr. 9	[1] 9.36		
					Apr. 11		1,250	11
7	Whisky Creek at Barnesville, Minn.	62.5	1961–65	1962			292	
		[5] 25 3		1962		[1] 8.29		
					Apr. 6	[1] 7.67		
					Apr. 9		175	(2)

See footnotes at end of table.

TABLE 9.—*Flood stages and discharges in Red River of the North basin, April–May, in northwestern Minnesota*—Continued

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods					
			Known before April 1965		April–May 1965	Gage height (feet)	Discharge	
			Period	Year			Cfs	Recurrence interval (years)
8	Hay Creek above Downer, Minn.	5.81	1961–65	1962		13.46	382	
					Apr. 10	7.47	103	(2)
9	South Branch Buffalo River at Sabin, Minn.	522	1945–65	1962		17.04	6,340	
					Apr. 8	[1]16.29		
					Apr. 11		4,130	[6]1.30
10	Buffalo River near Dilworth, Minn.	1,040	1931–65	1962		23.56	6,140	
					Apr. 11	23.37	5,960	[6]1.20
11	Wild Rice River tributary near Bagley, Minn.	3.34	1961–65	1963		8.34	37	
					Apr. 11	[1]10.30	67	(2)
12	Marsh River tributary near Mahnomen, Minn.	6.57	1961–65	1964		[1]12.52	140	
					Apr. 10	[1]12.90	241	(2)
13	Wild Rice River at Twin Valley, Minn.	888	1909–17, 1930–65.	1909		[7]20.0	9,200	
					Apr. 12	10.48	3,160	14
14	Wild Rice River tributary near Twin Valley, Minn.	2.25	1961–65	1962		12.39	107	
					Apr. 6	[1]14.16	86	(2)
15	Coon Creek near Twin Valley, Minn.	32.1	1962–65	1962		12.68	896	
					Apr. 10	[1]13.21	745	(2)
16	South Branch Wild Rice River near Ogema, Minn.	6.50	1963–65	1964		8.87	83	
					Apr. 10	[1]9.87	83	(2)
17	Wild Rice River at Hendrum, Minn.	1,600	1944–65	1947		[8]27.70		
				1956			4,660	
					Apr. 14		6,800	[6]1.02
					Apr. 15	[8]29.52		
18	Red River of the North at Halstad, Minn.	21,800	1897	1897		38.5	(2)	
		[5]18,000	1936–37, 1942–65.	1947		34.00	24,500	
					Apr. 17	35.22	25,600	41
19	Marsh River near Shelly, Minn.	151	1944–65	1950		18.96	4,660	
					Apr. 13	[8]16.87	3,120	(2)
20	Sandhill River at Climax, Minn.	405	1943–65	1950		16.31	3,040	
					Apr. 14	17.81	4,560	[6]1.72
21	Red Lake River at Highlanding near Goodrich, Minn.	[9]2,300	1930–65	1950		13.42	3,720	
					Apr. 13	11.42	2,740	7
22	Thief River near Thief River Falls, Minn.	959	1909–17, 1919–26, 1928–65.	1950		17.38	5,610	
					Apr. 12	[1]15.70	4,110	10
23	Red Lake River tributary near Thief River Falls, Minn.		1962–65	1963		7.29	81	
					Apr. 11	(2)	>150	(2)
24	Ruffy Brook near Gonvick, Minn.	45.2	1960–65	1962		6.70	364	
					Apr. 13	6.38	412	(2)
25	Clearwater River at Plummer, Minn.	512	1939–65	1962		11.90	3,640	
					Apr. 11	[1]11.97		
					Apr. 12		3,620	[6]1.13
26	Lost River at Gonvick, Minn.	30.9	1960–65	1962		9.06	255	
					Apr. 19	8.34	178	(2)
27	Lost River tributary near Clearbrook, Minn.	1.79	1960–65	1962		14.35	132	
					Apr. 11	12.19	98	(2)
28	Lost River tributary at Clearbrook, Minn.	3.05	1960–65	1962		15.83	147	
					Apr. 11	[1]12.99	89	(2)
29	Lost River at Oklee, Minn.	266	1897–1965	1950		18.39	2,790	
					Apr. 11	[1]11.53		
					Apr. 12		1,780	10
30	Clearwater River tributary near Plummer, Minn.	1.17	1961–65	1962		8.48	106	
					Apr. 11	[1]11.23	177	(2)
31	Clearwater River at Red Lake Falls, Minn.	1,370	1909–17	1913		[1,10]17.5		
			1935–65	1950			9,310	
					Apr. 13	10.86	8,680	30
32	Red Lake River at Crookston, Minn.	[9]5,280	1901–65	1950		25.70	27,400	
					Apr. 12	[1]25.82		
					Apr. 14		19,400	[6]1.21
33	Red River of the North at Grand Forks, N. Dak.	30,100	1882–1965	1897		[11]50.2	80,000	
		[5]26,300			Apr. 17	44.92	52,000	[6]1.02
34	Middle River at Argyle, Minn.	265	1945, 1950–65.	1950		15.25	2,790	
					Apr. 12	15.29	2,590	35

See footnotes at end of table.

TABLE 9.—*Flood stages and discharges in Red River of the North basin, April–May, in northwestern Minnesota*—Continued

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before April 1965: Period	Year	April–May 1965	Gage height (feet)	Discharge: Cfs	Recurrence interval (years)
35	Red River of the North at Drayton, N. Dak.	34,800	1860–1965	1950		[12] 41.58	86,500	
		[5] 31,000			Apr. 22	40.43	47,200	20
36	South Branch Two Rivers at Lake Bronson, Minn.	444	1929–37, 1941–47, 1953–65.	1962		12.82	2,960	
					Apr. 15	12.30	2,780	47
37	Red River of the North at Emerson, Manitoba, Canada.	40,200	1912–65	1950		90.89	95,500	
		[5] 36,400			Apr. 26	85.19	46,200	21
38	Roseau River below South Fork near Malung, Minn.	573	1947–65	1950		22.51	3,650	
					Apr. 13	21.90	4,660	[6] 1.37
39	Sprague Creek near Sprague, Manitoba, Canada.	[13] 169	1929–65	1942		15.31	2,070	
					May 7	13.02	1,250	25
40	Roseau River at Ross, Minn.	1,220	1896-1965,	1896		19	(2)	
			1928–65.	1950		18.25	6,560	
					Apr. 20	16.50	3,780	13
41	Roseau River below State ditch 51, near Caribou, Minn.	1,570	1916	1916		[14] 15.50	(2)	
			1917, 1920–65.	1950		11.81	4,080	
					May 6	9.64	2,690	3

1 Affected by backwater from ice.
2 Unknown.
3 At site 1½ miles downstream at datum 1 ft lower.
4 At site 1 mile downstream at datum 5.6 ft higher.
5 Contributing draingage area.
6 Ratio of peak discharge to 50-year flood.
7 At site ¼ mile downstream at different datum.
8 Affected by backwater from Red River of the North.
9 1,950 sq mi above Lower Red Lake outlet contributes little to flood peaks.
10 At site 40 ft upstream at different datum.
11 At site about 1½ miles upstream at datum ½ ft higher than present datum.
12 At site 1½ miles upstream at datum 1.59 ft higher.
13 Prior to October 1958, 151 sq mi; change due to construction of drainage ditch within basin.
14 At site at Caribou 0.6 mile upstream at datum 0.95 ft lower.

Six gaging stations, scattered throughout the area, recorded maximum peak discharges of record. Peak discharges at five other gaging stations were within 10 percent of their maximums of record, and four of 13 crest-stage gage sites had maximum peak discharges in short periods of record of only 4–6 years.

Considerable damage occurred to public and private facilities at urban centers in the basin. In Minnesota, the most extensive urban damage was on the main stem of the Red River of the North at Moorhead, East Grand Forks, and Oslo. The entire town of Oslo, population 400, was flooded. Crookston, on the Red Lake River, and Roseau, on the Roseau River, each sustained about $250,000 damage. The Corps of Engineers reported that the total urban damage in Minnesota was $2,384,100.

The inundation of approximately 377,750 acres of agricultural land in Minnesota caused a large loss in potential crops. Crop yields were reduced where planting was prevented or delayed, and in many fields substitute emergency crops had to be planted. Heavy losses were also sustained when stored grain, livestock, and other farm property were damaged. Total agricultural damage was $4,951,800.

Damage to bridges, culverts, and roads was confined primarily to Kittson, Marshall, and Polk Counties, wherein occurred 96 percent of the $1,284,900 transportation damage reported by the Corps of Engineers.

FLOODS OF MAY 14–15 IN THE NORTHERN BLACK HILLS, S. DAK.

By R. E. West

Flooding occurred on small streams in the northern Black Hills of South Dakota when heavy rainfall on May 14–15 fell within a week after a late-season heavy snowfall of May 8–9.

Snowfall was general over the Black Hills and a narrow strip of adjacent plains during the afternoon of May 8 and the morning of May 9. The storm was centered over the northern Black Hills where the Weather Bureau station at Lead recorded 34 inches of snow having a water equivalent of 4.16 inches. Although daytime temperatures following the snowstorm were mild, nighttime temperatures were mostly near freezing, and runoff from the snowmelt was moderate. The small increases in streamflow during the periods of snowmelt indicate that most of the melt water was absorbed by the soil. Scattered patches of snow remaining in shaded areas and ravines on the morning of May 14 were saturated.

On the morning of May 14, a second storm moved into the northern Black Hills which also centered over Lead where 6.93 inches of rainfall was recorded in the following 24 hours. This intense rainfall was 1½ times that of the 100-year 24-hour storm. Flooding began along the upper reaches of the Belle Fourche River tributaries (fig. 13) during the evening of May 14 and continued in the lower reaches until the morning of May 15.

Peak discharges were determined at three gaging stations, one crest-stage station, and four miscellaneous sites (table 10). The peak discharge (4,240 cfs) on Spearfish Creek at Spearfish (sta. 2) was 40 percent higher than the previous maximum in 19 years of record. Spearfish Creek had a peak flow of only 673 cfs near Cheyenne Crossing (sta. 1), 16 miles upstream from Spearfish. Field inspection of the area indicated that most of the flow at Spearfish originated in small, east bank tributaries downstream from Cheyenne Crossing.

Flows from Spearfish, False Bottom and Polo Creeks combined with the flow of Redwater Creek at the Wyoming–South Dakota State line, which had a peak discharge of 1,230 cfs, caused the second high-

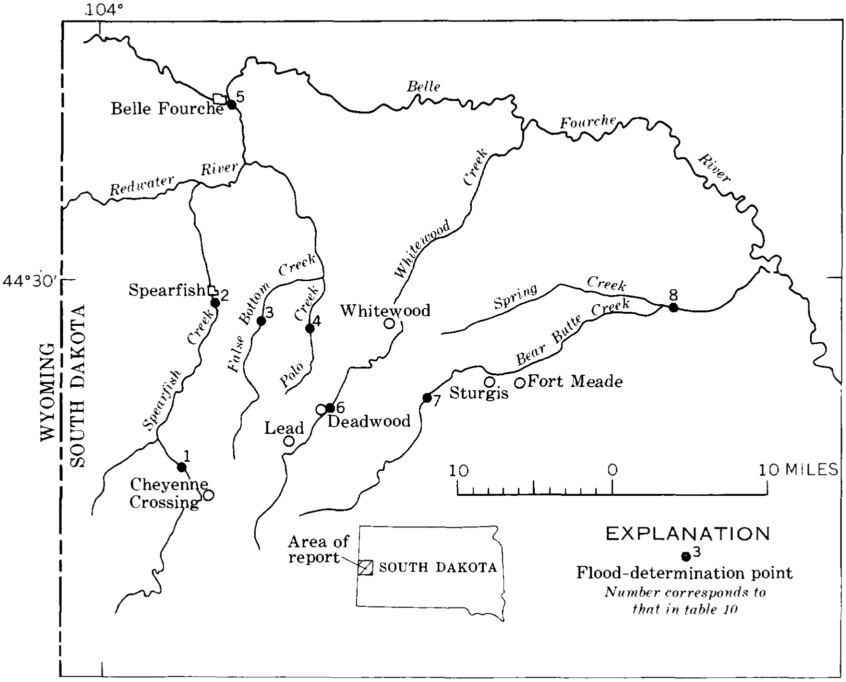

FIGURE 13.—Location of flood-determination points, floods of May 14–15 in the northern Black Hills, S.D.

est peak flow (8,480 cfs) in 20 years of record at Redwater River above Belle Fourche (sta. 5).

The middle and lower reaches of Whitewood and Bear Butte Creeks had severe floods on June 15–16, 1962 (Rostvedt and others, 1968), when it was reported that as much as 12 inches of rain had fallen in 6 hours in a small area centered 7 miles northeast of Lead. Indirect measurements were made of peak flow for the 1962 flood on white-wood Creek at the Chicago and North Western Railway bridge, 1 mile east of Whitewood, and on Bear Butte Creek at the State Highway 79 crossing, 2½ miles northeast of Fort Meade. Levels to high-water marks left by the floods of May 14–15, 1965, indicated that peak stages at these two sites were 0.6 foot and 1.2 feet lower, respectively, than those of the 1962 flood. The crest of May 15, 1965, on Bear Butte Creek flattened rapidly as it moved downstream and caused a peak discharge near Sturgis (sta. 8) that was only 21 percent of the maximum of record, which occurred during the June 1962 flood.

TABLE 10.—*Flood stages and discharges in the Belle Fourche River basin, May 14–15, in the northern Black Hills, S. Dak.*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods					
			Known before May 1965		May 1965	Gage height (feet)	Discharge	
			Period	Year			Cfs	Recurrence interval (years)
1	Spearfish Creek near Cheyenne Crossing	73.6			14		673	15
2	Spearfish Creek at Spearfish	168	1947–65	1964		7.97	3,040	
					15	10.53	4,240	[1] 2.1
3	False Bottom Creek near Spearfish	14.3			14		2,310	[1] 6.7
4	Polo Creek near Whitewood	10.6	1956–65	1964		3.77	794	
					14	4.10	1,060	[1] 3.8
5	Redwater River above Belle Fourche	920	1946–65	1962		11.69	16,400	
					15	10.53	8,480	[1] 1.3
6	Whitewood Creek at Deadwood	41.4			14		8,030	[1] 2.5
7	Bear Butte Creek near Galena	47.6			14		4,950	[1] 1.4
8	Bear Butte Creek near Sturgis	192	1946–65	1962		12.63	12,700	
					15	9.85	2,660	6

[1] Ratio of peak discharge to 50-year flood.

Streams in the Black Hills have steep slopes and flow at high velocities through deep, narrow canyons. Many roads and highways that occupy part of the canyon floors adjacent to streams were severely eroded during the flood; their destruction accounts for most of the rural damage. The most extensively damaged highway was U.S. Highway 14A in Spearfish and Boulder Canyons. The South Dakota Department of Highways estimated that in Spearfish Canyon alone there were at least 30 complete road-grade washouts, some of which were about a quarter of a mile in length. Boulder Canyon Road sustained heavy damage from Bear Butte Creek and was closed to traffic for a week. Throughout the flood area, more than 30 bridges were destroyed or damaged.

The towns of Spearfish, Deadwood, and Sturgis received most of the urban damage. In these three towns, 10 houses were destroyed, and an additional 90 houses and 20 commercial properties were flooded to some degree. Many utility lines were broken after being exposed by channel erosion. The high-velocity streams carried a very large debris load of rocks and boulders in addition to tree limbs that had been broken off by the heavy snow. Debris that lodged at the Nash Street bridge in Spearfish caused most of the flow in Spearfish Creek to be diverted into Third Street, which parallels the creek. Large sections of concrete curb and gutter were torn out, and the roadway was extensively eroded. A local engineer estimated that erosion had doubled the width of the Bear Butte Creek channel in Sturgis. Total damage from the flood was estimated by the Corps of Engineers to be $4.5 million.

FLOODS OF MAY 22 IN SOUTHEASTERN NEBRASKA

By H. D. Brice

Several severe storms hit southeastern and south-central Nebraska during the night of May 21–22 and caused much flood damage at or near the communities of Louisville, Cedar Creek, Deweese, Sutton, and other places (fig. 14). Some of the rainfall amounts reported by the Weather Bureau and the Lincoln Telephone Co. are shown in table 11. The largest amount, 6.80 inches, was observed at Louisville. An amount of 5.95 inches was recorded at the Weather Bureau gage 6 miles northwest of Weeping Water and near the head of Mill Creek; the first inch fell between 0400 and 0500 hours on May 21 and created conditions that contributed to the rapid runoff during and following the 4.75-inch downpour that began about 2400 hours on the same day (fig. 15). Because the two points of observation are several miles apart, it may be assumed that 5 or more inches of rain fell on an area of several square miles during the storm. The recurrence interval for a storm of this magnitude in this area is estimated to be about 100 years. Runoff from the storm caused Mill Creek to overflow and necessitated the evacuation of 18 families from their homes in Louisville. Inflow to

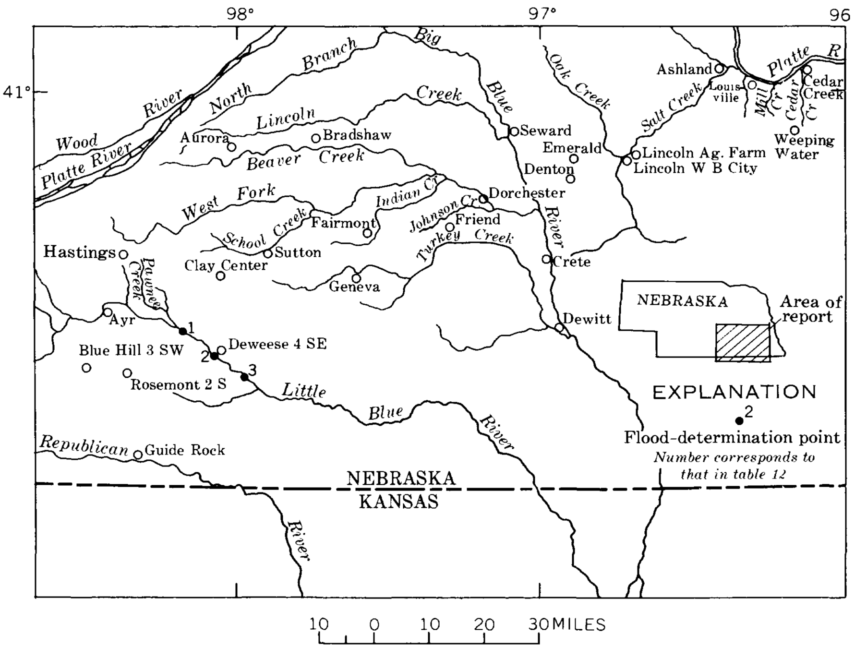

FIGURE 14.—Location of flood-determination points, floods of May 22 in southeastern Nebraska.

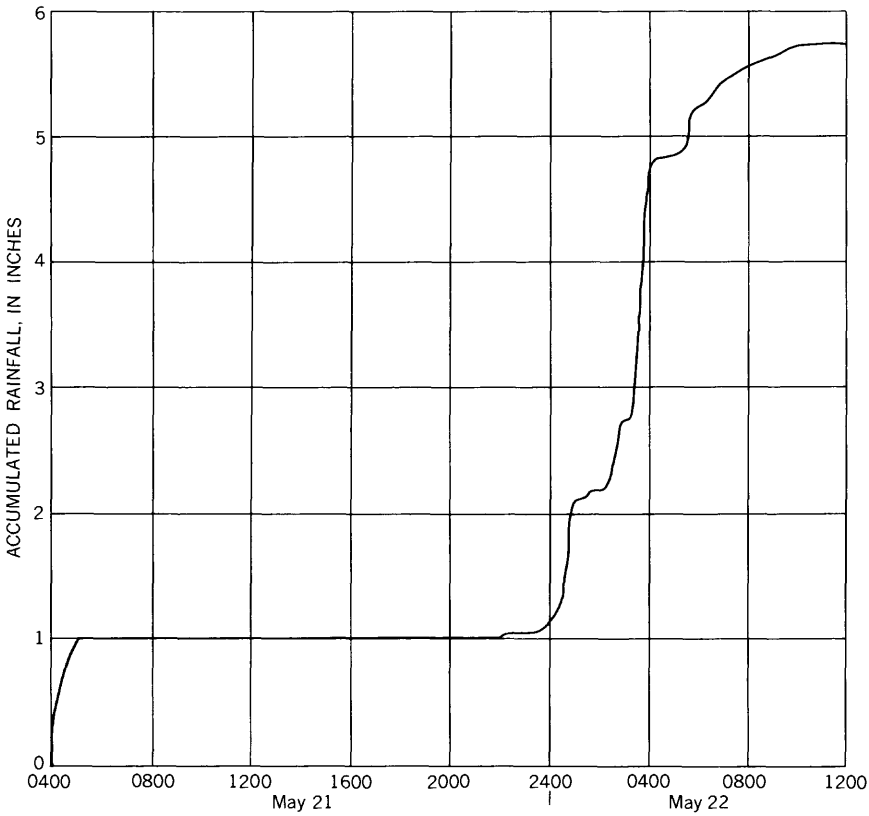

FIGURE 15.—Accumulated rainfall, 6 miles northwest of Weeping Water, Nebr., May 21–22.

Cedar Creek Lake caused the lake level to rise and forced six families to vacate their resort homes. At Louisville, State Highway 50 was flooded and badly damaged. A railroad washout near the village of Cedar Creek derailed 12 freight cars. The Omaha District of the Corps of Engineers estimated damage along Mill Creek in Louisville as follows:

Residential	$18, 500
Business	3, 500
Transportation	3, 400
Municipal	1, 200
Total	26, 600

Peak-discharge determinations were not made for either Mill Creek or Cedar Creek.

TABLE 11.—*Daily precipitation associated with floods of May 22 in southeastern Nebraska*

[Reported by U.S. Weather Bureau and Lincoln Telephone Co. Tr., trace]

Location	Time of observation (hours)	Precipitation, in inches		
		May		
		21	22	23
3 miles northeast of Ashland	0700	1.04	3.58	1.40
Aurora	0700	--------	.22	.57
3 miles southwest of Blue Hill	0700	--------	5.90	.49
Bradshaw	0700	--------	.35	.81
Clay Center	1700	Tr.	3.34	.12
Crete	1800	.01	2.72	.15
Denton			2.60	--------
Dewitt			2.85	--------
4 miles southeast of Deweese	0800	--------	2.85	.48
Emerald	0800	--------	2.95	1.12
Fairmont	0700	--------	4.10	.77
Friend	0700	--------	3.89	1.43
Geneva	1900	--------	4.55	.87
Hastings	1700	--------	2.90	3.89
Lincoln Agronomy Farm	0800	.17	2.62	.45
Lincoln Weather Bureau (city)	2400	.49	2.43	Tr.
Louisville			6.80	--------
2 miles south of Rosemont	0800	--------	6.24	1.18
Seward	0800	--------	.84	1.00
Sutton			3.50	--------
North of Sutton			5.50	--------
Weeping Water	1800	1.15	4.19	--------
6 miles northwest of Weeping Water	2400	1.17	4.78	--------

Concurrently with the storm in the Louisville area, severe storms occurred near Blue Hill, Rosemont, Sutton, Geneva, Fairmont, and other places in the Blue River basin (fig. 14). School Creek inundated a strip about a block wide through the central part of Suttor; basements in Geneva were flooded for the first time in the memory of local residents; and the village of Deweese was almost isolated at the crest of the flood. U.S. Highway 6 at the stream crossing 3 miles west of Sutton, State Highway 74 west of Ayr, and other roads in the area were overtopped temporarily by runoff from the storm. Numerous bridges were washed out. Hundreds of acres of farmland were inundated, and much of the area that was planted to corn had to be reseeded. The peak discharges and peak stages at three gaging stations on the Little Blue River were the greatest since those stations were established (table 12). The peak at the gaging station near Deweese (established in 1951) has a recurrence interval of 50 years.

TABLE 12.—*Flood stages and discharges in the Big Blue River basin, May 22, in southeastern Nebraska*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before May 1965 — Period	Year	May 1965	Gage height (feet)	Discharge: Cfs	Recurrence interval (years)
1	Little Blue River below Pawnee Creek near Pauline.	881	1962–65	1963		10.38	2,630	
					22	13.88	17,800	[1] 1.15
2	Little Blue River near Deweese.	979	1951–65	1951		14.9	16,000	
					22	15.99	17,070	50
3	Little Blue River near Angus.	1,038	1958–65	1960		15.97	11,800	
					22	17.20	17,100	48

[1] Ratio of peak discharge to 50-year flood.

FLOODS OF MAY 30–31 IN THE VICINITY OF CARLSBAD, N. MEX.

After RALPH W. CLEMENT (1967)

The floods of May 30–31 in the vicinity of Carlsbad, N. Mex., were caused by a storm system of several high-intensity thunderstorms. The storm area extended from the Texas-New Mexico border northward to the South Seven Rivers (fig. 16). Rain began at about 1400 hours on May 30 and lasted into the early evening. The most intense rainfall occurred between 1500 and 1700 hours during which time 2.14 inches was recorded at Carlsbad. The Howell Ranch in the South Seven Rivers basin reported 2.8 inches in a 1-hour period. About 3.4 inches fell in 1 hour at Carlsbad Caverns. Amounts greater than 4 inches were recorded at several points north of Carlsbad Caverns, west of Carlsbad, and along the South Seven Rivers. The rainfall pattern of figure 16 was derived from precipitation data obtained from the Weather Bureau and from a bucket survey conducted by the Soil Conservation Service.

Flooding in the Carlsbad area was confined to the tributaries west of the Pecos River. The northern boundary of the flood area was the north divide of the South Seven Rivers basin.

The peak discharge (table 13) on South Seven Rivers near Lakewood (sta. 2) was 25,500 cfs while in the adjoining basin of the North Seven Rivers there was no flow. The main stem of the Pecos River easily handled the flow, and the maximum recurrence interval of the flow at any point on the Pecos River was 8 years. Flooding on the South Seven Rivers was severe, and the peak discharge near Lakewood (sta. 2) was only slightly less than the previous maximum in 25 years of record, 30,000 cfs in 1954. Agricultural damage along the South Seven Rivers was estimated at $18,000.

Rocky Arroyo probably had the least flooding of any main tributary in the flood area north of the Delaware River. The peak discharge (9,700 cfs) of Rocky Arroyo near Carlsbad (sta. 3) was the fourth

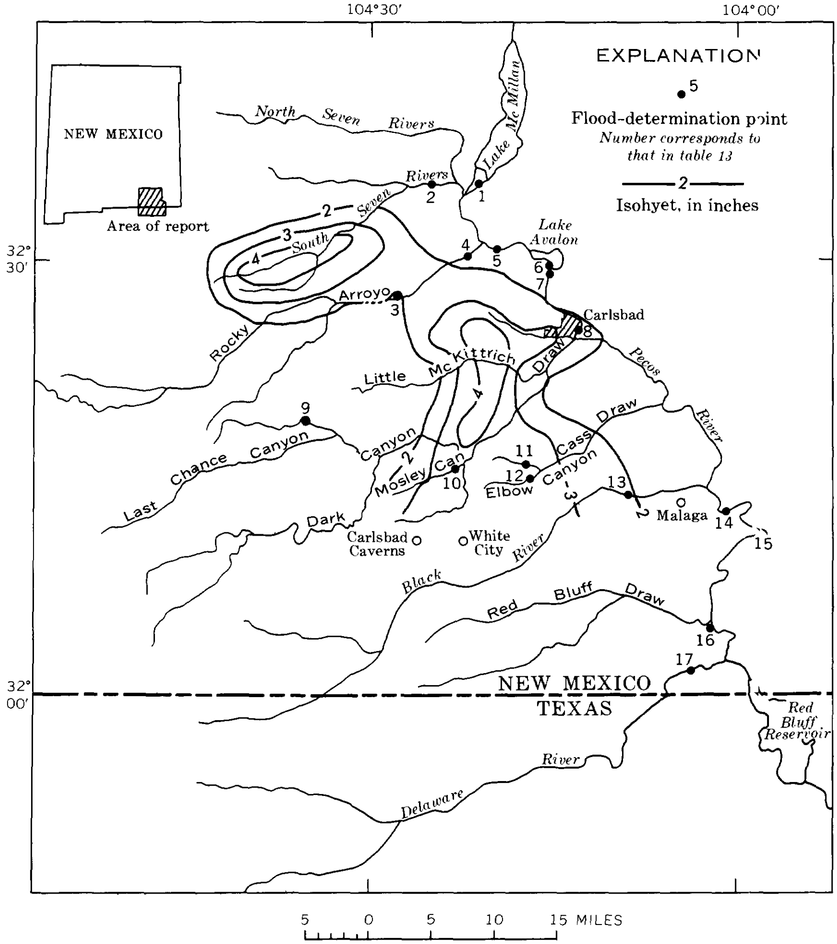

FIGURE 16.—Location of flood-determination points and isohyets for May 30, flood of May 30–31 in the vicinity of Carlsbad, N. Mex.

highest during a period of record beginning in 1916 and was the greatest since 1958, but it was considerably less than the maximum of record of 63,300 cfs in 1954.

The worst flooding occurred in the tributaries south of Carlsbad, and that along Cass Draw was the most severe in the area. The peak discharge of Cass Draw (sta. 11) and of Elbow Canyon (sta. 12) exceeded that for 50-year floods. The combined flow from both of the streams destroyed a part of the main canal of the Carlsbad Irrigation District and caused damage estimated at $31,000. The floodwaters from Cass Draw spread out over the flat area between the canal and the Pecos River and entered the river through several drainage ditches and small washes.

TABLE 13.—*Flood stages and discharges in the Rio Grande basin, May 30–31, in the Carlsbad, N. Mex., area*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before May 1965 — Period	Known before May 1965 — Year	May 1965	Gage height (feet)	Discharge — Cfs	Discharge — Recurrence interval (years)
1	Pecos River below McMillan Dam.	16,990	1904	1904		(1)	(2)	
			1940, 1947–65.	1954		(1)	[3] 16,100	
					30		0	
2	South Seven Rivers near Lakewood.	220	1941–65	1954		22.8	30,000	
					30	21.8	25,500	20
3	Rocky Arroyo near Carlsbad.	254	1916–65	1954		[4] 56.8	63,300	
					30	45.07	9,700	5
4	Rocky Arroyo at highway bridge near Carlsbad.	285	1941–65	1954		22.0	(1)	
			1964–65	1964		13.40	9,760	
					30	11.70	7,450	4
5	Pecos River at damsite 3 near Carlsbad.	17,980	1940, 1945–65.	1954		18.53	53,000	
					30	14.33	2[illegible],700	7
6	Lake Avalon near Carlsbad.	18,070	1939–65	1941		[5] 25.0	[6] 11,000	
					31	[5] 20.40	[6] 4,970	
7	Pecos River below Avalon Dam.	18,080	1952–65	1954		23.3	[3] 41,000	
					31	16.05	[3] 10,600	4
8	Pecos River at Carlsbad	18,100	1904–06, 1915, 1921–65.	1904		[4] 23.44	(7)	
					31	11.17	[3] 9,900	4
9	Last Chance Canyon tributary near Carlsbad Canyon.	.2	1959–65	1960		5.72	439	
					30	1.37	<30	
10	Mosley Canyon near White City.	14.6	1959–65	1960		6.67	2,850	
					30	13.7	16,400	[8] 1.5
11	Cass Draw near Carlsbad	9.3			30		32,500	[8] 3.8
12	Elbow Canyon near Carlsbad.	2.4			30		6,410	[8] 1.4
13	Black River above Malaga	343	1908–65	1941		19.0	33,000	
					30	13.95	18,400	9
14	Pecos River near Malaga	19,190	1921–65	1941		35.1	68,700	
					31	18.55	12,900	5
15	Pecos River at Pierce Canyon Crossing near Malaga.	19,260	1939–41, 1952–65.	1941		[4] 24.8	(1)	
					31	15.06	[3] 9,860	4
16	Pecos River at Red Bluff	19,540	1938–65	1941		28.3	52,600	
					30	19.06	16,800	8
17	Delaware River near Red Bluff.	689	1911–65	1955		27.0	81,400	
					30	7.26	2,710	2

1 Unknown.
2 May have reached 60,000 cfs.
3 Flow controlled wholly or in part by one or more reservoirs.
4 At different site or datum.
5 Elevation, in feet.
6 Contents, in acre-feet.
7 Probably exceeded 90,000 cfs.
8 Ratio of peak discharge to 50-year flood.

The peak discharge at Mosley Canyon (sta. 10) was 1.5 times that for a 50-year flood. The floodwater of Mosley Canyon combined with runoff from Last Chance Canyon and Little McKittrick and Hackberry Draws caused moderate flooding, but little damage, to the southern part of Carlsbad.

The peak discharge on Black River near Malaga (sta. 13) was the third highest since 1908, but only minor damage was reported. Flooding along the Delaware River, on the south edge of the flood area, was insignificant. Although extremely high discharges occurred on some tributary streams, flooding in the Pecos River was moderate.

The contents of Lake Avalon, which had been reduced to 1,280 acre-feet on May 30, began to increase during the evening. More than one-half of the runoff that originated above Lake Avalon (fig. 17, sta. 5) was retained in the lake or lost to bank storage. Water began flowing over the spillway at midnight on May 30 (fig. 17, sta. 7 and 8). Flood peaks of tributaries below Carlsbad had entered the main stem before the flow from Lake Avalon was added to the floodwater.

Two peaks of about equal magnitude occurred on Pecos River near Malaga (fig. 17, sta. 14). The first peak (12,000 cfs) from runoff from the Black River reached the station at midnight on May 30. The second peak (12,900 cfs) from runoff from Cass Draw, Dark Canyon, and intervening drainage areas reached the station at 0630 hours on May 31. Release from Lake Avalon extended the recession time of the second crest.

When the flow reached Pierce Canyon Crossing (fig. 17, sta. 15), the two peaks had merged into one with a peak discharge of 9,860 cfs. The peak was reduced further, to 8,820 cfs at Red Bluff (fig. 17, sta. 16), at 2110 hours on May 31.

The Pecos River at Red Bluff (sta. 16) had a peak discharge (16,800 cfs) on May 30 that was almost twice as great as that on May 31. The peak on May 30 was mostly from direct runoff from an area of 280 sq mi, of which about two-thirds was in the basin of Red Bluff Draw. Red Bluff Draw contributed a large volume of flow to the Pecos River. During the period May 30–June 3, 17,000 acre-feet of water passed the Pierce Canyon Crossing gage (sta. 15), and 25,000 acre-feet passed the Red Bluff gage (sta. 16), which is about 14 miles farther downstream.

Inflow from the Delaware River, a tributary below Red Bluff was small, and the peak discharge reached the Pecos River about 2 hours earlier than the peaks that originated above Red Bluff.

Although the magnitude of the flood on the Pecos River was not that of a rare flood, it was unusual because most of the flow originated from relatively small areas. Most of the flow above Lake Avalon came from the South Seven Rivers basin. The intensity of tributary flows below Carlsbad is illustrated by the high peak discharges from three small basins—Mosley Canyon (sta. 10), Cass Draw (sta. 11), and Elbow Canyon (sta. 12). The peak discharge of each of the three sites exceeded that for a 50-year flood.

Information on flood damage, which was mostly to agricultural lands and crops, was obtained from the Soil Conservation Service and from the Carlsbad Current-Argus newspaper. Damage along tributary streams west of the Pecos River from the South Seven Rivers to the

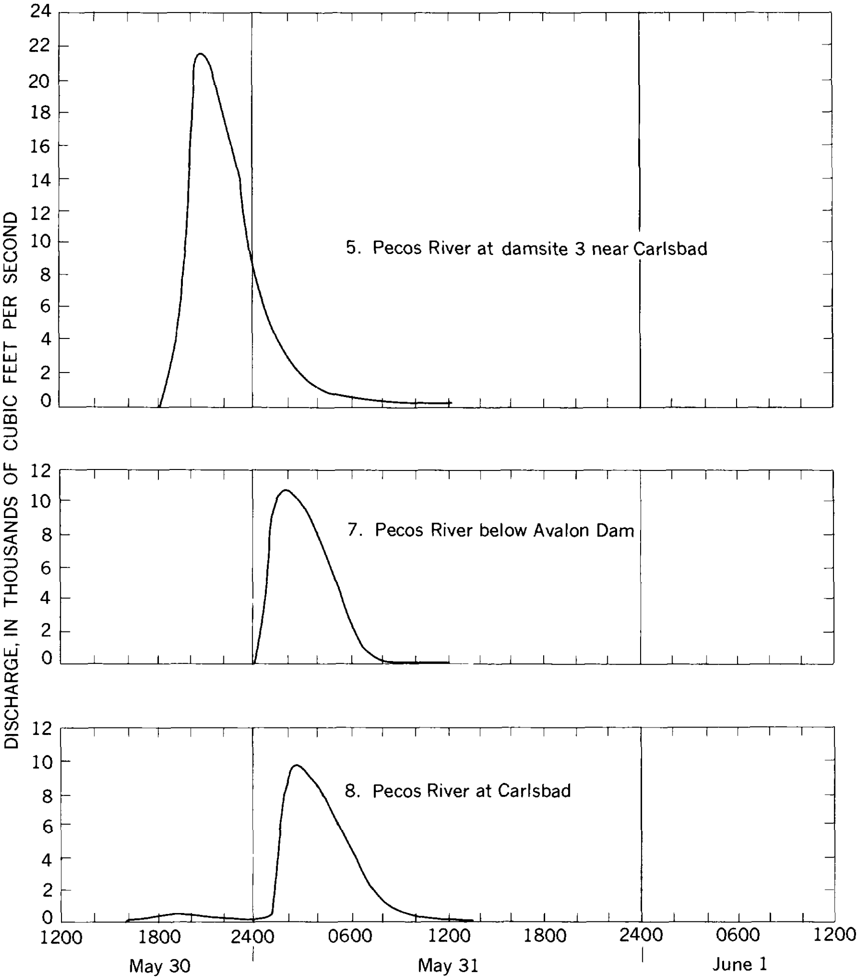

FIGURE 17.—Discharge of the Pecos River during the floods of May 30–31 in the Carlsbad, N. Mex., area.

Delaware River was moderate to severe. The Soil Conservation Service reported more than $50,000 damage on four of their watershed projects in this area. Communication facilities and power were disrupted in a few areas. Highway traffic was interrupted. Autos were washed off roads at several crossings—a woman was drowned in such an accident at the U.S. Highway 62 and 180 crossing of Cass Draw.

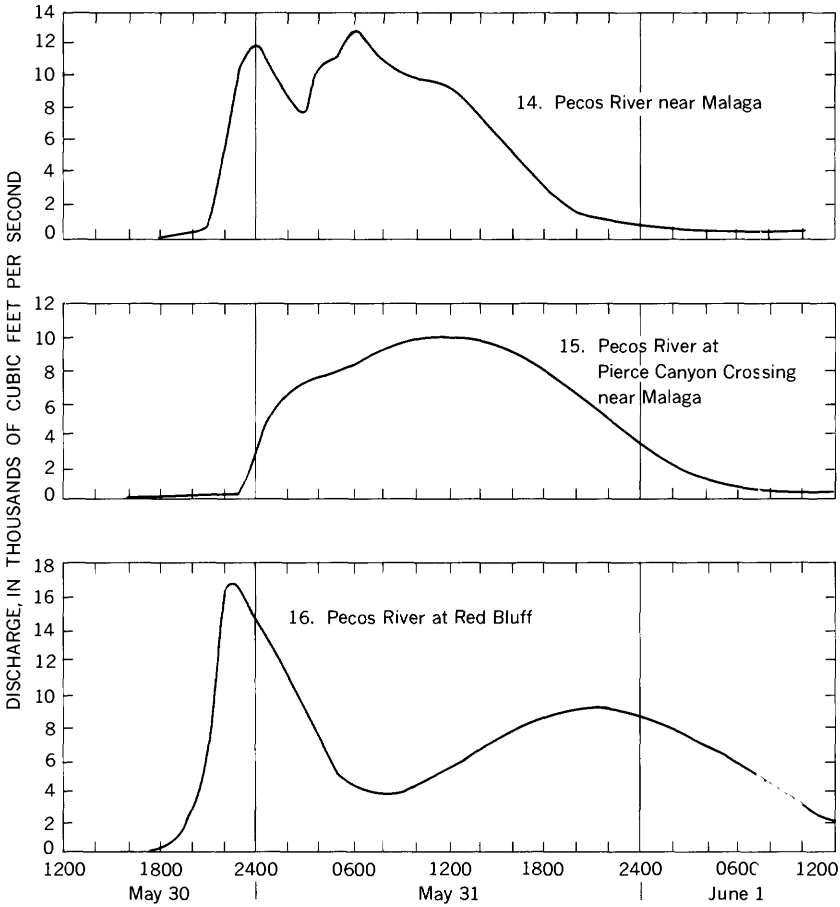

FIGURE 17.—Continued.

FLOODS OF MAY AND JUNE IN WYOMING

By STANLEY A. DRUSE and KENNETH B. RENNICK

Numerous floods occurred throughout Wyoming in May and June. A combination of snowmelt and rainfall runoff in May caused major floods on streams that flow from the northern one-half of the Laramie Mountains in east-central Wyoming, and in June on streams that flow northeasterly from the Uinta Mountains and from the Medicine Bow Mountains in southern Wyoming. Also, local heavy thunderstorms caused significant floods in the east-central and north-central parts of the State in June. Floods that are considered noteworthy are described in the order of their occurrence. The east-central floods of May and June were also described by Rennick (1966).

MAY IN EAST-CENTRAL WYOMING

The storm in May in east-central Wyoming was the result of weather patterns that combined "at the right place at the right time" to produce conditions conducive to heavy precipitation. Moisture-laden air moving into Wyoming from the southwest was raised over cold fronts from the north on May 7 and 13. On May 7 this resulted in a general storm, which started with rain and turned to snow that blanketed the Laramie Mountains with as much as 32 inches of snow by May 9. Much of the snow at lower elevations melted quickly; however, a general snow cover containing 4–6 inches of water equivalent remained at elevations above 6,000 feet when rain began on May 13. The latter storm, when combined with the snow cover, resulted in an estimated maximum water equivalent of 10 inches in some areas when the flood runoff began. The precipitation pattern was influenced by orographic factors; the heaviest precipitation occurred on the north side of the Laramie Mountains, and subsequently lighter precipitation fell on the south side. Up to 6 inches of precipitation was reported from a "bucket survey" of the area. An isohyetal map of the storm rainfall for May 13–15 is shown in figure 18.

Typical spring-runoff patterns were developing when the rains started on May 13. The snowfall during the period May 7–9 had "primed the pump," and the rains during May 13–15 produced spectacular results.

Highest runoff occurred on streams flowing from the Laramie Mountains (fig. 18) northeasterly from stations 2–10, 12, 17, 18, and 20 and southerly from stations 1 and 23 (table 14), resulting in heavy flood damage on several of the streams. Flooding on Deer Creek inundated many dwellings in the town of Glenrock and oil-well pumps on the flood plain. High water on Box Elder, La Prele, Wagonhound, La Bonte, and Horseshoe Creeks flooded range homes, destroyed bridges, eroded or deposited sediment on farm lands, and damaged or destroyed headworks of irrigation ditches.

Recurrence intervals for peak discharges on many streams are much in excess of 50 years (table 14). The peak discharge on Deer Creek (sta. 3), 12,800 cfs, was 4.5 times the previous maximum recorded discharge, which occurred in 1924. The peak discharge on La Bonte Creek

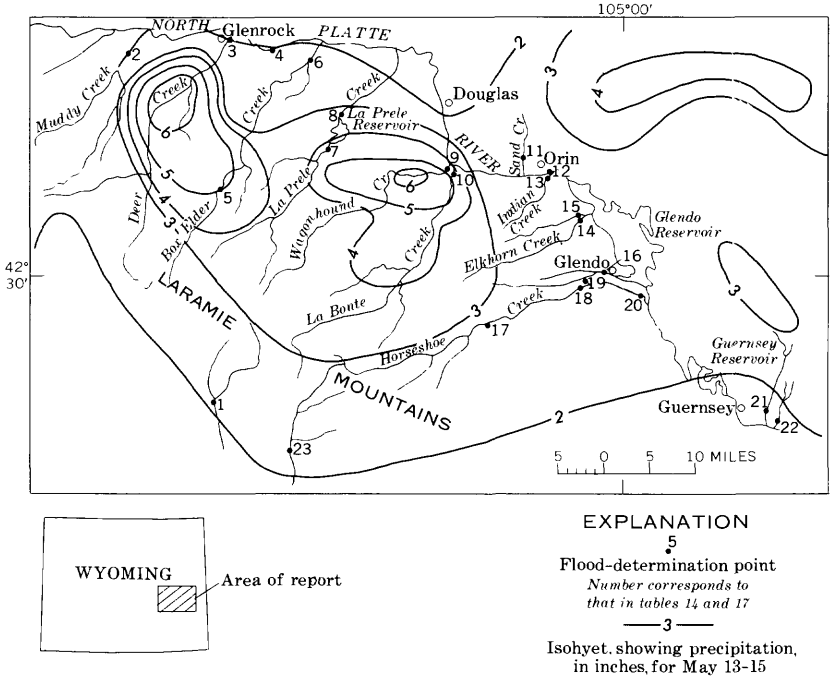

FIGURE 18.—Location of flood-determination points for May and June and isohyets for May 13–15, floods of May and June in east-central Wyoming.

(sta. 10), 8,770 cfs, was 3.2 times the previous maximum recorded discharge, which occurred in 1923. The great magnitude of the May floods is graphically represented by figure 19, which compares the discharges at two selected stations with previous maximum discharges of record.

Three reservoirs on the North Platte River played a major role in preventing flood damage. Releases from Alcova Reservoir (upstream from the area in fig. 18) and from Glendo Reservoir were decreased sharply on May 14, reducing flood stages along the North Platte River above Guernsey Reservoir. The peak discharge on North Platte River above Glendo Reservoir (sta. 12) was 23,800 cfs on May 15, whereas the daily mean discharge below the reservoir was only 1,510 cfs. Floodwaters from La Prele Creek were stored in La Prele Reservoir until spilling occurred on May 17. The peak discharge on La Prele Creek below the reservoir (sta. 8) was only 573 cfs on May 20, and above the reservoir (sta. 7) on May 14 it was 7,300 cfs (3.5 times the theoretical 50-year flood and 6 times the previous maximum in a 46–year period of record).

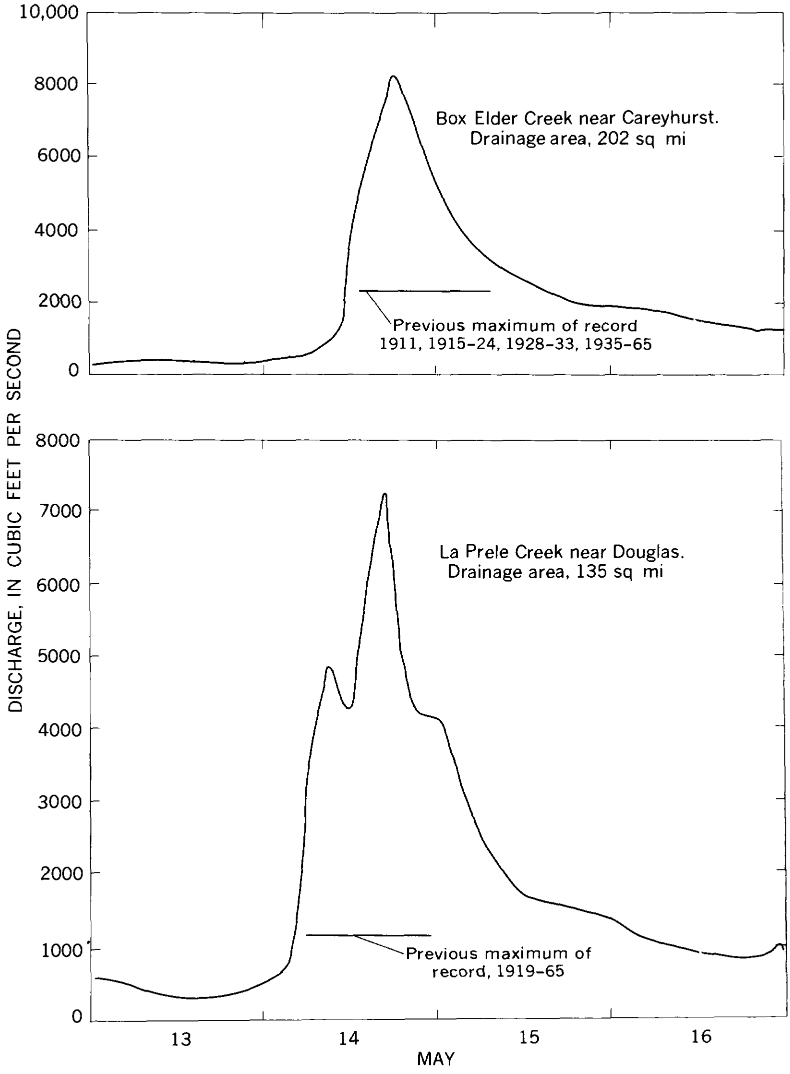

FIGURE 19.—Discharge of selected stations for May 13–16 in east-central Wyoming.

TABLE 14.—*Flood stages and discharges in the Platte River basin, May, in east-central Wyoming*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before May 1965 — Period	Year	May 1965	Gage height (feet)	Discharge: Cfs	Ratio to Q_{50}
1	Sheep Creek near Marshall	61.0	1961–65	1961		9.40	850	
					14	8.88	660	(1)
2	Muddy Creek near Glenrock.	122			14		2,160	(1)
3	Deer Creek below Millar diversion at Glenrock.	212	1916–24, 1928–33, 1935–65.	1924		[2] 6.5	2,840	
					14	9.45	12,800	4.3
4	North Platte River near Glenrock.	17,487 [3] 12,365	1960–65	1962		4.02	6,000	
					14	6.10	16,000	(1)
5	Box Elder Creek at Boxelder.	63.2	1946–51, 1962–65,	1964		6.64	1,040	
					14	8.58	4,530	3.1
6	Box Elder Creek near Careyhurst.	202	1911, 1916–24, 1928–33, 1935–65.	1933		9.04	2,360	
					14	11.85	8,250	2.9
7	La Prele Creek near Douglas.	135	1920–65	1920		11.4	1,220	
					14	12.00	7,300	3.5
8	La Prele Creek below La Prele Reservoir.	152	1962–65	1964		4.82	507	
					20	5.18	573	
9	Wagonhound Creek near La Bonte.	112	1916–24, 1929–32, 1937–65.	1937		[2] 10.00	2,000	
					14	11.83	3,500	1.6
10	La Bonte Creek near La Bonte.	287	1916–24, 1928–33, 1935–65.	1923		[2] 7.5	2,750	
					14	10.60	8,770	2.5
12	North Platte River at Orin	18,837 [3] 13,695	1895–99, 1917–18, 1924, 1958–65.	1899		[2] 7.2	23,300	
					15	10.00	23,800	(1)
17	Horseshoe Creek near Binford.	110	1961–65	1964		4.66	427	
					14	8.91	5,900	1.6
18	Horseshoe Creek near Cassa	180	1962–65	1962		4.28	498	
					14	7.70	4,780	.91
20	Horseshoe Creek near Glendo.	211	1916–18, 1921–24, 1928–33, 1935–65.	1935		8.80	11,900	
					14	7.15	5,000	.88
23	North Laramie River near Garrett.	46	1964–65	1964		5.03	362	
					14	6.78	1,200	.48

[1] Not determined.
[2] Site and datum then in use.
[3] Contributing drainage area.

JUNE IN SOUTHWESTERN WYOMING

Floods in southwestern Wyoming in June were the result of a combination of rainfall and snowmelt runoff from streams which flow northeasterly from the Uinta Mountains (fig. 20). The Uinta Mountains were overlain with heavy late-spring snowpack at the time the rains started on the evening of June 9. Precipitation data collected at nearby Weather Bureau stations are tabulated, in inches, below:

	Fort Bridger, Wyo.	Church Buttes Gas Plant, Wyo.	Manila, Utah
June 9	0	0.37	0.47
10	1.42	0	.30
11	.39	1.50	.45
12	.18	.17	.10

Maximum peak discharges of record were recorded at most stream-gaging stations in this area (table 15). Where determinable, most peaks exceeded the discharge of the theoretical 50-year flood.

Heavy flood damage was sustained by residents in Mountain View and by ranchers who had property on the floodplains. Several bridges were damaged or destroyed on both State and county roads.

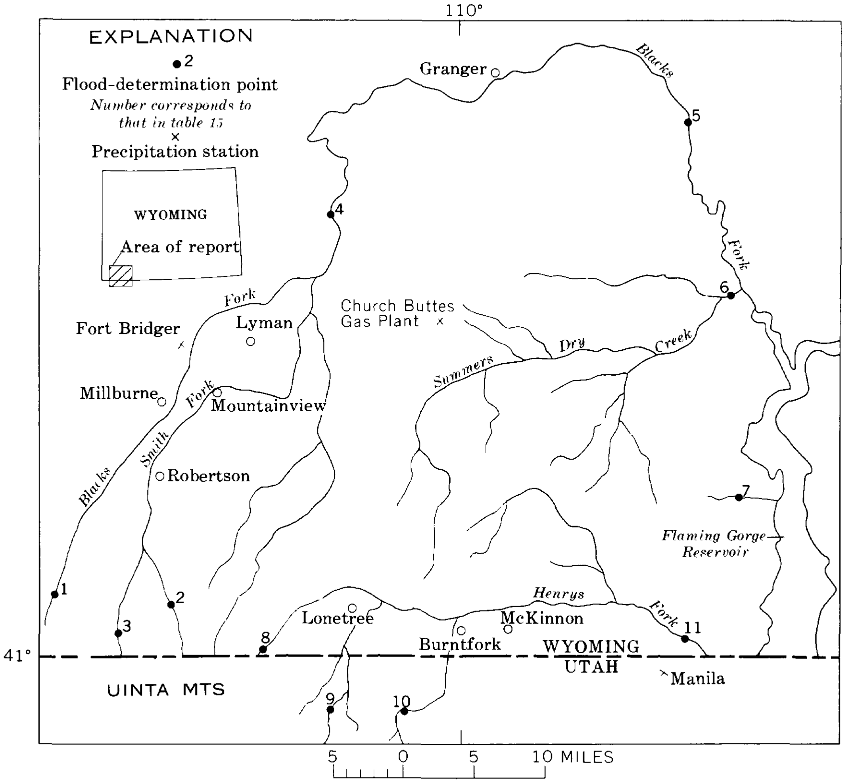

FIGURE 20.—Location of flood-determination points, floods of June in southwestern Wyoming.

TABLE 15.—*Flood stages and discharges in the Green River basin, June, in southwestern Wyoming*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before June 1965: Period	Known before June 1965: Year	June 1965	Gage height (feet)	Discharge: Cfs	Discharge: Ratio to Q_{50}
1	Blacks Fork near Millburne	156	1939–65	1957		6.00	2,530	
					12	6.76	1,910	[1]5
2	East Fork of Smith Fork near Robertson.	53	1939–65	1953		7.94	1,200	
					10	6.75	1,450	[1]40
3	West Fork of Smith Fork near Robertson.	37.2	1939–65	1950		3.08	920	
					10	3.60	2,100	2.0
4	Blacks Fork near Lyman	821	1938–57	1952		[2,3]8.17		
			1962–65	1953			2,900	
					11	12.68	7,960	(4)
5	Blacks Fork near Little America.	3,100	1962–65	1964		6.96	2,810	
					13	10.90	9,980	(4)
6	Summers Dry Creek near Green River.	423			10	9.63	3,230	(4)
7	Squaw Hollow near Burntfork.	6.57			10	7.98	620	(4)
8	Henrys Fork near Lonetree	56	1943–65	1953		6.28	1,860	
					10	6.30	2,010	1.7
9	Middle Fork Beaver Creek near Lonetree.	28	1949–65	1953		3.98	663	
					11	4.36	775	1.2
10	Burnt Fork near Burntfork	52.8	1943–65	1952		8.13	599	
					10	(4)	3,200	2.9
11	Henrys Fork at Linwood, Utah.	520	1929–65	1936		[2]7.19	6,750	
				1959		9.42	(4)	
					10	8.21	5,920	1.2

[1] Recurrence interval, in years.
[2] At site and datum then in use.
[3] Affected by ice jam.
[4] Not determined.

JUNE IN SOUTHEASTERN WYOMING

Precipitation was reported at all Weather Bureau stations along the eastern slope of the Medicine Bow Mountains in southeastern Wyoming on June 10 (fig. 21). The upper area of the Little Laramie River basin was subjected to a particularly heavy rainstorm on this date. The nearest Weather Bureau station is at Centennial, where 2.01 inches was reported for June 10 and 0.67 inch for June 11. This precipitation, plus the snowmelt due to the rain, combined to produce peaks of record at both Little Laramie River gaging stations (table 16, sta. 1, 2). High peak discharges were also recorded at two partial-record sites—Fourmile Creek (sta. 3) and Sevenmile Creek (sta. 4).

The peak discharge at Little Laramie River near Filmore (sta. 1) was 1.4 times the previous maximum of record—2,400 cfs in 1914—and the peak discharge at Little Laramie Rive at Two Rivers (sta. 2) was 1.3 times the previous maximum of record—1,800 cfs in 1914

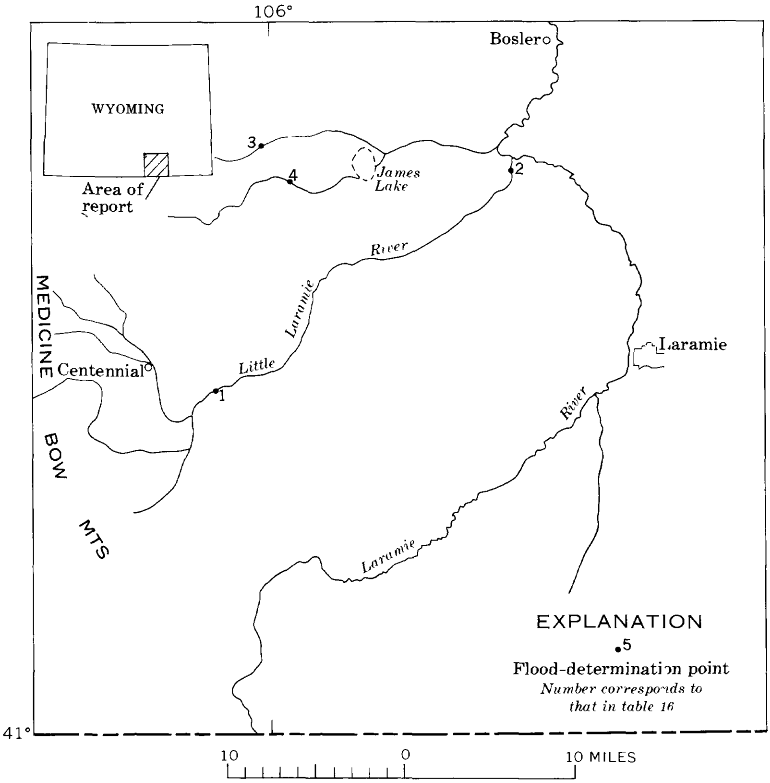

FIGURE 21.—Location of flood-determination points, floods of June in southeastern Wyoming.

TABLE 16.—*Flood stages and discharges in the Platte River basin, June, in southeastern Wyoming*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before June 1965, Period	Maximum floods: Known before June 1965, Year	Maximum floods: June 1965	Maximum floods: Gage height (feet)	Maximum floods: Discharge (cfs)
1	Little Laramie River near Filmore	156	1902–03, 1911–26, 1933–65.	1914		5.9	2,400
					10	5.33	3,450
2	Little Laramie River at Two Rivers	376 [1] 318	1903, 1911–27, 1933–65.	1914		6.44	1,880
					11	7.50	2,440
3	Fourmile Creek near Centennial	7.34	1963–65	1964		5.57	39
					10	7.6	1,040
4	Sevenmile Creek near Centennial	11.2	1962–65	1963		5.93	100
					10	8.11	528

[1] Contributing drainage area.

JUNE IN EAST-CENTRAL WYOMING

Flash floods in June occurred in scattered areas in east-central Wyoming due to locally intense precipitation from thunderstorms. Streams where significant flood peaks were measured were Sand and Indian Creeks near Orin; Elkhorn, North Elkhorn, Horseshoe, and Spring Creeks, and Whiskey Gulch near Glendo; and Whalen Canyon and County Line Draw near Guernsey. (fig. 18, sta. 11, 13–16, 18–22). Peak discharges are given in table 17. Only the official Weather Bureau data are available for this storm period; a maximum of 3.89 inches of precipitation was reported for the area on June 10. Damage from the floods was limited to rural areas.

JUNE IN NORTH-CENTRAL WYOMING

An intense thunderstorm occurred June 15 in north-central Wyoming over a small area near the mouth of Crazy Woman Creek (fig. 22). A stream-gaging station on Crazy Woman Creek (sta. 1) is about 4½ miles upstream from the mouth. Although only a small part of the drainage area was affected by the storm, the peak discharge at this site was 1.1 times that for the theoretical 50-year flood from the total drainage area of 945 sq mi (table 18).

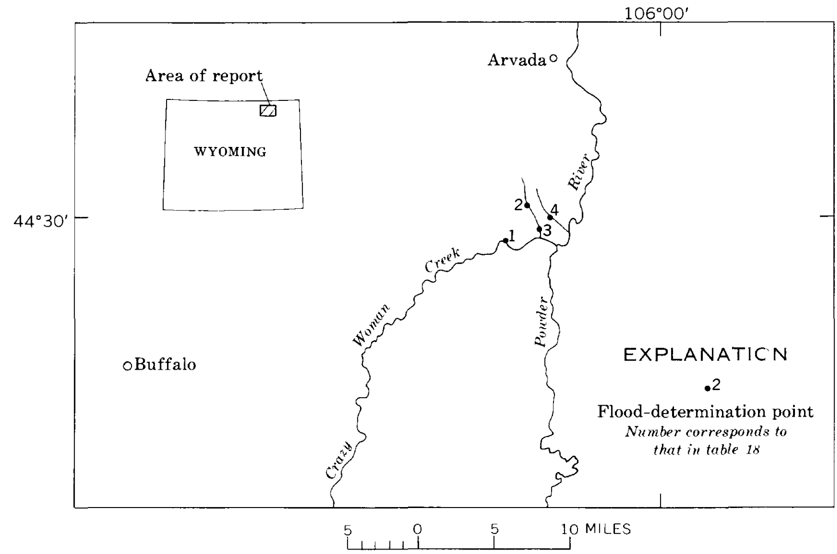

FIGURE 22.—Location of flood-determination points, floods of June in north-central Wyoming.

TABLE 17.—*Flood stages and discharges in the Platte River basin, June, in east-central Wyoming*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before June 1965 — Period	Known before June 1965 — Year	June 1965	Gage height (feet)	Discharge — Cfs	Discharge — Ratio to Q_{50}
11	Sand Creek near Orin	27.8	1955, 1961–65.	1955			20,700	
					16	9.50	2,360	(1)
13	Indian Creek near Orin	16.2			16		786	(1)
14	Elkhorn Creek near Glendo.	35.3	1960, 1965	1960			3,670	
					14		12,600	(1)
15	North Elkhorn Creek near Glendo.	21.5	1960, 1965	1960			9,940	
					14		4,310	(1)
16	Whiskey Gulch at Glendo	9.53			14		16,100	(1)
18	Horseshoe Creek near Cassa.	180	1962–65	1962		4.28	498	
					14	8.42	7,850	1.5
19	Spring Creek near Glendo	17.5			14		9,360	(1)
20	Horseshoe Creek near Glendo.	211	1916–18, 1921–24, 1928–33, 1935–65	1935		8.80	11,900	
					14	8.82	12,100	2.1
21	Whalen Canyon near Guernsey.	27.2	1955, 1965	1955			5,390	
					9		3,150	(1)
22	County Line Draw near Guernsey.	6.58	1955, 1965	1955			2,820	
					9		5,050	(1)

(1) Not determined.

TABLE 18.—*Flood stages and discharges in the Yellowstone River basin, June, in north-central Wyoming*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before June 1965 — Period	Known before June 1965 — Year	June 1965	Gage height (feet)	Discharge — Cfs	Discharge — Ratio to Q_{50}
1	Crazy Woman Creek at upper station near Arvada.	945	1963–65	1963		8.98	1,300	
					15	16.02	15,800	1.1
2	Headgate Draw at upper station near Buffalo.	1.1			15	11.27	5,490	(1)
3	Headgate Draw at lower station near Buffalo.	2.6			15	14.89	6,930	(1)
4	Powder River tributary near Buffalo.	1.5			15	7.86	2,180	(1)

(1) Not determined.

A partial-record gage equipped with stage-rainfall recorder, Headgate Draw at upper station near Buffalo (sta. 2), was destroyed prior to the peak, at a stage about 1.75 ft below the peak stage. At that time the rainfall recorded was 2.05 inches in 2 hours 25 minutes. The rainfall intensity for the last 18 minutes recorded was 2.23 inches per hour. The high rates of unit runoff at these sites are of particular interest: 4,990 cfs per sq mi at Headgate Draw at upper station (sta. 2), 2,670 cfs per sq mi at Headgate Draw at lower station (sta. 3), and 1,450 cfs per sq mi at Powder River tributary (sta. 4). Damage from the June 15 floods was limited to county bridges and roads and to ranch lands on the flood plains.

FLOODS OF JUNE IN NEBRASKA

By H. D. Brice

Flooding occurred in several parts of Nebraska in June. An intense rainstorm occurred June 8 over the drainage basin of Johnson Creek, a tributary of the Big Blue River (fig. 23); it caused a notable flood peak 3 miles north of Dorchester, at the bridge on U.S. Highway 6 (table 19, sta. 11), that was almost twice as great as that for a 50-year flood. Contributing to the flood event was the large antecedent rainfall (more than 3 inches at Friend) during the period June 2–6. The storm

Table 19.—*Flood stages and discharges, June, in Nebraska*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods					
			Known before June 1965		June 1965	Gage height (feet)	Discharge	
			Period	Year			Cfs	Reurrence interval (years)
	White River basin							
1	White River tributary near Glen.	7.97	1953–65	1962			435	
					17	19.06	740	[1] 1.40
	Niobrara River basin							
2	Pebble Creek near Dunlap	23.5	1953–65	1953			2,740	
					25	13.03	3,300	[1] 3.32
3	Cottonwood Creek near Dunlap.	82.2	1951–65	1951			28,100	
					25	15.15	4,380	[1] 2.11
	Platte River basin							
4	Pumpkin Creek near Bridgeport.	1,080	1931–65	1951		8.87	2,970	
					9	9.98	7,880	[1] 1.81
5	Lodgepole Creek at Ralton	3,307	1951–65	1951		5.70	1,150	
					16	5.13	1,110	35
6	South Platte River at Paxton.	23,700	1939–65	1942		9.5	16,900	
					21	10.69	34,600	[1] 1.19
7	South Platte River at North Platte.	24,300	1897, 1914–15, 1917–65	1935		14.02	37,100	
					22	10.43	22,200	25
8	Platte River at Brady	56,900	1937–65	1942			15,400	
					23		16,800	20
9	Platte River near Cozad	57,200	1932, 1937–65	1942			16,600	
					24		15,800	18
	Nemaha River basin							
10	Nemaha River at Falls City.	1,340	1944–65	1954		27.44	51,400	
					29	28.90	47,700	18
	Kansas River basin							
11	Johnson Creek near Dorchester.	86			8		8,600	[1] 1.96

[1] Ratio of peak discharge to 50-year flood.

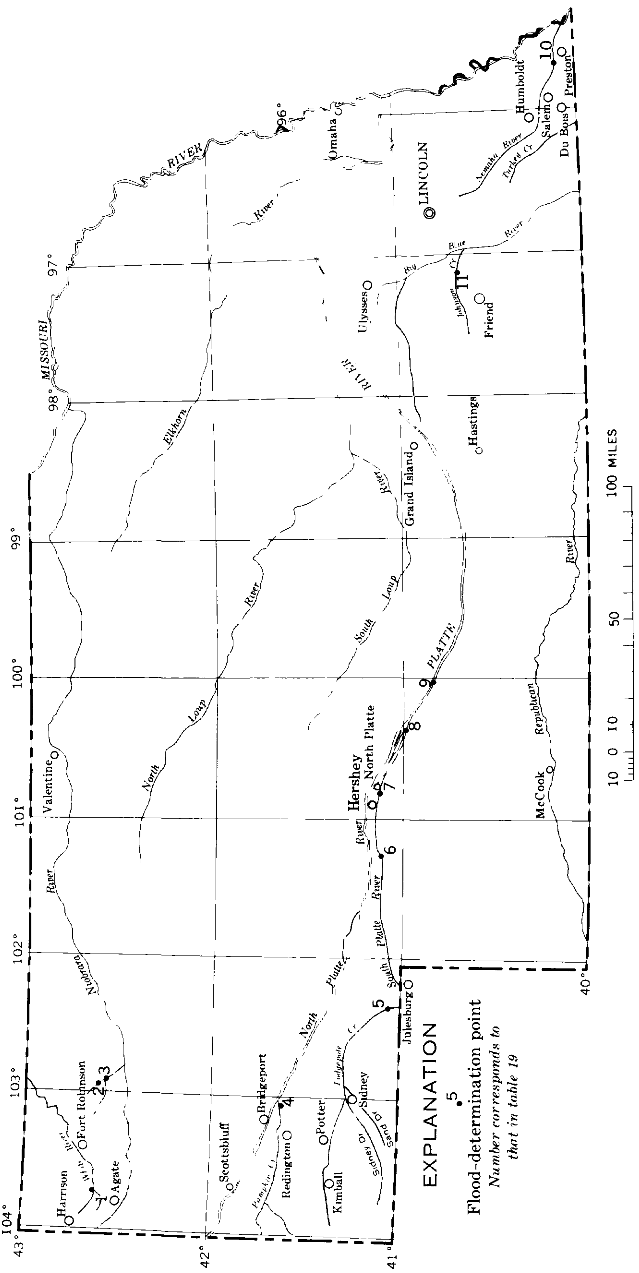

FIGURE 23.—Location of flood-determination points, floods of June in Nebraska.

on the 8th resulted in an additional 3.61 inches of rain at Friend and possibly larger amounts elsewhere in the basin. Extensive erosion was observed along the creek channel and in adjacent cultivated fields.

In a short period of time on June 9 and 10, 3–9 inches of rain fell in the eastern part of the Pumpkin Creek basin. Rainfall of 3.30 inches was measured in Bridgeport between 1700 hours on June 9 and 1700 hours on June 10. Ranchers living a few miles west of Redington reported 6–9 inches, and a rancher living 4 miles southeast of Redington reported 7 inches during the night of June 9–10. Areas between these points may have received even greater amounts. The resulting peak discharge of Pumpkin Creek at the gaging station 4 miles southeast of Bridgeport (sta. 4) was more than 2½ times the previous maximum since records began in 1931 (table 19). Several bridges were destroyed, and highways were overtopped and closed to traffic. Drainage ditches near Redington along State Highway 88 were scoured to a depth of 12 feet. At the crest, the floodwaters in some reaches of Pumpkin Creek were about three-fourths of a mile wide.

Rainfall of "cloudburst proportions" fell in the Sidney area on June 14–15. The FAA (Federal Aviation Agency) rain gage at the Sidney Airport recorded 4.09 inches between 1300 and 1500 hours on the 15th; the actual duration may have been less than 2 hours. U.S. Weather Bureau Technical Paper 40 (1961) ascribes a recurrence interval of 100 years to a point rainfall of 4 inches in 6 hours in this area but does not extrapolate to a 4-inch rainfall in 2 hours. Only light rainfall was observed June 14–15 at the Weather Bureau gages at Kimball and Potter. Flooding occurred in Sidney Draw and Sand Draw near Sidney. That in Sidney Draw inundated much farmland and isolated several farm homes on the 15th. Stage and discharge data were not collected in the draws, but the flood wave that passed the gaging station on Lodgepole Creek at Ralton (sta. 5) on the 16th was the second highest in the period of record beginning in 1951.

A record-breaking flood discharge (the greatest since 1953) at White River tributary near Glen (sta. 1) resulted from high-intensity rainfall on June 17th. The storm was of small areal extent, and very little or no rain was recorded at the Weather Bureau gages at Harrison, Agate, and Fort Robinson, on three sides of the flood area.

Torrential rains in the upper part of the South Platte River basin on June 14–17 caused record-breaking floods which are described only briefly here but are documented fully by Matthai (1969). The flood discharge of June 21–24 on the South Platte River was measured at Paxton (sta. 6) and at North Platte (sta. 7), and that on the Platte River was measured on the same days at Brady (sta. 8) and Cozad (sta. 9). Peak discharges at those sites and data for the previous maximum flood of record are given in table 19; unfortunately, of the four sites, the 1935 flood peak is known only at North Platte. During the June 21–24 flood, the flood plain of the South Platte River was inundated to a width of 2 miles along some reaches, a condition causing considerable damage to crop and pasture lands. Failure of a dike at Hershey resulted in the flooding of 12 homes and about one-third of the town. Farther downstream, below the confluence of the South Platte and the North Platte Rivers, the flooding diminished, but the peak discharge at Brady (table 19) was the largest and that at Cozad was the second largest since records began at those two gaging stations in 1937. However, on the basis of earlier records at stations upstream and downstream from these sites, the 1935 flood is believed to have been greater than the June 1965 flood at both Brady and Cozad. Based on regional studies, the recurrence intervals of the 1935 and June 1965 flood discharges of the South Platte River at North Platte are more than 50 years and 25 years, respectively. By contrast, the peak discharge of the 1935 flood on South Platte River at Julesburg, Colo. (period of record, 1902–64) was exceeded only by the flood of June 20, 1965.

Generally heavy rains over southeastern Nebraska on June 25–30 caused local flooding along many streams, but rainfall was heaviest and flooding most extensive in the Nemaha River basin. Of particular significance among causes of the flood was the heavy antecedent rainfall observed at some Weather Bureau gages June 26–28 that set the stage for the high percentage and the great volume of runoff from the heavy rainfall of June 28–29 (table 20). A farmer living near the Boy Scout camp south of Humboldt reported to the Falls City Journal that 13.10 inches of rain fell at his home on June 25–30. This amount included 6 inches during the night of June 28–29 and 3½ inches during the night of June 29–30. The peak stage at the gaging station on Nemaha River at Falls City (sta. 10) occurred on June 29 (table 19). It was the highest in the period of record, which began in 1944, but the peak discharge was less than that in 1954. About 14,000 acres of farmland along the Nemaha River between Salem and Preston was inundated. Much of this land was planted in wheat and was ready for harvesting. Several thousand acres along tributaries of the Nemaha River also were flooded. Many bridges and culverts were either destroyed or badly damaged, and a large amount of gravel surfacing was washed off flooded sections of county and State roads. Traffic was halted on U.S. Highway 73 south of Falls City (near sta. 10) for several hours at the height of the flood, and State Highway 8 between Du Bois and Salem was closed when approaches to two bridges were washed out on June 29. In the Pawnee City vicinity (about 10 miles northwest of

Du Bois), Turkey Creek flooded State Highway 65 south of town and State Highway 4 at the underpass west of town. A small creek that runs through Pawnee City was reported to have reached the highest stage in the memory of local residents. A farm family living south of Humboldt was isolated when two bridges in the immediate vicinity washed out during the flood. About 1 mile southwest of Du Bois another farm family was stranded; floodwater inundated their home, farm buildings, machinery, and automobile and drowned one horse and many of their chickens.

TABLE 20.—*Daily precipitation associated with the floods of June 29 in southeastern Nebraska*

Site of observation	Time of observation (hours)	Precipitation, in inches					
		June					
		26	27	28	29	30	26–30
Dawson	2400	0.05	0.38	4.62	1.80		6.85
Falls City	Sunset	1.08	.30	1.10	3.87	0.73	7.08
Pawnee City	0700	.80	.94	.84	6.31	.71	9.60
5 miles southeast of Pawnee City	2400	.91		(1)	9.16	.09	10.16
5 miles north of Table Rock	0700	.81	.72	.47	3.15	.52	5.67
Tecumseh	1900	.63	.13	.18	2.35	.70	3.99

1 Amount included in measurement for June 29; recorder not operating 2100–2400 hours: 5.66 inches recorded prior to 2100 hours.

FLOODS OF JUNE–AUGUST IN UTAH

By ELMER BUTLER

Many floods occurred throughout Utah from early June to the middle of August. In Utah, springtime floods are usually caused by snowmelt or rain on snow, and summertime floods are generally caused by thunderstorms. Summertime storms result from unstable moisture-laden airmasses that move in from the Gulf of Mexico, often cover small areas, and cause precipitation of high intensity. The resulting peak discharges from small contributing areas may be very high.

In many parts of Utah, rain gages are sparsely distributed, and if an area covered by a storm is small, the reported rainfall figures may not reflect the intensiy of a storm which produced a large flood.

The most noteworthy floods in Utah from early June to the middle of August are hereby described in chronological order. Figure 24 shows the locations of peak discharge determination points. The sites at which peak discharges were determined for the several flood periods are listed in downstream order in table 21.

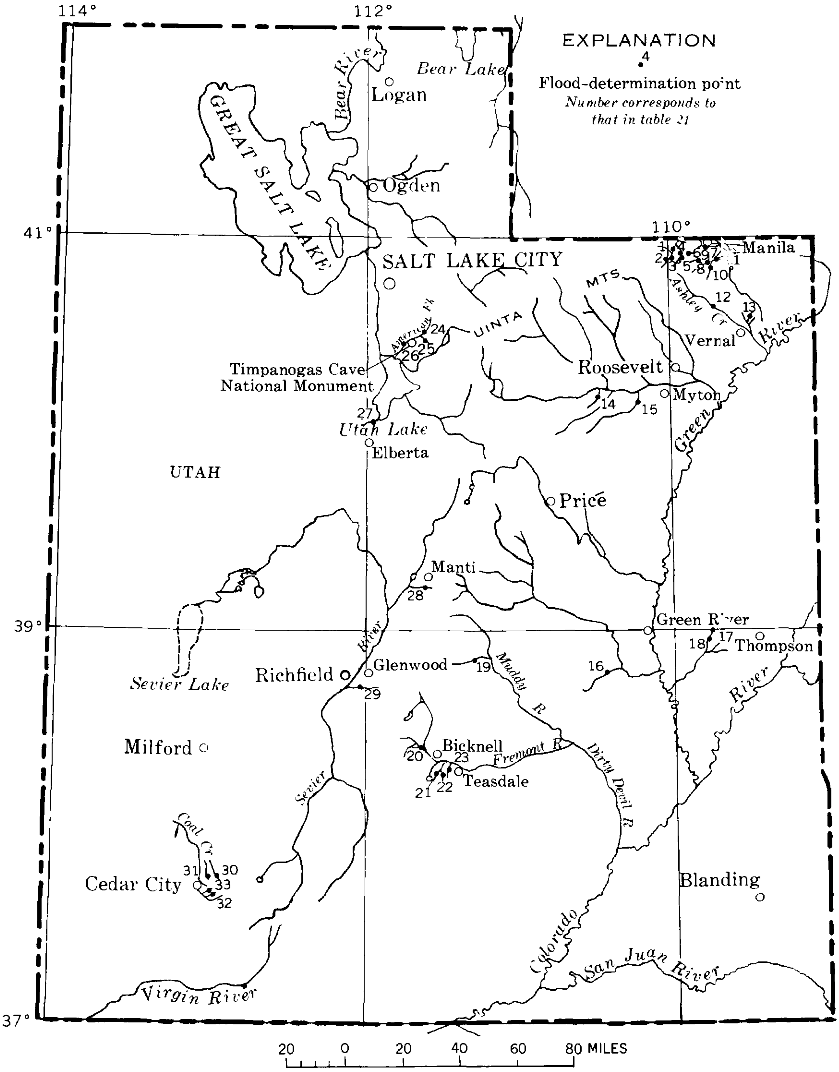

FIGURE 24.—Location of flood-determination points, June–August in Utah.

Rains of high intensity at high altitudes in the Uinta Mountains on June 9–11 and the melting of the unusually heavy snowpack caused flooding of several streams (sta. 1–12). The storms caused very little runoff from the lower altitudes. The worst flood in 40 years hit the Sheep Creek area on June 10 and 11 causing damage estimated at $660,000 to roads and bridges. Damage in the Ashley National Forest—to Deep Creek bridge, Trail Creek–Carter Creek bridge, and

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TABLE 21.—*Flood stages and discharges, June–August, in Utah*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before June 1965: Period	Maximum floods: Known before June 1965: Year	Maximum floods: June–August 1965	Maximum floods: Gage height (feet)	Maximum floods: Discharge: Cfs	Maximum floods: Discharge: Recurrence interval (years)
	Green River basin							
1	North Fork Sheep Creek near Manila.	10			June 10		[1] 320	[2] 1.5
2	Middle Fork Sheep Creek above Hickerson Park near Manila.	10			June 10		[1] 220	[2] 1.3
3	Middle Fork Sheep Creek at Hickerson Park near Manila.	10			June 10		[1] 270	[2] 1.6
4	Sheep Creek above South Fork and above diversion canal near Manila.	27			June 10		[1] 425	50
5	South Fork Sheep Creek near Manila.	12			June 10		[1] 1,630	[2] 7.4
6	Sheep Creek near Manila	42	1943–61	1948		6.05	1,020	
					June 10	9.36	2,320	[2] 3.7
7	Sheep Creek at gap near Manila.	93.2			June 11		2,620	[2] 2.7
8	Beaver Creek above Browne Lake near Manila.	9			June 10		[1] 110	28
9	Carter Creek above Deep Creek near Manila.	47			June 11		[1] 870	[2] 1.5
10	Deep Creek at mouth near Manila.	11			June 11		[1] 580	[2] 4.3
11	Carter Creek at State Highway 44 near Manila.	77			June 11		1,610	[2] 1.9
12	Ashley Creek above Red Pine Creek near Vernal.	58			June 10	12.13	7,410	[2] 8.8
13	Can Canyon near Vernal	2.9			July 22		[3] 3,600	(4)
14	Strawberry River tributary near Duchesne.	1.7	1960–65	1963		11.36	177	
					July 22	16.52	2,560	(4)
15	Antelope Creek at U.S. Highway 40 near Myton.	200			July 22		[3] 1,660	[2] 1.1
16	Iron Wash near Green River	179			Aug. 19		[3] 20,000	(4)
17	Crescent Wash above dam near Crescent Junction.	18.5			July 31		[3] 9,920	[2] 2.7
18	Crescent Wash at Crescent Junction.	[5] 23.3	1959–65	1961		13.08	1,460	
					July 31	23.57	4,160	50
	Dirty Devil River basin							
19	Ivie Creek above diversions near Emery.	50	1950–65	1955		13.24	700	
					July 25	15.06	1,420	[2] 1.3
20	Roads Creek at diversion near Loa.	91.6			July 31		[3] 487	[2] 3.5
21	Rabbitbrush Creek near Bicknell.	2.62			July 31		[3] 2,780	(6)
22	Government Creek near Bicknell.	4.82			July 31		[3] 2,430	(6)
23	Cigarette Hollow near Teasdale.	[7] 6.16			July 31		[3] 2,430	(6)
	Jordan River basin							
24	American Fork above South Fork near American Fork.	40.3			July 18		[3] 400	[2] 1.5
25	South Fork of American Fork at South Fork Ranger Station near American Fork.	8.5			July 18		[3] 92	[2] 1.3
26	American Fork at Riverside picnic area near American Fork.	57.6			July 18		[3] 1,890	[2] 1.7
27	Utah Lake tributary near Elberta.	4.71	1961-65	1963		[8] 11.35	101	
					July 18	12.83	773	[2] 9.7

See footnotes at end of table.

TABLE 21.—*Flood stages and discharges, June–August, in Utah*—Continued

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before June 1965 — Period	Known before June 1965 — Year	June–August 1965	Gage height (feet)	Discharge — Cfs	Discharge — Recurrence interval (years)
	Sevier Lake basin							
28	Sixmile Creek near Sterling	29	1959–65	1959		12.48	820	
					Aug. 1	13.26	1,050	[2] 1.6
29	Twist Canyon near Annabella.	2.57			Aug. 17		[3] 4,930	(4)
	Cedar City Valley							
30	Fiddlers Canyon near Cedar City.	7.8			Aug. 17		[3] 4,730	(4)
31	Dry Canyon near Cedar City.	.9			Aug. 17		[3] 3,670	(4)
32	Salt Creek near Cedar City	1.9			Aug. 17		1,720	(4)
33	Coal Creek tributary at east side of Red Hill near Cedar City.	.13			Aug. 17		[3] 300	(4)

1 From U.S. Forest Service.
2 Ratio of peak discharge to 50-year flood.
3 Estimate based on field survey.
4 Probably exceeds 50-year flood.
5 Area below the dam is 4.2 sq mi; the reservoir has not been used since 1958 because of reduced storage and break in left end of dam.
6 Several times the 50-year flood.
7 Includes that part of Bullberry Creek above flood dike.
8 Site and datum then in use.

Birch Creek road—was estimated at $8,000, $7,000, and $50,000 respectively. Damage to roads and bridges in the Wasatch National Forest was estimated at $35,000. Damage to cultivated land was considerable, and seven campers at Palisades campground on Sheep Creek were drowned when they were swept away by the floodwaters during the night.

The Soil Conservation Service reported flood damage in the Uinta basin as follows:

Type of damage	*Losses*
Roads and bridges	$4,700
Crops	4,970
Canal diversion	6,500
Canal headings	10,000
Canals	25,050
Dams	2,500
Damage to fences and land	560
Total	54,280

The U.S. Forest Service reported that there was above-average snowfall in the mountains for the water year. The area that mainly contributed to the flooding was above the 9,200-foot altitude, which was the approximate snowline before the flood. After the flood, the snowline had moved up to 9,900 feet. Therefore, the snow on about 14 square miles of the Sheep Creek drainage basin had completely melted during the period of flooding.

Precipitation at Half Moon Park in the Sheep Creek basin was about 3 inches during the period June 9–10. Other rainfall amounts, in inches, were:

	Manila	Allen's Ranch (east of Spirit Lake)	Roosevelt	Vernal
June 8	0.02	0		
9	.47	.17		
10	.30	.40	1.27	0.94
11	.45	.75		
12	.10	.03		

The highest rates of runoff from this storm were measured at Ashley Creek above Red Pine Creek near Vernal (sta. 12) and at South Fork Sheep Creek near Manila (sta. 5) where the peak discharges were respectively 8.8 and 7.4 times that of a 50-year flood.

On July 18, thunderstorms raged across northern Utah causing flooding in some areas. In American Fork Canyon seven mud slides caused floodwater to overtop the road and wash it out, and many campers were marooned between the mud slides for several hours. Floodwater swept through buildings at the Timpanogas Cave National Monument causing considerable damage. The U.S. National Park Service reported 2.18 inches of rain at Timpanogas Cave National Monument between 1800 hours and 2200 hours on July 18.

A section of Utah Highway 68 about 3 miles north of Elberta was washed out. Extensive damage was done to crops and young fruit trees at a land development project north of Elberta.

Peak flows in American Fork Canyon (sta. 24–26) and in Utah Lake tributary near Elberta (sta. 27) exceeded those of 50-year floods by ratios of from 1.3 to 9.7.

Flash floods occurred on small streams (sta. 13–15) in the Uinta basin on July 22. Only 0.30 inch of rain was recorded at Vernal Airport, and lesser amounts were recorded at other sites in the area. Because the storms were over small areas and were of high intensity, the reported rainfall figures show no relation to the intensity of the storms.

Peak discharges in Can Canyon near Vernal (sta. 13) and in Antelope Creek at U.S. Highway 40 near Myton (sta. 15) were greater than those for a 50-year flood. The flood in Can Canyon did some damage to crops and farmland.

In south-central Utah, thunderstorms on July 25 and 31 caused floods on several streams. On July 25 a flood in Ivie Creek above diversions near Emery (sta. 19) destroyed the crest-stage gage and caused $900 damage to fences, bridges, and irrigation-diversion structures. The peak discharge was 1.3 times that of a 50-year flood. No precipitation was recorded in the vicinity.

A flash flood occurred in Crescent Wash near Crescent Junction (sta. 17 and 18) on July 31. At Thompson, 15 miles to the east, 0.60 inch of rain was officially recorded on that day. Because of the scarcity of destructible property in the flood area, no damage was reported. The peak discharge above the detention dam was 2.7 times that of a 50-year flood.

Heavy rains on July 31 also caused floods in four streams in south-central Utah. In Roads Creek at diversion near Loa (sta. 20), the peak discharge was 3.5 times that of a 50-year flood. In Rabbitbrush Creek near Bicknell (sta. 21), Government Creek near Bicknell (sta. 22), and Cigarette Hollow near Teasdale (sta. 23), the peak flows were several times that of a 50-year flood. At Loa, 0.36 inch of precipitation was measured on July 31.

Severe thunderstorms in central Utah on August 1 and 17 caused flash floods on several streams. On August 1 the peak discharge in Sixmile Creek near Sterling (sta. 28) was 1.6 times that of a 50-year flood. On August 1, 0.39 inch of precipitation was measured at Manti, about 5 miles to the north, but this is not indicative of the intensity of the localized storm that cause the flood on Sixmile Creek. On August 17 the peak flow from a 2.57-sq-mi drainage basin in Twist Canyon near Annabella (sta. 29) was 4,930 cfs, which is 1,918 cfs per sq mi. The statistical probability of a flood of this magnitude occurring in Utah is very small.

The widely scattered official rain gages did not record amounts of precipitation that had a relation to the intensity of the storm in Twist Canyon; however, 2.12 inches of rain in 45 minutes was unofficially recorded at Glenwood on August 17. Approximately 2½ miles of county road east of Annabella was destroyed, and gully erosion in Twist Canyon was severe.

General rains over most of southern Utah on August 17 and local precipitation of cloudburst intensities caused floods in an area east of Cedar City.

Peak discharges for four streams (sta. 30–33) are listed in downstream order in table 21. All peak flows listed are believed to exceed those of 50-year floods, although flood-frequency relations are undefined for drainage areas of less than 15 sq mi in this section of Utah.

Reports of precipitation at nearby Weather Bureau stations show that the rainfall varied considerably within the area. The official records at Cedar City FAA Airport, Cedar City Steam Plant, and Cedar Breaks National Monument showed 0.04, 0.99, and 0.73 inch of precipitation, respectively, on August 17.

The most damaging flood was in Dry Canyon where considerable damage was done to farmland, industrial buildings, roads, bridges, a cemetery, a golf course and personal property. The Soil Conservation Service estimated the total damage at $176,000.

Thunderstorm activity on August 19 caused a flood in Iron Wash near Green River (sta. 16). On the same day 1.34 inches of rain was recorded at Green River. The peak discharge probably exceeds that of a 50-year flood. The rate of runoff was 112 cfs per sq mi from 179 square miles. Some damage was done to State Highway 24 at the ford, but no other damage was reported because there are no destructible structures along the wash.

FLOODS OF JUNE 11 IN SANDERSON CANYON, TEX.

By Leo G. Stearns

Three storms occurred in the Sanderson Canyon basin in the vicinity of Sanderson, Texas, on June 10 and 11. The first storm occurred at about 1800–2100 hours on June 10. The times of occurrence of the other two storms cannot be readily separated in some areas. The total storm rainfall at the Weather Bureau station in Sanderson on June 10 and 11 was 5.35 inches, of which 1.96 inches fell between 1930 and 2030 hours on June 10. At the Weather Bureau recording station 1 mile northwest of the Sanderson Post Office, 6.55 inches of rain fell on June 10 and 11, of which 2.24 inches fell between 1930 and 2045 hours on June 10. Total rainfall in the Sanderson Canyon basin for the storm period ranged from about 3 inches to a maximum of 9 inches Supplemental rainfall data, which were gathered by the Weather Bureau, the International Boundary and Water Commission, and the Corps of Engineers were used by the Corps to complete the isohyetal map of the storm (fig. 25).

Two indirect discharge measurements were made, one on Three Mile Draw and one on Sanderson Canyon above Three Mile Draw (fig. 25). Three Mile Draw joins Sanderson Canyon just upstream from the town of Sanderson. The peak discharge from a 36-sq-mi basin on

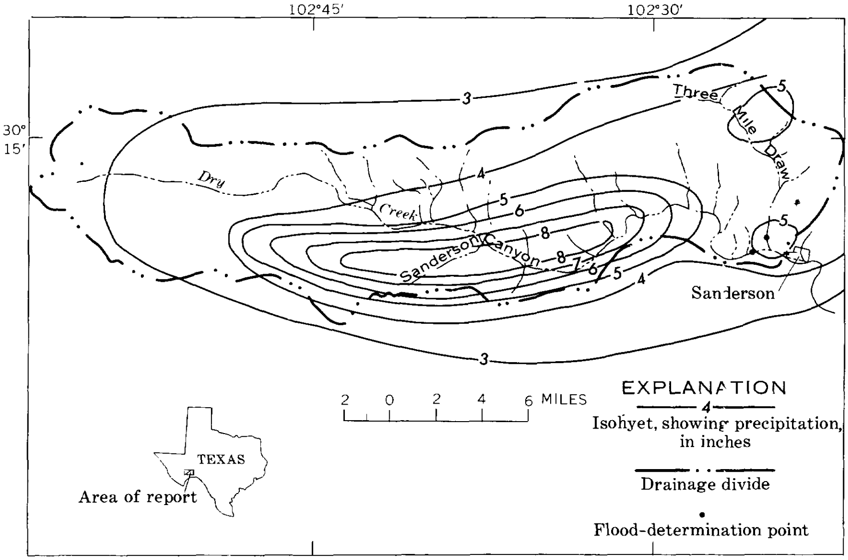

FIGURE 25.—Location of flood-determination points and isohyets for June 10–11, floods of June 11 in Sanderson Canyon, Tex. Isohyets from U.S. Army Corps of Engineers (unpub. data).

Three Mile Draw was 22,400 cfs, and the peak discharge from a 151-sq-mi basin on Sanderson Canyon was 76,400 cfs. Although Three Mile Draw peaked slightly earlier than Sanderson Canyon, the peak discharge through Sanderson was about equal to the sum of the two peaks, about 100,000 cfs. This, the maximum known flood at Sanderson, greatly exceeded the previous maximum known discharge, covered the valley floor, and inundated about 230 acres of the community. Longtime residents stated that the greatest flood previously known, in 1935, slightly exceeded the channel capacity (about 20,000 cfs). The statistical probability that a flood of similar magnitude will reoccur in Sanderson is very small because the peak discharges on Three Mile Draw and on Sanderson Canyon, respectively, were about 4.1 and 5.4 times that of a 50-year flood.

At least 24 persons were killed. About 85 persons were injured, 10 of whom were hospitalized. Property damage consisted of destruction of 54 houses and 13 trailer houses; major damage to 36 houses, 8 trailer houses, and 27 businesses; and minor damage to 106 houses. Three bridges of the Southern Pacific Lines were destroyed, and more than 20 miles of U.S. Highway 90 was damaged. Damage in Sanderson (estimated 1965 population, 2,189) and vicinity was estimated at $2,664,000.

FLOOD OF JUNE 15 IN THE YELLOWSTONE RIVER BASIN NEAR GLENDIVE, MONT.

By Melvin V. Johnson

Local rains of high intensities caused severe flooding in a sparsely settled area northeast of Glendive, Mont. (fig. 26). Weather Bureau information from unofficial gages shows that precipitation for the storm area ranged from 3.5 to 13.5 inches. A rancher who lives about 1 mile upstream from the flood-determination point on Griffith Creek stated "Seven inches of rain fell in about half an hour." Precipitation at the Weather Bureau station at Glendive on June 15 was only 0.56 inches.

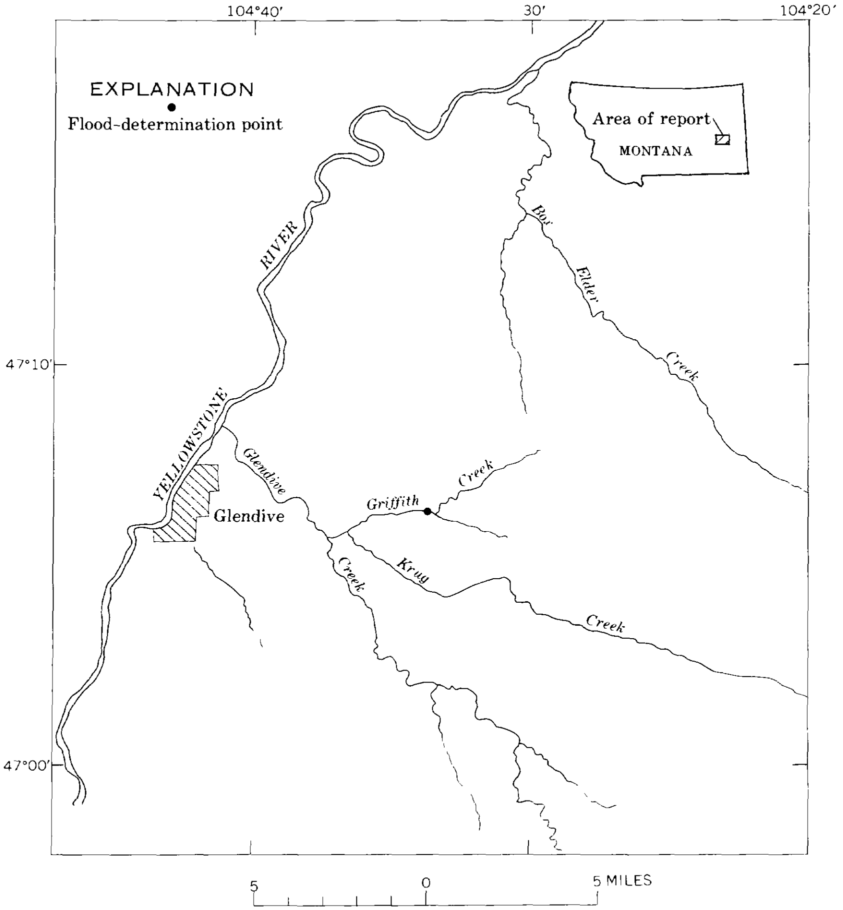

FIGURE 26.—Location of flood-determination point, flood of June 15 near Glendive, Mont.

Extensive road damage and erosion occurred during the flood runoff. Damage to county road bridges was estimated at $27,000 and, in addition, several drainage structures on Interstate Highway 94 were severely damaged. The Soil Conservation Service estimated $60,000 loss of crops and livestock. Two persons were drowned by a sudden surge of water in an unnamed coulee.

One determinatoon of peak flow, a slope-area measurement at a bridge on Interstate Highway 94, 8 miles east of Glendive, was made in the flood area. The peak discharge of 14,600 cfs (942 cfs per sq mi in a drainage area of 15.5 sq mi) greatly exceeds any previously known flood in this area. The previous maximum discharge at the measurement site during the period of record (1955–65) was 157 cfs. It is believed that the discharge per square mile from a large part of Box Elder Creek drainage was equally as great.

The magnitude of this flood is indicated by accretion of flow in the Yellowstone River. From June 15 to June 16, the daily mean discharge of the Yellowstone River at Sidney, 50 miles northeast of Glendive, increased more than 28,000 cfs. A study of weather records and tributary inflow indicates this rise was largely due to flows contributed from the Glendive flood area. The unusually high peak discharge at the site of the slope-area measurement is apparent when it is compared with the 50-year flood, which is 1,100 cfs (Patterson, 1968).

FLOODS OF JUNE IN THE SOUTH PLATTE RIVER BASIN, COLORADO

Heavy, intense rains in three areas on 3 different days caused outstanding floods on many streams in the South Platte River basin from Plum Creek, just south of Denver, all the way downstream to the Colorado-Nebraska State line (fig. 27). The flood-producing storms followed a relatively wet period, and rainfall up to 14 inches in a few hours was reported. The storms occurred over the Greeley-Sterling area on June 14–15, over the Plum and Cherry Creek basins on June 16, and over the headwaters of Kiowa and Bijou Creeks on June 17 after heavy rains on June 15. The flood crest did not pass Julesburg, in the northeast corner of Colorado, until June 20.

Previous record high discharges on many tributaries having drainage areas on the plains were exceeded, sometimes several fold. The six principal tributaries carrying snowmelt runoff were contributing but not significant factors in the causes of the floods. The attenuation of the peak flow by channel storage as the flood passed through Denver was considerable, yet the peak discharge of 40,300 cfs of the South Platte River at Denver was 1.8 times the previously recorded maximum of 22,000 cfs in a period of record that started in 1889. The 1965 peak would have been higher except that all flow from Cherry Creek was stored in Cherry Creek Reservoir.

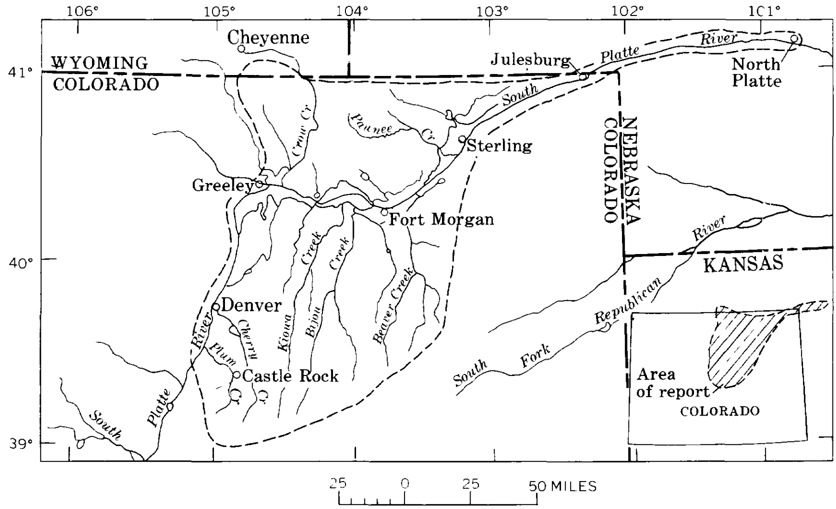

FIGURE 27.—Flood area in June in the South Platte River basin, Colorado.

Six persons were drowned, and two other deaths were attributed to the storms. The total damage amounted to $508.2 million, of which about 75 percent occurred in the Denver metropolitan area.

These floods are described in detail by Matthai (1969). The report contains descriptions of the storms and floods, detailed streamflow records at 50 sites, and information on damages, flood profiles, inundated areas, and flood frequency. Several comparisons of the magnitude of the flood are made, and all indicate that an outstanding hydrologic event occurred.

FLOODS OF JUNE IN THE ARKANSAS RIVER BASIN, COLORADO, KANSAS, AND NEW MEXICO

Major floods occurred June 16–18 on the Arkansas River and its principal tributaries from Pueblo, Colo., to Great Bend, Kans, and on the Canadian River in New Mexico (fig. 28). The floods were caused by torrential rains on June 14–18 which followed a relatively wet period. The greatest 24-hour total rainfalls at Weather Bureau stations were 11.08 inches at Holly, Colo., and 5.60 inches at Raton, N. Mex. Peak discharges at many tributary gaging stations exceeded the previous maximums in their periods of record. However, on the main stem of the Arkansas River, the floods of 1921 remain the maximum of record. It was estimated that 428,460 acres of land was flooded in the Arkansas River basin in Colorado and Kansas and that the damage was $57,283,000. The most severely damaged area was in Prowers County, in southeastern Colorado, where 31,500 acres of land along the Arkansas River, including the urban areas of Lamar, Granada, and Holly, was flooded, and damage amounted to $18,431,000.

Fourteen lives were lost in Colorado and Kansas as a result of the floods.

In New Mexico, flood damage was estimated at nearly $4 million, and two lives were lost. Two separate flood peaks occurred on the Canadian River above Conchas Reservoir near Conchas Dam, N. Mex. The runoff from these floods was retained in Conchas Reservoir, and no floodwater was released during the flood.

These floods are described in detail by Snites and Larimer (1970). The report contains descriptions of the storm and floods, detailed streamflow records at 126 sites, and information on damage, storage regulation, flood frequencies, and previous floods. A summary table gives the peak stages and discharges at flood-determination points for the floods of June 1965 and for the previous maximum floods of record.

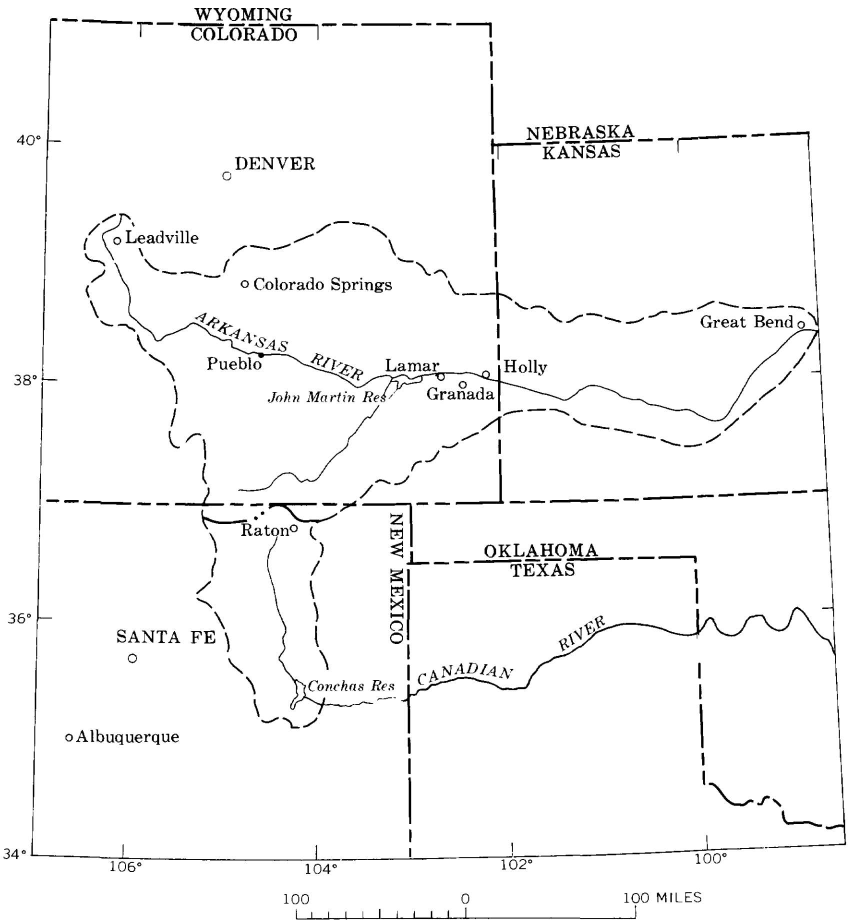

FIGURE 28.—Flood area in June in the Arkansas River basin, Colorado, Kansas, and New Mexico.

FLOODS OF JUNE 17–18 IN THE RIO HONDO VALLEY, SOUTHEASTERN NEW MEXICO

After ARDEN D. HAEFFNER (1967)

On June 17–18, severe flooding occurred in the Rio Hondo valley and in tributary valleys west of Roswell in southeastern New Mexico. The floods resulted from intense rainfalls in the upper reaches which moved downstream. Precipitation extended from Ruidoso to Picacho in an area approximately parallel to and centered over Rio Ruidoso (fig. 29). The greatest rainfall occurred in the vicinity of Ruidoso where an official measurement of 5.11 inches and an unofficial measurement of 8.0 inches were made. Rainfall was light in the upper Rio Bonito valley. In the lower part of the Rio Bonito valley near Hondo, the Soil Conservation Service reported 4.78 inches and 5.36 inches in two recording rain gages. The maximum storm duration at any point was 3 hours or less, and within 6 hours about 200 sq. mi. received 3 or more inches of rainfall.

Between Two Rivers Reservoir and Hondo the topography is rolling hills covered with sparse desert-type vegetation. West of Hondo, where most of the rainfall occurred, the terrain is mountainous and has cover ranging from heavy coniferous forest at higher altitude to juniper and piñon at the lower altitudes.

As the storm front moved downstream nearly simultaneously with the flood wave, it tended to compound the discharge and caused peaks that were unequaled within the memory of residents in the valley. In the unusual runoff pattern of this flood, the peaks from the tributary streams coincided with the flood wave of the main stream as it passed their respective mouths. A peak discharge of 1,340 cfs (table 22) occurred on Rio Ruidoso at Hollywood (sta. 1) at 1540 hours on June 17. As the peak moved downstream, through 26 miles of channel, it was supplemented by tributary inflow and by sheet inflow that caused a peak discharge of 42,700 cfs at about 1800 hours on Rio Ruidoso at Hondo (sta. 7). Rio Bonito joins Rio Ruidoso near Hondo to form Rio Hondo. The flow from Rio Bonito, Chaves Canyon, Alamo Canyon, and sheet inflow combined with the flow of Rio Ruidoso to cause a peak discharge in Rio Hondo at Picacho (sta. 14) of 115,000 cfs, which is about five times as great as the 50-year flood for this station. In the 30-mile meandering river reach from Picacho to the Diamond A Ranch, the peak discharge was reduced to 54,800 cfs at 0040 hours on June 18. This large reduction resulted from channel storage and subsurface infiltration.

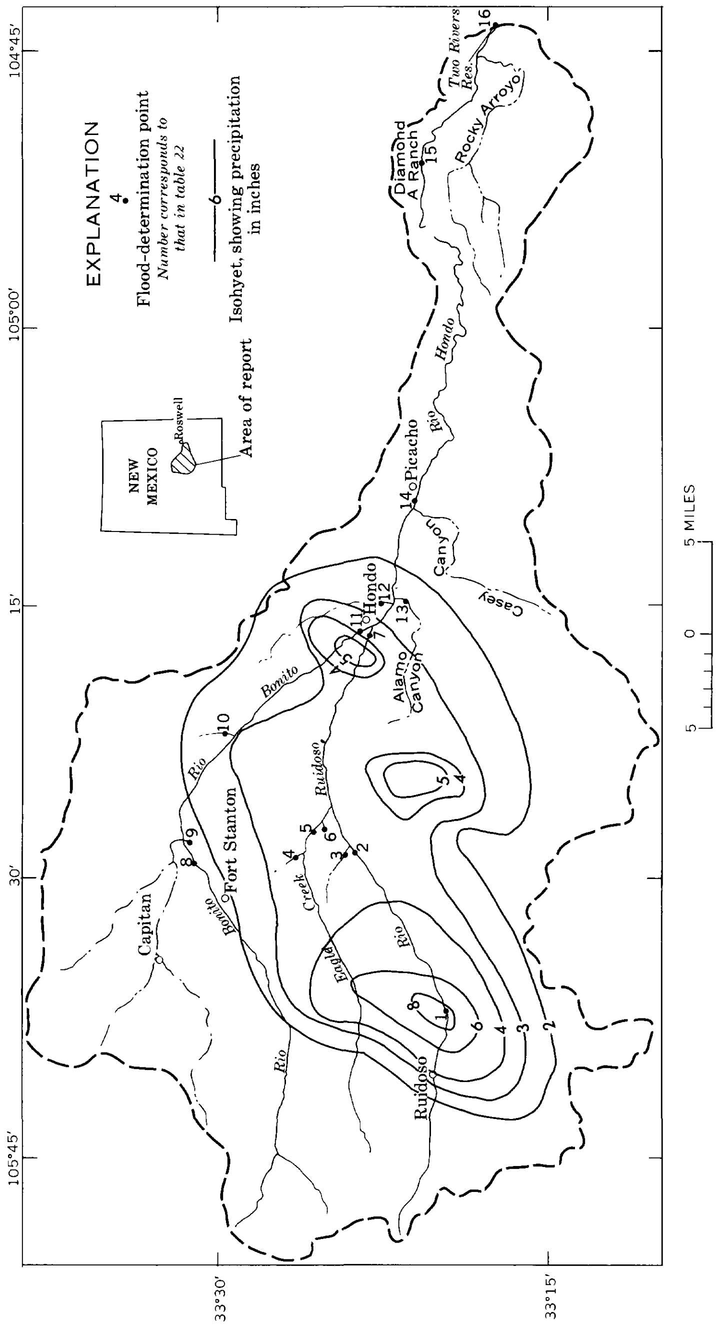

FIGURE 29.—Location of flood-determination points and isohyets for June 17, floods of June 17–18 in the Rio Hondo Valley, N. Mex.

TABLE 22.—*Flood stages and discharges in the Rio Hondo basin, June 17–18, in the Rio Hondo valley, southeastern New Mexico*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before June 1965: Period	Known before June 1965: Year	June 1965	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence interval (years)
1	Rio Ruidoso at Hollywood	120	1941	1941		[1] 11.50	(2)	
			1953–65	1957		7.80	1,070	
					17	9.05	1,340	3
2	Rio Ruidoso at Buckhorn Courts near Glencoe.	169			17		7,920	28
3	Silva Canyon near Glencoe	3.0			17		2,940	(2)
4	Devils Canyon near Glencoe.	.8			17		1,740	(2)
5	Eagle Creek near Glencoe	26.6			17		2,700	16
6	Devils Canyon at Glencoe	60			17		16,200	[3] 2.5
7	Rio Ruidoso at Hondo	290	1931–65	1941		21.13	[1] 12,400	
					17	24.4	42,700	[3] 3.2
8	Rio Bonito near Fort Stanton.	85	1956–65	1957		6.69	(2)	
					17	6.35	(2)	(2)
9	Rio Bonito tributary near Fort Stanton.	.72	1955–65	1955		4.80	240	
					17	4.63	(2)	(2)
10	Rio Bonito tributary near Hondo.	1.2			17		850	(2)
11	Rio Bonito at Hondo	[4] 295	1931–65	1941		20.92	[5] 11,000	
					17	21.1	28,200	[3] 2.0
12	Chaves Canyon near Tinnie.	46.4			17		5,710	[3] 1.1
13	Alamo Canyon near Tinnie	54.6			17		38,400	[3] 6.0
14	Rio Hondo at Picacho	715	1941	1941		30	(2)	
			1954	1954		18.1	6,600	
			1957–65	1958		13.30	3,510	
					17	26.9	115,000	[3] 5.0
15	Rio Hondo at Diamond A Ranch near Roswell.	[4] 947	1940–65	1941		28.78	[5] 27,000	
					18	26.4	54,800	[3] 2.0
16	Two Rivers Reservoir near Roswell.	1,030	1964–65	1964		[6] 3,969	[6] 742	
						[8] 3,953.1	[7, 8] 466	
					18		[7] 7,400	

[1] Probably greatest since at least 1904.
[2] Unknown.
[3] Ratio of peak discharge to 50-year flood.
[4] Contributing area.
[5] Greatest since about 1900.
[6] Rio Hondo Reservoir.
[7] Contents, in acre-feet.
[8] Rocky Arroyo Reservoir.

All the floodwater in Rio Hondo was intercepted and easily contained in the Two Rivers flood-control reservoir, constructed and maintained by the Corps of Engineers. The reservoir was empty before the storm, and it could have retained and released twice the floodflow of June 1965 without endangering areas downstream. The maximum storage in the reservoir was 7,400 acre-feet at 1500 hours on June 18, and the maximum release was 750 cfs. The Corps of Engineers stated that controlling the flow of Rio Hondo in the Two Rivers Reservoir prevented an appreciable amount of flood damage in the Roswell area.

Most of the towns in the valley are above the flood plain and therefore had little damage. Damage in agricultural areas, which received the full force of the flood, was high because the flood occurred after the land was planted and when the orchard trees were in full foliage. About 3,000 acres of irrigated land was flooded, and about 300 acres of orchards was destroyed. Owing to sediment deposition, 1,000 acres of irrigated land required releveling. Many rural structures, much farm equipment, and many irrigation facilities were demolished, and about 75 head of livestock were lost. Several miles of road repairs were necessary, and at least 10 bridges needed repair or replacement. The following table of flood damage was furnished by the Corps of Engineers:

Type of damage	*Losses*
Urban and suburban	$170,000
Rural	954,000
Transportation facilities	260,000
Business	426,000
Emergency costs	40,000
Total	1,850,000

FLOODS OF JULY IN NEBRASKA

By H. D. Brice

Intense precipitation caused exceptionally high discharges on five Nebraska streams during July 1965. The recurrence intervals for the peak discharges are all greater than 50 years.

Flooding on July 3 in the upper part of the Elm Creek drainage basin in eastern Dawson County (fig. 30) resulted from a localized

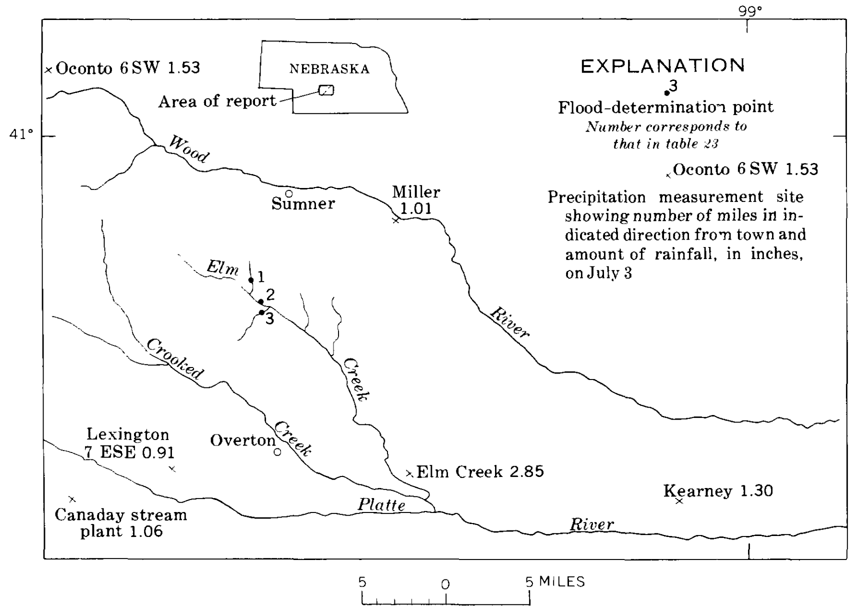

FIGURE 30.—Location of flood-determination points and precipitation stations, floods of July 3 in south-central Nebraska.

high-intensity storm that culminated several days of widespread general rain. Precipitation began on June 28 and continued until July 3, when 3 inches fell in a 3-hour period at the Weather Bureau rain gage in the village of Elm Creek. The village is about 13 miles downstream from the three gaging stations where peak discharges were measured (table 23). The amount of rainfall on July 3 at surrounding rain gages is given in figure 30. It is not known whether the amount of rain that fell on the basin above the gaging stations was greater or less than that at the village. The recurrence interval of a 3-inch rainfall in 3 hours at this site is about 25 years, according to the U.S. Weather Bureau (1961).

The peak discharges at all three gaging stations were maximum during the 15-year period of record. That on Elm Creek near Sumner (sta. 2) was about 6 times the previous maximum peak and had a recurrence interval much greater than 50 years. The peak discharges on the tributaries that enter Elm Creek about 1 mile upstream (sta. 1) and 0.5 mile downstream (sta. 3) from station 2 were from about 1½ times to 2 times that of the previous maximum discharges and had recurrence intervals of more than 50 years. Damage from the flood was slight and consisted mostly of bank and streambed erosion.

Rock Creek in south-central Dundy County (fig. 31) flooded on July 3 and 5, each time following cloudburst-type rainfall. After the first downpour, a few local residents reported that their rain gages indicated about 8 inches, and several others reported that their 5-inch-capacity gages had overflowed. The second storm not only dumped another 3 inches on the already wet ground but was accompanied by hail that caused much damage to crops.

TABLE 23.—*Flood stages and discharges, July, in Nebraska*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before July 1965: Period	Known before July 1965: Year	July 1965	Gage height (feet)	Discharge: Cfs	Discharge: Ratio to Q_{50}
	Platte River basin							
1	Elm Creek tributary near Overton	0.54	1951–65	1958		13.59	142	
					3	13.74	206	1.32
2	Elm Creek near Sumner	14.9	1951–65	1958		14.41	271	
					3	14.76	1,660	2.55
3	Elm Creek tributary No. 2 near Overton	5.19			3	[1]14.63	679	1.64
			1951–65	1961		13.13	307	
	Kansas River basin							
4	Rock Creek at Parks	180	1940–65	1962		4.57	110	
		[2]14			3	5.48	390	1.44
					5	6.00	493	1.84
5	Big Blue River at Surprise	345			19	11.52	10,900	1.15

[1] Datum changed; relation to previously published records unknown.
[2] Contributing drainage area.

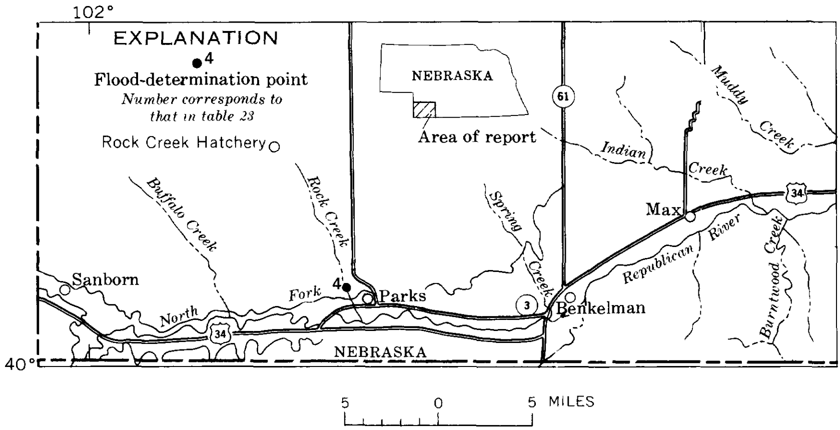

FIGURE 31.—Location of flood-determination point, flood of July 3 and 5 in southwestern Nebraska.

Considerable damage resulted from the flood. All roads leading to Parks, a village near the mouth of Rock Creek, were inundated, and water flowed knee deep through the town. Several sections of ranch fences were washed out, and poultry and many swine drowned. State Highway 3 near Parks was damaged, and new roadfill northwest of Parks was breached when floodwaters washed out the metal culverts and scoured a wide gap in the fill.

The peak discharges of the July 3 and July 5 floods were about 3.6 and 4.5 times the previous maximum discharge during the 25-year period of record. Each peak had a recurrence interval of more than 50 years.

The Big Blue River flood at Surprise in southwestern Butler County (fig. 32) on July 19 was caused by precipitation that, according to official and unofficial observations, ranged from about 2.5 to 7.5 inches on July 18 and 19. It was the most severe flood in the memory of local residents. About a dozen families were evacuated from their homes along the river in Surprise, and damage to crops in the vicinity was considerable. When the crest passed through Surprise in the early morning of the 19th, water was about 1 foot deep on the bridge floor or slightly more than 1 foot higher than the highest stage previously recorded at that site. The peak discharge (table 23) was more than that of a 50-year flood.

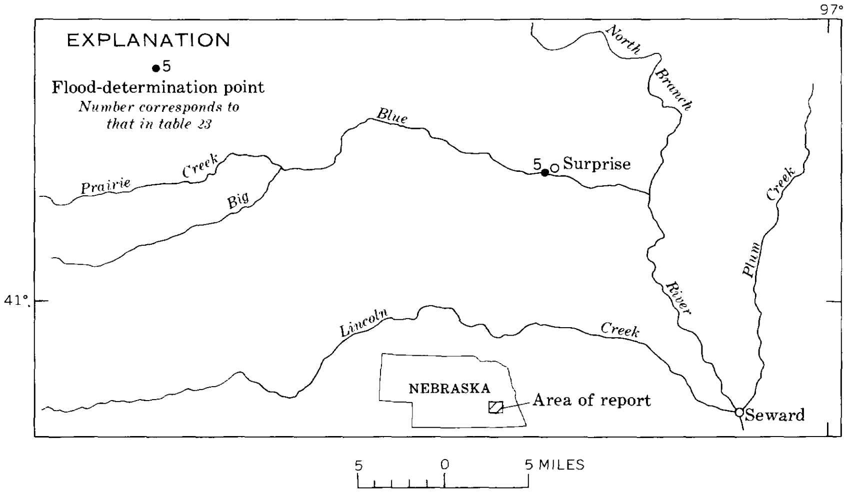

FIGURE 32.—Location of flood-determination point, flood of July 19 in southeastern Nebraska.

FLOODS OF JULY 18–23 IN NORTHWESTERN MISSOURI

By JAMES E. BOWIE

Outstanding floods occurred July 18–23 in Missouri on Missouri River tributaries in an area extending from the Iowa-Missouri State line on the north to the Blackwater River basin on the south and to the Grand River basin on the east (fig. 33). Floodwaters from these tributaries caused extensive flooding on the Missouri River from St. Joseph to its mouth near St. Louis. Data in this section are abstracted from a report by Bowie and Gann (1967).

The floods were due to torrential rains during July 17–20. Storm totals of more than 20 inches were reported at Rockport and Edgerton. Little Platte River at Smithville (sta. 22) crested 7.4 feet higher than any previously known flood. The crest on Platte River near Agency (sta. 14) was 4.6 feet higher than any previously recorded since records began in 1924. Nine lives were lost, 15 communities suffered damages, and thousands of acres of croplands were flooded.

Total precipitation for the storm of July 17–20 is shown on the isohyetal map of northwestern Missouri (fig. 34). The lines represent average amounts in areas where numerous supplemental observations were reported. Mass rainfall graphs (fig. 35) were plotted from selected recording rain-gage charts. These graphs were grouped by area and indicate time and duration of rainfall. The average rainfall over a 400-sq mi area, in 24 hours, was almost two times the amount expected for the 100-year rainfall.

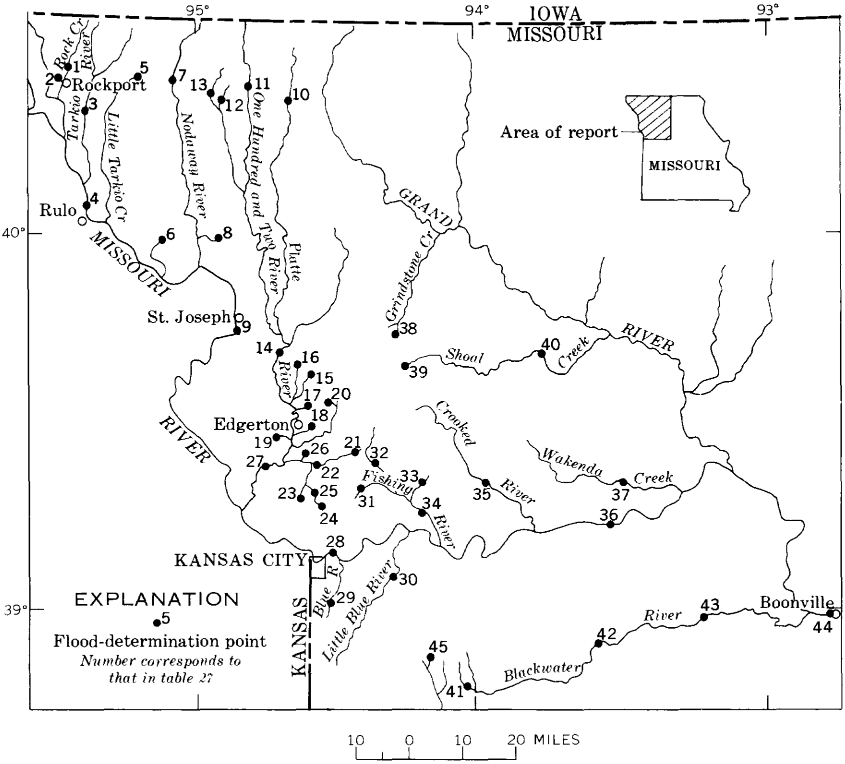

FIGURE 33.—Location of flood-determination points, floods of July 18–23 in northwestern Missouri.

The greatest rainfall amounts observed at official Weather Bureau stations were in an area immediately north of Kansas City and in the basins of the lower Platte and Little Platte Rivers. Nearly 11 inches of rain, substantially all of which fell in the 24-hour period of July 19, was recorded near Gower. The Weather Bureau 8-inch nonrecording rain-gage station at Edgerton reported a storm total of 20.23 inches, of which 18.18 inches was for the 24-hour period ending on the morning of July 20.

Estimated flood damage figures, furnished by the Corps of Engineers, are summarized in tables 24–26, which list respectively, urban property units flooded, urban damage, and rural damage. The total damage amounted to about $24 million of which about $5 million was concentrated in urban communities within the storm area, and about $19 million occurred in rural areas. At least 729 residences, 194 busi-

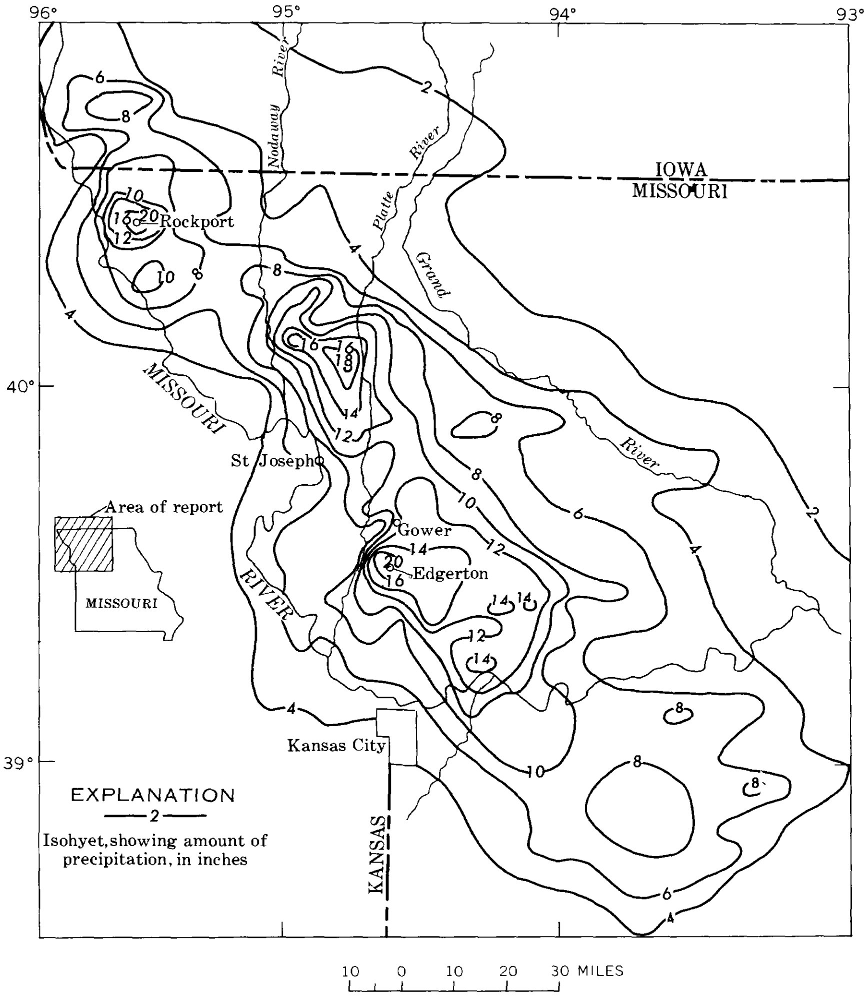

FIGURE 34.—Total precipitation for storm of July 17–20 in northwestern Missouri. Based on climatologic and hydrologic network records supplemented by about 200 unofficial reports. From U.S. Weather Bureau.

nesses, and 27 public and quasi-public buildings were damaged or destroyed in the 15 flooded communities. An estimated 433,700 acres of agricultural lands was flooded, including 281,700 acres along the Missouri River from above St. Joseph to the mouth and 152,000 acres along tributaries in the storm area. These figures do not include acreage flooded in the Rock Creek basin.

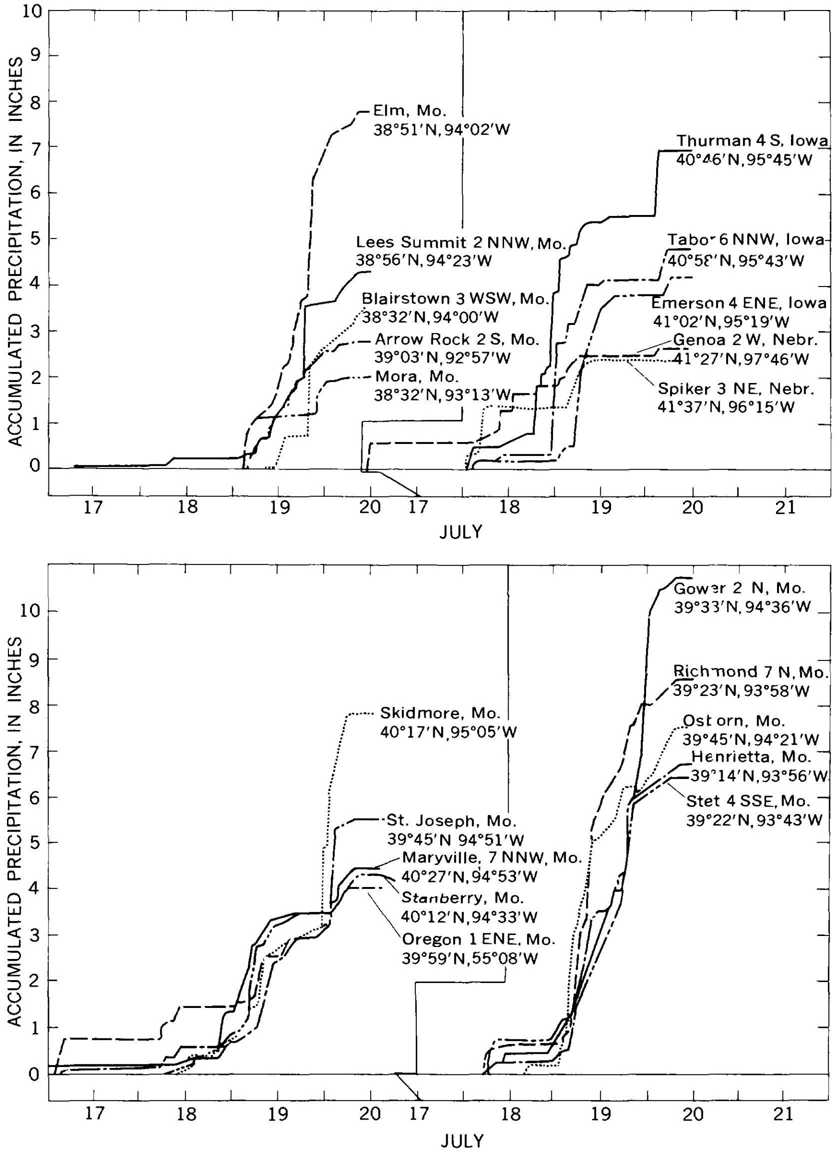

FIGURE 35.—Accumulated rainfall for storm of July 17–20 in northwestern Missouri and adjacent areas. Location of precipitation measurement sites given as number of miles in indicated direction from town. From U.S. Weather Bureau.

TABLE 24.—*Urban property units flooded in northwestern Missouri, July 1965 flood*

Basin and community	Population (1960 census)	Residences	Businesses	Public and quasi-public
Rock Creek:				
Rockport	1,310	100	40	(1)
Dillon Creek:				
Amazonia	326	8	5	
Line Creek:				
Riverside and Northmoor	2,011	49	12	1
Platte River:				
Rosendale	234	17	8	1
Agency	240	34	5	4
Edgerton	449	35	6	
Smithville	1,254	200	67	8
Tracy	208	30	6	3
Farley	120	8	4	1
Easton	198	3		
Fishing River:				
Excelsior Springs	6,473	68	28	4
Mosby	293	95	9	4
Crooked River:				
Hardin	727	77	4	1
Henrietta	497	4		
Blackwater River:				
Sweet Springs	1,452	1		
Total	15,792	729	194	27

[1] Not available.

TABLE 25.—*Urban damage in northwestern Missouri, July 1965 flood*

Basin and community	Residential	Business	Public and quasi-public	Other [1]	Total
Rock Creek:					
Rockport	$140,000	$160,000	$300,000	$5,000	$605,000
Dillon Creek:					
Amazonia	24,400	5,200	9,200	100	38,900
Line Creek:					
Riverside and Northmoor	105,400	66,700	800	1,600	174,500
Platte River:					
Rosendale	31,800	14,600	3,000	100	49,500
Agency	83,200	8,800	12,400	1,100	105,500
Edgerton	109,700	10,100	25,200	2,400	147,400
Tracy	79,600	50,000	10,300	2,900	142,800
Smithville	1,079,900	1,295,600	250,100	171,600	2,797,200
Farley	11,000	11,200	1,200	200	23,600
Maryville			3,000		3,000
Gower			1,800		1,800
Easton	6,300		2,000		8,300
Total Platte River	1,401,500	1,390,300	309,000	178,300	3,279,100
Fishing River:					
Excelsior Springs	82,500	119,700	162,000	9,700	373,900
Mosby	298,200	101,200	31,300	23,300	454,000
Total Fishing River	380,700	220,900	193,300	33,000	827,900
Crooked River:					
Hardin	54,100	5,000	5,500	1,400	66,000
Henrietta	1,600		400		2,000
Total Crooked River	55,700	5,000	5,900	1,400	68,000
Blackwater River:					
Sweet Springs	2,300		10,600	100	13,000
Total urban damages	2,110,000	1,848,100	828,800	219,500	5,006,400

[1] Other includes utility damage, costs of temporary shelter, and minor items not included elsewhere.

TABLE 26.—*Rural damage in northwestern Missouri, July 1965 flood*

Stream	Acres flooded		Estimate of damages		
	Total	Crop	Agricultural	Transportation and utilities	Total
Rock Creek	(1)	----------	$149,000	$320 000	$469,000
Missouri River:					
Main stem	281,700	199,600	10,400,000	500 000	10,900,000
Little Tarkio Creek	8,800	8,500	466,500	2,400	468,900
Squaw Creek	12,700	5,100	364,400	1,300	365,700
Nodaway River	7,900	7,600	792,100	21,300	813,400
Platte River and minor tributaries	35,100	34,100	2,383,800	16,600	2,400,400
One Hundred and Two River	18,100	17,800	677,500	24,900	702,400
Little Platte River	9,200	9,000	354,900	12,500	367,400
Little Blue River	3,000	2,400	111,800	0	111,800
Fishing River	10,000	9,000	588,700	165,000	753,700
Crooked River	19,900	17,700	855,300	22,000	877,300
Wakenda Creek	3,300	2,900	182,700	2,000	184,700
Blackwater River	24,000	22,600	868,800	3 000	871,800
Total	433,700	336,300	18,195,500	1,091,000	19,286,500

[1] Not available.

The monetary damages assessed to the floodwaters cannot evaluate human suffering, misery, and inconvenience. Nine deaths were reported by the American Red Cross. The Corps of Engineers, the Red Cross, nearby communities, and many individuals assisted in evacuation of people and property, helped maintain temporary shelters, and provided aid following the flood.

Peak stages and discharges at 22 continuous-recording stations, seven crest-stage gages, and at 17 miscellaneous sites within the flood area are summarized in table 27. Index numbers in the table apply to the location map (fig. 33). Peak discharges are referred to recurrence interval and to a ratio to the 50-year flood. Peak discharges at 24 of the flood-measuring sites equaled or exceeded the 50-year flood discharge. At 10 of these sites the peak discharge was from 2 to 6 times as large as the 50-year flood. The highest known unit rate of runoff ever recorded in Missouri, about 6,690 cfs per sq. mi, occurred at Boney Branch at Rockport (sta. 2; drainage area, 0.76 sq mi). The discharge hydrographs in figure 36 were prepared from detailed data of discharges at gaging stations in the flooded basins.

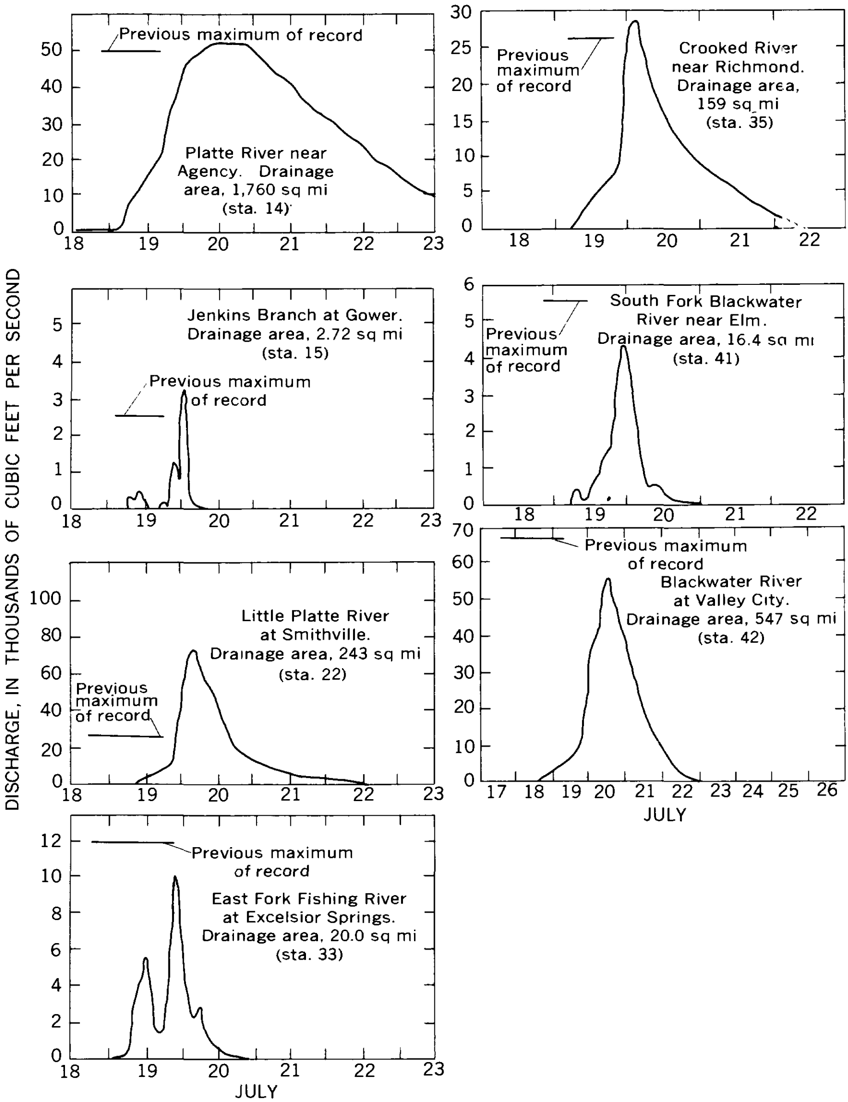

FIGURE 36.—Discharge at selected gaging stations, floods of July 18–23 in northwestern Missouri.

TABLE 27.—*Flood stages and discharges, July 18–23, in northwestern Missouri*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before July 1965: Period	Year	July 1965	Gage height (feet)	Discharge: Cfs	Recurrence interval (years)
	Rock Creek basin							
1	Rock Creek at Rockport	40.1			18		8,260	[1]1.1
2	Boney Branch at Rockport	.76			18		5,080	[1]6.0
	Tarkio River basin							
3	Tarkio River at Fairfax	508	1922–65	1929		22.33		
				1942			16,300	
					20	19.63	9,440	4
	Missouri River main stem							
4	Missouri River at Rulo, Nebr.	418,905	1949–65	1952		25.60	358,000	
					20	16.12	85,000	
	Little Tarkio Creek basin							
5	Staples Branch near Burlington Junction.	0.49	1959–65	1964		15.72	430	
					19	10.94	50	<2
	Mill Creek basin							
6	Mill Creek at Oregon	4.90	1951–65	1961		7.10	2,730	
					19	3.65	359	2
	Nodaway River basin							
7	Nodaway River near Burlington Junction.	1,240	1922–65	1947			32,000	
				1949		[2]19.69		
					19	8.4	7,120	2
8	Lincoln Creek near Fillmore	20.7			19		6,170	[1]1.2
	Missouri River main stem							
9	Missouri River at St. Joseph	424,300	1881	1881		27.2	370,000	
			1928–65	1952		26.82	397,000	
					20	18.22	119,000	
	Platte River basin							
10	Platte River at Ravenwood	486	1958–65	1960		[3]18.40	11,000	
					19	4.21	680	<2
11	One Hundred and Two River near Maryville.	500	1932–65	1947		21.20	14,200	
					19	11.20	2,520	<2
12	White Cloud Creek near Maryville.	6.06	1949–65	1949		13.41	4,100	
					19	10.63	1,030	5
13	Big Slough near Wilcox	1.30	1950–65	1964		6.43	1,040	
					19	3.33	320	3
14	Platte River near Agency	1,760	1924–30, 1932–65.	1947		30.46	50,000	
					20	35.05	53,000	50
15	Jenkins Branch at Gower	2.72	1950–65	1964		10.77	2,420	
					20	13.27	3,460	[1]2.0
16	Malden Creek near Gower	9.24			20		12,100	[1]3.7
17	Mitchell Branch near Edgerton.	1.56			19		3,490	[1]2.8

See footnotes at end of table.

TABLE 27.—*Flood stages and discharges, July 18–23, in northwestern Missouri*—Con.

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before July 1965: Period	Maximum floods: Known before July 1965: Year	Maximum floods: July 1965	Maximum floods: Gage height (feet)	Maximum floods: Discharge: Cfs	Maximum floods: Discharge: Recurrence interval (years)
	Platte River basin—Continued							
18	Grove Creek tributary near Edgerton.	1.03			19		2,770	[1] 2.8
19	Alger Creek at Camden Point.	2.36			19		3,000	[1] 1.9
20	Linn Branch tributary at Grayson.	.79			19		2,410	[1] 2.8
21	Camp Branch at Arley	9.78			19		5,430	[1] 1.6
22	Little Platte River at Smithville.	243	1947	1947		37.4	26,000	
			1964–65	1964		36.4	20,000	
					20	44.8	76,600	[1] 4.0
23	Second Creek at Linkville	9.99			19		10,000	[1] 2.9
24	First Creek near Nashua	.55	1959–65	1961		13.25	310	
					19	18.40	831	[1] 1.2
25	First Creek near Linkville	5.23			19		4,430	[1] 1.8
26	Little Platte River tributary near Smithville.	.44			19		1,270	[1] 2.0
27	Platte River at Platte City	2,400			20		114,000	[1] 1.8
	Missouri River main stem							
28	Missouri River at Kansas City.	489,200	1844	1844		38.0	625,000	
			1897–1965	1951		36.2	573,000	
					21	22.80	225,000	
	Blue River basin							
29	Blue River near Kansas City.	188	1935–65	1961		44.46	41,000	
					20	18.95	3,970	2
	Little Blue River basin							
30	Little Blue River near Lake City.	184	1948–65	1961		27.94	9,460	
					20	25.03	5,200	2
	Fishing River basin							
31	Fishing River near Roosterville.	24.7			19		13,500	[1] 1.6
32	Clear Creek near Kearney	29.4			19		17,900	[1] 1.9
33	East Fork Fishing River at Excelsior Springs.	20.0	1947	1947		[4] 23.7	([5])	
			1951–65	1951		15.3	12,000	
					19	16.05	10,500	[1] 1.4
34	Fishing River at Miltondale	238	1947	1947			32,000	
					20		80,200	[1] 2.7
	Crooked River basin							
35	Crooked River near Richmond.	159	1948–65	1951		28.8	27,000	
					20	30.70	29,000	[1] 1.2
	Missouri River main stem							
36	Missouri River at Waverly	491,200	1929–65	1951		[6] 28.20	549,000	
					22	26.80	276,000	

See footnotes at end of table.

TABLE 27.—*Flood stages and discharges, July 18–23, in northwestern Missouri*—Con.

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before July 1965: Period	Known before July 1965: Year	July 1965	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence interval (years)
	Wakenda Creek basin							
37	Wakenda Creek at Carrollton.	248	1948–65	1948, 1960			7,000	
				1951		[7] 23.4		
					21	22.90	5,500	2
	Grand River basin							
38	O'Neill Branch at Osborn	0.80	1955–65	1958		24.20	1,320	
					19	18.28	510	6
39	Shoal Creek near Turney	23.3			19		9,640	[1] 1.2
40	Shoal Creek near Braymer	391	1957–65	1964		29.05	[8] 26,000	
					22	26.00	8,600	2
	Lamine River basin							
41	South Fork Blackwater River near Elm.	16.4	1951	1951		14.8	([5])	
			1954–65	1960		12.0	5,600	
					19	11.12	4,610	13
42	Blackwater River at Valley City.	547	1958–65	1960			66,500	
				1961		31.75		
					20	31.38	[9] 57,000	[1] 1.4
43	Blackwater River at Blue Lick.	1,120	1922–33, 1938–65.	1928		41.25	54,000	
					23	37.50	26,000	5
	Missouri River main stem							
44	Missouri River at Boonville	505,700	1844	1844		32.7	710,000	
			1925–65	1951		32.82	550,000	
					23	26.05	253,000	
	Osage River basin							
45	West Branch Crawford Creek near Lees Summit.	0.80	1955–65	1960		15.57	839	
					19	15.73	900	20
	Missouri River main stem							
[10] 46	Missouri River at Hermann	528,200	1844	1844		35.5	892,000	
			1897–1965	1903			676,000	
				1951		33.33		
					24	25.40	256,000	

[1] Ratio of peak discharge to 50-year flood.
[2] Affected by backwater from ice.
[3] Outside gage reading, 18.8 ft.
[4] At right bank 200 ft. upstream from gage; floods of 1951 and 1965 reached stages of 20.0 and 19.7 ft respectively at the same site.
[5] Unknown.
[6] Peak stage occurred 2 days before peak discharge.
[7] Affected by backwater and overflow from Missouri River.
[8] Levee break; peak discharge occurred after crest and at stage of 28.0 ft.
[9] Occurred 5 hours before peak stage.
[10] This station is not shown in figure 33.

FLOODS OF JULY 23 IN THE VICINITY OF HILLSBORO, OHIO

After WILLIAM P. CROSS (1966)

Flash floods from small drainage areas caused by high-intensity rainstorms can be expected to occur in Ohio in almost any year. Although the floods may be annual events, they would rarely recur at any specific site. The rains that cause the intense floods are seldom measured by rain gages, and chances are small that the floods will occur at any established gaging station.

Rainfall data were collected following a cloudburst storm of July 22–23 near Hillsboro, Ohio, that was notable for an unusually high-intensity rainfall and for the large amounts accumulated. More than 10 inches of rain fell at some points during the storm.

A bucket survey was made by interviewing hundreds of local residents, and it produced adequate data to define an isohyetal map (fig. 37). A number of high-intensity cells are evident. More than 6 inches of rain fell on an area of about 140 sq mi. The intensity of the rain at the recording rain gage south of Hillsboro is illustrated by figure 38. The maximum rate was about 3 inches in 1 hour. Both the maximum point rainfall and the average storm rainfall exceeded the 100-year frequency for Ohio (U.S. Weather Bureau, 1961).

Peak discharges in streams in the storm area were relatively high (table 28). Before the storm of July 22–23, a serious drought persisted throughout the storm area, and it can be expected that the runoff produced from the storm would have been greater if normal soil-moisture conditions had existed.

Indirect measurements of discharge were made at eight sites on small streams that are tributary to the Scioto River. Frequencies can be computed for streams having about more than 20 sq mi of drainage area (table 28). The magnitudes of the peak discharges that can be computed are greater than 50-year floods before the peak in Rocky Fork was attenuated by storage in Rocky Fork Lake. The rate of increase in the contents of Rocky Fork Lake was extremely high. Calculations from the maximum rate of rise and from the capacity table gave an approximate peak inflow of 340 cfs per sq mi from 114 sq mi of drainage area. Storage of the floodwaters in the lake kept the outflow into Rocky Fork below flood stage.

Runoff from the storm of July 22–23 comprised most of the runoff for the month. The average storm rainfall above Rocky Fork Lake was about 6 inches and that above the Barretts Mills gage was about 5.5 inches. Runoff for July at the gage adjusted for storage changes in Rocky Fork Lake, was 2.66 inches. Runoff for July not associated with the storm of July 22–23 was of the order of only 0.1 inch. Thus, the ratio of runoff to storm rainfall was about 50 percent.

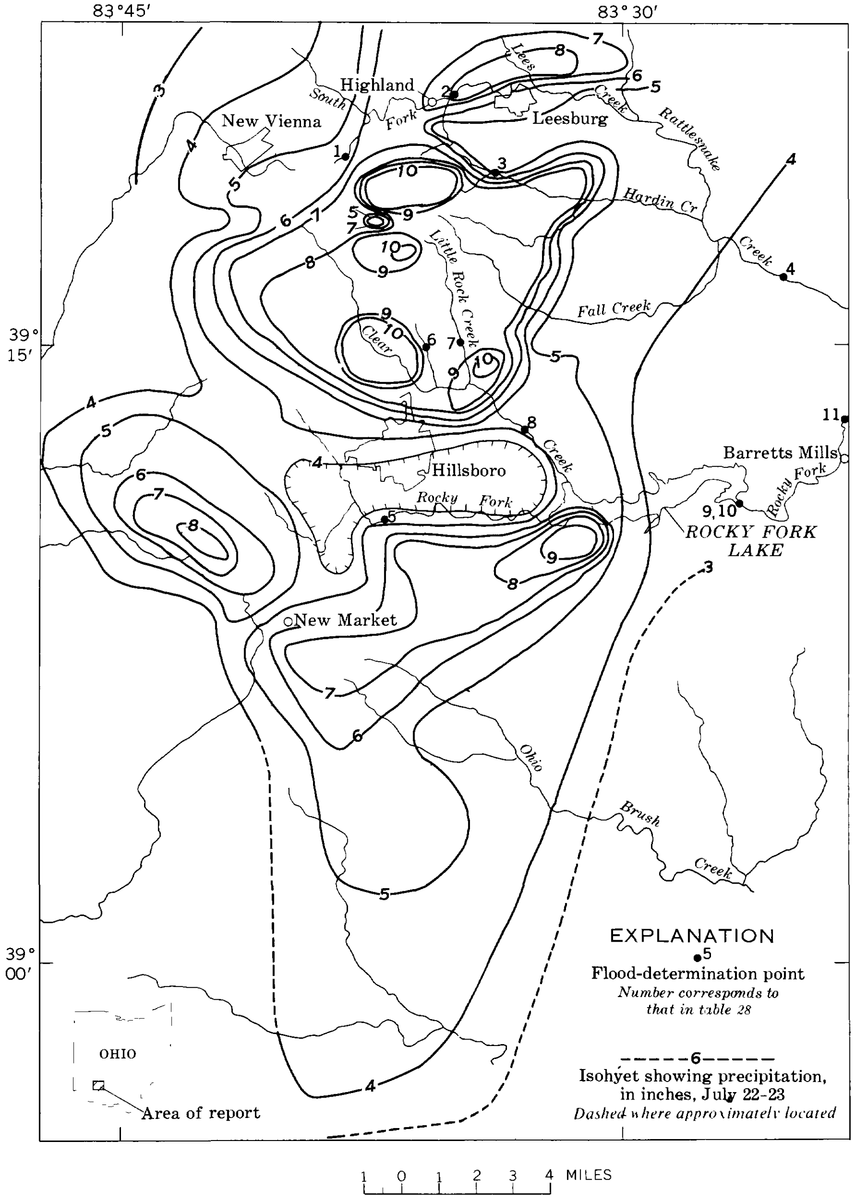

FIGURE 37.—Location of flood-determination points and isohyets for July 22–23 in the vicinity of Hillsboro, Ohio.

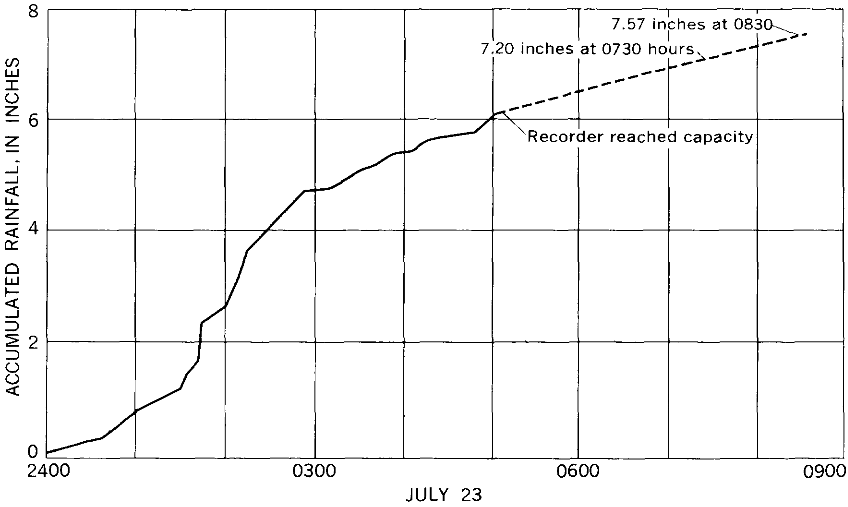

FIGURE 38.—Accumulated rainfall, in inches, at U.S. Weather Bureau station near Hillsboro, Ohio, July 23.

TABLE 28.—*Flood stages and discharges, July 23, in the Scioto River basin in the vicinity of Hillsboro, Ohio*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before July 1965: Period	Known before July 1965: Year	July 1965	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence interval (years)
1	Polk Cemetery Creek near New Vienna.	1.17			23		1,020	
2	South Fork Lees Creek near Highland.	19.7			23		7,200	[1] 3.13
3	Bridgewater Creek near Leesburg.	2.23			23		3,660	
4	Rattlesnake Creek near New Petersburg.	277			23		36,300	[1] 1.82
5	Rocky Fork near Hillsboro	15.8	1954	1954			6,520	
					23		4,680	
6	Clear Creek tributary at Hillsboro water-supply dam near Hillsboro.	.74	1954	1954		1.29	485	
					23	1.76	770	
7	Little Rock Creek near Hillsboro	3.32	1954	1954			2,520	
					23		4,100	
8	Clear Creek at U.S. Highway 50 near Hillsboro.	31.4			23		20,000	[1] 4.13
9	Rocky Fork Lake near Hillsboro.	114	1953–65	1964		36.13	[2] 50,680	
					23	35.05	[2] 48,040	
					23		[3] 38,800	[1] 3.3
10	Rocky Fork below Rocky Fork Dam near Hillsboro.	114	1953–65	1964		36.13	[4] 9,900	
					23	35.05	[4] 7,700	
11	Rocky Fork near Barretts Mills.	140	1940–65	1964		15.10	[4] 13,400	
					23	13.37	[4] 7,090	

[1] Ratio of peak discharge to 50-year flood.
[2] Contents, in acre-feet.
[3] Maximum rate of inflow to Rocky Fork Lake, based on maximum change of storage.
[4] Affected by storage.

Flood damage was widespread and extensive. Washout of a culvert on a stream draining less than 1 sq mi caused a train wreck on the Baltimore & Ohio Railroad near Highland. Most of the roads in the vicinity were closed because of washouts, and several bridges were washed out or seriously damaged. The bridge at the upper end of Rocky Fork Lake lost a center pier. The greatest damage was to road shoulders, pavements, and embankments. The Agricultural Stabilization and Conservation Service estimated costs for clearing fences, ditches, and levees at $144,000. Some cattle and sheep were lost. A small amount of corn and tobacco was washed out; however, this was estimated to have been less than 2 percent of the total crop. The stage of Rocky Fork Lake, although not the highest of record, was the highest during any summer recreation season, and this high stage was responsible for extensive damage to boats and docks. The Leesburg water-supply system was out of operation for a few days.

FLOOD OF JULY 24 IN SOUTHEASTERN KENTUCKY

By C. H. Hannum

The fact that two-thirds of the total rainfall for July in the Middlesboro area fell on July 23 and 24 caused severe flooding along tributary streams of Yellow Creek (fig. 39). Precipitation during June at Middlesboro was about 1.9 inches below the normal of 4.45 inches. Rainfall during the period July 1–22 totaled 4.84 inches. The Weather Bureau reported 7.16 inches of rainfall between midnight of July 23 and 0800 hours on July 24, of which 6.67 inches fell between midnight and 0400 hours at the recording precipitation station at Middlesboro. Local residents 4 miles north of Middlesboro reported catching up to 10 inches of rain in tubs. Heavy rainfall was also reported in the Bennetts Fork basin south of the Kentucky-Tennessee State line.

Extreme floods were confined to Bennetts Fork, Straight Creek, and Yellow Creek, and the most severe flooding occurred in the headwaters of Bennetts Fork and Straight Creek and their tributaries. For example, the peak discharge for Yellow Creek bypass at Middlesboro (sta. 2) was 1.4 times that of the 50-year flood, and the peak discharge for Yellow Creek near Middlesboro (sta. 3) had a recurrence interval of 50 years (table 29).

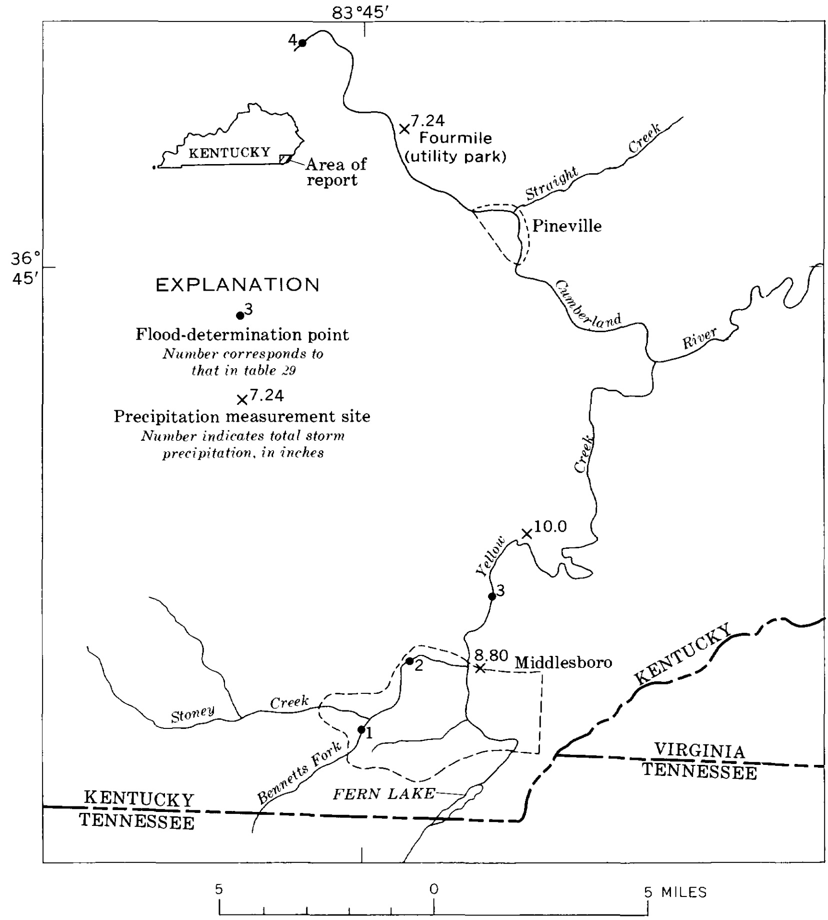

FIGURE 39.—Location of flood-determination points and precipitation sites, flood of July 24 in southeastern Kentucky.

Floodwaters backed up in Yellow Creek into Middlesboro and flooded some of the business district. The Corps of Engineers estimated damage in Middlesboro as follows:

Type of damage	*Losses*
Business	$25,000
Dwellings (150)	30,000
Kentucky Utility Co	7,000
Southern Bell Telephone Co	3,500
Perma Pipe Co	30,000
Sewage system	1,000
Water Co	1,000
Total	97,500

TABLE 29.—*Flood stages and discharges in the Cumberland River basin, July 24, in southeastern Kentucky*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before July 1965: Period	Known before July 1965: Year	July 1965	Gage height (feet)	Discharge: Cfs	Discharge: Recurrence interval (years)
1	Bennetts Fork at bridge on State Highway 74 at Middlesboro.	13.5			24	97.89	3,300	[1]
2	Yellow Creek bypass at Middlesboro.	35.3	1941–65	1951		4.72	6,580	
					24	6.16	10,900	[2] 1.4
3	Yellow Creek near Middlesboro.	58.2	1929, 1939–65.	1946		20.92	6,160	
					24	20.77	11,400	50
4	Cumberland River near Pineville.	809	1929, 1938–65.	1957		49.31	57,900	
					24	28.54	17,500	<2

[1] Unknown.
[2] Ratio to 50-year flood.

Railroad structures and highways were damaged along Bennetts Fork and Straight Creek, and some dwellings were damaged or destroyed. There was no loss of life.

FLOODS OF JULY 24 IN THE VICINITY OF CLINCHMORE, TENN.

By WILLIAM J. RANDOLPH

An intense rainstorm occurred over a section of the rugged slopes of the Cumberland Mountains at the Anderson-Campbell County line (fig. 40) in the early morning of July 24. The most intense part of the storm covered about 25 sq mi along the divide between the Cumberland and the Tennessee River basins about 6 miles southwest of Lake City, and the maximum rainfall in this area occurred on the divide. There were no rain gages within the area of the greatest rainfall intensity; however, a bucket survey made by the Tennessee Valley Authority indicated rainfall amounts in excess of 12 inches, most of which fell within the 3-hour period from 0130 to 0430 hours on July 24. This is three times the amount of the 100-year 3-hour rainfall for this area (U.S. Weather Bureau, 1961). Rainfall gages about 15 miles north and northeast of the storm center recorded 4–5 inches.

The streams in the storm area are relatively small headwater streams having steep slopes. Hardest hit were Stony Fork and Graves Gap Branch on the western side of the divide. From information obtained by the TVA from local residents, peak stages occurred abruptly, the rate of rise on Stony Fork above Clinchmore (sta. 4) being about 10 feet in 15 minutes. The peak had moved from the headwater to the mouth by about 0430 hours.

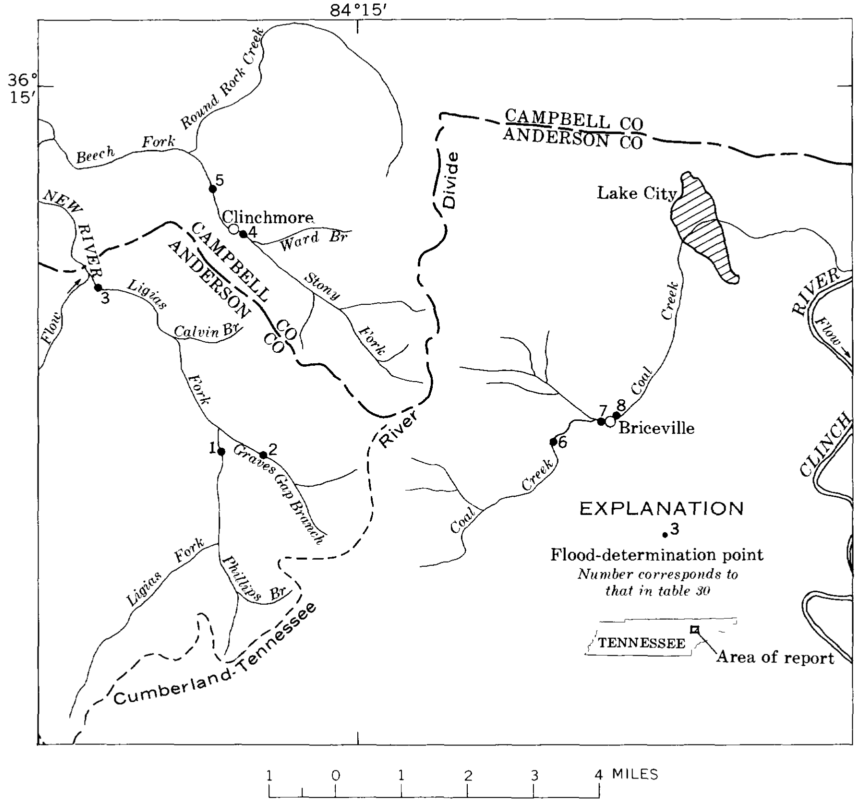

FIGURE 40.—Location of flood-determination points, floods of July 24 in the vicinity of Clinchmore, Tenn.

There are no stream-gaging stations in the area of heaviest runoff. Eight indirect measurements of peak discharge were made at miscellaneous sites by the Geological Survey and by the TVA (table 30). The sites at which peak discharges were determined are shown in figure 40. The most outstanding flood (1,940 cfs per sq mi from an area of 6.34 sq mi) occurred on Stony Fork above Clinchmore.

Damage from the flood was limited by the sparse settlement in this rugged country. However, almost everything in the narrow valleys was damaged. Several bridges were washed away, roads were damaged by washouts or deposition of debris, and several automobiles were demolished. Five persons drowned near Clinchmore when their house and several others were washed away. Several other houses were washed off their foundations or otherwise damaged. The railroad and the county road which paralled Stony Fork up to Clinchmore were

TABLE 30.—*Flood stages and discharges, July 24, in the vicinity of Clinchmore, Tenn.*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum discharge	
			Cfs	Cfs per sq mi
	Cumberland River basin			
1	Ligias Fork above Graves Gap Branch	8.99	3,430	382
2	Graves Gap Branch near mouth	3.16	3,890	1,230
3	Ligias Fork near mouth	20.4	9,750	478
4	Stony Fork above Clinchmore	6.34	12,300	1,940
5	Stony Fork below Clinchmore	7.67	13,500	1,760
	Tennessee River basin			
6	Coal Creek above Briceville	5.36	2,000	373
7	Slatestone Hollow Branch near mouth	3.66	500	137
8	Coal Creek at Briceville	10.3	2,500	243

completely destroyed. Tremendous amounts of rock, uprooted trees, and other debris were washed down the sides of the mountains and deposited in the streams and narrow valleys.

This flood is described in more detail by the Tennessee Valley Authority (1965).

FLOOD OF JULY 26 NEAR ECHO, OREG.

By D. D. HARRIS

A severe cloudburst on July 26 caused flash floods in a small area in western Umatilla County, Oreg., southeast of the town of Echo (fig. 41). The storm was centered over an area south of the Umatilla River near Nolin and extended into the upper Butter Creek basin. The resultant flash flood demolished a house at the mouth of Speare Canyon and swept away its six occupants. One person was drowned, and the others were injured. Flooding in Lane Canyon destroyed a Union Pacific Railroad bridge near the canyon mouth. Heavy erosion occurred throughout the cloudburst area. Considerable amounts of hay and wheat were flattened, washed away, or buried under layers of silt, rock, and other debris.

Local residents stated that most of the rain fell in about half an hour and was accompanied by much hail. The storm was most severe in the upper parts of the watersheds which are uninhabited; therefore, no measurements of precipitation intensities were made in these areas.

Extremely high peak discharges of the July 26 flood were measured by indirect methods at two sites: 28,500 cfs (5,650 cfs per sq mi from 5.04 sq mi) near the mouth of Lane Canyon and 14,600 cfs (635 cfs per sq mi from 23.0 sq mi) near the mouth of Speare Canyon. The degree of gully erosion indicated that the entire Lane Canyon drainage

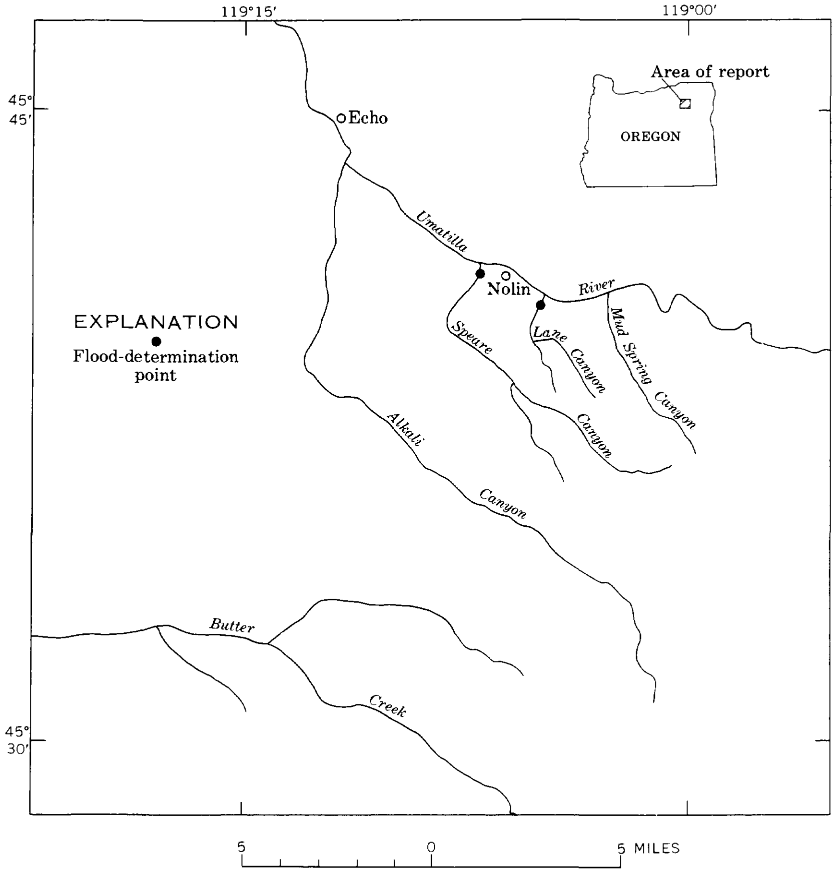

FIGURE 41.—Location of flood-determination points, floods of July 26 near Echo, Oreg.

basin had heavy runoff, whereas that in only a part of upper Speare Canyon drainage basin indicated heavy runoff. High flows also occurred in Mud Spring and Alkali Canyons and in Butter Creek (fig. 41), but they were not comparable in magnitude with those in Lane and Speare Canyons.

Recurrence intervals for the peak discharges in Speare and Lane Canyons were obviously high, although definite frequencies cannot be computed. The flood area is covered by a flood-frequency report (Hulsing and Kallio, 1964), but the report is not applicable to drainage areas less than 10 sq mi nor for recurrence intervals greater than 50 years. The extreme rarity of two such peak discharges in this area is illustrated by figure 42, which indicates the great ratio by which the discharges exceed 50-year floods.

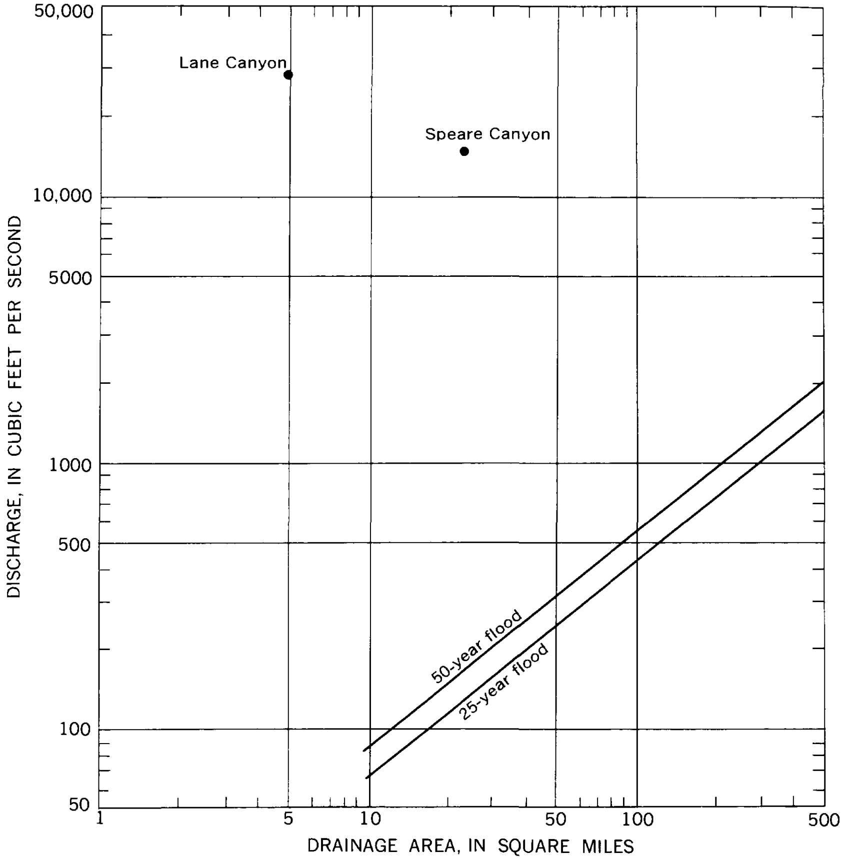

FIGURE 42.—Relation of peak discharges to 25- and 50-year floods, floods of July 26 near Echo, Oreg.

FLOODS OF AUGUST 22 IN THE YELLOWSTONE RIVER BASIN NEAR GREYCLIFF, MONT.

By MELVIN V. JOHNSON

Rain from a thunderstorm of 1-hour duration on August 22 caused flash floods in several small basins near Greycliff, Mont. (fig. 43). Unofficial reports of rainfall in the flood area ranged from 1.5 to 2.75 inches. Roads, culverts, and some private property were damaged by the flood runoff.

Indirect measurements of peak discharge were made at three sites. At site 1 the peak flow was obtained by combining the computed flow through a culvert with the computed flow over the road. At sites 2 and 3 the road was not overtopped, and peak discharges were obtained by computation of flow through culverts. Table 31 shows the flood stages

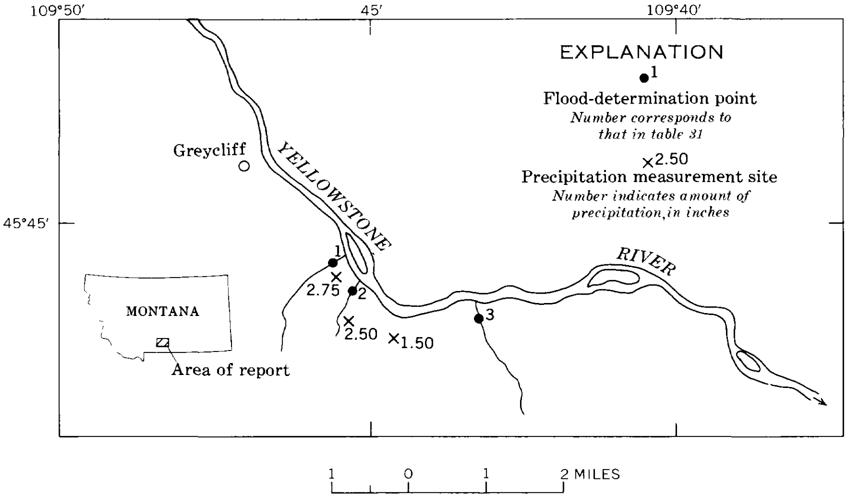

FIGURE 43.—Location of flood-determination points and precipitation sites, floods of August 22 near Greycliff, Mont.

TABLE 31.—*Flood stages and discharges in the Yellowstone River basin, August 22, near Greycliff, Mont.*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before August 1965 — Period	Known before August 1965 — Year	August 1965	Gage height (feet)	Discharge (cfs)
1	Overfeld Gulch near Greycliff	5.32			22		1,070
2	Yellowstone River tributary 6 near Greycliff.	1.03			22		577
3	Yellowstone River tributary near Greycliff.	2.72	1960–65	1963		0.55	4
					22	2.31	48

and discharges and, for site 3, gives the comparative values for the previous highest flood of record. No previous peak discharges have been determined for sites 1 and 2. Present frequency data are not available for such small drainage areas in this geographic area.

FLOODS OF SEPTEMBER 1 IN NORTH-CENTRAL KENTUCKY

By C. H. HANNUM

Rainfall in north-central Kentucky was generally below normal before August 31. Rainfall on the last 14 days of August ranged from 1.09 inches at LaGrange and 1.31 inches at Lexington to 2.20 inches at Lockport, most of which fell on August 19 and 20. Streamflows were generally low during August.

The movement of severe thunderstorms northeastward across north-central Kentucky on late August 31 and early September 1 caused various degrees of flooding in a 50-mile-wide band on the south side of the Ohio River. Rainfall ranged from 1.68 inches at Lexington to 7.30 inches at Lockport, at the center of the storm (fig. 44).

Flood peaks were generally high on the small streams within the boundaries of the 4-inch isohyet of figure 44. Flat Creek near Frankfort (sta. 1) on the south side of the area of highest rainfall had its third highest peak for the period of record 1951–65 (see table 32). The runoff there was 693 cfs per sq. mi., whereas it was 161 cfs per sq. mi. on Little Plum Creek near Waterford (sta. 7), which lies near the 4-inch isohyet and has approximately the same drainage area as Flat Creek near Frankfort. Little or no property damage occurred as a result of the floods, although minor crop damage occurred along the low-lying flood plains of the smaller streams.

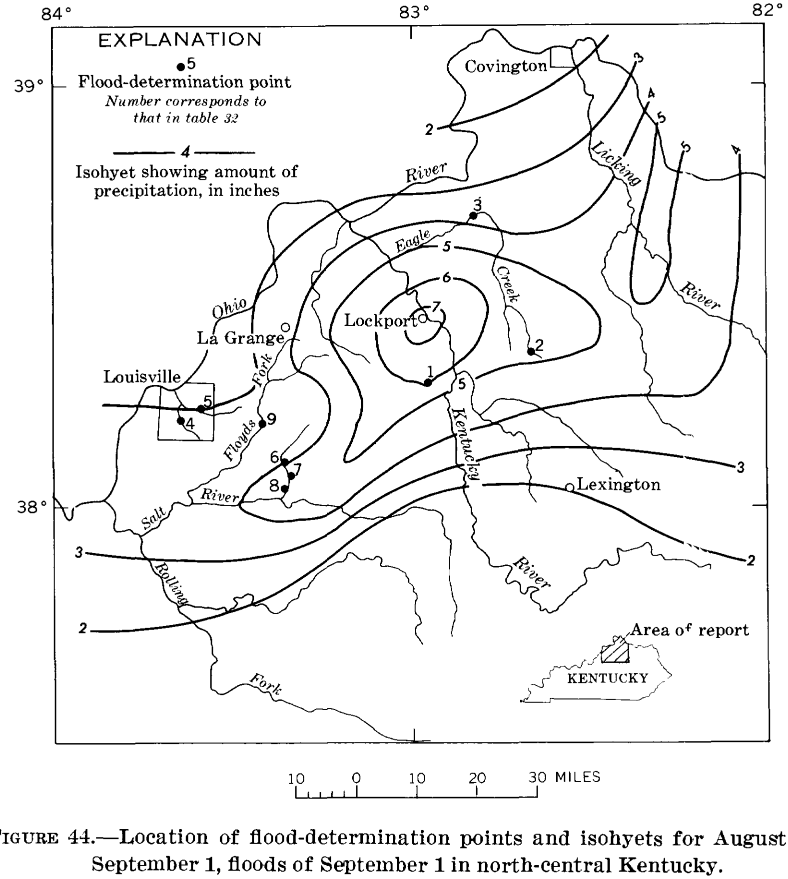

FIGURE 44.—Location of flood-determination points and isohyets for August 31–September 1, floods of September 1 in north-central Kentucky.

TABLE 32.—*Flood stages and discharges, September 1, in north-central Kentucky*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before September 1965: Period	Year	September 1965	Gage height (feet)	Discharge: Cfs	Recurrence interval (years)
	Kentucky River basin							
1	Flat Creek near Frankfort	5.63	1951–65	1955		11.50	7,100	
					1	10.68	3,900	(1)
2	Eagle Creek at Sadieville	42.9	1932	1932		22.0	(1)	
			1941–65	1943		21.96	9,870	
					1	12.12	3,730	<2
3	Eagle Creek at Glencoe	437	1913, 1915–20, 1928–31, 1937–65.	1964		26.05	58,200	
					1	17.20	19,500	<2
	Beargrass Creek basin							
4	South Fork Beargrass Creek at Louisville.	17.2	1943	1943		15.1	(1)	
			1939–40, 1944–65.	1964		14.17	4,940	
					1	9.60	1,680	(1)
5	Middle Fork Beargrass Creek at Cannons Lane, at Louisville.	18.9	1943	1943		8.1	(1)	
			1944–65	1964		6.6	3,920	
					1	4.47	1,150	(1)
	Salt River basin							
6	Plum Creek near Wilsonville	19.1	1954–65	1960		7.92	5,180	
					1	5.56	2,860	(1)
7	Little Plum Creek near Waterford.	5.15	1954–65	1960		6.12	3,810	
					1	3.78	831	(1)
8	Plum Creek at Waterford	31.8	1954–65	1960		11.84	13,200	
					1	7.52	6,580	50
9	Floyds Fork at Fisherville	138	1937, 1943	1937		16.8	(1)	
			1944–65	1964		15.25	24,800	
					1	11.79	8,680	3

1 Unknown.

FLOOD OF SEPTEMBER 30–OCTOBER 3 IN SOUTHWESTERN ALABAMA

By J. F. McCAIN

A system of squalls spawned by the remnants of tropical storm Debbie moved inland from the Gulf of Mexico across southwestern Alabama September 29–October 1 (fig. 45). Moderate to heavy rain covered a broad, area, but embedded in the general rainfall pattern were numerous intense thunderstorms, some of which caused record-breaking rainfalls in downtown Mobile.

In the 24-hour period beginning at 2100 hours on September 29, 16.85 inches of rain fell in downtown Mobile. This rainfall amount greatly exceeded the previous 24-hour rainfall record of 12.98 inches

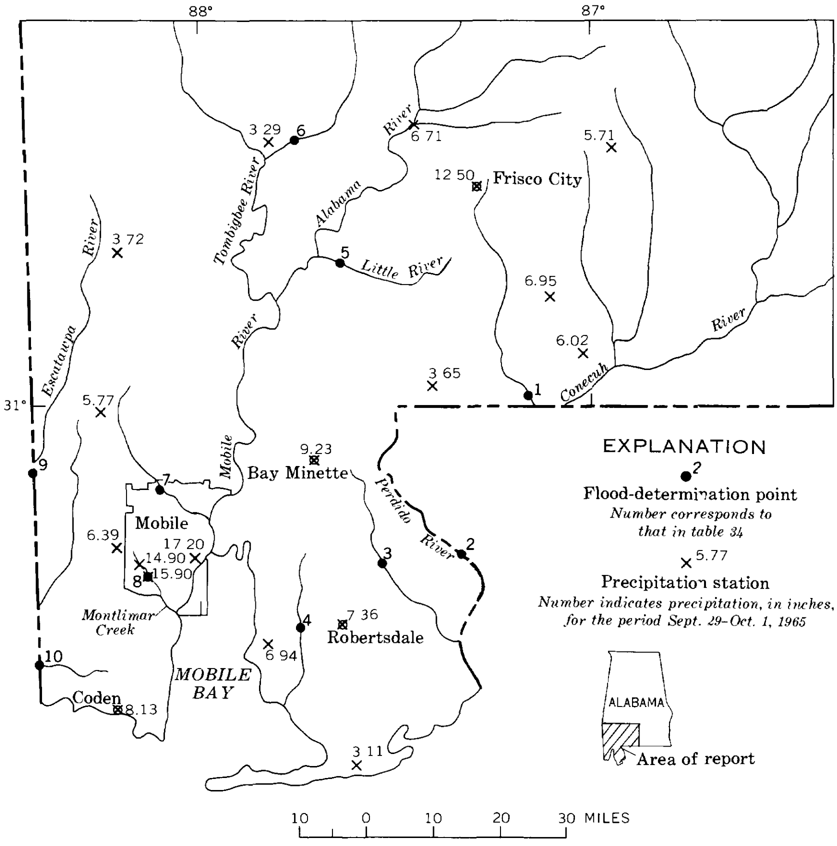

Figure 45.—Location of flood-determination points and precipitation sites, floods of September 30–October 3 in southwestern Alabama.

in June 1900. The Weather Bureau reported that 8.50 inches fell during a 3½-hour period in the early morning of September 30. A total rainfall of 17.20 inches was recorded at the downtown station during the 3-day period.

Other notable rainfall amounts for the 3-day period were 8.13 inches at Coden, 7.36 inches at Robertsdale, 9.23 inches at Bay Minette, and 12.50 inches at Frisco City. Rainfall amounts for these and several other locations are shown in figure 45.

Continuous records of rainfall were obtained by the Geological Survey at two rain gages on Montlimar Creek, about 5 miles west of the downtown area. Total rainfall at each station checks closely with the total measured in downtown Mobile; the continuous records can be used to illustrate rainfall frequency and duration for selected time periods during the storm.

A mass curve of rainfall for the gaging station on Montlimar Creek (sta. 8) at U.S. Highway 90 is shown in figure 46. Maximum rainfall amounts and intensities for selected durations during the storm are listed in table 33, and the intensities are plotted on a rainfall intensity-duration-frequency diagram for Mobile (fig. 47). The 24-hour rainfall of 15.9 inches greatly exceeds the 100-year rainfall.

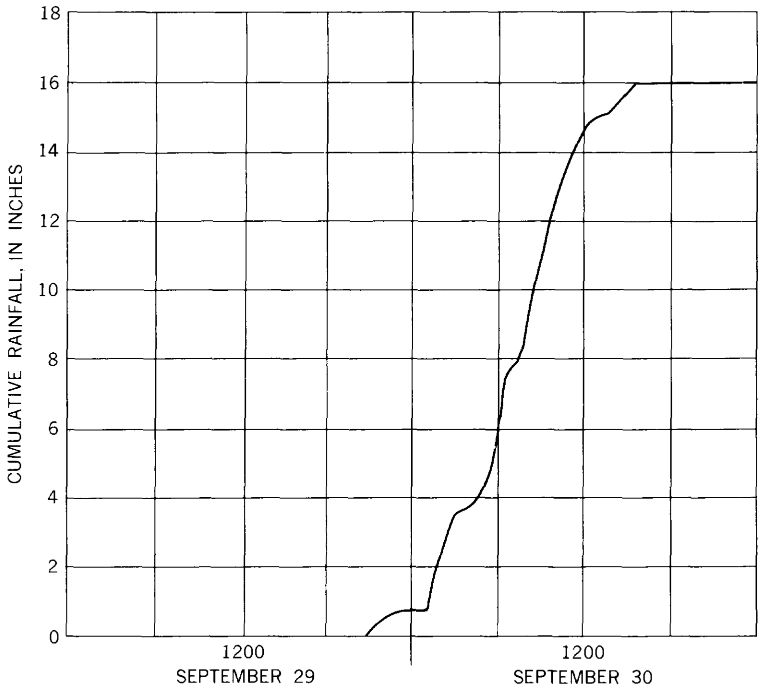

FIGURE 46.—Accumulated rainfall for September 29–30 at Montlimar Creek at U.S. Highway 90 at Mobile, Ala.

TABLE 33.—*Rainfall duration-intensity-frequency data for storm of September 29–30 at Montlimar Creek at U.S. Highway 90 at Mobile, Ala.*

Duration (minutes)	Rainfall (inches)	Maximum intensity (inches per hour)	Approximate recurrence interval (years)
15	1.1	4.4	2
30	1.8	3.6	4
60	3.1	3.1	15
120	4.0	2.0	20
180	6.3	2.1	100+
1,440	15.9	.66	100+

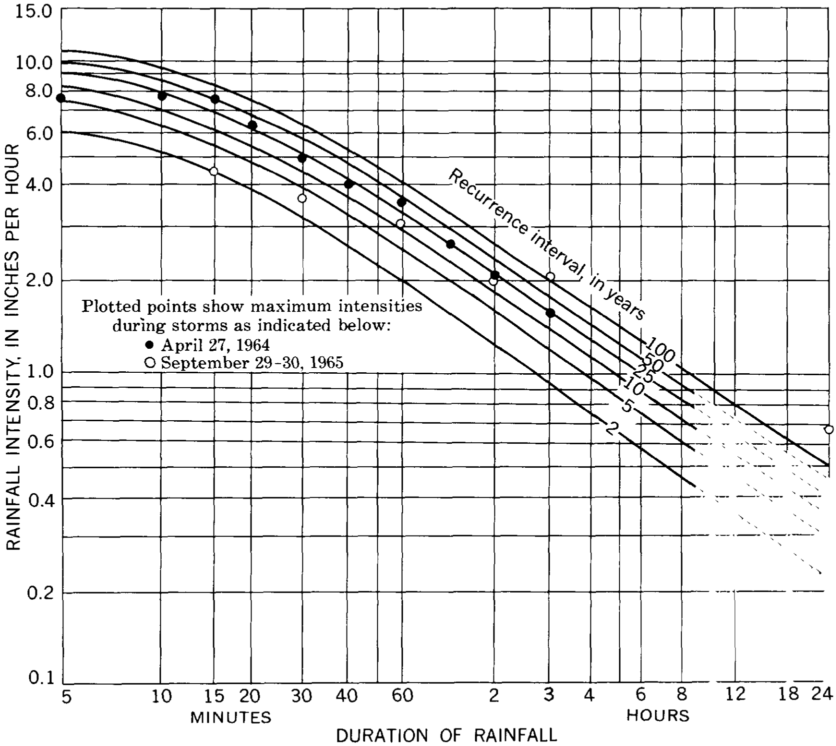

FIGURE 47.—Relation of rainfall intensity, duration, and frequency at Mobile, Ala. (after U.S. Weather Bureau).

Severe flooding during the storm period was confined to a narrow band along the eastern edge of Mobile County directly across downtown Mobile that extended north-northeastward to the Little River basin. Heavy runoff occurred from all areas in this band, but streams to the north, east, and west of the band had only minor flooding. Little River at State Highway 59 near the town of Little River (sta. 5) had a peak discharge of 28,600 cfs on October 1; this peak discharge is about 1.6 times the 50-year flood at the site. Peak discharges at gaging stations in and near the storm area are listed in table 34. At Montlimar Creek at U.S. Highway 90 at Mobile (sta. 8), a large volume of runoff occurred on September 30 (fig. 48), but the peak discharge of 2,500 cfs was much less than the maximum peak discharge of 4,000 cfs on April 27, 1964. Figure 48 shows the smaller volume of flow related to the higher peak discharge in April 1964 associated with an intense rainfall of about 5 inches in a short period of time falling on a basin that had been saturated in the preceding 48 hours.

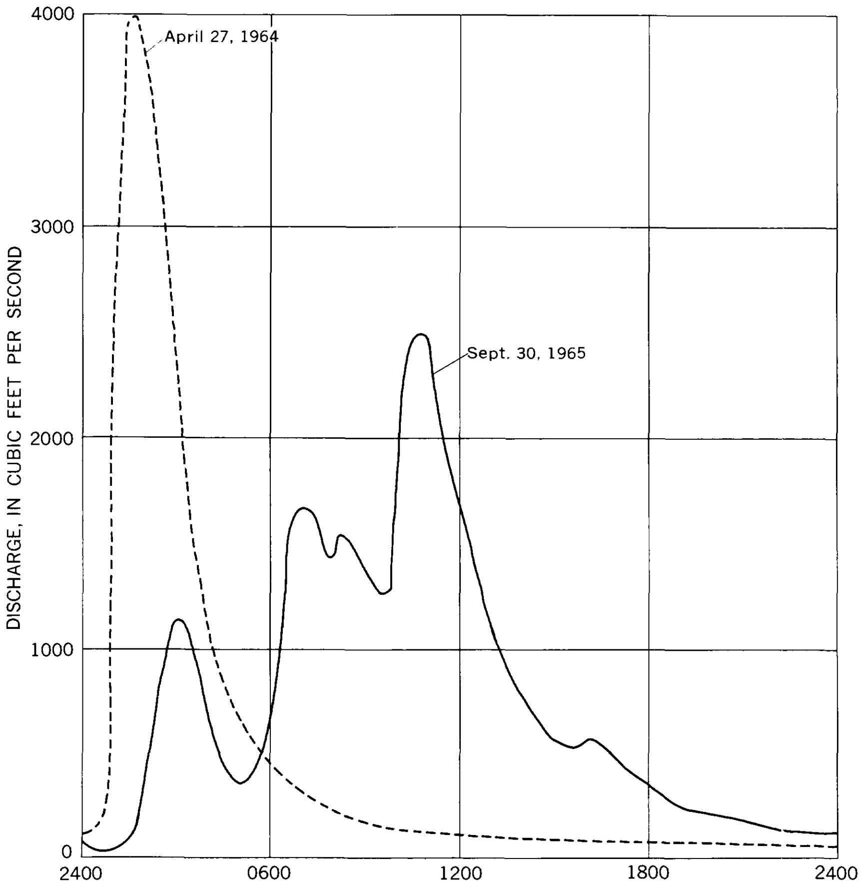

FIGURE 48.—Discharge for floods of April 27, 1964, and September 30, 1965, on Montlimar Creek at U.S. Highway 90, at Mobile, Ala.

The Weather Bureau at Mobile estimated flood damage in Mobile County to be about $25 million. About $2 million of this was crop damage mainly to soybeans, corn, and cotton. The heaviest runoff in Mobile was during the morning rush hours, and many motorists were stranded. Water 2–3 feet deep flowed through many of the downtown streets. No lives were lost during the flood period, but hundreds of people were evacuated from low-lying areas. Flood damage in Baldwin and Monroe Counties was relatively light because the path of the storm was over an uninhabitated area. Streams overtopped several roads in the area, and one bridge was damaged in Monroe County.

TABLE 34.—*Flood stages and discharges, September 30–October 3, in southwestern Alabama*

No.	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before September 1965 — Period	Year	September–October 1965	Gage height (feet)	Discharge: Cfs	Recurrence interval (years)
	Escambia River basin							
1	Big Escambia Creek at Flomaton, Ala	323	1939–65	1955		19.40	42,400	
					Oct. 2	12.69	10,600	4
	Perdido River basin							
2	Perdido River at Barrineau Park, Fla	394	1929	1929		25.7	[1]	
			1941–65	1955		23.94	39,000	
					Oct. 2	17.28	12,400	4
3	Styx River near Loxley, Ala	93.2	1926	1926		22.2	[1]	
			1952–65	1953		19.73	14,000	
					Oct. 1	16.19	5,370	4
	Fish River basin							
4	Fish River near Silver Hill, Ala	55.1	1953–65	1953		17.04	8,570	
					Oct. 1	12.13	2,420	2
	Mobile River basin							
5	Little River near Little River, Ala	140			Oct. 1		28,600	[2] 1.6
6	East Bassett Creek at Walker Sprngs, Ala	188	1956–65	1956		12.25	19,300	
					Oct. 3	5.43	718	<2
7	Chickasaw Creek near Whistler, Ala	123	1950–65	1955		25.4	42,000	
					Oct. 1	12.38	2,500	<2
	Dog River basin							
8	Montlimar Creek at U.S. Highway 90 at Mobile, Ala	8.26	1962–65	1964		8.60	4,000	
					Sept. 30	7.80	2,500	[1]
	Pascagoula River basin							
9	Escatawpa River near Wilmer, Ala	506	1945–65	1959		24.66	30,000	
					Oct. 1	10.25	2,960	<2
10	Franklin Creek near Grand Bay, Ala	16.4	1959–65	1961		16.54	2,750	
					Sept. 30	16.00	1,800	[1]

[1] Unknown.
[2] Ratio of peak discharge to 50-year flood.

FLOODS OF OCTOBER 17 IN THE CIMARRON RIVER BASIN, OKLAHOMA

By L. L. Laine

The deeply dissected mesas in the vicinity of the Cimarron River crossing of the New Mexico–Oklahoma State line were deluged by 6 inches of rain during October 16–17. A flood originated in the area downstream from the gage on the Cimarron River north of Guy, N. Mex. (fig. 49), where the drainage area is 545 sq mi. A tributary, Carrizozo Creek (drainage area, 111 sq mi at the gage), 4 miles southwest of Kenton contributed a peak discharge of 14,000 cfs (based on a rating curve defined in previous years). The peak was 1.75 times that for the 50-year flood for the area.

The flood peak of October 17 at the gage on the Cimarron River northeast of Kenton, Okla. (drainage area, 1,106 sq mi), was 43,400 cfs, 65 percent greater than the previous maximum in the 15-year record. The ratio of the peak discharge to a 50-year flood was 1.28. The peak stage was 17.32 feet, about 1.3 feet above bankfull stage, and the volume of the flow in 2 days, October 17–18, was slightly greater than the average annual runoff during the 15 years of record.

The stage graph of resurgent discharge in the Cimarron River, as given in figure 50, probably is indicative of the general precipitation sequences which totaled 6.37 inches at the town of Kenton. A similar rainfall amount (6.35 inches) occurred at a stage and rainfall recorder on a downstream tributary, Tesesquite Creek, 3.6 miles east of Kenton.

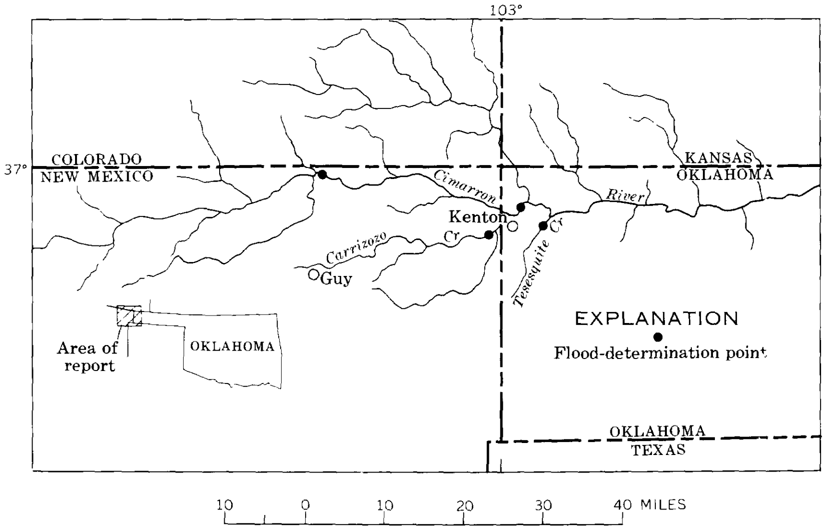

Figure 49.—Location of flood-determination points, floods of October 17 in the Cimarron River basin, Oklahoma.

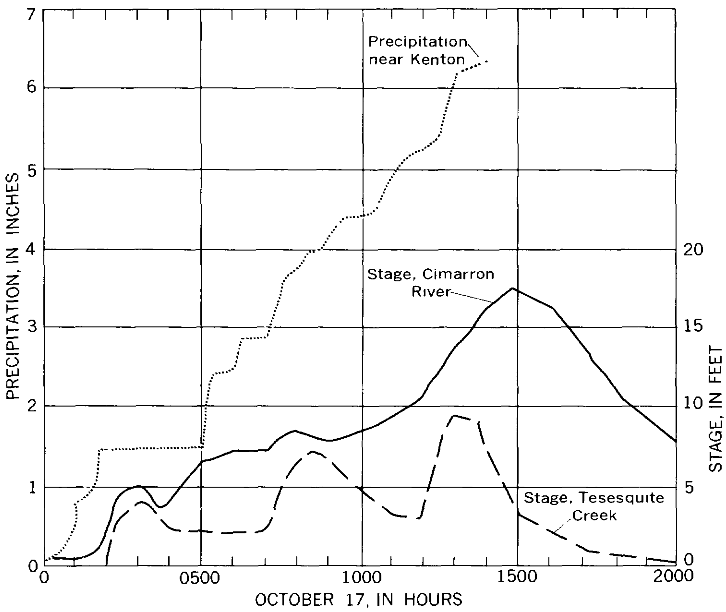

FIGURE 50.—Accumulated precipitation near Kenton and stage hydrographs of Cimarron River and Tesesquite Creek.

The time distribution of this rainfall is given in figure 50.

The maximum discharge from 27.5-sq-mi drainage area above the stage gage on Tesesquite Creek was 6,770 cfs, based on an estimate from field surveys of the channel. This discharge is equivalent to runoff of 246 cfs per sq mi from the basin or 0.38 inch per hour. Recurrence intervals cannot be computed for areas this small; however, comparison of the peak discharge with that from 50 sq mi indicates that the peak discharge on Tesesquite Creek was probably much greater than that for a 50-year flood.

The occurrence of three crests in the creek, as graphed in figure 50, is probably typical of runoffs in tributaries upstream from Kenton. Sequential flood peaks from recurrent storms over small drainage areas usually merge in the main river to form a sustained accrual in the flood wave. For this reason the flood-frequency relations of the small streams would not correlate with those of large drainage areas.

FLOODS OF NOVEMBER AND DECEMBER IN SOUTHERN CALIFORNIA

Severe flooding occurred in southern California (fig. 51) in late November and in late December as a result of three great storms. Rain fell on most of the days during the periods November 13–26 and

December 28–31. Most of the total was distributed in three periods—November 13–19, November 21–26, and December 28–31. More than 12 inches of precipitation fell at Mount Baldy and at Big Bear Lake on November 23, and more than 15 inches fell at Mount Baldy on December 29.

Peak discharges were generally the greatest since 1943. The Los Angeles River at Sepulveda Dam and the Santa Clara River at the Los Angeles–Ventura County line had peak discharges greater than those of March 1963, the greatest previously known.

Eleven deaths are attributed to the storms and the floods, and the amount of damage in the foothills and valley areas was estimated at more than $11 million. Flood-control, water-conservation, and power-production reservoirs effected a substantial reduction in the magnitude of the flood and prevented more extensive damage in many areas.

These floods are fully described in an open-file report by Hedman and Pearson (1966). The report gives a general description of storm precipitation, floods, storage regulation, and flood damage. Maximum stages and discharges are given at 205 discharge stations, and detail stages and discharges are given at 22 selected stations.

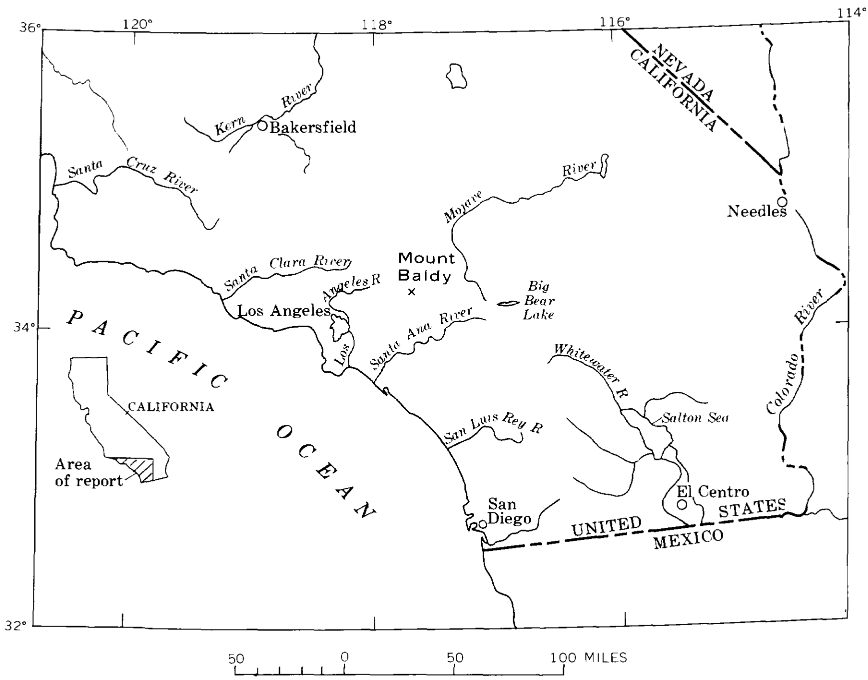

FIGURE 51.—Flood area, November and December in southern California.

FLOODS OF NOVEMBER AND DECEMBER IN ARIZONA AND NEW MEXICO

By B. N. Aldridge

Above-normal precipitation fell over much of Arizona and western New Mexico from November 21 to December 30; during this time there were five separate storms and four periods of flooding. Large-magnitude floods in small areas occurred November 23–25 along the Verde River (fig. 52), and minor floods occurred in a larger area to the west on December 9–11. Major floods occurred in most of the Gila River basin above the Salt River on December 22–26, during which time the San Francisco River and the Gila River from the San Francisco River to Coolidge Dam reached the highest stages recorded since 1916. The San Pedro and the Santa Cruz Rivers had the highest peaks since 1941. A flood occurred above Coolidge Dam on December 30–31. The floods of December 22–26 and December 30–31 caused about $5 million damage in the Gila River basin above the Salt River.

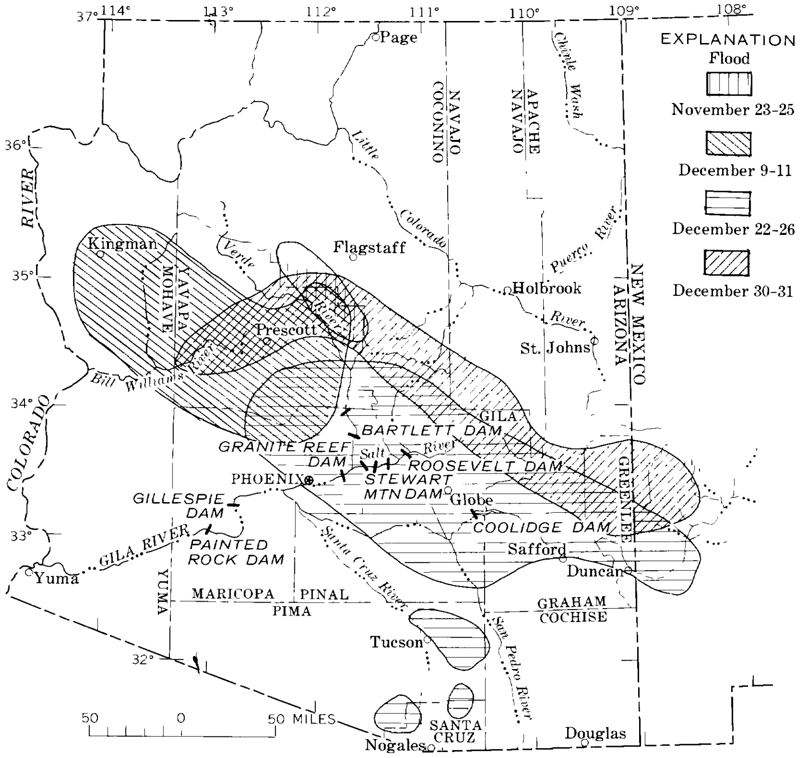

Figure 52.—Flood areas, November and December in Arizona and New Mexico.

The Salt River and its tributaries also had large flows during the periods of December 22–26 and December 30–31. Most of the flow of December 22–26 was contained in irrigation reservoirs and did little damage. The large volume of runoff added to the large amount of carryover storage raised the contents of the reservoirs on the Salt and Verde Rivers to an unusually high level. Reserve storage remaining in the reservoirs after the floods of December 22–26 was insufficient to permit complete detention of the large flow of December 30–31, and, beginning on December 31, large amounts of water were released from Stewart Mountain and Bartlett Dams. The resulting flood caused about $6 million damage along the Salt and Gila Rivers between the mouth of the Verde River and Gillespie Dam. Below the reservoirs, the flow in the Salt River was the largest since 1916, and the flow in the Verde River was the largest since 1941. The flow in the Salt River below the Verde River was the largest since 1938 and was the sixth largest since the completion of Roosevelt Dam in 1911. The five high peaks that occurred between 1911 and 1939 originated mainly in the Verde River, which was not regulated until the construction of Bartlett Dam in 1939. The peak at Gillespie Dam on the Gila River was the highest since 1927.

The maximum discharge of the Salt River through Phoenix during the flood of December 31 was 66,000 cfs. Without the storage provided by the system of reservoirs, the peak discharge during this flood would have been about 80,000 cfs, and the peak discharge on December 23, which was 9,500 cfs, might have exceeded 120,000 cfs. A flood equal to that of December 31 will occur on an average of about once every 6 years.

The peak discharge during the flood of December 31 was reduced less than 5 percent as it traveled 74 miles from Granite Reef Dam on the Salt River to Gillespie Dam on the Gila River. The volume of flow, however, was reduced nearly 30 percent in the same reach. About half the water that passed over Granite Reef Dam reached Painted Rock Dam, which is 39 miles downstream from Gillespie Dam, and less than 7 percent of the water reached the mouth of the Gila River. Increase in ground-water levels resulted from this flood, which was beneficial in some areas and detrimental in others.

The flow below Painted Rock Dam was completely regulated, and flood damage was minor. However, the Gila River road crossings below the dam were closed for several months because of the long period of sustained flow.

The floods are described in detail in water-supply paper 1850–C, "Floods of November 1965 to January 1966 in Gila River basin of Arizona and New Mexico and in adjacent basins in Arizona," by B. N. Aldridge (1970). The water-supply paper describes conditions causing the floods and includes detailed streamflow data from November 1965 to January 1966 for 152 gaging stations. The report includes isohyetal maps for the storms, discharge hydrographs for selected stations (including estimated natural unregulated flow of the Salt River), and a map of inundated areas in the Phoenix metropolitan area. Detailed estimates of the flood damage are given, and the effects of the flood on the ground-water table are discussed.

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