FLOODS OF 1959 IN THE UNITED STATES

SUMMARY OF FLOODS IN THE UNITED STATES DURING 1959

ABSTRACT

This report describes the most outstanding floods that occurred in the United States during 1959.

The floods of January–February in Ohio and adjacent States were the most outstanding floods of the year 1959 with respect to area affected, number of streams having maximum discharge of record, rare occurrence of peaks, and great amount of damage caused.

Floods in the Rock River basin in southern Wisconsin and northern Illinois during late March and early April produced maximum stages and discharges on many streams. The Rock River at Watertown, Wisc., was the highest in 40 years and Lake Mendota at Madison, Wisc., reached its maximum stage since 1916. Many towns were flooded and thousands of persons were forced from their homes.

What is possibly the greatest 24-hour rainfall ever to be noted in Iowa fell August 5–6. The resulting floods inundated an 80-block area in Fort Madison, Iowa, and caused damage estimated at $600,000 in the city. A total of 130,000 acres of land was inundated.

Major floods occurred in Texas in the upper Trinity, middle Brazos, middle Colorado, upper Guadalupe, and upper Nueces River basins in early October, following heavy general rains that covered most of Texas. The peak stage on North Bosque River near Clifton was the highest known since 1887. More than $1 million in damage was reported for Houston.

In addition to the 4 floods mentioned above, 22 others of lesser magnitude are considered important enough to report in this annual summary.

INTRODUCTION

The purpose of this summary chapter in the series "Floods of 1959 in the United States" is to assemble information relating to outstanding floods in the United States during 1959 into a single volume. The floods in this summary chapter were selected as being unusual hydrologic events in which large areas were affected, great amounts of damage resulted, or extreme discharges or stages occurred.

Water-Supply Paper 1750–A, "Floods of January–February 1959, in Ohio and Adjacent States" describes these floods in detail.

The areas for which flood reports have been prepared for 1959 are shown in Figure 1. The months in which the floods occurred are also

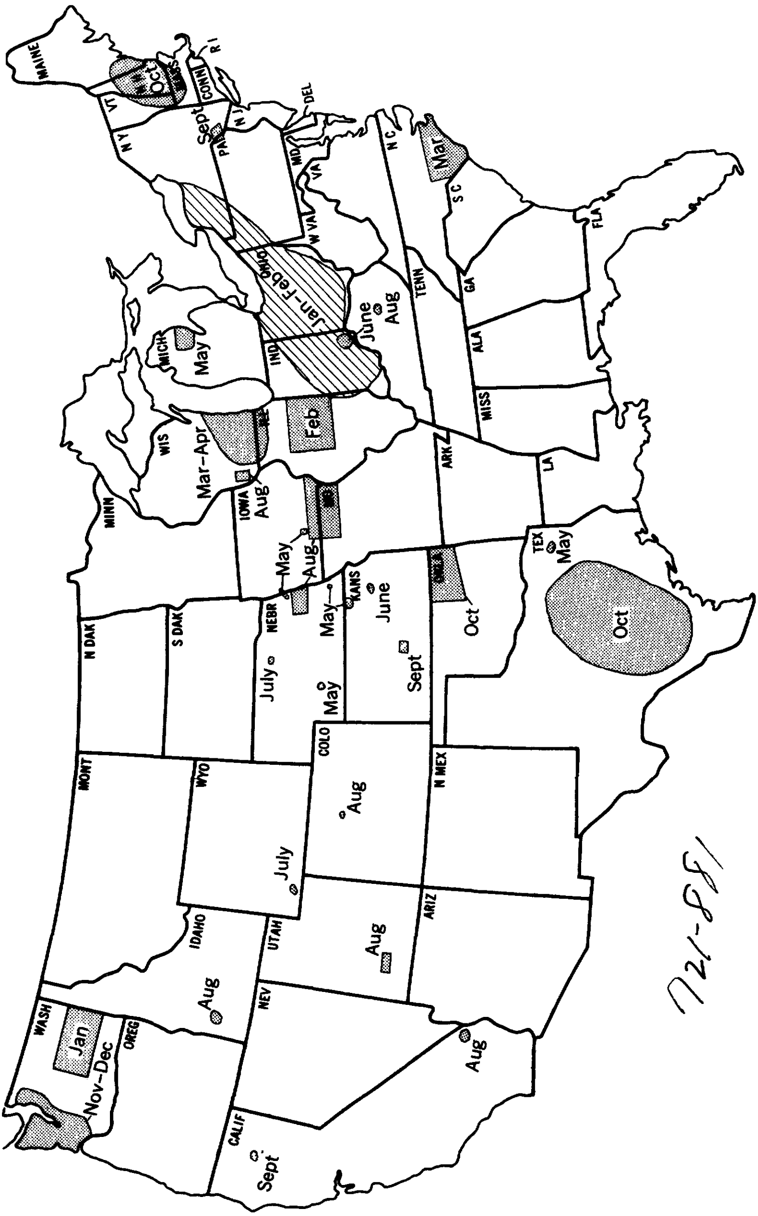

FIGURE 1.—Map of the conterminous United States showing areas and months of occurrence of floods in 1959 for which reports have been prepared. Crosshatch pattern indicates the area reported on in chapter A of this series; areas reported on in this summary chapter indicated by solid pattern.

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shown; both the location and the time distribution of floods during the year are thus given.

Of the 27 flood reports for the year, 14 are for floods in the 3 months August–October, and 8 are for floods in August. Most of the large-area floods occurred in a relatively small section of the United States, one that can be outlined by a triangle with apexes in middle Texas, in Lake Superior, and in central Maine. One other large-area flood occurred in North Carolina, and two occurred in Washington.

All reported floods from January to early May and from October through December were large-area floods; all those reported from the middle of May through September were small-area floods.

A flood is the occurrence of high streamflow that overtops the natural or artificial banks in any reach of a stream. By popular definition a flood is a discharge or a stage of extremely high magnitude that inundates large areas and causes much damage and (or) great loss of life. In a hydrologic sense an outstanding flood need not be newsworthy and may be one of which only a few or possibly no persons are aware. An outstanding flood is a rare flood; one which will not be often duplicated at a given site. An unusually rare flood on an unoccupied or nonutilized flood plain would be little noticed by the public, but to the hydrologist it could be an event of great interest.

Floods result from the combined effects of meteorological events and physiographic characteristics of a basin. The principal physiographic factors affecting flood flows are: drainage area, altitude, geology, basin shape, slope, aspect, and basin cover. With the exception of basin cover, which varies seasonally, the factors are fixed for any area.

The meteorological factors, of which precipitation is the principal one, are variable with respect to both place and time. Other meteorological factors influencing floods are: form of the precipitation, whether rain, snow, hail, or sleet; amount and intensity of the precipitation; moisture conditions of the soil antecedent to the flood-producing precipitation; and temperature, which may cause frozen soil or may cause variation in rate of snowmelt.

In general, the meteorological conditions determine when and where the floods will be. The combination of magnitude and intensity of meteorological factors and the effect of inherent physiographic features on runoff determine what the magnitude of a flood will be.

The many different and variable factors form innumerable combinations to produce floods of all degrees of severity.

Of two floods with equal peak discharges from different size drainage basins, if both sites had similar runoff and climatologic characteristics, the one from the smaller drainage area would be the rarer or the more outstanding flood. Of two floods of equal discharge from equal drainage areas, the flood from the site having geographic and climatologic characteristics that normally produce the smaller flood peak would be considered the rarer of the two.

The severity and prevalence of floods depends not so much on the absolute values of contributing factors but rather on the values of these factors relative to normal conditions.

When the locations of the floods of 1959 are compared with the annual precipitation pattern for 1959 (fig. 2), it can be seen that the locations in which the floods occurred do not necessarily correspond with the areas of high total annual precipitation. A large number of the floods in the Interior Plains were in areas where the annual precipitation ranged from 8 inches to 32 inches.

Figure 3 shows the 1959 annual precipitation in the conterminous United States in percentage of the normal annual precipitation. When the location of the 1959 floods (fig. 1) are compared with this map, it can be seen that the major floods of the year occurred in areas where the 1959 annual precipitation was above normal.

Total loss from floods in the United States during 1959 was estimated by the U.S. Weather Bureau at about $141 million, which was the lowest flood loss since 1956 and was about one-third less than that in 1958. The 1959 loss was 40 percent of the national average, which based on the 10-year period 1949–58 (adjusted to the 1958 price index), is $350 million.

The total loss of life in 1959 due to floods was 25, which was very much less than the national annual average of 83 lives lost during the 35 years 1925–59. Loss of life was 47 in 1958, 42 in 1956, and 302 in 1955.

The floods of January and February in Ohio and adjacent States caused damage ($100 million) equal to about 70 percent of the 1959 total for the entire United States and caused more than half of the flood deaths.

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

The collection of data, the computations, and some of the preparation of text were made by the district offices of the Surface Water Branch in whose district the floods occurred. Assistance in preparation of the data for the report was given by the Flood Specialist in their respective areas.

The report was assembled and prepared in the Floods Section, Tate Dalrymple, Chief.

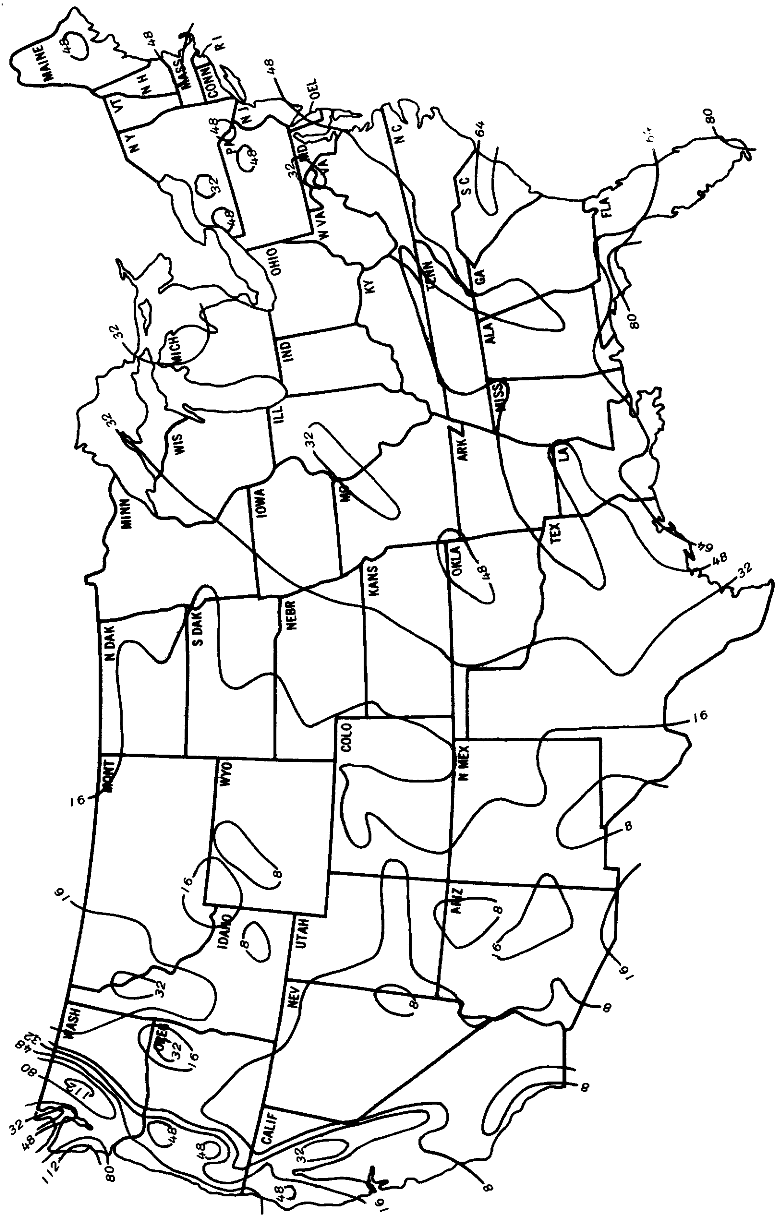

FIGURE 2.—Map of the conterminous United States showing total precipitation, in inches, for the year 1959.

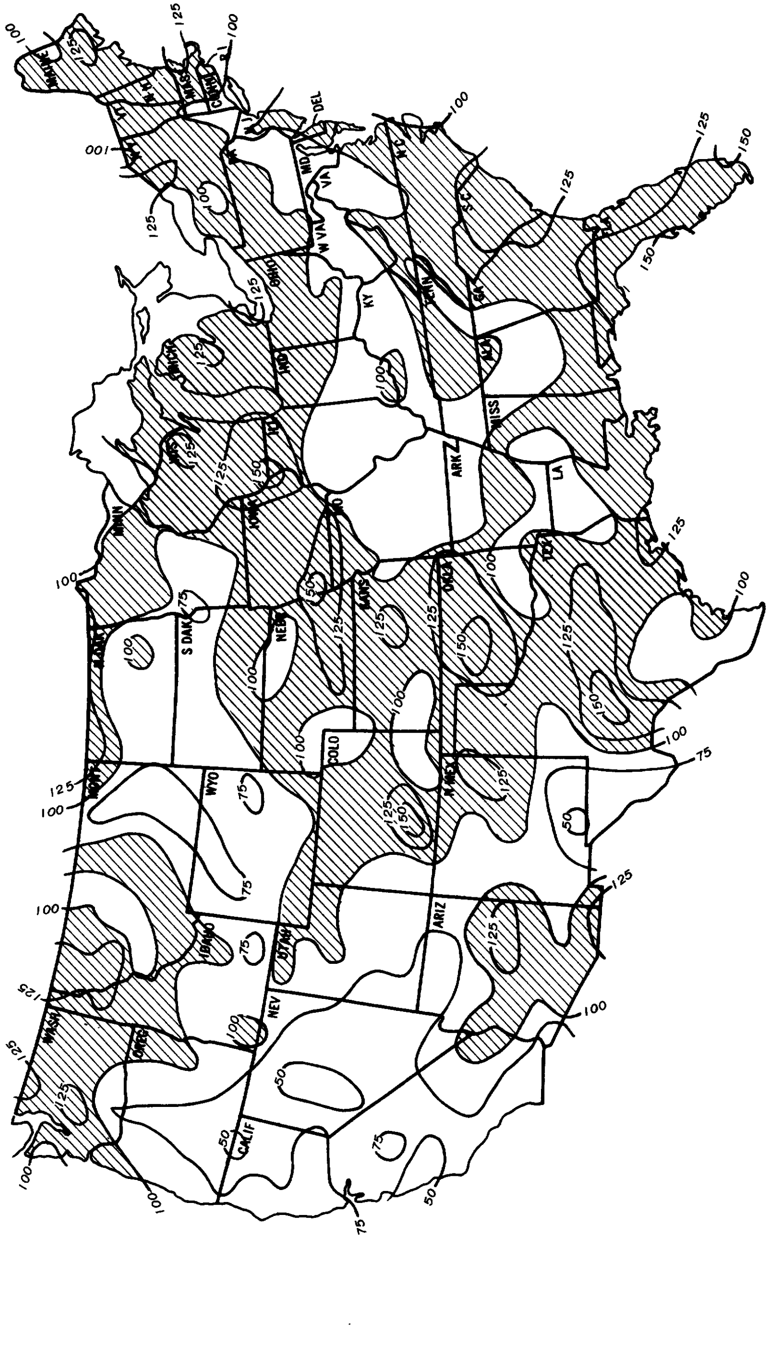

FIGURE 3.—Map of the conterminous United States showing the 1959 precipitation as percentage of the normal annual precipitation. Crosshatching indicates areas of more than 100 percent.

DETERMINATION OF FLOOD STAGES AND DISCHARGES

The data concerning peak stages and discharges at gaging stations and at miscellaneous sites in this chapter were obtained and compiled in the regular procedure of surface-water investigation by the Geological Survey.

The usual method of determining stream discharges at gaging stations is the application of a stage-discharge relation to its associated stage. The relationship is usually defined by current-meter measurements through the maximum range of stage at a station. However, the peak discharge at a station may be above the range of the stage-discharge relation, and 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 which are greatly above the range of the stage-discharge relation at gaging stations and peak discharges at miscellaneous sites are generally determined by various methods of indirect measurements at the sites. During major floods, when adverse conditions often make it impossible to obtain current-meter measurements at some sites, peak discharges may also be measured by indirect methods based on detailed surveys of selected channel reaches. A general description of these indirect methods is given in Water-Supply paper 888. Water-Supply Papers 773–E, 796–G, and 816 contain more detailed descriptions and illustrated examples.

EXPLANATION OF DATA

The floods described herein are in chronological order. Because of various characteristics of the floods and because of the different amounts of information available, no consistent form is used in reporting the events.

The data include a description of the storm, the flood, and the flood damage; a map of the flood area showing the location of flood-determination points, and at times the location of precipitation stations or isohyets; rainfall data; and flood-peak stages and discharges of the streams affected.

Usually, some rainfall data are included in the description of the flood. When considerable rainfall data are available, they are presented in tabular form and may show daily or storm totals. When sufficient data are available to determine the pattern and distribution of rainfall, an isohyetal map may be shown.

A tabular summary of peak stages and discharges is given for each flood, unless the number of stations in the report is small and the information is included in the text description.

In the summary tables the first column under maximum floods shows the period of known floods prior to those of 1959. This period does not necessarily correspond to that in which continuous records of discharge were obtained, but it often extends back to an earlier date. More than one period of known floods are shown for some stations. Periods are shown whenever maximum stages can be associated with them, even though the corresponding discharge may not be known—a second period of known floods is then given in which maximums of both discharge and stage are known.

The second column under maximum floods shows the year, within the period of known floods, in which the maximum stage or discharge occurred. The third column gives the date of the peak stage or discharge during the 1959 flood.

$Q_{2.33}$ in the headnote of the last column refers to the theoretical flood that has a recurrence interval of 2.33 years and by definition is the graphic interpretation of the mean annual flood. The data in the last column is the ratio by which the peak discharge of the 1959 flood exceeded the mean annual flood.

In many of the flood reports, recurrence intervals are given for flood peaks. Recurrence interval is the average interval of time in which a flood of a given magnitude 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 mean annual floods and recurrence intervals are obtained from reports on flood magnitude and frequency, which can be one of several statewide reports or Water-Supply Papers dealing with a specific part (principal river basins) of the United States.

SUMMARY OF FLOODS OF 1959

JANUARY 11–27, IN EASTERN WASHINGTON

Alternate periods of freezing weather, followed by warm winds and rain on snow and frozen ground, caused streams in the east-central part of Washington to exceed flood stage several times between January 9 and 27. Peaks occurred on January 9, 11–12, 24–25, and 27. The most severe flooding occurred in the basins of upper Palouse River, upper Spokane River, Douglas Creek, and Crab Creek (fig. 4) east of 120° long. and between 47° and 48° lat. In the Hartline-Almira area the January 11–12 peaks were the highest known to residents who have lived in the area about 50 years. The peak of January 24 was the highest recorded since 1948 on Hangman Creek at Spokane. The peak of January 24 on Douglas Creek near Trinidad is reportedly the highest peak known in 55 years.

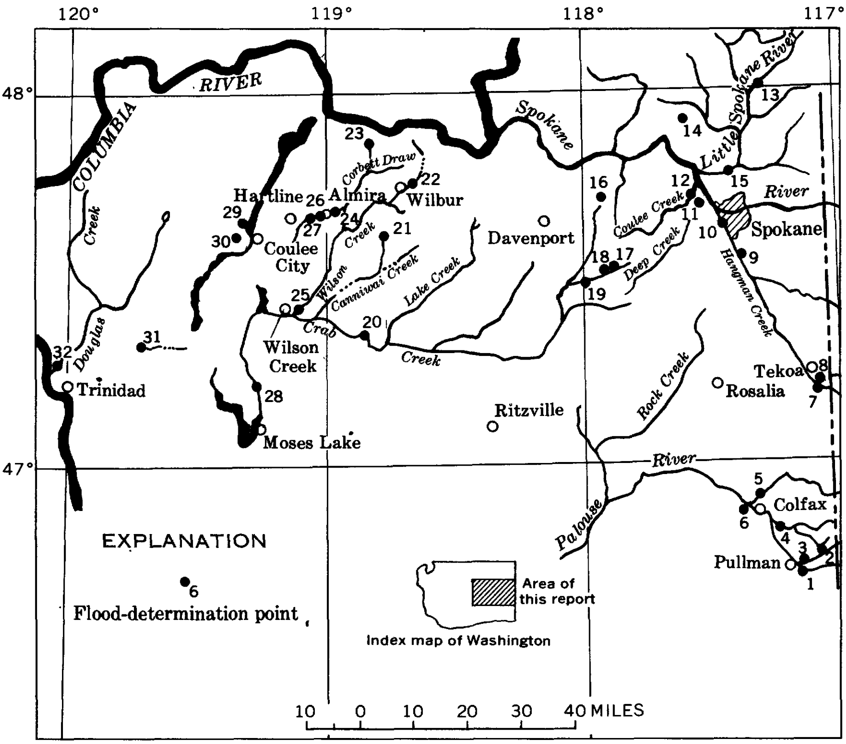

FIGURE 4.—Map of area floods of January 11–27, in eastern Washington, showing location of flood-determination points. (Numbers correspond to those in table 1.)

Localized flooding occurred in the towns of Wilson Creek, Wilbur, and Almira. Damage was confined largely to roads and to household belongings. In the northern part of the flood area, frozen ground protected the fields from extensive erosion, but in the southern part there was considerable erosion of top soil. Figure 4 shows the flood-determination points listed on table 1.

During each of the storms, precipitation was fairly uniform throughout the flood area, averaging about 0.6 inch in 24 hours except in the areas of heaviest concentration where the 24-hour rainfall was 1.0 to 1.1 inches. At both Hartline and Wilbur, 1.1 inches of rain was recorded during the 24-hour period ending 8 a.m. January 12. The precipitation stations at Rosalia, Tekoa, and Colfax received 1.0 to 1.1 inches of rainfall during the 24-hour period ending 8 a.m. January 24.

TABLE 1.—*Flood stages and discharges, January 11–27, in eastern Washington*

Flood-determination point fig (4).	Stream and place of determination	Drainage area (sq mi)	Maximum floods					
			Prior to Jan. 11, 1959		January 1959 (day)	Gage height (feet)	Discharge	
			Period	Year			Cubic feet per second	Ratio to $Q_{2.33}$
	Palouse River basin							
1	Palouse River near Colfax	491	1955–59	1955		7.60	4,790	
					25	8.18	6,310	1.4
2	South Fork Palouse River at Pullman.	132	1911–59	1948		9.5	5,000	
					24	6.5	1,860	1.3
3	Missouri Flat Creek tributary near Pullman.	1.14	1949–59	1956		11.92	140	
					27	12.11	80	1.3
4	Missouri Flat Creek at Pullman.	27.1	1934–59	1948		6.3	1,500	
					24	4.57	870	2.0
5	Fourmile Creek at Shawnee	71.6	1934–40	1935		4.13	786	
					24	6.0	1,990	1.6
6	Palouse River tributary at Colfax.	2.10	1955–59	1955		19.18	70	
					24	18.51	52	.9
	Spokane River basin							
7	Hangman Creek ¼ mi upstream from North Fork at Tekoa.	132	1904–05	1904		[1] 7.05	994	
					24		3,900	4.3
8	North Fork Hangman Creek ½ mi upstream from mouth at Tekoa.	60	1904–05	1905		[1] 2.9	336	
					24		3,750	4.0
9	Stevens Creek tributary near Moran.	1.82	1954–59	1957		8.24	52	
					24	6.63	14	.5
10	Hangman Creek at Spokane	619	1948–59	1948		[1] 18.73	11,900	
					24	12.30	16,200	2.4
11	Deep Creek 0.1 mile upstream from Coulee Creek near Spokane.	106			24		3,700	4.6
12	Conlee Creek 1 mile above mouth near Spokane.	51.6			24		1,530	4.6
13	Little Spokane River at Elk	115	1948–59	1956		1.87	148	
				1957		[2] 2.98		
					12	1.63	101	.5
14	Mud Creek near Deer Park	1.83	1954–59	1957		10.24	27	
					12	9.51	22	1.3
15	Little Spokane River at Dartford.	665	1929–32, 1946–59	1950		5.1	2,240	
					12		2,060	1.7
					25	4.94		
16	Spring Creek tributary near Reardan.	1.14	1954–59	1957		9.06	97	
					11	9.37	102	1.5

See footnotes at end of table.

TABLE 1.—*Flood stages and discharges, January 11–27, in eastern Washington*—Continued

Flood-determination point (fig. 4)	Stream and place of determination	Drainage area (sq mi)	Maximum floods					
			Prior to Jan. 11, 1959		January 1959 (day)	Gage height (feet)	Discharge	
			Period	Year			Cubic feet per second	Ratio to $Q_{2.33}$
			Crab Creek basin					
17	South Fork Crab Creek tributary at Waukon.	.68	1954–59	1957	--------	11.45	111	--------
			--------	------	24	10.43	45	1.5
18	South Fork Crab Creek tributary No. 2, 2.2 mi east of Edwall.	4.3	1957	1957	--------	--------	446	--------
			--------	------	24	--------	425	--------
19	South Fork Crab Creek at county road crossing 3.1 mi southwest of Edwall.	22.8	1957	1957	--------		580	--------
			--------	------	24	--------	1,520	--------
20	Crab Creek at Irby	1,057	1942–59	1957	--------	11.94	8,370	--------
			--------	------	24	10.54	5,550	2.4
21	Canniwai Creek tributary near Govan.	.25	1958–59	1958	--------	12.00	165	--------
			--------	------	24	9.13	30	--------
22	Goose Creek 1½ mi east of Wilbur.	48	1957	1957	--------	46.3	2,220	--------
			--------	------	11	--------	3,040	22.2
23	Broadax Draw tributary near Wilbur.	1.12	1955–59	1955	--------	14.64	205	--------
			--------	------	11	9.90	88	1.1
24	Corbett Draw tributary at U.S. Highway 2 at east edge of Almira.	18.2	[3] 1915–59	------	11	--------	1,000	--------
25	Wilson Creek at Wilson Creek.	427	1951–59	1957	--------	20.74	[4] 12,900	--------
			--------	------	24	14.11	4,620	7.8
26	Main Canal tributary at U.S. Highway 2, 4 miles southwest of Almira.	1.1	[3] 1915–59	------	11	--------	82	--------
27	Main Canal tributary No. 2 at U.S. Highway 2, 4½ mi. southwest of Almira.	3.3	[3] 1915–59	------	11		257	--------
28	Crab Creek near Moses Lake	2,040	1942–59	1957	--------	6.81	10,400	--------
			--------	------	27	5.96	5,000	2.8
29	Grand Coulee tributary near Coulee City.	2.7	--------	------	12	16.96	154	--------
30	Grand Coulee tributary No. 2 at State Highway 2, 4 mi. west of Coulee City.	.5	--------	------	11	--------	34	--------
31	Iron Springs Creek near Winchester.	1.57	--------	------	24	10.46	127	--------
			Douglas Creek basin					
32	Douglas Creek at old State Highway 10 near Trinidad.	[5] 690	[3] 1957, 1905–59	1957	--------	--------	3,620	--------
			--------	------	24	--------	4,800	5.1

[1] Site and datum then in use.
[2] Affected by backwater from ice.
[3] Approximate period during which flood is known to be a maximum.
[4] Result of dam failure; discharge above dam was 7,760 cfs.
[5] Contributing area.

JANUARY–FEBRUARY, IN OHIO AND ADJACENT STATES

Damaging floods in two periods only 3 weeks apart in January and February 1959 occurred in Ohio and adjacent States (fig. 5). The first floods, January 21–24, were in streams throughout Ohio; in Indiana in tributaries to the Ohio River above the Wabash River, in the East Fork White River and tributaries, and in the upper Mississinewa River; in western Pennsylvania; and in the southwestern tip of New York. The second floods, February 10–13, were in the Wabash River from Vincennes to Lafayette, Ind., and in tributaries above that point, and in streams in the Maumee River basin and tributaries in the extreme northwestern corner of Ohio.

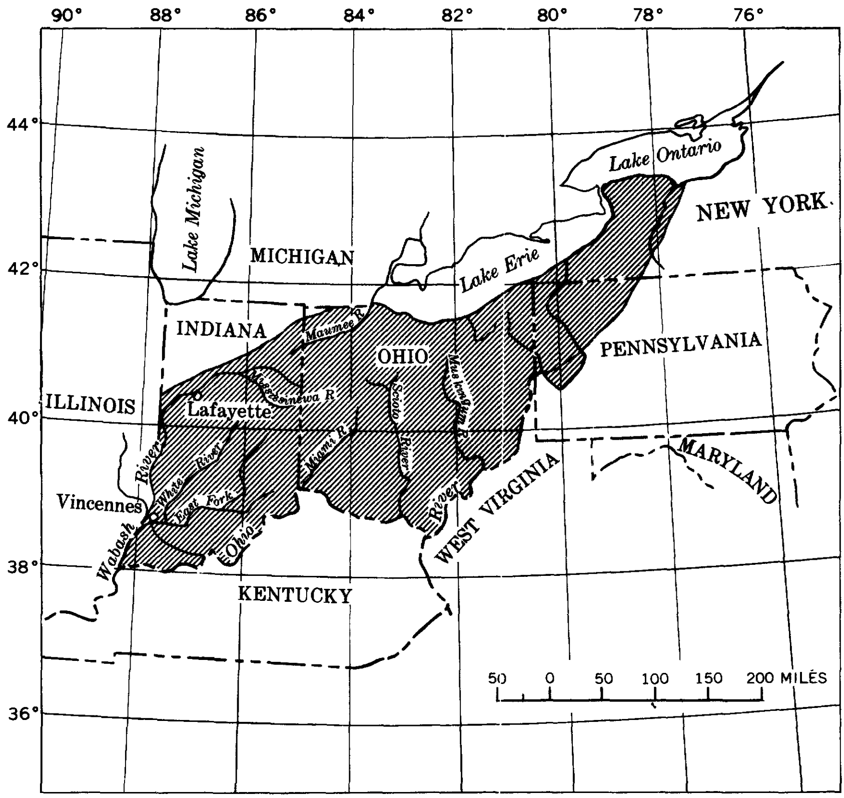

FIGURE 5.—Map showing area of floods of January-February 1959, in Ohio and adjacent States.

The floods of January 21–24 were the worst in a large part of the Ohio River basin since the outstanding floods of 1913. On several streams, stages and discharges exceeded those of 1913. The number of deaths reported due to the floods were 16 in Ohio, 12 in Pennsylvania, and 4 in Indiana. The total amount of damage from the destructive January flood was approximately $100 million.

December 1958 was a dry month over most of the flood area and was the driest December since 1931 in the northeastern and central part of Indiana. The snow cover at the end of the month was light in all areas except along the Great Lakes. December was extremely cold, as well as extremely dry, throughout the report area.

The cold weather continued into January 1959; again, without exception, the monthly average temperature was considerably below the long-term January means throughout the flood area, and precipitation was light during the early part of the month. Consequently, frost penetrated deeply into the ground.

A rapid rise in temperatures began January 20 in southern Indiana and Ohio, in western Pennsylvania, and in areas south of there. On January 21 the warm weather spread to include the northern part of Ohio and parts of Pennsylvania and New York.

Rain began, generally, on the night of January 20 and continued through January 21. The rain was of a high intensity in a southwest-northeast belt extending from the southwest corner of Indiana to the southwest corner of Ohio and continuing on to central Ohio. Storm totals (fig. 6) were generally less than those in March 1913, but intensities were greater.

The ground was deeply frozen by the extremely cold weather in December 1958 and January 1959 and was saturated from rains and melting of a moderate snow cover. Therefore, when the heavy rains fell in the warm period, most of it appeared in streams as direct runoff. Melting of the accumulated snow in northeast Ohio, western Pennsylvania, and southwestern New York added to the volume and rate of runoff produced by the rain.

The sudden influx of water into the stream channels caused the heavy ice cover on the streams to break up and form ice floes and ice gorges that backed up water to cause record floods on many streams.

After the floods of January 21–24, a cold spell again froze the topsoil and made it impervious; consequently when the rains of February occurred, the runoff was greater than in January. The heaviest rains were in an east-west band through the center of Ohio and Indiana.

Rainfall averaged more than 3 inches in less than 24 hours over the extreme upper Wabash and Mississinewa Rivers on February 9–10. Scattered areas in Ohio received 3 inches or more of rain (fig. 7). This intense rain falling on ice and frozen ground caused the greatest flooding in 46 years at numerous points on the Wabash River and may have exceeded the floods of 1913 at some points.

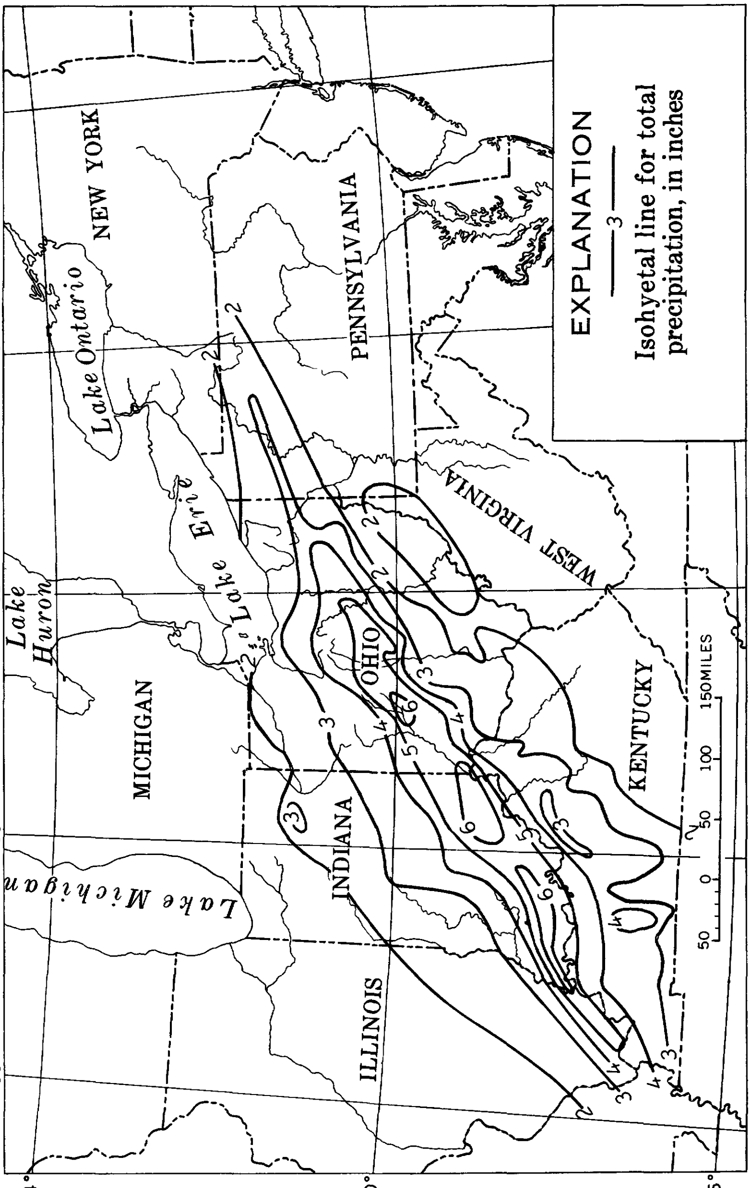

FIGURE 6.—Isohyetal map showing total precipitation, in inches, January 19–21, in Ohio and adjacent States.

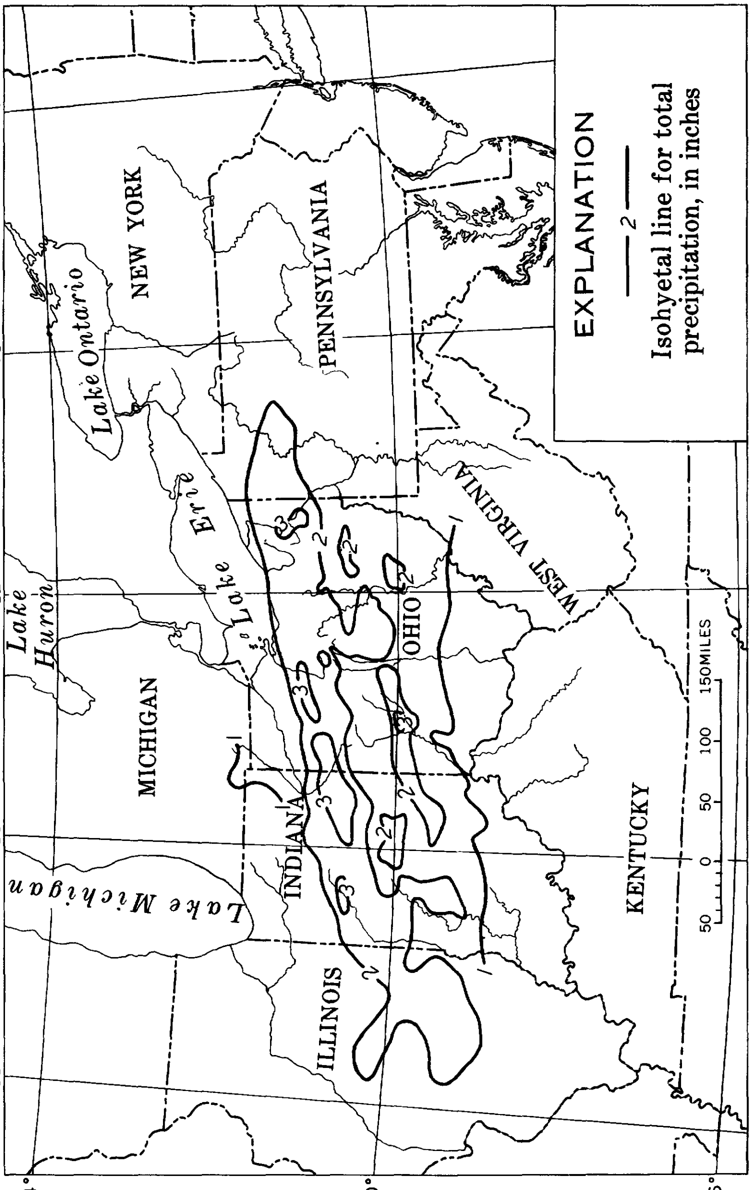

FIGURE 7.—Isohyetal map showing total precipitation, in inches, February 9–10, in Ohio and adjacent States.

The runoff was quick and was unretarded by infiltration, and stages higher than would be normally associated with the discharges occurred from backwater produced by large accumulations of ice that blocked stream channels.

The February floods were particularly severe on the tributaries of the Wabash River in Indiana above Lafayette and in the Maumee and Sandusky River basins in Ohio, partly because these streams were still high from the January floods. Much of the precipitation that fell as snow in January melted to add to the volume of runoff water. In addition, the extremely cold weather that followed the January floods produced a foot or more of ice on the streams. This ice resulted in a great deal of backwater owing to the formation ice gorges during the February floods.

Table 2 gives data on peak discharges at selected gaging stations in the flood area. Locations of these stations are shown on figure 8.

Flood stages were exceeded along the entire reach of the Allegheny River. Ice gorges broke up at various locations in the Allegheny River basin during the early morning of January 22. Meadville, Pa., had the worst flood in its history when an ice gorge 2 miles long blocked French Creek. Kittanning, Pa., a city of 10,000 inhabitants, about 45 miles north of Pittsburgh, was isolated for several hours when an ice jam in the Allegheny River sent 5 feet of water over an area of 30 blocks.

TABLE 2.—*Flood stages and discharges, January-February, in Ohio and adjacent States*

Flood-determination points (fig. 8)	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to January 1959: Period	Year	January-February 1959	Gage height (feet)	Discharge: Cubic feet per second	Ratio to $Q_{2.33}$
Oil Creek basin								
1	Oil Creek at Rouseville, Pa.	233	1932–58	1958		11.55	18,600	
					Jan. 2	11.97	21,000	2.9
Clarion River basin								
2	Clarion River near Piney, Pa.	951	1936	1936		[1]	50,000	
			1947–58	1950		17.66	32,000	
					Jan. 22	21.8	44,300	
Ohio River main stem								
3	Allegheny River at Parkers Landing, Pa.	7,671	1865	1865		29.4	250,000	
			1932–58	1934		[2] 27.85		
				1942		21.80	157,000	
					Jan. 21	[2] 29.60		
					Jan. 22		175,000	

See footnotes at end of table.

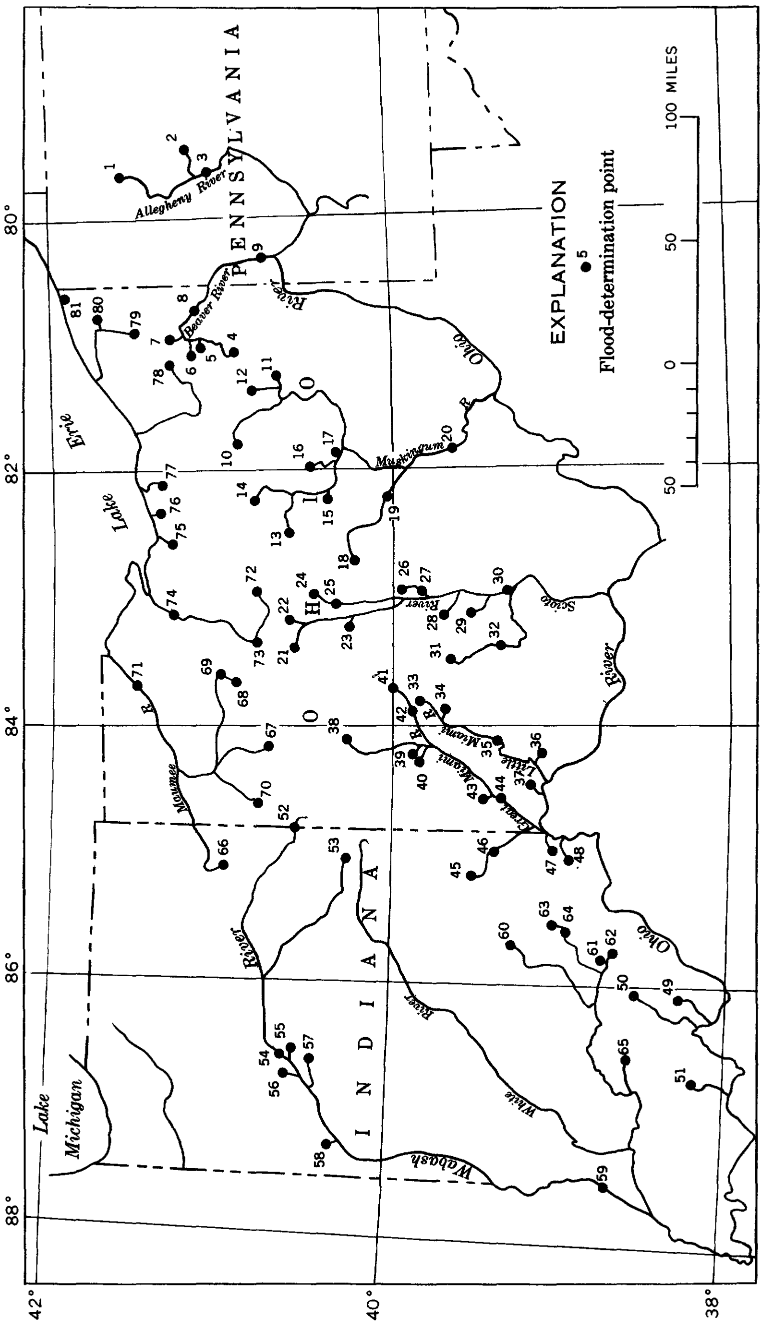

FIGURE 8.—Map of area of floods of January–February, in Ohio and adjacent States, showing location of flood-determination points. (Numbers correspond to those in table 2.)

TABLE 2.—*Flood stages and discharges, January-February, in Ohio and adjacent States*—Continued

Flood-determination points (fig. 8)	Stream and place of determination	Drainage area (sq mi)	Maximum floods					
			Prior to January 1959		January-February 1959	Gage height (feet)	Discharge	
			Period	Year			Cubic feet per second	Ratio to $Q_{2.33}$
	Beaver River basin							
4	Mahoning River at Alliance, Ohio.	87.9	1941–58	1946		7.90	7,000	
					Jan. 21	9.11	9,740	3.3
5	Kale Creek near Pricetown, Ohio.	20.9	1940–58	1944		8.3	3,630	
					Jan. 21	8.52	3,890	
6	West Branch Mahoning River near Newton Falls, Ohio.	97.8	1926–58	1929		11.8	6,090	
					Jan. 22	13.60	8,340	2.9
7	Eagle Creek at Phalanx Station, Ohio.	97.0	1926–34, 1937–58	1929		12.9	5,950	
					Jan. 22	13.12	6,700	2.9
8	Mahoning River at Youngstown, Ohio.	899	1913	1913		26.5	42,500	
			1925–58	1937		14.92	[3] 17,600	
					Jan. 22	[4] 18.62		
					do		[3] 16,900	
9	Beaver River at Beaver Falls, Pa.	3,106	1913	1913		17.4	103,000	
			1935–58	1937		13.8	[3] 64,500	
					Jan. 22	14.42	[3] 69,900	
	Little Beaver Creek basin							
10	Little Chippewa Creek near Smithville, Ohio.	13.9	1947–58	1957		13.33	1,360	
					Jan. 21–22.	14.30	1,800	2.6
11	Sandy Creek at Waynesburg, Ohio.	254	1938–58	1940			6,100	
				1952		7.95	6,100	
					Jan. 22	10.05	15,000	3.5
12	Middle Branch Nimishillen Creek at Canton, Ohio.	44.2	1941–58	1958		6.15	1,920	
					Jan. 22	6.50	2,470	3.1
	Muskingum River basin							
13	Clear Fork at Butler, Ohio.;	143	1944–58	1948, 1950			7,100	
				1956		8.16		
					Jan. 21	9.43	14,300	3.6
14	Jerome Fork at Jeromeville, Ohio.	120	1913	1913		15.1	(1)	
			1925–49	1937		11.40	3,720	
					Jan. 22	14.1	13,000	5.0
15	Kokosing River at Millwood, Ohio.	454	1913	1913		[5] 22.0	40,000	
			1921–58	1937		[5] 18.10	27,500	
					Jan. 21	34.00	75,900	7.2
16	Killbuck Creek at Killbuck, Ohio.	466	1930–58	1935		21.77	28,800	
					Jan. 22	21.75	28,400	6.4
17	Mill Creek near Coshocton, Ohio.	27.5	1936–58	1957		12.73	7,650	
					Jan. 21	11.40	4,440	3.7
18	Otter Fork near Centerburg, Ohio.	2.97	1947–58	1947		13.25	368	
					Jan. 21	13.52	445	2.7
19	Licking River at Toboso, Ohio.	672	1913	1913		20.0	35,000	
			1902–06, 1921–58	1952		18.75	32,500	
					Jan. 22	21.08	49,800	3.6
20	Muskingum River at McConnelsville, Ohio.	7,411	1913	1913		33.5	270,00	
			1921–58	1937		21.14	[3] 126,000	
					Jan. 23	14.38	[3] 81,600	

See footnotes at end of table.

TABLE 2.—*Flood stages and discharges, January-February, in Ohio and adjacent States*—Continued

Flood-determination points (fig. 8)	Stream and place of determination	Drainage area (sq mi)	Maximum floods					
			Prior to January 1959		January-February 1959	Gage height (feet)	Discharge	
			Period	Year			Cubic feet per second	Ratio to $Q_{2.33}$
			Scioto River basin					
21	Scioto River at LaRue, Ohio.	255	1913	1913		17.8	(1)	
			1926–35, 1938–58	1927		15.0	10,700	
					Jan. 21	15.30	16,300	3.0
22	Little Scioto River above Marion, Ohio.	70.0	1938–58	1947		8.16	3,720	
					Jan. 22	8.73	5,160	3.1
23	Mill Creek near Bellepoint, Ohio.	181	1913	1913		18.0	(1)	
			1942–58	1956		9.92	7,170	
					Jan. 21	13.85	20,300	4.1
24	Shaw Creek at Shawtown, Ohio.	25.2	1946–55	1948		6.05	1,250	
					Jan. 21	8.12	4,120	4.6
25	Olentangy River near Delaware, Ohio.	387	1923–34, 1938–58	1927		[5] 16.9	14,100	
					Jan. 31	88.11	[3] 6,000	
26	Alum Creek at Columbus, Ohio.	190	1923–35, 1938–58	1929		13.6	8,800	
					Jan. 22	19.59	26,400	5.2
27	Big Walnut Creek at Rees, Ohio.	544	1913	1913		[5] 20.5	(1)	
			1921–35, 1938–58	1929		18.0	21,800	
					Jan. 22	22.03	[3] 59,800	
28	Darby Creek at Darbyville, Ohio.	533	1921–35,	1929		[2] 15.9		
			1938–58	1929		14.9	22,600	
					Jan. 22	17.94	49,000	4.7
29	Deer Creek at Williamsport, Ohio.	331	1926–35,	1929			29,300	
			1938–58	1952		15.49		
					Jan. 22	17.6	39,600	4.0
30	Scioto River at Chillicothe, Ohio.	3,847	1913	1913		39.8	260,000	
			1920–58	1937		27.68	101,000	
					Jan. 23	32.50	[3] 144,000	
31	East Fork Paint Creek near Sedalia, Ohio.	4.23	1947–58	1948		13.77	292	
					Jan. 21	14.47	515	2.6
32	Paint Creek near Greenfield, Ohio.	251	1926–35, 1939–58	1940		10.8	13,900	
					Jan. 21	11.0	14,500	2.5
			Little Miami River basin					
33	North Fork Little Miami River near Pitchin, Ohio.	29.1	1952–58	1958		6.04	955	
					Jan. 21	7.58	3,350	
34	Massie Creek at Wilberforce, Ohio.	64.3	1952–58	1958		10.35	4,300	
					Jan. 21	11.25	7,300	
35	Little Miami River near Fort Ancient, Ohio.	677	1913	1913		20	(1)	
			1938–51	1945		16.80	32,900	
					Jan. 21	21.9	67,000	4.4
36	East Fork Little Miami River at Perintown, Ohio.	477	1915–20, 1925–58	1945		23.42	39,400	
					Jan. 21	21.24	32,000	1.5
			Mill Creek basin					
37	Mill Creek at Carthage, Ohio.	116	1946–58	1947		14.21	8,300	
					Jan. 21	16.17	[3] 8,900	
			Miami River basin					
38	Miami River at Sidney, Ohio.	545	1913–58	1913		19.6	44,000	
					Jan. 21	15.91	16,800	2.0
39	Poplar Creek near Vandalia, Ohio.	3.16	1947–58	1955		6.07	1,110	
					Jan. 21	6.10	1,130	2.1

See footnotes at end of table.

TABLE 2.—*Flood stages and discharges, January–February, in Ohio and adjacent States*—Continued

Flood-determination points (fig. 8)	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to January 1959: Period	Maximum floods: Prior to January 1959: Year	Maximum floods: January-February 1959	Gage height (feet)	Discharge: Cubic feet per second	Discharge: Ratio to $Q_{2.33}$
	Miami River basin—Continued							
40	Stillwater River at Englewood, Ohio.	646	1913	1913		(1)	[5] 85,400	
			1925–58	1958		80.88	9,980	
					Jan. 23	80.21	[3] 9,450	
41	Buck Creek at New Moorefield, Ohio.	67.3	1942–58	1948		7.46	5,150	
					Jan. 21	7.98	8,130	4.6
42	Mad River near Springfield, Ohio.	485	1904–5, 1913–58	1913		16.9	55,400	
					Jan. 21	15.76	30,500	3.4
43	Talawanda Creek near Hamilton, Ohio.	311	1937–58	1949		21.0	33,500	
					Jan. 21	21.9	44,500	2.8
44	Miami River at Hamilton, Ohio.	3,639	1910–18, 1927–58	1913		[5] 38.5	352,000	
					Jan. 21	79.49	[3] 108,000	
45	Whitewater River near Alpine, Ohio.	539	1928–58	1937		16.61	35,000	
					Jan. 21	16.14	31,600	2.6
46	Whitewater River at Brookville, Ind.	1,239	1813–1958	1913		39.0	(1)	
			1915–20, 1923–58	1929		25.56	69,200	
					Jan. 21	27.78	81,800	2.6
	Hogan Creek basin							
47	South Hogan Creek near Dillsboro, Ind.	36.6			Jan. 21		16,300	4.4
	Laughery Creek basin							
48	Laughery Creek near Farmers Retreat, Ind.	248	1940–58	1957		16.15	20,200	
					Jan. 21	[6] 21.13	47,800	4.0
	Big Indian Creek basin							
49	Big Indian Creek near Corydon, Ind.	129	1815–1958	1943		22.4	17,000	
					Jan. 21	[6] 22.22	23,800	3.1
	Blue River basin							
50	Middle Fork Blue River near Salem, Ind.	38.4			Jan. 21		11,400	2.9
	Anderson River basin							
51	Anderson River near Siberia, Ind.	44.8			Jan. 21		11,800	2.8
	Wabash River basin							
52	Wabash River near New Corydon, Ind.	258	1951–58	1957		19.27	6,390	
					Jan. 22	20.47	8,720	2.0
53	Mississinewa River near Ridgeville, Ind.	130	1913–58	1958		16.25	13,900	
					Jan. 21	14.70	9,120	2.4

See footnotes at end of table.

TABLE 2.—*Flood stages and discharges, January–February, in Ohio and adjacent States*—Continued

Flood-determination points (fig. 8)	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to January 1959: Period	Maximum floods: Prior to January 1959: Year	Maximum floods: January-February 1959	Maximum floods: Gage height (feet)	Maximum floods: Discharge: Cubic feet per second	Maximum floods: Discharge: Ratio to $Q_{2.33}$
	Wabash River basin—Continued							
54	Wabash River at Delphi, Ind.	4,032	1913	1913		28.4	145,000	
			1939–58	1943		25.60	85,300	
					Feb. 11	[2] 27.48	71,500	2.0
55	Deer Creek near Delphi, Ind.	278	1943–58	1943		19.8	18,000	
					Feb. 10	16.72	12,100	3.8
56	Tippecanoe River near Delphi, Ind.	1,857	1903–6, 1908, 1939–58	1958		14.72	21,400	
					Feb. 10	15.10	22,600	2.7
57	Wildcat Creek at Owasco, Ind.	390	1943–58	1943		14.0	(1)	
				1950		13.3	10,200	
					Feb. 11	11.74	9,880	2.4
58	Big Pine Creek near Williamsport, Ind.	329	1955–58	1957		14.2	9,260	
					Feb. 10	16.0	12,600	2.5
59	Wabash River at Vincennes, Ind.	13,700	1867–1958	1913			255,000	
				1943		29.33		
					Feb. 17	25.65		
					do		97,000	1.6
60	Clifty Creek at Hartsville, Ind.	88.8	1897–1958	1913		25.1	(1)	
			1948–58	1949		13.4	8,100	
					Jan. 21	14.29	11,300	3.1
61	Muscatatuck River near Austin, Ind.	365	1932–58	1933		26.60	26,000	
					Jan. 22	29.20	53,900	3.6
62	Stucker Fork near Scottsburg, Ind.	44.7			Jan. 21		12,100	2.8
63	North Fork of Vernon Fork near Butlerville, Ind.	87.3	1942–58	1945, 1949			[3] 10,900	
				1949		18.73		
					Jan. 21	25.41	[3] 26,200	
64	Vernon Fork at Vernon, Ind.	201	1939–58	1945		26.28	27,700	
					Jan. 21	[6] 32.83	56,800	3.9
65	Lick Creek near Paoli, Ind.	45.2			do		8,160	3.4
	Streams tributary to Lake Erie							
66	St. Marys River near Fort Wayne, Ind.	753	1930–58	1943		18.79	[3] 13,400	
					Feb. 11	[2] 19.42		
					do		[3] 13,600	
67	Ottawa River at Allentown, Ohio.	168	1939	1939		10.1	(1)	
			1923–35, 1943–58	1957		9.45	5,300	
					Jan. 22	10.88	7,740	2.6
68	Eagle Creek near Findlay, Ohio.	46.5	1947–57	1947			2,920	
				1957		13.45		
					Feb. 10	(1)	6,300	2.9
69	Blanchard River near Findlay, Ohio.	343	1913	1913		18.5	22,000	
			1923–35, 1940–58	1927		15.4	11,800	
					Feb. 11	16.76	15,000	2.7
70	Roller Creek at Ohio City, Ohio.	4.94	1947–58	1955		8.65	351	
					Feb. 10	9.58	890	3.7
71	Maumee River at Waterville, Ohio.	6,314	1921–35, 1939–58	1950		14.52	94,000	
					Feb. 12	[2] 16.17		
					do		85,000	1.7
72	Sandusky River near Bucyrus, Ohio.	89.8	1913	1913		14.5	(1)	
			1925–35, 1938–51	1927		9.15	5,800	
					Jan. 22	11.9	13,500	5.2
73	St. James Run near Upper Sandusky, Ohio.	5.35	1947–58	1947		12.25	356	
					Jan. 21	12.66	408	

See footnotes at end of table.

TABLE 2—*Flood stages and discharges, January-February, in Ohio and adjacent States*—Continued

Flood-determination points (fig. 8)	Stream and place of determination	Drainage area (sq mi)	Maximum floods					
			Prior to January 1959		January-February 1959	Gage height (feet)	Discharge	
			Period	Year			Cubic feet per second	Ratio to $Q_{2.33}$
			Streams tributary to Lake Erie—Continued					
74	Sandusky River near Fremont, Ohio.	1,248	1923–35, 1938–58	1930	--------	--------	27,300	--------
				1951	--------	[2] 12.12	--------	--------
			--------	--------	Feb. 10	[2] 15.20	28,000	1.9
75	Huron River at Milan, Ohio.	363	1950–58	1956	--------	21.10	18,200	--------
			--------	--------	Jan. 22	24.08	25,800	--------
76	Vermilion River near Vermilion, Ohio.	260	1950–58	1952	--------	11.5	9,820	--------
			--------	--------	Jan. 21	13.80	20,500	--------
77	Black River at Elyria, Ohio.	392	1944–58	1956	--------	18.02	14,900	--------
			--------	--------	Jan. 22	22.9	24,000	2.7
78	Cuyahoga River at Hiram Rapids, Ohio.	147	1927–35, 1944–58	1948	--------	7.00	2,760	--------
			--------	--------	Jan. 23	8.11	3,670	2.5
79	Phelphs Creek near Windsor, Ohio.	26.4	1942–58	1948	--------	--------	3,840	--------
				1958	--------	[4] 9.48	--------	--------
			--------	--------	Jan. 21	9.34	4,600	3.3
80	Mill Creek near Jefferson, Ohio	78.3	1942–58	1948	--------	--------	7,010	--------
				1950	--------	[2] 10.28	--------	--------
			--------	--------	Jan. 22	12.50	9,810	2.9
81	Conneaut Creek at Amboy, Ohio.	178	1922–35, 1950–58	1934	--------	[2] 12.94	--------	--------
				1954	--------	--------	12,900	--------
			--------	--------	Jan. 22	11.70	17,000	2.7

[1] Not determined.
[2] Affected by ice jams or backwater from ice.
[3] Affected or regulated by reservoirs.
[4] Affected by backwater.
[5] At different site or datum.
[6] Greatest known since at least 1897.

The January flood in the Mahoning River basin in Ohio was the highest since the construction of the Berlin and Mosquito Creek flood-control reservoirs. The reservoirs held back substantial runoff, but uncontrolled tributaries, principally the West Branch Mahoning River and Eagle Creek, caused high stages and severe damage. Crab Creek, a small tributary to the Mahoning River, flooded parts of Youngstown, where 1,000 persons were evacuated. Total damage in the Mahoning River basin exceeded $16 million. The Shenango River spilled over into Sharon, Pa. The water was 3 feet deep in parts of a 10-block area in the business district, and damage was estimated at $2 million.

The 14 flood-control reservoirs of the Muskingum Conservancy District, operated by the Corps of Engineers, reduced flooding by the Muskingum River in Ohio. However, uncontrolled tributaries in the western part of the basin were in the area of excessive rainfall, and the floods on some streams exceeded all previous records, including those of the flood of 1913, in some places. Mount Vernon had the worst flood in its history when the levee along the Kokosing River gave way; water rose rapidly in an extensive residential district and flooded about one-third of the city. The peak flow of Kokosing River at Millwood, downstream from Mount Vernon, was nearly twice that of the 1913 flood.

Uncontrolled tributaries of the Walhonding River caused similar disaster; total damage in Holmes County approached $5 million.

The flood extended into the Tuscarawas River basin. Industrial damage in Canton was reported as more than $5 million, and 400 persons were forced from their homes. Other small communities were flooded, and highway damage was extensive, several bridges having been washed out.

In Zanesville, the Licking River flooded 25 city blocks in the western part of the city. Railroads in the vicinity lost several miles of track.

Delaware Reservoir on the Olentangy River, the only flood-control reservoir in the Scioto River basin, stored all the runoff from 381 square miles and reduced flood stages and damages at downstream points. Hoover Reservoir on Big Walnut Creek stored more than 2 inches in equivalent depth on its drainage area of 190 square miles, but even so the flood downstream at the gage at Rees was 1.5 feet above the 1913 maximum stage. The peak discharge on Alum Creek, which was not affected by storage, was 5 times the discharge of the mean annual flood and 6 feet higher in stage than the highest flood in the past 35 years. At Chillicothe, one-third of the city was flooded and 9,000 persons were evacuated.

The floods of January 21 on the Little Miami River in Ohio exceeded the 1913 flood in a reach extending through Fort Ancient to the mouth of Todd Fork at Morrow. Damage, which exceeded $5 million, was locally severe, but it was confined largely to the small communities on the flood plains.

A large part of the Miami River basin was in the area of intense January rainfall. The five retarding basins of the Miami Conservancy District minimized flood stages and damages on the main streams, but uncontrolled tributaries caused widespread damage.

In Springfield, Ohio, Buck Creek reached a stage exceeded only by the record floods of 1913 and 1929, and damage was about $4 million.

Damage to roads and streets was widespread. In Dayton, Ohio, and its suburbs, 1,500 people were evacuated. Runoff of several small Miami River tributaries was unusually high, and these small uncontrolled streams caused the peak flow of 108,000 cfs (cubic feet per second) in the Miami River at Hamilton, Ohio, on the night of January 21, about 20 hours before the lower main-river peak.

Flooding occurred over the entire Whitewater River basin in January. The lower parts of the East Fork Whitewater River and main stem received the heaviest flooding, and damage in Franklin County was estimated at $1.6 million.

In Madison, Ind., the water of Crooked Creek fanned out over an area 5 city blocks wide and a mile long to cause the worst flash flood in Madison's history.

Little Indian Creek and Big Indian Creek flooded in Corydon, Ind., where damage was estimated at $750,000. The January flood on Big Indian Creek in Corydon was the second highest flood since at least 1889 and was slightly lower (0.2 to 0.5 foot) than the March 19, 1943, flood, which is the maximum known stage since at least 1815.

Although the Wabash River and its upper tributaries in Indiana experienced flooding from the January storm, the floods of February were generally greater in magnitude and caused considerably more damage. Along with the damaging effect of the inundation, huge ice chunks about 6 inches thick flowed in many of the channels. Ice jams along the Wabash and Salamonie Rivers backed up water and flooded areas larger than normally would be covered by similar discharges. During the peak of the ice floes on the Wabash River, ice jams covered about a 14-mile reach of the river from Delphi to Georgetown. Wabash was in one of the hardest hit areas during the February flood; 40 city blocks on the south side of Wabash were inundated. Flash flooding on two small creeks, one in the city and one in a small suburb south of the city, trapped residents without warning. According to local officials, these small streams rose several inches higher than they did during the 1913 floods, and stages were the highest known in Wabash. The Mayor of Peru estimated that 40 percent of that city was under 2 to 6 feet of water.

The Russell-Allison levee, which protects the farmland of Lawrence County, Ind., experienced a break 200 feet long. This break, south of Russellville, let the Wabash River overflow its banks and cover 33,000 acres. The Routein levee along the Embarrass River was dynamited to release the impounded flood waters of the Russell-Allison levee break.

The stage of Sand Creek at the small community of Brewersville, Ind., approached that of the 1913 flood and was higher than that of any subsequent flood. Long-time residents in the Vernon area stated that Vernon Fork was the highest since the March 1897 flood.

The January floods in the Maumee River basin were largely in the southern and eastern tributaries. Ice on the streams was as much as 18 inches thick; this ice added to flood stages and to the length of the periods of inundation. Many roads were temporarily blocked. Damage to roads and bridges was minimized by the flat terrain, which caused reduced velocities of flood flow and allowed the flood to spread across the wide lowlands. The February flood was higher than the January flood at many points in the basin, and it was more widespread. Thick ice was not entirely removed by the January flood, and ice jams contributed to the damage in February.

During the February floods, the stage at Fremont was slightly higher than it was in January and was prolonged by a heavy ice jam. In this city, 1,000 people were evacuated from their homes—more than 200 had not returned after the January flood. The resulting damage and hardship to inhabitants was greater in February than in January, although farther east the February flood peaks were well below January stages.

The Cuyahoga River has had few floods in the past because of storage in many lakes and ponds and in the Akron, Ohio, water-supply reservoirs. The January flood stage at the gaging station at Independence, Ohio, upstream from Cleveland, Ohio, surpassed all previous records since 1921 and approached that of the record flood of 1913. Damage in the basin, which approximated $2 million, was most severe in the downstream part of the river, in the vicinity of Cleveland.

The January floods on Lake Erie tributaries east of the Cuyahoga River generally reached unprecedented stages. Ice jams occurred on many streams, and damage to roads and bridges caused by swift currents in the narrow flood plains was unusually severe. The flood on the Chagrin River was the third largest of record, and damage was extensive. The Grand River near Madison, Ohio, reached a stage more than 2 feet higher than previously had been reached in 36 years of record. The springlike thaw in western New York unleashed the most destructive flash floods ever to hit Buffalo. Water flowing 4 feet deep roared through a 18-block section of South Buffalo on January 22. The raging water, which hurled huge chunks of ice through the streets, broke through the lower part of the walls of about 40 houses.

The floods in the Susquehanna River in northeastern Pennsylvania were not particularly high in discharge; that at Pittston was about equal to a 5-year flood. However, the tragic results of the flood from the Susquehanna River near Pittston made it a nationwide news item. The river, clogged by giant chunks of ice, overflowed its banks and broke through the roof of a coal mine beneath the river, flooding it and adjacent mines. Twelve miners were drowned deep in the mine and 33 others managed to escape. More than 3 days later, after thousands of tons of material including 560 mine cars and 38 gondolas had been dumped into the hole in a rescue attempt, the break was plugged, but by this time the water level in the mines had reached the level in the river. Measurement by the Harrisburg, Pa., office of the Federal-State Flood Forecasting Service indicated that about 35 billion gallons (105,000 acre-feet) of water entered the mine directly from the river. It was estimated that approximately onesixth of the peak discharge entered the mine and reduced the flood crest by 1.5 feet.

The floods of January-February caused heavy damage to industrial, urban, and agricultural areas. By far the greatest amount of the total damage occurred in Ohio, where the damage was second only to that which occurred in 1913. Table 3, a tabulation made by the American Red Cross, shows that personal and private property damage in Ohio greatly exceeded that in Indiana.

More detailed information on the flood is published in the preceding Chapter A of Water-Supply Paper 1750.

TABLE 3.—*Personal and private property losses as compiled by the American Red Cross*

Number of—	Ohio	Indiana
Persons killed	16	4
Dwellings:		
Destroyed	132	2
With major damage	2, 415	44
With minor damage	14, 535	1, 733
Other buildings:		
Destroyed	55	30
Damaged	1, 145	174

FEBRUARY 9-14, IN EAST-CENTRAL ILLINOIS

Widespread rain, above-freezing temperatures, and ice-covered ground combined to produce high runoff, ice jams, and flooding in east-central Illinois, February 9–14. The greatest total precipitation for the period ranged from 2 to 3 inches (fig. 9). The State was free of snow with the exception of the northern part. The runoff ratio was high owing to the frozen ground.

The weather pattern that caused the Illinois floods is the same pattern that caused the outstanding floods in Ohio and adjacent States, of which a complete report is given in chapter A of this series. The flood area in Illinois was adjacent to an area in Indiana where the flooding was minor, and for this reason was not considered a continuation of the large flood area described in chapter A. Of the 27 discharge stations for which peak discharges were determined in Illinois, 8 were in the Wabash River basin and the remaining 19 were in the Illinois and Kaskaskia River basins.

Damage due to flooding was low. Other elements of the storm, high winds, snow, and glazing, resulted in considerable damage, most of which was due to accidents on highways.

Peak discharges were the highest known at several gaging stations having 15 or less years of record (table 4). At two stations, Sugar Creek at Milford and Salt Creek near Rowell, the peak discharges were small; however, ice jams below the stations produced gage heights that were the highest known in 12 and 28 years, respectively. The discharge was the greatest in 16 years on Sangamon River at

Monticello, where records have been collected for 50 years. The highest computed recurrence interval was 28 years on Vermilion River near Danville,[1] in the eastern part of the flood area.

[1] Mitchell, W. D., 1954, Floods in Illinois, magnitude and frequency: Illinois Dept. of Public Works and Buildings, Division of Waterways, Springfield, Ill., 386 p.

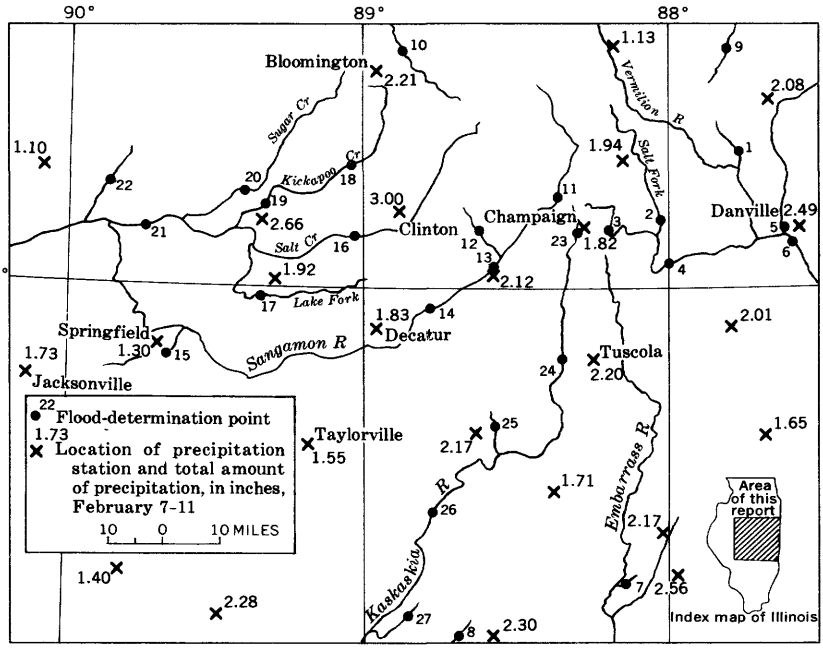

FIGURE 9.—Map of area of floods of February 9–14, in east-central Illinois, showing location of flood-determination points (numbers correspond to those in table 4) and precipitation stations.

TABLE 4.—*Flood stages and discharges, February 9–14, in east-central Illinois*

Flood-determination point (fig. 9)	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to February 1959: Period	Maximum floods: Prior to February 1959: Year	Maximum floods: February 1959 (Day)	Maximum floods: Gage height (feet)	Maximum floods: Discharge: Cubic feet per second	Maximum floods: Discharge: Recurrence interval
Wabash River basin								
1	Bluegrass Creek at Potomac	34.5	1949–59	1956		11.43	4,380	
					10	11.06	3,700	
2	Salt Fork near St. Joseph	134			10	18.99	6,030	
3	Saline Branch at Urbana.[2]	71.4	1933	1933		13.5	(1)	
			1937–59	1939		12.84	3,410	
					10	11.83	2,770	12
4	Salt Fork near Homer[3]	344	1939	1939		18.6	(1)	
			1945–59	1950		14.36	7,210	
					11	14.75	7,910	15
5	North Fork Vermilion River tributary near Danville.	1.88	1956–59	1956		[4] 16.16		
				1958		15.69	535	
					10	15.42	490	

See footnotes at end of table.

TABLE 4.—*Flood stages and discharges, February 9–14, in east-central Illinois*—Continued

Flood-determination point (fig. 9)	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to February 1959: Period	Maximum floods: Prior to February 1959: Year	Maximum floods: February 1959 (Day)	Maximum floods: Gage height (feet)	Maximum floods: Discharge: Cubic feet per second	Maximum floods: Discharge: Recurrence interval
	Wabash River basin—Continued							
6	Vermilion River near Danville	1,280	1914–21, 1928–59	1939		28.59	48,700	
					11	26.95	37,500	28
7	Embarrass River tributary near Greenup.	.08	1956–59	1958		11.58	26	
					10	11.56	26	
8	Second Creek tributary at Keptown.	1.56	1956–59	1957		17.36	479	
					10	15.30	227	
	Illinois River basin							
9	Sugar Creek at Milford	430	1948–59	1951		20.90	22,900	
					10	[5] 23.74	9,000	
10	Money Creek near Towanda	47.9	1958–59	1958		9.40	715	
					10	11.15	1,600	
11	Sangamon River at Mahomet	356	1948–59	1956		19.96	14,600	
					11	[5] 17.51	7,600	
12	Goose Creek near DeLand	47.3	1951–59	1958		11.77	2,890	
					10	12.13	3,340	
13	Sangamon River at Monticello	550	1908–12, 1914–59	1926		18.50	19,000	
					10	17.49	11,200	16
14	Sangamon River near Oakley	750	1943–59	1943		21.85	(1)	
			1951–59	1956		17.72	11,800	
					11	18.45	13,700	
15	Spring Creek near Springfield	107	1948–59	1951		12.16		
				1958			3,320	
					10	10.76	3,230	
16	Salt Creek near Rowell	334	1926	1926		(6)	(1)	
			1942–59	1943		24.77	12,400	
					11	[5] 24.84	7,500	8
17	Lake Fork near Cornland	207	1943	1943		23.4	29,000	
			1948–59	1951		21.60	4,570	
					10	21.00	4,900	
18	Kickapoo Creek at Waynesville	227	1948–59	1950		15.02	8,300	
					10	14.80	7,900	
19	Kickapoo Creek near Lincoln	306	1929–59	1929		17.4	(1)	
			1944–59	1950		13.66		
				1956			7,800	
					10	13.59	7,760	10
20	Sugar Creek near Hartsburg	335	1944–59	1947		14.44		
				1956			10,100	
					10	13.31	7,650	7
21	Salt Creek near Greenview	1,800	1941–59	1943		20.50	41,200	
					14	17.08	19,500	3
22	Crane Creek near Easton	28.7	1949–59	1951		8.48	381	
					10	9.08	425	
	Kaskaski River basin							
23	Kaskaskia River at Bondville	12.3	1948–59	1958		11.82	774	
					10	13.50	1,160	
24	Kaskaskia River at Ficklin	127	1954–59	1958		13.10	3,120	
					10	13.98	4,400	
25	Asa Creek at Sullivan	7.93	1950–59	1957		10.66	1,110	
					9	8.70	690	
26	Kaskaskia River at Shelbyville	1,030	1908–12, 1914, 1940–59	1957		22.37	25,900	
					11	18.50	16,200	10
27	Wolf Creek near Beecher City	48.0			10	11.59	2,290	

[1] Not determined.
[2] Formerly published as West Branch Salt Fork at Urbana, Ill.
[3] Formerly published as Salt Fork Vermilion River near Homer, Ill.
[4] Backwater from log jam at culvert entrance.
[5] Affected by ice jam.
[6] 1½ ft higher than in May 1943 at site 6½ miles downstream.

MARCH 6-13, IN SOUTHEASTERN NORTH CAROLINA

Heavy rain on March 5-6 in southeastern North Carolina caused high runoff. The heavy rain was preceded 4 days earlier by general rains of as much as 1½ inches. As much as 3½ inches of rain fell during the night of March 5 and during March 6 (fig. 10) in an area near South Carolina. Many roads and houses were flooded in the Whitesville-Lake Waccamaw area, and several families were evacuated.

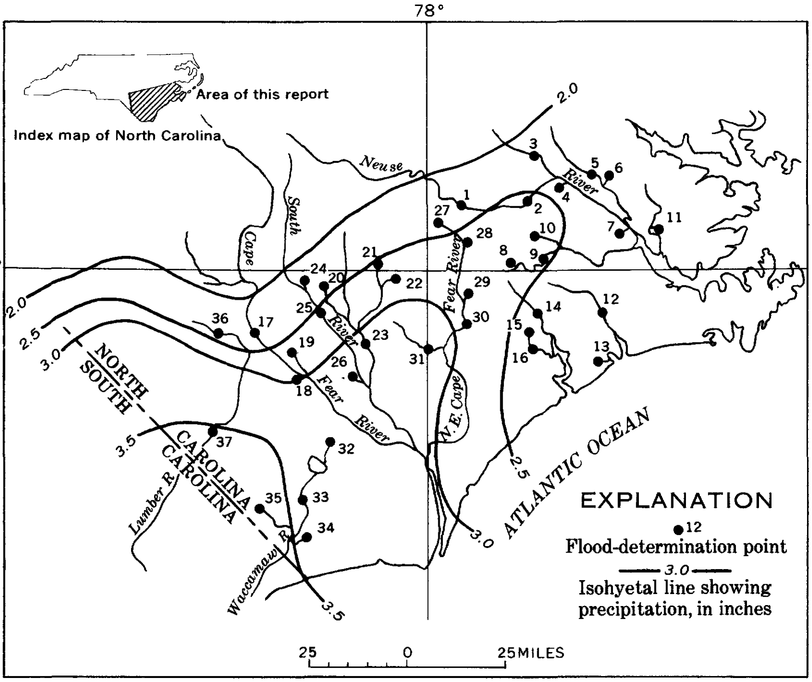

FIGURE 10.—Map of area of floods of March 6-13, in southeastern North Carolina, showing location of flood-determination points (numbers correspond to those in table 5) and precipitation for March 5-6.

A summary of peak stages and discharges for 15 gaging stations and 22 crest-stage stations is given in table 5. Two of the crest-stage stations had discharges that were maximum for their periods of record. The gaging stations Mill Branch near Tabor City, which was in an area receiving more than 3½ inches of rain, and Waccamaw River at Freeland had peak discharges that can be expected to occur, on the average, once in 12 years.

In the area near Willard, which received about 3 inches of rain during the storm period and about 1½ inches a few days earlier, the Northeast Cape Fear River near Chinquapin had a peak discharge that may be expected to occur, on the average, once in 19 years.

TABLE 5.—*Flood stages and discharges, March 6–13, in southeastern North Carolina*

Flood-determination point (fig. 10)	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to March 1959: Period	Maximum floods: Prior to March 1959: Year	Maximum floods: March 1959 (day)	Maximum floods: Gage height (feet)	Maximum floods: Discharge: Cubic feet per second	Maximum floods: Discharge: Ratio to $Q_{2.33}$
	Neuse River basin							
1	Neuse River near Goldsboro	2,390	1929–59	1929		27.3	38,600	
					11	17.12	9,050	0.6
2	Neuse River at Kinston	2,690	1919	1919		25.0	39,000	
			1930–59	1945		22.44	25,900	
					13	15.40	9,170	.6
3	Contentnea Creek at Hookerton	729	1928	1928		23.3	[1]	
			1928–59	1929		18.90	11,100	
					11	13.45	3,660	.5
4	Halfmoon Creek near Fort Barnwell.	4.87	1952–59	1955		21.67	1,600	
					6	19.61	385	
5	Swift Creek near Vanceboro	182	1909	1909		16	[1]	
			1950–59	1955		13.67	6,060	
					9	8.79	1,620	1.2
6	Palmetto Swamp near Vanceboro.	24.2	1953–59	1955		26.14	3,700	
					6	21.11	650	2.8
7	Batchelders Creek near New Bern.	33.6	1953–59	1955		23.58	7,000	
					6	16.10	820	2.7
8	Tuckahoe Swamp tributary near Comfort.	3.35	1953–59	1955		25.50	630	
					6	22.50	250	
9	Trent River near Trenton	168	1951–59	1955		17.84	9,100	
					8	15.47	3,760	3.1
10	Vine Swamp near Kinston	5.64	1953–59	1955		23.71	820	
					6	23.03	575	
11	Upper Broad Creek tributary near Grantsboro.	3.31	1953–59	1955		22.99	800	
					6	20.67	216	
	Whiteoak River basin							
12	Whiteoak River at Belgrade	53.3	1953–59	1955		23.49	8,900	
					8	14.28	840	1.9
	New River basin							
13	Queen Creek tributary near Hubert.	4.95	1953–59	1955		25.70	1,320	
					6	21.69	275	
14	New River near Gum Branch	74.5	1949–59	1955		19.99	7,900	
					7	14.09	1,730	2.8
15	Southwest Creek tributary near Jacksonville.	1	1953–59	1955		22.50	282	
					7	21.25	165	
16	Southwest Creek near Jacksonville.	26.9	1953–59	1955		26.9	5,500	
					7	19.67	750	3.0
	Cape Fear River basin							
17	Cape Fear River near Tarheel	4,810	1937–59	1945		43.44	[1]	
					8	12.30	19,700	.4
18	Browns Creek near Elizabethtown.	14.2	1953–59	1955		20.93	2,000	
					7	19.19	340	2.3
19	Turnbull Creek near Elizabethtown.	64.9	1953–59	1955		25.38	1,760	
					7	21.88	520	1.0
20	Little Coharie Creek near Roseboro.	96.4	1924	1924		11.6	[1]	
			1950–59	1955		9.00	1,860	
					7	7.06	635	.8
21	Turkey Creek near Turkey Creek.	15.7	1953–59	1955		22.60	1,190	
					7	22.02	810	5.1
22	Stewarts Creek tributary near Warsaw.	1	1953–59	1955		23.57	117	
					6	24.20	142	

See footnotes at end of table.

TABLE 5.—*Flood stages and discharges, March 6–13, in southeastern North Carolina*—Continued

Flood-determination point (fig. 10)	Stream and place of determination	Drainage area (sq mi)	Maximum floods					
			Prior to March 1959		March 1959 (day)	Gage height (feet)	Discharge	
			Period	Year			Cubic feet per second	Ratio to $Q_{2.33}$
	Cape Fear River Basin—Continued							
23	Black River near Tomahawk	680	1928	1928		47.0	9,000	
			1951–59	1955		44.16	6,550	
					9	42.56	5,420	1.4
24	Big Swamp near Roseboro	32.3	1953–59	1955		20.48	600	
					6	20.10	475	1.6
25	South River near Parkersburg	382	1951–59	1955		64.20	5,000	
					10	61.43	2,040	.8
26	Colly Creek near Kelly	108	1908	1908		11.1	(1)	
			1950–59	1955		7.20	910	
					11, 12	6.85	850	1.0
27	Northeast Cape Fear River tributary near Mount Olive.	.8	1953–59	1955		21.63	95	
					6	19.79	32	
28	Matthews Creek near Pink Hill.	9.29	1953–59	1955		21.96	809	
					6	21.58	570	5.5
29	Limestone Creek near Beulaville.	49.7	1953–59	1955		24.50	3,300	
					8	22.89	1,420	3.3
30	Northeast Cape Fear River near Chinquapin.	600	1908	1908		[2] 22.6	(1)	
			1940–59	1955		17.97	15,200	
					8	15.77	10,300	2.9
31	Rockfish Creek near Wallace	63.8	1940–59	1955		[3] 15.5	[3] 2,800	
					6	11.90	2,470	4.6
	Waccamaw River basin							
32	Friar Swamp tributary near Bolton.	21.1	1953–59	1955		23.19	950	
					6	22.72	850	4.1
33	Waccamaw River at Freeland	626	1939–59	1955			10,200	
				1955		16.63		
					11	16.12	8,390	2.2
34	Wet Ash Swamp near Ash	19.7	1953–59	1955		20.78	650	
					6	20.32	600	3.1
35	Mill Branch near Tabor City	3.85	1953–59	1955		21.56	195	
					6	23.21	575	
	Lumber River basin							
36	Tenmile Swamp near Lumberton.	16.1	1953–59	1955		20.67	465	
					6	20.75	570	3.4
37	Lumber River at Boardman	1,220	1928–59	1928		11.8	25,000	
					9, 10	8.89	5,990	.9

[1] Not determined.
[2] At site 1,000 ft. upstream.
[3] At site 1 mile downstream; drainage area, 65.2 square miles, at different datum.

Figure 11 is a curve by which the ratio of the peak discharge to the mean annual flood (the figure in the last column in table 5) can be converted to recurrence interval (the average interval of time in which the given flood will be equaled or exceeded once).

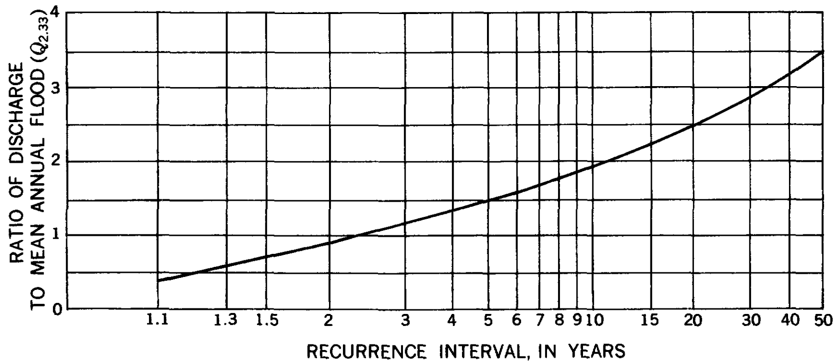

FIGURE 11.—Recurrence interval of peak discharges of floods of March 6–13, in southeastern North Carolina.

MARCH 29–APRIL 10, IN SOUTHERN WISCONSIN AND NORTHERN ILLINOIS

More than 1 inch of rain fell in southern Wisconsin and northern Illinois March 31–April 3, and more than 2 inches fell in the headwater area of the Pecatonica River basin (fig. 12).

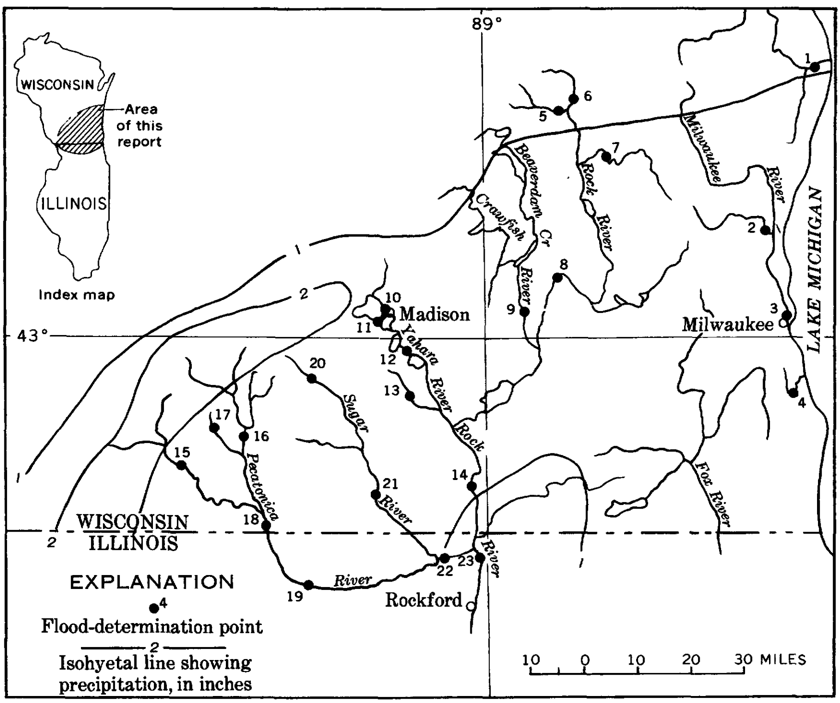

FIGURE 12.—Map of area of floods of March 29–April 10, in southern Wisconsin and northern Illinois, showing location of flood-determination points (numbers correspond to those in table 7) and precipitation for March 30–April 3.

Although this amount of rainfall is not unusual, the time of occurrence was an important factor that contributed to the magnitude of the floods. Because precipitation in the flood area was above normal in October and November 1958, the ground was wet when cold weather started. Because precipitation, in the form of snow, for December 1958 and January 1959 was deficient, ground cover was light in the early part of the winter. Snowfall was unusually heavy in February and March 1959. Many snow-reporting stations listed more than 20 inches of snow on the ground in the middle of March. A U.S. Weather Bureau snow survey made during the middle of March (table 6) showed water-equivalent figures as high as 7.5 inches at the northern edge of the flood area. By the end of March some Weather Bureau reporting stations in the area showed no snow on the ground. This absence was the result of warm daytime temperatures during the last part of March which melted the snow. The water produced thereby reached the streams gradually over a period of days.

TABLE 6.—*Snow-depth and water-equivalent measurements for March 1959*

[Data from U.S. Weather Bureau]

Station	Date	Snow depth (inches)	Water equivalent (inches)	Date	Water equivalent (inches)	Date	Water equivalent (inches)
Baraboo	18	28	6.9				
Fond du Lac 18 W [1]	20	22	7.5				
Beaver Dam 5 SE	20	18	6.6				
Watertown 3 S	20	11	4.8				
Mt. Horeb 2 SW	18	18	6.5				
Monroe 6 SE	17	11	3.8				
Martintown	18	7	3.4				
Darlington [1]	17	11	4.2				
Platteville	18	12	4.6				
Muscoda	18	15	4.0	27	0.6		
La Farge	17	26	6.9	27	3.2		
Viroqua	17	27	7.0	24	4.8	27	4.2
Cashton	18	21	5.3				
Madison [1]	17	15	2.8				

[1] No snow on ground on March 31; no data for March 31 for other stations listed.

These conditions set the stage for rapid run-off from rainfall in the steeper areas, such as the Pecatonica River basin, and for a high but more prolonged run-off period in the basins, such as the Rock River basin, where there is considerable storage available in swamps and marshes. Stages and discharges that were maximum of record were recorded for several Pecatonica and Rock River stations and for some adjoining tributary stream stations. It was reported that the Rock River at Watertown, Wis., was the highest in 40 years. The magnitude of the flood is evident from the table of peak discharges (table 7) and the flood hydrograph of several streams in south and south-central Wisconsin (fig. 13).

On April 5, Lake Mendota at Madison, Wis., reached its maximum stage since at least 1916. The stage on Lake Monona at Madison

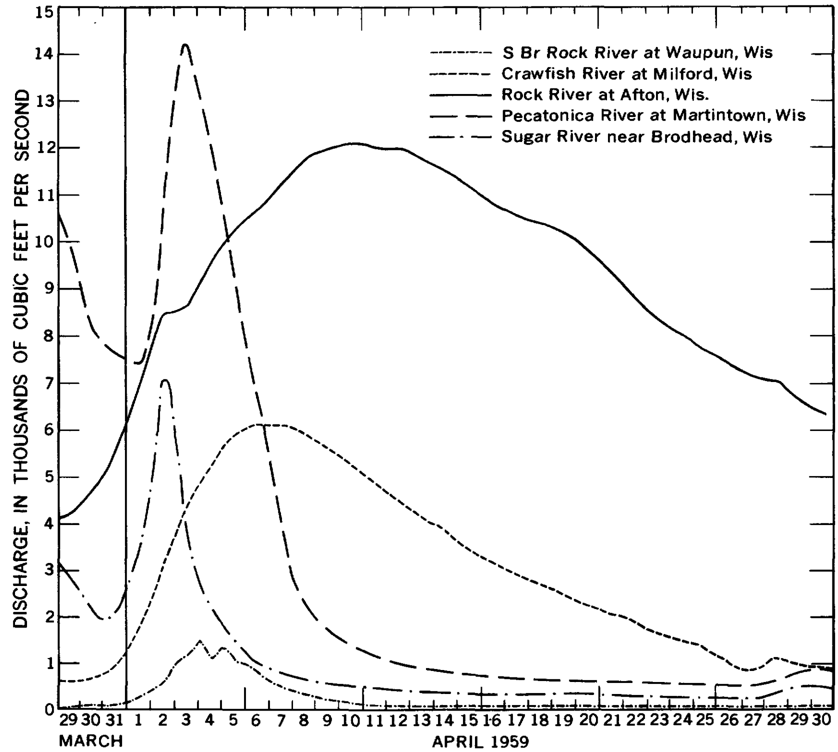

FIGURE 13.—Selected discharge hydrographs March 29–April 30 for streams in southern Wisconsin.

was 0.36 feet below its maximum stage in 1929. One day after the peak stage occurred on Lake Mendota a discharge of 917 cfs was measured on the Yahara River between the two lakes.

Flood damage was confined primarily to homes and industry within the river flood plains. Because the flood waters were generally slow in rising, there was ample time to take precautionary measures that held flood damage to a minimum.

The flood on Pecatonica River at Freeport, Ill., ended a 14-month period of deficient runoff at that point. The peak stage was the highest since 1937, although the discharge was exceeded in 1948 and had a recurrence interval of only 6 years. Fifty blocks in the eastern part of the city were flooded, and about 350 persons were driven from their homes. The flooding lasted from Mar. 29 through the first week in April. Consequently, the April runoff at Freeport was 2.71 inches, the highest of any April in 45 years of record.

On the Rock River at Rockford, Ill., 40 blocks were under water, and nearly 2,000 persons were made homeless. Blackhawk Island, south of the city, was entirely covered by flood waters and its 650

TABLE 7.—*Flood stages and discharges, April 1–12, in southern Wisconsin and northern Illinois*

Flood-determination point (fig. 12)	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to April 1959: Period	Maximum floods: Prior to April 1959: Year	Maximum floods: April 1959 (day)	Maximum floods: Gage height (feet)	Maximum floods: Discharge: Cubic feet per second	Maximum floods: Discharge: Ratio to $Q_{2.33}$
	Streams tributary to Lake Michigan							
1	Sheboygan River at Sheboygan, Wis.	432	1916–24, 1950–59	1920		9.40	[1] 7,140	
					3	9.48	4,790	1.5
2	Cedar River near Cedarburg, Wis.	121	1930–59	1952		11.40	3,500	
					1	[2] 11.7	3,400	3.0
3	Milwaukee River at Milwaukee, Wis.	686	1914–59	1918		9.00	15,100	
					3	7.92	8,780	1.9
4	Oak Creek near South Milwaukee, Wis.	13.9	1958–59					
					1	15.25	200	
	Rock River basin							
5	West Branch Rock River near Waupun, Wis.	41.4	1949–59	1950		6.56	949	
					2	[2] 6.54		
					3	6.07	730	1.1
6	South Branch Rock River at Waupun, Wis.	62.8	1948–59	1952		6.96	1,000	
					3	7.97	1,500	1.8
7	East Branch Rock River near Mayville, Wis.	179	1949–59	1950		8.80	2,160	
					3	[2] 11.02	3,400	1.6
8	Rock River at Watertown, Wis.	971	1931–59	1952		5.69	4,180	
					4	6.32	5,030	1.8
9	Crawfish River at Milford, Wis.	732	1931–59	1946		8.88	4,260	
					6	11.15	6,140	2.3
10	Lake Mendota at Madison, Wis.	254	1903, 1916–59	1937		3.70		
					5	4.19		
11	Lake Monona at Madison, Wis.	273	1915–59	1929		3.66		
					9, 11, 12	3.30		
12	Yahara River near McFarland, Wis.	351	1930–59	1937			672	
				1950		6.33		
					10	5.82	867	
13	Badfish Creek near Stoughton, Wis.	43.5	1956–59	1957		[2] 3.91		
				1958		2.15	252	
					1	3.87	682	
14	Rock River at Afton, Wis.	3,300	1914–59	1916		[2] 13.05		
				1929		11.81	13,000	
					10	11.77	12,100	1.9
15	Pecatonica River at Darlington, Wis.	274	1939–59	1950		20.71	22,000	
					1	17.16	10,700	1.8
16	East Branch Pecatonica River near Blanchardville, Wis.	221	1939–59	1948		15.74	11,700	
					1	15.61	9,680	2.5
17	Yellowstone River near Blanchardville, Wis.	29.1	1954–59	1957		9.65	1,820	
					1	10.00	2,000	
18	Pecatonica River at Martintown, Wis.	1,040	1939–59	1948		20.24	13,400	
					3	20.23	14,200	1.8
19	Pecatonica River at Freeport, Ill.	1,330	1914–59	1929		[1] 19.76	18,400	
					5	16.90	12,000	1.4
20	Mount Vernon Creek near Mount Vernon, Wis.	16.1	1954–59	1954		5.98	602	
					1	6.32	940	
21	Sugar River near Brodhead, Wis.	527	1914–59	1915		11.4	14,800	
					2	8.8	7,150	1.3
22	Pecatonica River at Shirland, Ill.	2,540	1939–59	1946		16.72	15,200	
					4	17.45	16,000	1.3
23	Rock River at Rockton, Ill.	6,290	1937	1937		[2] 14.6	(3)	
			1903–9, 1914–19, 1939–59	1916		[1] 13.06	32,500	
					4	14.08	25,400	1.2

[1] At different site or datum.
[2] Affected by backwater from ice.
[3] Not determined.

residents were evacuated to Rockford. Two Civil Air Patrol Officers were killed while on a reconnaissance mission, when their plane crashed into the Rock River above Rockford.

Smaller towns in Illinois also felt the effects of the floods. On March 29, water flooded the main street of Winslow, and the business district of McConnell was under 2 feet of water. The two Illinois counties in the flood area, Stephenson and Winnebago, were designated disaster areas by the Small Business Administration.

Rock River tributaries downstream from Rockford did not contribute appreciably to the flood, for they had their peak runoff early in March. Little damage occurred below the Rockford area, and for the most part flooding affected agricultural areas.

MAY, IN NEBRASKA, KANSAS, AND IOWA

Rainfall during the month of May was above normal in Iowa, in most of Nebraska, and in central and northeastern Kansas.

In Iowa the total monthly rainfall ranged from 3.59 inches at Clinton in the eastern part of the State to 13.48 inches at Britt in the north-central part. The departure from the long-term-mean May rainfall ranged from an excess of 1.77 inches to 6.16 inches in east-central and northwest Iowa and was as much as 9.86 inches in excess at Britt. Rainfall was general throughout the month; three major periods of precipitation occurred, on May 20, 28, and 30 (fig. 14).

In northeast Kansas the monthly average precipitation of about 7.3 inches was the greatest May average since 1938. In north-central Kansas, only May of 1950 was wetter since 1938, and since 1930 in the central part of the State the 7.07-inch average for May 1959 was exceeded only by 7.93 inches in May 1957.

In Nebraska the May precipitation was far above the long-term mean over all the State except in the western and north-central parts. Thunderstorms were reported at some point in the State nearly every day of the month, and many precipitation stations in the eastern third of Nebraska reported totals that were 2 to 3 times the long-term mean for May.

The large amount of rain that was spread out over the month (fig. 15) caused several moderate floods at scattered points in Iowa and in eastern Nebraska and Kansas.

Moderate rains of 1 to 2 inches on May 17 east of Salina, Kans., which followed a period of heavy antecedent rains, caused a flood on Lyon Creek near Woodbine (fig. 15). This peak discharge (table 8) did not approach that of the flood of 1951, but it had a recurrence interval of 11 years and exceeded the previous maximum in 6 years of continuous discharge records by 227 percent.

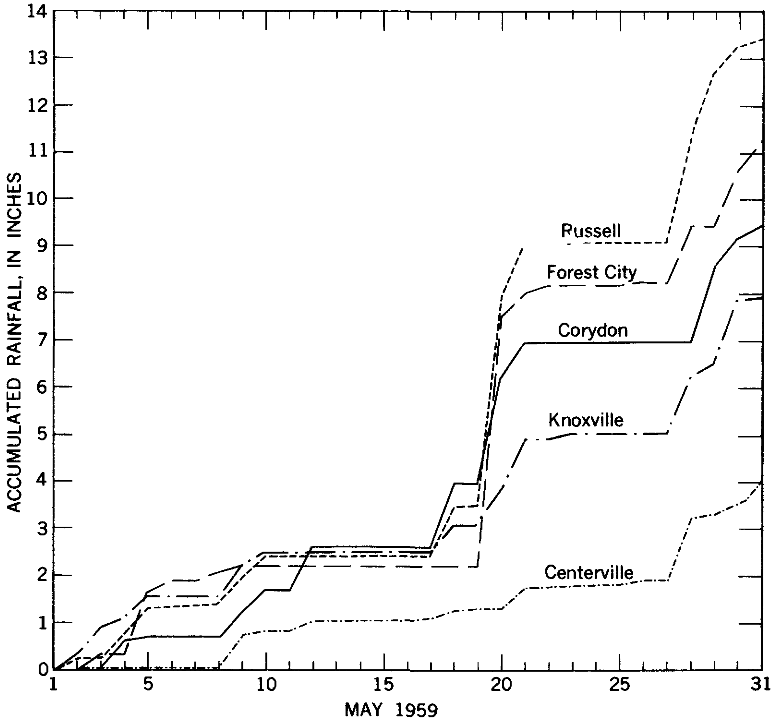

FIGURE 14.—Accumulated rainfall for May 1959 at selected precipitation stations in Iowa.

Intense precipitation in the headwaters of Little Nemaha River in Nebraska on May 18 produced a high peak discharge of 816 cfs per sq mi (table 8) on a small tributary near Syracuse (fig. 15). This discharge is the third highest at this site since 1950. Between noon and 1 p.m., 1.07 inches of rain was recorded 3 miles northeast of Syracuse and 1.82 inches was recorded 4 miles south of Nehawka, about 13 miles northeast of Syracuse. Daily totals of 1.59 to 2.27 inches were observed at rain gages in the vicinity. The unit runoff of 816 cfs per sq mi is equivalent to a rate of 1.26 inches per hour.

A flash flood of unusual severity in the Fox Creek basin north of Curtis, Nebr. (fig. 15), late on May 19 was caused by a 3-day storm that began on May 17. Precipitation associated with this storm is tabulated below.

Location	Time of observation	Precipitation, in inches				
		May 17	May 18	May 19	May 20	May 17–20
Curtis	5 p.m.		0.63	0.13	1.08	1.84
Gothenburg	7 p.m.		.79	.18	1.24	2.21
Hayes Center	7 a.m.		1.50	.20	1.16	2.86
Moorefield	7 a.m.		.47	.15	1.50	2.12
North Platte Experimental Farm	12 p.m.	1.54	1.02	.75	.22	3.53
Wellfleet	8 a.m.		.30	.30	1.57	2.17

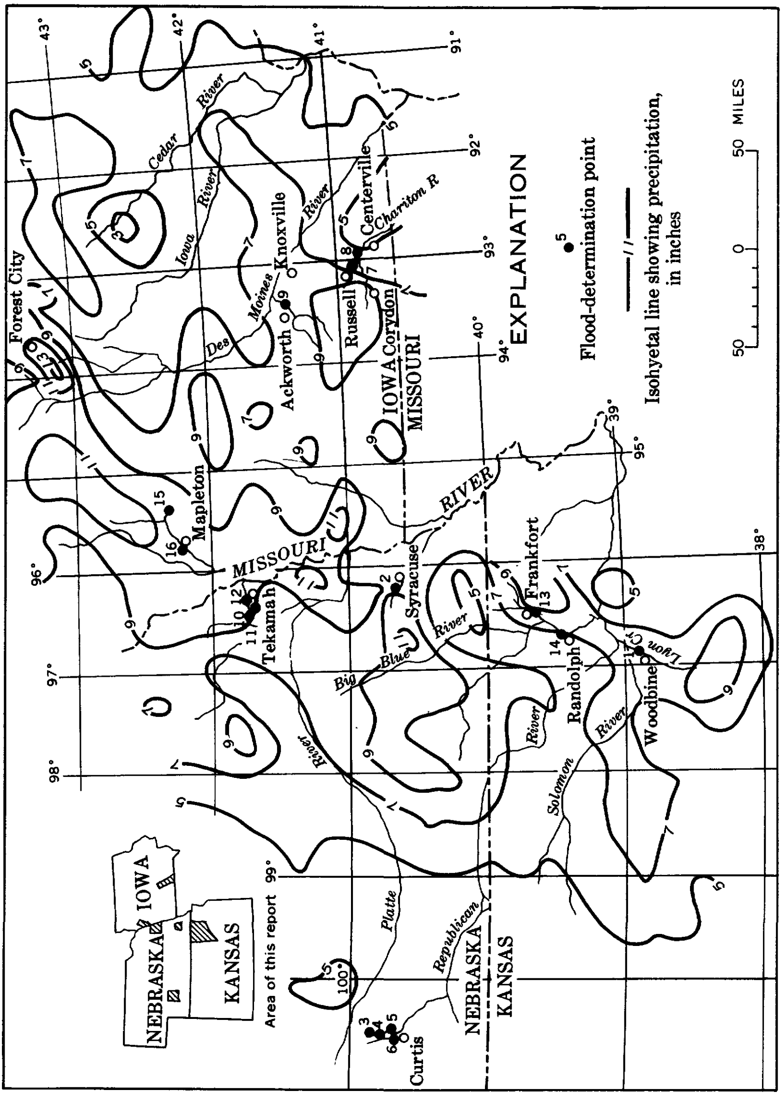

FIGURE 15.—Map of areas of floods of May 1959, in Nebraska, Kansas, and Iowa, showing precipitation and location of flood-determination points. (Numbers correspond to those in table 8.)

TABLE 8.—*Flood stages and discharges, May, in Nebraska, Kansas, and Iowa*

Flood-determination point (fig. 15)	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to May 1959: Period	Maximum floods: Prior to May 1959: Year	Maximum floods: May 1959 (day)	Maximum floods: Gage height (feet)	Maximum floods: Discharge: Cubic feet per second	Maximum floods: Discharge: Ratio to $Q_{2.33}$
Kansas River basin								
1	Lyon Creek near Woodbine, Kans.	230	1951–59	1951		30	93,000	
					17	27.21	14,100	2.8
Little Nemaha River basin								
2	Little Nemaha River tributary near Syracuse, Nebr.	.76	1950–59	1950		16.6	1,280	
					18	13.65	620	1.9
Kansas River basin								
3	Fox Creek tributary near Curtis, Nebr.	6.97	1952–59	1957		13.64	1,000	
					19	12.83	2,980	7.4
4	Fox Creek north of Curtis, Nebr.	13.8	1952–59	1957		11.76	1,320	
					19	12.85	2,080	3.6
5	Fox Creek above Cut Canyon near Curtis, Nebr.	31.8	1951–59	1951		23.0	2,810	
					19	19.58	1,370	1.5
6	Cut Canyon near Curtis, Nebr.	25.6	1951–59	1952		19.6	1,560	
					19	14.70	515	.6
Chariton River basin								
7	Honey Creek near Russel, Iowa	13.2	1952–59	1952		9.86	586	
					21	11.26	4,100	
8	Chariton River near Rathbun, Iowa.	551	1957–59					
					22	24.0	16,600	1.8
Des Moines River basin								
9	South River near Ackworth, Iowa.	474	1940–59	1947		24.60	34,000	
					22	22.81	13,700	1.6
Tekamah Creek basin								
10	South Branch Tekamah Creek near Craig, Nebr.	2.54	1950–59	1950		21.3	2,580	
					28	11.09	1,040	2.1
11	South Branch Tekamah Creek tributary near Tekamah, Nebr.	4.08	1950–59	1950		19.3	1,800	
					28	15.05	870	1.4
12	South Branch Tekamah Creek near Tekamah, Nebr.	9.73	1950–59	1954		20.17	3,130	
					28	17.31	1,230	1.2
Kansas River basin								
13	Black Vermillion River near Frankfort, Kans.	412	1948–59	1948		30.2	(1)	
				1951		28.6	30,400	
					30	29.4	38,300	5.9
14	Big Blue River at Randolph, Kans.	9,100	1897–1959	1941		30.81	98,000	
					31	23.05	30,100	1.1
Little Sioux River basin								
15	Odeboldt Creek near Arthur, Iowa.	39.3	1958–59					
					31	12.18	5,160	
16	Maple River at Mapleton, Iowa.	669	1941–59	1954		20.4	15,600	
					31	19.70	14,000	4.4

[1] Not determined.

The monthly rainfall total was not great in the flood area, but the concentration of rainfall in 3 days, and particularly on May 20, was high. The maximum rate of rainfall recorded was 0.72 inch per hour at Curtis, between 9 and 10 p.m. on May 19. The peak discharge (table 8) of Fox Creek tributary near Curtis (2,980 cfs from 6.97 sq mi) is equivalent to a runoff rate of 0.66 inch per hour and has a recurrence interval much greater than 25 years. The peak discharge in Fox Creek north of Curtis has a recurrence interval of about 25 years. The source of the 1959 flood was the headwater area of Fox Creek. The peak discharge of the flood of May 20, 1951, was the highest of record at the gage on Fox Creek above Cut Canyon, and it is estimated that this flood also exceeded the flood of May 19, 1959, at the gage on Fox Creek north of Curtis and probably on Fox Creek tributary.

In Iowa, unusually high volumes of runoff for May were produced from the rains. Streamflow in the upper Des Moines River and the upper Iowa River was the highest for any May since 1954. Most other major streams in south-central Iowa were at or near bankfull stage for almost the entire month. Discharge for all streams was above normal. There were no major floods on large streams, and, although flooding occurred on small creeks and streams throughout the month, damage was negligible.

The peak discharges on a few streams (table 8) were noteworthy. Those on Odeboldt Creek and Honey Creek were high but, because of their small drainage areas, no ratio to the mean annual flood or recurrence interval can be assigned to the peaks. The peak discharge on Maple River at Mapleton exceeded that of a 50-year flood.

High rates of runoff occurred on May 28 in the Tekamah Creek basin (fig. 15) north of Omaha, Nebr. South Branch Tekamah Creek near Craig had a discharge of 409 cfs per square mile (table 8). Precipitation of 1.40 inches was observed at the nonrecording rain gage in Tekamah for the 24-hour period ending at 8 a.m., May 29; 6.68 inches had fallen at that point between May 1 and May 27. Similarly, 1.40 inches was observed on May 28 at Lyons, where 7.44 inches had been observed between May 1 and May 26. It is probable that more than 1.40 inches fell over these small watersheds on May 28 and that the intensity of the rainfall was high, but there can be no doubt that the antecedent moisture content of the soil was high and, therefore, a significant cause of the high rate of runoff.

Storms on May 5–6, 9, 11, 21–22, and 26 made antecedent soil moisture conditions favorable for the flood on the Black Vermillion River (fig. 15) after heavy rains late on May 29. Morning readings on May 30 at Frankfort, Centralia, and Axtell showed 4.38, 5.20, and 1.60 inches of rain, respectively. The recording gage at Frankfort registered 1.35, 1.05, and 1.10 inches in the three consecutive hours ending at 11 p.m, May 29. By the morning of May 30, the Black Vermillion River near Frankfort crested at a near-record height (table 8) and flooded the business district of Frankfort to depths of 4 feet; damage was the heaviest known to local residents. A flood of this magnitude has a recurrence interval greater than 50 years. A flood only 10 months earlier, July 31, 1958, reached a stage of 28.25 feet, 1.2 feet lower than that of 1959. The flood on the Black Vermillion River caused essentially all of the rise on the Big Blue River at Randolph; the daily mean on May 29 was 4,360 cfs and that on May 31 was 22,400 cfs. The peak discharge at Randolph was only 1.1 times the mean annual flood, and its recurrence interval was about 2.5 years.

MAY 3–4, IN CHEROKEE BAYOU BASIN, TEXAS

Heavy rains during the night of May 2–3 produced severe floods on Cherokee Bayou, a tributary to the Sabine River in Texas, and caused three deaths and damage estimated at slightly more than $1 million. The storm covered all of Cherokee Bayou basin, but the heaviest rainfall occurred over that part of the watershed lying above the dam that forms Lake Cherokee (fig. 16).

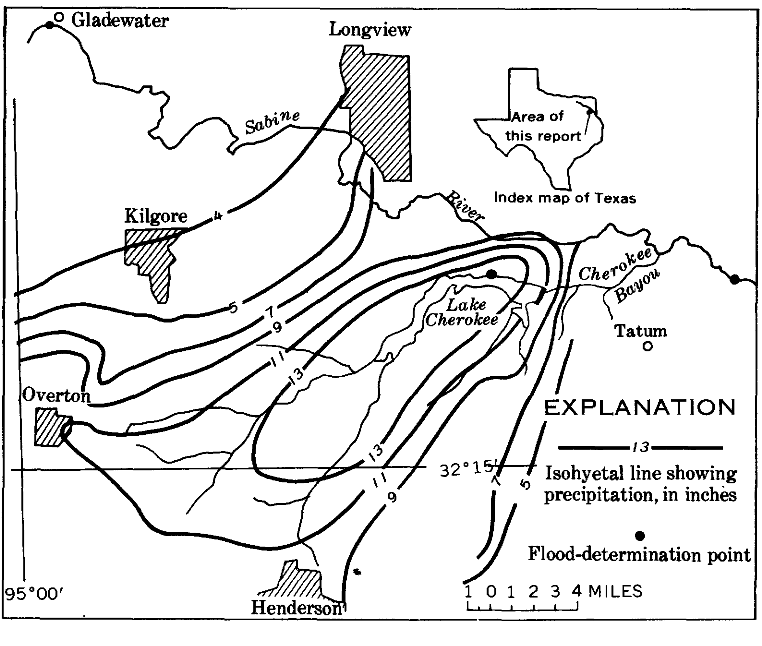

FIGURE 16.—Map of area of floods of May 3–4, in Cherokee Bayou basin, Tex., showing location of flood-determination points and precipitation for May 2–3.

The rainfall lasted only 4 to 6 hours. Totals of as much as 11 inches were recorded at U.S. Weather Bureau gages, and a bucket survey made by the U.S. Weather Bureau indicated rainfall of as much as 13.8 inches in the area.

The maximum elevation, since records began in April 1951, of Lake Cherokee near Longview occurred on May 3 and was 285.5 feet, which is 5.5 feet above the top of the service spillway. Geological Survey engineers estimated the peak discharge through the service spillway to be 28,600 cfs and, on the basis of outflow and change in contents of the reservoir, the maximum inflow was estimated to be 47,000 cfs, or 297 cfs per sq mi from the 158-square-mile area.

The localized nature of the storm is indicated by the fact that no rise occurred at the station Sabine River near Gladewater, above Cherokee Bayou, whereas at the station Sabine River near Tatum, 7 miles downstream from Cherokee Bayou, a peak discharge of 29,800 cfs occurred on May 4.

As a result of the heavy rains and floods, Rusk County and the city of Overton were declared disaster areas. Damage throughout Rusk County was heavy, estimated by the U.S. Weather Bureau at slightly more than $1 million. Estimated damages were as follows: (a) roads, bridges, and other public property, $500,000; (b) private property in urban areas, $400,000; and (c) farm property, slightly more than $100,000.

MAY 20–21, IN AU GRES AND RIFLE RIVER BASINS, MICHIGAN

The floods of May 1959 in the Au Gres and Rifle River basins, Michigan (fig. 17) resulted from heavy rainfall during the night of May 19–20. Peak unit discharges for small drainage areas (less than 15 square miles) were the highest ever measured in the Lower Peninsula of Michigan, and for very small areas (about 1 square mile) they were of the same order of magnitude as those for the record Ontonagon River flood of August 1942 in the Upper Peninsula.

Because the flood area is sparsely populated, damage was largely confined to farm lands and facilities and to secondary roads and their appurtenant drainage structures.

About 30 percent of the flood area is wooded, and much of the remaining area is marginal land no longer used for farming. The area is sparsely populated.

The U.S. Geological Survey operates six recording rain gages in a 75-square-mile area in the upper Rifle River basin. Data from these gages and from a number of other sources scattered throughout the report area are the basis for the isohyetal lines on figure 17. The Corps of Engineers reconnoitered the flood area shortly after the floods and collected rainfall data, some of which was of the unofficial

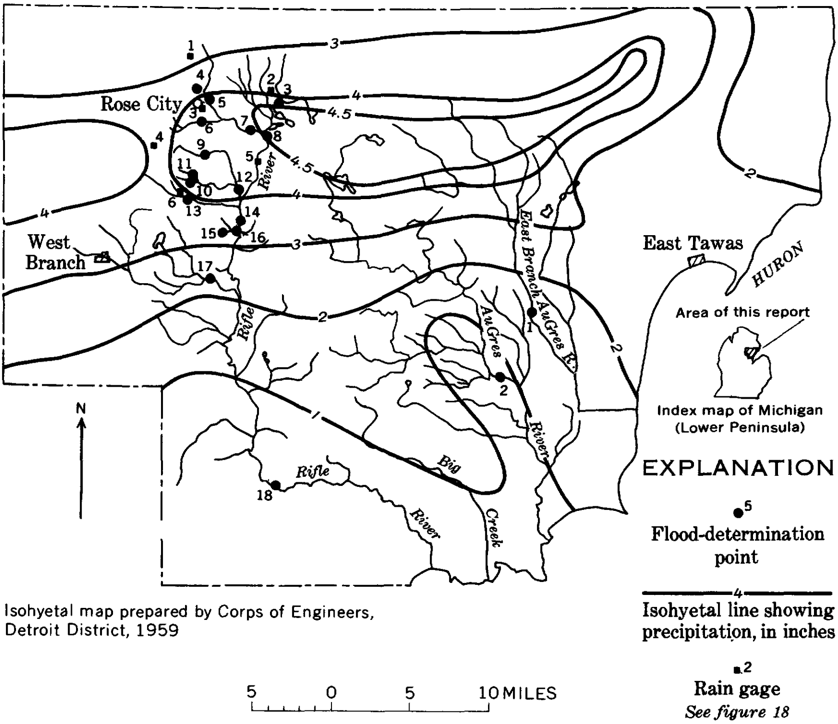

FIGURE 17.—Map of area of floods of May 20-21 in Au Gres and Rifle River basins, Michigan, showing location of flood-determination points (numbers correspond to those in table 9) and precipitation for May 19-20.

"bucket-catch" variety. Figure 17 is an adaptation of a map prepared and compiled by the Corps from the rainfall data they collected. No rain had fallen for a week prior to May 19.

The flood peaks were caused by the initial downpour; subsequent rain, although comparatively light (fig. 18), delayed recessions and added to flood volumes. An indication of the unusually high rainfall intensities at the beginning of the storm is given by figure 19, wherein selected maximum rainfall intensities during May 19–20, 1959, are plotted on the Weather Bureau's rainfall intensity-duration-frequency curves for Alpena, Mich. Alpena, the nearest first-order weather station, is about 50 miles northeast of Rose City.

Hydrographs (fig. 20) show the rapid increase in discharge as a result of the intense initial rain and the effects of the subsequent rain in slowing the recession.

The floods of May 1959 in the Au Gres and Rifle River basins were the maximum of record at five of the nine gaging stations in operation. Maxima occurred at all seven crest-stage stations in the upper Rifle River basin. (See table 9.)

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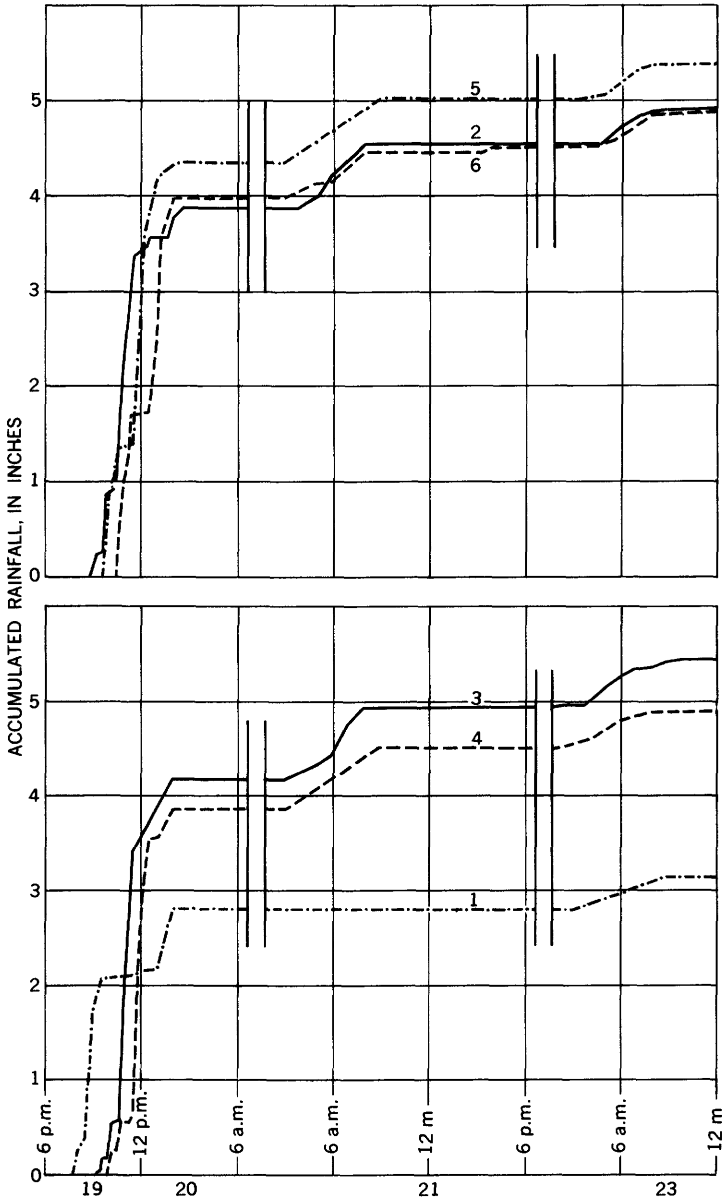

FIGURE 18.—Accumulated rainfall, May 19–23, for six rain gages (located by corresponding number in fig. 17) in the Rifle River basin, Michigan.

At the crest-stage stations, the peaks occurred early in the morning of May 20. Current-meter measurements were not made and, in many instances, could not have been made during the flood. Indirect measurements were made where peak flows could not be determined

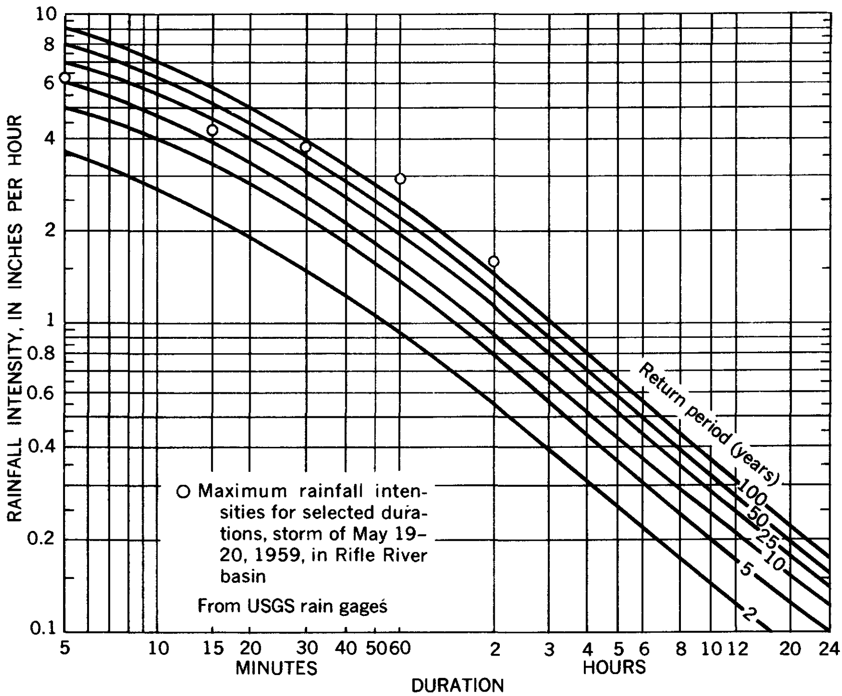

FIGURE 19.—Rainfall intensity-duration-frequency curves for Alpena, Mich. From U.S. Weather Bureau Technical Paper 25.

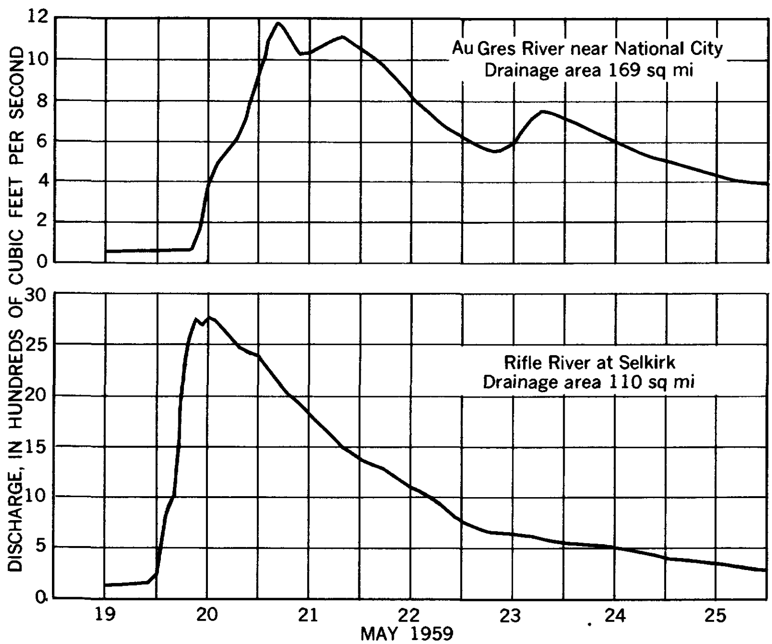

FIGURE 20.—Discharge hydrographs for two discharge stations.

from a stage-discharge relation based on current-meter measurements.

Rainfall was heaviest in the headwaters of the two basins; this fact explains why previous maxima were exceeded at headwater stations but not at downstream stations. Vagaries of rainfall are believed to be responsible for the difference in peak unit discharge at the Au Gres River station and the East Branch Au Gres River station. Flooding may have been severe in the upper Au Gres River basin, but information and data are lacking.

On Houghton and Prior Creeks the peak discharges at the upstream stations were greater than those at the downstream stations. This difference is probably due to the steeper gradients above the upstream stations and to the channel and overbank storage below.

TABLE 9.—*Flood stages and discharges, May 20–21, in Au Gres and Rifle River basins, Michigan*

Flood-determination point (fig. 17)	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to May 1959, Period	Prior to May 1959, Year	May 1959 (day)	Gage height (feet)	Discharge (cfs)
	Streams tributary to Lake Huron						
1	East Branch Au Gres River at McIvor.	84	1950–59	1952		7.67	865
					20	8.88	1,310
2	Au Gres River near National City	169	1950–59	1953		[1] 10.5	
				1959			2,480
					21	5.62	1,170
3	Gamble Creek at Lupton	8.86	1952–56, 1959.	1956		3.01	168
					20	7.00	223
4	Bixby Creek near Rose City	3.20	1952–59	1956		4.76	234
					20	6.55	423
5	Houghton Creek at Rose City	11.2	1952–59	1956		3.64	720
					20	4.34	1,090
6	Wilkins Creek near Rose City	8.22	1952–59	1956		2.95	255
					20	4.68	748
7	Houghton Creek near Lupton	27	1950–59	1956		6.31	575
					20	7.15	955
8	Rifle River at "The Ranch" near Lupton.	54	1950–59	1956		9.90	750
					20	10.10	1,330
9	Prior Creek near Rose City	5.22	1952–59	1956		2.44	123
					20	3.44	910
10	South Branch Ammond Creek near Rose City.	1.14			20		1,710
11	North Branch Ammond Creek near Rose City.	.65			20		1,240
12	Prior Creek near Selkirk	19	1950–59	1956		[2] 5.23	
				1959			314
					20	5.64	584
13	Klacking Creek near Selkirk	7.42	1952–59	1956		2.70	155
					20	6.59	738
14	Rifle River at Selkirk	110	1950–59	1956		4.94	1,680
					20	6.76	2,760
15	South Branch Shepards Creek near Selkirk.	1.20	1951–59	1956		4.42	181
					20	3.99	125
16	Shepards Creek near Selkirk	4.51	1952–59	1956		4.46	454
					20	4.57	726
17	West Branch Rifle River near Selkirk.	52	1952–59	1956		8.80	1,160
					20	8.39	884
18	Rifle River at Michigan Highway 70, near Sterling.	320	1936–59	1950		13.74	5,340
					21	10.99	3,760

[1] Affected by ice jam.
[2] Caused by backwater from logs.

There was no loss of life as a result of the floods. No homes or buildings were destroyed, nor were any trunkline highways closed.

The Ogemaw County Road Commission reported that five bridges and eight culverts were destroyed and that more than one-third of the sand fill in a 2-mile grading project was washed away. Some culverts were washed as far as one-quarter of a mile downstream from their road locations. Total damage to the Road Commission facilities was estimated as $108,000.

According to the Michigan Department of Conservation, soil loss from cultivated fields was very high, and intermittent drainage channels were severely gullied. At least $1,000 in direct damage occurred to stream improvement structures installed and maintained by the Department.

JUNE 22–24, IN LAUGHERY CREEK BASIN, INDIANA

The Weather Bureau rain gage at Batesville recorded the greatest 2-hour rainfall of record in Indiana on June 22, 1959. Rainfall of 0.70 inch was recorded in 30 minutes, from 3:05 p.m. to 3:35 p.m. In the interval, 6:30 p.m. to 7:30 p.m., 4.58 inches fell and between 7:30 p.m. and 8:00 p.m. an additional 0.98 inch fell, a total of 5.56 inches in 1.5 hours. In a period of 5 hours and 25 minutes, 6.32 inches was recorded. According to the Weather Bureau, almost every basement in

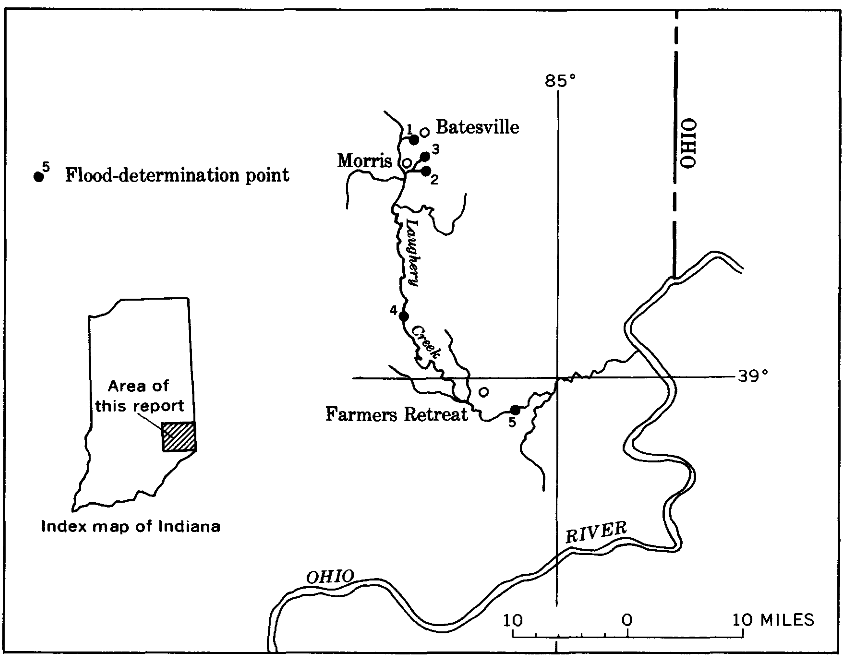

FIGURE 21.—Map of flood area showing location of flood-determination points. (Numbers correspond to those in table 10.) Floods of June 22–24, in Laughery Creek basin, Ind.

the city of Batesville was flooded and one of the greatest losses was that which occurred to basement-stored veneer worth $100,000.

Indirect measurements of peak flow were made on three small drainage areas (fig. 21) following the storm. A maximum unit discharge of 1,470 cfs per sq mi on a 0.20-square-mile drainage area occurred in a tributary to Bobs Creek at Morris (table 10). In contrast to the high peak discharge in small streams was the very low peak discharge recorded at the gaging station downstream on Laughery Creek near Farmers Retreat, drainage area 248 square miles. The small increase in flow at this site indicates that the intense storm covered only a small area in Laughery Creek basin. The recurrence interval for a flood of this magnitude at the gaging station is only about 1 year in the annual flood series.

TABLE 10.—*Flood stages and discharges, June 22–24, in Laughery Creek basin, Indiana*

Flood-determination point (fig. 21)	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to June 1959, Period	Maximum floods: Prior to June 1959, Year	Maximum floods: June 1959 (day)	Maximum floods: Gage height (feet)	Maximum floods: Discharge (cfs)
	Laughery Creek basin						
1	Little Laughery Creek tributary at Batesville.	1.47			22		1,930
2	Bobs Creek near Morris	2.75			22		3,810
3	Bobs Creek tributary at Morris	.20			22		294
4	Laughery Creek at Versailles	167	1913–59	1959		36.43	17,000
					23		[1]4,950
5	Laughery Creek near Farmers Retreat.	248	1897	1897		18	(2)
			1940–59	1959		21.13	47,800
					24	10.42	4,880

1 Result of current-meter measurements, 0.25 ft below crest.
2 Not determined.

JUNE 28, IN MILL CREEK TRIBUTARY NEAR McFARLAND, KANS.

Flash floods occurred on June 28 on several small tributaries to Mill Creek northeast of McFarland and 30 miles west of Topeka, Kans. (fig. 22). Precipitation totaling 5.14 inches was recorded at McFarland, and 3 to 7 inches fell north and west of Paxico. Most of the rain occurred in a 2-hour period during the afternoon of June 28. The runoff did not produce a noteworthy crest at the gaging station on Mill Creek near Paxico because only a small part of the drainage area contributed to the runoff. An indirect measurement of 1,350 cfs, or 2,050 cfs per sq mi, was made on a small tributary to Mill Creek with a drainage area of 0.66 square mile, northeast of McFarland.

Existing flood-frequency studies in Kansas are not applicable to such a small drainage area. If the unofficial 6.5 inches measured within this drainage area fell in 2 hours, the recurrence interval for

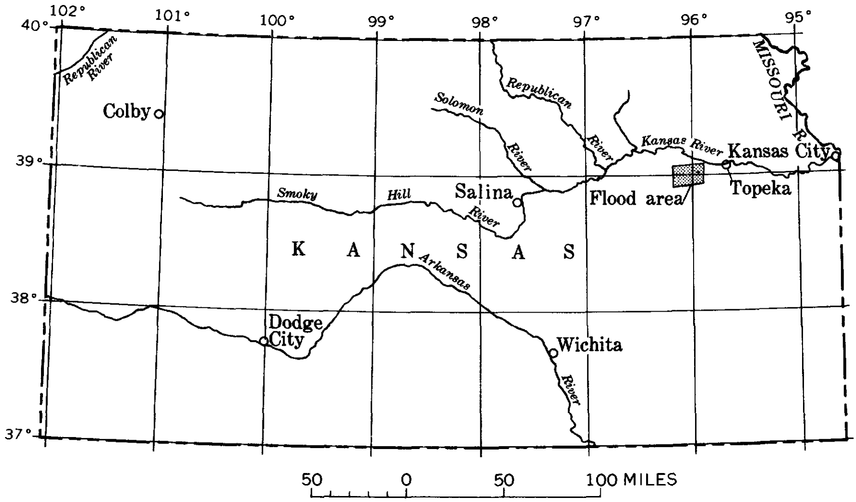

FIGURE 22.—Map of Kansas showing location of area of flood of June 28 in Mill Creek tributary near McFarland, Kans.

such a rate of rainfall is greater than 100 years (from U.S. Weather Bureau Technical Paper 25). Factors other than rainfall intensity influence the flood runoff; the recurrence interval of the peak discharge is not necessarily the same as that of the rainfall.

JULY 3, IN BONE CREEK BASIN, NEBRASKA

An intense storm on July 3 produced 5 inches of rain in 2 hours about 4 miles northwest of Ainsworth, Nebr. (fig. 23), and 4.7 inches was observed during the same period about 6 miles northwest of Ainsworth. The observations were made by local residents for the Bureau of Reclamation and were furnished with discharge data, by the Bureau.

The peak discharge on a small tributary (drainage area, 0.39 square mile) to Bone Creek, 4 miles northwest of Ainsworth was 150 cfs and that on a tributary (drainage area, 1.07 square miles) to Sand Draw, 6 miles northwest of Ainsworth was 126 cfs. The previous maximum discharges during a short period (1956–59) of record occurred in 1958 and were 22.6 cfs and 56.3 cfs respectively.

The ratio of the peak discharge on Bone Creek tributary to the mean annual flood is about 7.5; this ratio indicates a recurrence interval much greater than 25 years. The ratio on the Sand Draw tributary was about 3, and indicates a recurrence interval of 13 years.

The small areal extent of the storm is typical of many summer storms in Nebraska—another tributary to Bone Creek only 6 miles east of the one in flood was dry.

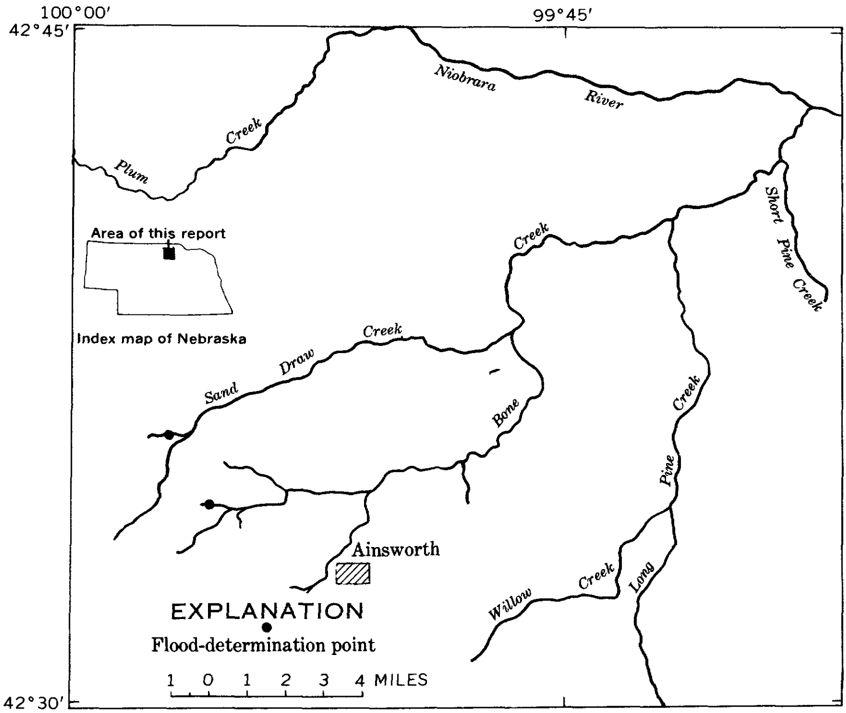

FIGURE 23.—Map of area of flood of July 3 in Bone Creek basin, Nebraska, showing location of flood-determination points.

U.S. Weather Bureau Technical Paper 25 shows a return period in excess of 100 years for the rainfall given above at Valentine, Nebr., about 35 miles northwest of these sites. Antecedent conditions and other factors can radically change the runoff; a storm with a 100-year return period does not necessarily produce a 100-year flood.

JULY 15, IN COTTONWOOD CREEK, WYO.

Local heavy rains near McKinnon, Wyo., caused a flash flood in Cottonwood Creek near McKinnon (fig. 24) on July 15. The only damage reported was to a county road and culvert. When the road was repaired, the culvert was replaced.

Although damage was slight and the area flooded was small, the discharge at one site illustrates the extreme discharges possible from storms over small areas in this region.

A slope-area measurement on Cottonwood Creek in SW¼ sec. 15, T. 12 N., R. 109 W., 1,000 feet upstream from mouth, 1.4 miles north of Wyoming-Utah State line, 2 miles west of State Highway 530, 4½ miles northwest of Manila, Utah, and 13 miles east of Mc-

Kinnon, Wyo., showed a peak discharge of 10,900 cfs from 8.63 square miles, or 1,263 cfs per sq mi.

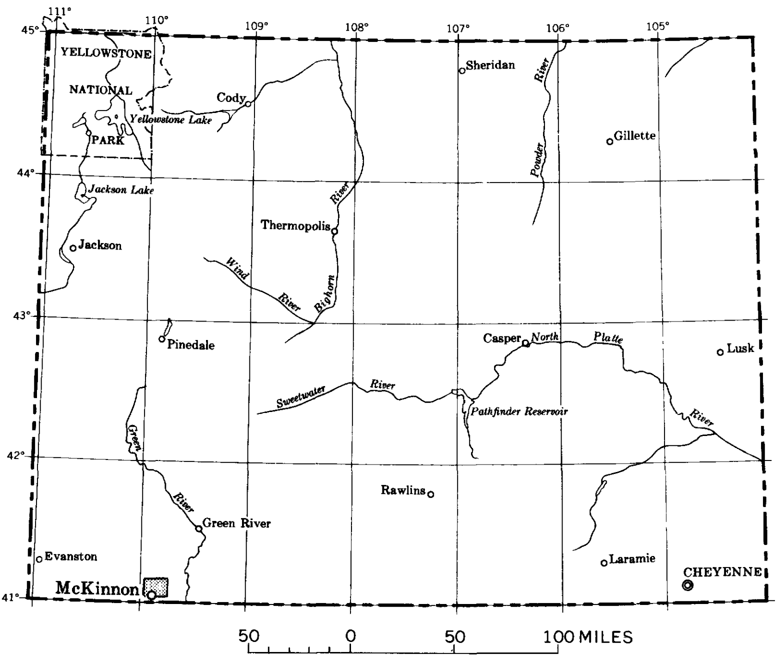

FIGURE 24.—Map of Wyoming showing location of area of flood of July 15 in Cottonwood Creek, Wyo.

AUGUST 2, NEAR BRYCE CANYON, UTAH

Severe thunderstorm activity on August 1 and 2 caused flash floods on two streams near Bryce Canyon. Summer storms in Utah are generally quite intense, and, as they cover only a small area, precipitation records are not indicative of rainfall amounts over the flood-producing drainage area. At Hatch only 0.08 inch was recorded on August 2, and at Bryce Canyon 1.79 inches fell on August 1.

The peak discharge on Rock Canyon near Hatch, about 15 miles west of Bryce Canyon (fig. 25), was 5,230 cfs from 36 square miles, and the peak discharge on Upper Valley Creek near Escalante, about 25 miles northeast of Bryce Canyon, was 5,560 cfs from 53 square miles.

The peak discharges were the maximum known. The peak discharge on Upper Valley Creek was about 6 times the mean annual flood and that on Rock Canyon was about 24 times the mean annual flood. These ratios indicate a discharge slightly greater than the 50-year flood on Upper Valley Creek and a discharge more than 4 times as great as the 50-year flood on Rock Canyon.

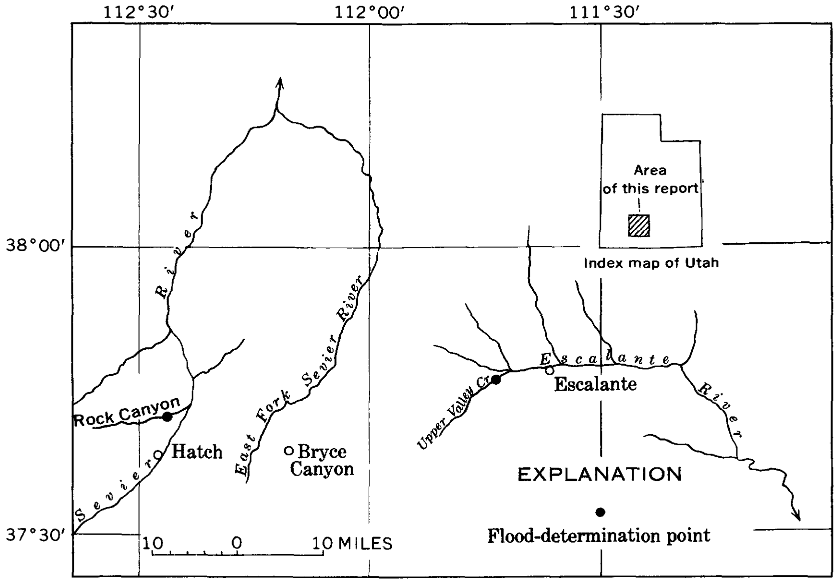

FIGURE 25.—Map of area of floods of August 2 near Bryce Canyon, Utah, showing location of flood-determination points.

The flood on Rock Canyon destroyed a 20 by 8 foot concrete box culvert on U.S. Highway 89, and minor highway damage was caused by the flood on Upper Valley Creek.

AUGUST 2, IN EAST-CENTRAL NEBRASKA

Heavy rains on July 31 were followed by more unusually heavy and intense rainfall during the night and early morning of August 1–2, in a 10-county area of east-central Nebraska (fig. 26).

A Weather Bureau rain gage 1 mile east of Malmo recorded 4.12 inches during the 2-hour period, 1–3 a.m., August 2, and about 1.25 inches falling in one 15-minute period. The total recorded by this gage from 9 p.m., August 1, to 6 a.m., August 2, was 5.85 inches.

The maximum amount observed at an official Weather Bureau nonrecording rain gage for the night of August 1–2 was 9.30 inches at Schuyler, but a field survey by U.S. Corps of Engineers representatives showed unofficial amounts in excess of 11 inches observed near Rescue. (Data collected during this survey are published in USWB Climatological Data, Nebraska, August 1959.)

Severe flooding occurred throughout the 10-county area, and that in Wahoo and Silver Creek basins was described by local residents as the worst in their memories, some of which cover a 75-year period. Damage in these basins was estimated as greater than $1 million, including damage to at least 105 bridges and culverts and to many

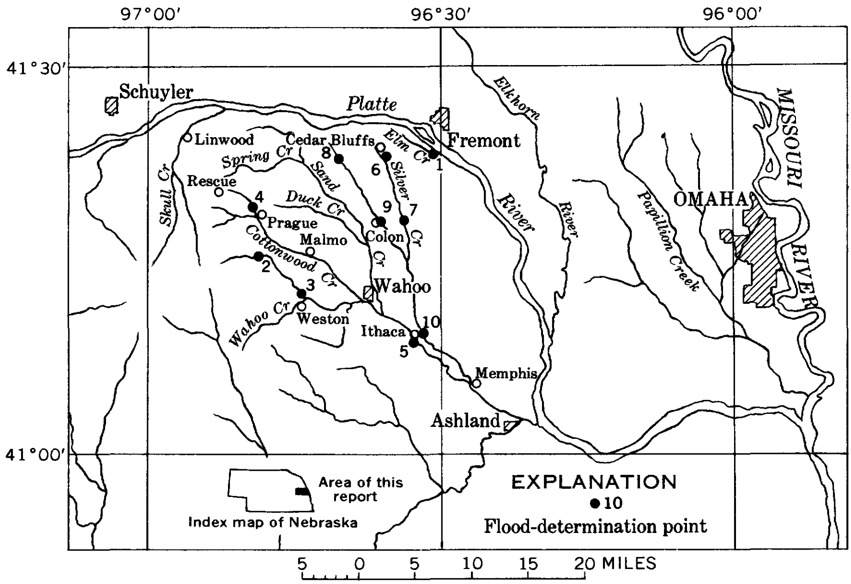

FIGURE 26.—Map of area of floods of August 2 in east-central Nebraska, showing location of flood determination points. (Numbers correspond to those in table 11.)

homes and businesses, but not including loss of topsoil by erosion in the upland areas. Railroad tracks were washed out at several points in Wahoo and Silver Creek valleys, and both State and Federal highways were temporarily closed at Prague, Wahoo, Ithaca, Memphis, and Ashland. In the Prague and Malmo areas, farmers reported large livestock losses, and water flowed to a depth of about 5 feet through the business section of Prague. The peak discharge of 4,780 cfs on North Fork Cottonwood Creek near Prague (table 11) produced the highest unit runoff, 919 cfs per square mile, of any flood reported in Nebraska during 1959.

Damaging floods also occurred in smaller basins surrounding the Wahoo-Silver Creek area. In Linwood (population 168), between Schuyler and Prague, every home was flooded, and in Schuyler many basements were flooded and trees were uprooted. In Fremont, the Chicago, Burlington & Quincy Railroad tracks were washed out and just south of the city U.S. Highway 77 was flooded. More than 5 inches of rain fell in West Omaha August 1 and 2, hundreds of basements were flooded in the western residential area of Omaha as Papillion Creek and its tributaries overflowed their channels, and several highway bridges were threatened.

The rarity of some of the flood peaks can be evaluated from the ratio of the peak discharges to the mean annual flood (last column in table 11). Figure 27 relates these ratios to the recurrence interval

TABLE 11.—*Flood stages and discharges, August 2, in east-central Nebraska*

Flood determination point (fig. 26)	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to August 1959: Period	Maximum floods: Prior to August 1959: Year	Maximum floods: Gage height (feet)	Maximum floods: Discharge: Cubic feet per second	Maximum floods: Discharge: Ratio to $Q_{2.33}$
	Platte River Basin						
1	Elm Creek near Fremont	4.7			[1] 1,203.40	2,840	3.0
2	North Fork Wahoo Creek near Prague.	15.2	1951–59	1951	30.68	12,800	
					31.12	12,800	7.1
3	North Fork Wahoo Creek at Weston.	44.0	1951–59	1951	22.36	9,600	
					21.43	5,830	1.8
4	North Fork Cottonwood Creek near Prague.	5.2				4,780	4.8
5	Wahoo Creek at Ithaca	272	1910–59	1951	22.34	18,900	
					23.22	45,300	5.1
6	Silver Creek near Cedar Bluffs	10.9	1950–59	1951		2,670	
				1958	13.41		
					15.02	4,040	2.7
7	Silver Creek near Colon	29.9	1950–59	1950	16.8	4,500	
					19.22	12,000	4.6
8	Silver Creek tributary near Colon.	14.3	1952–59	1958	14.56	770	
					17.32	5,000	2.8
9	Silver Creek tributary at Colon	22.4	1951–59	1958	15.15	1,200	
					19.29	4,640	2.1
10	Silver Creek at Ithaca	72	1949–59	1958	12.81	4,040	
					16.92	21,600	5.1

[1] Elevation, in feet, above mean sea level.

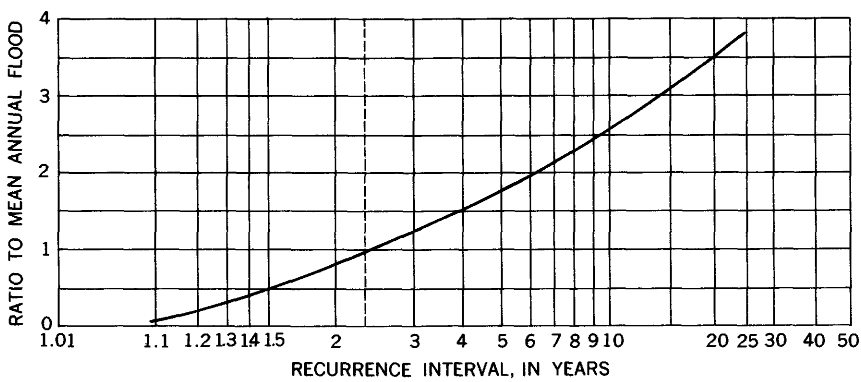

FIGURE 27.—Frequency curve for east-central Nebraska.

(average interval of time in which a given flood will be equaled or exceeded once). Figure 27 shows that the discharge at some of the flood-determination points had recurrence intervals greatly exceeding 25 years.

AUGUST 2, IN BIG ALKALI CREEK, COLO.

A high stage occurred on Big Alkali Creek near Burns, Colo. (fig. 28) on August 2. None of the few scattered rain gages in the area

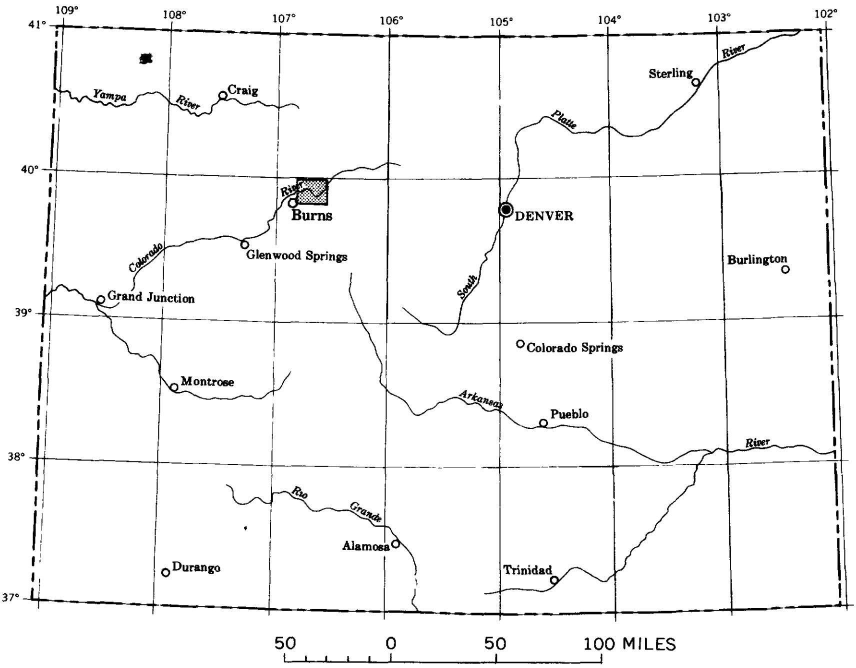

FIGURE 28.—Map showing location of area of flood of August 2, in Big Alkali Creek, Colo.

caught an appreciable amount of rain. The 16-square mile drainage area above the gaging station near Burns is about 35 miles northeast of Glenwood Springs, is sparsely settled, and contains Hurt Reservoir, capacity about 100 acre-feet. The peak discharge of 715 cfs may have been affected by storage in Hurt Reservoir; however, the runoff of 44.7 cfs per square mile is from 3 to 4 times the runoff for snowmelt floods in this area. The streamflow record was started in October 1958, and no previous flood history is available. The maximum discharge, in 7 years of record, of 443 cfs from 48 square miles at Rock Creek near Toponas and, in 15 years of record, of 1,110 cfs from 82.6 square miles at Piney River near State Bridge occurred during snowmelt periods having runoff of only 9 to 13 cfs per sq mi.

AUGUST 5–8, IN IOWA AND MISSOURI

Possibly the greatest 24-hour rainfall ever to be noted in Iowa fell in the south-central part of the State on the night of August 5–6, 1959. Amounts of 16.70 and 17.00 inches were measured in oil drums at two different locations in Decatur County, Iowa, by employees of the Corps of Engineers and the Weather Bureau. There are no Weather Bureau gages in the area of maximum precipitation. According to reports of residents of the area, most of the rain may have fallen in 6 hours or less. The two rainfall measurements were classed as good,[2] and this amount was at least 3 inches more than the previous greatest officially reported rainfall in Iowa. The 17-inch amount is only 3 inches less than the generalized estimate of the maximum possible 12-hour precipitation for 200 square miles from Weather Bureau studies[3] and is about 3.2 times the 100-year 6-hour rainfall for the flood area. It is therefore obvious that the storm was of extremely rare occurrence.

A second area of heavy precipitation was centered in the Fort Madison (southeastern) area of Iowa and had a 24-hour amount of 8.5 inches recorded on the Weather Bureau gage at Fort Madison. Amounts may have been greater in the area, although there were no rain gages or reliable reports to verify this supposition.

Precipitation occurred over the flood area throughout the period August 2–7. However, in the area of the extreme storms nearly all of the precipitation fell August 4–6. The isohyetal map (figure 29) of the accumulated rainfall for the 3-day period was prepared from published Weather Bureau data.

Swollen streams in both areas of heavy precipitation caused damage to property. The urban area of Fort Madison, Iowa, was particularly hard hit, and damage was estimated at $600,000 in an 80-block area. Rural damage was heavy in the Decatur County (surrounding Leon), Iowa, area where it is estimated that crops were damaged on 32,000 to 34,000 acres of land. Damage to roads and bridges throughout the flood areas was estimated at $144,000. No loss of life was reported. A total of 130,000 acres of land was inundated.

Flooding was limited to streams in southern Iowa and the north central part of Missouri, the outstanding floods occurring in Decatur County and Lee County (adjacent to Keokuk and Fort Madison), Iowa. The Weldon River near Leon, Iowa, discharged 48,600 cfs from a drainage area of 104 square miles and produced one of the most outstanding floods ever recorded in Iowa. The crest-stages and peak discharges at Weldon River near Mercer and at Mill Grove, Mo., exceeded previously known maximums, and the stage on Weldon River near Leon, Iowa, was the highest in 40 years. Devil Creek and its tributaries near Fort Madison, Iowa, also produced large floods that were second in magnitude only to the floods of June 10 1905. Peak discharge data for 10 sites in the flood area are shown in table 12.

[2] U.S. Weather Bureau: Climatological data for August 1959.

[3] U.S. Weather Bureau, 1947, Generalized estimates of maximum possible precipitation over the United States east of the 105th meridian: Hydrometeorological Rept. 23.

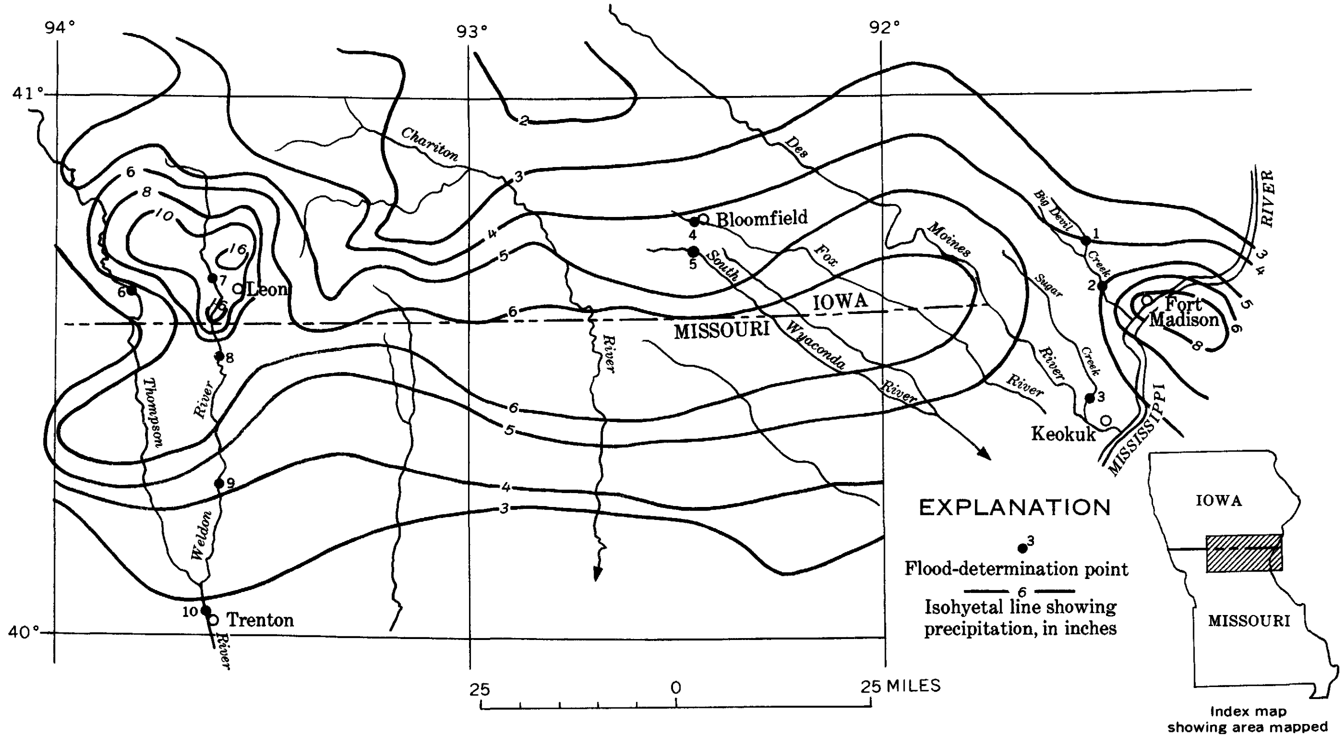

FIGURE 29.—Map of area of floods of August 5–8 in Iowa and Missouri, showing location of flood-determination points (numbers correspond to those in table 12) and precipitation for August 4–6.

TABLE 12.—*Flood stages and discharges, August 4–8, in Iowa and Missouri*

Flood-determination point (fig. 29)	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to August 1959: Period	Maximum floods: Prior to August 1959: Year	Maximum floods: August 1959 (day)	Maximum floods: Gage height (feet)	Maximum floods: Discharge: Cubic feet per second	Maximum floods: Discharge: Ratio to $Q_{2.33}$
	Big Devil Creek basin							
1	Little Devil Creek near Fort Madison, Iowa.	20.3	1905	1905			[1] 10,700	
					6		9,260	
2	Big Devil Creek near Fort Madison, Iowa.	151	1905	1905			[2] 80,000	
					6		13,600	
	Des Moines River basin							
3	Sugar Creek near Keokuk, Iowa.	105	1905–59	1905		20.6	[3] 33,000	
					6	10.88	2,270	
	Fox River basin							
4	Fox River at Bloomfield, Iowa.	87.7	1957–59	1958		19.18	3,970	
					5	21.62	5,660	
	Wyaconda River basin							
5	South Wyaconda River near West Grove, Iowa.	4.69	1953–59	1958		11.95	(4)	
					5	9.64	1,970	
	Grand River basin							
6	Thompson River at Davis City, Iowa.	701	1885	1885		22.8	30,000	
			1918–25, 1941–59	1947		20.14	21,300	
					6	18.42	17,500	2.4
7	Weldon River near Leon, Iowa.	104	1920–59	(4)		(5)	(5)	
					6	25.27	48,600	3.0
8	Weldon River near Mercer, Mo.	246	1939–59	1947		25.71	28,000	
					6	28.4	50,000	7.2
9	Weldon River at Mill Grove, Mo.	494	1909–59	1909		23.9	(4)	
			1929–59	1947		22.79	27,600	
					7	26.02	46,000	4.2
10	Thompson River at Trenton, Mo.	1670	1909–59	1909		[7] 30.7		
			1921–23, 1928–59	1947		25.7	95,000	
					8	22.5	47,300	2.2

[1] At different site, drainage area 19 sq mi, discharge estimated.
[2] At different site, drainage area 143 sq mi.
[3] Estimated.
[4] Unknown.
[5] Less than for August 6, 1959.
[6] Not necessarily maximum for period.
[7] Occurred before dredging of new channel.

AUGUST 17, NEAR NEEDLES, CALIF.

A series of thunderstorms occurred in the Colorado Desert near Needles, Calif., on the afternoon and evening of August 17. Precipitation was centered in the basin of Sacramento Wash, an ungaged ephemeral stream (fig. 30) just west of Needles. The Weather Bureau gages reporting rainfall were all on the fringes of the storm, and the reported catches are probably a poor indication of the peak

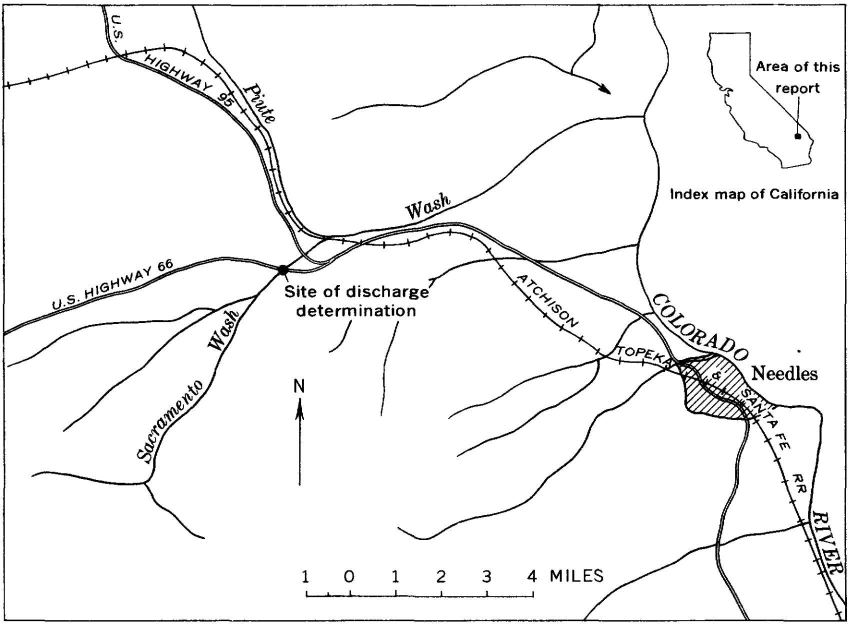

FIGURE 30.—Map of area of floods of August 17, near Needles, Calif., showing location of flood-determination point.

intensity of the cloudburst. As an example, Needles, the site of the rain gage closest to the storm center, reported only 1.23 inches of rain in 11 hours and a maximum hourly catch of 0.60 inch.

As a result of the thunderstorms, flash floods occurred on several ungaged desert arroyos. These floods were of short duration, but they caused three deaths and almost isolated the town of Needles. It is estimated that 500 motorists were stranded as parts of U.S. Highways 66 and 95 were washed out or covered with debris. Railway travel was also disrupted as washouts marooned two sections of the Santa Fe Grand Canyon Limited. Three railroad section hands were drowned when the flood swept their truck from the highway. A peak discharge of very rare occurrence, 43,000 cfs, was measured by the slope-area method from the 29.5 square-mile drainage area of Sacramento Wash (1,460 cfs per sq mi).

AUGUST 20, AT BOISE, IDAHO

Damaging floods carrying large quantities of mud, rocks, and other debris poured into Boise from the foothills to the east early in the morning on August 20. The flood of water and debris was the result of moderate rains on August 19, followed by thunderstorms accompanied by heavy rainfall on steep slopes denuded by recent

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fires. The runoff was unusually high from six small contiguous basins tributary to the Boise River having a total drainage area of 25.6 square miles (fig. 31). Average channel slopes of the flooding

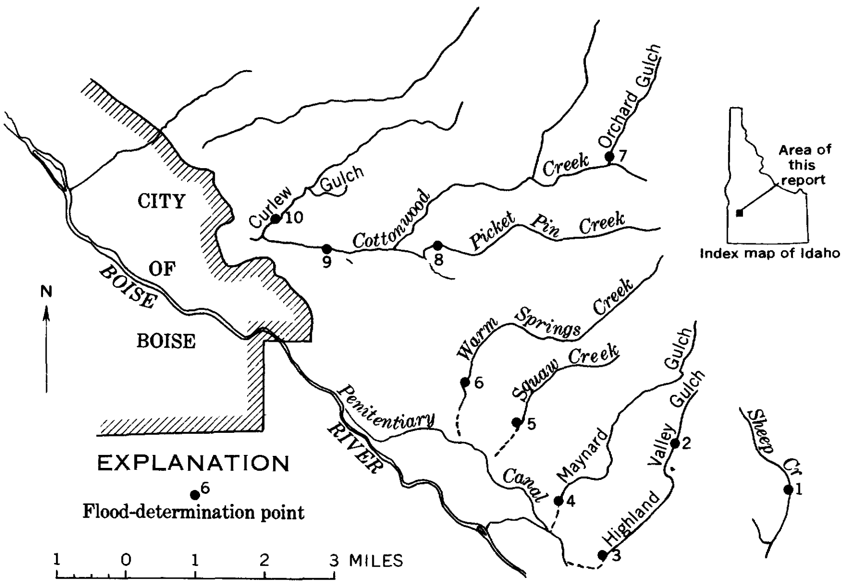

FIGURE 31.—Map of area of floods of August 20 at Boise, Idaho, showing location of flood-determination points. Numbers correspond to those in table 13.

streams ranged from 8 to 19 percent, and some of the drainage basin slopes were more than 40 percent.

Some rain was recorded at nearly every precipitation station in Idaho during August 19–21; the largest amounts were recorded near Boise. Weather Bureau records for August 19–21 show that 2.10 inches fell at Deer Point (6 miles north of the flood area), 1.26 inches fell at Lucky Peak Dam (8 miles east of Boise), and 0.40 inch fell at the Boise airport. Intermittent showers occurred during the evening of August 19 and moistened the topsoil before the heavy rains began. About 4:15 a.m. August 20, a severe thunderstorm moved into the area; the storm was most intense over the hills east and northeast of Boise.

The intensity of rainfall determines to a large degree the magnitude of a cloudburst flood. No record of rainfall within the area contributing to the flood was obtained. The Weather Bureau's recording precipitation gage at Deer Point recorded 0.50 inch in 10 minutes and at least 0.30 inch in 5 minutes.

The foothills and mountains north and east of Boise are the highest and have the most abrupt uplift, within several hundred miles, of any barrier that lies across the paths of the air currents which flow into the area from the south and the west. Air masses moving toward the north or east rise suddenly over these uplands and will produce precipitation of high intensity when temperature, humidity, and wind direction are favorable.

Slope-area measurements of peak discharge were made at 10 sites in the flood area (table 13). The unit peak discharge varies from 132 cfs per sq mi from 12 square miles of drainage area on Cottonwood Creek, the largest area, to 5,380 cfs per sq mi from 0.39 square mile of drainage area on upper Highland Valley Gulch, the smallest area. All these discharges are extremely high for Idaho. When these great discharges do occur, they are from occasional severe, cloudburst-type precipitation falling on drainage areas that have characteristics conducive to efficient runoff.

A huge quantity of mud, rock, and other debris was disgorged onto the city and valley. The ability of these streams to transport sediment at their peaks was very great because of extremely high velocities due to steep channel slopes and because of high water turbulence. Lack of vegetative cover, looseness of the soil, a cover of ash from recent fires, steep slopes, and intensity of the storm combined to make large quantities of debris available for transport.

TABLE 13.—*Flood stages and discharges, August 20, at Boise, Idaho*

Flood-determination point (fig. 31)	Stream name	Location	Drainage area (square miles)	Peak discharge	
				Cubic feet per second	Cfs per sq mi
1	Sheep Creek	NE¼SE¼, Sec. 25, T. 3N., R. 3E.	0.40	210	525
2	Highland Valley Gulch	SE¼SW¼, Sec. 23, T. 3N., R. 3E., at old homestead.	.39	2,100	5,380
3	Highland Valley Gulch	SE¼NW¼, Sec. 34, T. 3N., R. 3E., at Seelye ranch.	1.69	3,370	1,990
4	Maynard Gulch	NW¼SE¼, Sec. 28, T. 3N., R. 3E.	2.25	9,540	4,240
5	Squaw Creek	S½NW¼, Sec. 21, T. 3N., R. 3E.	1.47	7,320	4,980
6	Warm Springs Creek	SE¼SW¼, Sec. 17, T. 3N., R. 3E., at power line.	3.84	9,390	2,450
7	Orchard Gulch	SE¼SW¼, Sec. 34, T. 3N., R. 3E., 6.0 miles east of Boise.	.73	1,500	2,050
8	Picket Pin Creek	NE¼SE¼, Sec. 7, T. 3N., R. 3E., at Oberbillig ranch.	2.50	7,720	3,090
9	Cottonwood Creek	NE¼NW¼, Sec. 12, T. 3N., R. 2E., at Aldape ranch.	12.0	1,580	132
10	Curlew Gulch	NE¼SE¼, Sec. 2, T. 3N., R. 2E., at Military Cemetery.	3.95	2,300	582

In Boise about 50 blocks were covered by mud and water, mainly from Cottonwood Creek, and damage in the city was estimated at $162,000, of which about one-half was damage from sediment.

Several hundred acres of farmland were covered by water, mud, and rocks. State Highway 21 was blocked in several places. Other roads were damaged, canals were filled with debris, and the soil mantle was severely eroded in large areas of the hills.

AUGUST 26-27, IN SOUTHWESTERN WISCONSIN

Torrential rains during the night of August 26–27 on the headwaters of the Kickapoo River in southwestern Wisconsin (fig. 32)

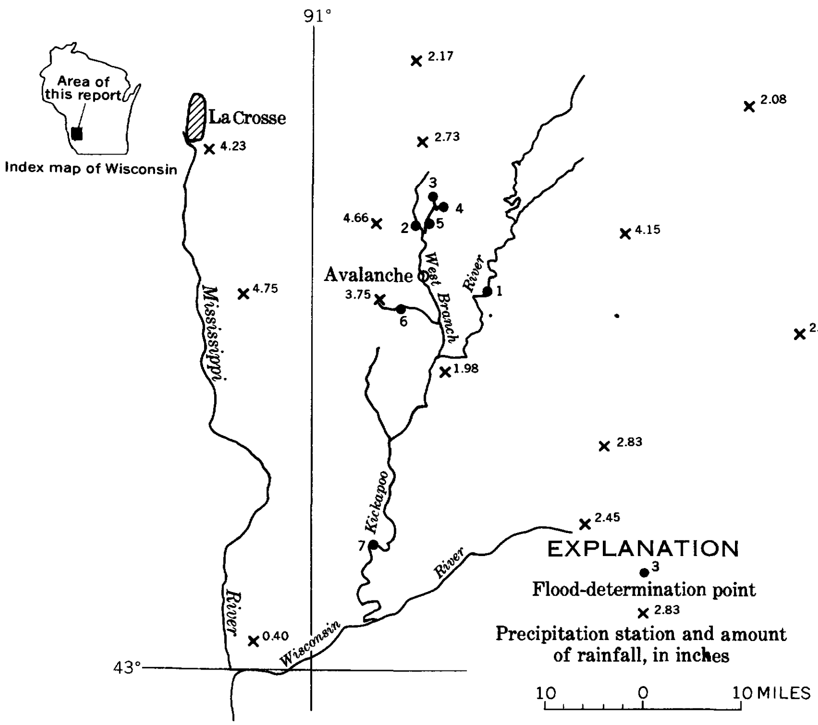

FIGURE 32.—Map of area of floods of August 26–27, in southwestern Wisconsin, showing location of flood-determination points. (Numbers correspond to those in table 14.)

caused a very destructive flood. Two lives were lost near Avalanche. Property and crop damage probably exceeded $500,000. The gaging station on Knapp Creek near Bloomingdale recorded a peak discharge of 3,710 cfs, which is 438 cfs per sq mi (table 14). Two retention reservoirs located on tributaries to Knapp Creek had peak capacities of 80 and 210 acre-feet. These peaks occurred 2 and 4 hours, respectively, after the peak at the Knapp Creek gaging station; the drainage area above the reservoirs did not contribute greatly to the magnitude of the flood at the Knapp Creek gaging station. Rainfall data (fig. 32) shows heavy precipitation between the reservoirs and the gaging station. A slope-area measurement was made of the peak flow on the upper West Fork Kickapoo River, which adjoins Knapp Creek. The peak discharge was 5,450 cfs from 11.2 square miles of drainage area, or 487 cfs per square mile.

Records at the La Farge and Steuben gaging station on the main stem of the Kickapoo River indicated that flood stages were exceeded along the river. Tobacco growing on the flood plain was damaged considerably.

TABLE 14.—*Flood stages and discharges, August 26–30, in southwest Wisconsin*

Flood-determination point (fig. 32)	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to August 1959: Period	Maximum floods: Prior to August 1959: Year	Maximum floods: August 1959 (day)	Maximum floods: Gage height feet	Maximum floods: Discharge: Cubic feet per second	Maximum floods: Discharge: Ratio to $Q_{2.33}$
Wisconsin River basin								
1	Kickapoo River at La Farge	266	1938–59	1956	-----	12.35	6,750	-----
			-----	-----	27	11.67	4,880	1.6
2	West Fork Kickapoo River above Knapp Creek near Bloomingdale.	11.2	-----	-----	26	-----	5,450	-----
3	Mlsna Reservoir near Cashton	1.48	-----	-----	27	13.55	[1] 80	-----
4	Klinkner Reservoir near Cashton.	2.40	-----	-----	27	17.93	[1] 210	-----
5	Knapp Creek near Bloomingdale.	8.47	1954–59	1954	-----	10.5	([2])	-----
				1955	-----	4.56	1,030	-----
			-----	-----	26	8.76	[3] 3,710	-----
6	Bishops Branch near Viroqua	7.08	-----	-----	26	13.64	5,820	-----
7	Kickapoo River at Steuben	690	1933–59	1951	-----	13.66	10,300	-----
			-----	-----	30	9.66	3,720	-----

[1] Acre-feet; greatest of record since 1954.
[2] Not determined.
[3] Affected by storage in Mlsna and Klinkner Reservoirs.

AUGUST 28–29, NEAR RICHMOND, KY.

Heavy local rains fell in the vicinity of Richmond, Ky., on August 28–29. The Weather Bureau reported 7.12 inches of rain at Richmond for the 24-hour period ending at 7:00 a.m., August 29. Local residents estimated that at least 6 inches of this rain fell in two hours on the evening of August 28. Data from Weather Bureau records and observations and from estimates of local inhabitants are shown on figure 33. The heaviest rain occurred southeast of Richmond, and was estimated at about 10 inches at Speedwell. This figure was based on rainfall collected in an iron kettle that was empty before the rain and that overflowed during the storm.

Tate Creek heads in the vicinity of Richmond and flows northwest to the Kentucky River. Several county and private bridges were damaged or destroyed on the road from Richmond to Valley View that lies in the Tate Creek valley. The Madison County road superintendent estimated $25,000 damage to roads and bridges. About 100 persons were marooned in a rural church for several hours until the flood receded.

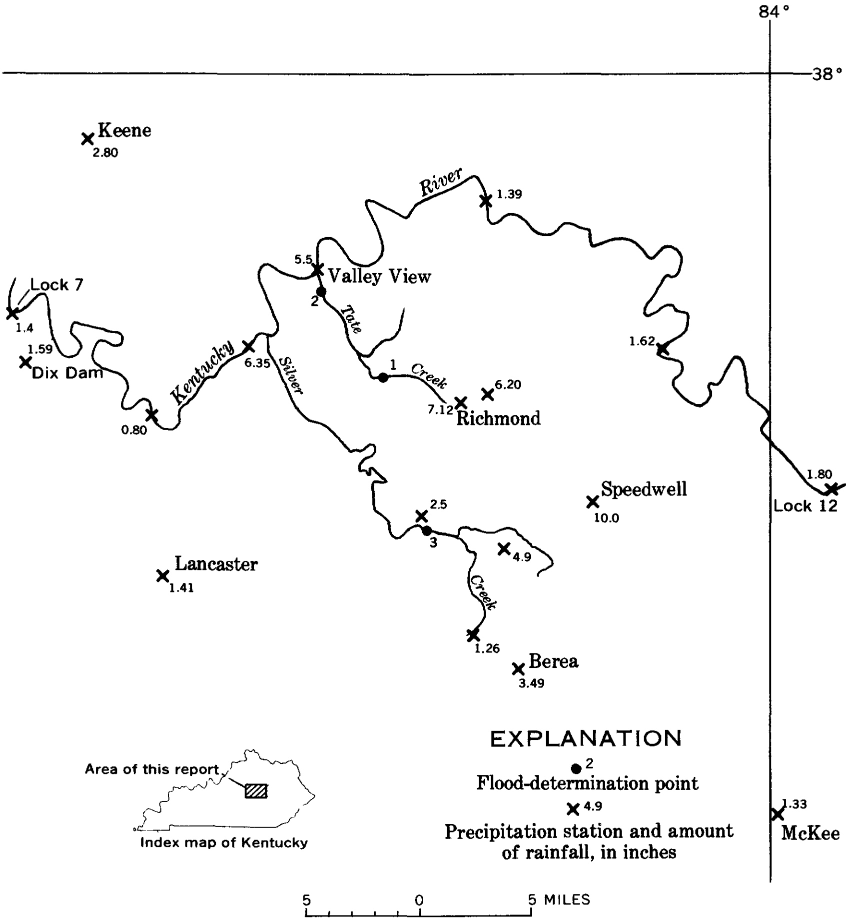

FIGURE 33.—Map of area of floods of August 28-29, near Richmond, Ky., showing location of flood determination points (numbers correspond to those in table 15) and precipitation stations.

According to information from several long-time residents, the flood of August 28-29 was greater than the flood of August 2, 1932, which was the greatest previously known flood on Tate Creek.

Ratios of the peak discharge of the August 1959 flood to the mean annual flood were determined from a report by J. A. McCabe.[4] Ratios on Tate Creek were high; the ratio near Million was 3.8 and near Valley View was 3.4, but near Berea was only 1.0.

The ratio of the 50-year flood to the mean annual flood is 1.92, the floods near Million and Valley View were about 2.0 and 1.8 times as great, respectively, as the 50-year flood, whereas that near Berea was equal to the mean annual flood.

[4] McCabe, J. A., 1958, Floods in Kentucky, magnitude and frequency: U.S. Geol. Survey open-file report.

The location and size of the storm area were such that no floods were recorded at Geological Survey gaging stations. Discharge data from indirect measurements made at two sites on Tate Creek and at one site on Silver Creek are shown in table 15.

TABLE 15.—*Flood stages and discharges, August 28, near Richmond, Ky.*

Flood-determination point (fig. 33)	Stream and place of determination	Drainage area (sq mi)	Maximum floods				
			Prior to August 1959		Gage height (feet)	Discharge	
			Period	Year		Cubic feet per second	Ratio to $Q_{2.33}$
Kentucky River basin							
1	Tate Creek near Million	9.71	----------	----------		3,680	3.8
2	Tate Creek near Valley View	32.2	1932–59	(1)		---------	---------
			----------	----------		7,930	3.4
3	Silver Creek near Berea	53.5	----------	----------		3,190	1.0

[1] Unknown, but discharge less than that of August 28, 1959.

SEPTEMBER 10, IN THE VICINITY OF CALLICOON, N.Y.

Several thunderstorms between 6 p.m. and midnight on September 9 produced a heavy concentration of rain in a small area a few miles northeast of Callicoon, N.Y. (fig. 34). Buck Brook, which drains

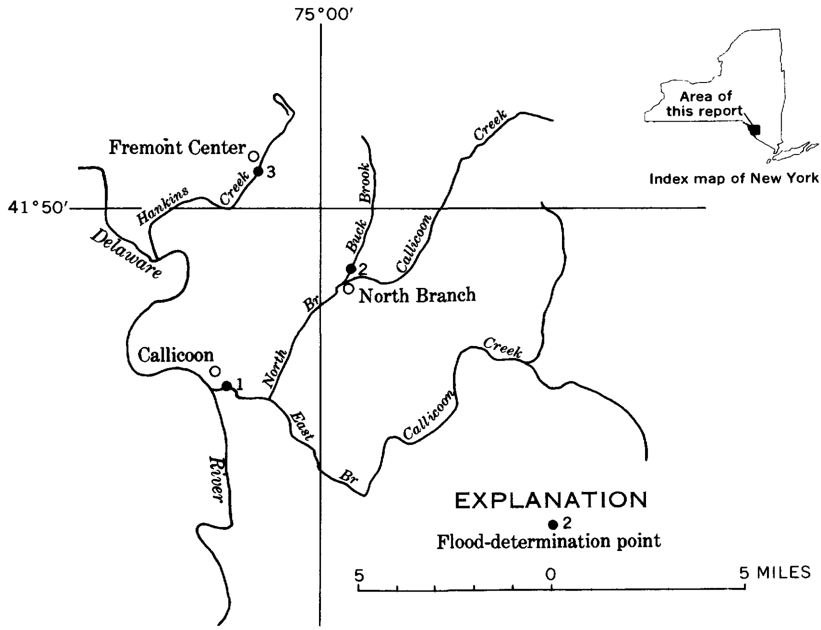

FIGURE 34.—Map of area of floods of September 10, in the vicinity of Callicoon, N.Y., showing location of flood-determination points. (Numbers correspond to those in table 16.)

the northeastern part of Callicoon Creek basin, and Hankins Creek, a tributary to Delaware River, had severe floods that caused extensive property damage.

The thunderstorms were of the convection type, which occur frequently in this area during the summer, and were concentrated in a small geographic area because of the orographic uplift provided by Mandrake and Obernburg Hills.

Weather Bureau records do not show appreciable rainfall at any point in the flood area. Residents in the area were questioned regarding amounts of rainfall, and three reliable figures were obtained. Probably more than 8 inches of rain fell at one point in Buck Brook basin; 4.3 inches and 2.5 inches of rain were reported at and near Fremont Center.

The peak discharge in Callicoon Creek at Callicoon was not high because of the small area affected by the storm, but the peak discharges from the two small-area drainages were extremely high (table 16). No discharge measurements had been previously made at these two sites, but measurements were made in 1947 and 1952 on Buck Creek near the site where the peak discharge was measured September 10, 1959.

Flash floods will usually produce a rapid increase in runoff followed by a quick decline to base flow. This runoff pattern was maintained at the gaging station on Callicoon Creek, as shown on the hydrograph in figure 35.

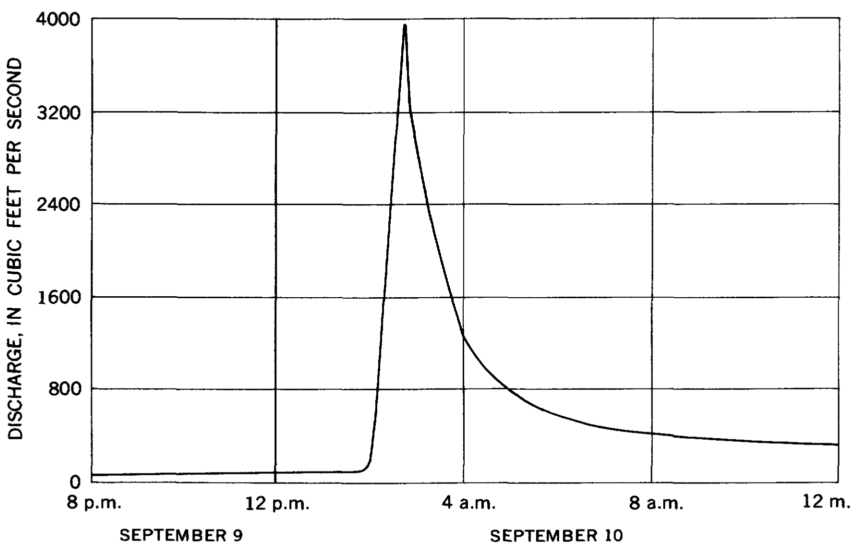

FIGURE 35.—Discharge hydrograph for Callicoon Creek at Callicoon during floods of September 10, in the vicinity of Callicoon, N.Y.

TABLE 16.—*Flood stages and discharges, September 10, 1959, in the vicinity of Callicoon, N.Y.*

Flood-determination point (fig. 34)	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to Sept. 1959: Period	Maximum floods: Prior to Sept. 1959: Year	Maximum floods: Gage height (feet)	Maximum floods: Discharge: Cubic feet per second	Maximum floods: Discharge: Ratio to $Q_{2.33}$
1	Callicoon Creek at Callicoon	111	1940–59	1947	9.68	16,000	
					5.62	3,980	
2	Buck Brook at North Branch	6.70				4,620	
	Buck Brook near North Branch	4.89	1952	1952		833	
	Buck Brook near North Branch	4.75	1947	1947		2,300	
3	Hankins Creek at Fremont Center	8.36				3,340	

SEPTEMBER 18, NEAR REDDING, CALIF.

On the afternoon of September 18, a cloudburst occurred near Redding, Calif., and caused major flooding on streams in and just north of the city. This cloudburst climaxed the heaviest general September storm since 1904. The general storm was of the frontal type, such as normally occurs in the late fall or winter. The localized high-intensity rainfall resulted from a series of thunderstorm cells moving northeasterly through the affected area in a path 6 to 8 miles wide that extended from Redding on the south to Shasta Dam on the north. In the city of Redding, 3.2 inches of rain fell in a 4-hour period on September 18. Observed precipitation totals in the flood-affected area ranged from 5 to 10 inches for the maximum 24-hour rainfall and from 5 to 15 inches for the 48-hour period ending at 7 a.m. on September 19.

Flooding was in small Sacramento River tributaries in the area in which the thunderstorms were centered (fig. 36). None of these streams are gaged. No nearby gaging station had unusually high peak discharges, although the localized storm runoff in the vicinity of Redding increased the discharge of the Sacramento River by several thousand cubic feet per second. Peak discharges, determined by indirect measurements, on four ungaged streams in the area are shown in table 17.

Total damage was estimated at $250,000, of which $25,000 represented damage to county roads and bridges. Traffic on U.S. Highway 99 was disrupted. The greatest damage, by far, occurred in Redding, where water in Calaboose Creek and its tributaries backed up at culverts to send water coursing through the streets. Hardly a business place on Market Street escaped damage as water swept over curbs. At a few places in the city, water reached depths as great as 4 feet, and over large areas the lower floors of homes and business establishments were covered by water and mud.

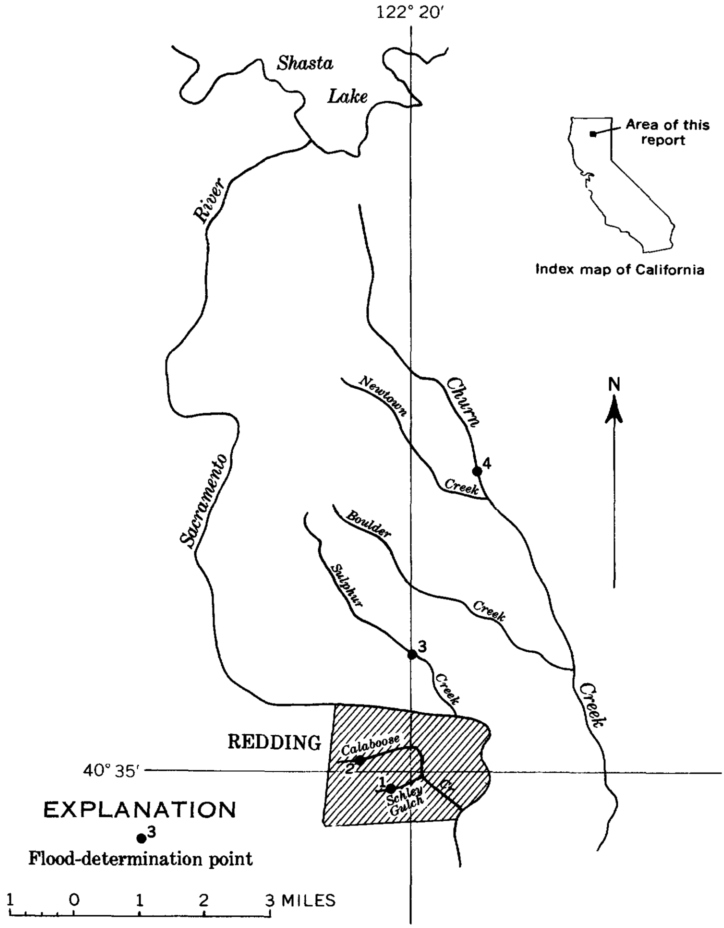

FIGURE 36.—Map of area floods of September 18, near Redding, Calif., showing location of flood-determination points. (Numbers correspond to those in table 17.)

TABLE 17.—*Flood stages and discharges, September 18, near Redding, Calif.*

Flood-determination point (fig. 36)	Stream	Location	Drainage area (sq mi)	Peak discharge	
				Cubic feet per second	Cfs per sq mi
1	Schley Gulch (tributary to Calaboose Creek).	Sonoma St., Redding, Calif.	0.22	[1] 390	1,770
2	Calaboose Creek	Olive St., Redding, Calif.	.22	502	2,280
3	Sulphur Creek	Southern Pacific R.R. culvert, NW¼ sec. 25, T. 32 N., R. 5 W., near Redding, Calif.	3.28	2,220	677
4	Churn Creek	NE¼SW¼ sec. 7, T. 32 N., R. 4 W., near Redding, Calif.	9.34	4,860	520

[1] Estimated.

SEPTEMBER 21-26, IN WALNUT CREEK, KANS.

A storm of unusually great severity started late on September 20 and centered over Walnut Creek basin about 50 miles west of Great Bend. Except for a small part of Rush Center, every town on Walnut Creek from Bazine to Heizer (fig. 37) was entirely inundated, most of them by as much as 6 feet. More than 1,000 persons were evacuated from

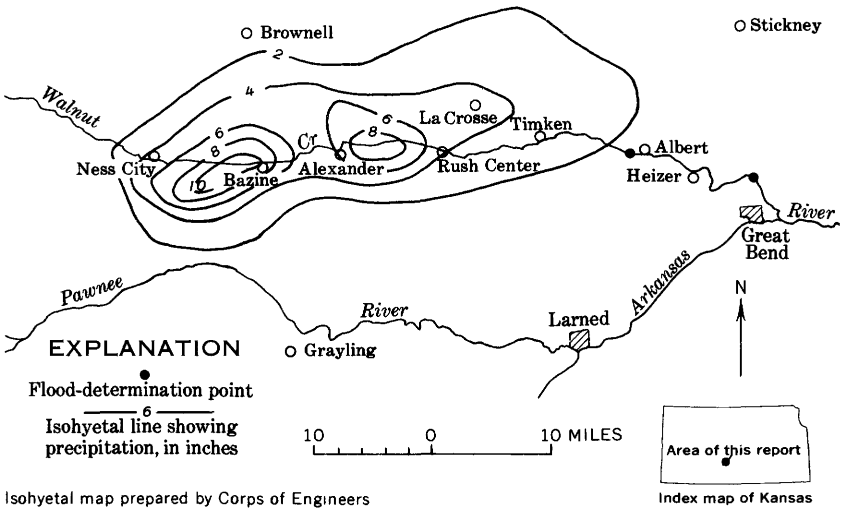

FIGURE 37.—Map of area of floods of September 21-26, in Walnut Creek, Kans., showing location of flood-determination points and precipitation for September 20-21.

their homes, and nearly all schools in the area were closed for periods ranging from several days to a week. Transportation and communication facilities were disrupted, and utilities were severely damaged. Old residents in the valley, who had considered the 1927 flood the most disastrous, stated that the 1959 flood exceeded those of both 1927 and 1951. Damage in Ness County alone was more than $1 million.

A "bucket survey" was made by personnel from the Weather Bureau and Corps of Engineers (Albuquerque District). Precipitation ranging from about 2 inches to a maximum of more than 11 inches occurred over Walnut Creek basin from Albert to Ness City. Because the major axis of the storm coincided with the stream, Walnut Creek remained above flood stage for 6 days, September 21–26.

The peak discharge at the gaging station at Albert was 12,700 cfs, the maximum discharge known (gage height 25.75 feet). A flood of this magnitude at Albert has a recurrence interval of about 15 years. The previous maximum stage since 1908 was 21.3 feet in August 1927; the peak discharge of this flood is not known, but it must have been substantially greater than would be indicated by the present stage-discharge relation because levees were built in 1934. By the time the peak of September 22, 1959 reached the bridge on U.S. Highway 281 north of Great Bend, channel storage had reduced it to 9,300 cfs.

The peak discharges through the main channel and overflow bridges on U.S. Highway 56 were approximately 3,500 cfs and 3,000 cfs respectively. The combined discharge at these bridges does not represent the total flow, for a number of small culverts beyond the basin divide carried an undetermined amount of flow.

During the flood on Walnut Creek, the maximum daily discharge at the gaging station on Arkansas River at Great Bend, 4½ miles upstream from Walnut Creek, was only 740 cfs on September 24.

OCTOBER 1–9, IN EAST-CENTRAL TEXAS

Major floods occurred in the upper Trinity, middle Brazos, middle Colorado, upper Guadalupe, and upper Nueces River watersheds October 1–9, following heavy general rains that blanketed most of Texas (fig. 38). Light rains fell September 28–30, and heavy rains occurred October 1–4.

Table 18 is a summary of flood stages and discharges at the stations shown on figure 38.

Rainfall amounts of as much as 12 inches fell in the upper Trinity River basin and caused extensive flooding on Big Fossil, Big Sandy, Chambers and Richland Creeks. Big Fossil Creek flooded parts of Richland Hills, a suburb of Fort Worth; damage was estimated at $300,000 by the Weather Bureau. Damage to agricultural interests and rural public properties by flooding on Big Sandy, Chambers, and Richland Creeks was estimated at $700,000 by the Weather Bureau. The Trinity River at Dallas peaked at 5 feet above flood stage, but damage was slight. Flooding along the main stream was minor owing to impoundment of floodwaters by reservoirs above and below Dallas. No historical floods were exceeded in the Trinity River basin (table 18).

Floods exceeding all those previously known occurred on the North Bosque River and Cowhouse Creek in the middle Brazos River basin, in which rains totaled more than 14 inches at some points. Farms suffered heavy damage. The North Bosque River at the gaging station near Clifton reached a peak stage of 34.88 ft (discharge 92,800 cfs), the highest since at least 1887. Cowhouse Creek at the gaging station at Pidcoke reached a peak stage of 40.1 ft (discharge 66,200 cfs), the highest since at least 1882. The floods were near-record since about 1880 on Palo Pinto and Paluxy Creeks and since about 1858 on the Leon River. Floods of outstanding magnitude occurred on the Nolands and Lampasas Rivers (table 18). Extensive flooding was experienced on all of the above-mentioned streams, whereas

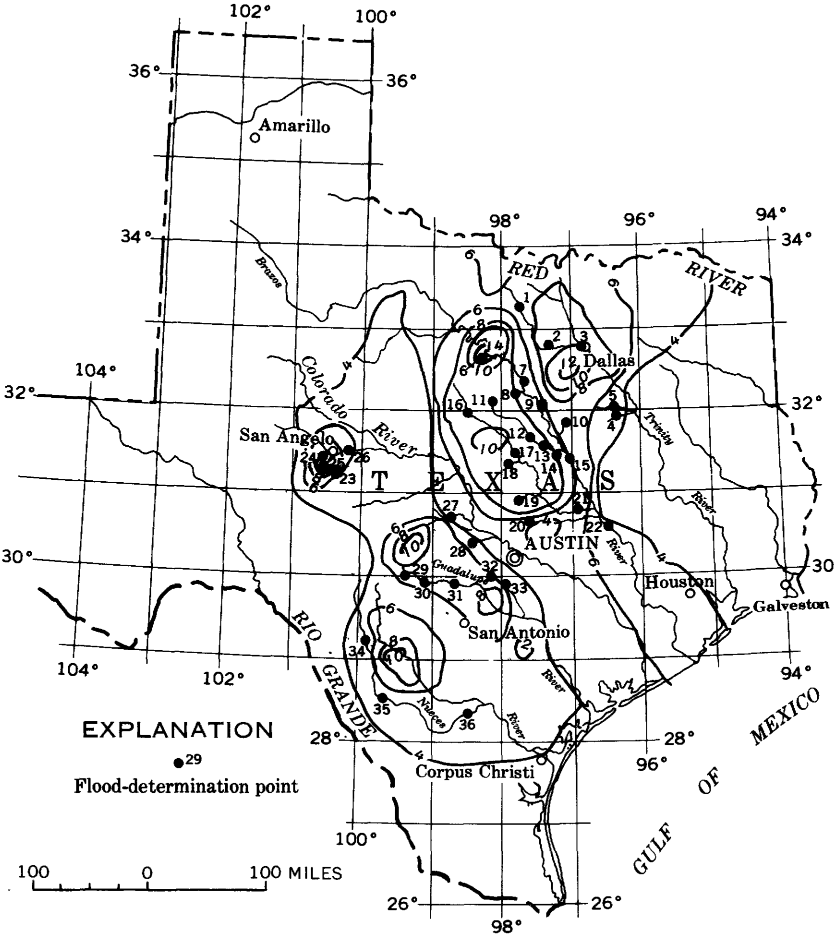

FIGURE 38.—Map of area of floods of October 1-9, in east-central Texas, showing location of flood-determination points (numbers correspond to those in table 18) and precipitation for September 28–October 14.

flooding along the main stem of the Brazos River was minor owing to impoundment of floodwaters by reservoirs above and below Waco. Figure 39 illustrates the effects of flood-water control by reservoirs. North Bosque and San Gabriel Rivers are virtually uncontrolled Little River is partially controlled, and the Brazos River is controlled to a considerable extent.

Spring Creek, in the middle Colorado River basin, reached its highest stage since 1882, following rainfall of more than 10 inches. The peak discharge of Spring Creek, 82,100 cfs, combined with peak discharges of 25,000 cfs at the gaging station on South Concho River

TABLE 18.—*Flood stages and discharges, October 1–9, in east-central Texas*

Flood-determination point (fig. 38)	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before October 1959: Period	Known before October 1959: Year	October 1–9, 1959 (day)	Gage height (feet)	Discharge (cfs)
	Trinity River basin						
1	Big Sandy Creek near Bridgeport	332	1887–1959	1908		(1)	(2)
			1936–1959	1941		15.69	53,000
					4	11.96	20,900
2	Big Fossil Creek at Haltom City	53.0	1900–59	1942		24.8	(2)
					1	21.08	12,600
3	Trinity River at Dallas	6,120	1840–1959	1908		52.6	[3]184,000
					5		[4]21,400
					5	35.39	
4	Richland Creek at Richland	737	1899–1959	1913		25.5	(2)
			1939–59	1948		24.16	58,900
					5	21.65	13,400
5	Chambers Creek near Corsicana	971	1870–1959	1887		30	(2)
			1939–59	1944			48,000
				1958		28.10	
					6	25.08	17,800
	Brazos River basin						
6	Palo Pinto Creek near Santo	567	1880–1959	1957		31.05	[3]45,100
					4	30.34	36,800
7	Brazos River near Glen Rose	[5]24,830	1900–59	1922		(2)	(2)
			1923–59	1935			97,600
				1957		33.89	
					5	28.10	[6]65,500
8	Paluxy Creek at Glen Rose	399	1877–1959	1908		27.2	59,000
					4	25.4	50,000
9	Nolands River at Blum	276	1887–1959	1922		35.0	(2)
			1947–59	1949		24.0	25,000
					4	22.50	22,400
10	Aquilla Creek near Aquilla	309	1887–1959	1887		34	(2)
			1939–59	1944		30.84	34,200
					5	26.90	8,240
11	North Bosque River at Stephenville	92.4	1854–1959	1955		23.5	49,000
					4	19.90	12,100
12	North Bosque River near Clifton	971	1887–1959	1922		32	(2)
			1923–59	1945		23.2	39,000
					4	34.88	92,800
13	North Bosque River at Valley Mills	1,149	1868–1959	1908		43	(2)
					4	40.22	107,000
14	Middle Bosque River at McGregor	182	1889–1959	1889		28.5	(2)
					4	17.30	20,300
15	Brazos River at Waco	[5]28,500	1847–1959	1936		40.90	246,000
					5	29.73	[6]80,900
16	Leon River near Hasse	1,242	1858–1959	1908		27	(2)
			1939–59	1952		21.49	38,500
					4	21.72	36,100
17	Leon River at Gatesville	2,279	1854–1959	1908		35	(2)
			1950–59	1957		31.30	27,100
					4	34.14	51,200
18	Cowhouse Creek at Pidcoke	475	1882–1959	1956		38.76	55,800
					4	40.1	66,200
19	Lampasas River at Youngsport	1,242	1873–1959	1873		44.2	(2)
			1924–59	1957		36.4	84,000
					4	35.2	70,600
20	San Gabriel River at Georgetown	415	1852–1959	1921		36.1	[3]160,000
					4	26.25	71,500
21	Little River at Cameron	7,000	1852–1959	1921		53.2	[3]647,000
					6	37.07	71,500
22	Brazos River near Bryan	[5]38,400	1854–1959	1921		54.0	(2)
					7	35.32	[6]93,000

See footnotes at end of table.

TABLE 18.—*Flood stages and discharges, October 1–9, in east-central Texas*—Con.

Flood-determination point (fig. 38)	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Known before October 1959, Period	Year	October 1–9, 1959 (day)	Gage height (feet)	Discharge (cfs)
Colorado River Basin							
23	South Concho River at Christoval	434	1882–1959	1906		23	115,000
					3	15.4	25,000
24	Middle Concho River near Tankersly.	[7] 1,280	1900–59	1922		27.2	(2)
			1930–59	1946		24.30	27,500
					3	23.59	21,100
25	Spring Creek near Tankersly	734	1853–1959	1882		26	(2)
			1930–59	1957		21.35	29,400
					3	24.00	82,100
26	Concho River near San Angelo	[8] 4,492	1853–1959	1906		47.5	246,000
					3	40.70	122,000
27	Llano River at Llano	4,233	1879–1959	1935		41.5	380,000
					4	22.28	103,000
28	Pedernales River near Johnson City	947	1859–1959	1952		42.5	441,000
					4	26.1	142,000
Guadalupe River basin							
29	Johnson Creek near Ingram	115	1852–1959	1932		35	[9] 138,000
					4	24.25	95,900
30	Guadalupe River at Comfort	836	1848–1959	1932		38.4	[3] 182,000
					4	33.15	93,200
31	Guadalupe River near Spring Branch	1,282	1859–1959	1869		53	(2)
			1922–59	1932		42.10	121,000
					5	29.61	42,500
32	Blanco River at Wimberly	364	1869–1959	1929		31.10	113,000
					4	19.9	40,100
33	Blanco River near Kyle	424	1882–1959	1929		40	(2)
			1956–59	1958		36.3	66,500
					4	28.70	36,600
Nueces River basin							
34	Nueces River below Uvalde	1,947	1836–1959	1935		40.4	616,000
					4	12.98	37,500
35	Nueces River near Asherton	4,082	1900–59	1935		33	(2)
			1939–59	1944		30.40	24,000
					6	30.88	28,500
36	Nueces River at Cotulla	5,260	1879–1959	1935		32.4	82,600
					9	24.03	23,300

1 About the same as 1941 flood, from information by local residents.
2 Unknown.
3 Not necessarily maximum for period.
4 Flow largely regulated by upstream reservoirs since 1932.
5 9,240 sq mi, probably noncontributing.
6 Flow largely regulated by upstream reservoirs.
7 152 sq mi, probably noncontributing.
8 275 sq mi, probably noncontributing.
9 At site 6 or 7 miles upstream.

and 21,100 cfs on Middle Concho River, caused only moderate flooding along the Concho River. The Llano and Pedernales Rivers also had peak flows of considerable magnitude. There was little flooding along the main stem of the Colorado River. Damage in the Colorado River basin was primarily to farms.

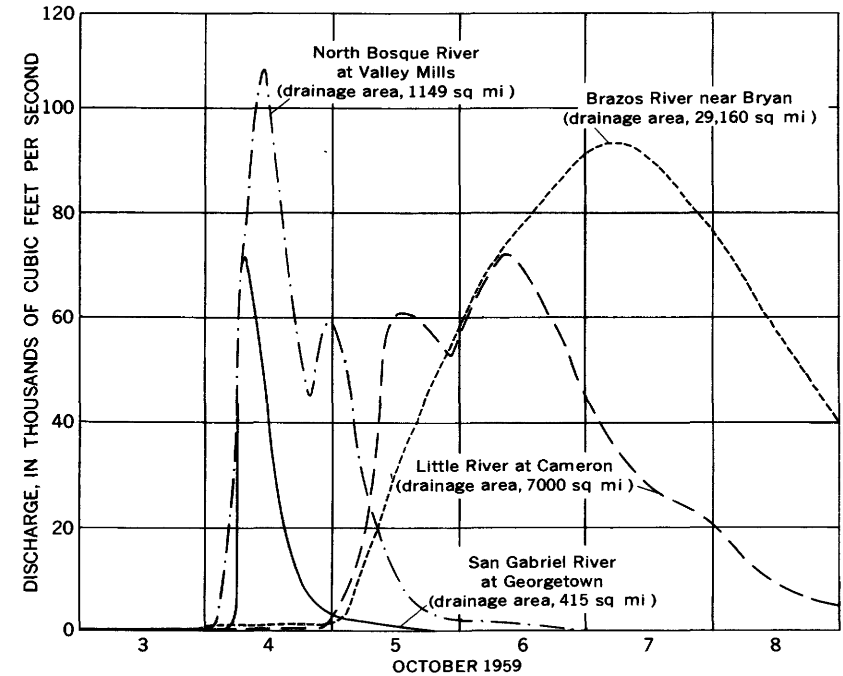

FIGURE 39.—Discharge hydrographs for selected streams in Brazos River basin.

Johnson Creek, in the headwaters of the Guadalupe River, had a peak discharge of 95,900 cfs from a drainage area of 115 square miles. This flood was the second highest known since at least 1852. Figure 40 illustrates the flattening of this peak flow as it moved down the Guadalupe River from Comfort to Spring Branch. A moderate flood was also experienced on the Blanco River, but very little flooding occurred along the main stem of the Guadalupe River. Damage in the Guadalupe River basin, primarily to farms was estimated at $256,000 by the Weather Bureau. One person was drowned during the flood.

Flash flooding on the upper Nueces River followed heavy rains on October 3–4. Unofficial totals of as much as 16 inches of rain were reported, and the heaviest rainfall centered on Turkey Creek, an ungaged tributary of the Nueces River. Turkey Creek flooded 107 homes in Crystal City, according to the Weather Bureau, and caused extensive crop damage in the Crystal City area. The Nueces River at the gaging station near Asherton reached its highest stage since 1935. Roads and bridges suffered heavy damage in the upper Nueces River basin.

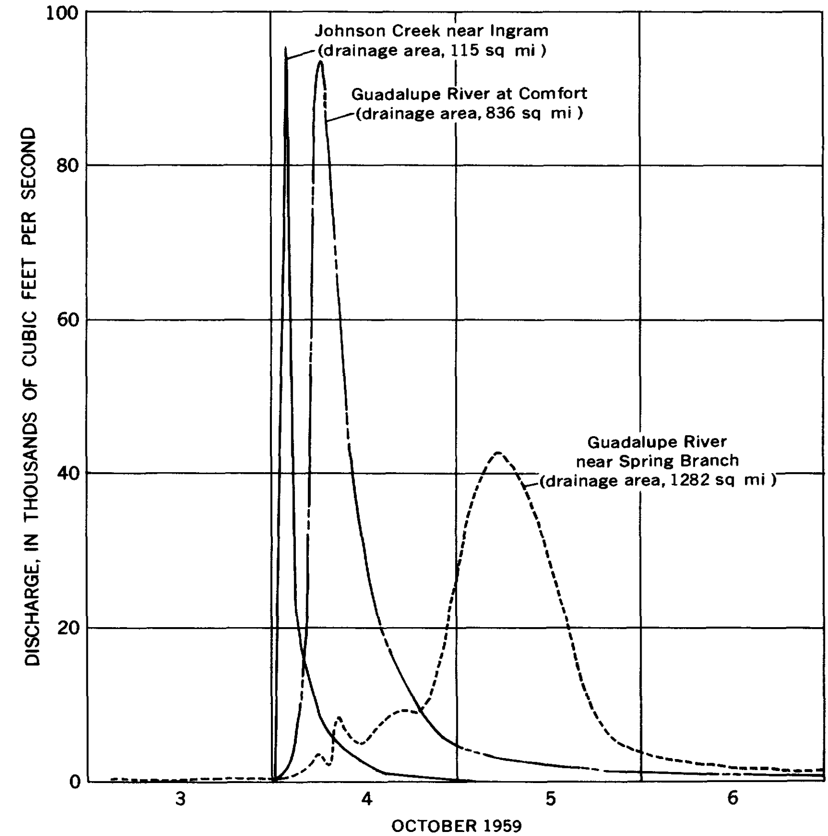

FIGURE 40.—Discharge hydrographs for selected streams in Guadalupe River basin.

OCTOBER 2-7, IN NORTHEASTERN OKLAHOMA

Record-breaking floods occurred October 2–7 on the Black Bear, Council, Bird, Hominy, Big Cabin, and Pryor Creeks and on the Arkansas and Verdigris Rivers in northeastern Oklahoma. These floods followed the heavy rains of September 28–October 5. Two centers of about 17 inches of rainfall occurred in the vicinity of Maramec and Vinita (fig. 41). Antecedent conditions of the area were wet owing to heavy rains of September 24–25.

The peak discharge (table 19) of the Arkansas River at Tulsa on October 5, 1959, exceeded all others since 1925, and the stage for this peak was known to have been exceeded only by the peak of 1923, for which no discharge has been computed. The peak discharge of Black Bear, Council, Bird, Hominy, and Pryor Creeks exceeded all peaks of record. The peak discharge from this storm in the Verdigris

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River at Inola and Big Cabin Creek near Big Cabin was second in magnitude since 1943.

TABLE 19.—*Flood stages and discharges, October 2–7, in northeastern Oklahoma*

Flood-determination point (fig. 41)	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to October 1959: Period	Maximum floods: Prior to October 1959: Year	Maximum floods: Oct. 2–7, 1959 (day)	Maximum floods: Gage height (feet)	Maximum floods: Discharge: Cubic feet per second	Maximum floods: Discharge: Ratio to $Q_{2.33}$
	Arkansas River basin							
1	Arkansas River at Ralston	[1] 54,465	1923–59	1923		23.8		
			1925–59	1944		[2] 23.65	179,000	
					5	21.62	158,000	2.3
2	Black Bear Creek at Pawnee	576	1943–59	1943		28.19	17,800	
					3	31.43	30,200	6.3
3	Cimarron River near Guthrie	[3] 16,892	1937–59	1957		18.58	158,000	
					2	14.90	86,800	2.5
4	Skeleton Creek near Lovell	410	1949–59	1957		34.58	75,200	
					4	28.60	14,600	3.8
5	Cimarron River at Perkins	[3] 17,852	1939–59	1957		19.53	149,000	
					3	16.40	98,600	2.7
6	Council Creek near Stillwater	31	1934–59	1942		17.54	18,000	
					2	18.9	25,000	12.2
7	Cimarron River at Mannford	[3] 18,849	1938–50	1940		[4] 25.2	103,000	
					3	27.37	131,000	3.4
8	Arkansas River at Tulsa	[5] 74,615	1923–59	1923		22.8		
			1925–59	1957		21.53	235,000	
					5	22.00	246,000	2.6
9	Verdigris River near Claremore.	6,534	1935–59	1943		55.05	182,000	
					5	45.76	60,500	1.2
10	Bird Creek at Avant	364	1943–59	1943		29.6		
			1945–59	1957		29.00	25,400	
					2	31.40	32,400	3.5
11	Hominy Creek near Skiatook	340	1943	1943		35.0		
			1944–59	1949		35.06	14,200	
					3	38.82	35,600	4.0
12	Bird Creek near Sperry	905	1938–59	1943		31.68	86,500	
					3	32.60	90,000	5.8
13	Verdigris River near Inola	7,911	1943–59	1943		54.93	224,000	
					5	53.20		
					5		101,000	1.8
14	Big Cabin Creek near Big Cabin.	466	1943–59	1943		34.96	63,000	
					3	34.55	52,000	4.5
15	Pryor Creek near Pryor	229	1943	1943		20.4		
			1947–59	1957		19.41	15,700	
					3	23.10	32,000	4.7
16	Arkansas River near Muskogee.	[5] 96,674	1834–1959	1943		48.20	700,000	
					7	34.00	286,000	1.4

[1] 7,615 sq mi is probably noncontributing.
[2] From outside gage; 22.82 ft in gage well.
[3] 4,926 sq mi is probably noncontributing.
[4] At site 1 mile upstream (drainage area, 17,940 sq mi) at datum 5.00 ft higher.
[5] 12,541 sq mi is probably noncontributing.

Figure 42 shows that the recurrence interval of the peak discharges at the stations varied somewhat in an inverse relationship to the size of the drainage area. The data on size of drainage area and ratio of peak discharge to mean annual flood are from table 19. The ratio of selected recurrence intervals, 10-year and 50-year, to the mean annual flood was obtained from a study of magnitude and frequency of floods for part 7 in the lower Mississippi River basin, as published in the Geological Survey series on magnitude and frequency.

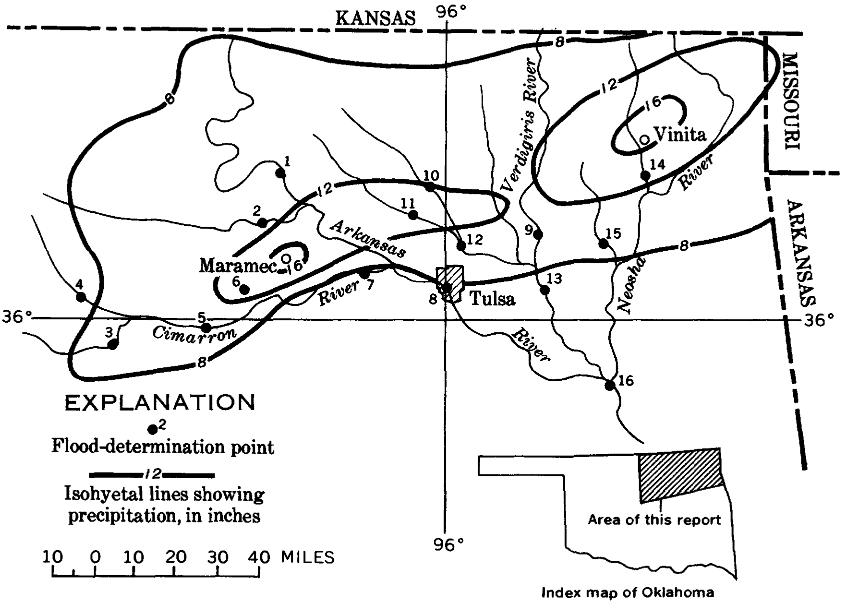

FIGURE 41.—Map of area of floods of October 2-7 in northeastern Oklahoma, showing location of flood-determination points (numbers correspond to those in table 19) and precipitation, September 28-October 5.

The recurrence intervals of peak discharges in large streams, the Arkansas, Cimarron, and Verdigris Rivers, were small, ranging from the mean annual flood to 18 years, because of the nature of the storm, which covered only a small part of each basin. The intense storm covered a large part of the smaller basins, and the peak discharges were of a much greater recurrence interval. Of the seven stations whose drainage areas ranged from 229 to 905 square miles, two had recurrence intervals greater than 50 years, two others had recurrence intervals slightly less than 50 years, and the remaining three had recurrence intervals ranging downward to about 20 years. The entire basin of Council Creek near Stillwater probably received about 12 inches of rain, and the peak discharge that resulted was 2.5 times that for a 50-year flood.

Some flooding occurred on other streams of the state during this period but did not exceed peaks of record at any gaging stations The most notable flooding occurred on Stillwater and Cottonwood Creeks, each causing much property damage in the towns of Stillwater and Guthrie, respectively. A great loss to agricultural land resulted from the washing away of topsoil from fields that had been recently plowed and planted to winter grains and other crops.

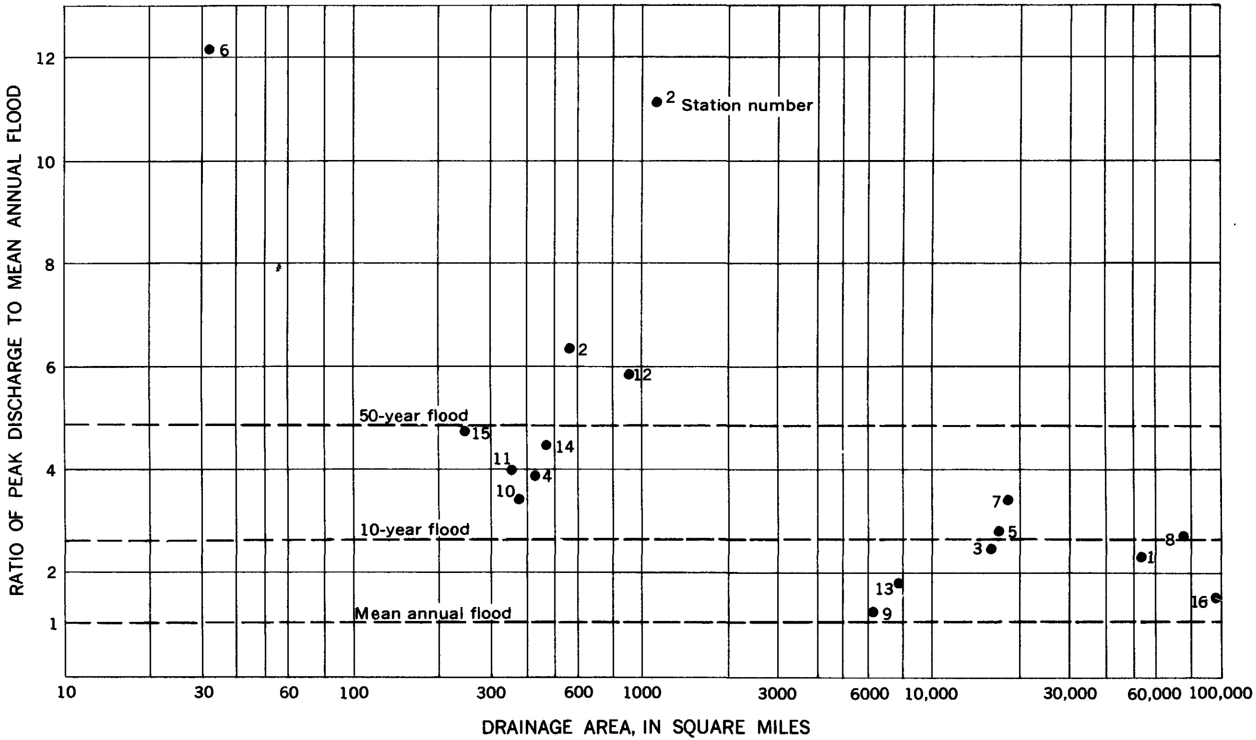

FIGURE 42.—Graph of ratio of October 1959 peak discharges to the mean annual flood versus size of drainage area, related to floods of 10- and 50-year recurrence intervals. Floods of October 2–7, in northeastern Oklahoma. (Station numbers correspond to those in figure 41 and table 19.)

OCTOBER 24-25, IN NEW HAMPSHIRE AND ADJACENT STATES

Heavy rain fell over central New England and southern Maine on October 23–26. Most of this rain fell on October 24, and the area of heaviest concentration was central New Hampshire and central-west Maine (fig. 43). The greatest 1-day precipitation was 8.98 inches at Pinkham Notch, N.H.

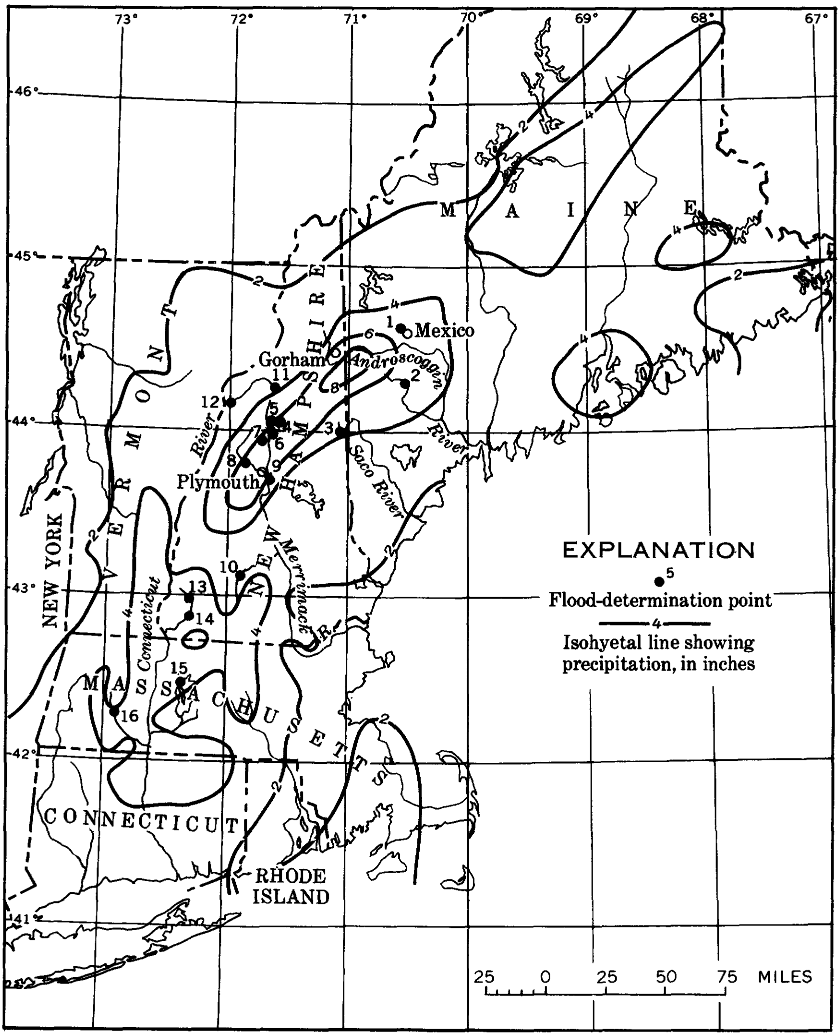

FIGURE 43.—Map of area of floods of October 24-25, in New Hampshire and adjacent States, showing precipitation, for October 23-26, and location of flood-determination points. (Numbers correspond to those in table 20.)

Peak discharges on a few streams, notably those whose drainage areas were mostly within the 6-inch isohyet, were extremely high (table 20). A new maximum discharge, greater than any other since 1929, occurred on the Swift River near Roxbury, Maine. Some of the streams draining the White Mountains of New Hampshire had the highest peaks since the 1938 hurricane floods. The peak discharges

TABLE 20.—*Flood stages and discharges, October, in New Hampshire and adjacent States*

Flood-determination points (fig. 43)	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to October 1959: Period	Year	October 1959 (day)	Gage height (feet)	Discharge: Cubic feet per second	Ratio to $Q_{2.33}$
Androscoggin River basin								
1	Swift River near Roxbury, Maine.	95.8	1929–59	1932		12.58		
				1942			14,500	
					24	12.87	16,800	3.8
2	Little Androscoggin River near South Paris, Maine.	76.2	1913–24, 1931–59	1953		12.41	8,000	
					25	7.26	2,040	.8
Saco River basin								
3	Saco River near Conway, N.H.	386	1903–9, 1929–59	1953		17.20	43,900	
					24, 25	16.39	40,600	2.7
Merrimack River basin								
4	Hancock Branch near Lincoln, N.H.	17.2			24.		5,600	5.8
5	East Branch Pemigewasset River near Lincoln, N.H.	104	1929–53	1936		9.80	17,000	
				1942		[1] 10.51		
					25		24,200	5.1
6	Pemigewasset River at Woodstock, N.H.	193	1939–59	1957		12.43	24,600	
					24	16.13	47,000	5.7
7	Hubbard Brook near West Thornton, N.H.	11.5			24		4,700	7.0
8	Baker River near Rumney, N.H.	143	1927–59	1927		17.4	25,900	
					24	14.00	18,000	2.9
9	Pemigewasset River at Plymouth, N.H.	622	1903–59	1936		29.0	65,400	
					25		52,700	2.2
					25	22.68		
10	Beards Brook near Hillsboro, N.H.	55.4	1945–59	1950		6.59	2,070	
					25	6.53	2,190	1.5
Connecticut River basin								
11	Ammonoosuc River at Bethlehem Junction, N.H.	87.6	1939–59	1953		11.22	10,500	
					24	12.09	10,800	2.7
12	Ammonoosuc River near Bath, N.H.	395	1935–59	1936		15.40	27,900	
					25	14.28	23,500	1.5
13	Ashuelot River below Surrey Mountain Dam near Keene, N.H.	101	1945–59	1959		9.15	[3] 1,160	
					28	9.60	[3] 1,320	
14	South Branch Ashuelot River at Webb, near Marlboro, N.H.	36.0	1920–59	1938		7.89	5,960	
					24	7.40	4,350	4.3
15	Hop Brook near New Salem, Mass.	3.39	1947–59	1955		3.13	275	
					24	3.17	289	
16	Middle Branch Westfield River at Goss Heights, Mass.	52.6	1910–59	1938		10.61	19,900	
					24	5.97	4,700	1.8

[1] Affected by backwater from ice.
[2] Not necessarily maximum for period.
[3] Flow regulated by Surry Mountain Reservoir.

on the upper Pemigewasset River basin approximated those of 1938. Storage in major reservoirs increased and ranged from 85 to 150 percent of average.

Some of the peak discharges were of very rare occurrence and exceeded the expected 100-year flood at the following sites: Swift River near Roxbury, Maine; Hancock Branch near Lincoln, N.H.; East Branch Pemigewasset River near Lincoln, N.H.; Pemigewasset River at Woodstock, N.H.; and Hubbard Brook near West Thornton, N.H. The peak discharge in South Branch Ashuelot River at Webb, N.H., was equal to that of a 60-year flood.

Newspapers reported that floods and landslides caused $4 million in damage and eight deaths. A massive landslide in the White Mountains of New Hampshire blocked the main highway from Boston to Canada with 28 feet of rubble.

General flooding and damage was confined to areas receiving 6 or more inches of rain. The flash floods on Pemigewasset River and tributaries near and above Plymouth, N.H., caused evacuation of 75 families. The flooding in upper Androscoggin River and tributaries caused evacuation of about 20 families in Gorham, N.H., and 150 families in Mexico, Maine. A number of bridges were washed away and some buildings were damaged.

NOVEMBER AND DECEMBER, IN WEST-CENTRAL WASHINGTON

A series of weather fronts that moved across western Washington November 17–23, and again December 14–15, caused heavy precipitation over most of the western side of the Cascade mountains and over the headwater parts of the Yakima and Wenatchee River basins on the east side of the Cascades. Temperatures rose quickly even at high elevations and caused rapid decreases in snow depth. Runoff from the heavy precipitation and melting snow produced major flooding in many of the river basins (fig. 44).

NOVEMBER 17–23

Rainfall was unusually heavy in western Washington November 17–23. Rainfall records at several Weather Bureau stations were used to draw the isohyetal map, figure 45, which shows the maximum 96-hour amount of precipitation during this period. Hourly rainfall of as much as 0.7 inch occurred during the heaviest part of the storm. Accumulated precipitation, November 20–23, at selected Weather Bureau stations is shown in figure 46. The total precipitation during the storm period generally exceeded the 96-hour precipitation by 30 to 45 percent.

Temperatures became unseasonably warm after November 20 (table 21), and the freezing elevation was above 5,000 feet. By

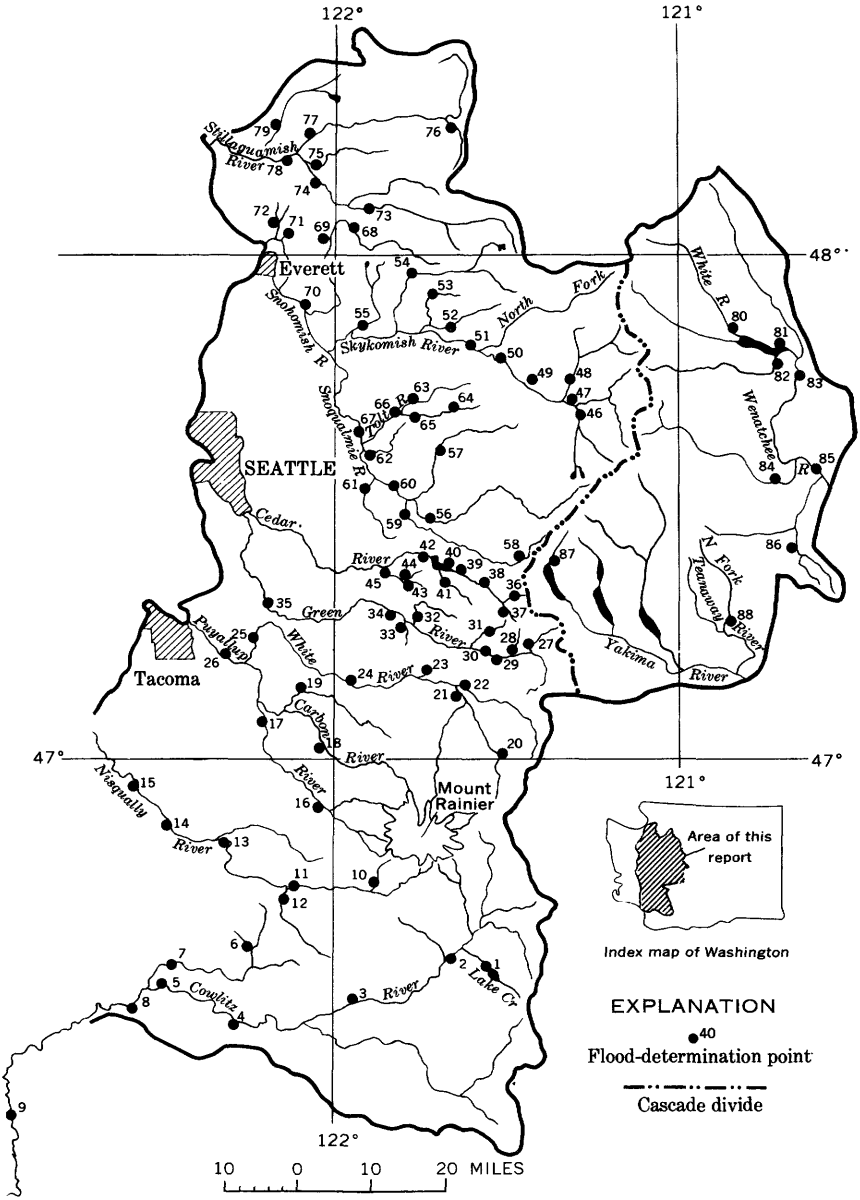

FIGURE 44.—Map of area of floods of November and December in west-central Washington, showing location of flood-determination points. (Numbers correspond to those in table 22.)

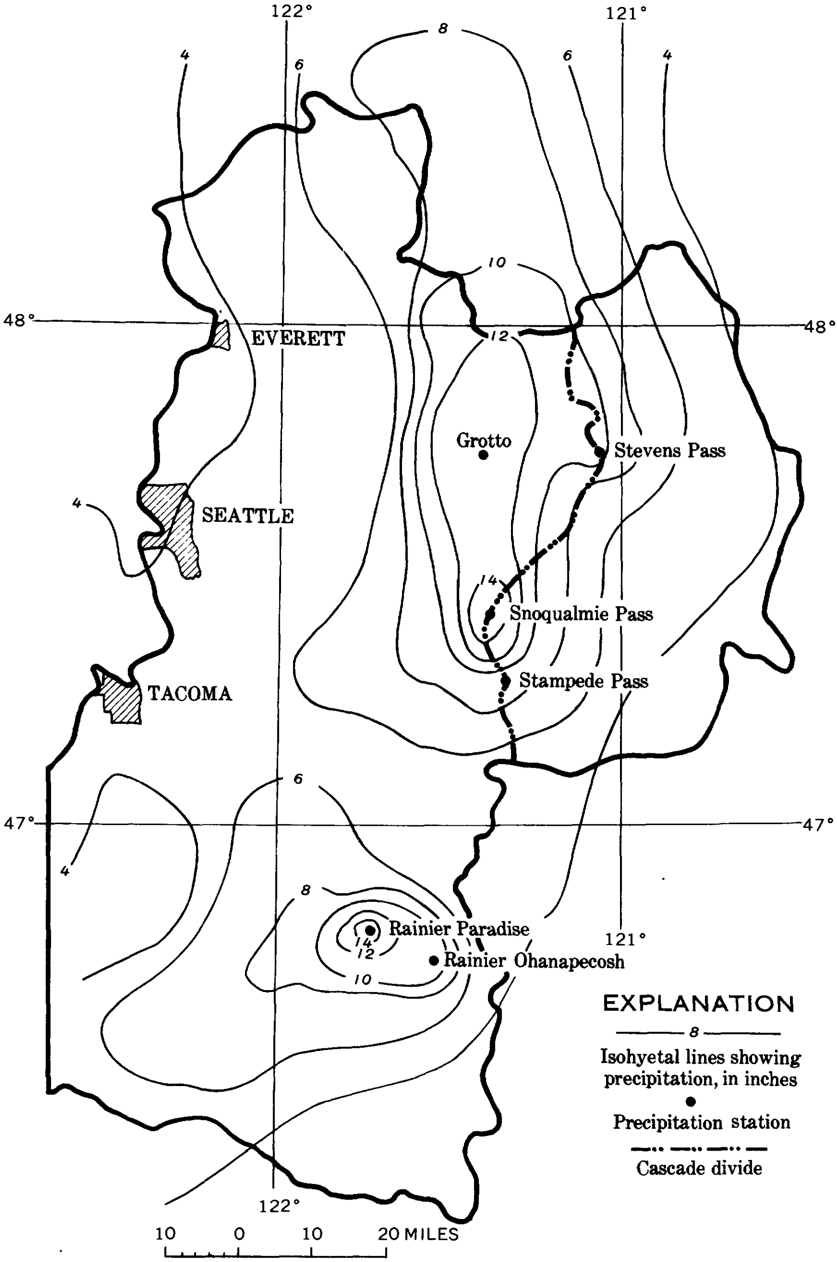

FIGURE 45.—Map of flood area showing maximum 96-hour precipitation during storm period, November 17–23, in west-central Washington.

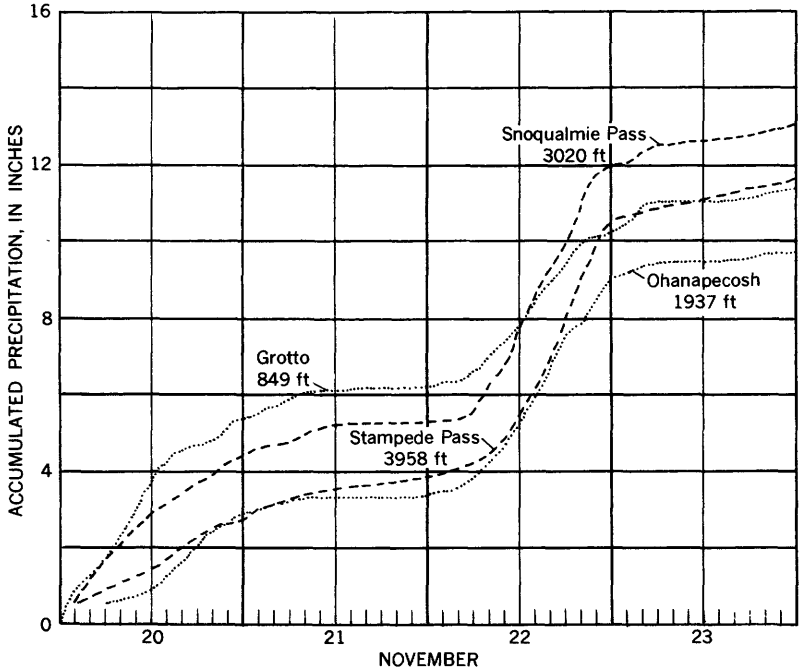

FIGURE 46.—Graph of accumulated precipitation at selected Weather Bureau stations, November 20–23, in west-central Washington.

November 23 the freezing elevation had risen to above 8,000 feet. The Weather Bureau reported that on November 22, 9 inches of snow having a water equivalent of over 3 inches melted at Stampede Pass (elevation 3,958 feet). The snow depth at Rainier Paradise ranger station (elevation 5,550 feet) decreased from 42 to 16 inches, and the snow depth at Stevens Pass (elevation 4,085 feet) decreased from 28 to 9 inches during the storm.

Previous rains had raised the soil moisture content. The combined conditions of soil saturation from previous rains, heavy precipitation, and abnormally warm temperatures produced a high rate of runoff. Discharges on practically all streams in the mountain regions approached or exceeded previously recorded peaks.

Discharge began increasing in most western Washington streams on November 20, and generally reached an initial crest below major flood stage on November 21. After a recession of about 24 hours the streams rose again on November 22 and most of the mountain streams crested on this date. Streams reached maximum stages in the flooded areas on November 23. By noon of November 24, all streams had crested and were rapidly receding. Discharge hydrographs for 4 stations are shown in figure 47.

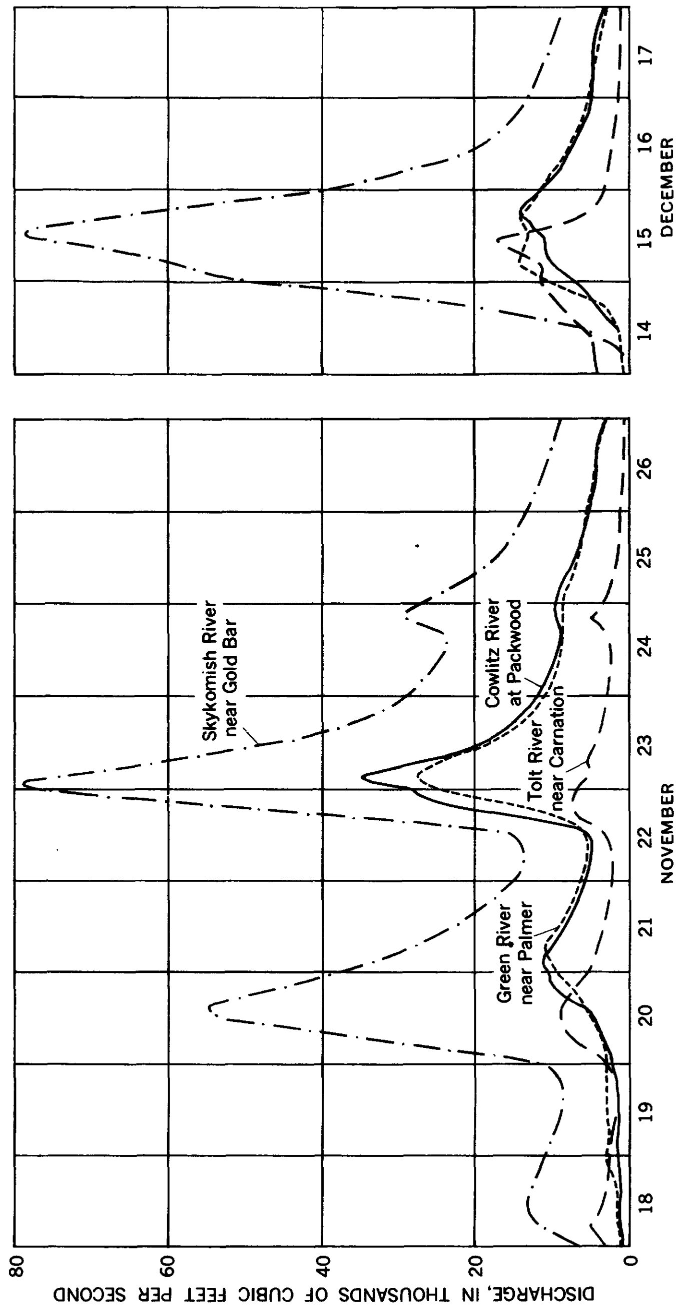

FIGURE 47.—Discharge hydrographs during floods of November and December, in west-central Washington.

TABLE 21.—*Maximum-minimum temperatures, in degrees Fahrenheit, at selected Weather Bureau stations, November 19–24 and December 14–17, in west-central Washington*

Station	Temperature	November 19	November 20	November 21	November 22	November 23	November 24	December 14	December 15	December 16	December 17
Grotto (elevation 849 ft)	Max	42	44	47	44	59	60	39	54	44	45
	Min	34	37	39	37	42	48	33	38	32	34
Stevens Pass (elevation 4,085 ft)	Max	33	36	37	34	47	47	34	42	42	26
	Min	22	32	30	30	30	40	16	33	22	19
Snoqualmie Pass (elevation 3,020 ft)	Max	38	45	39	52	49	47	44	48	39	33
	Min	20	32	33	34	34	33	25	35	24	26
Stampede Pass (elevation 3,958 ft)	Max	39	41	33	48	47	47	43	44	30	28
	Min	31	32	30	31	43	32	26	30	23	23
Rainier Paradise (elevation 5,550 ft)	Max	33	36	34	40	43	42	36	39	32	36
	Min	27	31	25	25	39	36	18	32	20	22

A summary of flood stages and discharges for the streams most affected by this flood is shown in table 22. The numbers of these stations correspond to those on the location map (fig. 44).

TABLE 22.—*Flood stages and discharges, November and December, in west-central Washington*

Flood-determination points (fig. 44)	Stream and place of determination	Drainage area (sq mi)	Maximum Floods: Prior to November 1959: Period	Prior to November 1959: Year	November-December 1959 (day)	Gage height (feet)	Discharge: Cubic feet per second	Discharge: Ratio to $Q_{2.33}$
	Cowlitz River basin							
1	Lake Creek near Packwood.	18.8	1911–24, 1930–42, 1949–54, 1959	1933		5.9	1,400	
					Nov. 23	4.9	1,000	2.6
2	Cowlitz River at Packwood.	287	1911–19, 1929–59	1933		13.0	36,600	
					Nov. 23	13.54	34,300	3.3
3	Mill Creek at Randle	2.95	1950–59	1954		14.95	105	
					Nov. 20	15.39	133	.9
4	Cowlitz River near Kosmos.	1,042	1947–59	1951		16.60	33,800	
					Nov. 24	19.50	47,500	1.7
5	Cowlitz River at Mossyrock.	1,170	1906–59	1933		[1] 37.53	83,500	
					Nov. 24	28.1	52,000	1.7
6	West Fork Tilton River near Morton.	16.4	1950–59	1955		7.55	6,620	
					Nov. 20	5.76	2,120	1.0
7	Tilton River near Cinebar.	158	1941–59	1955		15.13	23,200	
					Nov. 23	13.65	16,600	1.5
8	Cowlitz River near Mayfield.	1,400	1910–11, 1934–59	1946		[2] 24.75	67,000	
					Nov. 24	23.71	60,800	1.6
9	Cowlitz River at Castle Rock.	2,238	1926–59	1933		31.6	139,000	
					Nov. 24	21.16	62,700	1.2
	Nisqually River basin							
10	Tahoma Creek at highway crossing 4 miles west of Longmire and 7 miles east of Ashford.	14.0			Nov. 22		3,130	4.0
11	Nisqually River near National.	133	1942–59	1946		10.34	8,100	
					Nov. 23	11.77	10,900	1.7

See footnotes at end of table.

TABLE 22.—*Flood stages and discharges, November and December, in west-central Washington*—Continued

Flood-determination points (fig. 44)	Stream and place of determination	Drainage area (sq mi)	Maximum floods					
			Prior to November 1959		November-December 1959 (day)	Gage height (feet)	Discharge	
			Period	Year			Cubic feet per second	Ratio to $Q_{2.33}$
	Nisqually River basin—Continued							
12	Mineral Creek near Mineral.	74.3	1942–59	1953		9.02	7,600	
					Nov. 20	7.60	4,880	1.1
13	Nisqually River at La Grande.	292	1906–11, 1919–31, 1943–59	1921		(3)	19,500	
					Nov. 23	9.63	[4] 20,700	1.6
14	Nisqually River near McKenna.	445	1941–59	1955		12.06	[4] 20,800	
					Nov. 23	11.74	[4] 19,300	1.3
15	Nisqually River at McKenna.	517	1947–59	1955		12.38	[4] 20,200	
					Nov. 23	11.78	[4] 20,500	1.2
	Puyallup River basin							
16	Puyallup River near Electron.	92.8	1908–33, 1944–49, 1957–59	1946		8.75	9,160	
					Nov. 22	11.9	10,800	2.2
17	Puyallup River near Orting.	172	1931–59	1933		[1] 11.87	12,800	
					Nov. 22	8.47	12,900	2.1
18	Carbon River near Fairfax.	78.9	1910–12, 1929–59	1933		10.2	11,000	
					Nov. 23	8.56	9,970	2.3
19	South Prairie Creek at South Prairie.	78.6	1949–59	1955		9.78	6,850	
					Nov. 20	7.56	3,900	1.5
20	Dry Creek near Greenwater.	1.01	1956–59	1959		6.84	48	
					Nov. 22	6.28	39	1.1
21	White River at Greenwater.	216	1911–12, 1929–59	1933		9.38	18,100	
					Nov. 23	8.96	14,300	2.8
22	Greenwater River at Greenwater.	73.9	1911–12, 1929–59	1946		7.50	4,280	
					Nov. 22	7.67	5,360	3.8
23	Cyclone Creek near Enumclaw.	2.35	1950–59	1954		25.04	286	
					Nov. 22	23.18	142	.9
24	White River near Buckley.	401	1899–1902, 1910–59	1933		[1] 23.4	28,000	
					Nov. 23	807.91	[4] 13,000	1.2
25	White River near Sumner.	470	1945–59	1955		61.40	[4] 15,100	
					Nov. 24	60.96	[4] 14,700	
26	Puyallup River at Puyallup.	948	1914–59	1933		31.0	57,000	
					Nov. 23	25.05	35,600	1.6
	Duwamish River basin							
27	Snow Creek near Lester.	11.9	1945–59	1956		4.0	1,730	
					Nov. 23	8.0	3,400	4.5
28	Friday Creek near Lester.	4.55	1945–59	1958		4.76	738	
					Nov. 22	6.04	1,370	4.3
29	Green River near Lester.	104	1945–59	1946		12.7	10,200	
					Nov. 22	16	22,000	5.1
30	Green Canyon Creek near Lester.	3.23			do.	3.36	359	1.0
31	Smay Creek near Lester.	8.71	1946–59	1946		(3)	(3)	
					Nov. 23	8.14	2,380	3.8
32	North Fork Green River near Eagle Gorge.	16.5	1956–59	1959		[1] 6.44	1,350	
					Nov. 23	(3)	2,000	2.7
33	Bear Creek near Eagle Gorge.	4.10	1946–55	1955		4.46	1,010	
					Nov. 22	4.01	710	1.4
34	Green River near Palmer.	230	1917–59	1917		20.0	25,000	
					Nov. 23	21.0	27,800	2.3
35	Green River near Auburn.	382	1936–59	1946		[5] 68.16	22,000	
					Nov. 23	69.75	28,100	2.7

See footnotes at end of table.

TABLE 22.—*Flood stages and discharges, November and December, in west-central Washington*—Continued

Flood-determination points (fig. 44)	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to November 1959: Period	Year	November-December 1959 (day)	Gage height (feet)	Discharge: Cubic feet per second	Ratio to $Q_{2.33}$
	Lake Washington basin							
36	North Fork Cedar River near Lester.	8.81	1944–59	1956		4.95	2,320	
					Nov. 22	8.40	3,160	3.5
37	South Fork Cedar River near Lester.	6.00	1944–59	1956		10.41	[6] 2,340	
					Nov. 22	9.8	1,940	3.6
38	Cedar River below Bear Creek near Cedar Falls.	25.4	1945–59	1956		7.08	2,720	
					Nov. 22	6.98	7,620	3.8
39	Cedar River near Cedar Falls.	41.8	1945–59	1951		[7] 11.4		
				1956		10.16	6,090	
					Nov. 22	11.34	9,490	3.3
					Dec. 15	8.88	3,950	1.4
40	Green Point Creek near Cedar Falls.	.89	1956–59	1956		15.52	119	
					Nov. 22	13.22	81	1.0
					Dec. 15	15.11	113	1.3
41	Rex River near Cedar Falls.	13.0	1945–59	1956		7.57	2,550	
					Nov. 22	8.20	4,200	3.3
					Dec. 15	6.99	2,140	1.7
42	Cedar River at Cedar Falls.	84.2	1914–59	1933		11.5	[4] 6,440	
					Nov. 24	9.89	[4] 3,560	
					Dec. 16	9.25	[4] 2,730	
43	Middle Fork Taylor Creek near Selleck.	4.85	1956–59	1959		3.14	452	
					Nov. 22	3.10	390	1.7
					Dec. 15	4.08	823	3.5
44	North Fork Taylor Creek near Selleck.	3.16	1956–59	1959		3.13	243	
					Nov. 20	3.09	235	1.4
					Dec. 15	4.17	522	3.2
45	Taylor Creek near Selleck.	16.4	1956–59	1958		4.65	1,240	
					Nov. 20	4.36	886	1.4
					Dec. 15	5.20	2,170	3.6
	Snohomish River basin							
46	Foss River at mouth 5 miles southeast of Skykomish.	55.0			Nov. 22		7,370	1.5
47	South Fork Skykomish River near Skykomish.	135	1929–31, 1946–59	1951		11.0	14,000	
					Nov. 22	12.74	20,000	2.5
					Dec. 15	11.92	16,700	2.1
48	Beckler River near Skykomish.	96.5	1929–31, 1946–59	1951		10.10	11,800	
					Nov. 22	11.8	16,800	2.9
					Dec. 15	11.9	17,100	2.9
49	South Fork Skykomish tributary at Baring.	1.25	1951–59	1956		16.02	217	
					Dec. 15	16.26	196	2.8
50	South Fork Skykomish River near Index.	355	1897–1959	1897		[1] 27.8	70,000	
					Nov. 23	21.76	49,700	2.4
					Dec. 15	22.12	51,800	2.5
51	Skykomish River near Gold Bar.	535	1928–59	1933		21.3	88,700	
					Nov. 23	20.20	78,800	2.5
					Dec. 15	20.18	78,600	2.5
52	Wallace River at Gold Bar.	19.8	1928–33, 1946–59	1932		[1] 8.5	2,740	
					Nov. 22	8.09	3,070	1.9
					Dec. 14	8.22	3,220	2.0
53	Olney Creek near Gold Bar.	8.03	1923–26, 1929–34, 1946–59	1946		6.30	4,020	
					Dec. 15	4.46	994	.9
54	Sultan River near Startup.	74.5	1911–26, 1929–59	1951		17.22	34,600	
					Nov. 20	15.4	23,500	2.3
					Dec. 15	16.17	28,000	2.7
55	Woods Creek near Monroe.	55.0	1946–59	1950		7.18	1,710	
					Nov. 21	6.60	2,220	1.9
					Dec. 16	4.84	1,440	1.2

See footnotes at end of table.

TABLE 22.—*Flood stages and discharges, November and December, in west-central Washington*—Continued

Flood-determination points (fig. 44)	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to November 1959: Period	Maximum floods: Prior to November 1959: Year	Maximum floods: November-December 1959 (day)	Maximum floods: Gage height (feet)	Maximum floods: Discharge: Cubic feet per second	Maximum floods: Discharge: Ratio to $Q_{2.33}$
Snohomish River basin—Continued								
56	Middle Fork Snoqualmie River near North Bend.	169	1907–26, 1929–32	1909		14.6	26,700	
					Nov. 23		49,000	3.2
57	North Fork Snoqualmie River near Snoqualmie Falls.	65.0	1929–59	1932		17.5	15,800	
					Nov. 23	([3])	13,700	1.8
58	South Fork Snoqualmie River tributary near North Bend.	.15	1951–59	1953		13.96	35	
					Nov. 22	14.52	44	2.0
59	South Fork Snoqualmie River at North Bend.	83	1907–26, 1929–38, 1945–49	1934		11.2	7,620	
					Nov. 22	10.6	13,000	2.6
60	Snoqualmie River near Snoqualmie.	375	1898–1900, 1902–4, 1926–27, 1958–59	1958		14.43	26,000	
					Nov. 23	19.78	61,000	2.2
61	Raging River near Fall City.	30.6	1945–59	1951		6.76	3,420	
					Nov. 22	6.27	2,930	1.8
62	Griffin Creek near Carnation.	17.1	1945–59	1951		[1]5.03	738	
					Nov. 21	4.41	764	2.3
					Dec. 15	4.07	491	1.6
63	North Fork Tolt River near Carnation.	39.2	1952–59	1955		12.2	7,360	
					Nov. 20	10.29	4,690	1.1
					Dec. 15	13.15	9,560	2.3
64	South Fork Tolt River near Index.	5.34	1959	1959			1,330	
					Dec. 14	6.28	1,780	1.7
65	South Fork Tolt River near Carnation.	19.7	1952–59	1955		7.46	5,900	
					Nov. 20	6.67	4,340	1.4
					Dec. 15	7.45	6,500	2.1
66	Tolt River near Carnation.	79.7	1928–32, 1937–59	1951		12.92	16,800	
					Nov. 20	10.92	9,160	1.1
					Dec. 15	13.04	17,400	2.0
67	Snoqualmie River near Carnation.	608	1918–59	1921		61.1	([3])	
			1929–59	1932			59,500	
				1932		59.93		
					Nov. 23	58.93	49,400	1.5
					Dec. 15	58.91	49,200	1.4
68	Pilchuck River near Granite Falls.	53.5	1943–59	1945		10.4	10,500	
					Nov. 22	9.1	7,400	1.5
					Dec. 15	9.21	7,640	1.6
69	Little Pilchuck Creek near Lake Stevens.	17.5	1946–59	1955		5.11	382	
					Nov. 21	6.02	625	2.2
					Dec. 15	([3])	350	1.2
70	Snohomish River at Snohomish.	1,720	1898–1959	1906		35.0	([3])	
			1941–59	1951		30.12	136,000	
					Nov. 23	30.89	113,300	1.7
					Dec. 16	30.05	103,500	1.6
71	Munson Creek near Marysville.	.97	1949–59	1950		10.97	50	
					Nov. 21	10.45	40	2.0
72	Quilceda Creek near Marysville.	13.9	1946–59	1954		6.68	229	
					Nov. 21	6.83	240	1.0
					Dec. 15	6.02	188	.8
Stillaguamish River basin								
73	South Fork Stillaguamish River near Granite Falls.	119	1928–59	1932		19.7	38,800	
					Nov. 22	16.50	23,100	1.3
					Dec. 15	17.17	24,800	1.4
74	South Fork Stillaguamish River above Jim Creek near Arlington.	199	1936–57	1951		27.26	27,700	
					Nov. 22	27.84	28,800	1.2

See footnotes at end of table.

TABLE 22.—*Flood stages and discharges, November and December, in west-central Washington*—Continued

Flood-determination points (fig. 44)	Stream and place of determination	Drainage area (sq mi)	Maximum floods: Prior to November 1959: Period	Maximum floods: Prior to November 1959: Year	Maximum floods: November-December 1959 (day)	Maximum floods: Gage height (feet)	Maximum floods: Discharge: Cubic feet per second	Maximum floods: Discharge: Ratio to $Q_{2.33}$
	Stillaguamish River Basin—Continued							
75	Jim Creek near Arlington.	48.9	1937–59	1949		9.28	4,730	
					Nov. 22	9.12	4,530	1.5
					Dec. 15	8.14	3,490	1.2
76	Squire Creek near Darrington.	18.8	1950–59	1951		10.52	6,440	
					Nov. 20	9.89	4,490	1.3
					Dec. 15	9.37	4,080	1.1
77	North Fork Stillaguamish River near Arlington.	269	1928–59	1951			30,600	
				1951		13.46		
					Nov. 23	13.15	29,400	1.3
					Dec. 15	12.26	25,100	1.1
78	Stillaguamish River at confluence of North and South Forks at Arlington.	546	1947–59	1951		20	(3)	
					Nov. 23	19.85	58,600	1.3
					Dec. 15	19.45	(3)	
79	Pilchuck Creek near Bryant.	49.7	1929–31, 1950–59	1956		7.60	6,240	
					Nov. 22	7.49	6,030	1.7
					Dec. 14	5.76	3,150	.9
	Wenatchee River basin							
80	White River near Plain	150	1911–14, 1954–59	1958		13.25	5,780	
					Nov. 25	11.61	4,080	1.0
					Dec. 15	12.02	4,320	1.0
81	Wenatchee River below Wenatchee Lake.	276	1932–56	1948		1,879.65	13,700	
					Nov. 25	1,876.20	8,100	1.3
82	Nason Creek 2 miles upstream from mouth and 5 miles north of Winton.	86.0	1948	1948			5,270	
					Nov. 22		6,850	3.1
83	Wenatchee River at Plain.	591	1910–59	1948		12.43	22,700	
					Nov. 25	8.61	11,500	1.0
84	Icicle Creek above Snow Creek near Leavenworth.	193	1936–59	1948		13.93	11,600	
					Nov. 23	12.55	8,620	2.1
					Dec. 15	11.76	7,200	1.8
85	Wenatchee River at Peshastin.	1,000	1905–59	1948		15.88	32,300	
					Nov. 23	10.58	16,300	1.0
					Dec. 16	10.62	16,400	1.0
86	Peshastin Creek at Blewett, 1.8 miles upstream form Nigger Creek and 12 miles southwest of Cashmere.	40.0	1911–12, 1948	1948			713	
					Nov. 22		1,030	1.3
	Yakima River basin							
87	Gold Creek at U.S. Highway 10, 1 mile southeast of Hyak.	13.8			Nov. 23		5,000	9.0
88	North Fork Teanaway River at county road crossing 3 miles upstream from mouth and 7 miles northeast of Cle Elum.	84.0			do		3,180	1.4

1 At different site or datum.
2 Flood of December 1933 is known to be higher.
3 Not determined.
4 Affected or regulated by reservoir.
5 Flood occurring shortly after 1900 may have been slightly higher than the November 1959 flood.
6 May have been caused by release from logjam.
7 Affected by backwater.

Major flooding occurred in the Green (head of Duwamish), Snohomish, Snoqualmie, Skykomish, and Stillaguamish River basins. About 32,000 acres of land were inundated in the Snohomish River basin and more than 400 people were evacuated. Approximately 580 buildings were flooded, of which 450 were farm buildings and homes, 70 were urban dwellings, and 60 were industrial or commercial buildings. No loss of human life was reported in the inundated area, but a considerable number of livestock were lost. The flood damage in the Snohomish River basin was estimated by the Corps of Engineers to be more than $6 million.

In the Green River basin about 15,000 acres of land were flooded, and about 500 people were evacuated. About 1,300 farm and residential buildings and 90 commercial groups were flooded. The damage in the Green River basin was estimated by the Corps of Engineers at about $4½ million.

Estimates of damage as reported by the Corps of Engineers, Seattle District, are shown in tables 23 and 24.

TABLE 23.—*Estimate of damage in the Snohomish River basin resulting from the floods of November 1959*

[Data furnished by Corps of Engineers, Seattle district]

Items damaged	*Estimated loss*
Agricultural (erosion, cleanup, weed, and so forth)	$700, 000
Livestock and reduced milk production	30, 000
Buildings and contents	590, 000
Fences, farm equipment, and stock feed	100, 000
Levees	551, 000
Pumping plants and drainage systems	100, 000
Channel snagging and special debris removal	200, 000
Highways and roads	677, 000
Railroads	340, 000
Traffic interruptions:	
highways	1, 833, 000
railways	127, 000
Wirelines and loss of revenue	94, 000
Municipalities:	
Index	8, 000
Garland Springs Resort	26, 000
Skykomish	30, 000
North Bend	50, 000
Flood fighting	6, 000
Evacuation and care of refugees	50, 000
National Forest roads, bridges, camp grounds, buildings, and so forth	330, 000
Miscellaneous items	200, 000
Total	$6, 042, 000

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TABLE 24.—*Estimate of damage in the Green River basin resulting from the floods of November 1959*

[Data furnished by Corps of Engineers, Seattle district]

Items damaged	*Estimated value*
Land and crops	$573,000
Building and contents	2,620,000
Fences	15,000
Highways and roads	150,000
Railroads, physical damage	8,000
Wirelines	15,000
Ditches	7,000
Municipal streets and sewers, Kent and Auburn	25,000
Traffic interruptions, highway and road	12,000
Railroad traffic interruptions	1,000
Erosion of land and deposition of sand	280,000
Care of refugees and flood rescue operations	21,000
Automobiles	18,000
Loss of livestock and income from dairy herds	45,000
River improvements	210,000
Howard A. Hanson Dam—construction facilities and miscellaneous contractors losses	200,000
City of Tacoma Water Supply system	10,000
Fish hatchery at Kanasket (privately owned buildings) and contents in vicinity of hatchery	90,000
Other miscellaneous damage	200,000
Total	$4,500,000

Loss of transportation facilities constituted a large part of the damage. About 1,400 feet of U.S. Highway 10, the main cross-State route over Snoqualmie Pass, was washed out when a log jam caused the South Fork Snoqualmie River to cut a new channel; this washout resulted in damage of nearly three-quarters of a million dollars. The highway was completely closed until December 14 when a by-pass was completed, but full service of the highway was not restored for several months. On the east side of the Cascade Range, two lanes of this highway were blocked for several months as a result of damage to the Gold Creek bridge. The other three highways through Cascade Range passes were also blocked for several days by slides and small washouts. The three cross-State railroads were blocked for about a week; the Northern Pacific Railroad suffered the heaviest loss owing to several washouts in the upper Green River basin. Several county road bridges were damaged or washed out. In the mountain areas a large number of Forest Service and private logging company bridges were completely destroyed.

Localized flooding also occurred throughout the flood area. In the Stillaguamish River basin, the Stanwood area was flooded owing to the failure of a drainage ditch levee on November 23. Elsewhere, flooding was generally limited to farm lands where, except for some erosion, damage was negligible.

High discharges occurred in the upper Yakima River basin November 20–23. Substantially all reservoir inflow during the flood period (170,000 acre-feet) was stored in 5 days. The Columbia River Inter-Agency Committee estimated that the maximum unregulated mean daily flow of the Yakima River near Parker during this flood would have been 55,000 cfs. The recorded peak flow at the Parker gage was 27,400 cfs on November 22, and there is evidence that the peak rate of storage in the five reservoirs may have reached 40,000 cfs. Without storage control, near record flows could have occurred. The maximum discharge recorded (1908–59) at this gage was 65,000 cfs on December 23, 1933.

The reduction of peak flow from 55,000 to 27,400 cfs by the five reservoirs prevented damage estimated at $2.5 million. The actual damage resulting from the November flood in the Yakima valley was estimated at $924,000 by the Water Management Subcommittee, Columbia Basin Inter-Agency Committee.

DECEMBER 14–15

Major flooding occurred again December 15 in the northern part of the area affected by the November floods. In the Skykomish, Snoqualmie, and Stillaguamish River basins the December floods were very nearly as large as the one in November, and, in general, the same areas in these basins were again inundated. Peak discharges for these floods are shown on table 22 along with those for the November floods.

High runoff was again generated by heavy precipitation, warm winds, and above-normal temperatures in the mountainous area (table 22). The isohyetal map (fig. 48) was drawn from Weather Bureau data of 48-hour precipitation, December 14–15. In general, the amounts shown for the 48-hour period are the storm total, which, in most cases, occurred in about a 40-hour period. The amount of accumulated precipitation at selected Weather Bureau stations December 14–16 is shown in figure 49. Hourly rainfall amounts were as much as 0.5 inch during the heaviest part of the storm. The Weather Bureau reported that between December 14 and 16 the snow depth at Stevens Pass (elevation 4,085 feet) decreased from 41 to 30 inches and that the snow depth at Stampede Pass (elevation 3,958 feet) decreased from 28 to 3 inches.

The December floods peaked much more quickly than the November floods. A single crest followed by a rapid recession was recorded on most streams (fig. 47). Discharge began increasing on December

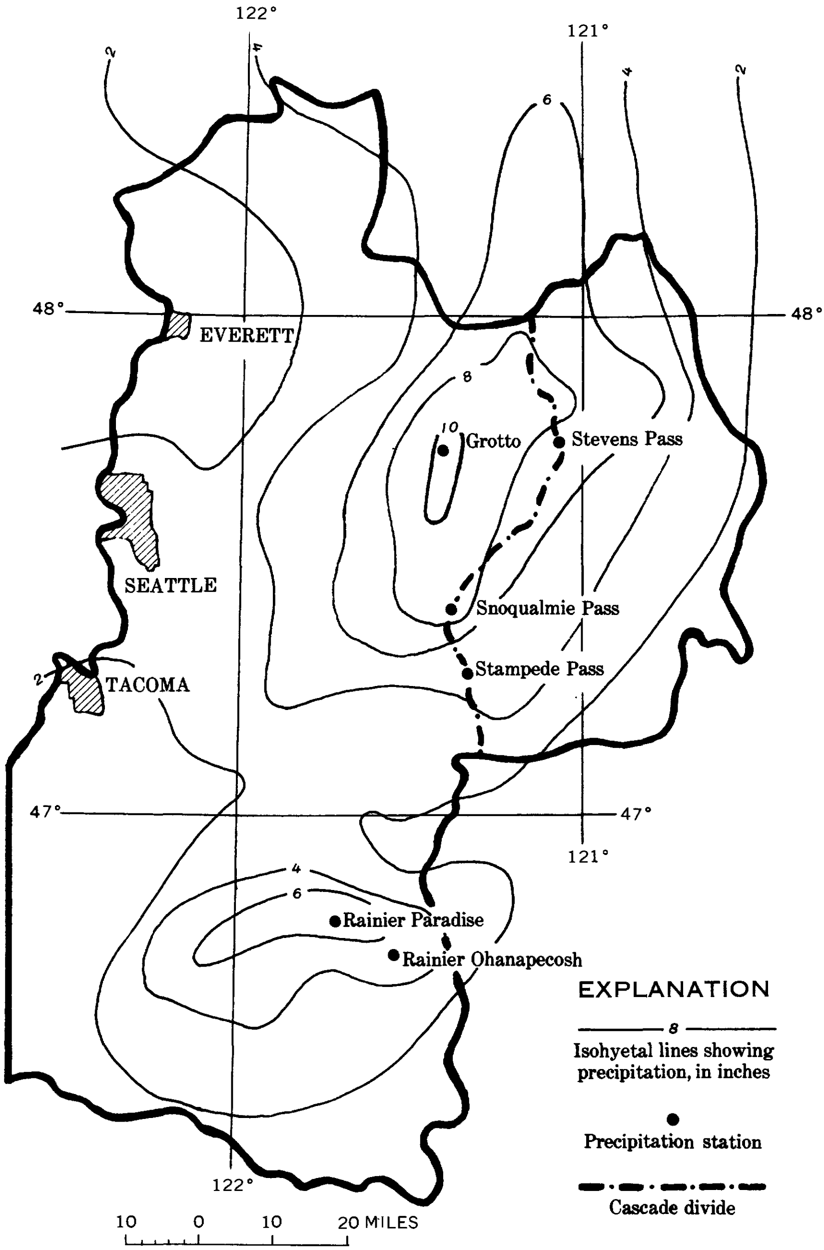

FIGURE 48.—Map of flood area showing total precipitation December 14–15, in west-central Washington.

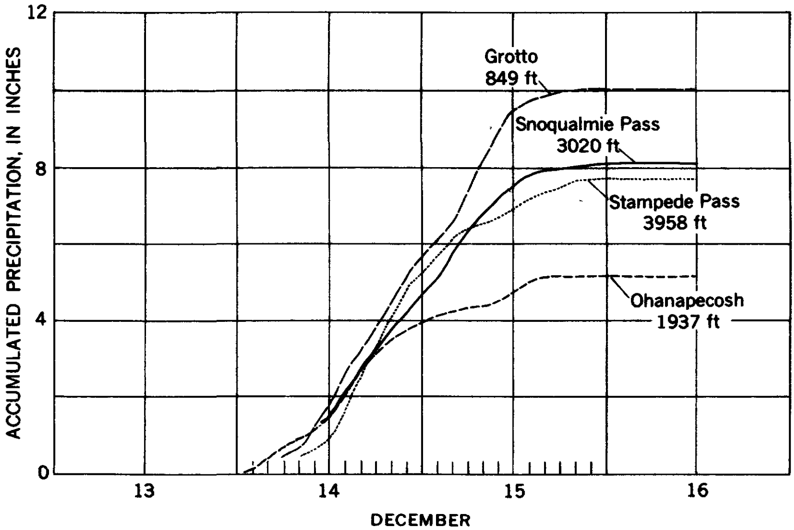

FIGURE 49.—Graph of accumulated precipitation at selected Weather Bureau stations December 14-16, in west-central Washington.

14, and, with few exceptions, streams crested on December 15 or early December 16.

Some temporary dikes were destroyed, and considerable flooding occurred where dikes had not been repaired after the November flood. The Corps of Engineers, Seattle District, reported that no estimate was made of damage resulting from the December flood, for any additional damage to that caused by the November flood was insignificant. Stevens Pass Highway, U.S. 2, was closed during the afternoon of December 15 when 3 to 4 feet of water spilled over it in the vicinity of Gold Bar and Grotto. Water was a foot deep in the main street at Sultan, and 23 families were evacuated at Startup when Wallace River, a tributary of the Skykomish, was backed into town.

The open-file report, "Floods in Washington, Magnitude and Frequency," was prepared by the Tacoma district in cooperation with the State Highway Department of Washington. In the report the State is divided into 13 flood regions (each having distinctive runoff characteristics) of which five (regions 2, 3, 5, 12, 13) are represented in the flood area. Relations of the two values: (1) the ratio of peak discharge to the mean annual flood and (2) the recurrence interval have been determined for each region. If the ratio of a peak discharge to the mean annual flood at any discharge station is known, the recurrence interval may be computed. Recurrence interval curves for discharge stations in the flood area are shown in figure 50.

The curve for two regions, 2 and 5, are identical and are represented by one curve. Data are available for only one station in region 13, and they are not represented by a curve. The station numbers shown for each curve are those used in figure 44 and table 22. The recurrence interval for a peak discharge may be determined by referring the ratio of the discharge to the mean annual flood (figure in last column of table 22) to the appropriate curve in figure 50.

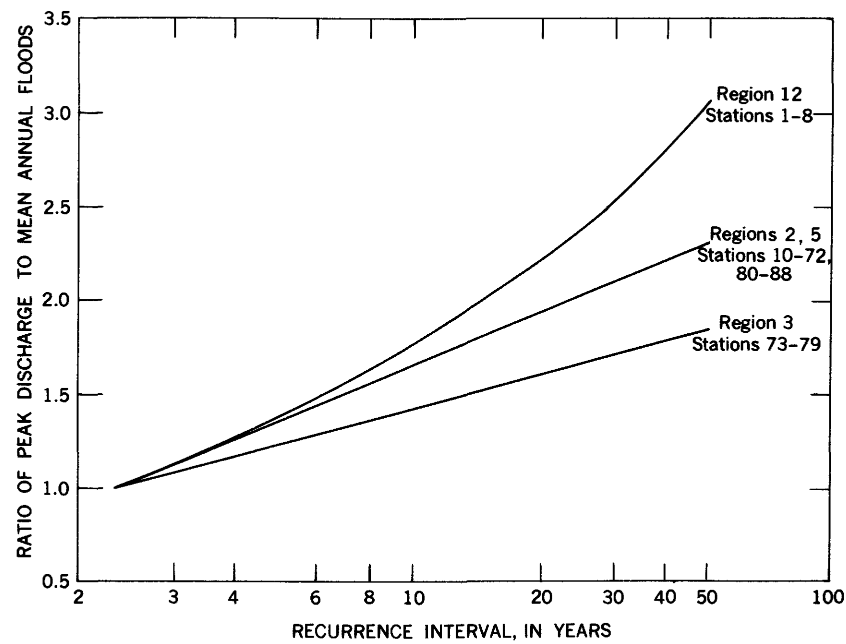

FIGURE 50.—Relationship of ratio of peak discharge to mean annual flood versus recurrence interval of floods of November and December in west-central Washington. (Station numbers correspond to those in table 22.)

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