

RIVERS AND FLOODS

[River and Flood Division, MERRILL BERNARD in charge]

By BENNETT SWENSON

The outstanding floods during the month of September 1938 occurred in New England from September 20 to 28. These floods were caused by heavy rains antecedent to, and accompanying, the passage of a hurricane which passed inland over the southern New England coast during the afternoon of September 21. A discussion of the hurricane appears as a special article in this REVIEW. The floods were most severe in Contocook River, a tributary of the Merrimack, and in the lower Connecticut River. The crest stage at Hartford, Conn., 35.42 feet on September 23, was within 2.1 feet of the highest stage of record in March 1936. A more complete report on these floods will be given in the next issue of the REVIEW.

Severe floods occurred also in some of the tributaries of the Upper Mississippi River, principally in the Chippewa, Black, and Wisconsin Rivers in Wisconsin. Prolonged heavy rains over that area and its vicinity resulted in considerable overflowing. The heavy discharge of the tributaries caused the Mississippi River to pass flood stage from the vicinity of La Crosse, Wis., to Louisiana, Mo. This flood, which was unusual for this time of the year, will be discussed at greater length in the following issue of the REVIEW.

Atlantic Slope drainage.—The heavy rains that produced the New England floods also extended over the Mohawk-Hudson River basin and resulted in floods in these rivers.

The crest stage at Albany, N. Y., was 16.5 feet on September 22, 1.3 feet lower than the crest stage in March 1936 and within 4.8 feet of the greatest flood of record, March 28, 1913.

The mean rainfall for the period September 17–21 of 21 rainfall stations in the Hudson and Mohawk watersheds was 5.57 inches, ranging from 4.08 inches at North Creek to 7.61 inches at Albany, N. Y. The latter is the greatest amount ever recorded at Albany for a period of 5 days since the establishment of the station in 1874.

Considerable damage resulted in the Hudson River Valley from a combination of the wind, heavy rain, and flood. The total is estimated at more than \$5,000,000.

The curvature of the tropical disturbance to the northwest, after passing inland, caused heavy rain to spread over western New York on the 21st and 22d, resulting in moderate overflows in the upper reaches of the Delaware and Susquehanna River systems.

An overflow in the lower Neuse River in North Carolina was caused mainly by a heavy flood in the Little River. Stages in the upper Neuse River were low and did not reach bankful stage at Smithfield, N. C., the first gaging station above the mouth of the Little River.

Missouri Basin.—Excessive rain over a period of about 2 hours on the night of September 4, in the vicinity of Hot Springs, S. Dak., resulted in sudden floods in Fall River and Beaver Creek, upper tributaries of the Cheyenne River and located in the southern Black Hills region. The rainfall recorded at Hot Springs between 7 and 9:30 p. m. was 2.10 inches, while it has been estimated that three times as much rain occurred a few miles northeast over Beaver Creek.

Two persons were drowned in a tributary canyon of Beaver Creek and the loss from the Fall River overflow is estimated to be about \$25,000.

A moderate flood occurred in the Big Sioux River in Iowa from September 14 to 19. The stage at Akron, Iowa, rose rapidly to 12.1 feet on the 14th and then slightly for 2 days, after which a rise of 3.4 feet occurred on the 17th. The highest stage was 16.3 feet on September 17, 4.3 feet above flood stage, but no damage of consequence resulted.

A rise in the middle Missouri River about September 14 approached but did not exceed bankful stage. At Nebraska City, Nebr., the crest stage was 14.0 feet, flood stage 15 feet.

A 3-day rainfall of high intensity beginning August 31, along the eastern slope of the Rocky Mountains, extending from the Wyoming State line southward to Colorado Springs, Colo., a distance of 150 miles, caused flood damage estimated at more than \$500,000. Practically every stream in the foothills region was at or above flood stage; the greatest damage occurred in the vicinities of Morrison and Eldorado Springs, Colo. Six persons were drowned in Bear Creek, near Morrison, and one in Coal Creek, near Louisville, Colo.

Arkansas Basin.—Moderately heavy rains over the upper North Canadian River basin during most of the first week of September resulted in flooding above, but not at, Oklahoma City from September 6 to 16. The South Canadian River reached, but did not exceed flood stage. Practically all of the damage occurred in the Panhandle counties of Oklahoma.

West Gulf of Mexico drainage.—The flood in the lower Rio Grande, which was in progress at the close of August and the beginning of September, is described by the official in charge, Brownsville, Tex., as follows:

Heavy to torrential rains occurred at and in the vicinity of Monterrey, Mexico, and probably over most of the San Juan and other nearby watersheds on August 28 and 29. The rains resulted from the tropical storm that went inland about 100 miles south of Brownsville, Tex., during the night of August 27–28, causing a rapid and decided rise in the San Juan and probably other smaller streams tributary to the Rio Grande in the section of Rio Grande City, Tex., on August 29 and 30.

These streams emptying into the Rio Grande between Rio Grande City and Roma, Tex., caused a rapid and decided rise in the Rio Grande at Rio Grande City on August 29, and it continued to rise there during the following 2 days until it reached the unusual crest stage of 30.1 feet during the forenoon of August 31. This great volume of water caused stages above flood all along the lower valley, amounting to practically a major flood, but kept under remarkable control by the various flood control levees, flood control outlets, etc., on both the American and Mexican sides of the river. Monetary damages were therefore almost negligible for such a great volume of water. The greatest item of estimated damage was to a few breaks in the main levees and erosion of the river banks near one or two of the large irrigation pumping plants.

The destructive flood¹ that occurred in the Colorado River in Texas from July 22 to August 3, 1938, inundated portions of 12 counties. Six people were reported drowned and the property and crop loss has been estimated at \$5,000,000.

The flood was caused by unusually heavy rains over a small area centered over the Brady Creek-San Saba River, a tributary of the Colorado River. The rains were heaviest from July 21 to 23, inclusive, but heavy rains were more or less general from 19th to 24th and rain-

¹ Table of flood stages appears in the MO. WEA. REV., August 1938.

fall was recorded at most stations from July 18 to 25 in that area.

Table 1 shows the daily precipitation at the stations in the Colorado Basin. The precipitation decreased in amount toward the upper and lower portions of the basin, the least rainfall occurring in the lower portion from Wharton, Tex., downstream. In the middle and upper portions rain occurred generally from July 18 to 25, while in the lower portion they began on July 21 and continued to July 25.

At Sloan, Tex., located on the San Saba River near its confluence with the Colorado, rainfall was recorded as follows: 3.70 inches on the 21st, 3.92 on the 22d, and 8.47 on the 23d, with a total of 21.49 inches from July 18 to 25; Eden, Tex., located on Brady Creek, reported 1.58 on the 21st, 1.39 on the 22d, and 6.89 inches on the 23d, with a total of 16.89 inches from the 18th to 25th.

Small streams in the Brady Creek-San Saba River watershed rose rapidly, damaging highways, bridges, and crops. The losses in McCulloch and San Saba Counties are estimated at \$500,000. However, the greater portion of the flood loss occurred along the main channel of the Colorado River from Austin to Bay City, Tex.

The reservoir formed by Buchanan Dam, located west of the town of Burnet, was well filled, although not to capacity, before excessive rains occurred approximately 50 to 75 miles upstream. To prevent the reservoir overflowing the dam, a number of flood gates were opened. At Marble Falls, first gaging station below the dam, the stage rose from 6.0 feet on July 22 to 25.6 feet on the 23d, to 31.0 feet on the 24th, with a crest of 36.4 feet on the 25th. Hourly gage readings at Austin, Tex., from 3 p. m. July 23 to 8 p. m. July 27 are given in table 2.

No losses occurred at Marble Falls as the river banks are high, but communities along the river including Austin, Bastrop, La Grange, Columbus, Wharton, and Bay City sustained heavy losses. The losses for the section of the river from Austin to the Gulf of Mexico have been estimated at \$4,500,000.

Flood warnings were issued for Austin and vicinity on July 23, when the river stage was zero or lower. On July 24, warnings were issued for the lower sections of the river.

Strong southerly winds prevailed over southern Texas during much of the period from July 17 to 24, transporting warm moist tropical air over that region. A cold, dry air mass to the north extended into Oklahoma and northern Texas. There was evidence of a front separating the two air masses at the surface on the 17th and 18th which remained more or less stationary. The rainfall was only moderately heavy during this time. However, following this time, when the heaviest rainfall occurred, there were no indications of a distinct front at the surface, the surface winds being southerly over most of Texas, and the excessive rains of the 21st to the 23d may be explained as follows: The strong southerly winds continued over southern Texas and extended to a considerable elevation following an anticyclonic curvature. In the cold air mass to the north the winds were northerly aloft, swinging to the northeast at high elevations. These opposing streams of contrasting air masses in the upper air caused convergence, or a piling up of the air, along a line situated approximately over the middle Colorado River Basin much of the time from about July 19 to 22. This lifting of the warm moist tropical air along the line of

convergence produced general excessive rain over a limited area, mostly in the form of thunderstorms.

Heavy rainfall over much of eastern New Mexico during the first 10 days of September, although they did not cause any floods in the main streams, caused considerable overflow in the smaller streams.

TABLE 1.—Precipitation (inches) in Colorado River Basin (Tex.), July 18 to 25, 1938, inclusive

[Precipitation measured in morning unless otherwise indicated]

Station	July								Total
	18	19	20	21	22	23	24	25	
Austin ¹			0.06	0.13	0.39	0.62	0.06	T	1.26
Ballinger	0.10	T	T	T	.10	.70	T	.28	1.18
Big Spring	T	2.56	.09	1.31	.06	.15	.61	.49	5.27
Blanco					.15	.20	.40		.85
Brackettsville					.37	3.69	5.92	.08	10.06
Brady	.04	.02	1.42	2.63	4.39	3.54	1.10	.51	13.65
Brownfield ²				.16	.10				.26
Brownwood	1.23	.89	.21	.46	1.02	1.15	3.50	1.50	9.96
Coleman ²		.23		.32	.21	.70	3.50	1.40	6.38
Columbus				1.26		.06		.23	1.55
Comanche ²	T	.38		.44	.50	1.58	2.18	1.72	6.80
Eastland	T	1.10	.10	.07	T	2.35	1.30	1.20	6.12
Eden	.45	2.10	1.60	1.58	1.39	6.89	2.86	.02	16.89
Fort Stockton ²	1.20	.80	.15	1.35	1.40	.15			5.05
Garden City ²			.10		.25	.75	.90	.75	2.75
Gatesville ²		2.35		.27	2.58	3.92	.14	.27	9.53
Goldthwaite ²	T	1.50	.06	1.50	2.37	4.37	.83	1.76	12.39
Kerrville				.47	.13	.14	.72	.12	1.58
Kuapp (near) ²	.10	.12	.71		.45	.36	2.50	.34	4.58
Lamesa	.25	.20	.02	2.80	.05	.03	.05	.04	3.44
Lampasos			.92	.32	1.11	1.46	3.23	.96	8.00
Llano		T	.13	2.00	.51	1.10	.70	6.75	10.19
Marble Falls					.01	1.70	.59	.14	2.44
McCamey			.03	.63	.40	.04	.22	.13	1.45
Menard			2.02	4.40	4.00	1.93	1.59	.19	14.13
Montell			.26	T	.70	1.42	2.04	.50	4.92
Morris Ranch ^{2,3}		.04	.50	.90	.10	.07	.06	.85	2.52
Putnam ²	1.55		1.02		2.18	.22	1.24	.12	6.33
Roscoe ²	1.35	T	.54		.31	.18	.43	T	2.81
San Angelo	.23	T	1.32	.49	.13	.83	.36	.20	3.61
Seminole ²	.63	T	.12	.39	.02	.37	T	1.62	3.15
Sloan ²	.25	1.37	.70	3.70	3.92	8.47	.22	2.86	21.49
Smithville ²				.61	.43	1.64	T	T	2.68
Snyder			.07	.92	.06	.21	1.47	.32	3.05
Sonora ²			.12	.34	4.39	4.22	.44	3.04	12.55
Sterling City ²	.20	.10		.30	.60	2.15	.10	1.75	5.20
Wharton					.09	.65	.37	1.43	2.44

¹ Midnight to midnight.
² 24 hours ending near sunset.
³ Post office, Kerrville.

TABLE 2.—Hourly gage readings, Colorado River at Austin, Tex., July 23-27, 1938

Hour	July				
	23	24	25	26	27
A. M. 1		27.47	31.05	32.11	25.12
2		28.28	31.13	31.84	24.67
3		28.93	31.13	31.61	24.22
4		29.50	31.06	31.27	23.82
5		29.88	31.17	31.03	23.44
6		30.17	31.14	30.82	23.26
7		30.29	31.25	30.55	23.00
8		30.31	31.37	30.33	22.85
9		30.37	31.53	30.18	22.80
10		30.37	31.64	29.96	22.77
11		30.17	31.82	29.65	22.84
Noon		30.17	32.06	29.45	22.80
P. M. 1		30.15	32.15	29.20	22.72
2		30.09	32.60	29.05	22.60
3	15.76	30.04	32.76	28.84	22.36
4		30.07	32.90	28.41	22.12
5		30.14	33.01	28.24	21.85
6		18.76	30.19	33.05	28.00
7		20.26	30.31	33.00	27.80
8		21.51	30.47	33.03	27.43
9		22.82	30.58	32.84	27.13
10		24.24	30.67	32.68	26.70
11		25.62	30.87	32.48	26.13
Midnight		26.73	30.98	32.28	25.67

¹ Crest 33.05.

Flood losses during September 1938 ¹

Atlantic Slope drainage:	
Hudson River.....	\$, 220, 000
Upper Susquehanna River.....	150, 725
Neuse River.....	4, 500
Missouri Basin:	
Small streams in Colorado.....	679, 735
Fall River in South Dakota.....	25, 000
Arkansas Basin: North Canadian River.....	49, 350
West Gulf of Mexico drainage:	
Small streams in eastern New Mexico.....	116, 500
Lower Rio Grande.....	8, 175
Gulf of California drainage:	
Gila River.....	905
Verde River.....	550
Colorado River in Arizona.....	200
Total.....	6, 255, 640

¹ Estimates on damages in Connecticut and Merrimack and upper Mississippi Basins are not available.

² Includes damages also from wind and heavy rain.

Table of flood stages during September 1938

[All dates in September unless otherwise specified]

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
ATLANTIC SLOPE DRAINAGE					
	<i>Feet</i>			<i>Feet</i>	
Pemigewasset: Plymouth, N. H.....	11	20	23	23.6	21
Contoocook: Penocook, N. H.....	6	21	25	13.5	23
Nashua: East Pepperell, Mass.....	8			14.1	23
Merrimack:					
Franklin, N. H.....	14	20	24	28.5	22
Manchester, N. H.....	7	21	25	13.7	23
Lowell, Mass.....	55	21	24	63.0	23
Lawrence, Mass.....	25	21	24	31.4	23
White: West Hartford, Vt.....	18	22		19.4	22
Connecticut:					
South Newbury, N. H.....	22	21	24	27.9	22
White River Junction, Vt.....	18	21	24	26.6	22
Walpole, N. H.....	30	21	23	39.1	22
Montague City, Mass.....	28	21	25	44.6	22
Holyoke, Mass.....	9	21	25	14.9	22
Springfield, Mass.....	20	21	24	25.8	22-23
Hartford, Conn.....	16	21	28	35.4	23
Mohawk: Tribes Hill, N. Y.....	23	22	22	23.5	22
Hudson: Albany, N. Y.....	11	21	23	16.5	22
Lackawaxen: Hawley, Pa.....	6	21	22	(¹)	21
Tionghnioga: Whitney Point, N. Y.....	12	21	24	13.3	22
Chenango:					
Sherburne, N. Y.....	8	22	22	8.4	22
Greene, N. Y.....	8	22	22	9.0	22

¹ Crest not obtained, gage read 8.8 at 8 a. m. of 22d.
² Flood stages continued into October.

Table of flood stages during September 1938—Continued

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
ATLANTIC SLOPE DRAINAGE—continued					
	<i>Feet</i>			<i>Feet</i>	
Susquehanna:					
Oneonta, N. Y.....	12	21	25	21.3	22
Bainbridge, N. Y.....	13	21	24	16.7	22
Little: Kenly, N. C.....	8	19	22	15.4	21
Neuse:					
Goldsboro, N. C.....	14	22	25	18.0	24
Kinston, N. C.....	14	25	27	15.3	26
MISSISSIPPI SYSTEM					
<i>Upper Mississippi Basin</i>					
Chippewa: Durand, Wis.....	11	11	13	15.2	11
Black: Galesville, Wis.....	10	10	15	13.7	12
Wisconsin:					
Knowlton, Wis.....	12	{ Aug. 31	1	14.3	1
		9	12	19.9	11
Wisconsin Rapids, Wis.....	12	11	12	13.4	11-12
Wisconsin Dells, Wis.....	16	13	16	18.8	14
Portage, Wis.....	17	12	18	20.5	14
Rock: Moline Bridge, Ill.....	10	9	Oct. 5	11.9	{ 18, 20, 22-26
Des Moines:					
Boone, Iowa.....	20	16	20	23.1	18
Tracy, Iowa.....	14	21	24	15.0	23-24
Ottumwa, Iowa.....	9	25	25	9.0	25
Mississippi:					
La Crosse, Wis.....	12	13	16	12.3	15
Prairie du Chien, Wis.....	18	17	20	18.4	18
Dubuque, Iowa.....	18	17	24	20.5	20
Clinton, Iowa.....	16	19	28	18.3	22, 23
Le Claire, Iowa.....	10	19	28	11.6	23
Davenport, Iowa.....	15	21	27	15.8	24
Muscatine, Iowa.....	15	19	Oct. 1	18.5	24
Keithsburg, Ill.....	12	20	30	14.3	25
Keokuk, Iowa.....	12	21	(²)	16.4	26
Quincy, Ill.....	14	21	(²)	18.3	27
Hannibal, Mo.....	13	20	(²)	18.1	27
Louisiana, Mo.....	12	21	(²)	16.3	28
<i>Missouri Basin</i>					
Big Sioux: Akron, Iowa.....	12	14	19	16.3	17
<i>Arkansas Basin</i>					
North Canadian:					
Woodward, Okla.....	5	6	7	5.3	7
Canton, Okla.....	6	7	9	9.1	8
Yukon, Okla.....	8	7	16	12.3	9
WEST GULF OF MEXICO DRAINAGE					
Rio Grande:					
Rio Grande City, Tex.....	21	Aug. 29	1	30.1	Aug. 31
Hidalgo, Tex.....	21	Aug. 30	3	24.7	2
Mercedes, Tex.....	21	Aug. 31	4	22.4	3
		2	5	18.4	4
Brownsville, Tex.....	18	{ 29	Oct. 3	18.6	Oct. 1

WEATHER ON THE ATLANTIC AND PACIFIC OCEANS

[The Marine Division, I. R. TANNEHILL in charge]

NORTH ATLANTIC OCEAN, SEPTEMBER 1938

By H. C. HUNTER

Atmospheric pressure.—During most of the month the Azores HIGH was stronger than normal, but it was weak during the period from the 19th to 26th. It is worth noting that this was the time of special intensity of the Icelandic low; also the time when there occurred nearly all the particularly violent winds that were met over the eastern North Atlantic.

For the month as a whole, the southeastern North Atlantic had pressure averaging moderately above normal. Also in the region to the northeastward, including most of the vicinity of the British Isles, there was a slight excess; while to the northwestward and westward, the Grand Banks-St. Lawrence Gulf region likewise averaged a little

above normal. Deficiencies appeared along the eastern coast of the United States and thence southward to the Bahamas and Puerto Rico, while the Greenland-Iceland area had a considerable deficiency.

The extreme pressure readings of the month found in vessel reports at hand are 30.68 and 27.85 inches. The former reading was reported by radio from an unidentified vessel near 46° north, 22° west, late on the forenoon of the 11th. The latter reading was radioed by the British steamship *Corrales*, in the month's hurricane, near 23° 23' N., 67° 05' W., about 7 p. m. of the 18th. Apart from data for the western Atlantic connected with the hurricane, the lowest reading found is 28.43 inches, near 51° N., 18° W., at a late hour of the 22d, noted by the American steamship *Collamer*.