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In cooperation with the Federal Emergency Management Agency

Floods in South-Central Texas, June 1997

Severe flooding in parts of 18 south-central Texas counties resulted from heavy rainfall during June 21–22, 1997. Of the 18 counties in the study area (fig. 1), all except Kimble, Gillespie, and Travis were declared Federal disaster areas. Kimble and Gillespie Counties were later declared eligible for disaster assistance. The majority of the property damage occurred along Cibolo Creek in Kendall and Guadalupe Counties, the Medina River in Bandera County, and the Llano River in Mason and Llano Counties (Jack Quarrels, Federal Emergency Management Agency, oral commun., 1997). The total property damage for which owners were eligible for disaster assistance was estimated to be $10.4 million (Jack Quarrels, written commun., 1997). Several rain gages and streamflow-gaging stations located in the 18-county area were available for the U.S. Geological Survey (USGS), in cooperation with the Federal Emergency Management Agency, to assess the magnitude and historical perspective of the flooding. This fact sheet summarizes maximum rainfall and streamflow and associated recurrence intervals for selected rain gages and streamflow-gaging

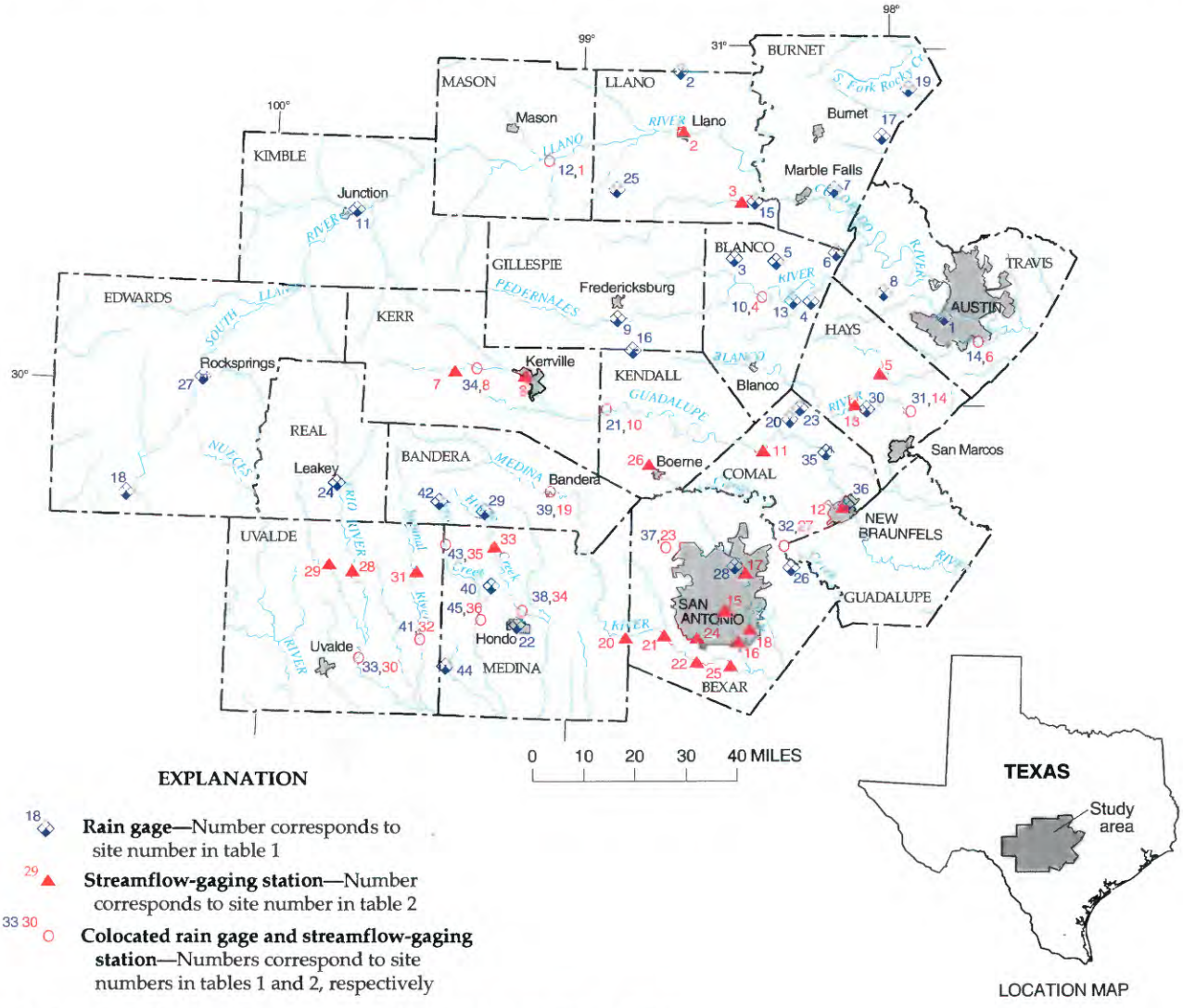

Figure 1. Location of selected rain gages and streamflow-gaging stations.

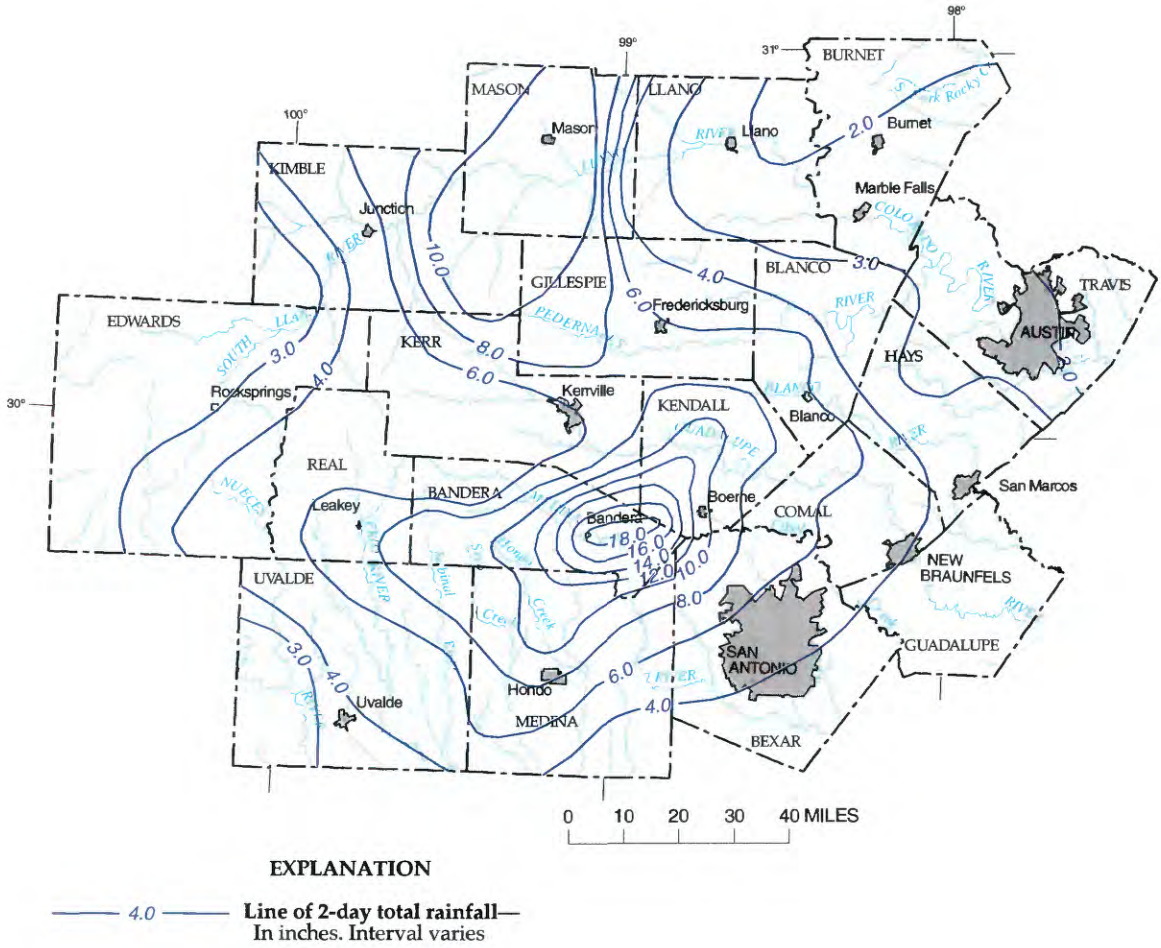

Figure 2. Two-day total rainfall during June 21–22, 1997.

stations (fig. 1) in the 18-county study area during June 21–23, 1997.

Maximum Rainfall

Rainfall data measured by recording rain gages and by daily-observer rain gages during June 21–22 were obtained from the Lower Colorado River Authority (LCRA), the National Weather Service (NWS), and the USGS. A recording rain gage measures incremental rainfall every hour or less, whereas a daily-observer rain gage measures only the total daily rainfall. The recording rain gage data were aggregated by maximum 1-, 2-, 6-, 12-, 24-, and 48-hour (hr) rainfall for 15 LCRA, 15 NWS, and 15 USGS rain gages (fig. 1, table 1).

The maximum 1-hr rainfall ranged from 0.20 to 5.93 inches (in.) and the maximum 48-hr rainfall ranged from 2.16 to 19.47 in. for the 45 recording rain gages. The 48-hr maximum recording rainfall was comparable to the 2-day daily-observer rainfall. A map of 2-day total rainfall (fig. 2) was prepared on the basis of more than 100 total daily-observer and recording rain gages (including the 45 recording rain gages listed in table 1). The areas of greatest (more than about 10 in.) 2-day rainfall are in eastern Bandera, southern Kendall, and northern Medina Counties and northwestern Gillespie, eastern Kimble, and Mason Counties. The map of 2-day total rainfall compares well with a storm total radar image map obtained from the NWS.

The recurrence interval for each duration at each of the 45 recording rain gages (table 1) was estimated from the results of a regional duration-frequency analysis in which the generalized extreme value (GEV) distribution (Stedinger and others, 1993) was fit to L-moment statistics (Hosking, 1990) of the annual maxima time series for each specified duration for about 80 active and discontinued NWS recording rain gages in or near the study area with at least 10 years of data. The GEV distribution is a three-parameter distribution that is a function of shape, scale, and location parameters. The recurrence interval is the inverse of the exceedance probability of the distribution. A 100-year recurrence interval has a 1-percent exceedance probability or a 1-in-100 chance of being equaled or exceeded in any year.

The rainfall recurrence intervals ranged from less than 2 years to greater than 500 years (table 1). The recurrence interval exceeded 500 years for the 24- and 48-hr durations and equaled or exceeded 70 years for all other durations at Medina River at Bandera. The recurrence interval was 60 years or less for all durations at the remaining 44 stations. A map of 2-day total rainfall recurrence intervals (fig. 3) was prepared using the same

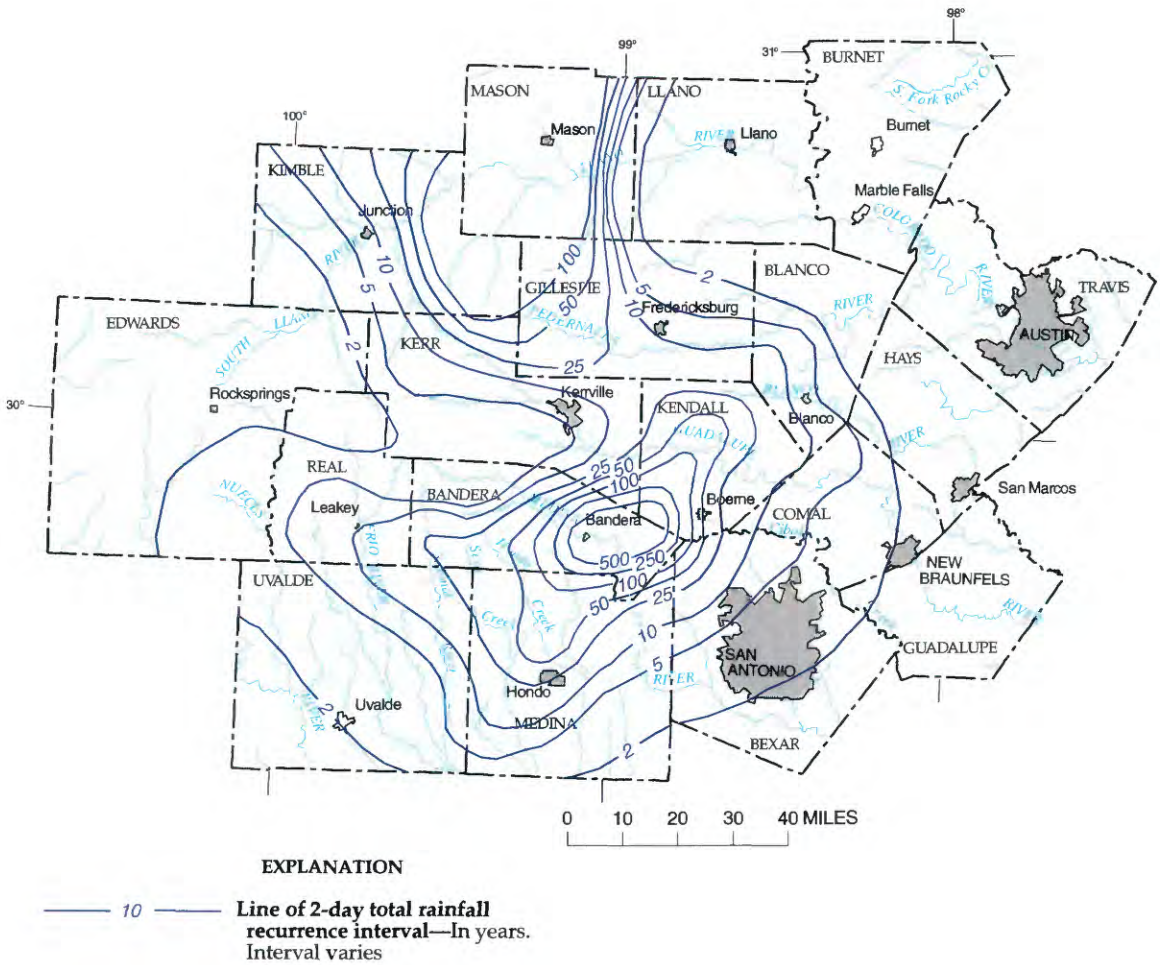

Figure 3. Two-day total rainfall recurrence intervals during June 21–22, 1997.

rain gages that were used for the map of 2-day total rainfall. The areas of greatest (exceeding 100 years) 2-day rainfall recurrence intervals coincide with the areas of greatest 2-day total rainfall—eastern Bandera, southern Kendall, and northern Medina Counties and northwestern Gillespie, eastern Kimble, and southern Mason Counties.

Peak Gage Heights and Streamflows

Gage height (stream elevation above a datum) during June 21–23, 1997, was recorded at each of 36 streamflow-gaging stations in the 18-county area (fig. 1, table 2). Two stations, Llano River near Mason and Sandy Creek near Kingsland, were operated by the LCRA. The remaining 34 stations are operated by the USGS. Peak gage heights recorded during June 21–23 exceeded the previous known maximum gage heights at 9 of the 36 streamflow-gaging stations (table 2). The peak gage heights at four stations (Leon Creek at IH–35 at San Antonio, Cibolo Creek at Selma, Sabinal River at Sabinal, and Seco Creek at Rowe Ranch) exceeded the previous peaks by at least 2 ft.

The peak streamflow for 30 stations was computed from the station stage-discharge rating curve (a relation between measured gage height and measured streamflow). The peak streamflow for the remaining six stations (Llano River at Llano, Cibolo Creek at IH–10 above Boerne, Cibolo Creek at Selma, Hondo Creek at King Waterhole, Seco Creek at Miller Ranch, and Seco Creek at Rowe Ranch) was estimated using indirect methods. An indirect method of streamflow computation involves hydraulic analysis of surveyed channel cross sections, high-water marks, channel slope, and estimates of the channel roughness. The peak streamflows for the 36 stations ranged from 1,880 cubic feet per second (ft^3/s) at Comal River at New Braunfels to 269,000 ft^3/s at Llano River near Mason (table 2). Peak streamflows computed during June 21–23 exceeded the previous known maximum streamflow at 8 of the 36 stations. The peak streamflows at three stations (Leon Creek at IH–35 at San Antonio, Sabinal River at Sabinal, and Seco Creek at Rowe Ranch) exceeded the previous peaks by more than 25 percent. The ratios of the June 1997 peak streamflow to the previous known maximum peak streamflow ranged from 0.03 to 1.44. The peaks along Cibolo Creek, the Sabinal River, Hondo Creek, and Seco Creek coincide with the areas of heavy rainfall in Bandera, Kendall, and Medina Counties, and the peaks along the Llano River coincide with the areas of heavy rainfall in Gillespie, Kimble, and Mason Counties. The streamflow for the Llano River at Llano during June 21–23 is shown in figure 4.

Table 1. Maximum rainfall depths and recurrence intervals for selected recording rain gages during June 21–22, 1997

[hr, hour; in., inches; RI, recurrence interval; yr, years; LCRA, Lower Colorado River Authority; <, less than; NWS, National Weather Service; USGS, U.S. Geological Survey; >, greater than]

Site no. (fig. 1)	Station name	Agency	County	1 hr (in.)	RI (yr)	2 hr (in.)	RI (yr)	6 hr (in.)	RI (yr)	12 hr (in.)	RI (yr)	24 hr (in.)	RI (yr)	48 hr (in.)	RI (yr)
1	Barton Creek	LCRA	Travis	0.66	<2	1.01	<2	1.36	<2	2.37	<2	2.52	<2	3.22	<2
2	Council Creek 13	LCRA	Llano	.20	<2	.36	<2	.92	<2	1.56	<2	2.24	<2	2.60	<2
3	Flat Rock Creek 1	LCRA	Blanco	.96	<2	1.12	<2	1.48	<2	1.60	<2	2.04	<2	2.16	<2
4	Flat Rock Creek 3	LCRA	Blanco	.40	<2	.68	<2	1.40	<2	2.04	<2	3.24	2	3.52	<2
5	Flat Rock Creek 9	LCRA	Blanco	.40	<2	.60	<2	1.16	<2	1.84	<2	2.88	<2	3.28	<2
6	Flat Rock Creek 10	LCRA	Blanco	.80	<2	1.08	<2	1.88	<2	2.52	<2	3.64	2	3.92	2
7	Flat Rock Creek 11	LCRA	Burnet	.88	<2	1.00	<2	1.36	<2	2.12	<2	3.28	2	3.40	<2
8	Flat Rock Creek 13	LCRA	Travis	.92	<2	.96	<2	1.28	<2	1.72	<2	2.56	<2	2.76	<2
9	Fredericksburg	LCRA	Gillespie	1.15	<2	2.02	<2	4.06	5	4.76	10	6.26	15	7.28	15
10	Johnson City	LCRA	Blanco	.46	<2	.63	<2	1.14	<2	1.85	<2	2.98	<2	3.52	<2
11	Junction	LCRA	Kimble	1.23	<2	1.60	<2	1.97	<2	3.11	2	4.53	5	5.56	10
12	Mason[1]	LCRA	Mason	.74	<2	1.21	<2	2.33	2	2.63	2	4.41	10	4.84	5
13	Miller Creek	LCRA	Blanco	.52	<2	.88	<2	1.48	<2	2.24	<2	3.24	2	3.36	<2
14	Onion Creek	LCRA	Travis	.79	<2	.79	<2	1.49	<2	1.79	<2	2.82	<2	2.91	<2
15	Sandy Harbors	LCRA	Llano	.28	<2	.44	<2	1.04	<2	1.60	<2	2.28	<2	2.56	<2
16	Bankersmith	NWS	Kendall	1.70	2	2.20	<2	4.30	5	5.70	15	7.30	30	8.10	25
17	Bertram 3ENE	NWS	Burnet	1.00	<2	1.15	<2	1.46	<2	2.11	<2	2.76	<2	4.31	2
18	Brackettville	NWS	Edwards	1.30	<2	1.90	<2	2.30	<2	2.40	<2	2.40	<2	2.70	<2
19	Briggs	NWS	Burnet	.40	<2	.60	<2	1.20	<2	1.40	<2	1.80	<2	2.40	<2
20	Canyon Dam 6	NWS	Comal	1.20	<2	1.45	<2	3.02	2	4.08	5	6.05	15	7.60	15
21	Comfort 2	NWS	Kendall	1.00	<2	1.50	<2	5.40	15	6.20	15	8.15	40	8.55	25
22	Fischers Store	NWS	Comal	.75	<2	1.10	<2	2.70	<2	3.50	2	5.25	10	5.95	5
23	Hondo	NWS	Medina	1.87	2	3.39	10	7.12	40	7.91	40	7.91	30	8.52	30
24	Leakey	NWS	Real	2.00	2	3.10	5	5.90	20	7.10	25	7.30	25	7.30	10
25	Prairie Mountain	NWS	Llano	.50	<2	.70	<2	1.30	<2	2.30	<2	2.80	<2	3.20	<2
26	Randolph Field	NWS	Bexar	.60	<2	.90	<2	1.40	<2	2.70	<2	3.40	<2	3.80	2
27	Rocksprings	NWS	Edwards	1.20	<2	1.40	<2	2.30	<2	2.70	<2	2.80	<2	2.90	<2
28	San Antonio Airport	NWS	Bexar	.71	<2	1.07	<2	1.44	<2	2.40	<2	2.65	<2	4.27	2
29	Tarpley	NWS	Bandera	2.40	5	3.80	10	6.30	25	7.50	25	9.40	60	10.20	45
30	Wimberley 2ESE	NWS	Hays	1.55	<2	1.85	<2	2.55	<2	3.30	2	3.80	2	5.05	2
31	Blanco River near Kyle	USGS	Hays	1.41	<2	1.88	<2	2.52	<2	3.52	2	3.85	2	4.44	2
32	Cibolo Creek at Selma	USGS	Bexar	1.02	<2	1.09	<2	1.58	<2	2.60	<2	3.84	2	4.91	2
33	Frio River below Dry Frio River	USGS	Uvalde	2.10	2	2.41	2	2.59	<2	2.77	<2	2.78	<2	4.61	5
34	Guadalupe River at Hunt	USGS	Kerr	1.17	<2	1.57	<2	1.81	<2	2.82	<2	4.52	5	5.61	5
35	Guadalupe River at Sattler	USGS	Comal	.26	<2	.44	<2	.89	<2	1.47	<2	2.22	<2	2.70	<2
36	Guadalupe River above Comal River	USGS	Comal	1.33	<2	1.42	<2	2.01	<2	2.94	<2	3.40	2	4.23	2
37	Helotes Creek at Helotes	USGS	Bexar	1.12	<2	1.38	<2	2.14	<2	3.34	2	6.04	10	7.68	10
38	Hondo Creek at King Waterhole	USGS	Medina	1.87	2	3.13	5	7.01	40	7.62	30	7.63	25	9.99	60
39	Medina River at Bandera	USGS	Bandera	5.93	400	6.65	150	8.21	70	13.19	250	18.74	>500	19.47	>500
40	Parkers Creek Reservoir	USGS	Medina	2.41	5	3.29	5	6.75	30	7.79	30	8.81	50	10.33	60
41	Sabinal River at Sabinal	USGS	Uvalde	1.40	<2	2.34	2	4.99	10	5.28	10	5.28	5	5.84	5
42	Seco Creek gage 1	USGS	Bandera	2.92	10	3.00	5	4.64	10	5.46	10	6.00	10	7.03	10
43	Seco Creek at Miller Ranch	USGS	Medina	2.97	10	5.32	50	7.31	40	7.86	30	8.48	40	8.97	25
44	Seco Creek Reservoir inflow	USGS	Medina	2.60	5	3.45	10	6.23	25	6.86	20	6.95	20	7.33	20
45	Seco Creek at Rowe Ranch	USGS	Medina	1.38	<2	2.13	<2	5.12	10	6.13	15	6.51	15	6.97	10

[1] Recording rain-gage depths appear to be low compared to reports by daily observers in Mason County.

Table 2. Peak gage heights and streamflows during June 21–23, 1997

[mi^2, square miles; ft, feet; ft^3/s, cubic feet per second; $ft^3/s\text{-}mi^2$, cubic feet per second per square mile; <, less than; --, recurrence interval not estimated because flow might be affected by regulation; >, greater than]

Site no. (fig. 1)	Station no.	Station name	Drainage area (mi^2)	Previous known maximum peak data			June 21–23 maximum peak data					
				Date	Gage height (ft)	Streamflow (ft^3/s)	Gage height (ft)	Streamflow (ft^3/s)	Ratio to previous peak	Peak basin yield ($ft^3/s\text{-}mi^2$)	RI[1] (years)	Ratio to 100-year peak[2]
1	08150700	Llano River near Mason	3,242	06/15/35	[3]46.0	[3]380,000	[4]39.00	[4]269,000	0.71	83.0	50	0.73
2	08151500	Llano River at Llano	4,192	06/15/35	[3]41.5	[3]380,000	39.10	[5]260,000	.68	62.0	50	.70
3	08152000	Sandy Creek near Kingsland	346	09/11/52	[3]34.2	[3]163,000	[4]9.11	[4]5,100	.03	14.7	<2	.07
4	08153500	Pedernales River near Johnson City	901	09/11/52	42.50	441,000	25.16	95,000	.22	105	15	.38
5	08158700	Onion Creek near Driftwood	124	06/06/85	16.38	8,990	13.50	6,640	.74	53.5	5	.17
6	08159000	Onion Creek at U.S. Highway 183, Austin	321	12/21/91	30.50	44,200	17.04	7,210	.16	22.5	--	--
7	08165300	North Fork Guadalupe River near Hunt	169	07/01/32	[3]37.2	[3]140,000	8.08	5,490	.04	32.5	<2	.04
8	08165500	Guadalupe River at Hunt	288	07/02/32	[3]36.6	[3]206,000	13.99	9,960	.05	34.6	2	.05
9	08166200	Guadalupe River at Kerrville	510	07/02/32	[3]39.0	[3]196,000	14.16	33,800	.17	66.3	5	.16
10	08167000	Guadalupe River at Comfort	839	08/02/78	40.90	240,000	25.91	73,700	.31	87.8	15	.32
11	08167500	Guadalupe River near Spring Branch	1,315	08/03/78	45.25	160,000	45.00	117,000	.73	89.0	45	.70
12	08169000	Comal River at New Braunfels	130	05/11/72	36.55	60,800	7.04	1,880	.03	14.5	--	--
13	08171000	Blanco River at Wimberley	355	05/28/29	31.10	113,000	20.40	33,900	.30	95.5	10	.31
14	08171300	Blanco River near Kyle	412	05/28/29	[3]40.0	[3]139,000	25.78	33,600	.24	81.6	5	.21
15	08178000	San Antonio River at San Antonio	41.8	09/27/73	14.78	6,090	11.04	2,060	.34	49.3	--	--
16	08178565	San Antonio River at Loop 410 at San Antonio	125	07/15/90	32.20	64,300	16.74	5,850	.09	46.8	--	--
17	08178700	Salado Creek (upper station) at San Antonio	137	05/05/93	15.91	28,100	8.43	3,790	.13	27.7	--	--
18	08178800	Salado Creek (lower station) at San Antonio	189	09/27/73	28.83	13,100	16.46	2,730	.21	14.4	--	--
19	08178880	Medina River at Bandera	427	06/03/87	24.90	55,800	24.53	52,400	.93	123	15	.31
20	08180640	Medina River at La Coste	805	05/30/87	24.04	24,600	23.97	24,200	.98	30.1	--	--
21	08180700	Medina River near Macdona	885	05/30/87	20.58	36,800	18.65	22,100	.60	25.0	--	--
22	08180800	Medina River near Somerset	967	07/17/73	29.39	30,500	23.40	14,800	.49	15.3	--	--
23	08181400	Helotes Creek at Helotes	15.0	07/16/73	10.80	7,680	7.96	4,560	.59	304	10	.23
24	08181480	Leon Creek at IH–35 at San Antonio	219	06/11/87	22.30	21,100	24.60	27,900	1.32	127	--	--
25	08181500	Medina River at San Antonio	1,317	07/17/73	43.59	31,900	28.14	13,000	.41	9.87	--	--
26	08183850	Cibolo Creek at IH–10 above Boerne	30.4	(6)	(6)	(6)	20.82	[5]20,100	--	661	--	--
27	08185000	Cibolo Creek at Selma	274	07/16/73	26.20	65,000	29.73	[5]69,600	1.07	254	60	.78
28	08195000	Frio River at Concan	389	07/01/32	34.44	162,000	24.40	61,000	.38	157	15	.31
29	08196000	Dry Frio River near Reagan Wells	126	08/13/66	27.60	123,000	23.28	31,900	.26	253	15	.39
30	08197500	Frio River below Dry Frio River near Uvalde	631	05/29/87	25.05	99,600	25.09	100,000	1.00	158	25	.55
31	08198000	Sabinal River near Sabinal	206	06/17/58	28.30	55,200	28.51	52,500	.95	255	90	.95
32	08198500	Sabinal River at Sabinal	241	06/17/58	33.30	73,300	35.86	93,600	1.28	388	>100	1.32
33	08200000	Hondo Creek near Tarpley	95.6	06/17/58	28.20	69,800	29.64	76,900	1.10	804	100	1.01
34	08200700	Hondo Creek at King Waterhole near Hondo	149	05/29/87	17.19	51,800	18.96	[5]63,600	1.23	427	>100	1.06
35	08201500	Seco Creek at Miller Ranch near Utopia	45.0	06/17/58	[3]16.4	[3]52,600	17.70	[5]64,900	1.23	1,440	>100	1.18
36	08202700	Seco Creek at Rowe Ranch near D'Hanis	168	05/29/87	28.20	35,800	30.62	[5]51,400	1.44	306	70	.87

[1] Recurrence interval for peak streamflow estimated from Asquith and Slade, 1997.

[2] 100-yr peak streamflow from Asquith and Slade, 1997.

[3] Historical peak data from land-owner account before systematic data collection.

[4] Peak gage height and peak streamflow from Lower Colorado River Authority.

[5] Peak streamflow estimated from slope-area analysis.

[6] No previous maximum; station relocated in 1996 from downstream station 08183900 Cibolo Creek near Boerne.

The rapid rise and recession of the streamflow resulting from the heavy rainfall is typical for all stations in the study.

Another measure of flood magnitude is the peak basin yield (ratio of peak streamflow to contributing drainage area). The peak basin yields ranged from 9.87 to 1,440 cubic feet per second per square mile [$(ft^3/s)/mi^2$] and exceeded 100 $(ft^3/s)/mi^2$ for 15 of the 36 stations. The two largest peak basin yields were calculated for Hondo Creek near Tarpley and Seco Creek at Miller Ranch. The smallest [less than 50 $(ft^3/s)/mi^2$] peak basin yields generally were for stations where flow is affected by regulation.

The recurrence interval for the peak streamflow at 24 of the 36 stations (table 2) was estimated from Asquith and Slade (1997). The recurrence interval for the remaining 12 stations was not estimated because the streamflow might be affected by regulation from upstream reservoirs or flood-retarding structures. Asquith and Slade (1997) estimated the recurrence intervals for the 2-, 5-, 10-, 25-, 50-, and 100-year peak streamflows for all stations in Texas with at least 8 years of natural peak streamflow data using the guidelines established by the Interagency Advisory Committee on Water Data (1982) in Bulletin 17B. Bulletin 17B recommends fitting the logarithms of annual discharge maxima to the log-Pearson Type III distribution. The log-Pearson Type III distribution is a three-parameter distribution that is a function of the mean, standard deviation, and skew of the annual maxima data.

At the 24 stations, the recurrence interval ranged from less than 2 years to greater than 100 years. The recurrence interval equaled or exceeded 100 years at 4 of the 24 stations (Sabinal River at Sabinal, Hondo Creek near Tarpley, Hondo Creek at King Waterhole, and Seco Creek at Miller Ranch), and the recurrence interval was between 50 and 90 years at 5 other stations (Llano River near Mason, Llano River at Llano, Cibolo Creek at Selma, Sabinal River near Sabinal, and Seco Creek at Rowe Ranch). The ratios of the June 1997 peak streamflow to the 100-year peak ranged from 0.04 to 1.32.

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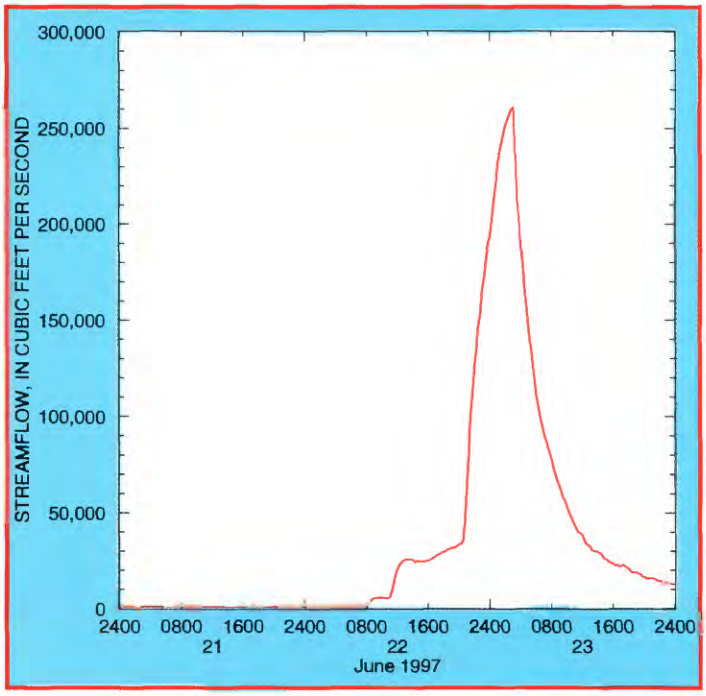

Figure 4. Hydrograph showing streamflow for 08151500 Llano River at Llano.

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