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Effects of August 1995 and July 1997 Storms in the City of Charlotte and Mecklenburg County, North Carolina

Charlotte-Mecklenburg STORM WATER Services
Prepared in cooperation with the City of Charlotte and Mecklenburg County

INTRODUCTION

Floods that occurred in parts of the city of Charlotte and Mecklenburg County, North Carolina, in August 1995 and again 2 years later in July 1997 were among the most severe and damaging on record. These floods were the result of excessive rainfall amounts from the remnants of Tropical Storm Jerry and Hurricane Danny, respectively. Flood insurance claims for the August 1995 flood totaled $4 million, and an additional $1 million was issued as loans to repair property damage. The more widespread flood of July 1997 caused as much as $60 million in property damage. Although property damage was extensive in July 1997, an even greater consequence was the tragic loss of three lives in flood waters caused by the storm.

A TOW TRUCK DRIVER WADES THROUGH WAIST-DEEP WATER TO ASSIST MOTORISTS AS STEWART CREEK OVERTOPS MOREHEAD STREET. *(Photograph from The Charlotte Observer/Kent D. Johnson)*

The U.S. Geological Survey (USGS), in cooperation with the City of Charlotte and Mecklenburg County, operates a dense hydrologic data-collection network within the city and county. In 1995, the network included 28 raingages and 12 streamflow gaging stations, mainly within the Charlotte city limits. By 1997, the network was expanded to 46 raingages and 16 streamflow gaging stations (fig. 1). This network provides valuable data for the documentation and interpretation of water-resources information, including flooding, for the city of Charlotte and Mecklenburg County.

This report presents selected hydrologic information associated with the August 1995 and July 1997 storms and addresses some commonly asked questions concerning these events. Information presented includes rainfall, streamflow, and water-quality conditions.

HOW CAN WE HAVE TWO "100-YEAR FLOODS" IN LESS THAN TWO YEARS?

This question points out the importance of proper terminology. The term "100-year flood" is used in an attempt to simplify the definition of a flood that statistically has a 1-percent chance of occurring in any given year. Likewise, the term "100-year storm" is used to define a rainfall event that statistically has this same 1-percent chance of occurring. In other words, over the course of 1 million years, these events would be expected to occur 10,000 times. The amount of rainfall in the city of Charlotte and Mecklenburg County and the subsequent flooding in August 1995 had no influence on the events of July 1997. These events, as well as any recurring events, are assumed to be statistically independent of each other. Therefore, each year begins with the same 1-percent chance that a 100-year event will occur.

Recurrence interval, in years	Probability of occurrence in any given year	Percent chance of occurrence in any given year
100	1 in 100	1
50	1 in 50	2
25	1 in 25	4
10	1 in 10	10
5	1 in 5	20
2	1 in 2	50

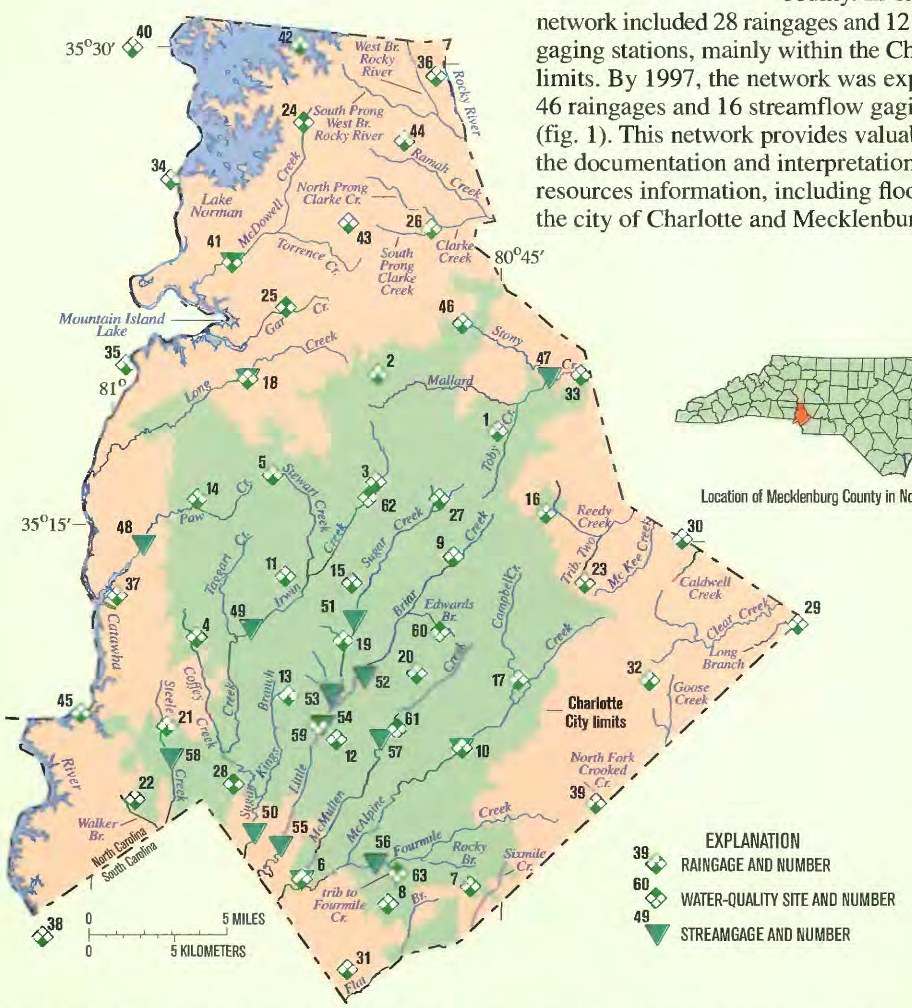


Figure 1. U.S. Geological Survey raingage and streamflow gaging network in the vicinity of the city of Charlotte and Mecklenburg County, North Carolina, 1997.

FLOODED HOMES ALONG MYERS PARK DRIVE WHEN BRIAR CREEK OVERFLOWED ITS BANKS. *(Photograph from The Charlotte Observer/Gary O' Brien)*

RAINFALL IN THE CITY OF CHARLOTTE AND MECKLENBURG COUNTY DURING THE STORMS OF AUGUST 26–28, 1995, AND JULY 22–24, 1997

Total rainfall in Mecklenburg County ranged from 3.87 to 9.37 inches during the August 1995 storm (fig. 2). Highest rainfall amounts were concentrated in the southeastern part of Charlotte between Providence Road and East Independence Boulevard, primarily in the Little Sugar Creek and McAlpine Creek drainage basins (table 1). The recurrence interval for a 24-hour storm exceeded 100 years in this part of the city, but the recurrence interval was less than 5 years in much of the northwestern part of Charlotte (fig. 3).

Rainfall amounts during the July 1997 storm generally exceeded those of the August 1995 storm, with a maximum total rainfall of 13.11 inches recorded for the event (fig. 4) The maximum rainfall amount measured in a continuous 24-hour period during the July 1997 storm was 11.40 inches (table 2), which exceeds the 100-year storm total by 4.3 inches. The 24-hour rainfall recurrence interval exceeded 100 years for much of the central part of Mecklenburg County, including a large percentage of the Irwin Creek and Little Sugar Creek Basins (fig. 5, table 1).

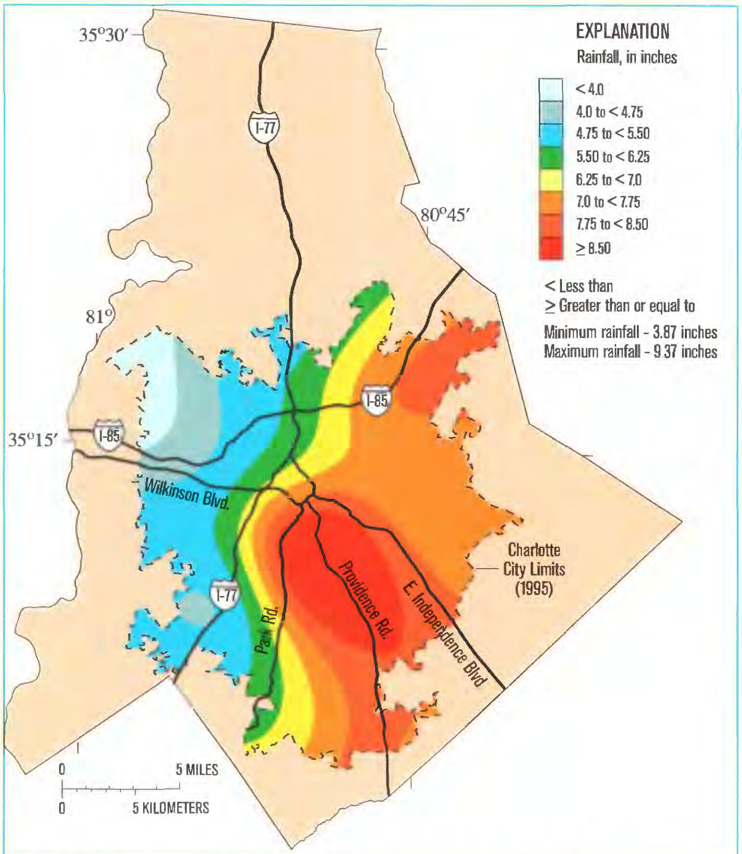


Figure 2. Rainfall distribution in Charlotte during August 26–28, 1995.

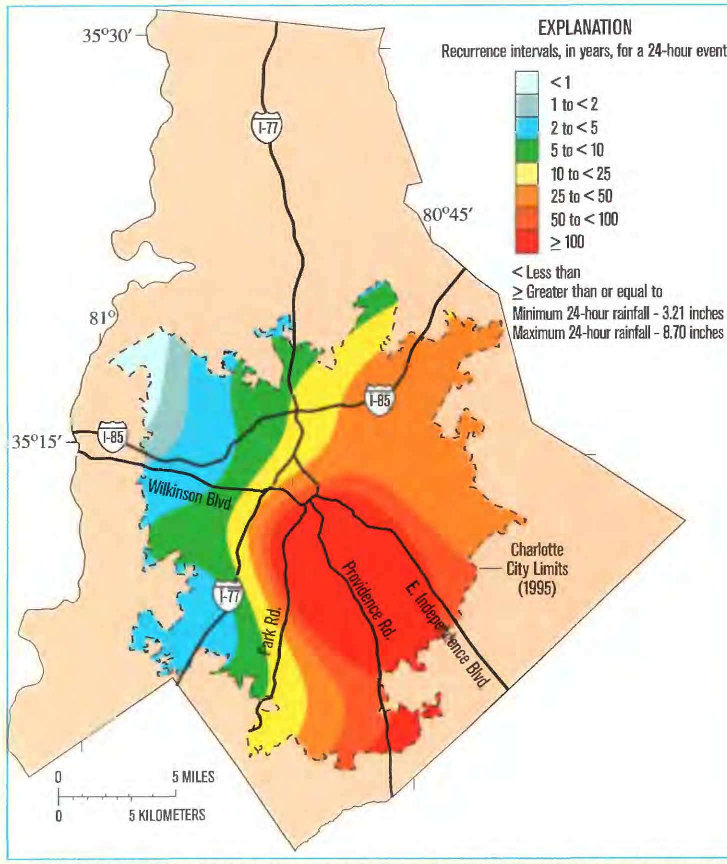


Figure 3. 24-hour rainfall recurrence intervals in Charlotte for the storm of August 26–28, 1995 (revised from Hazell and Bales, 1997).

Table 1. Percentage of stream basins with indicated 24-hour rainfall recurrence intervals in the city of Charlotte and Mecklenburg County
[<, less than; ≥, greater than or equal to]

Basin	2 to <5	5 to <10	10 to <25	25 to <50	50 to <100	≥100
August 26-28, 1995 — Basin[a]	Rainfall recurrence interval, in years; Percentage[b] of basin					
Irwin/Sugar Creek	30	40	25	5	0	0
Little Sugar Creek[c]	0	5	5	40	15	35
McAlpine Creek	0	0	10	25	25	40
July 22-24, 1997 — Basin[d]	Rainfall recurrence interval, in years; Percentage[b] of basin					
Irwin/Sugar Creek	0	0	5	25	10	60
Little Sugar Creek[c]	0	0	10	15	5	70
McAlpine Creek	0	10	30	20	10	30
Mallard Creek	0	0	0	40	30	30

[a]Basin coverage within the city of Charlotte, including all major and minor tributaries.
[b]Values rounded to the nearest 5 percent.
[c]Includes Briar Creek.
[d]Basin coverage within the city of Charlotte and Mecklenburg County, including all major and minor tributaries.

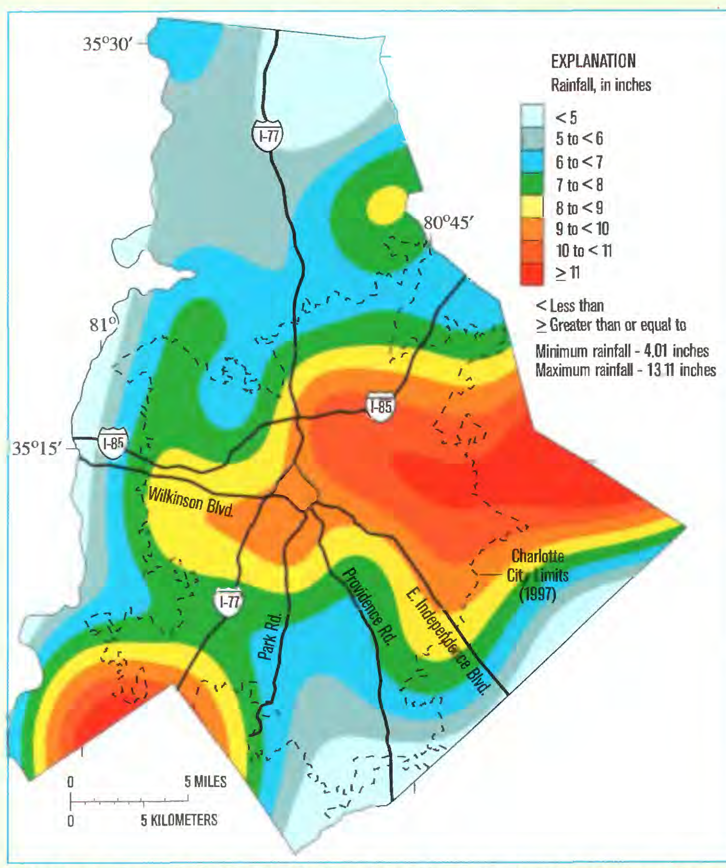


Figure 4. Rainfall distribution in the city of Charlotte and Mecklenburg County during July 22–24, 1997.

In order to determine the distribution of rainfall recurrence intervals in Mecklenburg County, the USGS developed software to compute the maximum amount of rainfall recorded during specified periods for the durations listed in this fact sheet. The rainfall amounts for each of the durations are summarized in table 2. For example, the values listed for the 30-minute duration were obtained by identifying the largest rainfall amount that occurred during a consecutive 30-minute period at each of the raingages in the network. The maximum, then, represents the highest of these values for the network, and the minimum represents the lowest of these values.

Table 2. Statistical summary of rainfall totals, in inches, at raingages in the city of Charlotte and Mecklenburg County for the indicated durations during the storms of August 26–28, 1995, and July 22–24, 1997

	30-minute		1-hour		2-hour		3-hour		6-hour		12-hour		24-hour	
	1995	1997	1995	1997	1995	1997	1995	1997	1995	1997	1995	1997	1995	1997
Maximum	1.93	2.44	2.86	3.76	3.62	5.57	3.90	6.69	5.51	7.47	6.48	10.67	8.70	11.40
Minimum	.34	.50	.51	.73	.75	.89	1.01	1.28	1.22	2.02	1.94	2.89	3.21	3.11
Median	.98	1.13	1.38	1.79	1.96	2.43	2.22	2.83	2.84	3.46	4.52	5.18	5.76	5.98
Mean	1.02	1.20	1.45	1.89	2.02	2.63	2.33	3.15	3.18	4.00	4.24	5.38	5.65	6.22

WHAT IS A RECURRENCE INTERVAL?

Statistical techniques, through a process called frequency analysis, are used to estimate the probability of the occurrence of a given event. The recurrence interval (sometimes called the return period) is based on the probability that the given event will be equalled or exceeded in any given year. For example, there is a 1 in 50 chance that 6.60 inches of rain will fall in Mecklenburg County in a 24-hour period during any given year. Thus, a rainfall total of 6.60 inches in a consecutive 24-hour period is said to have a 50-year recurrence interval (see table below). Likewise, using a frequency analysis (Interagency Advisory Committee on Water Data, 1982) there is a 1 in 100 chance that a streamflow of 15,000 cubic feet per second (ft^3/s) will occur during any year at Little Sugar Creek at Archdale Drive (site 54, fig. 1). Thus, a peak flow of 15,000 ft^3/s at site 54 is said to have a 100-year recurrence interval. Rainfall recurrence intervals are based on both the magnitude and the duration of a rainfall event, whereas streamflow recurrence intervals are based solely on the magnitude of the annual peak flow.

Ten or more years of data are required to perform a frequency analysis for the determination of recurrence intervals. More confidence can be placed in the results of a frequency analysis based on, for example, 30 years of record than on an analysis based on 10 years of record.

The rainfall recurrence intervals presented in this fact sheet were developed almost 40 years ago (Hershfield, 1961). The USGS is currently (1998) collecting data and developing software to re-evaluate the rainfall recurrence intervals for Mecklenburg County by using more recent, locally collected data. These recurrence intervals may become better defined as more data become available for analysis.

Recurrence intervals for the annual peak streamflow at a given location change if there are significant changes in the flow patterns at that location, possibly caused by an impoundment or diversion of flow. The effects of development (conversion of land from forested or agricultural uses to commercial, residential, or industrial uses) on peak flows is generally much greater for low-recurrence interval floods than for high-recurrence interval floods, such as 25- 50- or 100-year floods. During these larger floods, the soil is saturated and does not have the capacity to absorb additional rainfall. Under these conditions, essentially all of the rain that falls, whether on paved surfaces or on saturated soil, runs off and becomes streamflow.

Rainfall estimates for selected durations and recurrence intervals in Mecklenburg County
[Values are inches of rainfall, plus or minus 0.04 inch. Values interpolated for Mecklenburg County from Hershfield, 1961]

Recurrence interval, in years	Duration, in hours						
	0.5	1	2	3	6	12	24
1	1.05	1.34	1.60	1.77	2.09	2.51	2.86
2	1.29	1.57	1.94	2.15	2.54	3.00	3.48
5	1.60	2.07	2.46	2.77	3.24	3.87	4.39
10	1.85	2.38	2.92	3.18	3.71	4.39	5.04
25	2.18	2.77	3.31	3.60	4.38	5.00	5.88
50	2.40	3.09	3.76	3.97	4.78	5.71	6.60
100	2.73	3.39	4.08	4.44	5.40	6.22	7.09

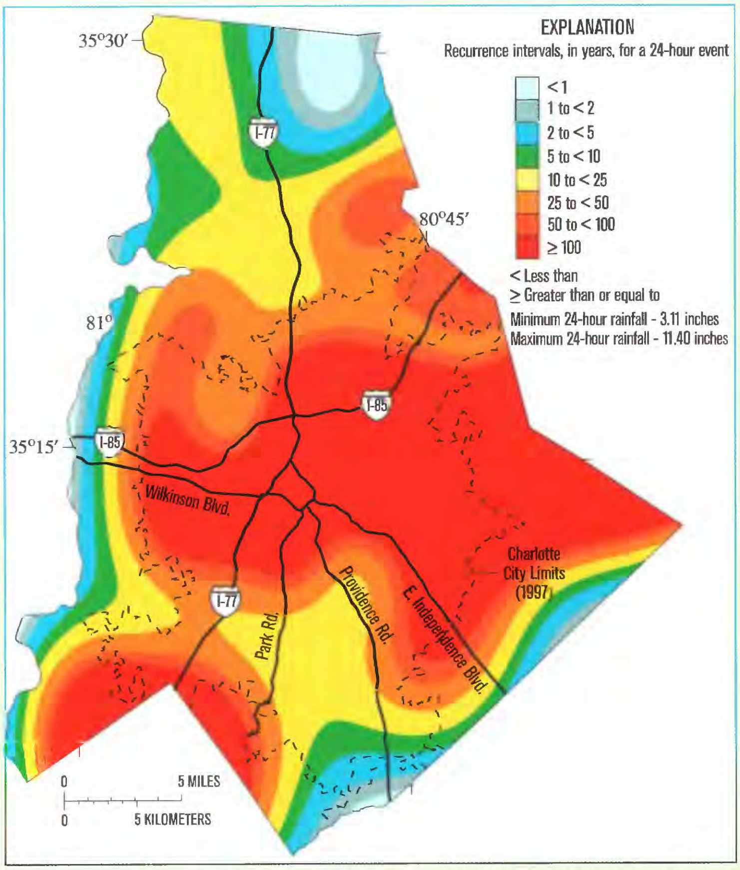


Figure 5. 24-hour rainfall recurrence intervals in the city of Charlotte and Mecklenburg County for the storm of July 22–24, 1997.

FLOODING IN THE CITY OF CHARLOTTE AND MECKLENBURG COUNTY AS A RESULT OF THE STORMS OF AUGUST 26–28, 1995, AND JULY 22–24, 1997

Flooding that resulted from the August 1995 storm was greatest in the Briar, McMullen, and McAlpine Creek Basins in southeast Charlotte where rainfall amounts were greatest and generally exceeded 6 inches (fig. 2). Peak flows in the McAlpine Creek Basin exceeded the 100-year recurrence interval at both streamflow gaging stations. Although rainfall amounts in the Irwin Creek Basin were generally 4 to 6 inches during the storm, the peak flow at the Irwin Creek streamflow gaging station had a recurrence interval of 5 to 10 years (table 3).

In comparison, the upstream part of the Irwin Creek Basin received 7 to 10 inches of rain during the July 1997 storm, and the peak flow at the Irwin Creek gage had a recurrence interval of 100 years. During the 1997 flood, water levels increased by 20 feet or more in Irwin Creek near Charlotte and in Little Sugar Creek near Pineville. Likewise, water levels increased by more than 10 feet at 10 of the 16 streamflow gaging stations (table 3). The change in water level in Little Sugar Creek at Medical Center Drive, relative to the bridge crossing, is depicted in figure 6.

A HOME ON SENTINEL POST ROAD FLOODED BY MCALPINE CREEK. *(Photograph courtesy of Mecklenburg County Stormwater Services)*

Peak flows can move downstream rapidly during extreme events (fig. 7), and flooding can occur with little or no time for people to prepare. The USGS, in cooperation with Charlotte-Mecklenburg Stormwater Services, is currently (1998) investigating technologies that can be added to the existing data-collection network to facilitate early warning of possible flooding.

Table 3. Summary of peak stages and discharges for streams in Mecklenburg County during the August 26–28, 1995, and July 22–24, 1997, storms

[mi^2, square mile; ft, foot; ft^3/s, cubic foot per second; nd, not determined; na, not applicable; <, less than; >, greater than]

				Peak stages				Previous peak streamflow (prior to 8-27-95)		Peak streamflow			
				8-27-95		7-23-97				8-27-95		7-23-97	
Site no. (fig. 1)	USGS station name and no.	Period of record[a]	Drainage area (mi^2)	Stage[b] (ft)	Change from previous day (ft)	Stage[b] (ft)	Change from previous day (ft)	Date	Flow (ft^3/s)	Flow (ft^3/s)	Recurrence interval (years)	Flow (ft^3/s)	Recurrence interval (years)
47	Mallard Creek below Stony Creek (0212414900)	1994–	34.6	17.4[c]	14.7	16.4	13.6	6-6-95	1,280	6,260	nd	4,970	nd
41	McDowell Creek near Charlotte (0214266000)	1996–	26.3	na	na	10.7	9.4	na	na	na	na	880	nd
18	Long Creek near Paw Creek (02142900)	1965–	16.4	11.4	10.2	13.4	12.4	6-18-82	4,300	1,140	< 2	3,150	10–25
48	Paw Creek at Wilkinson Boulevard (0214295600)	1994–	10.8	7.4	7.0	9.8	9.3	2-16-95	985	920	nd	2,760	nd
49	Irwin Creek near Charlotte (02146300)	1963–	30.7	15.0	14.5	20.4	19.8	5-30-75	8,880	5,510	5–10	11,600	100
50	Sugar Creek at NC 51 near Pineville (02146381)	1994–	65.3	14.7[d]	13.4	18.7	17.3	5-2-95	1,860	3,340[d]	nd	9,980	nd
51	Little Sugar Creek at Medical Center Drive (02146409)	1994–	12.2	12.8	11.1	14.8	13.1	7-28-95	2,400	3,580	nd	5,310	nd
52	Briar Creek above Colony Road (0214645022)	1995–	19.0	15.6[c]	na	15.4[c]	13.4	na	na	nd	nd	5,680	nd
53	Little Hope Creek at Seneca Place (02146470)	1982–90, 1994–	2.6	7.8	4.7	8.5	5.5	7-7-85	1,680	1,280	5	1,700	10–25
54	Little Sugar Creek at Archdale Drive (02146507)	1978–	42.6	13.1	11.0	15.1	13.1	7-7-85	8,100	11,100	10–25	13,600	50–100
55	Little Sugar Creek at NC 51 near Pineville (02146530)	1997–	49.2	na	na	23.0[c]	21.4	na	na	na	na	11,200	nd
10	McAlpine Creek at Sardis Road (02146600)	1962–	39.6	17.8	16.7	16.2	15.2	3-24-79	6,690	9,040	>100	6,220	10–25
56	Fourmile Creek at Elm Lane (02146670)	1997–	17.8	na	na	11.4	8.4	na	na	na	na	900	nd
57	McMullen Creek at Sharon View Road (02146700)	1963–	7.0	11.0	10.2	10.3[c]	9.5	6-10-82	3,150	3,470	25–50	2,890	10–25
6	McAlpine Creek below McMullen Creek (02146750)	1974–	92.4	19.4[c]	17.7	16.6[e]	15.3	8-19-94	7,370	12,500	>100	9,310[e]	10-25
58	Steele Creek near Shopton (0214677974)	1990–	3.6	8.6	7.6	10.4[c]	9.2	8-19-94	1,090	625	nd	2,000[e]	nd

[a]Data collection is ongoing (1998).
[b]Values rounded to nearest 0.1 foot.
[c]Based on flood mark.
[d]Occurred August 28, 1995.
[e]Occurred July 24, 1997.

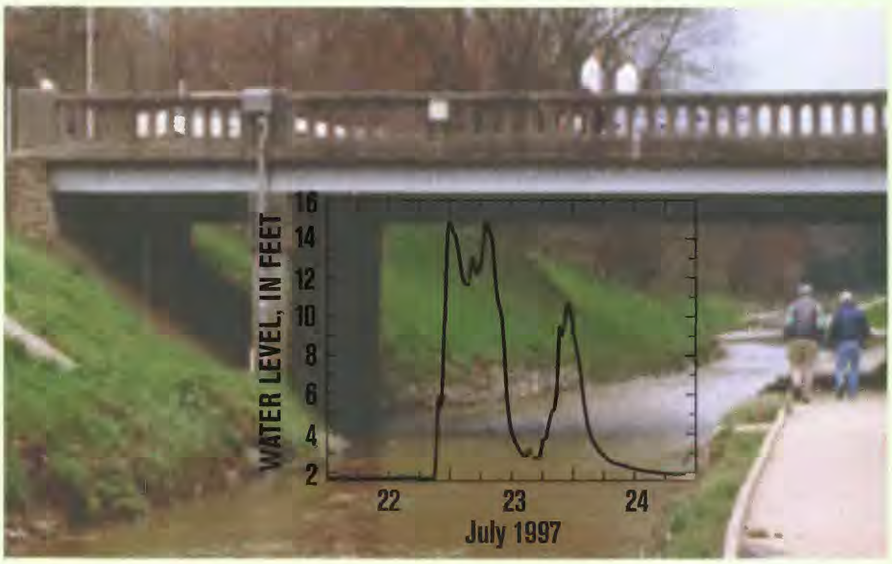


Figure 6. Water-level hydrograph, relative to the bridge crossing, for Little Sugar Creek at Medical Center Drive during the storm of July 22–24, 1997. *(Background photograph by William F. Hazell, USGS)*

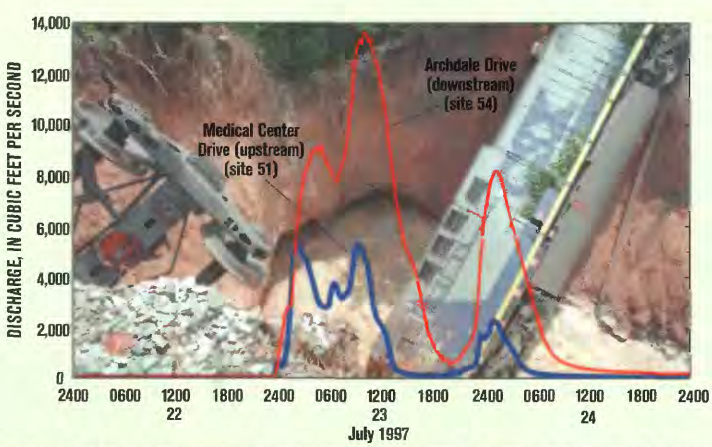


Figure 7. Flood hydrographs for Little Sugar Creek during the storm of July 22–24, 1997. *(Background photograph from The Charlotte Observer/Jeff Siner.* A locomotive plunged into Little Sugar Creek when tracks near Seigle Avenue and I-277 were washed away by flood waters.)

DOES A 100-YEAR STORM ALWAYS CAUSE A 100-YEAR FLOOD?

No. Several factors can independently influence the cause-and-effect relation between rainfall and streamflow.

When rainfall data are collected at a point within a stream basin, it is highly unlikely that this same amount of rainfall occurred uniformly throughout the entire basin. During intensely localized storms, rainfall amounts throughout the basin can differ greatly from the rainfall amount measured at the location of the raingage. Some parts of the basin may even remain dry, supplying no additional runoff to the streamflow and lessening the impact of the storm. Consequently, only part of the basin may experience a 100-year rainfall event; for example, in July 1997 only 30 percent of the McAlpine Creek Basin experienced rainfall amounts greater than or equal to a 100-year event (table 1).

Existing conditions prior to the storm can influence the amount of stormwater runoff into the stream system. Dry soil allows greater infiltration of rainfall and reduces the amount of runoff entering the stream. Conversely, soil that is already wet from previous rains has a lower capacity for infiltration, allowing more runoff to enter the stream.

Another factor to consider is the relation between the duration of the storm and the size of the stream basin in which the storm occurs. For example, a 100-year storm of 30-minutes duration in a 1-square-mile (mi^2) basin will have a more significant effect on streamflow than the same storm in a 50-mi^2 basin. Generally, streams with larger drainage areas require storms of longer duration for a significant increase in streamflow to occur. These and other factors determine whether or not a 100-year storm will produce a 100-year flood.

EFFECTS OF THE AUGUST 26–28, 1995, AND JULY 22–24, 1997, STORMS ON WATER QUALITY

In addition to the rainfall and streamflow data-collection network, the USGS operates a network of small-basin stormwater-runoff monitoring sites for the City of Charlotte and Mecklenburg County. Land use within each of these small basins generally is uniform, and samples are collected during storms throughout the year.

Water-quality samples were collected at four sites during the August 1995 event and at nine sites during the July 1997 event (table 4; Robinson and others, 1998). During a runoff event, increased streamflow may dilute concentrations of constituents. However, the total amount of material transported by the stream, referred to as load or export, may increase dramatically because load is a function of the concentration and the streamflow.

Instantaneous loads, in pounds per acre per day, were computed for baseflow conditions and a typical summer rainfall event, which was sampled in the summer of 1996 (table 4). Water-quality samples were collected near the time of maximum streamflow in selected small basins during the August 1995 and July 1997 flood events, and an instantaneous load was computed for total nitrogen and suspended sediment.

Vehicle storage lot in southern Mecklenburg County flooded by Sugar Creek. *(Photograph from The Charlotte Observer/ Stephanie Grace Lim)*

It is apparent from table 4 that most of the export of nitrogen and sediment occurs during storm events. Nitrogen export appears to be greatest from residential land-use basins, and high runoff during the floods had a greater effect on nitrogen export in these basins than in the other basins.

Sediment yields generally were much larger for the two flood events than for a typical summer runoff event.

The effect of basin size on material load also is evident from these data. In the small basins, essentially all of the material that washes off the land surface reaches the basin outlet, so the load is high. In the large basins, runoff material travels farther and load decreases as material settles to the streambed, undergoes instream chemical transformations, and is diluted by inflows.

Table 4. Nitrogen and sediment loads during baseflow, a typical summer storm, and the storms of August 26–28, 1995, and July 22–24, 1997, at nine sites in Mecklenburg County with various land uses

[lb/acre/day, pound per acre per day; na, not applicable; ns, no sample collected]

Site no. (fig. 1)	Stream	Drainage area (acres)	Land use	Instantaneous total nitrogen load (lb/acre/day)				Instantaneous suspended sediment load (lb/acre/day)			
				Baseflow	Summer 1996	August 1995	July 1997	Baseflow	Summer 1996	August 1995	July 1997
59	Tributary to Little Sugar Creek	78.7	Residential	0.0043	8.47	13.6	29.5	0.055	1,470	4,460	6,800
60	Tributary to Edwards Branch	14.7	Residential	na	.13	11.6	15.5	na	6.34	4,060	9,460
61	Tributary to McMullen Creek	80.6	Residential/ institutional	.0012	3.26	28.1	29.3	.031	1,470	10,000	16,500
62	Tributary to Irwin Creek	14.1	Heavy industrial	.0050	8.33	ns	6.04	.121	1,040	ns	1,270
28	Tributary to Sugar Creek	40.3	Light industrial	.0005	.15	ns	.76	.036	9.17	ns	45
63	Tributary to Fourmile Creek	170	Residential/ commercial	.0016	4.80	6.99	3.74	.258	11,800	8,610	12,900
25	Gar Creek	1,710	Mixed	.0041	2.19	ns	3.63	.182	112,000	ns	140,000
24	McDowell Creek (Westmoreland Road)	1,500	Mixed	.0073	2.41	ns	3.43	.293	1,410	ns	14,100
41	McDowell Creek (Beatties Ford Road)	16,800	Mixed	.0047	ns	ns	.44	.189	ns	ns	82

HOW CAN THE SAME STREAMFLOW BE A 100-YEAR FLOOD AT ONE LOCATION AND ONLY A 50-YEAR FLOOD AT ANOTHER?

Recurrence intervals are based on the probability of the peak streamflow occurring at a given location in any year. As water flows downstream from point "A" to point "B" and the drainage area increases, the volume of streamflow increases. Given this, it may seem reasonable to think that peak flows would increase in the same manner, but this is not necessarily true. The upstream-downstream relation that might be expected is illustrated in figure 7. During the July 1997 flood, as Little Sugar Creek flowed downstream from Medical Center Drive to Archdale Drive, significant increases occurred in both total and peak streamflow. A somewhat different situation is illustrated in figure 8. During the same flood, a higher peak flow was measured at the upstream gaging station at Irwin Creek near Charlotte than was measured at the downstream gaging station at Sugar Creek at NC 51 near Pineville (Irwin Creek becomes Sugar Creek at the confluence with Taggart Creek).

It is apparent from figure 8 that Irwin Creek rose and fell much more quickly than did Sugar Creek at the streamflow gaging locations. While Sugar Creek did not have a higher peak flow, it did have a higher volume of streamflow for the event as the streamflow remained elevated for a longer period of time. This phenomenon, known as peak attenuation, can be attributed to several variables. A narrow, efficient stream channel will allow the water to pass quickly, resulting in a nearly instantaneous increase in peak flow. At locations where the stream channel widens or may contain heavy vegetation, the water velocity may decrease. Also, as the peak flow moves downstream, water may move into the floodplain where it is stored until the water level begins to recede. As the water level recedes, the stored water in the floodplain will slowly re-enter the stream. These combined factors explain why the peak flow may be less in magnitude but longer in duration as the flood progresses downstream.

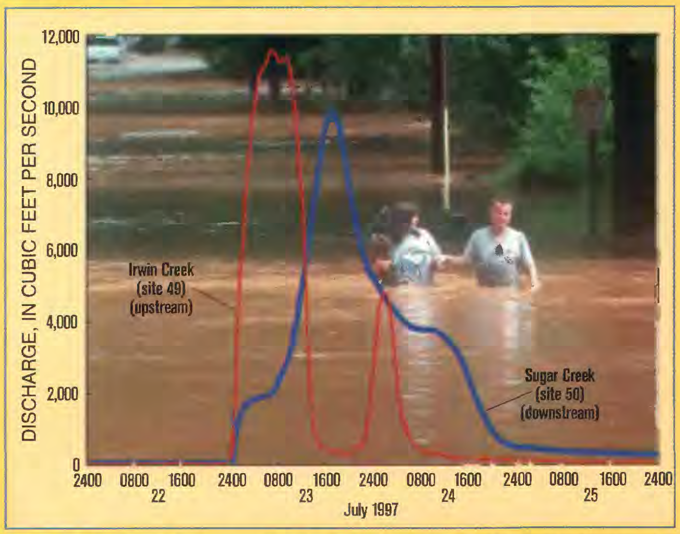


Figure 8. Flood hydrographs for Irwin Creek, site 49 (upstream), and Sugar Creek, site 50 (downstream), during the storm of July 22–24, 1997. *(Background photograph from The Charlotte Observer/Kent D. Johnson.* Local residents wade through waist-deep waters of Sugar Creek.)

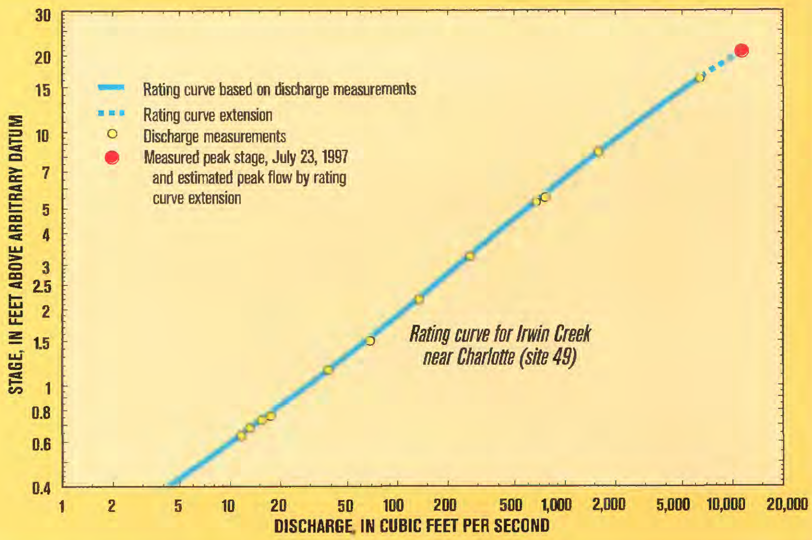
DETERMINATION OF PEAK FLOWS

Stream stage (or water level) and streamflow (or discharge) are measured at locations called streamflow gaging stations. Stage is measured and recorded continuously by electronic instruments to an accuracy of 0.01 foot. Stage information from the City of Charlotte and Mecklenburg County network is transmitted daily by telephone line to USGS computers.

Flow is more difficult to measure accurately and continuously than is stage. Discharge for a gaging station is typically determined from an established stage-discharge relation, or rating curve. Individual discharge measurements are made by USGS personnel at a gaging station by using standard procedures (Rantz and others, 1982); ideally, these measurements are made when the stage is not changing. A series of these measurements made over a range of flow conditions defines the rating curve, which is used to convert continuous measurements of stage to a continuous record of discharge. Channel changes, resulting from scour, deposition, vegetation, or other processes, alter the stage-discharge relation, so that discharge measurements must be made routinely and continuously to ensure that the rating curve remains accurate.

A rating curve is considered accurate only over the range for which discharge measurements have been made. Discharge measurements sometimes are not available for the full range of flows at gaging stations that have been in operation for only a few years. Even at gaging stations that have been in continuous operation for 30 years or more, direct discharge measurements for extremely high flows, such as those occurring during August 1995 and July 1997, are difficult to obtain because (1) these events are rare, (2) debris often accumulates in the channel, (3) extreme peak flows may persist for only a short period of time, and (4) measurement sites are often inaccessible due to road or bridge closures.

Estimates of peak flows, which are outside the range of the established rating curve, may be made by an extrapolation of the rating curve to the peak stage. At some gaging stations, indirect methods of discharge determination based on high-water marks, channel properties, and hydraulic principles may be used to obtain an independent estimate of discharge. These indirect methods generally require accurate field surveys to determine high-water marks, channel properties, and channel shape. The information obtained in the field is then processed using computer programs to determine the discharge. Continued evaluation of these discharge computations may result in some revision of the peak flows presented in this fact sheet.



U.S. Geological Survey personnel, Charlotte Field Office, making a discharge measurement on Little Sugar Creek at Archdale Drive. *(Photograph by William F. Hazell, USGS)*

Rising flood waters overtopping a local bridge. *(Photograph by Jerald B. Robinson, USGS)*

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Prepared by Jerald B. Robinson, William F. Hazell, and Wendi S. Young

For additional information contact:

District Chief
U.S. Geological Survey
3916 Sunset Ridge Road
Raleigh, NC 27607-6416
(919) 571-4000

The North Carolina District Home Page:
<http://wwwnc.usgs.gov>

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