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THE STORM OF JULY 5, 1989: HYDROLOGIC CONDITIONS

BY

JOHN H. TALLEY

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PREFACE

As part of its routine program, the DGS (Delaware Geological Survey) regularly gathers and evaluates a variety of water resources data. In extreme events (storms, floods, droughts, earthquakes) special efforts are made to obtain detailed measurements, sometimes under difficult conditions. Through the rapid collection and dissemination of data, the DGS assists emergency response agencies in evaluating and predicting conditions during the specific events. Afterwards, the DGS compiles information and prepares reports and maps to help assess the nature and effects of the events and in predicting the impact of future ones. Although most such reports and maps are not formally published, they are available and are used by officials and citizens. Because the magnitude of the storm of July 5, 1989, prompted many requests for quantitative data, the DGS is publishing these data in Open File Report format.

THE STORM OF JULY 5, 1989: HYDROLOGIC CONDITIONS

John H. Talley

INTRODUCTION

Heavy precipitation associated with intense thunderstorm activity occurred in northern New Castle County, Delaware, from 0500 to 1300 hours on July 5, 1989. The most intense rainfall, which fell between 0600 and 1100 hours, is classified as a 100-year event in New Castle County. Record high stream discharges occurred at five gaged sites and three miscellaneous sites. One hundred-year floods were recorded at four sites.

The Delaware DEPO (Division of Emergency Planning and Operations), FEMA (Federal Emergency Management Agency), and NCCOEP (New Castle County Office of Emergency Preparedness) reported that three deaths occurred and more than 420 dwelling units were affected by flood waters. Two homes were destroyed and 48 apartment units were rendered uninhabitable. Although damage occurred throughout northern New Castle County, the areas most affected were concentrated in the flood plains of the Shellpot Creek watershed north of Wilmington, the Little Mill Creek watershed west of Wilmington in the vicinity of Elsmere, Brack Ex, Richardson Park, Maryland Avenue and nearby areas, the Red Clay Creek watershed near Stanton, and the Christina River watershed near the town of Christiana. During and immediately following the storm, emergency efforts were undertaken to evacuate those affected and to assist in ensuring public safety.

Numerous roads throughout northern New Castle County were impassable during the storm. The areas of most severe damage were concentrated in the Shellpot Creek, Stoney Run, and Little Mill Creek watersheds. North and east of Wilmington, roads and bridges were also damaged, requiring extensive repairs at several locations.

ACKNOWLEDGMENTS

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METEOROLOGICAL CONDITIONS

On June 26, 1989, tropical storm Allison moved from the Gulf of Mexico over the central Texas coast. The storm dissipated rapidly over land; however, the moisture field persisted over the southern United States through the end of June. This tropical air mass drifted northward during the first days of July and by July 4 spread eastward to the middle Atlantic. Two to 4 inches of rainfall associated with a thunderstorm fell on the afternoon of July 4 in the Elkton, Maryland, area.

By the morning of July 5, the moist air mass was over Delaware. Early on July 5, a weak trough of low pressure formed along a line from Washington, D. C., through northern Delaware to New York City. The trough had sufficient uplift to cause heavy rain and subsequent flooding from the Washington, D.C., area through Baltimore, northern Delaware, southeastern Pennsylvania, and central New Jersey to the New York City area. Upper-level steering currents were so weak that once the rain area formed, it remained virtually stationary, resulting in intensive rainfall that exceeded the 100-year 6-hour maxima in several locations from Virginia to New York.

PRECIPITATION AND STREAMFLOW ANALYSIS

Barker (1976) used reports published by NOAA (National Oceanic and Atmospheric Administration) pertaining to rainfall intensity, duration, and frequency from 1951 through 1961 to extrapolate that data to New Castle County and develop rainfall-intensity and rainfall-frequency curves for this area. Recurrence intervals for particular storm events are extrapolated from graphs and tables contained in his report. Precipitation since 1962 has not been incorporated into the entire period of record and analyzed. In addition, the effects of urbanization on flooding since those earlier studies have not been determined.

Simmons and Carpenter (1978) established recurrence intervals for discharges of various magnitudes at numerous locations in Delaware and nearby Pennsylvania and Maryland. Discharge frequencies for each station were derived from statistical analyses of streamflow records available for a particular watershed and analyses of precipitation and runoff characteristics in the general region of the watershed.

The frequency of a given high flow is a measure of the average number of times that flow will be exceeded during a specified period of years. The recurrence interval is the average time in years between occurrences of a given flow. Although a particular peak stream discharge may have an average frequency of occurrence of some number of years (10, 20, 100), that discharge may occur in any year. For example, a discharge having an average frequency of occurrence on the order of 100 years may occur in any year and may possibly occur in 2 consecutive years. However, in any 1 year there is only a 1-percent chance of the 100-year discharge occurring.

PRECIPITATION

Precipitation data were collected and compiled from 21 locations in Delaware and nearby Pennsylvania, New Jersey, and Maryland (Table 1 and Figure 1). Most data were provided by businesses and private citizens who monitor precipitation for various purposes. Not all stations are operated to NOAA standards; nevertheless, such information is valuable in determining trends.

Total precipitation ranged from 9.52 inches at Arden, Delaware, to 2.64 inches at North East, Maryland. Precipitation values contoured from the 21 stations are shown on the isohyetal map of northern New Castle County, Delaware (Figure 1). The heaviest precipitation was concentrated east of Wilmington and in the Claymont area. Less intense, but, nevertheless, heavy precipitation occurred along a southwest-northeast trending line from near Newark through Wilmington to Claymont.

Hourly precipitation was recorded at the National Weather Service in New Castle and at the University of Delaware in Newark. Total precipitation at New Castle for the 5-hour period from 0600 to 1100 hours was 5.96 inches or an average of about 1.2 inches per hour (Table 2 and Figure 2). This exceeded the 100-year recurrence interval for a 5-hour period as determined by Barker (1976). The largest 1-hour total was 1.64 inches recorded between 0700 and 0800 hours. During the same 5-hour period 3.9 inches fell in Newark, an average of approximately 0.78 inches of rainfall per hour (Table 2 and Figure 2). The total rainfall for the 5-hour period and the maximum in inches per hour correspond to a 25-year recurrence interval.

Table 1. Precipitation, July 5, 1989.

Location Number	Location	Latitude of Raingage	Longitude of Raingage	Precipitation (inches)
1	Arden, DE	N39°49'	W75°29'	9.52
2	Yorklyn, DE	N39°48'	W75°41'	*5.50
3	Mt. Cuba, DE	N39°47'	W75°39'	6.35
4	Wilmington, DE	N39°46'	W75°32'	6.15
5	Wooddale, DE	N39°46'	W75°38'	6.34
6	Stanton, DE	N39°42'	W75°39'	6.81
7	Choate, DE	N39°42'	W75°42'	>6.00
8	New Castle, DE	N39°40'	W75°36'	6.63
9	Newark, DE	N39°40'	W75°44'	4.60
10	Ogletown, DE	N39°40'	W75°43'	4.85
11	Christiana, DE	N39°39'	W75°40'	6.73
12	Near Newark, DE	N39°37'	W75°47'	**4.00
13	Glasgow, DE	N39°36'	W75°44'	5.55
14	Phila. Intl. Aprt.	N39°53'	W75°15'	4.38
15	Chadds Ford, PA	N39°52'	W75°37'	4.15
16	Longwood Gardens, PA	N39°53'	W75°41'	3.65
17	London Grove, PA	N39°52'	W75°47'	2.68
18	Burnt Mills, PA	N39°50'	W75°39'	5.38
19	Toughkenamon, PA	N39°49'	W75°44'	5.10
20	Carney's Point, NJ	N39°42'	W75°30'	9.22
21	North East, MD	N39°40'	W75°57'	2.64

* July 4-6, 1989
** Approximate

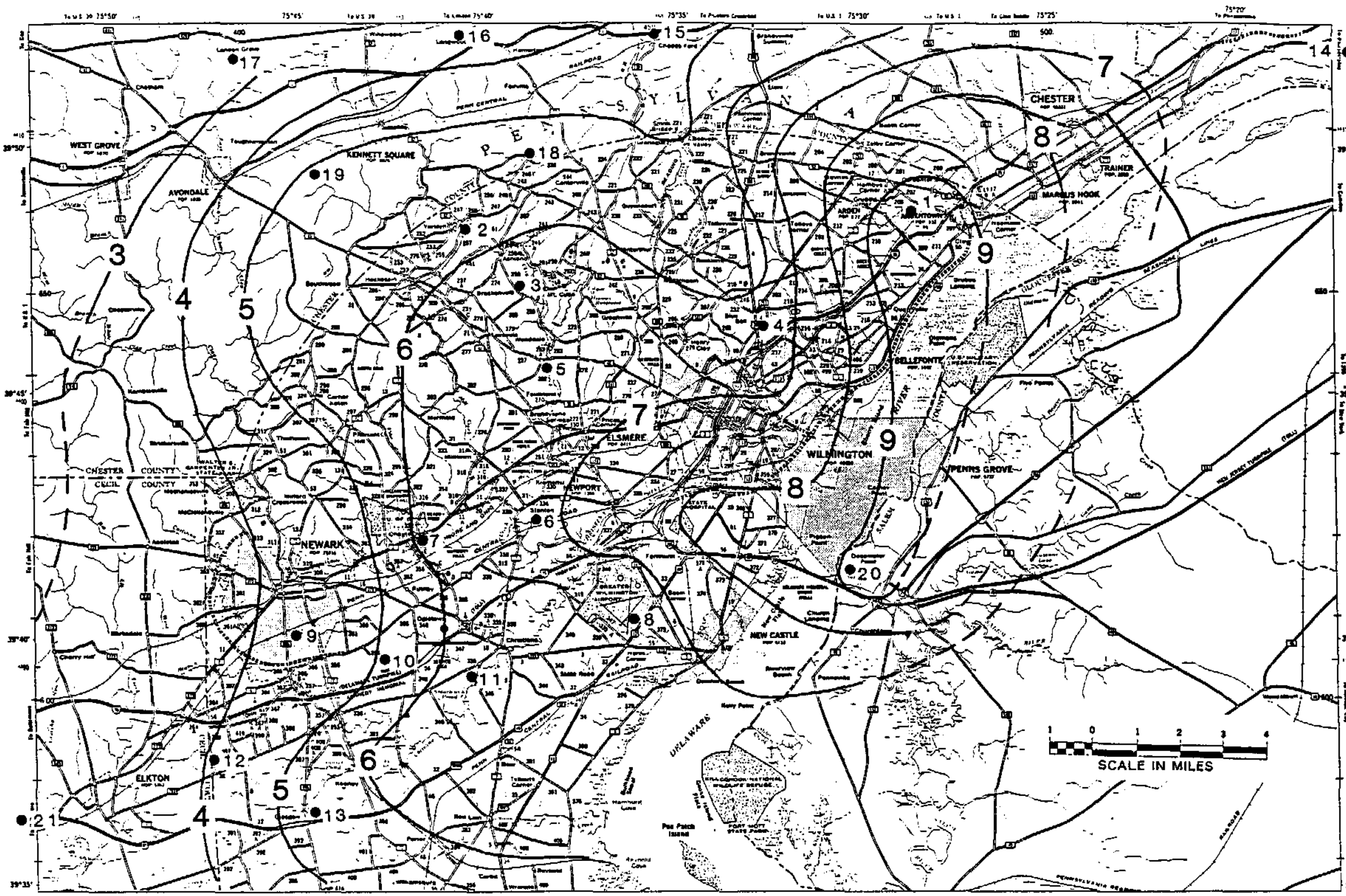

Figure 1. Isohyetal map (in inches of rainfall) of northern New Castle County for the storm of July 5, 1989. Numbered precipitation stations (●) are those of Table 1.

Table 2. Hourly Precipitation on July 5, 1989, at Newark and New Castle, Delaware

	Station 07 6410 01 Newark, DE	Station 07 9595 01 New Castle, DE
Time	Amount (inches)	Amount (inches)
0000-0100	0.00	0.00
0100-0200	0.00	0.00
0200-0300	0.00	0.00
0300-0400	0.00	0.00
0400-0500	0.00	Trace
0500-0600	0.20	0.21
0600-0700	0.60	0.95
0700-0800	1.00	1.64
0800-0900	0.50	1.30
0900-1000	1.10	1.00
1000-1100	0.70	1.07
1100-1200	0.10	Trace
1200-1300	0.30	0.42
1300-1400	0.10	0.03
1400-1500	0.00	0.00
1500-1600	0.00	0.00
1600-1700	0.00	0.00
1700-1800	0.00	0.00
1800-1900	0.00	0.00
1900-2000	0.00	0.01
2000-2100	0.00	Trace
2100-2200	0.00	0.00
2200-2300	0.00	0.00
2300-2400	0.00	0.00
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Total	4.60	Total 6.63

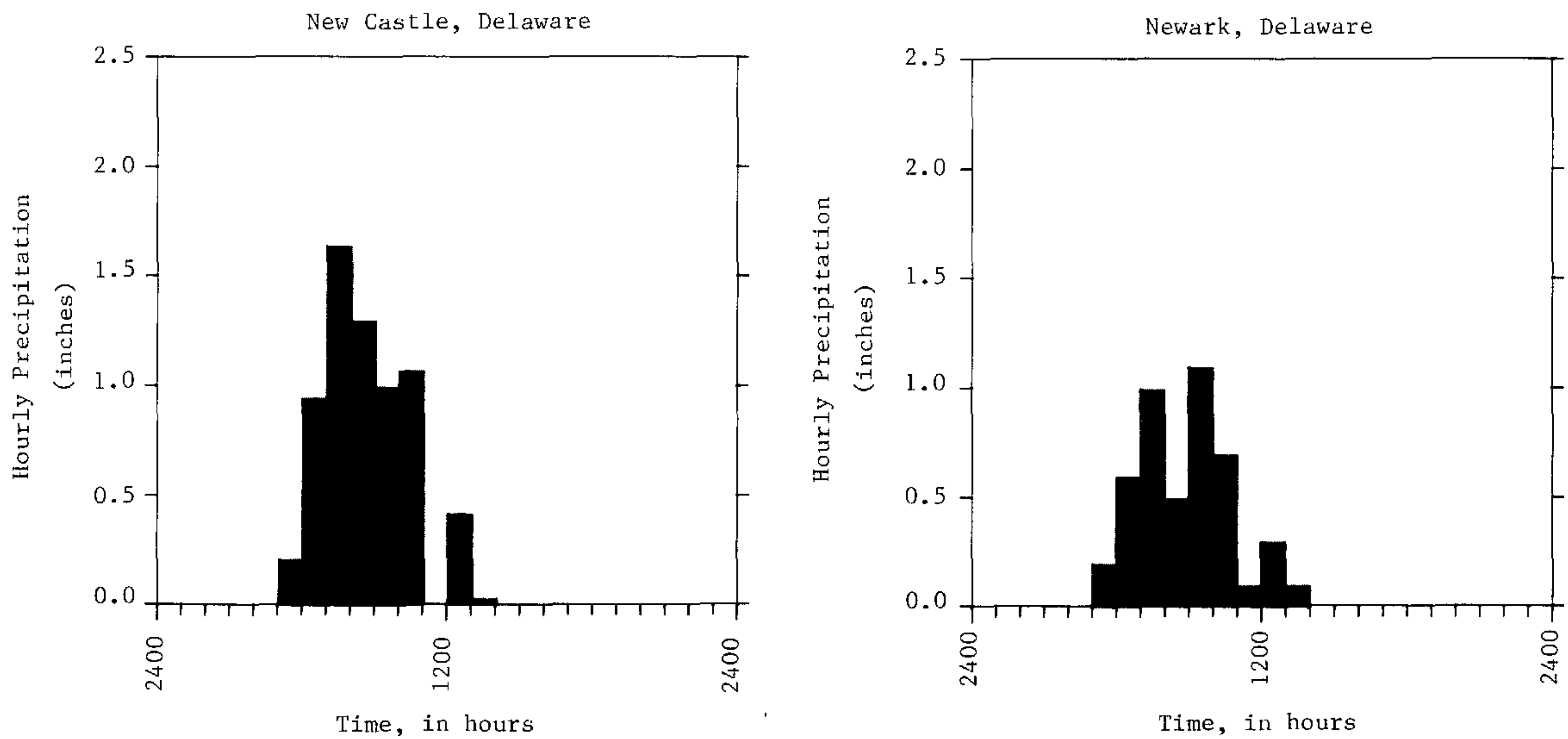

Figure 2. Hourly precipitation at New Castle and Newark, Delaware, on July 5, 1989.

Cumulative hourly precipitation for the storm at New Castle and at Newark is given in Table 3 and Figure 3. The 9-hour total of 6.63 inches at New Castle was a 100-year event whereas the 4.60 inches measured during the same time period at Newark was a 25-year event. The 24-hour total at Wilmington has a return period of about 50 years whereas that at Newark has a return period of less than 10 years.

STREAM DISCHARGES

Above normal precipitation recorded in northern Delaware during May and June resulted in saturated to near saturated soil conditions. The wet ground conditions and intense rainfall on July 5 resulted in severe stream and street flooding in northern New Castle County. Peak instantaneous unit discharges (highest discharges for a particular storm event) were calculated at nine continuous-record gaging stations and at four miscellaneous sites. Eleven of the sites are located in Delaware, one in Pennsylvania, and one in Maryland (Figure 4).

Table 4 summarizes peak stages and corresponding discharges for maximum historical floods and the flood of July 5, 1989. Peak discharges are preliminary figures subject to revision by the U. S. Geological Survey. Record peak discharges were established at seven stations: Shellpot Creek at Wilmington, Little Mill Creek at Elsmere, Pike Creek near Newark, White Clay Creek near Newark, Christina River at Coochs Bridge, Christina River near Bear, and Doll Run at Red Lion. Peak discharges at five other locations (Brandywine Creek at Chadds Ford, Brandywine Creek at Wilmington, Red Clay Creek at Wooddale, White Clay Creek above Newark, and Big Elk Creek at Elk Mills, Maryland) were below established records; significant portions of the drainage basins above those stream gages are located outside the areas of most intense precipitation (Figures 1 and 4).

Peak discharges equal to or exceeding a 100-year recurrence interval were recorded on Shellpot Creek at Wilmington, Pike Creek and White Clay Creek near Newark, and Christina River at Coochs Bridge (Table 4). The recurrence interval on Little Mill Creek at Elsmere is about 46 years. These basins are located within the area of highest precipitation (Figure 1).

High stream flows and associated flooding occurred on other watercourses such as Naamans Creek and Stoney Run north of Wilmington, Cool Run near Newark (a tributary of White Clay Creek), and Muddy and Belltown runs (tributaries of the Christina River). Quantitative determinations of discharges were not made on these watercourses.

Table 3. Cumulative Precipitation on July 5, 1989, at Newark and New Castle, Delaware.

	Station 07 6410 01 Newark, DE	Station 07 9595 01 New Castle, DE
Time	Amount (inches)	Amount (inches)
0000-0100	0.00	0.00
0100-0200	0.00	0.00
0200-0300	0.00	0.00
0300-0400	0.00	0.00
0400-0500	0.00	Trace
0500-0600	0.20	0.21
0600-0700	0.80	1.16
0700-0800	1.80	2.80
0800-0900	2.30	4.10
0900-1000	3.40	5.10
1000-1100	4.10	6.17
1100-1200	4.20	6.17
1200-1300	4.50	6.59
1300-1400	4.60	6.62
1400-1500	4.60	6.62
1500-1600	4.60	6.62
1600-1700	4.60	6.62
1700-1800	4.60	6.62
1800-1900	4.60	6.62
1900-2000	4.60	6.63
2000-2100	4.60	6.63
2100-2200	4.60	6.63
2200-2300	4.60	6.63
2300-2400	4.60	6.63
Total	4.60	6.63

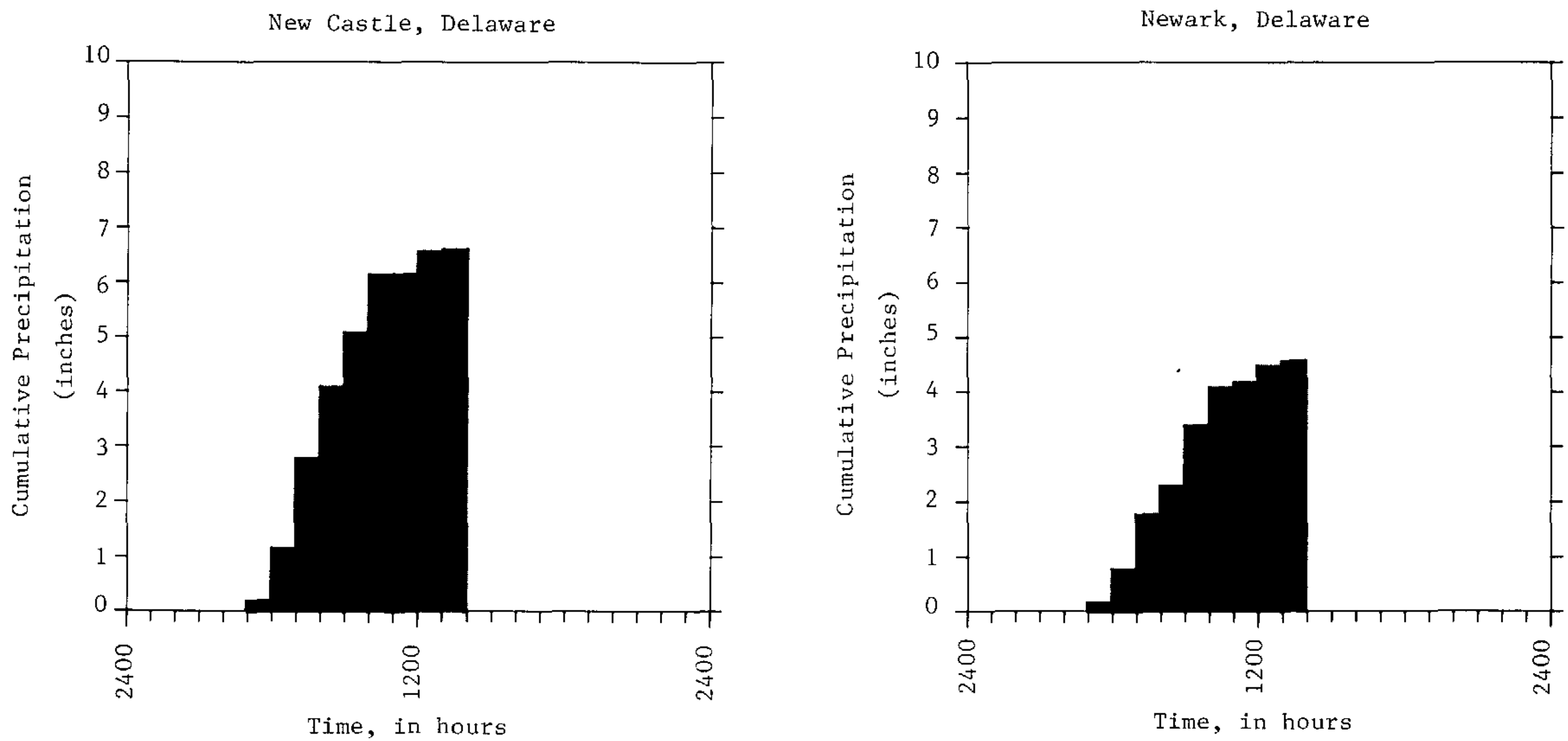

Figure 3. Cumulative precipitation at New Castle and Newark, Delaware, on July 5, 1989.

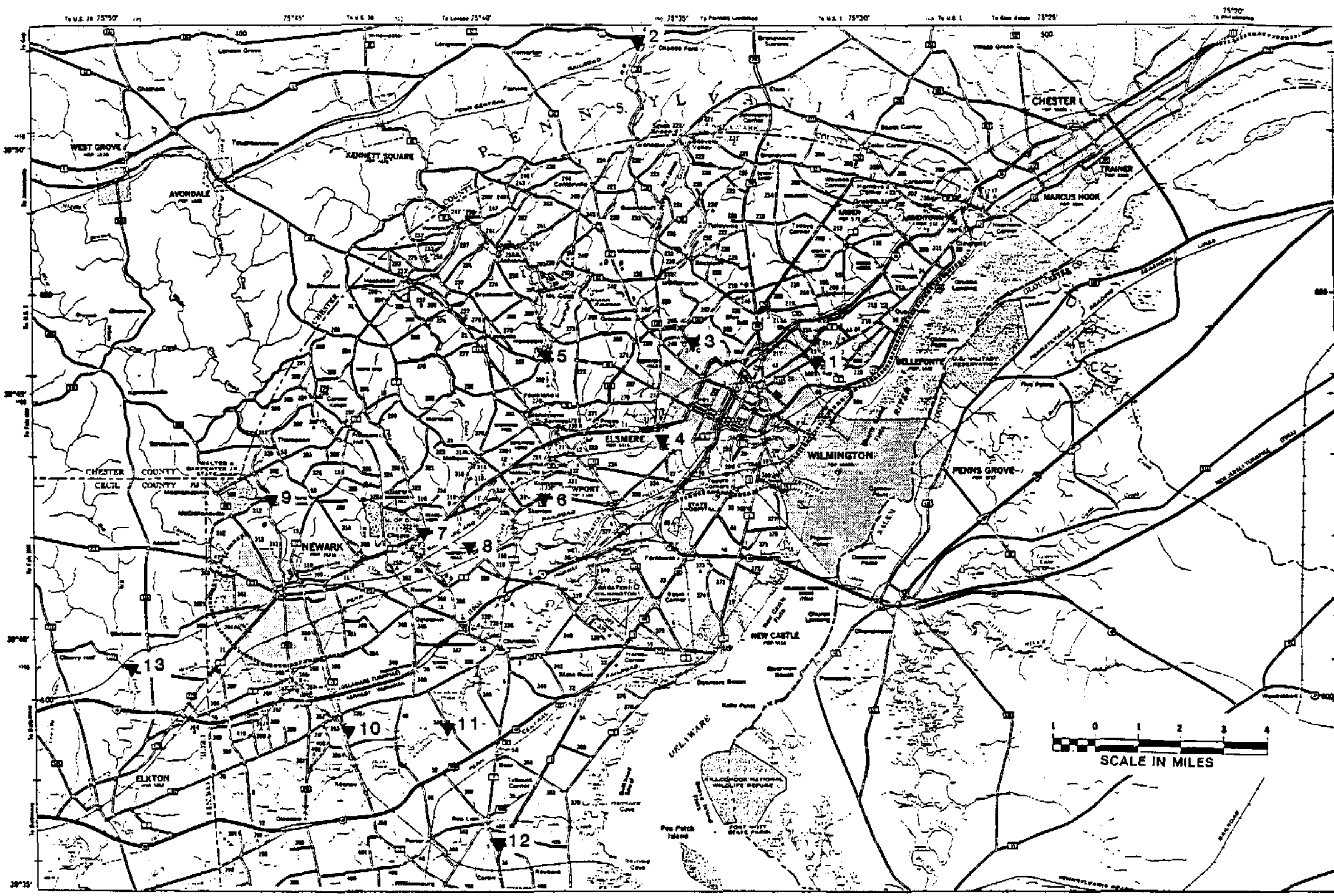

Figure 4. Map showing locations of stream gages and other sites where discharges were measured. These sites are referred to in Tables 4 and 5.

Table 4. Summary of peak stages and discharges in Delaware and nearby Pennsylvania and Maryland for the flood of July 5, 1989.

Local number	WRD station number	Stream and place of determination	Drainage area (square miles)	Maximum flood previously known			Maximum during present flood				Recurrence interval (years)
				Date	Stage (feet)	Discharge (cfs)	Date	Stage (feet)	Discharge Cfs	Discharge Cfs per square mile	
1	01477800	Shellpot Creek at Wilmington	7.46	9/13/71	11.91	6,850	7/05/89	13.76	8,040	1077	> 100
2	01481000	Brandywine Creek at Chadds Ford,PA	287	6/22/72	16.56	23,800	7/05/89	8.94	5,232	18	-
3	01481500	Brandywine Creek at Wilmington	314	6/23/72	15.49	29,000	7/05/89	9.94	9,850	31	3
4	01480100	Little Mill Creek at Elsmere	6.70	8/10/67	8.58	3,960	7/05/89	* 8.8	4,400	657	46
5	01480000	Red Clay Creek at Wooddale	47.0	7/21/75	10.32	5,010	7/05/89	8.59	3,860	82	> 10
6	01480015	Red Clay Creek at Stanton	52.4	***	-	-	7/05/89	12.80	5,320	102	-
7	01478950	Pike Creek near Newark	6.04	7/28/69	9.15	2,550	7/05/89	11.3	5,450	902	100
8	01479000	White Clay Creek near Newark	89.1	6/22/72	**17.74	9,080	7/05/89	16.55	11,600	130	> 100
9	01478500	White Clay Creek above Newark	66.7	6/22/72	13.77	10,200	7/05/89	* 10.4	4,910	74	< 10
10	01478000	Christina River at Coochs Bridge	20.5	5/01/47	12.41	4,330	7/05/89	13.12	5,530	270	> 100
11	01478040	Christina River near Bear	40.6	5/19/88	11.57	3,470	7/05/89	14.34	7,500	185	---
12	01482310	Doll Run at Red Lion	1.2	7/15/73	8.51	360	7/05/89	* 8.6	363	303	< 10
13	01495000	Big Elk Creek at Elk Mills, MD	52.6	7/05/37	14.5	10,600	7/05/89	8.64	5,030	95.6	5

* From floodmarks at discontinued gage site.
** At previous site and datum, 0.5 miles upstream at datum 2.6 feet higher.
*** Station was established October 1, 1988.

Table 5 contains information pertaining to times that it took for various streams from start of rise to reach flood stage and the duration that they remained in flood stage. The rapid rise in discharge is directly associated with the intensity of precipitation and rapid overland runoff. Approximately 0.2 inch of rain fell at New Castle and Newark between 0500 and 0600 hours. Between 0.6 and 0.95 inch fell during the next hour. Streams located in areas of intense precipitation started to respond almost immediately. For example, water levels in Shellpot Creek at Wilmington, Red Clay Creek at Stanton, White Clay Creek near Newark, and Christina River at Coochs Bridge and near Bear started to rise between 0600 and 0630 hours. Flood stages were reached on four gaged sites within 2 hours after the stream levels started to rise. From 0600 to 0730 hours the Christina River at Coochs Bridge rose from 4.01 feet [discharge of 55 cfs (cubic feet per second)] to 9.86 feet (discharge of 1,020 cfs), a rate of 3.9 feet per hour.

Shellpot Creek at Wilmington

The largest amount of precipitation was concentrated in the vicinity of the Shellpot Creek watershed north and northeast of Wilmington (Figure 1). Instantaneous discharge at the gage increased from 2.9 cfs or 1,300 gpm (gallons per minute) at 0600 hours to 8,040 cfs or 3.6 mgm (millions of gallons per minute) at 1000 hours. Water levels in the creek rose to flood stage in 1 hour and 20 minutes and remained above bankfull for approximately 7 hours (Figure 5 and Table 5). The discharge of 8,040 cfs exceeded the previously measured maximum discharge by 1,190 cfs. The largest discharge of record, 1,077 cfs per square mile of drainage basin, occurred on Shellpot Creek. This high discharge relects the intensity of rainfall in a small drainage basin and is accentuated by urbanized development and associated impervious surfaces that enhance overland runoff. The calculated recurrence interval for this event exceeds 100 years.

Flash flooding in this basin resulted in water damage to homes, apartments, and businesses located along Shellpot Creek. Severe damage to bridge decks, roadways, and parking lots was concentrated along Philadelphia Pike.

Brandywine Creek at Wilmington and Chadds Ford

The localized nature of the storm is evident from review of discharge hydrographs for the Brandywine Creek at Wilmington, Delaware, and Chadds Ford, Pennsylvania (Figure 6). The peak discharge at Wilmington was nearly twice that measured at Chadds Ford, although the increase in the size of the drainage basin

Table 5. Summary of flooding data for the storm of July 5, 1989.

Location Number	Location	Time of start of rise	Time flood stage reached	Time to reach flood stage	Time of Peak discharge	Time flood stage over	Floodstage duration
1	Shellpot Creek at Wilmington	0625	0745	1 hr. 20 min.	1000	1435	6 hrs. 50 min.
2	Brandywine Creek at Chadds Ford, PA	0800	1200	4 hrs.	2400	*0415 7/6/89	16 hrs. 15 min.
3	Brandywine Creek at Wilmington	0700	0830	1 hr. 30 min.	1015	1245	4 hrs. 15 min.
5	Red Clay Creek at Wooddale	0715	0950	2 hrs. 35 min.	1430	2035	10 hrs. 45 min.
6	Red Clay Creek at Stanton	0630	**	-	1445	-	-
8	White Clay Creek near Newark	0630	0830	2 hrs.	1215	2345	15 hrs. 15 min
10	Christina River at Coochs Bridge	0600	0720	1 hr. 20 min.	1430	2050	13 hrs. 30 min
11	Christina River near Bear	0615	-	-	1730	-	-
13	Big Elk Creek at Elk Mills	0630	0945	3 hrs. 15 min.	1815	1930	9 hrs. 45 min.

* Peak for Brandywine Creek at Chadds Ford, PA, was not directly associated with the intense thunderstorm activity that occurred in New Castle County, DE on July 5, 1989.

** Flood stage (bankfull) not determined.

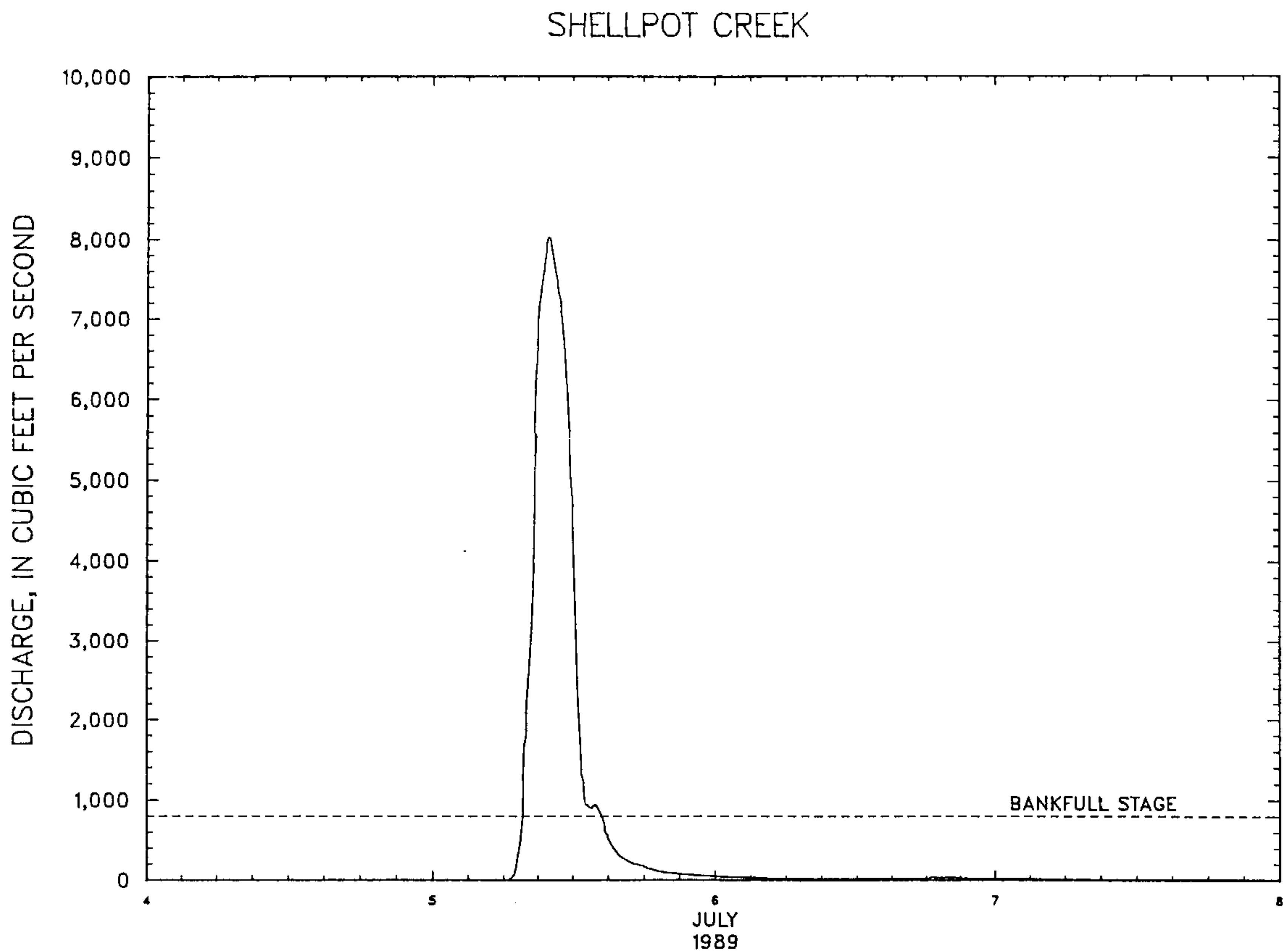

Figure 5. Discharge hydrograph for Shellpot Creek (station 01477800), July 4-7, 1989.

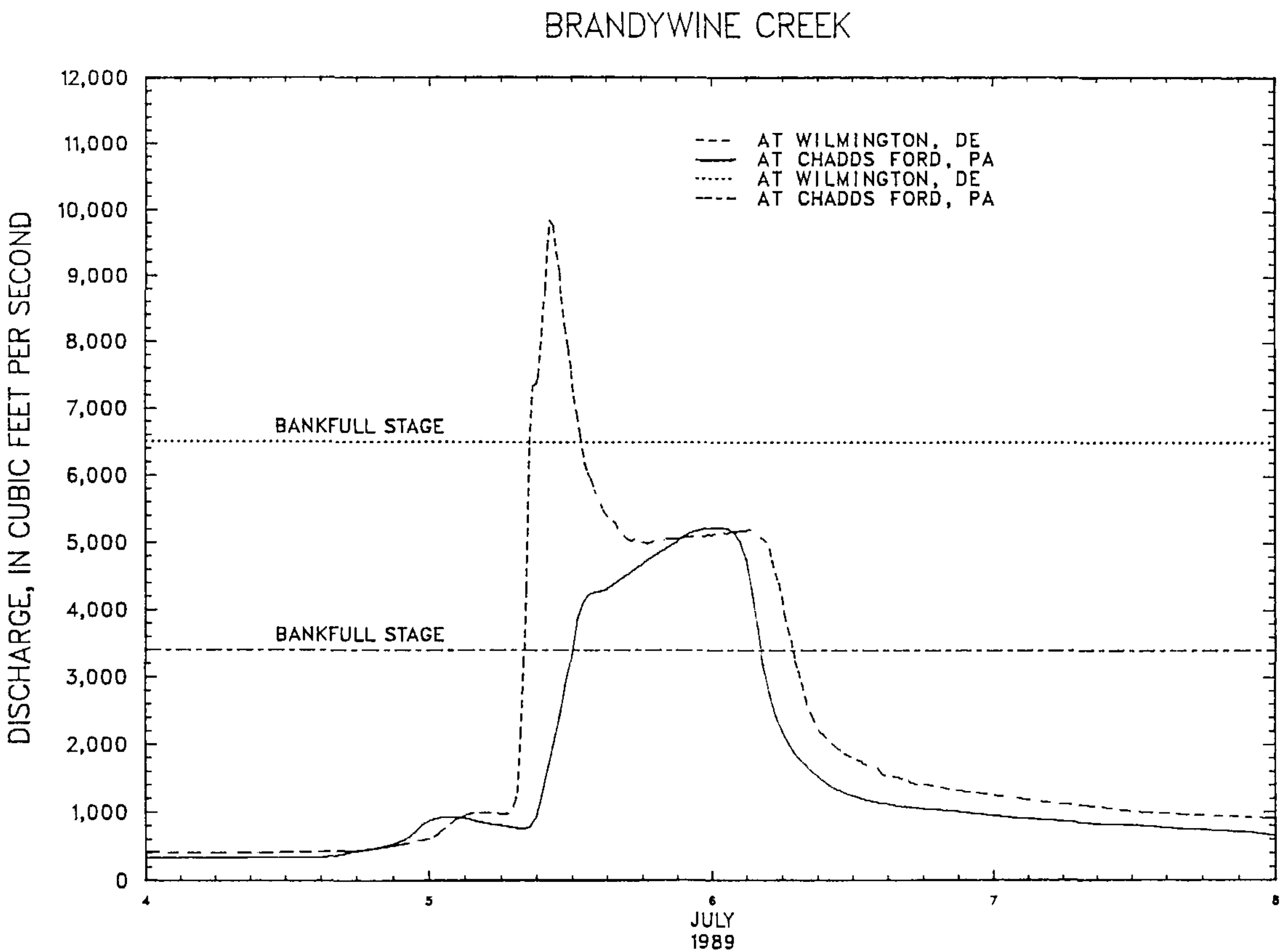

Figure 6. Discharge hydrograph for Brandywine Creek at Chadds Ford, Pennsylvania (station 01481000) and Wilmington, Delaware, (station 014815000), July 4-7, 1989.

between Chadds Ford and Wilmington is 10 percent. Intense rainfall in the lower portion of the drainage basin resulted in a rapid rise of water levels on the Brandywine Creek at Wilmington. The rise started at 0700 hours, reached flood stage at 0830 hours, and crested at 1015 hours with a peak discharge of 9,850 cfs (4.4 mgm). Discharge receded relatively rapidly after passage of the storm system. The Brandywine Creek at Wilmington remained in flood stage for 4 hours and 15 minutes (Table 5).

The fact that no corresponding peak discharge occurred on the Brandywine Creek at Chadds Ford during the morning on July 5 indicates that total precipitation in the upper portion of the basin was less than in the lower portion. The peak at Chadds Ford occurred approximately 15 hours after the peak at Wilmington and peak discharge was about half that measured at Wilmington. During periods of basin-wide precipitation, the peak at Wilmington usually occurs 3 to 4 hours following the peak at Chadds Ford. A secondary peak at Wilmington occurred in the early morning hours of July 6, 1989, about 3 hours following the peak at Chadds Ford.

Minor flooding was reported along portions of Brandywine Creek in Delaware; the recurrence interval for this flooding is 3 years.

Little Mill Creek at Elsmere

Between 6 and 8 inches of rain fell in a 6-hour period in the Little Mill Creek drainage basin. The peak stage as determined from flood marks at Du Pont Road was 8.8 feet, a discharge of 4,400 cfs (2 mgm) which is a new record high for the creek (Table 4). The recurrence interval for a flood of this magnitude is about 46 years.

As in the Shellpot Creek drainage basin, intense precipitation in a short period of time in the small urbanized drainage basin resulted in rapid runoff and flash flooding and caused damage from Kirkwood Highway (Rt.2) to the confluence of Little Mill Creek with the Christina River. Several hundred residents had to be evacuated from an apartment complex in Elsmere where 39 apartment units were heavily damaged. In nearby Brack Ex, single family units were evacuated, homes were flooded, and basement walls of two homes collapsed. Evacuation of businesses took place in the lowermost portion of Little Mill Creek basin and several businesses suffered water damage.

Red Clay Creek at Wooddale and Stanton

Red Clay Creek was in flood stage at both Wooddale and Stanton for approximately 11 hours (Table 5). Precipitation in the Pennsylvania portion of the basin was generally less than 5.5 inches. In the Delaware portion it ranged from 5.5 to nearly 7 inches.

The peak flow measured at Wooddale was 3,860 cfs (1.7 mgm). The calculated recurrence interval for an event of this magnitude is approximately 10 years (Table 4). There are not enough historical data available from the gage at Stanton to calculate recurrence intervals.

Figure 7 shows times and associated discharges for the Red Clay Creek at Wooddale and Stanton. During normal widespread precipitation events, the peak at Stanton usually occurs several hours after the peak at Wooddale; however, for the storm of July 5, 1989, they occurred at nearly the same time. In addition, the discharge at Stanton is generally on the order of 9 percent greater than that farther upstream at Wooddale. For this event, the peak flow at Stanton was 38 percent greater than that at Wooddale (5,320 cfs vs. 3,860 cfs), more evidence that intense precipitation was limited to local areas. In addition, overland runoff during heavy precipitation was greater in the lower part of the basin where development is concentrated.

Although flooding damaged roads between the Delaware-Pennsylvania line and Wooddale, damage was most severe in the more urbanized low-lying flood plain area south of Rt. 4 in Stanton.

Pike Creek near Newark

The Pike Creek drainage basin, like those of Shellpot Creek and Little Mill Creek, is relatively small, encompassing an area of 6.04 square miles. The 5 to 6.5 inches of rain that fell in the basin resulted in significant and rapid overland runoff. The peak runoff of 5,450 cfs (2.4 mgm) was greater than that computed for Little Mill Creek at Elsmere. However, damage along Pike Creek was relatively minor because of little development in the flood plain of this stream.

The contribution of water from Pike Creek to the main channel of White Clay Creek increased flows on the White Clay Creek at Stanton. The peak flow of 5,450 cfs was a record discharge and was classified as a 100-year event (Table 4).

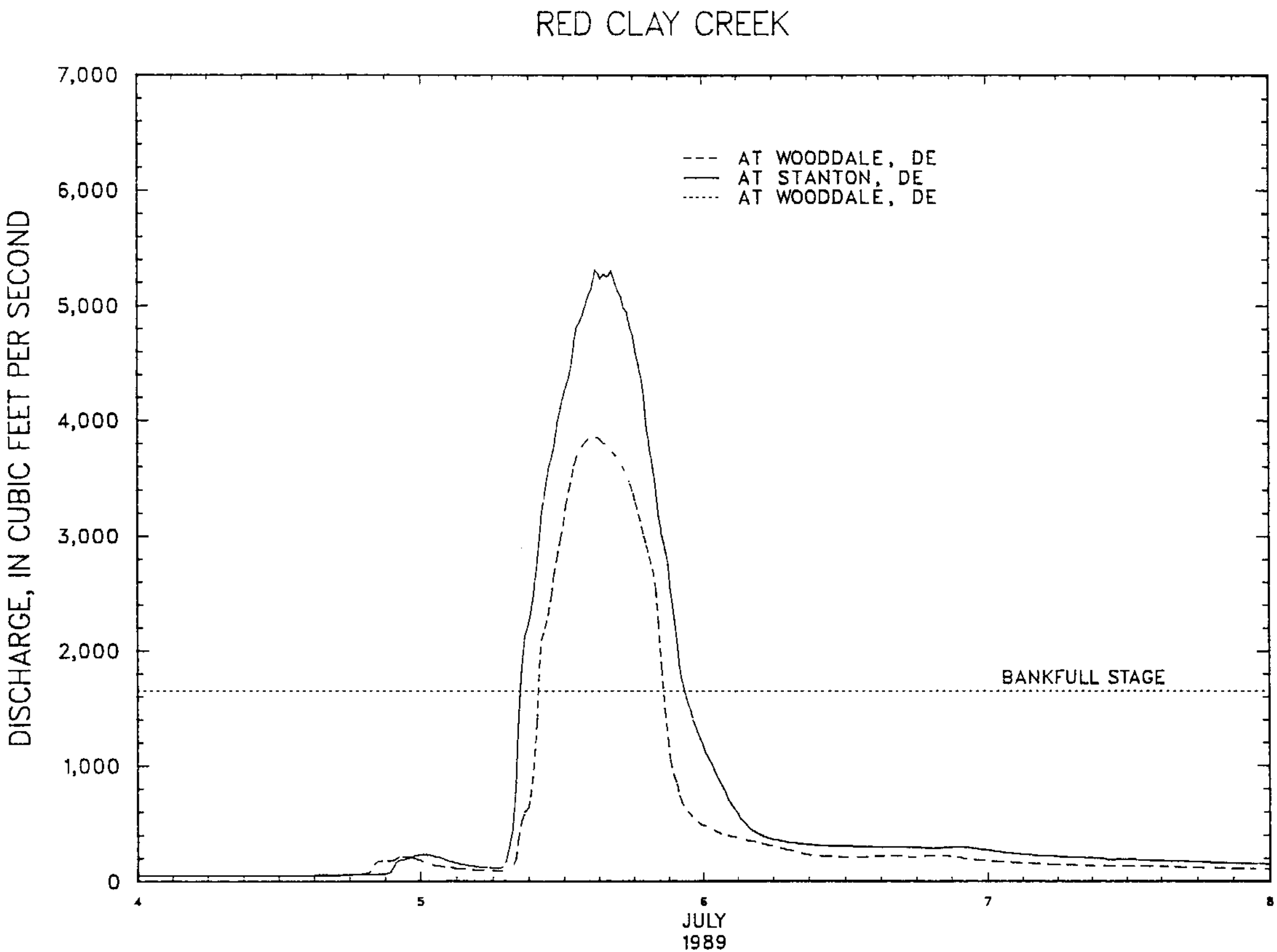

Figure 7. Discharge hydrograph for Red Clay Creek at Wooddale (station 01480000) and Stanton (station 01480015), July 4-7, 1989.

White Clay Creek above and near Newark

The peak flow as measured from flood marks at the gage site above Newark (Figure 4, number 9) was 4,910 cfs (2.2 mgm). This is classified as a less than 10-year event (Table 4). The relatively low discharge reflects a decrease in the intensity and amount of precipitation received in the upper part of the White Clay Creek watershed as opposed to that received in the lower portion of the basin. Less than 5 inches fell in the upper drainage basin. In addition, the upper basin is less developed which allows for a lower rate of overland runoff.

A new discharge record of 11,600 cfs (5.2 mgm), that exceeded the previous record by approximately 2,000 cfs, was established on White Clay Creek near Newark (Table 4). Figure 8 shows the rapid rate of increase in discharge. The water level in the creek started to rise at 0630 hours and reached flood stage 2 hours later and remained in flood stage from 0830 hours until 2345 hours (Table 5).

The event at this location has a calculated recurrence interval of greater than 100 years in contrast to the 10-year event recorded several miles upstream at the discontinued gage site (Table 4). The difference in flows and associated recurrence intervals is attributable to the variation in the total storm rainfall in northwestern Delaware. The lower portion of the basin received between 4 and 7 inches of rainfall over a 4 to 5-hour period whereas the upper part received less than 5 inches.

The peak discharge on White Clay Creek was considerably greater than that recorded on Red Clay Creek. The peak on the White Clay near Newark occurred approximately 2 hours before the peak on the Red Clay at Stanton (Figures 7 and 8).

Flood damage along the White Clay Creek was concentrated on the flood plain in the Stanton area where several businesses are located. Road flooding and associated damage also occurred along several tributaries to White Clay Creek.

Christina River near Coochs Bridge and near Bear

The Christina River watershed above the stream gage on Rt. 72 near Coochs Bridge received approximately 4 inches of rain during a 5-hour period from 0600 to 1100 hours on July 5. Approximately 2 to 3 inches of rain fell southwest of Newark on the previous afternoon (M. Peleski, personal communication). The effects of the July 4 precipitation are evident in Figure 9. Stream flows in the early morning hours of July 5 were above normal background flows for this time of the year.

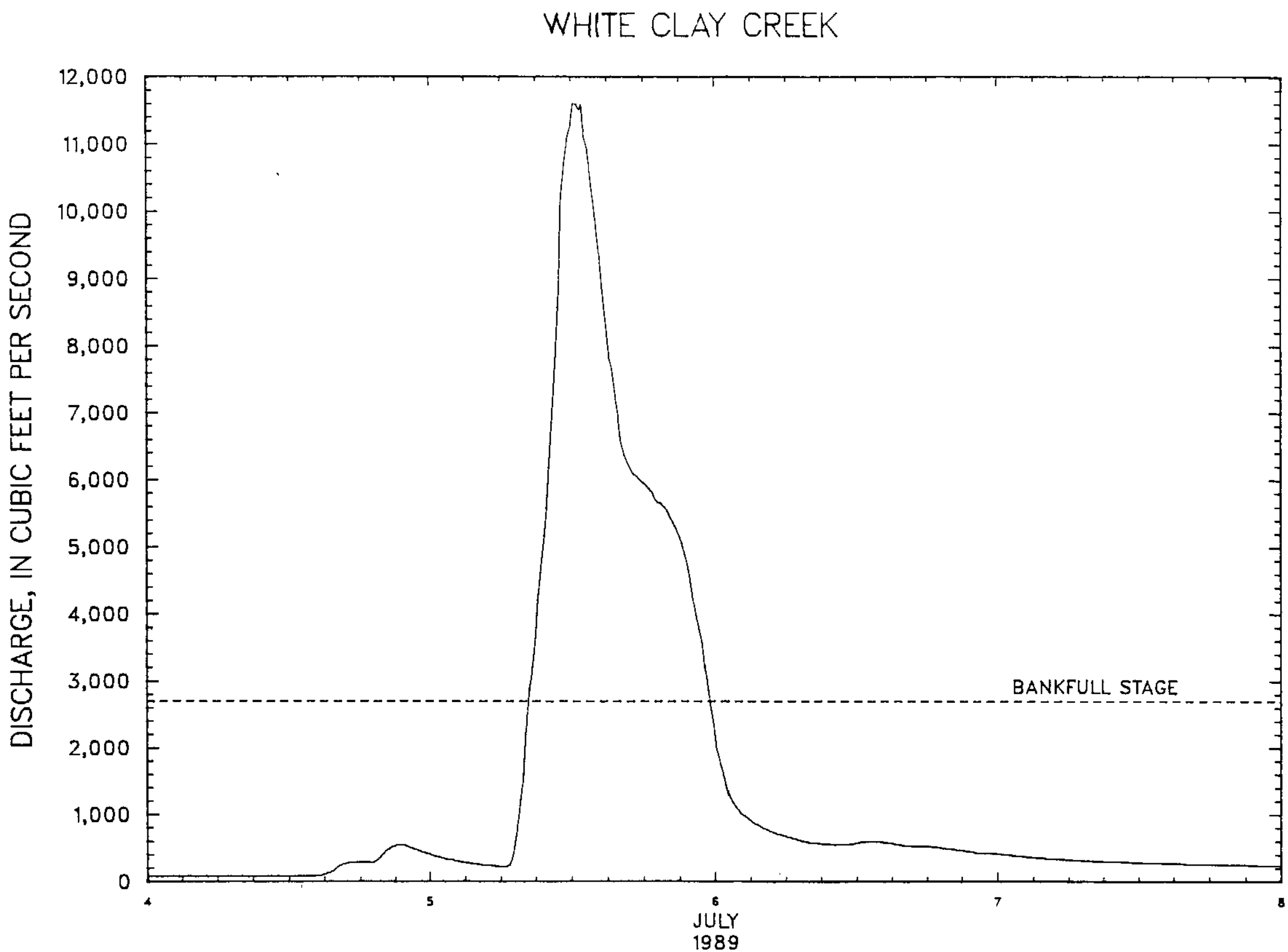

Figure 8. Discharge hydrograph for White Clay Creek near Newark (station 01479000), July 4-7, 1989.

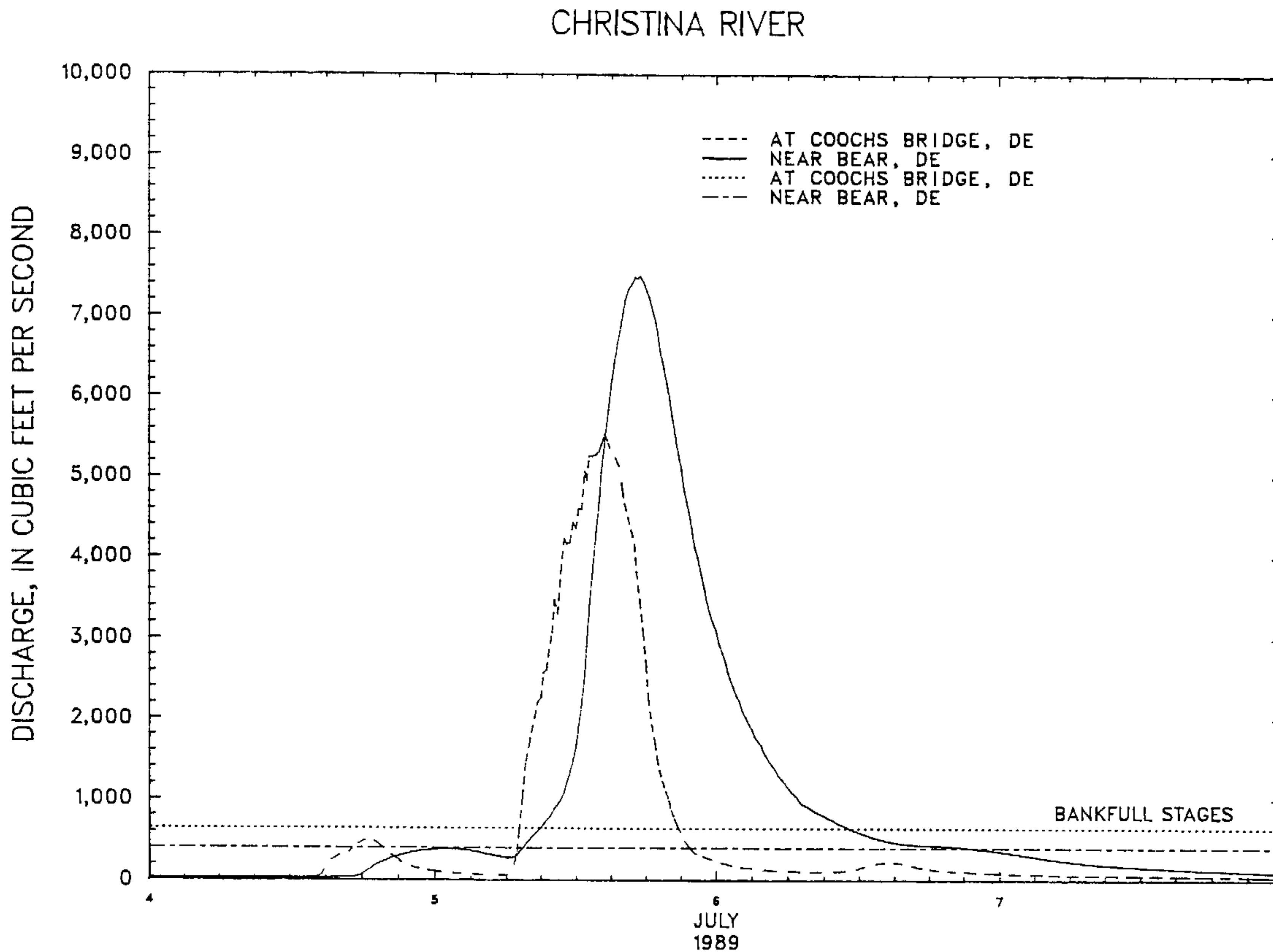

Figure 9. Discharge hydrograph for Christina River at Coochs Bridge (station 01478000) and near Bear (station 01478040), July 4-7, 1989.

The discharge at Coochs Bridge increased rapidly from 55 cfs (24,700 gpm) at 0600 hours to 5,530 cfs (2.5 mgm) at 1430 hours, a record high instantaneous discharge (Table 4 and Figure 9). The recurrence interval for the storm event on the Christina River is greater than 100 years.

The intensity of precipitation and associated runoff are reflected by the rise in river stage from 4.01 feet to flood stage at 9.0 feet in less than 1-1/2 hours (Table 5 and Figure 9). The Christina crested at 13.12 feet at 1430 hours and remained in flood stage for 13 hours and 30 minutes. Several roads were flooded; some suffered damage that made them impassable. Severe erosion occurred in many new housing developments located in the watershed.

Maximum discharge measured at a stream gage located in the lower portion of the basin near Bear was 7,500 cfs (3.4 mgm) (Table 4). The peak discharge near Bear occurred 3 hours after the peak near Coochs Bridge (Figure 9). There are not enough historical data available from the gage near Bear to calculate recurrence intervals.

Big Elk Creek at Elk Mills, Maryland

Precipitation in the Big Elk Creek drainage basin west of Newark, Delaware, amounted to less than 3 inches. The maximum discharge of 5,030 cfs (2.3 mgm) has a 5-year recurrence interval (Table 4). Farther downstream in Elkton, the Big Elk Creek crested above flood stage and streets were flooded. Although precipitation data are not available for the Elkton area, it appears that the lower part of the Big Elk Creek drainage basin received considerably more rainfall than the upper part.

DAMAGE ASSESSMENT

Three deaths were directly attributable to the July 5 storm and associated flooding. Flooding caused severe to minor damage to apartment buildings, homes, businesses, personal property such as vehicles, and roads and bridges. Considerable soil erosion occurred in construction areas where vegetation and top soil had been removed.

The most severe damage to occupied dwelling units occurred in the Elsmere-Brack Ex areas (Little Mill Creek drainage basin) where two homes were classified as destroyed, six had major damage, and 183 units were evacuated. Several homes and apartments located along Shellpot Creek were evacuated and numerous businesses suffered water damage. Table 6 is a summary of damage as reported by DEPO and FEMA.

DEPO reported that 75 businesses were impacted by flooding. As with private dwelling units, most businesses that were affected are located in the Little Mill Creek and Shellpot Creek drainage basins. Several located in the lower portion of the White Clay Creek drainage basin and the Christina River basin were also affected. The Small Business Administration estimated that damage to residences and structures totaled $2,326,000 (New Castle County Office of Emergency Preparedness, 1989). Figure 10 shows inundation along Rt. 7 in Stanton by flood waters of White Clay Creek.

The NCCOEP reported extensive damage to public facilities including park and recreational facilities operated and maintained by the County, County sewerage and drainage systems, and the dam at Becks Pond.

Thirty-three roads were closed during at least a portion of the flood period; many roads were flooded but passable. Numerous roads and bridges in northern New Castle County were damaged by flood waters with damage ranging from severe to minor. Table 7 is a listing of areas damaged. Estimated costs of repairs at the first three locations shown are $591,000. Figure 11 shows pavement damage. The most significant damage to roads and bridges occurred north of Wilmington (Shellpot Creek and Stoney Run) where precipitation generally exceeded 7 inches.

The carrying capacity of many stream channels has been reduced as the channels have become filled with sediment and debris. During intense rainfall, flood stages are reached more rapidly with spreading of water onto flood plains and associated higher elevations. The rapid accumulation of sediment in stream channels resulting from soil and rock erosion from higher elevations can be seen at numerous nearby construction sites. In many instances sediment and erosion control measures are not working properly.

During high runoff some bridge openings restricted flow. In addition, debris collected on the upstream sides of bridges further restricted the carrying capacity of stream channels with resulting ponding of water and extensive flooding.

Table 6. Report on damage assessment prepared by the Delaware Division of Emergency Planning and Operations and the Federal Emergency Management Agency for the Storm of July 5-6, 1989.

Location	Drainage Basin	Destroyed	Major Damage Uninhabitable	Minor Damage Uninhabitable	Affected
<u>Apartments</u>					
Colony North	Shellpot Creek			9	
Elsmere Park	Little Mill Creek			39	
<u>Homes</u>					
Elsmere Area	Little Mill Creek			73	68
Brack Ex Area	Little Mill Creek	2	6	71	6
Glenville Area	Red Clay Creek				104
Christiana Acres/ Airport Road Area	Christina River			2	5
Christiana Area	Christina River		2	6	2
Heather Woods Area	Christina River			1	3
Newark	Christina River		1		20
Total		2	9	201	208

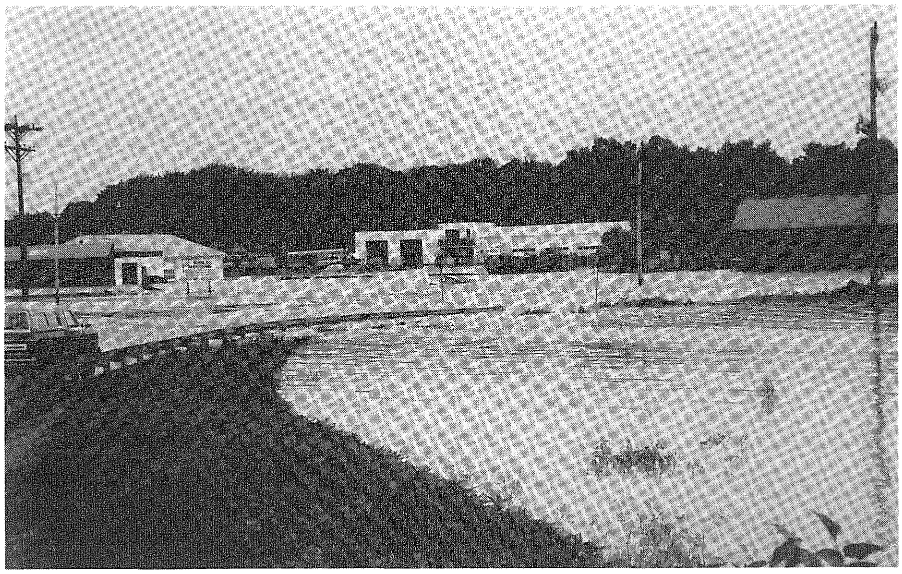

Figure 10. Inundation along Rt. 7, Stanton, by flood waters of White Clay Creek. (Courtesy, Gary Paulachok)

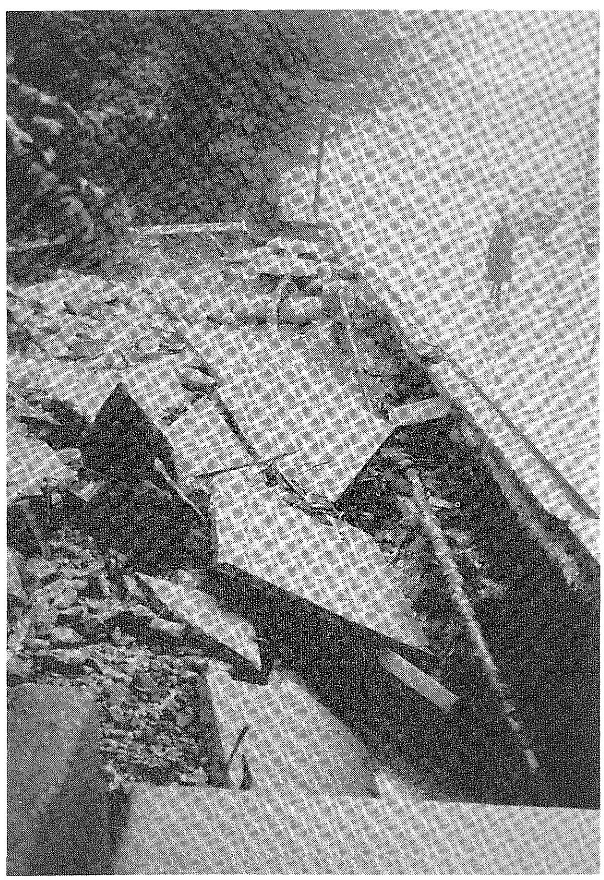

Figure 11. Damage to bridge and sidewalk on Market Street, Wilmington caused by flood waters of Shellpot Creek. (Courtesy, Gary Paulachok)

Table 7. Report on damage assessment compiled from information provided by Peter Klabunde, Delaware Department of Transportation, for the storm of July 5, 1989.

Location	Damage
Philadelphia Pike at Stoney Run	Stone arch bridge support and pavement
Market Street at Shellpot Creek	Retaining wall and pavement
Governor Printz Boulevard and Shellpot Creek	Embankment and pavement
Shipley Road & Shellpot Creek	Bridge approach pavement
Philadelphia Pike near Princeton Avenue	Embankment, sidewalks, curbing & pipe
Carr Road and Shellpot Creek	Shoulder, guard rail, rip-rap along bridge
I-95 S & Shellpot Creek, Marsh Road entrance to I-95 southbound	Retaining wall and pavement
I-495 S at Philadelphia Pike	Pavement and shoulder
Jefferson Avenue & Chestnut Run	Bridge approach, sidewalk, curb, and embankment
Old Capitol Trail & Mill Creek	Structural damage to under portions of bridge; sidewalk approaches, embankment
Welsh Tract Road & Christina River	Bridge approach pavement
Salem Church Road at Becks Pond	Washout around dam

SUMMARY

The intense thunderstorm activity associated with the remnants of tropical Storm Allison dumped up to 9 inches of rain in northern New Castle County in about a 9-hour period on July 5, 1989. Rainfall recorded at the National Weather Service was a 100-year event; a 25-year event was recorded during the corresponding period at Newark.

The storm followed a period of above normal precipitation (4 to 6 inches) during the spring that created saturated soil conditions and a high water table. The intense rainfall was concentrated in the urbanized areas and rapidly ran off the ground and caused severe stream and street flooding. The localized nature of the storm and associated precipitation are evident from the isohyetal map and analysis of stream flow data. Record high stream discharges were established at eight locations in the lower parts of drainage basins in northern New Castle County; four 100-year and one 46-year events were recorded.

The majority of dwelling units and businesses affected are located on flood plains in areas mapped by FEMA (1986, 1987) as special flood hazard areas inundated by 100-year floods. Thus, one should expect that such areas will be inundated on the average of once every 100 years. Damage to bridges, road pavement surfaces, road shoulders, guard rails, and bridge approaches was documented throughout northern New Castle County. The most severe damage was concentrated along Stoney Run, Shellpot Creek, and Little Mill Creek. Less extensive damage occurred along the Red and White Clay creeks, and the Christina River and its tributaries.

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