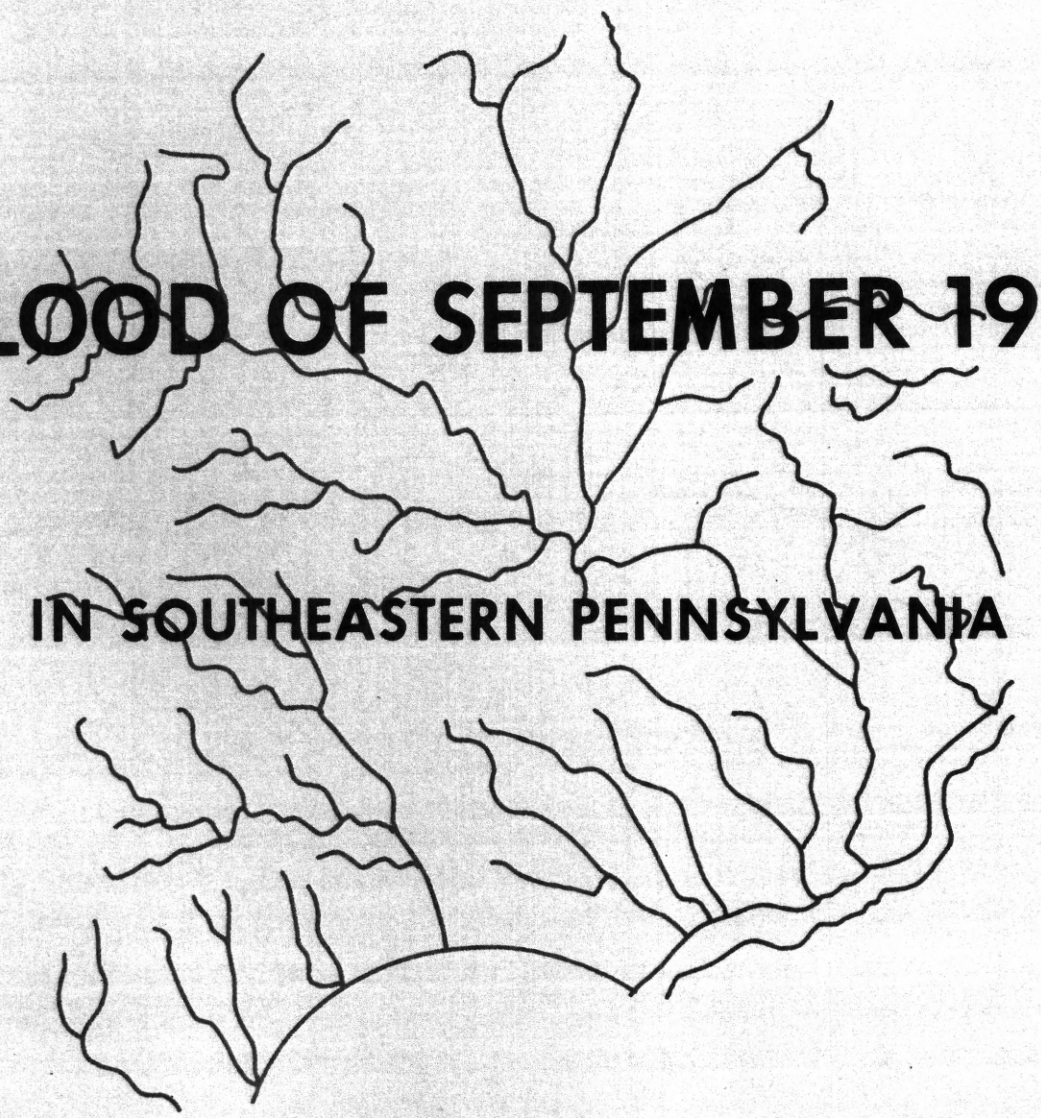
UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY



FLOOD OF SEPTEMBER 1971

IN SOUTHEASTERN PENNSYLVANIA

Open-file report 73-217
Harrisburg, Pennsylvania
1973

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WASHINGTON, D. C.

FLOOD OF SEPTEMBER 1971

IN SOUTHEASTERN PENNSYLVANIA

by
Leland V. Page
and
Lewis C. Shaw

Open-file report
Harrisburg, Pennsylvania
1973

FLOOD OF SEPTEMBER 1971 IN SOUTHEASTERN PENNSYLVANIA

By

Leland V. Page and Lewis C. Shaw

ABSTRACT

Record-breaking floods on Sept. 13, 1971, occurred in some urbanized basins of southeastern Pennsylvania. This flooding resulted from heavy, intermittent thunderstorms on Sept. 11-13, 1971, which produced 8 to 12 inches of rainfall in the basins of Skippack, Stony, and Chester Creeks. Rain was heaviest during mid-day of the 13th.

Damage to homes, businesses, and public property amounted to many millions of dollars. Twelve persons lost their lives and more than 400 families were driven from their homes. The Chester and Norristown areas were declared Flood Disaster Areas by the Federal and State Governments.

Peak stages and discharges are given for 25 gaging staions and 4 miscellaneous sites.

Flood profiles are shown for Chester Creek, West Branch Chester Creek, and Stony Creek.

INTRODUCTION

Heavy rainfall during the 5-day period of Sept. 11-13, 1971, resulted in the worst floods in the history of Chester, Delaware, and Montgomery Counties in southeastern Pennsylvania. Floods on many streams in the Philadelphia suburban area were the highest in at least 50 years. The death toll and the property damage caused by the floods of September 13 were the highest in the area's history. Twelve lives were lost in Delaware and Montgomery Counties. The most severe flooding occurred in the Chester and Norristown areas, which sustained damages of about $17 million. Total property damages for the flood-affected area were estimated at $100 million, according to newspaper reports.

This report deals primarily with flooding on the small streams in southeastern Pennsylvania, particularly Chester and Stony Creeks. Figure 1 shows the locations of gaging stations operated by the U.S. Geological Survey in the study area. Peak stages and discharges at these stations during the September 1971 flood, with comparative data for previously known maximum floods, are summarized in table 1.

Data furnished by all government agencies are specifically acknowledged where they appear in the text.

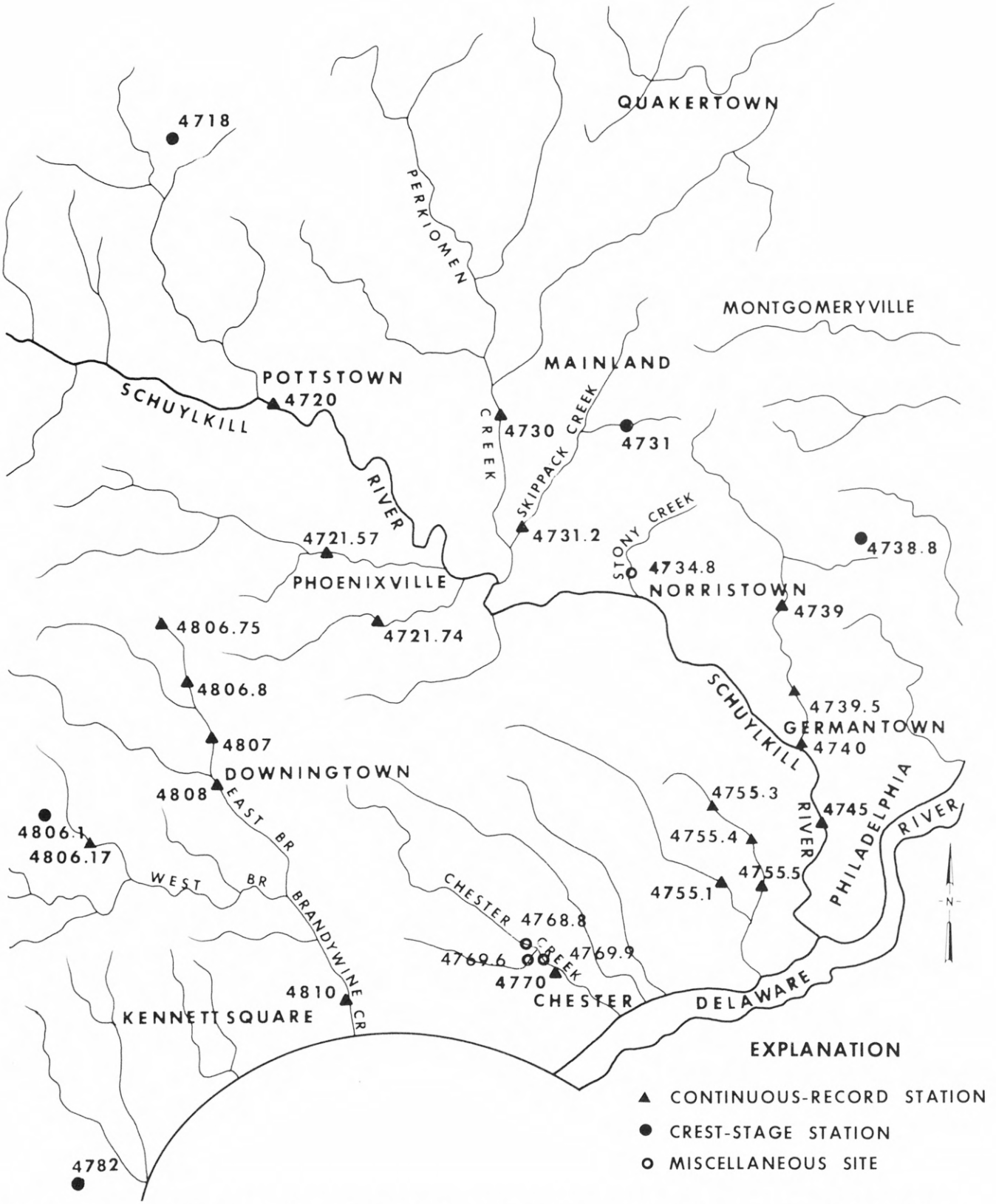


FIGURE 1.--Flood area; location of flood-determination points and precipitation stations at Montgomeryville and Phoenixville, floods of September 13, 1971 in southeastern Pennsylvania (numbers are abbreviated from table 1).

Table 1.--Summary of flood stages and discharges

Station No.	Location	Drainage area (sq mi)	Period of record (water years)	Maximum flood previously known				Maximum during flood of September 1971			
				Date	Gage height (ft)	Discharge cfs	Discharge cfs per sq mi	Date	Gage height (ft)	Discharge cfs	Discharge cfs per sq mi
01471800	Pine C nr Manatawny	15.6	1961-70	2- 7-65	7.30	623	40.0	13	5.62	398	-------
01472000	Schuylkill R at Pottstown	1,147	1927-70	5-23-42	20.15	50,800	44.3	13	7.00	8,380	7.3
				2-28-02	21.0	53,900	47.0				
01472157	French C at Phoenixville	59.1	1969-71	2-13-71	9.63	3,290	55.7	13	9.66	3,330	56.3
01472174	Pickering C nr Chester Springs	5.98	1967-71	8-28-71	4.58	752	126.0	13	4.99	1,640	274.0
01473000	Perkiomen C at Graterford	279	1915-70	7- 9-35	18.26	39,900	143.0	13	14.57	25,300	90.7
01473100	Zacharias C nr Skippack	7.27	1960-70	4- 2-70	8.68	2,890	398.0	13	10.8	10,000	1,376.0
01473120	Skippack C nr Collegeville	53.7	1966-71	8-28-71	13.02	9,740	181.0	13	22.5	40,400	752.0
01473480	Stony C at Norristown	20.8	-------	-------	-----	-------	-----	13	----	13,600	654.0
01473880	Pine Run trib at Ft. Washington	2.01	1962-70	3- 7-67	7.34	300	149.0	13	5.94	83	41.3
01473900	Wissahickon C at Ft. Washington	40.8	1962-69	3- 7-67	12.11	3,490	85.5	13	13.32	4,250	104.0
01473950	Wissahickon C at Bells Mill Rd	53.6	1966-70	3- 7-67	9.52	4,180	78.0	13	10.67	5,460	102.0
01474000	Wissahickon C at Mouth	64.0	1966-70	3- 7-67	6.45	4,310	67.3	13	7.31	5,750	89.8
01474500	Schuylkill R at Philadelphia	1,893	1932-70	8-24-33	14.7	96,200	50.8	13	13.28	74,300	39.2
				3- 1-02	17.0	135,000	71.3	--	-----	------	-------
01475510	Darby C nr Darby	37.4	1964-70	6-12-68	9.12	4,610	123.0	13	8.90	4,370	117.0
01475530	Cobbs C at U.S. Hwy No. 1	4.78	1965-70	7-28-69	6.66	892	187.0	11	6.97	1,040	218.0
01475540	Cobbs C bl Indian Creek	9.65	1965-70	8-23-70	10.09	2,260	234.0	11	11.12	2,920	303.0
01475550	Cobbs C at Darby	22.0	1964-70	6-12-70	7.20	4,380	199.0	11	7.21	4,390	200.0
01476880	E Br Chester C nr Chester Heights	34.3	-------	-------	-----	-------	-----	13	-----	10,900	318.0
01476960	W Br Chester C nr Rockdale	19.0	-------	-------	-----	-------	-----	13	-----	10,100	532.0
01476990	Chester C at Middletown	59.9	-------	-------	-----	-------	-----	13	-----	20,100	336.0
01477000	Chester C nr Chester	61.1	1932-70	6-25-50	16.21	14,400	236.0	13	24.59	21,000	344.0
01478200	M Br White Clay C nr Landenberg	12.7	1960-70	9-12-60	9.41	1,900	150.0	13	7.34	994	78.3
01480610	Sucker Run nr Coatesville	2.57	1964-70	6- 5-70	5.78	590	230.0	13	4.85	250	97.3
01480617	W Br Brandywine C at Modena	55.0	1970	7-31-70	5.82	1,720	31.3	13	5.22	929	16.9
01480675	Marsh C nr Glenmoore	8.57	1967-71	2-13-71	3.73	884	103.0	13	2.54	191	22.3
01480680	Marsh C nr Lyndell	17.8	1960-69	9-12-60	6.32	1,150	64.6	13	5.90	955	53.7
01480700	E Br Brandywine C nr Downingtown	60.6	1966-71	2-13-71	8.49	4,440	73.3	13	6.62	2,610	43.1
01480800	E Br Brandywine C at Downingtown	81.6	1958-68	7- 6-59	8.57	5,180	63.5	--	-----	------	-------
				8- 9-42	12.49	11,900	146.0	--	-----	------	-------
01481000	Brandywine C at Chadds Ford	287	1912-53	3- 5-20	15.0	17,200	59.9	13	14.39	14,300	49.8
			1963-70	-------	-----	-------	-----	--	-----	------	-------

PRECIPITATION

The flooding resulted from a stationary frontal system that produced a succession of intense thunderstorms beginning the morning of September 11 and ending in the afternoon September 13. Small amounts of rain fell September 14 and 15 and may have prolonged the recessions from the crest stages of September 13. Daily rainfall for 41 precipitation stations ranged from a trace of 7.11 inches during the 5-day period. A 5-day total of 12.39 inches for West Chester was the greatest officially reported for the storm. Unofficial sources reported 5-day totals as great as 14 inches for several sites.

Table 2 consists of 5-day rainfall data for the 41 stations. Reported daily rainfalls were adjusted, as necessary, to represent 24-hour periods ending about 0800 on the days indicated.

Isohyetals for the 24-hour rainfall ending about 0800 on September 14 are shown in figure 2. Isohyetals for the 5-day period are shown in figure 3. These isohyetals are based upon the data in table 2 and other information furnished by the Harrisburg office of the National Weather Service.

Table 2.--Rainfall, in inches, for 24-hour period ending at 0300 hours on dates shown.

[National Weather Service, Harrisburg Office]

Station	Rainfall, in inches September 1971 11	12	13	14	15	Total
Allentown-Bethlehem Airport 1/	(2)	1.03	0.92	0.90	0.24	3.09
*Bechtelsville	0.01	1.58	1.62	1.29	.52	5.02
Center Bridge 1/	----	1.55	2.04	.95	.68	5.22
Center Point Southeast	----	----	----	----	----	11.8
Center Point Southwest	----	----	----	----	----	9.0
*Coatesville (Philadelphia Electric Company)	.08	2.60	1.38	1.34	.30	5.70
*Conshohocken (Philadelphia Electric Company)	1.12	3.83	.92	3.73	.23	9.83
*Devault (Turnpike Maintenance)	----	2.60	3.07	5.80	.07	11.54
*Doylestown	1.27	.50	2.86	1.0	----	5.63
Dreshertown	----	----	----	----	----	3.0
Eastern Game Farm	----	----	----	----	----	11.0
Flourtown	.8	4.1	1.8	.9	.3	7.9
Fort Washington	----	----	----	----	----	7.2
*Geigertown	----	2.00	1.14	1.07	(2)	4.21
*Glenmoore	----	1.49	1.63	.97	(2)	4.09
Graterford	----	----	----	----	----	10.4
*Green Lane	.26	1.42	1.25	2.63	.18	5.74
Gwynedd Valley	----	----	----	----	----	8.6
*Honey Brook 1/	.08	2.45	.67	.52	.30	4.02
Lansdale	----	2.78	1.96	6.60	.08	11.42
Longwood Gardens (nursery)	----	2.80	1.80	4.00	.05	8.65
*Maple Glen	.53	.59	3.10	1.10	.25	5.57
Media Water Works	----	3.95	.91	6.38	.05	11.29
Montgomeryville	.2	2.7	2.0	3.3	.2	8.4
*Norristown	.40	2.95	1.38	3.90	.12	8.75
North Philadelphia Airport 1/	----	3.76	1.32	.64	.32	6.04
*Palm	(2)	1.52	1.91	2.00	.14	5.57
*Perkasie	----	2.73	2.25	3.92	.03	8.93
Philadelphia International Airport	1.06	1.94	.71	.94	.13	4.78
*Phoenixville	.28	2.00	1.66	2.73	.20	6.87
*Reading 1/	.08	.85	.82	.53	(2)	2.28
*Sellersville	.05	2.39	2.25	3.62	----	8.31
*Southampton	----	----	----	.73	.38	5.31
Spring House	.08	2.30	1.02	2.20	.26	5.86
Telford	----	.6	5.2	5.3	.1	11.2
Trenton, N.J. 1/	----	2.09	1.25	1.81	.10	5.25
Vernfield	----	----	----	----	----	12.15
Vernfield Northeast	----	----	----	----	----	9.95
*West Chester (Daily Local News)	.10	3.00	2.18	7.11	----	12.39
*Willow Grove Naval Air Station	----	1.40	1.49	1.69	.26	4.84
Wilmington, Del. 1/	.54	1.06	1.81	1.91	.03	5.35

* Official Weather Bureau Station.
1/ Station is not within area of figures 2 and 3.
2/ Trace.

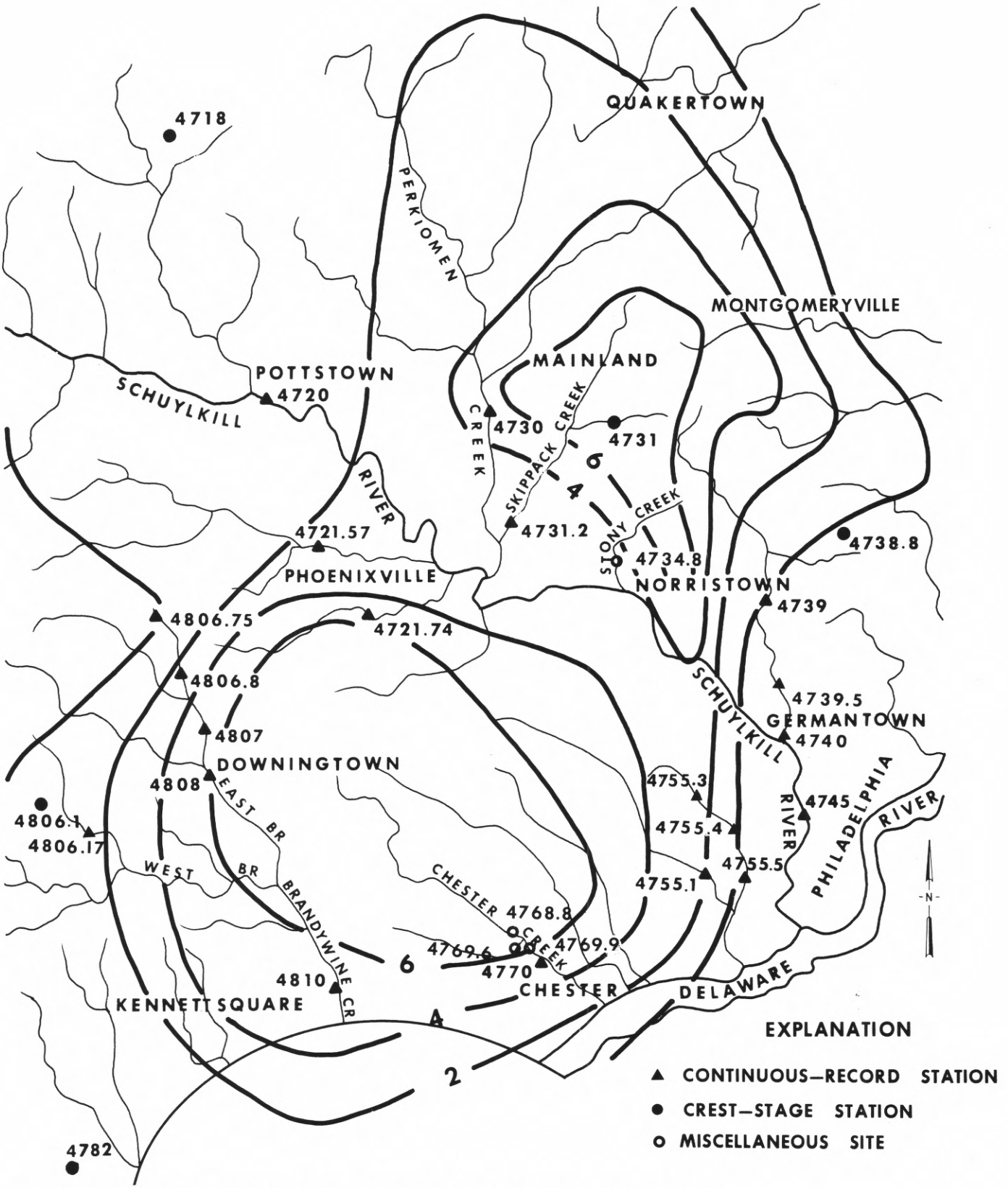


FIGURE 2.--Flood area; location of flood-determination points and isohyets for September 13-14 (24-hour period ending 0800 hours September 14), floods of September 13 in southeastern Pennsylvania.

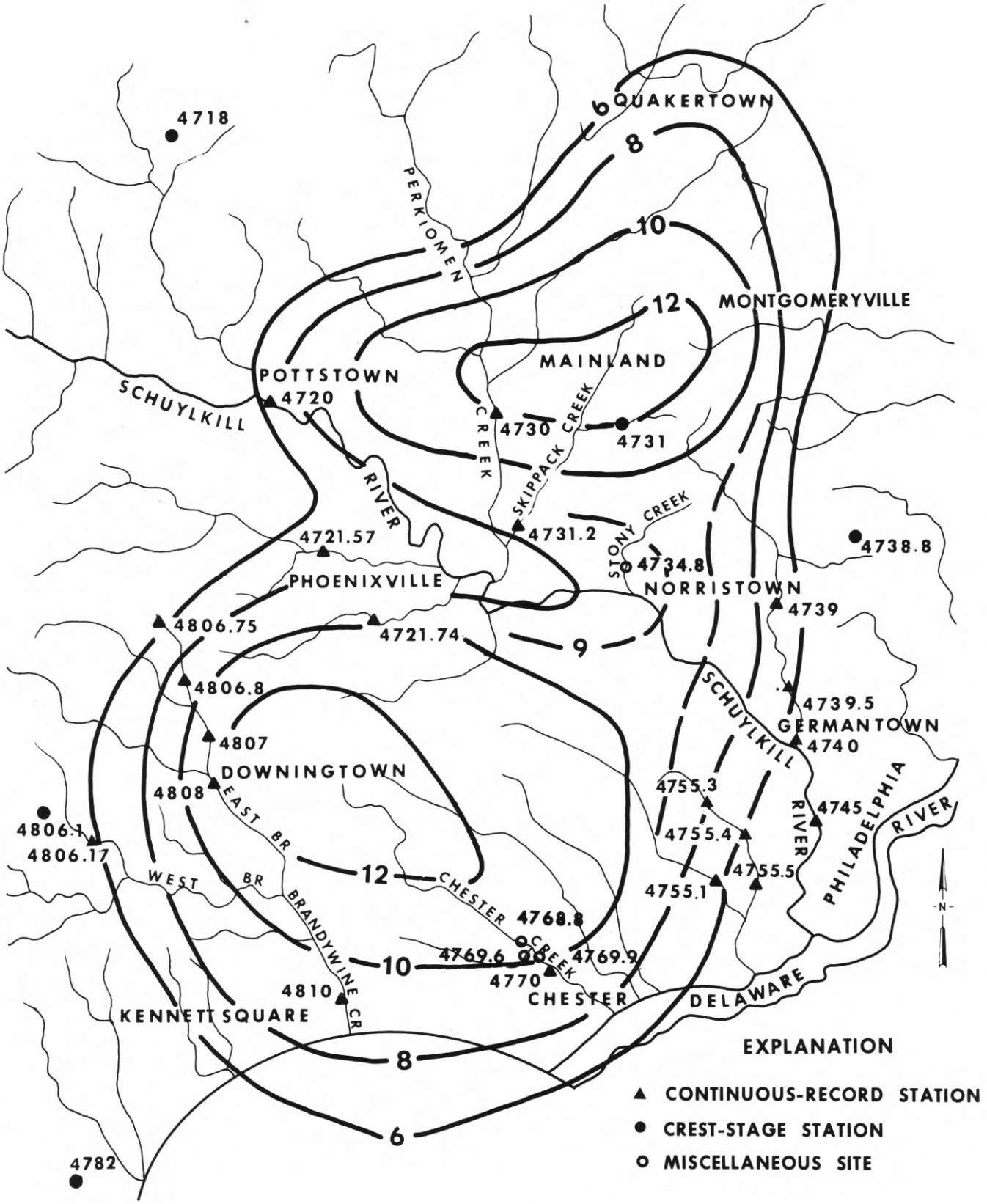


FIGURE 3.-- Isohyetal map of total rainfall, Sept. 11-15, 1971

FLOOD DAMAGES

The Chester and Norristown areas were declared Flood Disaster Areas by the Federal and State Governments.

Chester Creek caused most of the damage done in Chester, and Stony Creek was responsible for much of the damage in Norristown. More than 400 families were driven from their homes. Rescue work by police, firemen and servicemen saved many lives. Others saved themselves by clinging to tree tops until the water receded. One volunteer fireman lost his life when his boat capsized while he was trying to rescue flood victims. Bridges washed out, and roads and railroads were undermined by floodwaters. The water supplies for nearly a dozen communities were dangerously polluted, leaving 115,000 persons without readily available drinking water.

Figures 4 and 5 are photographs of the flood in Chester, and figures 6 and 7 are typical of flood scenes in Norristown.

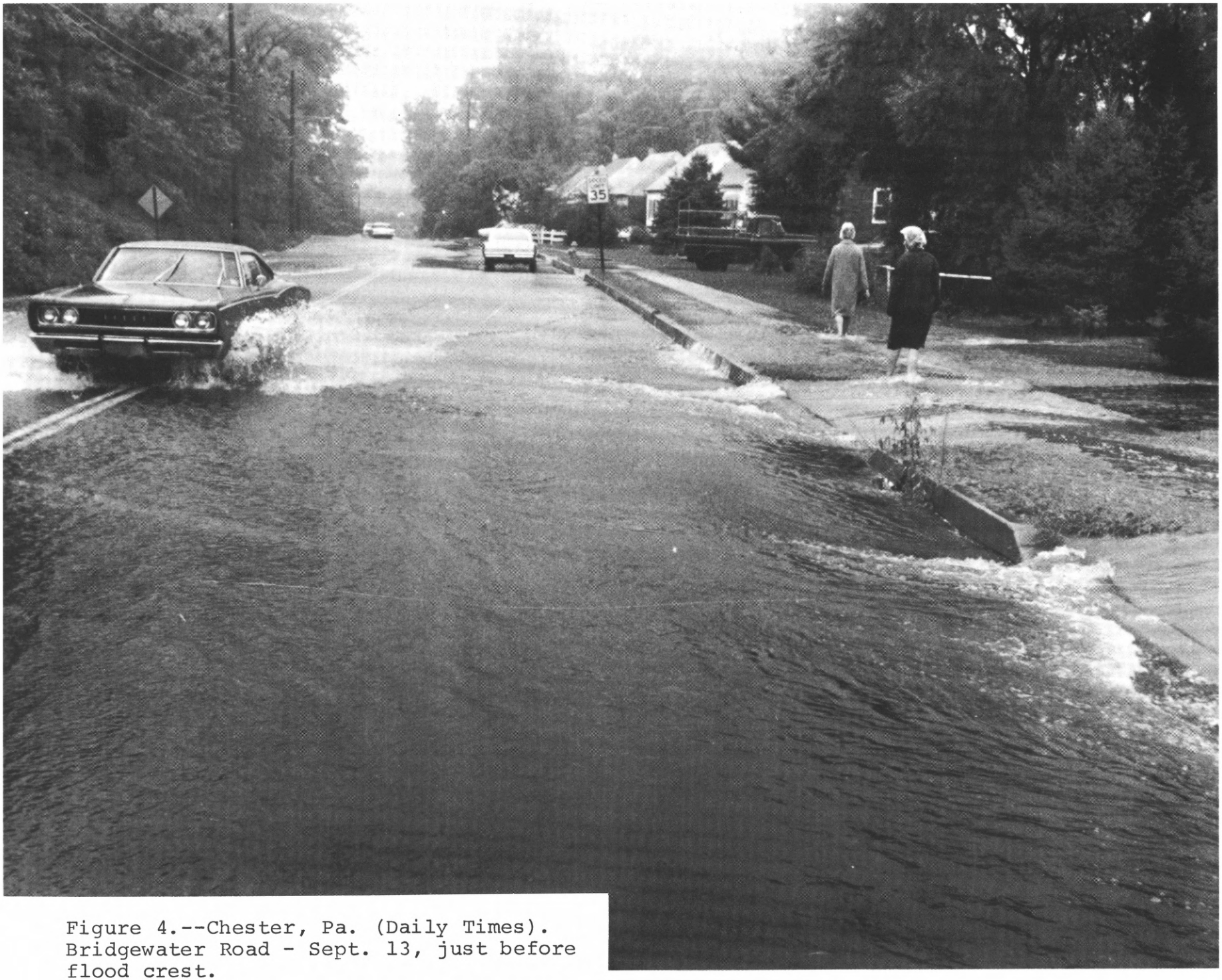


Figure 4.--Chester, Pa. (Daily Times). Bridgewater Road - Sept. 13, just before flood crest.



Figure 5.--Chester, Pa. (Daily Times). 9th Street and Welsh Street - Sept. 13, Pep Boys on right corner and Delaware



Figure 6.--Norristown, Pa.
West Main Street and Markley Street.
(The Times Herald)



Figure 7.--Norristown, Pa. Marshall Street Bridge. (The Times Herald)

DESCRIPTION OF FLOODS

The record-breaking flood of Sept. 13, 1971, in the Chester Creek and Stony Creek basins, occurred on the third day of a 5-day storm. The ground was almost saturated with water at the onset of the September storm, owing to approximately 5 inches of rain that fell August 26-28, as tropical storm Doria passed by the area.

Flood stages on Chester and Stony Creeks exceeded all previous maximums of record. For example, the peak gage height of 24.59 feet on Chester Creek at Chester (station number 01477000), where continuous water-stage records have been collected since August 1931, was 8.38 feet above the previous peak of 16.21 feet. The dates and stages for the ten highest peaks at the Chester Creek gaging station during 1932-70 shown in table 3.

Table 3.--Stages of ten highest floods on Chester Creek at Chester (01477000) 1932-70

Date	Stage	Elevation above mean sea level (ft)
Nov. 25, 1951	16.21	39.62
Sept. 12, 1960	13.89	37.30
July 28, 1969	13.66	37.07
Aug. 18, 1955	13.57	36.98
Aug. 23, 1933	11.48	34.89
July 23, 1938	10.57	33.98
Jan. 9, 1936	10.50	33.91
Aug. 3, 1950	10.48	33.89
Mar. 15, 1940	10.26	33.67
Aug. 1, 1945	9.98	33.39

The peak discharge of 344 cfs (cubic feet per second) per square mile at the Chester Creek gaging station was nearly 50 percent greater than the previous maximum discharge of 236 cfs per square mile, in November 1951. The Chester Creek basin has a drainage area of 66.4 square miles, 61.1 square miles of which lies upstream from the Chester gaging station.

In the Chester area, time-stage distributions of Darby and Chester Creeks followed nearly identical patterns on September 11-12, but the peak produced on Chester Creek by the rainfall of September 13 was considerably higher than the corresponding peak on Darby Creek, as shown by the hydrographs in figure 8. None of the hourly rainfall data available correlated well with the stages on these two streams.

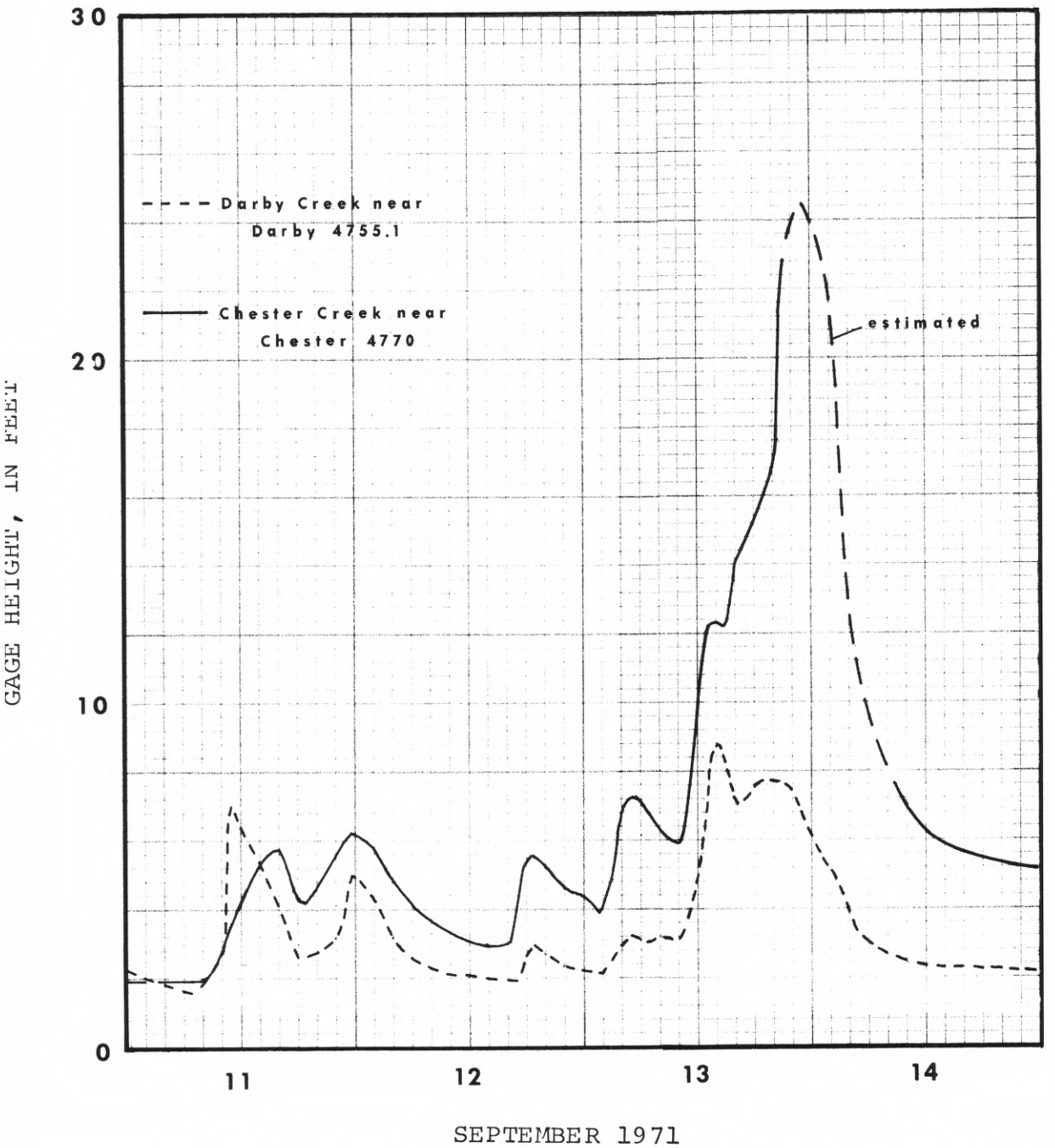
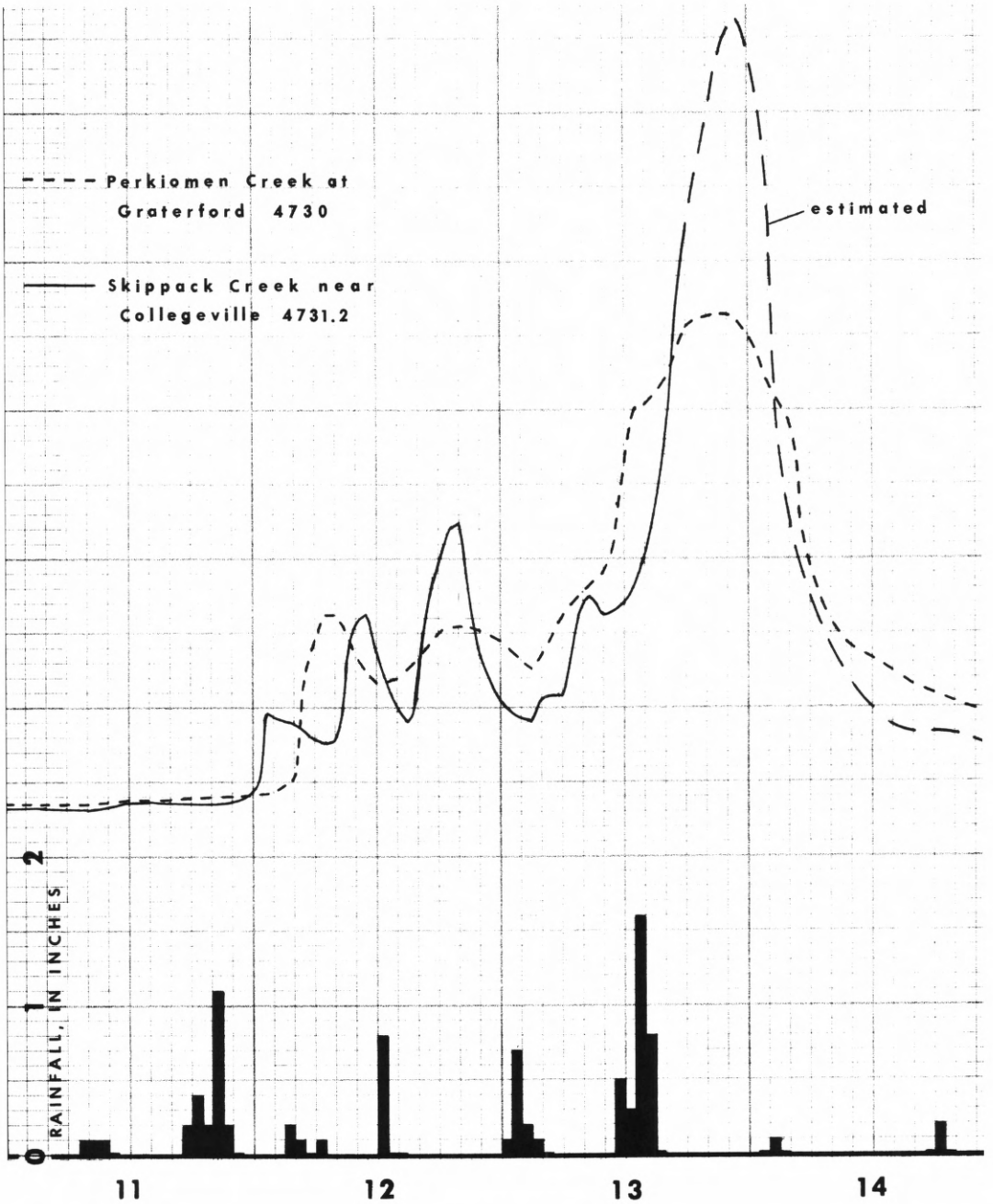


FIGURE 8.--Stage hydrographs from gaging stations on Darby and Chester Creeks, Sept. 11-14, 1971.

Flood stages in the Skippack Creek basin were much higher than any others in the past 40 years or more. The peak unit discharges at the gaging stations on Zacharias Creek (01473100) and Skippack Creek (01473120) were the highest recorded for the storm. (See table 1.)

Figure 9 shows the flood hydrograph for the Skippack Creek gaging station, as well as that for Perkiomen Creek at Graterford (01473000), and the corresponding hourly rainfall at Montgomeryville. No stage record is available for Stony Creek, but the time distribution of flood heights on this stream was probably similar to that on Skippack Creek.

The peak discharge of Stony Creek at the Elm and Markley Streets bridge in Norristown was computed by a contracted-opening method. The peak discharge of 13,600 cfs corresponds to 654 cfs per square miles for the 20.8 square miles upstream from this site.



SEPTEMBER 1971

9.--Stage hydrographs from gaging stations on Perkiomen and Skippack Creeks and corresponding rainfall at Montgomeryville, Sept. 11-14, 1971.

Figure 10 shows stage hydrographs recorded at the French Creek (01472157) and Pickering Creek (01472174) gaging stations, which are near the center of the study area. These two streams exhibited very similar responses to the rainfall of September 13.

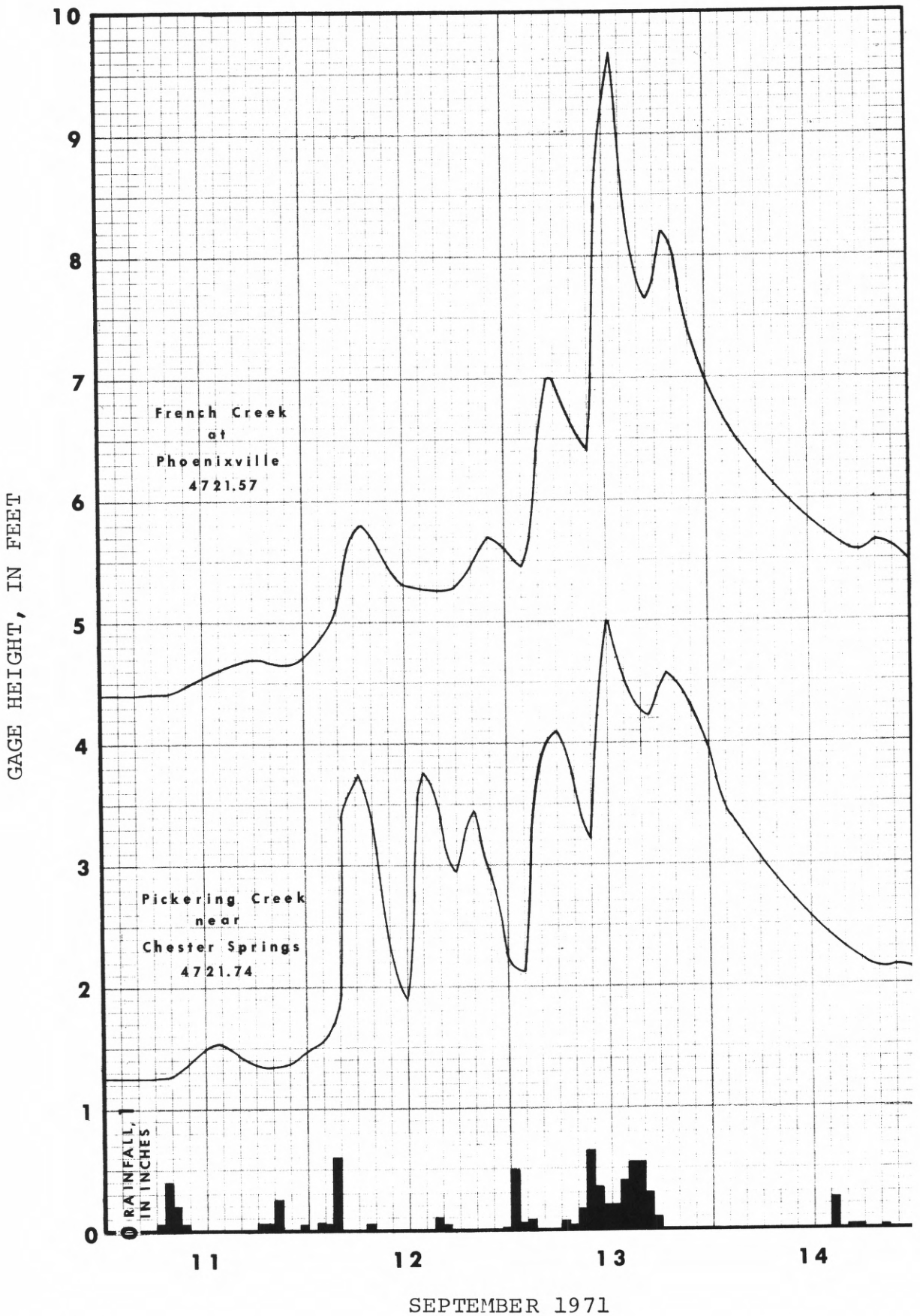


Figure 10.--Stage hydrographs from gaging stations on French Pickering Creeks and corresponding rainfall at Phoenixville, Sept. 11-14, 1971

FLOOD FREQUENCY

Flood discharge (or stage) is related to recurrence intervals by means of a flood-frequency curve. The recurrence interval is the average interval of time within which a flood of a given magnitude will be exceeded once. For example, a 25-year flood is exceeded once in 25 years, on the average; no regularity of occurrence is implied.

Flood-frequency curves were prepared, by means of the log-Pearson Type III analysis of historical flood records, for three streams in the study area for which long-term flood records are available. The results of these analyses are given in figure 11. The recurrence interval for a peak of the 1971 magnitude on Chester Creek, which had a much higher peak unit runoff than either Perkiomen or Brandywine Creeks (table 1), is estimated to be over 100 years. The recurrence intervals for the 1971 peaks on other severely flooded streams, such as Zacharias, Skippack, Stony, and West Branch Chester Creeks, were probably also in excess of 100 years. The records for these streams are not of sufficient length to make reliable estimates of the respective recurrence intervals.

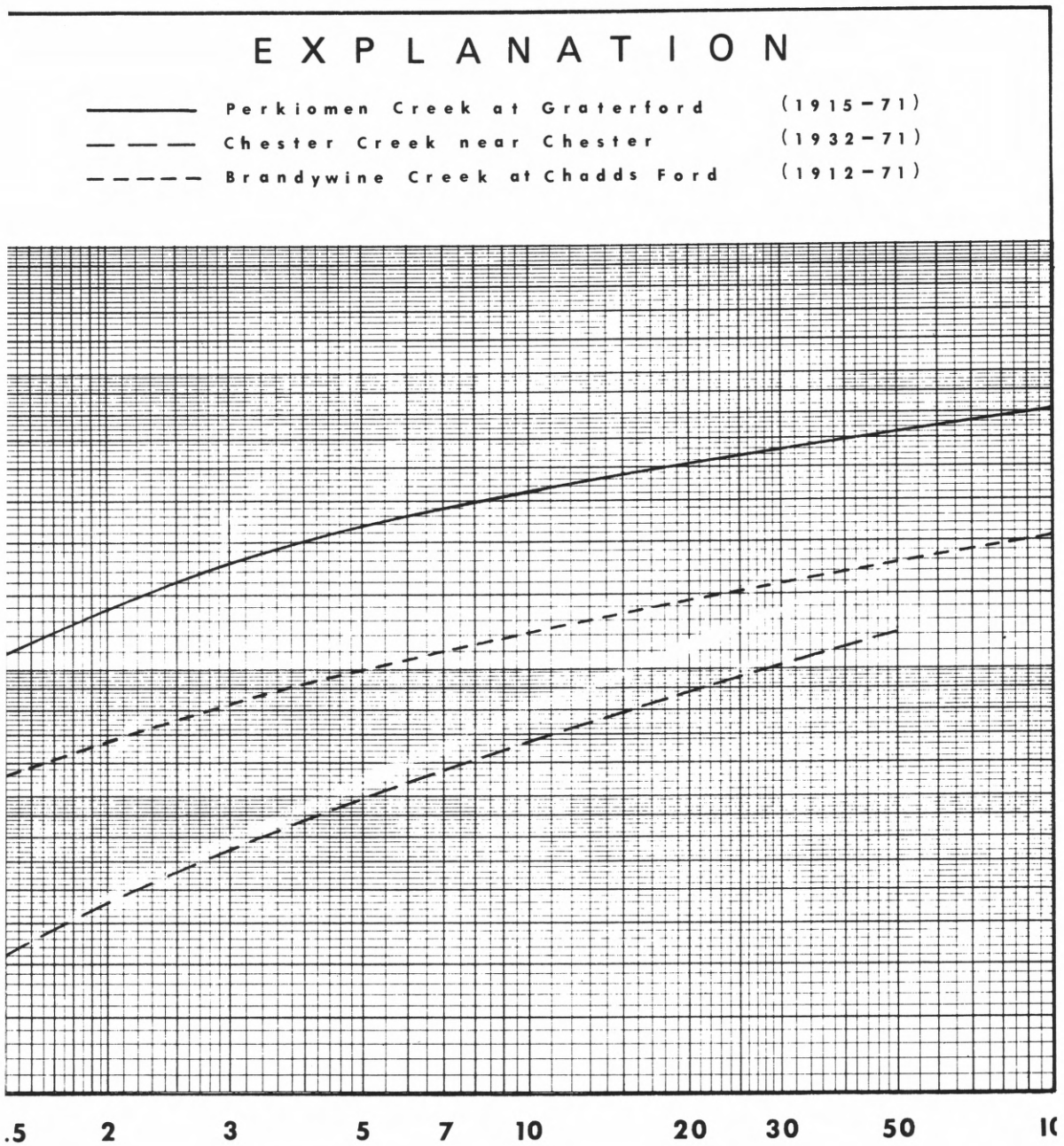


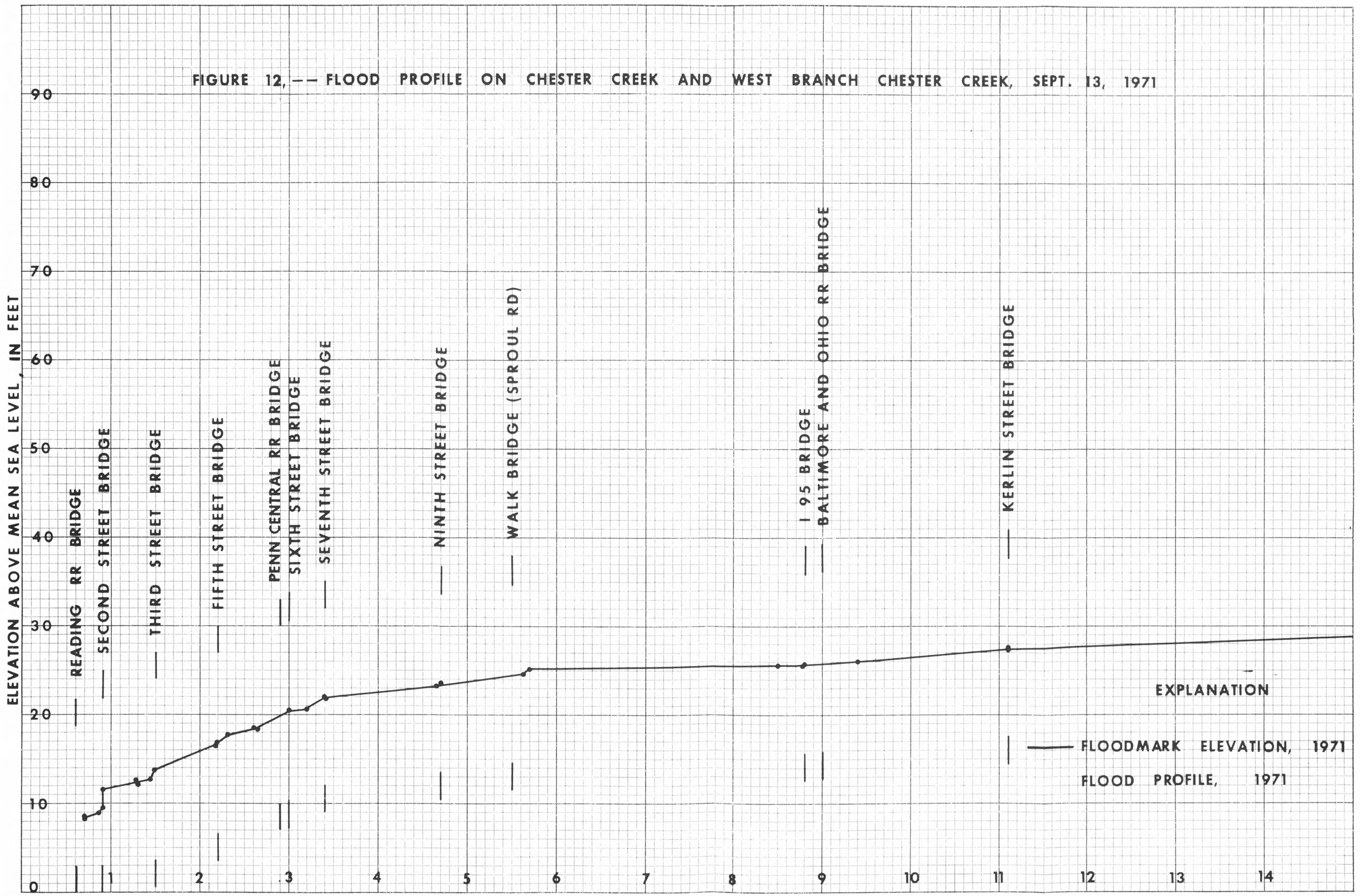
FIGURE 11.--Flood-frequency relations for selected stream-gaging sites.

STREAM PROFILES

Flood marks were surveyed along Chester and Stony Creeks. Profiles of the water surface for Chester Creek in figure 12 are shown (in four parts) for the reach from 700 feet to 56,700 feet upstream from the mouth. The profile for the lower 3,000 feet of West Branch Chester Creek is also in figure 12. The profile for Stony Creek in figure 13 is shown (in four parts) for the reach from 575 feet to 6,200 feet upstream from the mouth.

The flood gradients of both Chester and Stony Creeks exhibit marked increases in slope in the urbanized lower reaches of the floodways. These changes in gradient, which are most pronounced at bridges, suggest that bridges, buildings, and other structures create a considerable amount of backwater.

FIGURE 12, -- FLOOD PROFILE ON CHESTER CREEK AND WEST BRANCH CHESTER CREEK, SEPT. 13, 1971



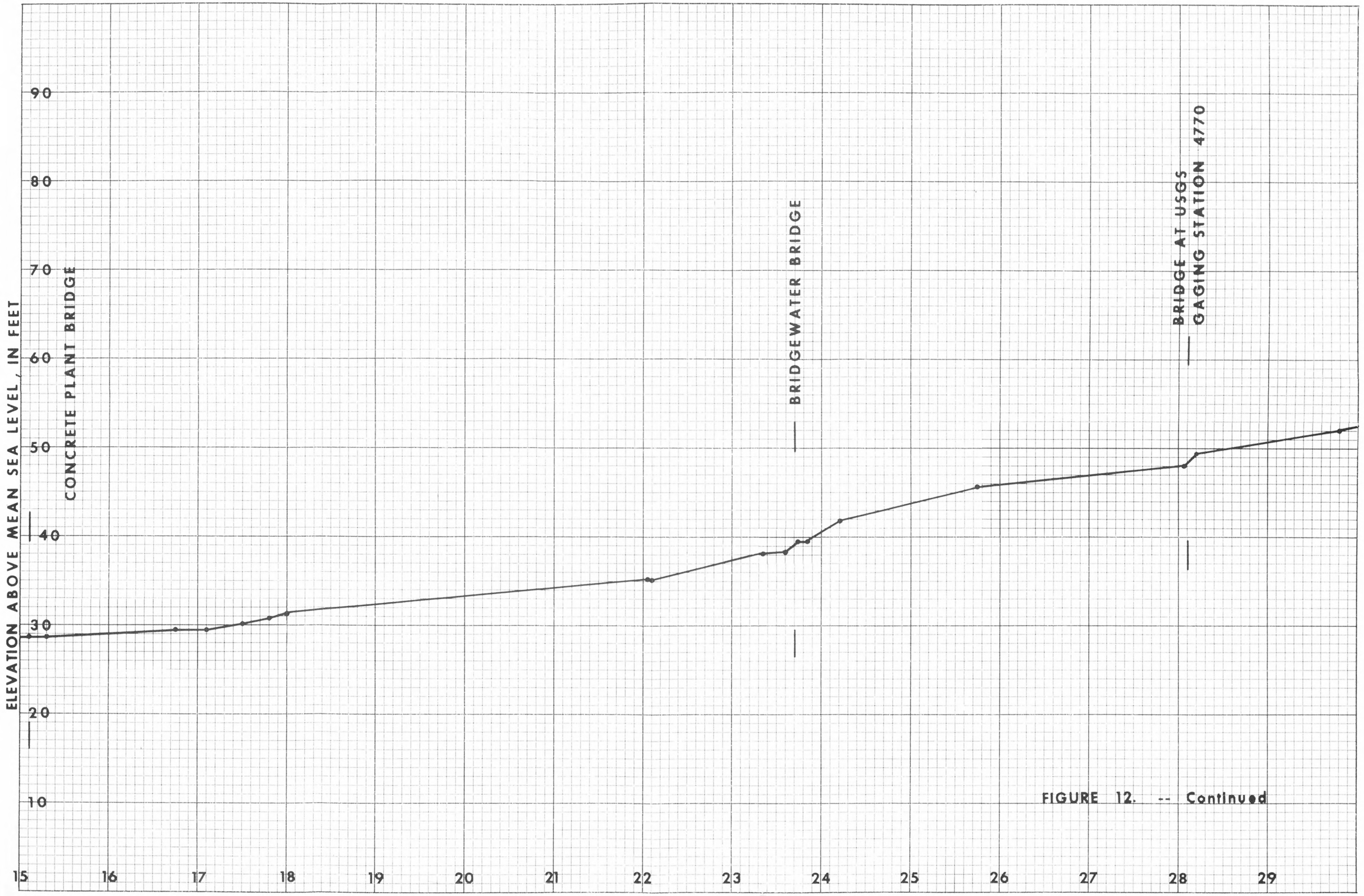


FIGURE 12. -- Continued

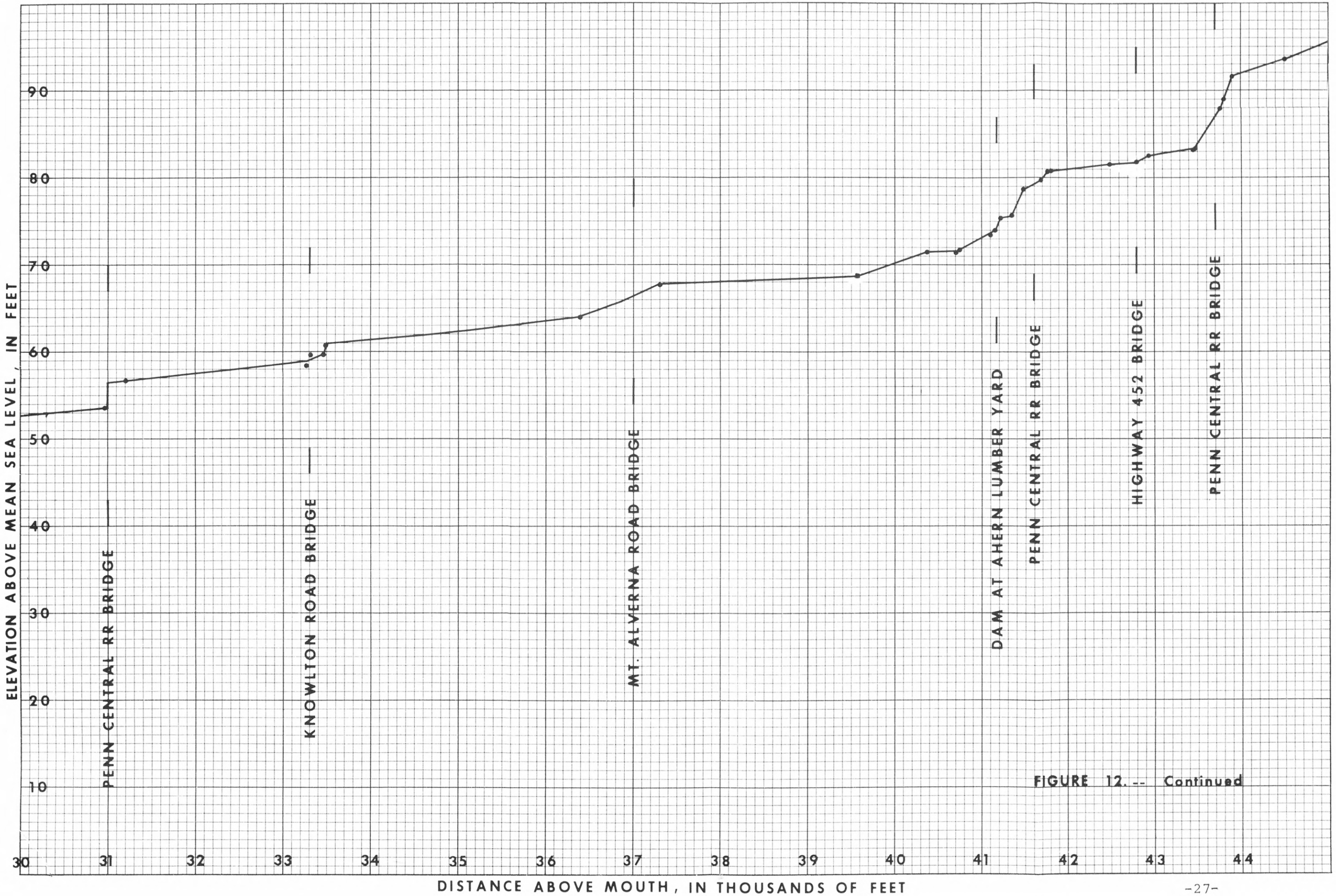


FIGURE 12. -- Continued

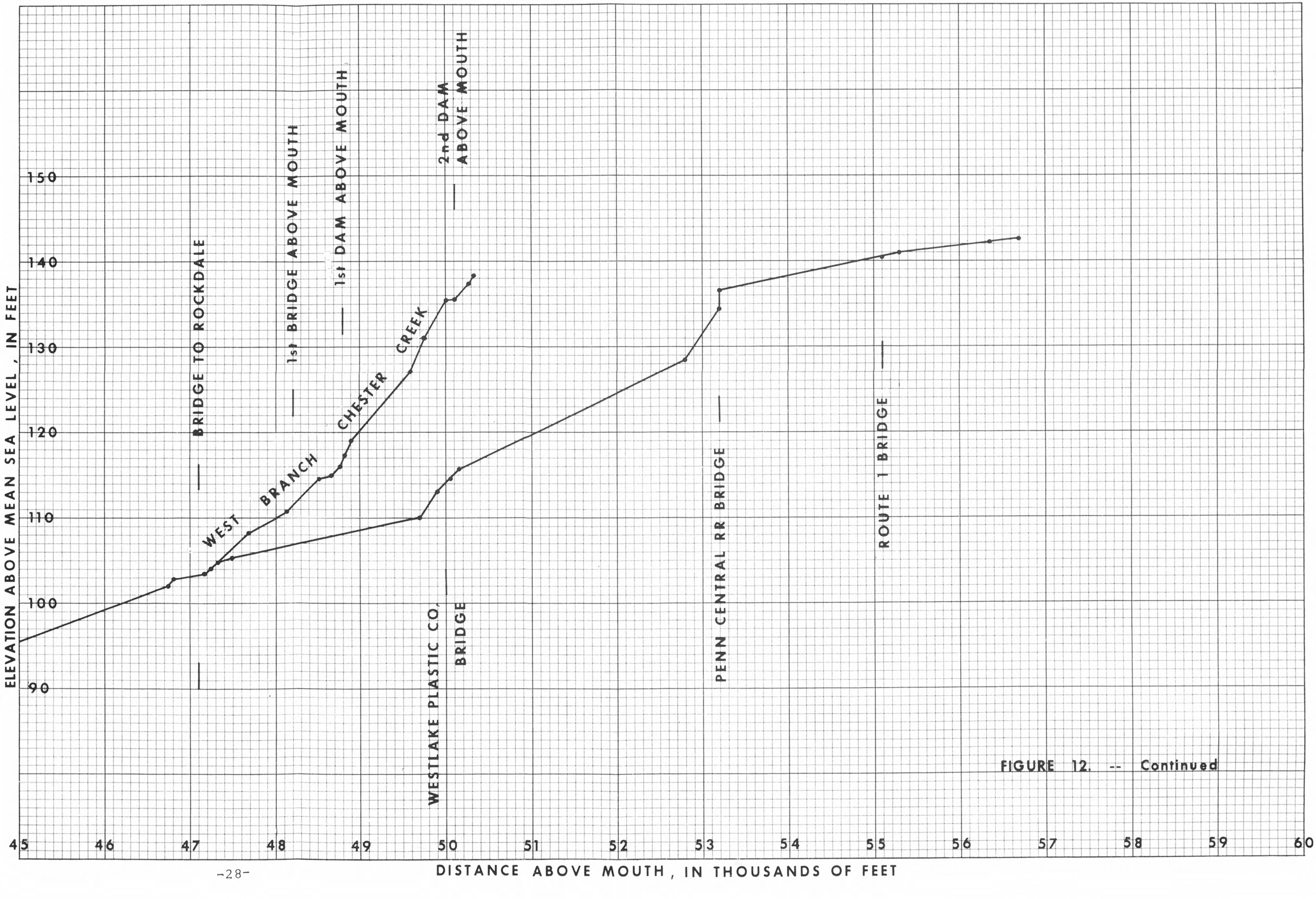
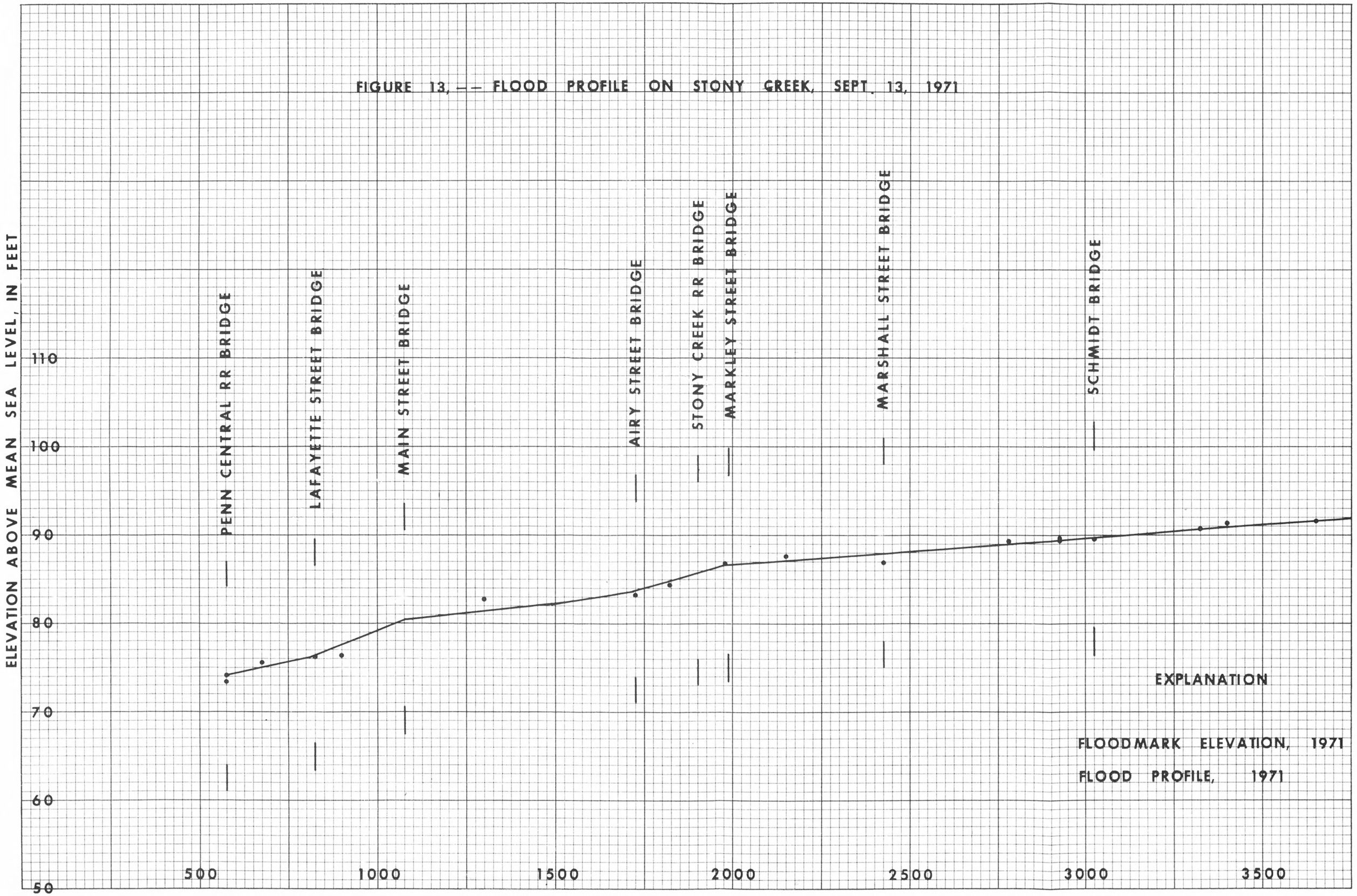


FIGURE 12. -- Continued

FIGURE 13. -- FLOOD PROFILE ON STONY CREEK, SEPT. 13, 1971



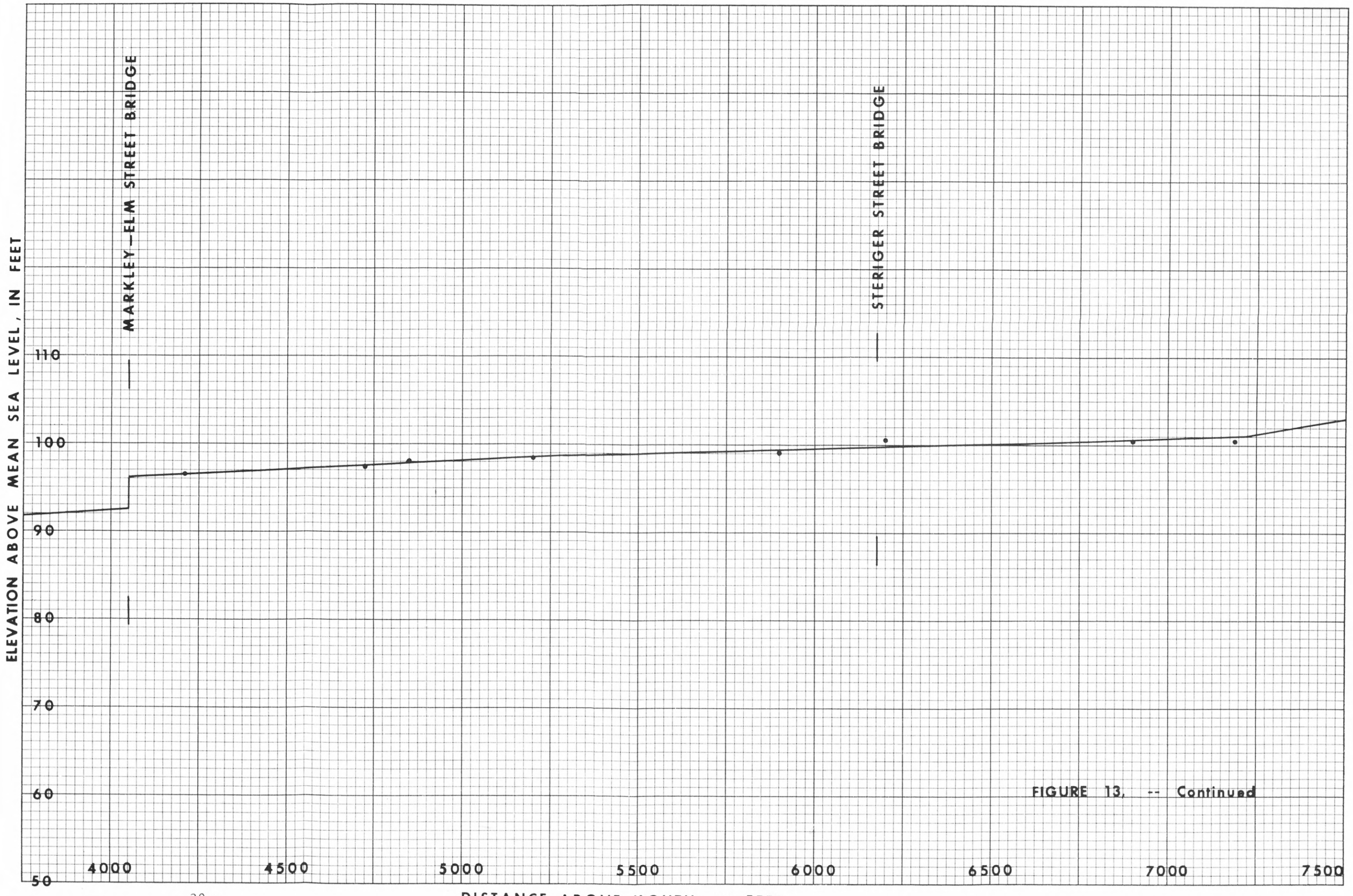


FIGURE 13. -- Continued

ELEVATION ABOVE MEAN SEA LEVEL, IN FEET

130
120
110
100
90
80

7500 8000 8500 9000 9500 10000 10500 11000

DISTANCE ABOVE MOUTH, IN FEET

FIGURE 13. -- Continued

ELEVATION ABOVE MEAN SEA LEVEL, IN FEET

140

130

120

110

100

90

11500

12000

12500

13000

13500

DISTANCE ABOVE MOUTH, IN FEET

FIGURE 13. -- Continued

CONCLUSIONS

The floods of Sept. 11-14, 1971, in southeastern Pennsylvania resulted from unusually heavy rainfall in Chester, Delaware, and Montgomery Counties. Because of the irregular time distribution and intensity of this rainfall, hydrographs for streams in nonadjoining basins exhibit marked differences. Streams with small to moderate drainage areas where more severely flooded than larger streams. The flood heights attained by some streams are expected to recur once in 100 years or more, on the average.

Flood profiles for Chester Creek in Chester and for Stony Creek in Norristown suggest that flood heights on these streams are increased by backwater caused by various structures.