204

GEOLOGICAL SURVEY CIRCULAR 204

FLOODS IN YOUGHIOGHENY AND KISKIMINETAS RIVER BASINS PENNSYLVANIA AND MARYLAND

FREQUENCY AND MAGNITUDE

Prepared by Water Resources Division

UNITED STATES DEPARTMENT OF THE INTERIOR
Oscar L. Chapman, Secretary

GEOLOGICAL SURVEY
W. E. Wrather, Director

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Prepared in cooperation with the
Pennsylvania State Department of Forests and Waters

Washington, D. C., 1952

Free on application to the Geological Survey, Washington 25, D. C.

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INTRODUCTION

Engineers have long appreciated the fact that it is seldom economically sound to design hydraulic structures either for the maximum previous floods or for the computed maximum probable floods, unless failure of such structures involves loss of life or serious property damage. Such floods may not occur more often, on an average, than once in a hundred or possibly even several thousand years. In planning sound design for structures, such as culverts or bridges, which may involve flood frequencies of only 10 to 50 yr, the factors of economics and useful life of the structure should be considered.

In the past, records of streamflow have been so meager and of such short duration that little reliable information could be obtained on the magnitude and frequency of floods in any particular region. As a result it has been the tendency of engineers to overdesign, often causing needless expenditure.

The accumulation of reliable streamflow records over a relatively long period now permits satisfactory studies of flood probabilities in many regions.

This report presents a method, based on actual flood data, for obtaining the magnitude and frequency of floods at any place in the watersheds of the Youghiogheny and Kiskiminetas River basins, an area comprising 3,651 sq mi in the upper Ohio River basin of western Pennsylvania and Maryland.

The data contained in this report were compiled and prepared for publication under a cooperative agreement on water resources investigations between the Pennsylvania Department of Forests and Waters, and the Water Resources Division, U. S. Geological Survey. J. W. Mangan directs the surface-water investigations in Pennsylvania for the U. S. Geological Survey. The data presented in this report were analyzed, and the text prepared, by the Pittsburgh suboffice, Max Noecker, engineer-in-charge, in collaboration with engineers of the Water Resources Division, U. S. Geological Survey, Washington, D. C.

METHOD

With streamflow records available for gaging stations located on various sized watersheds in the area, the study resolved itself into two parts: the determination of the flood-frequency characteristics of the region expressed as a curve in terms of the ratio of a given flood to the mean annual flood, and the definition of a curve of mean annual flood expressed as a function of the drainage area. With these known factors, it is possible to compute the magnitude-frequency relation of floods at any location in the region.

RECORDS AVAILABLE

All gaging-station records of sufficient length in the two river basins in which the peaks are not seriously affected by artificial regulation were used in this study. These stations all located in Pennsylvania, are:

1. Stony Creek at Ferndale.
2. Conemaugh River at Seward.
3. Conemaugh River at Tunnelton.
4. Kiskiminetas River at Avonmore.
5. Little Conemaugh River at East Conemaugh.
6. Blacklick Creek at Blacklick.
7. Loyalhanna Creek at Kingston.
8. Loyalhanna Creek at New Alexandria.
9. Youghiogheny River at Ohiopyle.
10. Youghiogheny River at Connellsville.
11. Youghiogheny River at Sutersville.
12. Casselman River at Markleton.
13. Big Piney Run near Salisbury.
14. Laurel Hill Creek at Ursina.
15. Green Lick Run at Green Lick Reservoir.

The locations of these stations are shown on the map presented as figure 1.

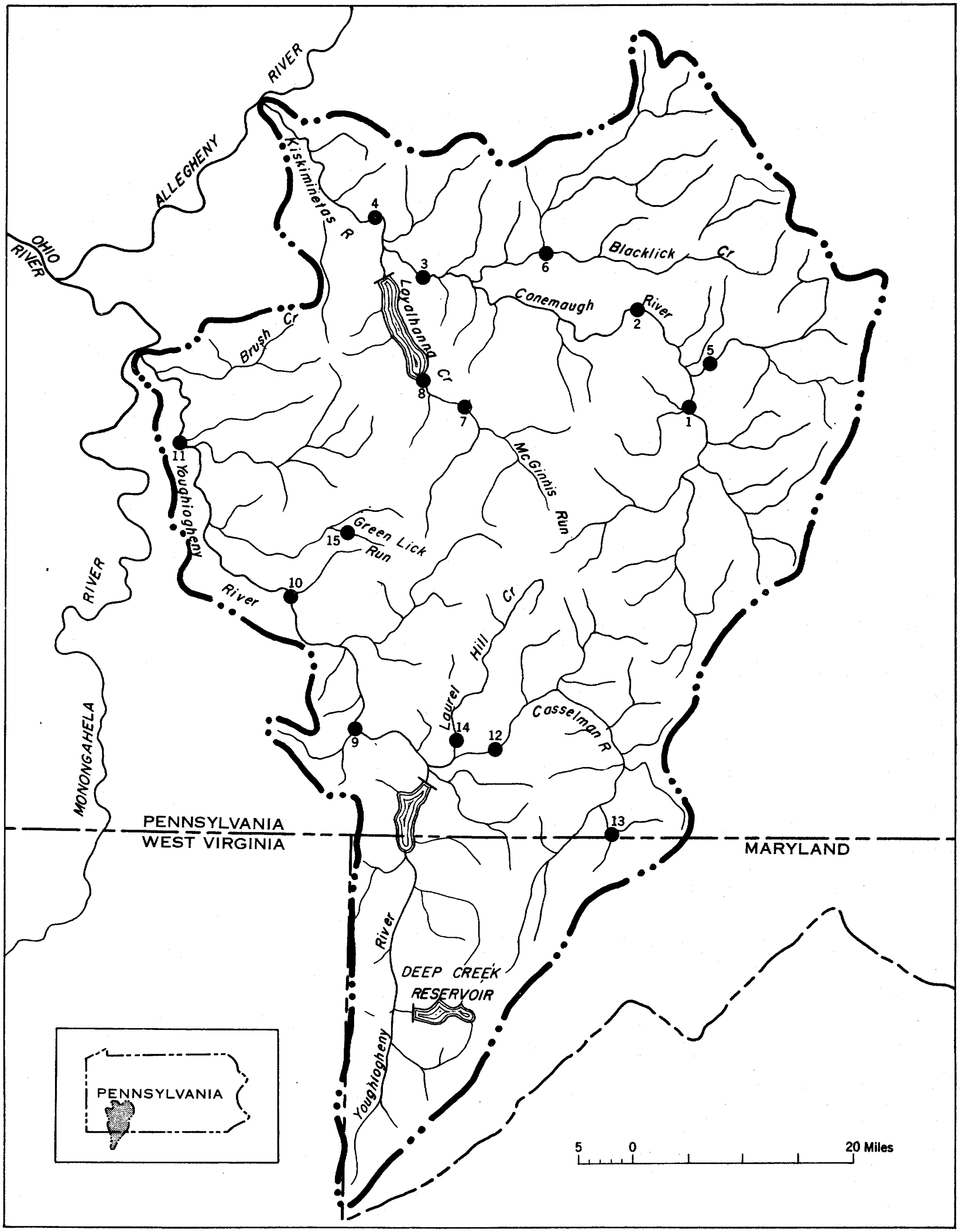

Figure 1.--Map showing location of gaging stations included in this report.

Records for the following stations, operated presently or in the past within this area, have not been used in this report:

Casselman River at Confluence, Pa.,
Laurel Hill Creek at Confluence, Pa.,
Youghiogheny River at Youghiogheny River Dam, Pa.,
Casselman River at Grantsville, Md.,
Youghiogheny River at Oakland, Md.,
Youghiogheny River at Friendsville, Md.

The first three stations listed were not used because they were affected by backwater for the greater part of the time. The records at the remaining stations were of too short duration to obtain satisfactory correlations with other stations necessary to extend them to the length of the base period. (See Adjustment to base periods.)

Whenever possible, gaging-station records were supplemented by historical flood data obtained prior to the systematic collection of stream-gaging records.

Tabulations of the momentary peak stages and discharges at gaging stations during each "water year" of record are presented in the last section of this report. The water year extends from October 1 to September 30.

FLOOD-FREQUENCY RELATIONSHIPS

Analysis of flood data

In developing flood-frequency relationships in this report, the annual-flood method was used. By this method each flood has been treated as an independent event, and only the maximum momentary discharge occurring in each water year of record was used.

An objection often raised to the annual-flood method is that it utilizes only one flood in each year and may discard one or more floods that occurred during the year that may be higher than some of the annual floods in other years. This objection is met by the partial-duration-series method in which all floods are listed above a selected base irrespective of the number of floods occurring in any time period. This method involves the difficulty that flood peaks occurring close together may not be independent events, and some arbitrary criterion must be set up for separating such peaks.

The methods used for analysis are statistical, and a "complete" series such as the annual-flood series can be treated by a rigid statistical method.

The partial-duration-series method tells how often, on the average, a given flood will occur; the annual-flood method tells how often, on the average, it will occur as an annual peak.

The following table[1] gives the comparative values of the recurrence intervals, in years, by the two methods. Both methods give essentially the same results for recurrence intervals greater than 10 yr.

Annual floods	Partial-duration-series
1.16	0.5
1.58	1.0
2.00	1.45
2.54	2.0
5.52	5.0
10.5	10
20.5	20
50.5	50
100.5	100

Plotting positions

In analyzing the relation between frequency and magnitude of floods, the discharges were arranged by number in order of magnitude. Appropriate recurrence intervals were then assigned to each flood, depending upon the order number, the period of record, and any additional historical information indicating the frequency of recurrence.

Recurrence intervals were computed from the formula $(N+1)/M$, where N equals number of years of record and M equals the order of relative magnitude of the event beginning with the highest as one. In the case of a historical flood, N is the number of years during which it is known that the flood was of the order assigned. This formula, adopted by the Geological Survey, is simple to compute, is applicable both to annual-flood data and the partial-duration series, and gives results acceptably in conformance with some of the latest theories.

Annual floods were plotted on a special form[2] developed for analysis of flood frequencies by the theory of extreme values.[3] On the basis of this theory the discharge at a recurrence interval of 2.33 yr is the same as the arithmetical mean of an infinitely long series of annual floods and is known as the "mean annual flood." As generally is done with relatively short series, such as are treated here, the value of the discharge at a recurrence interval of 2.33 yr has been picked graphically from a flood-frequency curve and used as the mean annual flood.

Adjustment to base periods

Figure 2 shows graphically the length of usable records in the two basins. In order to combine records, it is necessary for them to be on the same time basis. The longer the time basis, the more reliable is the resulting frequency curve. The longest continuous record, Youghiogheny River at Ohiopyle (Confluence), Pa., began in 1873; the next longest, Kiskiminetas River at Avonmore, Pa., began in 1884. The objective of this study was to obtain a composite frequency curve for the 67-yr period, 1884-1950. The procedure adopted, using all available data, was to compute the annual-flood figures for years of missing record for all stations. After computing them, they were not used directly as peak discharges for those years but were used indirectly so as to obtain values for the mean annual flood based on a

1 Langbein, W. B., Annual floods and the partial-duration flood series, Amer. Geophys. Union, Trans., vol. 30, p. 879, 1949.

2 Powell, R. W., A simple method of estimating flood frequency, Civil Eng., pp.105-106, Feb. 1943.

3 Gumbel, E. J., Floods estimated by the probability method, Eng. News-Record, June 14, 1945.

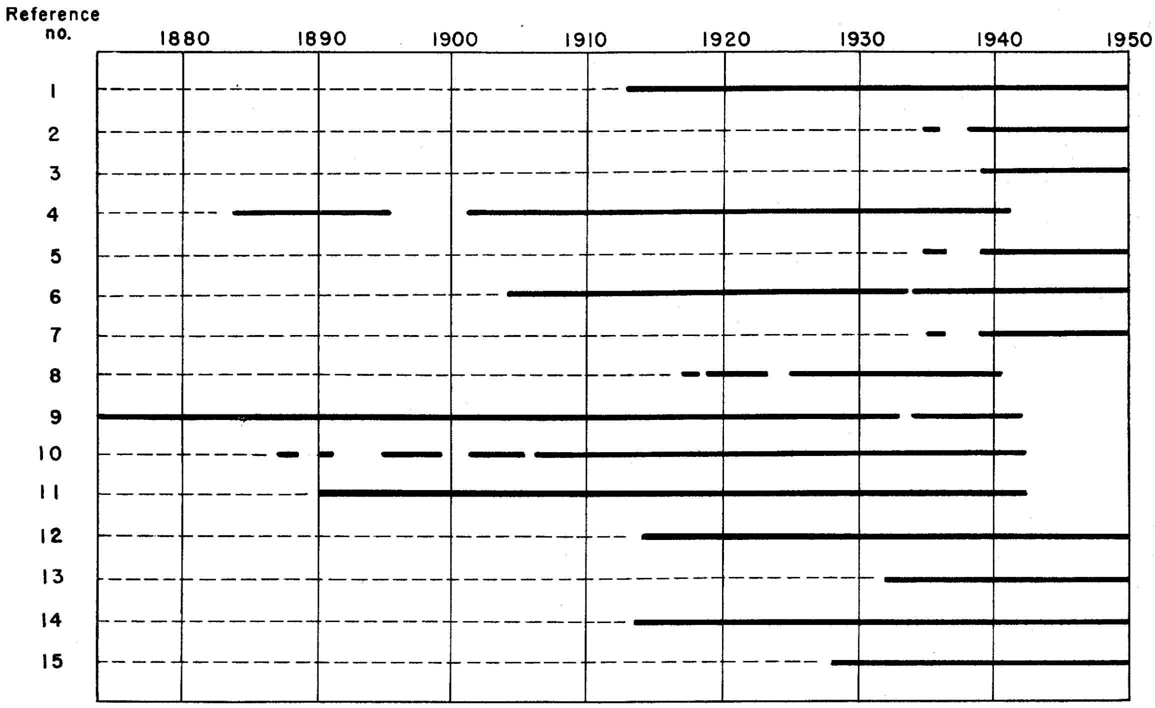

Figure 2.--Period of record of maximum annual peaks at gaging stations.

uniform time period and the correct order numbers in the base period for the actual known peaks.

In this report it did not appear feasible to fill in or extend all records back to 1884. Only five records, those for Avonmore, Blacklick, Ohiopyle, Connellsville, and Sutersville, were used for the period 1884-1950. All others were used for the period 1914-50. The initial procedure was to work up composite frequency curves for all stations for the base period 1914-50, the five long-term stations for the base period 1884-1950, and the five long-term stations for the shorter period 1914-50.

Test for homogeneity

A test for homogeneity was applied to the individual station records in order to assure that all records represent part of a region having uniform frequency characteristics. This is a statistical test applied to the slopes of the individual frequency graphs to determine whether deviations from an average slope are such as may be due to chance alone. The graphs were those for all stations for the 1914-50 period and the five long-term stations for the 1884-1950 period. The graphs were drawn using only peaks of actual record, with order numbers based on a complete listing as described in the preceding section. The test showed all records to be homogeneous for both base periods.

Median flood ratios

In order to compare floods at different stations and combine them to define composite relationships, it was necessary to convert them to a dimensionless basis. This was done by expressing each flood as a ratio to the mean annual flood for the particular station, derived for a definite base period. The mean annual floods for the base periods were determined from the individual frequency graphs described in the preceding section.

Tables 1 and 2 list by order number and station the peak floods of only those years for which there is actual record, expressed as a ratio to the mean annual flood. For the period 1914-50, table 1 shows the medians for each order of flood computed for all stations and for the five stations with long-term record. In table 2, medians were computed for each order of flood for the 67-yr stations.

Composite flood-frequency graphs

In figures 3 to 5 the median ratios from tables 1 and 2 were plotted against the recurrence intervals for the corresponding order numbers. Average frequency curves were drawn. It will be noted that the composite curve for all stations, 1914-50 (fig. 3), is identical with that for the five index stations, 1914-50 (fig. 4). For this reason the long-term composite frequency curve (fig. 5), as defined by the five index stations, can be taken to represent the frequencies for the period 1884-1950 for all stations. If the curves of figures 3 and 4 had not coincided, it would have beem necessary to compute a new curve from the curve of figure 5 by ratios representing the differences between the first two curves at specified recurrence intervals.

Table 1.-- Ratios to mean annual floods, base period 1914-50

Order no.	Station no. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Recurrence interval	All Stations: Number of items	All Stations: Median	Stations 4, 6, 9, 10, 11: Number of items	Stations 4, 6, 9, 10, 11: Median
1	5.36	4.74		4.40	4.61	4.50	3.50	4.19	3.12	2.94	2.62	3.20	4.06	2.12	5.00	38.0	14	4.12	5	3.12
2	2.30		1.74	1.74	1.89	1.87		2.16	3.08	2.67	2.07	2.20	3.87	1.94	2.11	19.0	13	2.11	5	2.07
3	2.17	1.84	1.64			1.70		1.89	2.06	2.02	2.04	2.04	3.26	1.67	1.95	12.7	12	1.98	4	2.03
4	2.05	1.59	1.56			1.61	1.55		1.54	1.75	1.54	1.67		1.34	1.88	9.50	11	1.59	4	1.58
5	1.93			1.50	1.50	1.57	1.52		1.54	1.59	1.37	1.45	1.79	1.24	1.86	7.60	12	1.53	5	1.54
6	1.91	1.48		1.35		1.50	1.45		1.40	1.54		1.45	1.75	1.23	1.81	6.33	11	1.48	4	1.45
7	1.56	1.39		1.31		1.33	1.36	1.35	1.38	1.52		1.45		1.23		5.43	10	1.37	4	1.36
8	1.52			1.25		1.30	1.26	1.31	1.34	1.42	1.30	1.40		1.20		4.75	10	1.30	5	1.30
9	1.37			1.25	1.20	1.30	1.26		1.23	1.33	1.30	1.37		1.17	1.19	4.22	11	1.26	5	1.30
10	1.32		1.24	1.18		1.30			1.17	1.27	1.28	1.18	1.42	1.16		3.80	10	1.26	5	1.27
11	1.24	1.16	1.20	1.16		1.24			1.14	1.21	1.16	1.17		1.16		3.45	10	1.16	5	1.16
12	1.15			1.15	1.19	1.22					1.12	1.12	1.22	1.16		3.17	8	1.16	3	1.15
13	1.13					1.19		1.24	1.11	1.17	1.10	1.12	1.19	1.06	1.06	2.92	10	1.12	4	1.14
14	1.10		1.06			1.06	1.11		1.04		1.10	1.12	1.11	1.03	1.01	2.71	10	1.08	3	1.06
15	1.00	1.11		1.06	1.05	1.06					1.09	1.06	.991	1.03	.993	2.53	10	1.06	3	1.06
16	.936	1.07				1.03		.946	1.02	.981	1.04	1.05		1.00		2.38	9	1.02	4	1.02
17	.927			1.01		.991		.919	.985	.981	1.03	1.04		1.00		2.24	9	.991	5	.991
18	.895		.988	1.00		.965		.905	.970	.965				.922	.964	2.11	9	.965	4	.968
19	.851	.958		.919	.995	.939		.878		.933	.955	.887	.913	.909	.950	2.00	12	.926	4	.936
20	.840			.910		.939			.913	.902	.948	.885	.857	.899		1.90	9	.902	5	.913
21	.818			.893	.928	.870	.817	.824	.897	.886	.885	.835	.826	.887		1.81	12	.878	5	.886
22	.755			.893		.846		.824	.897	.886	.812	.835		.880	.929	1.73	10	.863	5	.886
23	.755	.795	.803	.776	.894	.823			.875	.810	.806	.835		.854	.914	1.65	12	.816	5	.810
24	.755			.767		.776	.793		.871		.806	.833	.751	829		1.58	9	.793	4	.791
25	.741			.752		.709	.793		.844	.781		.810		.779		1.52	8	.780	4	.766
26	.709					.666		.743	.814	.781	.738	.810		.755		1.46	8	.749	4	.760
27	.662	.695		.726	.728	.666	.712		.814		.738	.810		.738		1.41	10	.727	4	.732
28	.649	.695				.645		.703		.752		.785	.598	.687	.771	1.36	9	.695	2	.698
29	.649		.671			.645		.662		.724		.785		.664	.682	1.31	8	.668	2	.684
30	.636			.710		.625		.662	.757		.602	.780	.592	.641	.664	1.27	10	.652	4	.668
31	.624			.676		.625			.738	.683		.780		.641	.654	1.23	8	.665	4	.680
32	.624			.660		.605				.670	.594	.736		.639	.621	1.19	8	.632	4	.632
33	.611		.574	.643		.567			.715		.579	.729		.598	.621	1.15	9	.611	4	.611
34	.525			.586	.618	.549		.514	.688			.687	.466	.573		1.12	9	.573	3	.586
35	.478					.512		.459		.632	.563	.680		.489		1.09	7	.512	3	.563
36	.453		.526	.543		.495		.459		.606	.555	.594	.445	.447	.546	1.06	11	.526	4	.549
37	.399	.455		.493	.472	.477		.419	.635	.530	.495	.571		.427	.450	1.03	12	.474	5	.495

Table 2.--Ratios to mean annual floods, base period 1884-1950

Order no.	Station no. 4	6	9	10	11	Number of items	Median	Recurrence interval
1	4.40	4.31	2.69	2.60	2.50	5	2.69	a78
2	2.35	3.78	2.66	2.36	2.50	5	2.50	b39
3	2.10	2.12	2.31	2.11	1.97	5	2.11	22.7
4	1.98		2.26	1.97		3	1.98	17.0
5	1.93		1.93	1.85	1.95	4	1.93	13.6
6	1.86		1.78			2	1.82	11.3
7	1.74	1.79	1.63	1.79	1.73	5	1.74	9.71
8	1.65	1.62	1.63	1.72	1.62	5	1.63	8.50
9			1.54	1.55	1.52	3	1.54	7.56
10		1.54	1.44	1.53	1.48	4	1.50	6.80
11		1.51	1.38		1.30	3	1.38	6.18
12	1.50		1.33	1.40	1.30	4	1.36	5.67
13	1.48	1.44	1.32	1.37		4	1.40	5.23
14	1.35	1.44	1.31	1.37	1.28	5	1.35	4.86
15	1.31	1.41	1.30	1.35		4	1.33	4.53
16	1.26	1.34	1.28	1.31		4	1.30	4.25
17	1.25	1.27	1.21	1.25	1.24	5	1.25	4.00
18	1.25	1.24	1.20	1.25	1.24	5	1.24	3.78
19	1.22	1.24	1.19	1.18	1.22	5	1.22	3.58
20	1.18	1.24	1.18		1.20	4	1.19	3.40
21	1.16		1.18	1.12	1.10	4	1.14	3.24
22	1.15	1.19	1.15	1.12	1.10	5	1.15	3.09
23		1.19	1.11	1.09	1.06	4	1.10	2.96
24	1.08	1.17	1.10	1.07	1.06	5	1.08	2.83
25		1.14	1.07			2	1.10	2.72
26	1.06	1.12	1.06		1.05	4	1.06	2.62
27		1.02	1.02	1.04	1.05	4	1.03	2.52
28	1.04	1.02	1.01	1.02	1.04	5	1.02	2.43
29			.997	1.01		2	1.00	2.34
30	1.02	.992	.987		1.00	4	.996	2.27
31	1.01			1.01	.990	3	1.01	2.19
32	1.00	.950	.967	1.01	.982	5	.982	2.12
33	.926	.925	.967	.961		4	.944	2.06
34	.919	.900	.954		.948	4	.934	2.00
35	.910	.900	.898	.927	.940	5	.910	1.94
36				.871	.912	2	.892	1.89
37	.893	.833	.875	.868	.905	5	.875	1.84
38	.893		.875	.868	.905	4	.884	1.79
39	.876	.811	.875	.854	.905	5	.875	1.74
40	.852		.875	.854	.878	4	.864	1.70
41	.819	.788	.849			3	.819	1.66
42	.819	.788	.836	.843	.845	5	.836	1.62
43	.776			.826	.828	3	.826	1.58
44	.767	.743	.787	.798	.820	5	.787	1.55
45			.787		.820	2	.804	1.51
46	.752	.679	.774	.787		4	.763	1.48
47			.774	.784	.775	3	.775	1.45
48	.726		.761	.784	.770	4	.766	1.42
49		.638	.754	.742	.770	4	.748	1.39
50		.638	.751	.717		3	.717	1.36
51	.710	.618	.728		.705	4	.708	1.33
52	.710	.618	.725	.691	.705	5	.705	1.31
53		.618	.725	.691		3	.691	1.28
54	.676	.599	.702		.650	4	.663	1.26
55	.660	.599	.702	.666	.650	5	.660	1.24
56	.660	.580		.641		3	.641	1.21
57	.643				.598	2	.620	1.19
58	.600		.652	.604	.575	4	.602	1.17
59	.600	.543	.636	.593		4	.596	1.15
60	.586	.526		.590	.568	4	.577	1.13
61		.491	.616		.552	3	.552	1.11
62	.543		.593			2	.568	1.10
63	.514	.474		.559	.538	4	.526	1.08
64	.507			.537	.530	3	.530	1.06
65	.493	.457	.548	.525	.492	5	.493	1.05
66			.538	.469	.472	3	.472	1.03
67	.419		.518	.469	.465	4	.467	1.01

a Highest since 1874.
b Second highest since 1874.

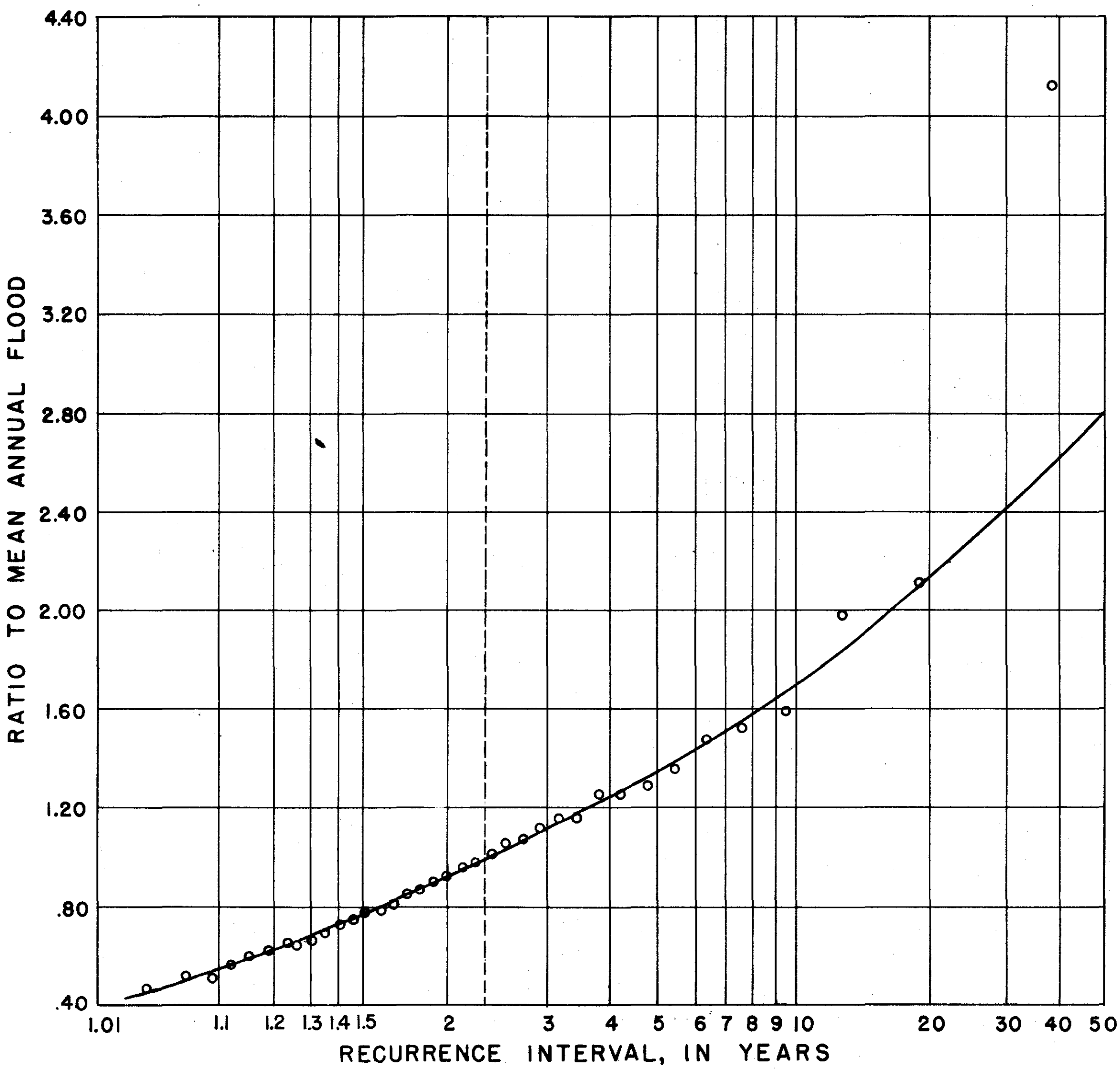

Figure 3.--Frequency of annual floods, all stations, period 1914-50.

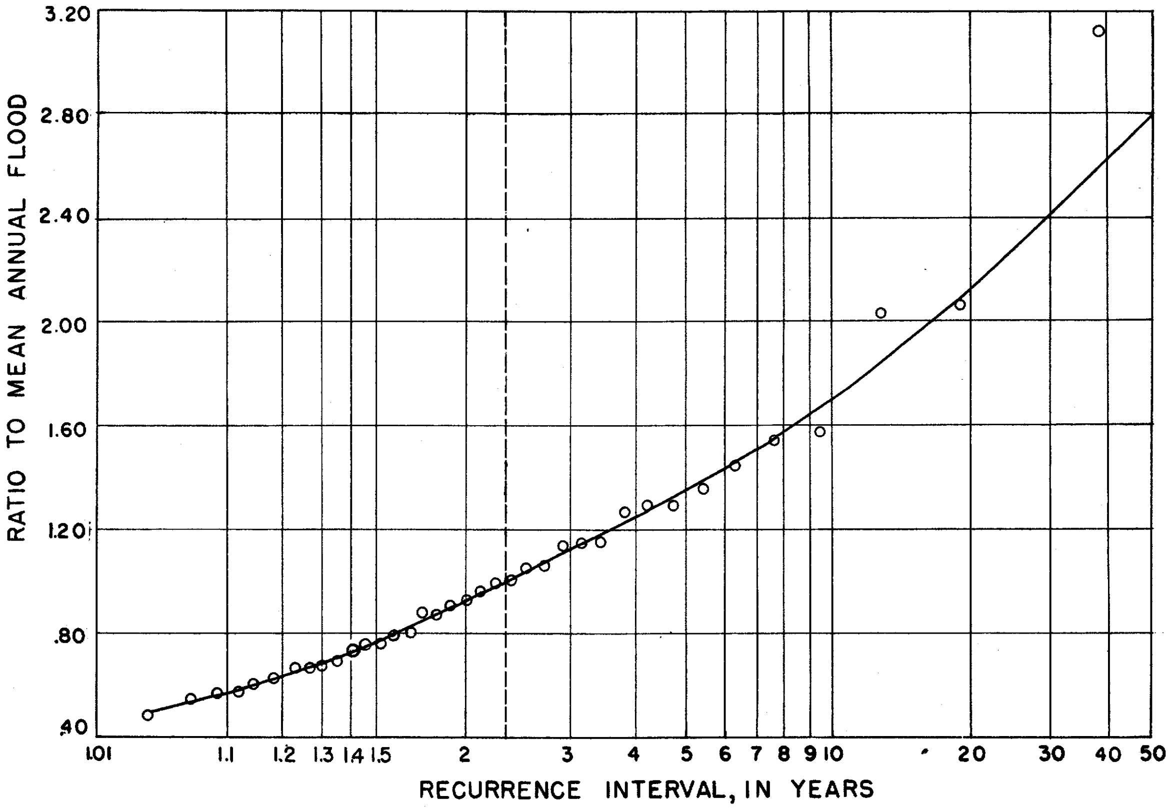

Figure 4.--Frequency of annual floods, stations 4, 6, 9, 10, and 11, period 1914-50.

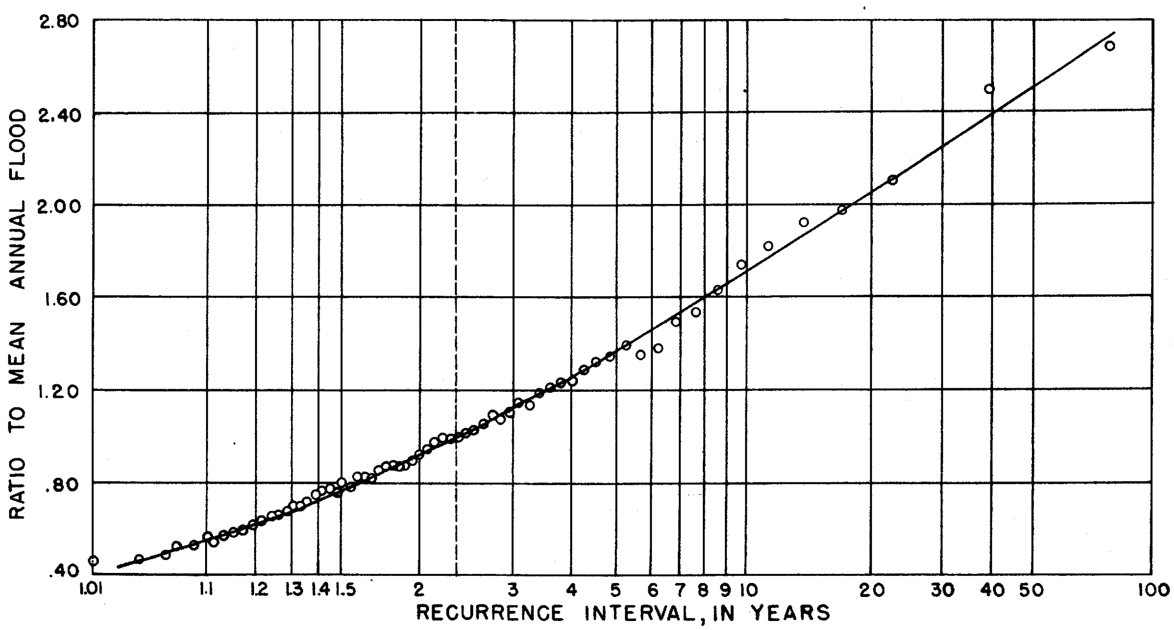

Figure 5.--Frequency of annual floods, stations 4, 6, 9, 10, and 11, period 1884-1950.

MEAN ANNUAL FLOOD

Computation of comparable means

The value of the mean annual flood will vary with the length of the record from which it is derived and will be dissimilar for different periods of record even though the same number of years is being considered. In analyzing the relation between mean annual flood and drainage area, it is necessary to use values for the mean annual flood that are based on the same time period. It is also desirable to make this time period as long as possible.

In this study the observed mean annual floods, adjusted to the 67-yr period 1884-1950, were used in the development of the mean annual flood-drainage area relation. The average ratio of the 67-yr to the 37-yr mean annual floods, obtained from the five index stations (table 3), was 1.076. Values of the 37-yr mean annual floods for the other stations were adjusted to the 67-yr values by applying the coefficient 1.076.

Mean annual flood versus drainage area

The adjusted values for mean annual floods were plotted against drainage areas in figure 6 and an average curve was obtained. The correlation of mean annual floods to drainage areas alone is remarkably consistent.

An attempt was made to investigate the relation between mean annual floods and physical characteristics, other than size of drainage area, that might explain the spread of some points from the average curve. There was not conclusive evidence to indicate that other variables were sufficiently effective to influence the results of the present study.

There are a few points that vary as much as 15 to 20 percent from the average curve as drawn, but these results are considered acceptable. Owing to the chance elements involved and depending upon the length of record, there is an expected variation in the mean annual flood that can be computed by statistical methods for any desired confidence interval. A 95 percent confidence interval was used.

Table 3.--Computation of mean annual floods for period 1884-1950 Kiskiminetas and Youghiogheny River basins
(All gaging stations are located in Pennsylvania)

No.	Station	Drainage area	I Mean annual flood (cfs) 1914-50	II Mean annual flood (cfs) 1884-1950	Ratio II÷I
4	Kiskiminetas River at Avonmore	-	42,000	42,000	1.000
6	Blacklick Creek at Blacklick	-	11,500	12,000	1.043
9	Youghiogheny River at Ohiopyle	-	26,300	30,500	1.160
10	Youghiogheny River at Connellsville	-	31,500	35,600	1.130
11	Youghiogheny River at Sutersville	-	38,200	40,000	1.047
	Average				1.076
1	Stony Creek at Ferndale	451	11,000	11,800	
2	Conemaugh River at Seward	715	19,000	20,400	
3	Conemaugh River at Tunnelton	1,358	34,000	36,600	
4	Kiskiminetas River at Avonmore	1,723	42,000	42,000	
5	Little Conemaugh River at East Conemaugh	183	6,250	6,720	
6	Blacklick Creek at Blacklick	390	11,500	12,000	
7	Loyalhanna Creek at Kingston	168	6,000	6,460	
8	Loyalhanna Creek at New Alexandria	265	7,400	7,960	
9	Youghiogheny River at Ohiopyle	1,062	26,300	30,500	
10	Youghiogheny River at Connellsville	1,326	31,500	35,600	
11	Youghiogheny River at Sutersville	1,715	38,200	40,000	
12	Casselman River at Markleton	382	11,200	12,100	
13	Big Piney Run near Salisbury	24.5	1,060	1,140	
14	Laurel Hill Creek at Ursina	121	4,850	5,220	
15	Green Lick Run at Green Lick Reservoir	3.07	280	301	

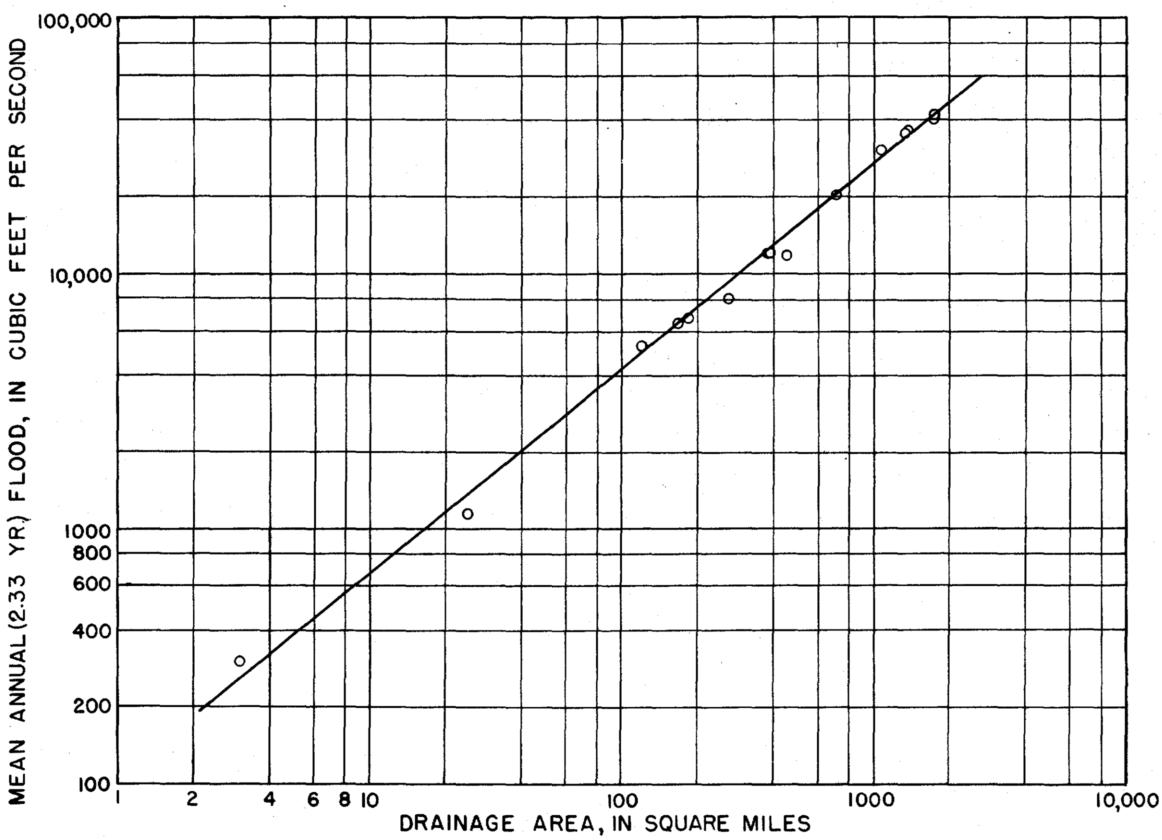

Figure 6.--Variation of mean annual flood with drainage area.

The significance of this is that 95 percent of the time the mean annual flood, on the basis of chance alone, can be expected to fall within the computed limits. The deviations from the average curve are within these limits and are therefore considered satisfactory.

APPLICATION OF FLOOD DATA

Two basic curves have been developed from the available data that can be used to determine the frequency relationship of any area, gaged or ungaged, in the Youghiogheny and Kiskiminetas River basins.

Figure 5 represents the general frequency relation, expressed as a ratio to the mean annual flood, at any point within the two basins.

Figure 6 represents a satisfactory relation between drainage area and mean annual flood for any point within the two basins with a drainage area greater than 3 sq mi.

These curves should not be extrapolated beyond the limits of the available data because this procedure could lead to serious error.

Only two station records were available on drainage areas less than 100 sq mi. The size of drainage area generally has not been found to have any effect on the characteristics of the frequency curve. More small-area records would be desirable in the definition of mean annual floods. However, the consistency of the plotting of points on figure 6 gives some confidence in the lower part of the curve.

The results are applicable to unregulated conditions only. Some of the stations used are slightly affected by regulation. However, it is likely that the annual peak discharges for these stations have not been materially affected. Other stations have been materially affected in recent years, but the peak discharges for these years were not used.

To determine the frequency curve at a desired site, enter the curve of figure 6 with the known drainage area and obtain the value of the mean annual flood. Then from the curve of figure 3, select values at several recurrence intervals of the ratio to mean annual flood. These ratios when multiplied by the mean annual flood will give the values of peak discharge that can be plotted against the corresponding recurrence intervals to define the desired frequency curve.

To illustrate the use of the data, let us suppose that it is desired to determine the flood frequency curve for an ungaged site, within this area, that has a drainage area of 100 sq mi.

From figure 6, it is found that the mean annual flood on a watershed of 100 sq mi is 4,200 cfs.

From figure 5, the values of ratio to mean annual flood have been selected arbitrarily at recurrence intervals of:

1.1, 1.5, 2.33, 5, 10, 25, and 50 yr.

These ratios were found to be:

0.55, 0.77, 1.00, 1.38, 1.71, 2.16, and 2.50, respectively.

These values when multiplied by the mean annual flood, 4,200 cfs, give discharges of:

2,310, 3,230, 4,200, 5,800, 7,180, 9,070, and 10,500 cfs, respectively.

The frequency curve for the site may be obtained by plotting these discharges against the corresponding recurrence intervals.

If it is desired to determine only the discharge for a specific recurrence interval for the site, the frequency curve need not be plotted. For example, if the discharge for a 25-yr flood is required, it is necessary only to determine the mean annual flood (4,200 cfs) and the ratio for the 25-yr recurrence interval (2.16). By multiplying these two factors, the 25-yr flood is found to be 9,070 cfs.

STAGE FREQUENCIES

Information on stage frequency rather than discharge may sometimes be desired. Where the relation between stage and discharge is known, it is possible to convert from a discharge-frequency curve to a stage-frequency curve. This relation is usually known only at gaging-station sites, and no general stage-frequency relationships can be formulated for a region.

Although for Pennsylvania streams the relation at high stages between stage and discharge at any particular site is fairly stable, there is enough change so that current information should always be utilized. For this reason no attempt has been made to furnish information on stage frequencies in this report, except that gage heights are shown for annual floods at the individual gaging stations. The necessary data, whereby stage frequencies may be determined at any gaging-station site in these basins, is on file at the offices of the U. S. Geological Survey in Harrisburg and Pittsburgh, Pa.

GAGING-STATION RECORDS

Annual-peak gage heights and discharges at gaging stations used in this report have been tabulated in this section.

The annual peaks listed were the highest momentary peaks in each water year, which includes the period October 1 to September 30. The water year was used rather than the calendar year because September and October are usually months of low flow; hence the use of the water year tends to eliminate any influence that one annual flood might have upon another. Although the maximum flood in each water year is listed, the date shown is for the calendar year in which the event occurred.

Gage heights represent the water level in feet above an arbitrary datum that is referenced to local benchmarks at the gage. At most stations the gage datum has been tied into the level net of the Coast and Geodetic Survey, and for these stations the mean-sea-level elevation of the datum of gage is given under "Gage" in descriptive material. The gage heights were generally obtained from water-stage recorder charts, recorded flood marks, or graphs based on gage readings by an observer.

Peak discharges are listed in cubic feet per second. This term in abbreviated form is designated in the tables and station records as "cfs." Peak discharges are computed directly from the peak gage heights by means of the stage-discharge relation.

Before data from these stations were used, the stage-discharge relation during the period of record at each gaging station was reviewed and records were revised where necessary. Most of these revisions were based on data obtained after the discharges were already published. For the most part, the changes were made in the interests of consistency in this report. Some records involve significant differences with already published figures. These major revisions are being published in the water-supply papers and will supersede earlier figures. Where no such revisions are made, it can be assumed that figures originally published can be used without loss of accuracy.

Source of the data is indicated under "Remarks" for records other than those collected by the U. S. Geological Survey.

Kiskiminetas River basin

(1) Stony Creek at Ferndale, Pa.

Location.--Lat 40°17'10", long. 78°55'10", at highway bridge at Ferndale, Cambria County, 0.4 mile downstream from Bens Creek, 1.2 miles upstream from Johnstown city limit, and 5.2 miles upstream from confluence with Little Conemaugh River.

Drainage area.--451 sq mi; 467 sq mi at site in Johnstown prior to 1939.

Gage.--Nonrecording gage at Johnstown, July 1913 to March 1936; datum of gage 1,154.0 ft above mean sea level. Nonrecording gage at Ferndale, December 1938 to May 1940 and recording gage thereafter; datum of gage 1,183.84 ft above mean sea level.

Stage-discharge relation.--Defined by current-meter measurements below 12,000 cfs and extended to 59,000 cfs on basis of slope-area and contracted-opening measurements.

Remarks.--Regulation by mine pumpage and by reservoirs above station, the five largest of which have a combined capacity of 1,788,000,000 cu ft. Some diversion from Quemahoning Reservoir to Cambria plant of Bethlehem Steel Co., and from Mill Creek, Dalton Run, and North Fork Bens Creek Reservoirs for water supply of city of Johnstown. Annual peak discharges not materially affected by regulation or diversion.

Records from July 1913 to March 1936, and December 1938 to September 1941 in reports of Pennsylvania Department of Forests and Waters. Annual flood of 1937 from crest elevation furnished by city engineer of Johnstown. Annual flood for 1938 computed from U. S. Weather Bureau gage records.

Annual flood stages and discharges

Date	Gage height (feet)	Discharge (cfs)	Date	Gage height (feet)	Discharge (cfs)
1914, Mar. 30	7.85	5,260	1933, Mar. 15	11.72	11,000
1915, Jan. 7	10.70	9,360	1934, Jan. 7	8.9	6,720
1916, Mar. 28	11.30	10,300	1935, Aug. 2	9.26	7,280
1917, Mar. 12	14.00	15,100	1936, Mar. 18	30.26	59,000
1918, Feb. 26	12.7	12,700	1937, Apr. 26	18.8	25,300
1919, May 10	8.15	5,780	1937, Oct. 28	10.0	8,300
1920, Mar. 12	11.2	10,200	Change in site and datum		
1921, Mar. 3	8.98	6,860	1939, Feb. 3	8.8	9,240
1921, Nov. 28	13.7	14,500	1940, Mar. 31	13.3	23,900
1923, Feb. 2	7.1	4,390	1941, June 5	12.27	22,600
1924, Mar. 29	16.9	21,000	1942, Apr. 9	8.72	9,000
1925, Feb. 11	10.0	8,300	1942, Dec. 30	11.07	17,200
1926, Feb. 23	10.0	8,300	1944, Mar. 17	7.90	7,140
1927, Jan. 22	10.96	9,840	1945, Mar. 6	11.97	21,200
1928, May 1	13.23	13,600	1946, June 2	10.95	16,700
1929, Feb. 26	9.15	7,140	1947, June 8	6.85	4,980
1930, Feb. 25	9.90	8,150	1948, Apr. 14	9.78	12,100
1931, Apr. 4	9.02	6,860	1949, Jan. 26	8.15	7,800
1932, Apr. 1	9.1	7,000	1950, Mar. 28	9.90	12,400

(2) Conemaugh River at Seward, Pa.

Location.--Lat 40°25'10", long. 79°01'40", at highway bridge at Seward, Westmoreland County, 2 miles downstream from Findley Run, and 9 miles northwest of Johnstown.

Drainage area.--715 sq mi.

Gage.--Recording gage. Datum of gage is 1,075.64 ft above mean sea level, unadjusted.

Stage-discharge relation.--Defined by current-meter measurements below 21,000 cfs and extended to 90,000 cfs on basis of contracted-opening measurement.

Historical data.--Flood of March 18, 1936; 90,000 cfs (gage height, 26.4 ft) from floodmarks.

Remarks.--Regulation by steel mills and by several reservoirs above station, the eight largest of which have a combined capacity of 2,060,170,000 cu ft. Annual peak discharges not materially affected by regulation.

(2) Conemaugh River at Seward, Pa.--Continued

Annual flood stages and discharges

Date	Gage height (feet)	Discharge (cfs)	Date	Gage height (feet)	Discharge (cfs)
1936, Mar. 18	26.4	90,000	1944, Mar. 17	8.39	13,200
			1945, Mar. 6	13.76	30,200
1939, Feb. 3	9.00	15,100	1946, June 2	11.27	22,000
1940, Mar. 31	15.22	35,000	1947, June 8	6.75	8,650
1941, June 5	13.15	28,200	1948, Apr. 14	11.04	21,000
1942, Apr. 9	10.07	18,200	1949, Jan. 26	8.37	13,200
1942, Dec. 30	12.70	26,500	1950, Mar. 28	10.80	20,400

(3) Conemaugh River at Tunnelton, Pa.

Location.--Lat 40°27'15", long. 79°23'30", at highway bridge at Tunnelton, Indiana County, 0.9 mile downstream from Boatyard Run, 3¾ miles southeast of Saltsburg, and 5.5 miles upstream from confluence with Loyalhanna Creek.

Drainage area.--1,358 sq mi.

Gage.--Nonrecording gage. Datum of gage is 844.64 ft above mean sea level, datum of 1929.

Stage-discharge relation.--Defined by current-meter measurements throughout.

Remarks.--Regulation by steel mills and by several reservoirs above station, the eight largest of which have a combined capacity of 2,060,170,000 cu ft. Annual peak discharges not materially affected by regulation.

Annual flood stages and discharges

Date	Gage height (feet)	Discharge (cfs)	Date	Gage height (feet)	Discharge (cfs)
1940, Mar. 31	20.18	55,600	1946, June 13	14.6	33,600
1941, June 5	16.9	42,300	1947, June 8	10.1	17,900
1942, Apr. 10	15.3	36,200	1948, Apr. 14	16.5	40,800
1942, Dec. 30	19.6	53,100	1949, Jan. 27	10.6	19,500
1944, Mar. 17	11.6	22,800	1950, Mar. 28	12.9	27,300
1945, Mar. 7	21.0	59,200			

(4) Kiskiminetas River at Avonmore, Pa.

Location.--Lat 40°32'05", long. 79°27'55", at highway bridge at Avonmore, Westmoreland County, 1 mile above mouth of Long Run.

Drainage area.--1,723 sq mi.

Gage.--Nonrecording gage May 1907 to July 1937. Datum of gage is 805.64 ft above mean sea level.

Stage-discharge relation.--Defined by current-meter measurements below 30,000 cfs and extended to 185,000 cfs on basis of slope-area measurement.

Remarks.--Regulation by steel mills, since 1942 by Loyalhanna Creek Reservoir and other reservoirs above station, the nine largest of which have a combined capacity of 2,108,300,000 cu ft. Annual peak discharges not materially affected by regulation.

Records from May 1907 to September 1941 in reports of Pennsylvania Department of Forests and Waters. Records prior to May 1907 from Water Supply Commission of Pennsylvania, Water Resources Inventory Report, Part 8, Floods (computed from Signal Service and Weather Bureau gage readings at Saltsburg). Records after July 1937 computed on basis of record of recording gage at Vandergrift, drainage area 1,825 sq mi.

Annual flood stages and discharges

Date	Gage height (feet)	Discharge (cfs)	Date	Gage height (feet)	Discharge (cfs)
1884, Feb. 6	24.1	52,900	1916, Mar. 22	20.0	37,500
1885, Jan. 17	16.4	25,200	1917, Jan. 22	24.0	52,500
1886, Jan. 5	19.1	34,400	1918, Feb. 20	22.0	44,500
1886, Dec. 14	13.8	17,600	1919, Jan. 2	16.2	24,600
1888, Aug. 21	31.8	88,000	1919, Nov. 27	20.3	38,600
1889, June 1	29.8	78,000	1921, Jan. 23	15.6	22,800
1890, Mar. 23	17.8	29,800	1921, Nov. 29	24.65	54,900
1891, Feb. 17	30.4	81,000	1923, May 13	18.0	30,500
1892, Jan. 14	15.1	21,300	1924, Mar. 30	24.0	52,500
1893, Feb. 11	15.2	21,600	1925, Feb. 12	17.8	29,800
1894, May 20	19.5	35,800	1926, Sept. 6	18.5	32,200
1895, Jan. 8	19.8	36,800	1927, Jan. 22	21.3	42,000
			1927, Oct. 20	25.1	56,900
1902, Mar. 1	26.4	62,300	1929, Feb. 26	16.96	27,000
1903, Mar. 1	16.4	25,200	1930, Feb. 25	23.3	49,700
1904, Jan. 23	21.8	43,800	1931, Apr. 4	20.2	38,200
1905, Mar. 8	20.4	38,900	1932, Apr. 1	18.3	31,600
1906, June 7	19.1	34,400	1933, Mar. 15	23.0	48,500
1907, Mar. 14	33.8	98,900	1934, Sept. 30	14.90	20,700
1908, Mar. 19	30.8	83,000	1935, Aug. 4	18.6	32,600
1909, Feb. 24	17.2	27,700	1936, Mar. 18	47.2	185,000
1910, Feb. 17	23.7	51,300	1937, Apr. 26	28.8	73,100
1911, Sept. 15	21.5	42,800	1937, Dec. 18		37,500
1912, Mar. 21	28.0	69,500	1939, Feb. 4		28,400
1913, Jan. 8	22.2	45,300	1940, Mar. 31		62,800
1914, Mar. 17	17.2	27,700	1941, June 5		48,900
1915, Feb. 2	21.40	42,400			

(5) Little Conemaugh River at East Conemaugh, Pa.

Location.--Lat 40°20'35", long. 78°53'05", at highway bridge at East Conemaugh, Cambria County, 0.3 mile downstream from Clapboard Run and 2.5 miles upstream from confluence with Stony Creek.

Drainage area.--183 sq mi.

Gage.--Recording gage. Datum of gage is 1,207.92 ft above mean sea level (Corps of Engineers benchmark).

Stage-discharge relation.--Defined by current-meter measurements below 5,200 cfs and extended to 29,000 cfs on basis of slope-area measurement.

Historical data.--Flood of March 17, 18, 1936, 28,800 cfs by slope-area determination.

Remarks.--Regulation by small reservoirs and diversion works above station. Annual peak discharges not materially affected by regulation.

Annual flood stages and discharges

Date	Gage height (feet)	Discharge (cfs)
1936, Mar. 17, 18		28,800
1940, Mar. 30	8.80	11,800
1941, June 5	7.19	7,530
1942, Apr. 9	6.77	6,590
1942, Dec. 30	7.29	7,410
1944, Mar. 17	6.06	4,550

Date	Gage height (feet)	Discharge (cfs)
1945, Mar. 6	8.03	9,350
1946, June 2	6.29	5,800
1947, June 8	4.83	2,950
1948, Apr. 14	6.47	6,220
1949, July 12	5.36	3,860
1950, Mar. 28	6.22	5,590

(6) Blacklick Creek at Blacklick, Pa.

Location.--Lat 40°28'25", long. 79°12'15", at highway bridge at Gratton, a quarter of a mile northwest of Blacklick, Indiana County, and three-quarters of a mile downstream from Two Lick Creek.

Drainage area.--390 sq mi.

Gage.--Nonrecording gage. Datum of gage is 945.94 ft above mean sea level (Pennsylvania State highway benchmark).

Stage-discharge relation.--Defined by current-meter measurements below 18,000 cfs and extended to 52,000 cfs on basis of slope-area determination.

Remarks.--Records August 1904 to December 1905 and January 1907 to September 1941 in reports of Pennsylvania Department of Forests and Waters.

Annual flood stages and discharges

Date	Gage height (feet)	Discharge (cfs)
1905, Mar. 21	8.6	8,920
1905, Dec. 3	11.2	16,900
1907, Mar. 14	15.4	45,400
1908, Mar. 19	11.3	17,300
1909, Feb. 24	8.8	9,460
1910, Jan. 18	10.97	16,100
1911, Jan. 14	10.2	13,400
1912, Sept. 3	12.9	25,500
1913, Jan. 8	10.5	14,300
1914, May 6	8.0	7,420
1915, Jan. 7	10.72	14,900
1915, Oct. 19	10.7	14,900
1917, Jan. 22	11.3	17,300
1918, Feb. 20	10.8	15,300
1918, Oct. 31	7.9	7,190
1920, June 17	10.5	14,300
1921, May 5	7.3	5,890
1921, Nov. 29	9.85	12,200
1923, May 13	9.5	11,400
1924, June 29	12.2	21,500
1925, Feb. 11	7.2	5,690
1926, Sept. 5	8.9	9,730
1927, Jan. 22	9.40	11,100

Date	Gage height (feet)	Discharge (cfs)
1927, Oct. 20	9.80	12,200
1929, Feb. 26	8.10	7,660
1930, Feb. 25	9.70	11,900
1931, Apr. 4	9.30	10,800
1932, Apr. 1	7.5	6,310
1933, Mar. 15	9.28	10,800
1935, May 10	8.30	8,150
1936, Mar. 18	15.88	51,700
1937, Jan. 25	8.8	9,460
1937, Dec. 18	10.3	13,700
1939, Jan. 31	7.8	6,960
1940, Mar. 31	11.5	18,100
1941, June 5	8.0	7,420
1942, Apr. 9	9.01	10,000
1942, Dec. 30	11.76	19,500
1944, Mar. 17	8.1	7,660
1945, Mar. 6	10.4	14,000
1946, June 13	11.65	18,500
1947, June 8	7.10	5,490
1948, Apr. 12	10.7	14,900
1949, Jan. 24	7.65	6,520
1950, July 5	7.90	7,190

(7) Loyalhanna Creek at Kingston, Pa.

Location.--Lat 40°17'35", long. 79°20'25", at Kingston, Westmoreland County, 60 ft downstream from highway bridge, 150 ft upstream from Millers Run, 1.9 miles upstream from Ninemile Run, and 3 miles southeast of Latrobe.

Drainage area.--168 sq mi.

Gage.--Recording gage. Datum of gage is 1,014.16 ft above mean sea level, datum of 1929 (Corps of Engineers benchmark).

Stage-discharge relation.--Defined by current-meter measurements below 8,200 cfs and extended to 21,000 cfs by logarithmic plotting.

Historical data.--Flood of March 17 or 18, 1936, reached stage of 14.5 ft; discharge 21,000 cfs.

Remarks.--Regulation by Trout Run Reservoir (capacity, 48,130,000 cu ft) and diversion work at Kingston. Annual peak discharges not materially affected by regulation or diversion.

Annual flood stages and discharges

Date	Gage height (feet)	Discharge (cfs)	Date	Gage height (feet)	Discharge (cfs)
1936, Mar. 17 or 18	14.5	21,000	1945, Mar. 6	10.00	9,100
			1946, June 2	9.46	8,140
1940, Mar. 30	9.83	8,710	1947, June 8	7.57	4,760
1941, June 5	10.06	9,300	1948, Apr. 14	9.22	7,570
1942, Apr. 9	8.72	6,640	1949, Jan. 26	7.74	4,900
1942, Dec. 30	9.17	7,570	1950, Jan. 7	7.32	4,270
1944, May 7	7.61	4,760			

(8) Loyalhanna Creek at New Alexandria, Pa.

Location.--Lat 40°23'40", long. 79°25'55", at highway bridge at New Alexandria, Westmoreland County, 1¾ miles downstream from Crabtree Creek.

Drainage area.--265 sq mi; 270 sq mi at site in use prior to August 1913.

Gage.--Nonrecording gage October 1910 to August 1918, August 1919 to July 1923, and November 1925 to September 1940. Datum at New Alexandria site 917.26 ft above mean sea level (general adjustment of 1912).

Stage-discharge relation.--Defined by current-meter measurements below 3,300 cfs and extended to 31,000 cfs on basis of discharge measurements up to 14,000 cfs at Loyalhanna Creek Dam site and on basis of slope-area and contracted-opening measurements.

Remarks.--Regulation by Trout Run Reservoir (capacity, 48,130,000 cu ft). Annual peak discharges not materially affected by regulation.

Records August 1919 to July 1923, and November 1925 to September 1940 in reports of Pennsylvania Department of Forests and Waters. Records July 1910 to August 1913 in reports of Pennsylvania Department of Forests and Waters are incomplete. Unpublished records August 1913 to August 1918 considered unreliable.

Annual flood stages and discharges

Date	Gage height (feet)	Discharge (cfs)	Date	Gage height (feet)	Discharge (cfs)
1918, Feb. 9	10.4	6,800	1930, June 10	10.1	6,500
			1931, Apr. 4	10.3	6,700
1920, June 17	8.70	4,900	1932, Jan. 30	7.2	3,400
1921, Jan. 8	7.2	3,400	1933, Mar. 15	12.3	9,200
1921, Nov. 28	10.60	7,000	1934, Aug. 16	6.78	3,100
1923, May 13	7.6	3,800	1935, Aug. 3	16.0	16,000
			1936, Mar. 18	20.96	31,000
1926, Sept. 6	9.8	6,100	1937, Apr. 26	15.09	14,000
1927, Jan. 21	8.95	5,200	1937, Oct. 28	9.8	6,100
1927, Oct. 20	12.65	9,700	1939, Feb. 3	8.7	4,900
1929, Feb. 26	9.3	5,500	1940, Mar. 31	12.9	10,000

(9) Youghiogheny River at Ohiopyle, Pa.

Location.--Lat 39°47'17", long. 79°29'44", at highway bridge in Ohiopyle, Fayette County, half a mile upstream from Meadow Run.

Drainage area.--1,062 sq mi; 1,029 sq mi at site of Weather Bureau gage at Confluence used prior to 1927.

Gage.--Prior to December 1927, Weather Bureau nonrecording gages at Confluence; thereafter, West Penn Power Co. recording gage at Ohiopyle. Datum of recording gage 1,198.91 ft above mean sea level.

Stage-discharge relation.--Defined by current-meter measurements below 16,000 cfs and extended to 83,000 cfs on basis of area-velocity studies.

Historical data.--Flood of March 18, 1936, known to be highest and flood of March 29, 1924, second highest since 1873.

Remarks.--Regulation since July 1943 by Youghiogheny River Reservoir and since 1925 by Deep Creek Reservoir (combined capacity, 352,770 acre-ft). Annual peak discharges not materially affected by regulation.

Records 1924, and 1928 to 1942 furnished by West Penn Power Co.; gage-height records 1873 to 1923, and 1925-27 from graphs based on nonrecording gage record at Confluence as published in reports of the U. S. Weather Bureau. Ohiopyle record extended back to 1884 by this method.

Annual flood stages and discharges

Date	Gage height (feet)	Discharge (cfs)
1874, Jan. 7	10.9	26,300
1875, Aug. 2	16.1	49,700
1876, Sept. 18	14.0	39,500
1877, Jan. 16	12.6	33,900
1877, Nov. 24	13.7	38,000
1879, Jan. 28	12.1	31,200
1880, Feb. 13	13.0	34,700
1881, Feb. 12	14.5	42,000
1882, Feb. 21	12.3	31,600
1883, Feb. 7	16.1	49,700
1884, Feb. 5	15.5	47,000
1885, Jan. 17	13.3	36,100
1886, Jan. 5	11.0	26,700
1887, Feb. 4	11.7	29,500
1888, Aug. 21	19.5	68,800
1889, May 31	16.1	49,700
1890, Mar. 22	14.0	39,500
1891, Feb. 17	14.9	44,000
1892, Jan. 14	11.8	29,500
1893, Feb. 10	12.0	30,400
1894, Feb. 10	10.1	23,200
1895, Jan. 8	13.4	36,600
1896, July 25	14.5	42,000
1897, Feb. 22	16.0	49,700
1898, Mar. 25	9.8	22,100
1899, May 18	12.5	32,500
1900, Feb. 8	8.0	15,800
1901, Apr. 7	12.1	31,200
1902, Feb. 28	13.3	36,100
1903, Feb. 4	11.0	26,700
1904, Jan. 22	14.3	39,000
1905, Mar. 21	10.3	22,100
1906, Jan. 23	10.8	24,000
1907, Mar. 14	20.1	70,600
1908, Feb. 15	14.5	40,000

a Ohiopyle site and datum.

Date	Gage height (feet)	Discharge (cfs)
1909, Feb. 24	8.7	16,400
1910, June 19	13.1	33,400
1911, Jan. 30	13.2	33,800
1912, Mar. 21	18.1	59,000
1913, Jan. 8	11.5	26,700
1913, Nov. 16	10.7	23,600
1915, Jan. 7	11.2	25,500
1916, Mar. 22	13.5	35,200
1917, Jan. 22	14.6	40,500
1918, Feb. 20	12.5	30,800
1919, Jan. 1	11.3	25,900
1920, June 17	12.1	29,100
1921, Mar. 3	10.1	21,400
1921, Nov. 28	11.5	26,700
1923, Feb. 13	10.1	21,400
1924, Mar. 29	a13.0	81,000
1925, Feb. 12	9.4	18,800
1926, Feb. 22	9.7	19,900
1927, Jan. 21	10.7	23,600
Change in site and datum		
1928, May 1	8.23	32,300
1929, Feb. 27	6.28	18,100
1929, Oct. 3	7.33	24,000
1931, Apr. 4	6.27	16,700
1932, Apr. 1	7.11	22,200
1933, Mar. 14	8.94	36,800
1935, Jan. 22	7.18	22,900
1936, Mar. 18	13.30	82,100
1937, Apr. 26	10.74	54,200
1937, Oct. 28	8.86	36,300
1939, Feb. 3	8.15	30,100
1940, Mar. 31	7.79	27,400
1941, June 5	9.34	40,400
1942, Apr. 10	6.69	19,400

(10) Youghiogheny River at Connellsville, Pa.

Location.--Lat 40°01'05", long. 79°35'40", at Crawford Avenue Bridge in Connellsville, Fayette County, three-quarters of a mile upstream from Mounts Creek.

Drainage area.--1,326 sq mi.

Gage.--Nonrecording gage prior to August 1928 and recording gage thereafter. Datum of gage is 860.13 ft above mean sea level (Baltimore & Ohio Railroad benchmark).

Stage-discharge relation.--Defined by current-meter measurements below 55,000 cfs and extended to 93,000 cfs.

Historical data.--Flood of April 12, 1860, reached stage of 16.5 ft (prior to destruction of slackwater dams).

Remarks.--Regulation since July 1943 by Youghiogheny River Reservoir and since 1925 by Deep Creek Reservoir (combined capacity, 352,770 acre-ft). Annual peak discharges not materially affected by regulation.

Records from July 1908 to September 1941 in reports of Pennsylvania Department of Forests and Waters. Annual floods prior to 1909 from Water Supply Commission of Pennsylvania Report, Part 8, Floods. (Record for 1891 computed from Weather Bureau gage readings at West Newton. Records for 1896-1908 computed from Trotter Water Co., gage readings).

Annual flood stages and discharges

Date	Gage height (feet)	Discharge (cfs)	Date	Gage height (feet)	Discharge (cfs)
1888, Aug. 21-22	17.8	70,000	1918, Feb. 20	14.0	42,000
			1919, Jan. 1	11.51	27,900
1891, Feb. 17	14.7	46,600	1920, Mar. 13	12.13	30,900
			1921, Mar. 3	10.10	21,500
1896, July 25	15.0	48,600	1921, Dec. 24	11.60	28,400
1897, Feb. 23	16.7	61,200	1923, Feb. 2	8.9	16,700
1898, Aug. 11	11.2	26,400	1924, Mar. 29	19.4	84,000
1899, May 18	13.0	35,800	1925, May 10	9.70	19,900
1900,----(less than)	8.9	16,700	1926, Feb. 23	10.4	22,800
			1927, Jan. 22	11.8	29,400
1902, Feb. 28	15.8	54,400	1928, May 1	13.7	40,000
1903, Feb. 28	12.7	34,200	1929, Feb. 27	9.48	19,100
1904, Mar. 1	13.7	40,000	1929, Oct. 3	12.00	30,400
1905, Mar. 21	12.0	30,400	1931, Apr. 4	9.95	21,100
			1932, Apr. 1	11.00	25,500
1907, Mar. 14	18.4	75,200	1933, Mar. 14	14.9	48,000
1908, Feb. 15	14.4	44,600	1934, Mar. 4	10.77	24,600
1909, Feb. 24	9.36	18,700	1935, Jan. 22	10.83	24,600
1910, June 19	13.09	36,400	1936, Mar. 18	20.28	92,500
1911, Jan. 30	12.98	35,800	1937, Apr. 26	15.87	55,100
1912, Mar. 21	17.28	66,000	1937, Oct. 28	14.35	44,600
1913, Jan. 8	13.50	38,800	1939, Feb. 3	13.37	38,200
1913, Nov. 16	11.50	27,900	1940, Mar. 31	13.16	37,000
1915, Jan. 7	12.13	30,900	1941, June 5	17.02	63,600
1916, Mar. 22	15.00	48,600	1942, Mar. 9	10.62	23,700
1917, Jan. 22	15.20	50,000			

(11) Youghiogheny River at Sutersville, Pa.

Location.--Lat 40°14'25", long. 79°48'25", at Sutersville, Westmoreland County, 500 ft upstream from highway bridge and 2.1 miles downstream from Sewickley Creek.

Drainage area.--1,715 sq mi.

Gage.--Nonrecording gage June 1915 to September 1936 and December 1938 to June 1939; recording gage thereafter. Datum of gage is 733.36 ft above mean sea level, datum of 1929, Parkersburg-Uniontown supplementary adjustment of 1944.

Stage-discharge relation.--Defined by current-meter measurements below 77,000 cfs and extended to 100,000 cfs on basis of slope-area method.

Remarks.--Regulation since July 1943 by Youghiogheny River Reservoir and since 1925 by Deep Creek Reservoir (combined capacity, 352,770 acre-ft). Annual peak discharges not materially affected by regulation.

Records from June 1915 to September 1929, June 1931 to September 1936, and December 1938 to September 1941 in reports of Pennsylvania Department of Forests and Waters. Records from November 1890 to June 1915 and October 1929 to June 1931 computed on basis of comparison with Weather Bureau records for West Newton about 2 miles upstream.

Annual flood stages and discharges

Date	Gage height (feet)	Discharge (cfs)
1891, Feb. 17	21.1	52,200
1892, Jan. 14	15.9	32,800
1893, Feb. 11	13.8	26,000
1894, Feb. 10	11.7	19,700
1895, Jan. 8	16.9	36,200
1896, July 25	20.0	47,800
1897, Feb. 23	24.2	64,800
1898, Mar. 22	13.8	26,000
1899, May 18	16.9	36,200
1900, Feb. 9	11.3	18,600
1901, Apr. 7	16.6	35,100
1902, Mar. 1	23.2	60,600
1903, Mar. 1	17.3	37,600
1904, Jan. 22		44,000
1905, Mar. 21	16.0	33,100
1906, Jan. 23	15.9	32,800
1907, Mar. 14	30.6	100,000
1908, Feb. 15	20.8	51,000
1909, Feb. 24	13.1	23,900
1910, Jan. 19	17.4	37,900
1911, Jan. 30	18.0	40,000
1912, Mar. 21		69,100
1913, Jan. 8	18.7	42,600
1914, Mar. 16	17.8	39,300
1915, Feb. 2	17.9	39,600
1916, Mar. 23	20.5	49,800
1917, Jan. 22	20.5	49,800
1918, Feb. 20	18.73	42,600
1919, Jan. 2	16.2	33,800
1919, Nov. 27	17.0	36,500
1921, Mar. 3	12.8	23,000
1921, Nov. 29	19.1	44,200
1923, Feb. 14	11.4	18,900
1924, Mar. 30	27.5	78,900
1925, Feb. 8	12.26	21,500
1926, Feb. 23	12.5	22,100
1927, Jan. 22	14.50	28,200
1927, Oct. 20	18.50	41,900
1929, Feb. 27	12.17	21,200
1929, Oct. 3	16.9	36,200
1931, Apr. 5	12.7	22,700
1932, Apr. 1	15.3	30,800
1933, Mar. 14	21.06	52,200
1934, Mar. 4	23.0	31,000
1935, Jan. 22	15.3	30,800
1936, Mar. 18	30.65	100,000
1937, Apr. 26	22.8	59,000
1937, Oct. 29	20.3	49,000
1939, Feb. 4	18.5	41,900
1940, Mar. 31	18.40	41,500
1941, June 5	27.34	78,000
1942, Apr. 10	14.46	28,200

(12) Casselman River at Markleton, Pa.

Location.--Lat 39°51'35", long. 79°13'40", at highway bridge at Markleton, Somerset County, 2 miles southwest of Casselman and 7 miles downstream from Coxes Creek.

Drainage area.--382 sq mi.

Gage.--Nonrecording gage August 1913 to November 1940 and recording gage thereafter. Datum of gage is 1,655.29 ft above mean sea level, adjustment of 1907.

Stage-discharge relation.--Defined by current-meter measurements below 13,000 cfs and extended to 36,000 cfs by slope-area method.

Remarks.--Slight diversions above station to borough of Salisbury, Pa., and to city of Frostburg, Md., do not materially affect annual peak discharges. Records August 1913 to September 1941 in reports of Pennsylvania Department of Forests and Waters. Records for station at Confluence not used because of severe backwater effect at flood stages. Fragmentary records prior to 1915.

Annual flood stages and discharges

Date	Gage height (feet)	Discharge (cfs)	Date	Gage height (feet)	Discharge (cfs)
1915, Jan. 7	8.5	11,900	1933, Mar. 14	9.8	15,700
1916, Mar. 22	8.9	13,100	1934, Aug. 16	8.7	12,500
1917, Jan. 22	10.0	16,200	1935, Jan. 22	7.6	9,350
1918, Feb. 26	9.7	15,400	1936, Mar. 17	16.4	35,800
1919, Jan. 2	7.5	9,070	1937, Apr. 26	12.8	24,600
1920, Mar. 12	8.4	11,600	1937, Oct. 28	10.0	16,200
1921, Mar. 3	7.5	9,070	1939, Feb. 3	8.7	12,500
1921, Nov. 28	7.55	9,350	1940, Mar. 31	7.8	9,910
1923, Feb. 2	6.6	6,650	1941, June 5	10.24	18,700
1924, Mar. 29	12.17	22,800	1942, Mar. 9	7.35	9,330
1925, Feb. 12	6.5	6,400	1942, Dec. 30	8.42	12,500
1926, Jan. 19	7.5	9,070	1944, May 7	6.77	7,620
1927, Jan. 5	7.4	8,790	1945, Feb. 27	8.63	13,200
1928, Apr. 30	10.00	16,200	1946, June 2	7.24	8,740
1929, Feb. 26	7.0	7,700	1947, July 31	6.98	8,170
1929, Oct. 3	7.6	9,350	1948, Apr. 13	8.16	11,800
1931, Apr. 4	7.4	8,790	1949, Jan. 26	7.23	8,740
1932, Apr. 1	7.2	8,240	1950, Mar. 28	7.55	9,940

(13) Big Piney Run near Salisbury, Pa.

Location.--Lat 39°43'32", long. 79°02'57", an eighth of a mile upstream from Little Piney Run, a quarter of a mile north of Maryland-Pennsylvania State line, and 2½ miles southeast of Salisbury, Somerset County.

Drainage area.--24.5 sq mi.

Gage.--Recording gage.

Stage-discharge relation.--Defined by current-meter measurements below 500 cfs and extended to 4,300 cfs on basis of slope-area determination at 4,100 cfs.

Annual flood stages and discharges

Date	Gage height (feet)	Discharge (cfs)	Date	Gage height (feet)	Discharge (cfs)
1933, Mar. 14	6.1	1,900	1942, May 16	4.67	1,290
1934, Jan. 7	5.1	968	1943, Oct. 15	6.21	3,460
1935, Feb. 15	4.05	494	1944, May 7	3.88	628
1936, Mar. 17	7.5	4,100	1945, Feb. 27	4.42	1,050
1937, Apr. 26	7.6	4,300	1946, June 19	4.26	908
1937, Oct. 28	6.04	1,860	1947, Mar. 14	3.89	634
1939, Jan. 31	5.28	1,180	1948, Jan. 1	4.21	876
1940, Aug. 27	5.69	1,510	1949, Jan. 26	3.62	472
1941, June 4	5.38	1,260	1950, Mar. 27	4.12	796

(14) Laurel Hill Creek at Ursina, Pa.

Location.--Lat 39°49'15", long. 79°19'15", at Ursina, Somerset County, 500 ft downstream from bridge on State Highway 53 and 2.7 miles upstream from mouth.

Drainage area.--121 sq mi.

Gage.--Nonrecording gage from August 1913 to July 1939 and recording gage thereafter. Datum of recording gage 1,335.26 ft above mean sea level, unadjusted. Datum of nonrecording gage, at site 0.7 miles downstream, 1,329.06 ft above mean sea level.

Stage-discharge relation.--Prior to July 1939, defined by current-meter measurements below 4,600 cfs, and extended to 11,000 cfs on basis of slope-area determination; thereafter, defined by current-meter measurements below 5,400 cfs and extended to 9,400 cfs.

Remarks.--Slight regulation at low flow by mills upstream. Records from August 1913 to September 1941 in reports of Pennsylvania Department of Forests and Waters. Records for station at Confluence not used because of severe backwater effect at flood stages.

Annual flood stages and discharges

Date	Gage height (feet)	Discharge (cfs)
1914, June 28	6.20	3,220
1915, Jan. 7	6.99	4,140
1916, Mar. 22	8.0	5,630
1917, Jan. 22	8.2	5,970
1918, Feb. 20	8.0	5,630
1919, Jan. 2	6.1	3,110
1920, June 17	7.2	4,410
1921, Jan. 23	6.1	3,110
1921, Dec. 24	6.31	3,330
1923, July 11	5.1	2,070
1924, Mar. 29	9.30	8,090
1925, Feb. 9	7.9	4,300
1925, Oct. 25	6.66	3,780
1927, Jan. 21	8.0	5,630
1927, Oct. 19	8.20	5,970
1929, June 28	5.15	2,170
1929, Oct. 3	7.10	4,270
1931, Apr. 4	5.76	2,780
1932, Mar. 31	5.45	2,370
1933, Mar. 14	7.5	4,860
1934, Aug. 16	6.6	3,660
1935, Aug. 2	6.86	4,020
1936, Mar. 17	10.28	10,300
1937, Apr. 26	7.5	4,860
1937, Oct. 28	7.6	5,010
1939, Feb. 3	7.58	5,010
Change in site and datum		
1940, Mar. 30	6.28	6,510
1941, June 4	7.98	9,400
1942, Apr. 9	4.57	3,580
1942, Dec. 30	5.81	5,660
1944, Apr. 23	4.24	3,100
1945, Mar. 6	5.96	6,000
1946, June 2	5.12	4,470
1947, July 31	5.91	5,830
1948, Apr. 13	5.48	5,150
1949, Aug. 18	5.20	4,360
1950, Apr. 24	4.31	2,900

(15) Green Lick Run at Green Lick Reservoir, Pa.

Location.--Lat 40°06'20", long. 79°30'05", at upstream end of Green Lick Reservoir, Fayette County, 1.3 miles upstream from Latter Run, and 3½ miles southeast of Mount Pleasant.

Drainage area.--3.07 sq mi.

Gage.--Recording gage.

Stage-discharge relation.--Defined by current-meter measurements below 150 cfs and extended to 550 cfs by logarithmic plotting. Discharges for flood crests affected by backwater determined by slope-area method.

Remarks.--Records prior to August 1941 furnished by Municipal Authority of Westmoreland County. Records prior to 1929 incomplete; gage placed in operation about 1915.

Annual flood stages and discharges

Date	Gage height (feet)	Discharge (cfs)	Date	Gage height (feet)	Discharge (cfs)
1929, Feb. 26	2.21	126	1940, Mar. 30	2.73	282
1929, Oct. 2	2.69	266	1941, June 4	3.20	520
1931, May 7	2.77	298	1942, Mar. 9	2.72	278
1932, Mar. 31	2.32	153	1943, Aug. 13	5.1	1,400
1933, Mar. 13	2.67	260	1944, May 24	5.42	590
1934, Mar. 3	2.44	186	1945, Mar. 6	2.54	216
1935, Aug. 2	2.85	332	1946, July 1	3.24	546
1936, Mar. 17	3.18	508	1947, June 7	2.70	270
1937, Apr. 25	2.46	191	1948, Apr. 12	2.40	174
1938, July 18	3.21	526	1949, Aug. 18	2.66	256
1939, Feb. 3	2.40	174	1950, Jan. 6	2.43	183

INT.-DUP. SEC., WASH., D.C. 27096