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TECHNIQUES FOR ESTIMATING MAGNITUDE AND FREQUENCY OF PEAK FLOWS FOR PENNSYLVANIA STREAMS

by Marla H. Stuckey and Lloyd A. Reed

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CONVERSION FACTORS AND ABBREVIATIONS

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter
	Area	
square mile (mi^2)	2.590	square kilometer
acre	0.4047	square hectometer
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
	Volume	
acre-foot (acre-ft)	1,233	cubic meter

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ABSTRACT

Regression equations for estimating the magnitude and frequency of floods on ungaged streams in Pennsylvania with drainage areas less that 2,000 square miles were developed on the basis of peak-flow data collected at 313 streamflow-gaging stations. All streamflow-gaging stations used in the development of the equations had 10 or more years of record and include active and discontinued continuous-record and crest-stage partial-record streamflow-gaging stations. Regional regression equations were developed for flood flows expected every 10, 25, 50, 100, and 500 years by the use of a weighted multiple linear regression model.

The State was divided into two regions. The largest region, Region A, encompasses about 78 percent of Pennsylvania. The smaller region, Region B, includes only the northwestern part of the State. Basin characteristics used in the regression equations for Region A are drainage area, percentage of forest cover, percentage of urban development, percentage of basin underlain by carbonate bedrock, and percentage of basin controlled by lakes, swamps, and reservoirs. Basin characteristics used in the regression equations for Region B are drainage area and percentage of basin controlled by lakes, swamps, and reservoirs. The coefficient of determination (R^2) values for the five flood-frequency equations for Region A range from 0.93 to 0.82, and for Region B, the range is from 0.96 to 0.89.

While the regression equations can be used to predict the magnitude and frequency of peak flows for most streams in the State, they should not be used for streams with drainage areas greater than 2,000 square miles or less than 1.5 square miles, for streams that drain extensively mined areas, or for stream reaches immediately below flood-control reservoirs. In addition, the equations presented for Region B should not be used if the stream drains a basin with more than 5 percent urban development.

INTRODUCTION

Flood-flow statistics are used in the design of bridges and flood-control structures as well as for flood-plain management. It is important for engineers and planners to have access to methods that produce reliable flood-flow statistics for inclusion in the design and implementation of these projects. Regional regression equations as well as any available data from streamflow-gaging stations are used to estimate flood-flow statistics for such projects. Commonly used flood-flow statistics in flood-related projects include the flood flows expected every 10, 25, 50, 100, and 500 years (Q_{10}, Q_{25}, Q_{50}, Q_{100}, and Q_{500}, respectively). Regression equations for computing flood-flow frequencies for streams in Pennsylvania were last developed by the U.S. Geological Survey (USGS) by use of peak-flow data collected through 1975 (Flippo, 1982). Analysis of these equations indicated the need to revise the flood-frequency equations by use of the most recent flood-frequency data (Ehlke and Reed, 1999).

The USGS, in cooperation with the Pennsylvania Department of Transportation (PennDOT), conducted an investigation to develop updated flood-flow regression equations for sites on ungaged reaches of streams in Pennsylvania with drainage areas less than 2,000 mi^2. Regression equations were developed for Q_{10}, Q_{25}, Q_{50}, Q_{100}, and Q_{500} on the basis of streamflow records at gaging stations with 10 or more years of record. Basin characteristics used in the development of the regression equations were drainage area, percentage of forest cover, percentage of urban development, percentage of basin underlain by carbonate bedrock, and percentage of basin controlled by lakes, swamps, and reservoirs. The development of the regression equations produced two flood-flow regions; the larger region encompasses most of Pennsylvania with the exception of the northwestern part of the State.

Purpose and Scope

This report presents equations that predict flood frequencies with return intervals of 10, 25, 50, 100, and 500 years for ungaged streams in Pennsylvania. Flood-flow regression equations were developed by use of data from 311 continuous-record and crest-stage partial-record streamflow-gaging stations (crest-stage stations) on streams in Pennsylvania and 2 in the adjacent states with 10 or more years of peak-flow data generally through water year[1] 1997. The spatial distribution of the stations used in the development of the equations is shown in figure 1. The spatial distribution of the streamflow-gaging stations represents most of the various flow conditions and geology found throughout Pennsylvania. Although no major regions are ungaged, only a few streamflow-gaging stations were available in the south central and northeastern parts of the State (fig. 1).

Previous Investigations

Equations that could be used to predict flood frequencies for ungaged streams in Pennsylvania were presented by Flippo in 1982. These equations were an updated form of previously published regression equations by Flippo (1977). The flood-flow regression equations published in 1982 were evaluated by Ehlke and Reed (1999) on the basis of a comparison between flood frequencies calculated from the regression equations and peak-flow data collected through the 1996 water year. This comparison found significant variation among flood-frequency statistics computed from the equations developed by Flippo (1982) and peak-flow data, indicating that a revised or an updated version of these equations was warranted.

DEVELOPMENT OF FLOOD-FREQUENCY PREDICTION EQUATIONS

Flood-frequency statistics were computed for all active and discontinued streamflow-gaging stations in Pennsylvania with at least 10 years of peak-flow data by use of methods described in Water Resource Council Bulletin 17B (Water Resources Council, Hydrology Committee, 1981). Drainage area and basin characteristics were tabulated for each station with flood-frequency data. Regression equations for predicting flood discharges were developed by weighting each data set with the number of years of peak-flow data collected at the station. Following the first analysis, which included the entire State, departures of predicted to observed flood frequencies were used to divide the State into regions and the development of the regression equations was repeated on a regional basis.

Description of Stations Used

Peak-flow data from 313 continuous-record and crest-stage stations with 10 or more years of record within Pennsylvania and the surrounding states were used in the development of the regression equations. Some of these streamflow-gaging stations have a combined operational history that includes a period when the station was operated as a continuous-record station and another period when it was operated as a crest-stage station. Only stations with drainage areas less than 2,000 mi^2 were used. Rivers with drainage areas greater than 2,000 mi^2 generally have an adequate number of streamflow-gaging stations to represent all reaches of the river and have long periods of record to include the various flood conditions. Flood-frequency statistics were computed using all available peak-flow data, generally

[1] Water year refers to the 12-month period October 1 - September 30.

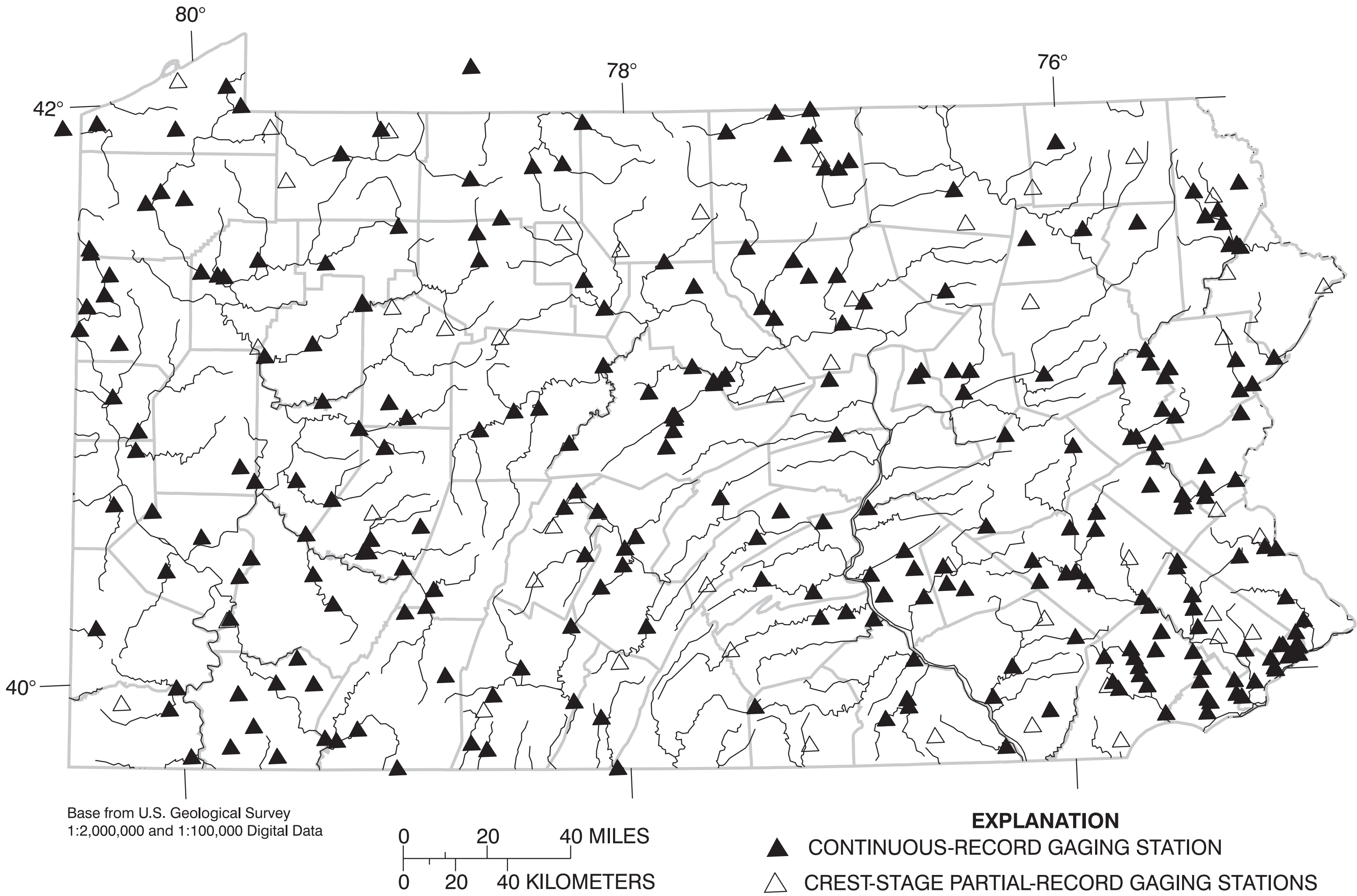

Figure 1. Streamflow-gaging stations used in development of flood-flow regression equations for Pennsylvania streams.

through water year 1997, as described in Water Resources Council Bulletin 17B (Water Resources Council, Hydrology Committee, 1981). Five stations with short periods of record were greatly affected by Hurricane Floyd in the fall of 1999. Because of this significant rainfall event, flood frequencies for these stations were computed using data through water year 1999.

For most streamflow-gaging stations, the length of record was the period from the start of record to the year flood frequencies were computed, or to the year the station was discontinued. Several stations were operated before and after construction of large flood-control projects and these stations were assigned two periods of record, one before and one after construction of the flood-control project. As an example, the station on the Lackawaxen River at Hawley (01431500) was operated before and after construction of two large flood-control reservoirs, which increased the percentage of basin controlled by lakes, swamps, and reservoirs by 32 percent. Construction of the flood-control reservoirs affected the flood frequency and two flood-frequency analyses were computed, one for before and one for after construction.

Period of record used in analysis for stations that have a gap in operational history was determined by the total number of years the station was actually in operation. However, if a peak flow was determined prior to the start of a station, which is coded as an historical peak, the total number of years from the historical peak to the end of record are included in the period of record used in analysis, which would include the period the station was not operating (Water Resources Council, Hydrology Committee, 1981). This situation affects a small number of stations used in the analysis and usually adds only a few years to the period of record used in analysis. For example, station 01543500, Sinnemahoning Creek at Sinnemahoning, was started in 1939, but because an historical peak was recorded in 1936, the period of record used in analysis includes the period between 1936 and 1939 that the station was not in operation.

Basin Characteristics Used in Equation Development

The basin characteristics used to develop the regression equations are drainage area, percentage of forest cover, percentage of urban development, percentage of basin underlain by carbonate bedrock, and percentage of basin controlled by lakes, swamps, and reservoirs. These basin characteristics are known to affect flood flow. The basin characteristics for all streamflow-gaging stations used in the development of the regression equations are listed in Appendix 1.

Other basin characteristics considered for use in the equations include channel slope and precipitation index, two factors previously included in equations developed by Flippo (1982). Channel slope was found to be significant for Flippo’s equations in only 1 region out of 10 regions, and that region was developed entirely from New York stations (Flippo, 1977, 1982). Because of these findings, channel slope was not included in the development of the present equations. A precipitation factor was not included in the development of the equations because of a report by Reich and Jackson (1971) that found that estimates of the 100-year flood were not improved with the inclusion of rainfall statistics.

Drainage area

Drainage areas for each of the streamflow-gaging stations were determined at the time the stations were established, and most drainage areas were checked by use of the most recent topographic maps available. These drainage areas are found in USGS Water-Resources Data Reports for the 1997 water year (Durlin and Schaffstall, 1998a; Durlin and Schaffstall, 1998b; Coll and Siwicki, 1998). Drainage area for ungaged sites can be determined from the most recent topographic maps.

Percentage of forest cover

Percentage of forest cover in the drainage basin upstream of each streamflow-gaging station was determined from land-use data by use of Geographic Information Systems (GIS) methods (U.S. Geological Survey, 1996) or from topographic maps. Values for percentage of forest cover in basins upstream of streamflow-gaging stations still in operation and for streamflow-gaging stations recently discontinued were determined from current land-use data.

Percentage of forest cover upstream of streamflow-gaging stations discontinued prior to about 1960 were determined from land-use data shown on 15-minute topographic maps produced from about 1920 to about 1940. Not all 15-minute maps showed forest cover and estimates were made by use of 15-minute maps of adjacent areas with similar topography or the oldest available 7.5-minute maps that showed forest cover.

Percentage of urban development

Percentage of urban development in the drainage basin upstream of a streamflow-gaging station was determined using the same methods used to determine percentage of forest cover. Percentage of urban development was calculated as the land classified as low-intensity developed plus the land classified as high-intensity residential, and the land classified as high-intensity commercial / industrial (U.S. Geological Survey, 1996). Percentage of urban development in basins in which the streamflow-gaging station was discontinued prior to about 1960 was determined from 15-minute topographic maps much the same as was done for percentage of forest cover.

Percentage of basin underlain by carbonate rock

Percentage of the basin underlain by carbonate rock was computed by use of GIS methods (Environmental Resources Research Institute, 1996). All calculations were made by use of GIS methods except for a few streamflow-gaging stations in which the percentage carbonate bedrock in the basin was obtained from Aron and Kibler (1981). Although not intended for determination of the carbonate bedrock variable needed for input into the equations, figure 2 shows the areas underlain by carbonate bedrock for the State.

Percentage of basin with controlled by lakes, swamps, and reservoirs

Percentage of drainage basin with streamflow controlled, or attenuated, by lakes, swamps, and reservoirs was computed by use of the technique recommended by Aron and Kibler (1981). The technique is based on two assumptions. The first assumption is that the temporary storage of 2.4 in. of runoff from the area upstream of a lake, swamp, or reservoir can reduce flooding from storms that would, in an uncontrolled basin, produce a flood with a recurrence interval of 100 years. The second assumption is that the water-surface elevation in most unregulated lakes, swamps, and reservoirs will increase 24 in. during a storm that would cause a flood with a recurrence interval of 100 years. Combining these assumptions into an example, the water-surface elevation of an unregulated lake, swamp, or reservoir can increase 24 in. during a large storm. As a result, a 10-acre lake, swamp, or reservoir can store 20 acre-feet of runoff, enough storage to control the 100-year flood from a drainage area of 100 acres. If the drainage area above the 10-acre lake or reservoir or swamp is larger than 100 acres, the percentage of the drainage area that is controlled can be calculated by dividing 100 acres, the controlled area, by the total area in the basin.

To summarize, if the area of a watershed above a lake, swamp, or reservoir is more than 10 times the surface area of the lake, swamp, or reservoir, the controlled area becomes the surface area multiplied by 10. If the drainage area above the lake, swamp, or reservoir is smaller than 10 times the surface area of the lake, swamp, or reservoir, the controlled area is equal to the drainage area above the lake, swamp, or reservoir. A careful evaluation of streams with multiple lakes or swamps is required because double counting of controlled areas must be avoided. Reservoirs built especially for flood control are assumed to control the entire upstream basin for a flood with a recurrence interval of 100 years. The surface area of lakes, swamps, and reservoirs, which determines the percentage of basin controlled by lakes, swamps, and reservoirs, is determined from the most recent topographic maps.

As an example, a site on Middle Creek, at latitude 40°12'36" and longitude 76°15'05", has an upstream reservoir with a surface area of 0.55 mi^2. The drainage area at the reservoir is 7.59 mi^2, and the drainage area at the site is 23.3 mi^2. Because the reservoir is not a flood-control reservoir and the drainage area at the reservoir is greater than 10 times the surface area of the reservoir, the area controlled by the reservoir is 5.5 mi^2 (10 times the surface area of the reservoir). The percentage of the basin controlled by lakes, swamps, and reservoirs is 24 percent.

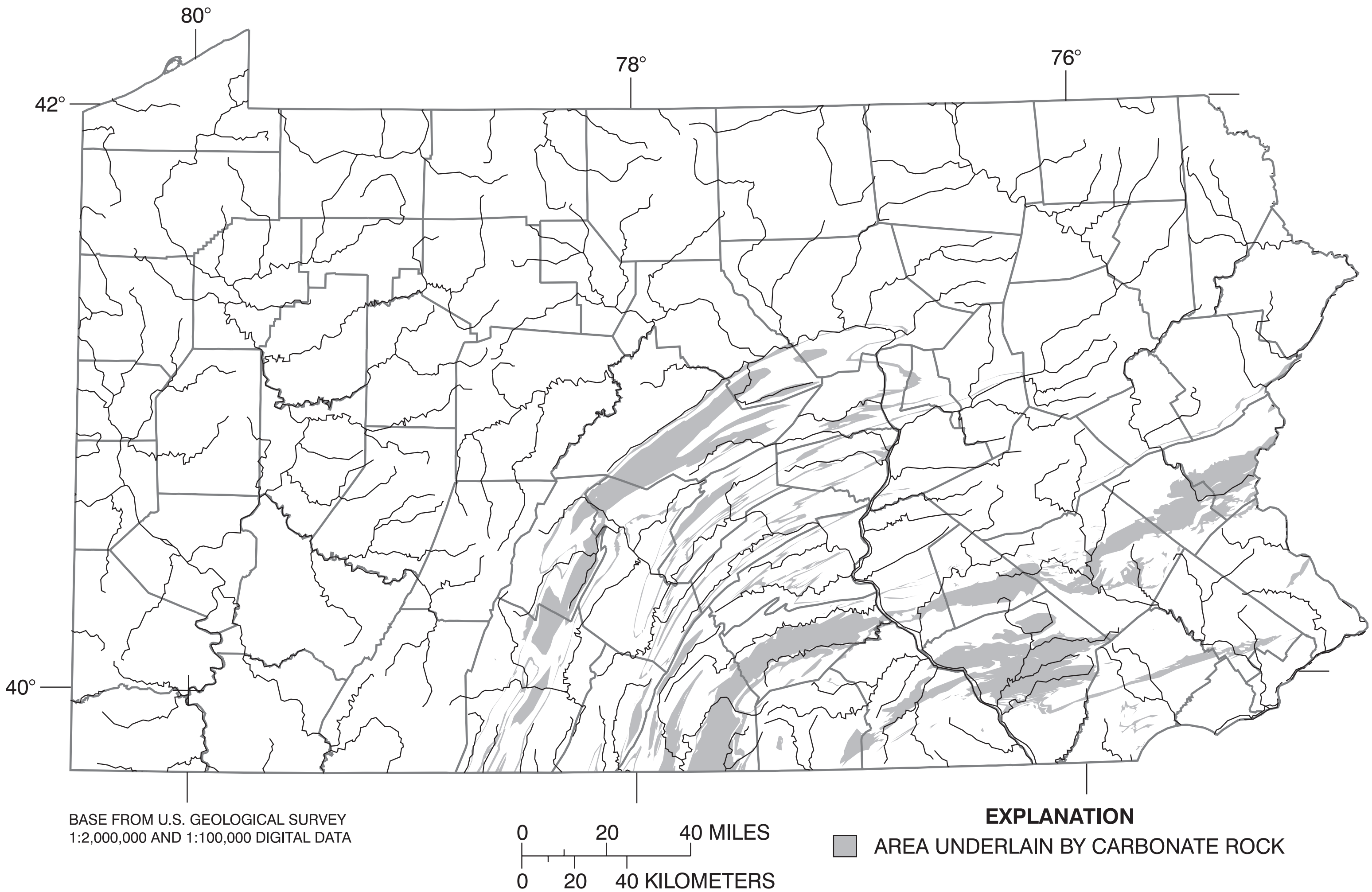

Figure 2. Carbonate regions in Pennsylvania (modified from Environmental Resources Research Institute, 1996).

Regression Analysis and Resultant Equations

The regression equations were developed by use of a multiple linear regression model from MathSoft, Inc. statistics package S-Plus4. The flood-frequency discharges calculated for each streamflow-gaging station were weighted as per the number of years in operation. In order to form a near linear relation between differences in flood flow and differences in land use, all percentages were converted to the form [1.0 + 0.01(percent of basin characteristic)] before the regression equations were developed.

A review of the records indicated most of the largest floods in the eastern part of the State occurred during the summer and fall; most of the largest floods in the northwestern part of the State occurred in the winter and spring. For example, the five largest floods on the Perkiomen Creek at Graterford, Pa. (station number 01473000, latitude 40°13'46", longitude 75°27'07") occurred, from largest to smallest, on July 7, 1935; August 23, 1933; June 2, 1946; August 9, 1942; and November 25, 1950; on Brokenstraw Creek at Youngsville, Pa. (station number 03015500, latitude 41°51'09", longitude 79°19'03"), a similar station in both drainage area and period of record, the five largest floods occurred on March 25, 1913; April 5, 1947; March 22, 1948; January 22, 1959; and January 19, 1996. Serious flooding from tropical storms in the summer and fall months is more common in the central and eastern part of the State.

An evaluation of the residuals from the initial regression analysis for 100-year recurrence interval floods for the entire State indicated that the northwestern part of the State, including the headwaters of the Allegheny River and the basins of Brokenstraw Creek, French Creek, Clarion River, Beaver Creek, Redbank Creek, and Mahoning Creek, had consistently smaller flood flows (resulting in large negative residuals) than streams in the rest of the State. These findings support the seasonal flooding differences discussed previously.

Because flooding in the northwestern part of the State does not appear to be related to flooding in the rest of the State, Pennsylvania was divided into two flood-flow regions, Region A and Region B (fig. 3). Region A includes about 78 percent of the State. Region B encompasses the northwestern corner, about 22 percent of the State. Regression equations to predict the 10, 25, 50, 100, and 500-year floods were then computed for Regions A and B. The basin characteristic coefficients and their residual standard error and coefficient of determination (R^2) are shown in table 1. The residual standard error provides a rough estimate of reliability of the predicted discharges and R^2 is a measure of the percentage of variance explained by regression (Helsel and Hirsch, 1997). The R^2 values range from 0.93 to 0.82 for Region A and 0.96 to 0.89 for Region B (table 1). The residual standard errors have some effect from the weighting and should not be directly compared to standard errors from a non-weighted analysis (Freund and Littell, 1986). The calculated Q_{10}, Q_{25}, Q_{50}, Q_{100}, and Q_{500} from streamflow-gage data and regression equations are listed in Appendix 2 for all streamflow-gaging stations used in the development of the regression equations.

The regression model took the form:

$$LogQ_T = A + bLogDA + cLog(1.0 + 0.01F) + dLog(1.0 + 0.01U) + eLog(1.0 + 0.01C) + fLog((1.0 + 0.01CA)) \quad (1)$$

where Log is log to base 10;

Q_T is return interval peak flow, in cubic feet per second;

A is the intercept;

DA is drainage area, in square miles;

F is percentage of forest cover, in percent;

U is percentage of urban development, in percent;

C is percentage of basin underlain by carbonate rock, in percent;

CA is percentage of basin controlled by lakes, swamps, or reservoirs, in percent; and

b, c, d, e, f are basin characteristic coefficients of regression.

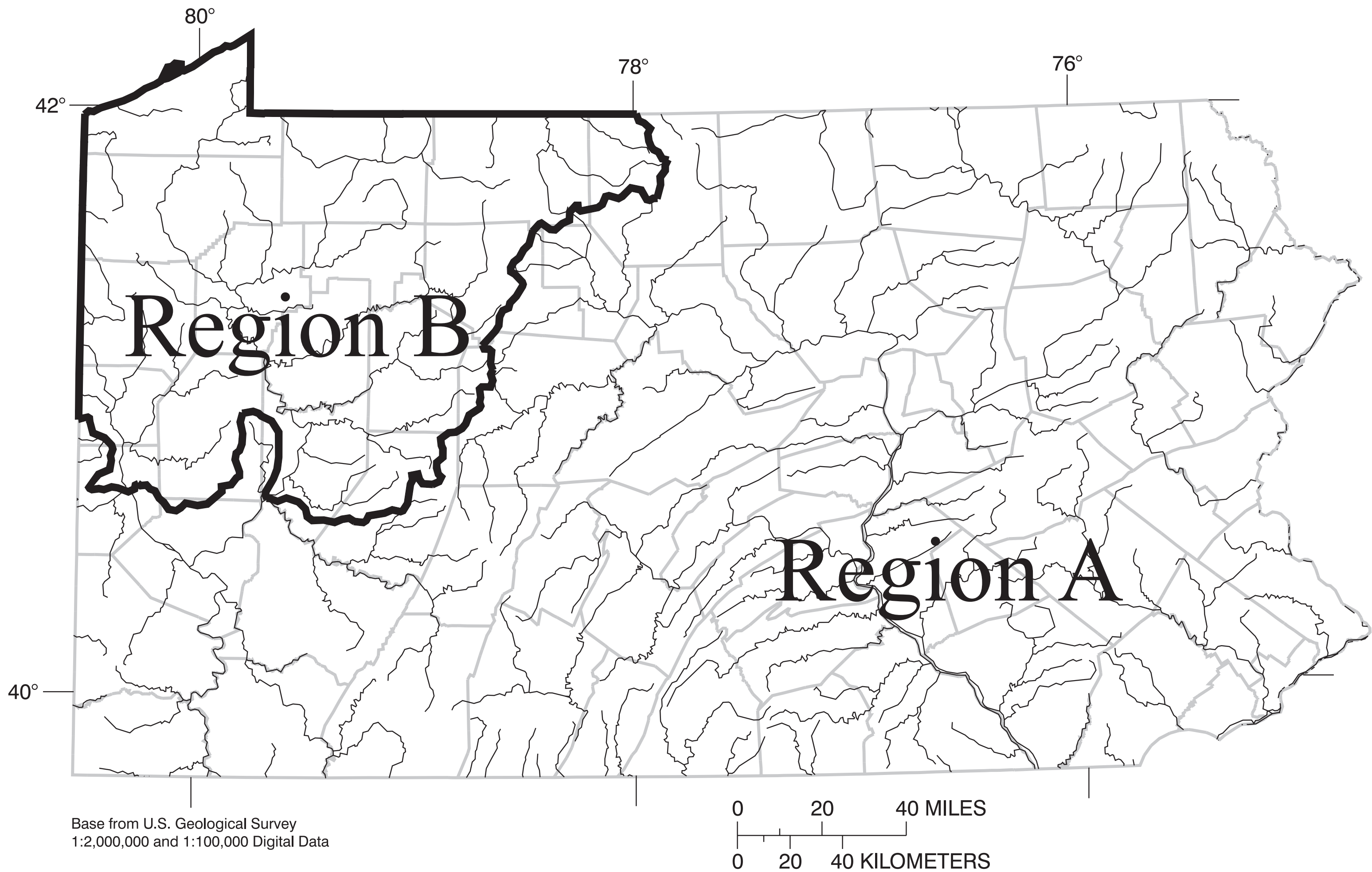

Figure 3. Flood-frequency regions in Pennsylvania.

Table 1. *Regression coefficients for use with regression equations for peak flows on Pennsylvania streams*

[Q_T, discharge for the T-year flood; ft^3/s, cubic feet per second; Q_{10}, 10-year flood flow; Q_{25}, 25-year flood flow; Q_{50}, 50-year flood flow; Q_{100}, 100-year flood flow; Q_{500}, 500-year flood flow; ---, basin characteristic coefficient not used in regression equation]

Q_T return flow (ft^3/s)	Basin characteristic coefficients						Residual standard error		Coefficient of determination (R^2)
	Intercept (A)	Drainage area (b)	Percentage forested area (c)	Percentage urban development (d)	Percentage carbonate area (e)	Percentage controlled area (f)	Log units	Percent	
Region A									
Q_{10}	2.5243	0.7770	-0.9712	1.0217	-1.7184	-0.5719	0.18	43	0.93
Q_{25}	2.7145	.7556	-1.0324	.7608	-1.5302	-.5302	.19	45	.91
Q_{50}	2.8441	.7414	-1.0821	.5785	-1.3955	-.4980	.21	50	.89
Q_{100}	2.9665	.7278	-1.1342	.4040	-1.2691	-.4637	.23	55	.87
Q_{500}	3.2294	.6994	-1.2666	.0208	-.9877	-.3834	.27	66	.82
Region B									
Q_{10}	2.3105	.7255	---	---	---	-1.2425	.12	28	.96
Q_{25}	2.4418	.7108	---	---	---	-1.3700	.13	30	.95
Q_{50}	2.5276	.7017	---	---	---	-1.4695	.14	33	.94
Q_{100}	2.6069	.6932	---	---	---	-1.5677	.16	38	.92
Q_{500}	2.7673	.6776	---	---	---	-1.8055	.19	45	.89

OR

Region A

$Q_{10} = 334.4\ DA^{.7770} (1 + .01F)^{-.9712} (1 + .01U)^{1.0217} (1 + .01C)^{-1.7184} (1 + .01CA)^{-.5719}$

$Q_{25} = 518.2\ DA^{.7556} (1 + .01F)^{-1.0324} (1 + .01U)^{.7608} (1 + .01C)^{-1.5302} (1 + .01CA)^{-.5302}$

$Q_{50} = 698.4\ DA^{.7414} (1 + .01F)^{-1.0821} (1 + .01U)^{.5785} (1 + .01C)^{-1.3955} (1 + .01CA)^{-.4980}$

$Q_{100} = 925.8\ DA^{.7278} (1 + .01F)^{-1.1342} (1 + .01U)^{.4040} (1 + .01C)^{-1.2691} (1 + .01CA)^{-.4637}$

$Q_{500} = 1{,}696\ DA^{.6994} (1 + .01F)^{-1.2666} (1 + .01U)^{.0208} (1 + .01C)^{-.9877} (1 + .01CA)^{-.3834}$

Region B

$Q_{10} = 204.4\ DA^{.7255} (1 + .01CA)^{-1.2425}$

$Q_{25} = 276.6\ DA^{.7108} (1 + .01CA)^{-1.3700}$

$Q_{50} = 337.0\ DA^{.7017} (1 + .01CA)^{-1.4695}$

$Q_{100} = 404.5 DA^{.6932} (1 + .01CA)^{-1.5677}$

$Q_{500} = 585.2\ DA^{.6776} (1 + .01CA)^{-1.8055}$

Regression equations for Region A have five variables: drainage area, percentage of forest cover, percentage of urban development, percentage of basin underlain by carbonate bedrock, and percentage of basin controlled by lakes, swamps, and reservoirs and were developed from 270 streamflow-gaging station records. All variables were significant predictors for the 10, 25, 50, 100, and 500-year floods at a 95-percent confidence level except percentage urban; percentage urban lost significance with the 100 and 500-year flood levels but was kept as a variable in the 100 and 500-year equations to provide consistency. With larger floods, the amount of runoff due to urban areas does not influence the peak flood as much as in smaller floods. If a 5-mi^2 basin that was 30 percent forest cover with no carbonate area, no urban area, and no controlled area was developed and percentage urban area increased 30 percent, the 10-year flood would increase 31 percent but the 500-year flood would increase only 1 percent. In smaller floods the runoff from pavement and roofs in urban areas makes up a substantial part of the peak, however, with larger floods, unpaved areas become saturated and additional precipitation produces substantial runoff from both paved and unpaved areas. A comparison between the Q_{100} computed from streamflow-gage data and regression equations for Region A is shown in figure 4.

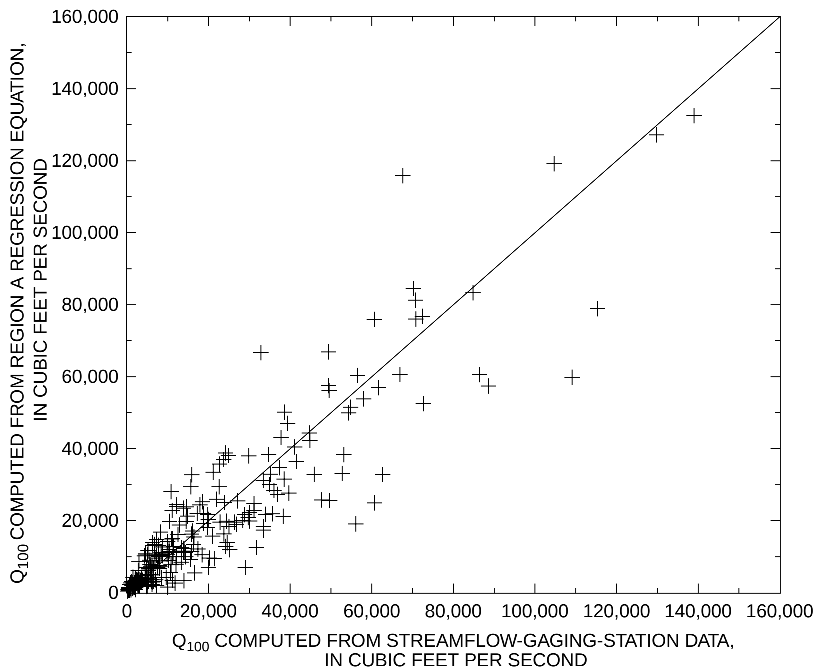

Figure 4. Comparison of 100-year flood-flow statistic (Q_{100}) computed from streamflow-gaging- station data and regression equation for flood frequency Region A in Pennsylvania.

Regression equations for Region B were developed from 54 streamflow-gaging station records and have 2 variables, drainage area and the percentage of basin controlled by lakes, swamps, and reservoirs. The area of the State that comprises Region B does not contain any carbonate rocks (figs. 2 and 3). The percentage urban area is consistently low for streamflow-gaging stations in Region B, without enough stations with high percentage urban areas to produce meaningful results.[2] Percentage forest was not a significant variable and was dropped from the analysis. The comparison between the Q_{100} computed from streamflow-gage data and regression equations for Region B is shown in figure 5.

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[2] When the percentage of urban area in a basin was included in the model for Region B, the regression coefficient was -6.20, indicating a large reduction in the 100-year peak flow when going from an undeveloped to a fully developed basin.

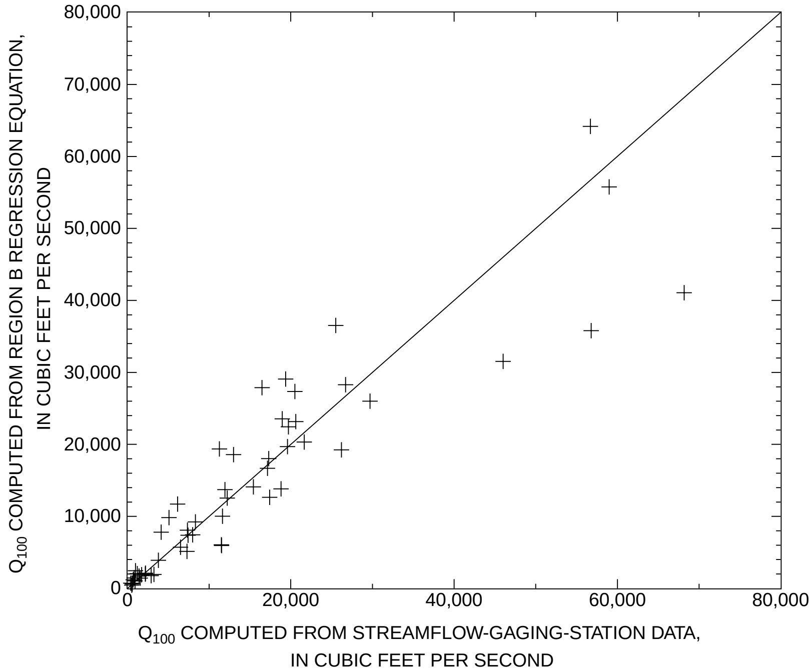

Figure 5. Comparison of 100-year flood-flow statistic (Q_{100}) computed from streamflow-gaging-station data and regression equation for flood frequency Region B in Pennsylvania.

A t-test on signed-ranks was used to determine if the results from the regression equations were significantly different than the flood frequencies computed from streamflow-gaging-station data (Helsel and Hirsch, 1997). This analysis was done using a 95-percent confidence level. The results of the t-test on signed-ranks showed that there was no significant difference between the flood frequencies predicted from regression equations and those predicted from streamflow-gaging-station data.

Just as a streamflow-gaging station has a period of record that should be taken under consideration when computing flood frequencies from the data for that station, the regression equations each have an equivalent years of record that should be taken under consideration when using the equations to compute flood frequencies. The equivalent years of record for the regression equations are computed from a factor on the basis of the skew coefficient of the population of annual peaks at individual stations used in the development of the regression equations, the standard deviation of the logs of the annual events at the individual stations used in the development of the regression equations, and the standard error of prediction of the regression equations. This methodology is presented by Hardison (1971). The equivalent years of record for all the regression equations are shown in table 2. The Q_{100} equation developed for Region A is comparable to a streamflow-gaging station that has been in operation for 10 years. The equivalent period of record for Regions A and B range from 5 to 16 years (table 2).

Table 2. *Equivalent period of record for regression equations developed for predicting flood recurrence intervals in Pennsylvania*

[Methodology used described by Hardison (1971)]

Flood recurrence interval	Equivalent period of record (years)	
	Region A	Region B
10-year	5	5
25-year	6	5
50-year	8	8
100-year	10	10
500-year	16	13

LIMITATIONS OF REGRESSION EQUATIONS

Several situations can limit the use of the regression equations presented for Regions A and B. The equations should not be used if the drainage area is less than 1.5 mi^2 or greater than 2,000 mi^2. The equations presented for Region B should not be used to predict flood flows from basins with more than 5 percent urban development because the largest percentage urban development in the data used to develop the equations was 4.5 percent. Because the equations for Region B do not include a variable for percentage of urban development, the equations do not incorporate the increased flooding that is likely to be associated with urban areas. A summary of the range of variables used to develop the regression equations for Regions A and B is presented in table 3.

Table 3. *Summary of the variables used to develop the regression equations for flood frequency Regions A and B in Pennsylvania*

[mi^2, square miles]

Region	Number of stations used	Number of records used[1]	Range					
					Percentage of basin			
			Drainage area (mi^2)	Years of record	In forest cover	In urban development	Underlain by carbonate bedrock	Controlled by lakes, swamps, and reservoirs
A	261	270	0.93 - 1,893	11- 109	1.8 - 100	0 - 86.7	0 - 98	0 - 94
B	52	54	2.12 - 1,608	11- 92	20 - 96	0 - 4.5	0 - 0	0 - 89

[1] Some streamflow-gaging stations have two records because of the construction of reservoirs or other changes in land use.

The equations should not be used to predict flood flows if streamflow at the site of interest is significantly affected by an upstream flood-control reservoir. The streamflow-gaging stations that were not used to develop the regression model are listed in table 4, along with the associated controlled area and flood frequencies computed from streamflow data. The 500-year flood is not listed in table 4 because the storage capacity for some flood-control reservoirs may not be sufficient to store all the runoff that contributes to the 500-year flood. The equations can be used to compute flood flows from basins that contain lakes, swamps, and non-flood-control reservoirs, provided the controlled area is computed and input to the regression equation.

The regression equations should not be used downstream of areas that have or have had significant surface mining in the past. The streamflow-gaging stations that were not used to develop the regression model due to extensive upstream surface mining are listed in table 5. Flood frequencies computed from streamflow-gaging-station data using the entire period of record are reported by Ehlke and Reed (1999). Extensive surface mining tends to reduce peak flood flows (Growitz and others, 1983). Reduced flooding due to surface mining is most likely caused by increased permeability into the fractured rock and into underground voids.

Table 4. *Streamflow-gaging stations in Pennsylvania with drainage areas less than 2,000 square miles and streamflow significantly affected by upstream regulation*

[Data from these streamflow-gaging stations was not included in the regression analysis; mi^2, square miles; water year, 12-month period October 1-September 30; ft^3/s, cubic feet per second]

U.S. Geological Survey streamflow-gaging station	Station name	Drainage area (mi^2)	Controlled area (percent)	Period of record (water year)	Computed from streamflow-gaging-station data			
					10-year (ft^3/s)	25-year (ft^3/s)	50-year (ft^3/s)	100-year ft^3/s)
[1]01429000	West Branch Lackawaxen River at Prompton	59.7	100	1961-97	2,780	3,130	3,630	4,150
[1]01429500	Dyberry Creek near Honesdale	64.6	100	1960-97	2,050	2,290	2,450	2,600
[1]01430000	Lackawaxen River near Honesdale	164	83	1960-97	6,020	7,070	7,830	8,570
01447800	Lehigh River below Francis Walter near White Haven	290	99	1961-97	9,430	11,700	13,500	15,400
[1]01449500	Wild Creek at Hatchery	16.8	98	1959-78	400	532	643	764
01449800	Pohopoco Creek below Beltzville Lake near Parryville	96.4	100	1971-97	1,680	1,840	1,950	2,060
01464645	North Branch Neshaminy Creek below Lake Galena near New Britain	16.2	94	1986-97	1,750	2,740	3,690	4,840
[1]01470960	Tulpehocken Creek at Blue Marsh Damsite near Reading	175	100	1978-97	4,030	4,920	5,590	6,290
[1]01471000	Tulpehocken Creek near Reading	211	83	1979-97	4,480	5,550	6,400	7,280
01480685	Marsh Creek near Downingtown	20.3	99	1974-97	638	786	898	1,010
[1]01518000	Tioga River at Tioga	282	100	1980-97	7,030	7,470	7,760	8,030
01518700	Tioga River at Tioga Junction	446	90	1980-97	8,970	9,990	10,700	11,500
[1]01520000	Cowanesque River near Lawrenceville	298	100	1980-97	5,500	6,140	6,610	7,080
01534300	Lackawanna River near Forest City	38.8	95	1960-97	1,040	1,180	1,270	1,360
[1]01541200	West Branch Susquehanna River at Curwensville	367	100	1966-97	6,230	7,000	7,580	8,160
01541303	West Branch Susquehanna River at Hyde	474	77	1979-97	6,930	7,540	7,980	8,400
01544000	First Fork Sinnemahoning Creek near Sinnemahoning	245	99	1956-97	7,150	8,140	8,850	9,550
01545000	Kettle Creek near Westport	233	97	1962-97	6,420	7,130	7,640	8,120
[1]01547500	Bald Eagle Creek at Blanchard	339	100	1971-97	4,140	4,670	5,050	5,420
01563200	Raystown Branch Juniata River below Raystown Dam near Huntingdon	960	100	1973-97	15,700	17,000	17,800	18,600
03020000	Tionesta Creek at Tionesta Dam	479	100	1941-91	9,440	10,800	11,700	12,600
03021520	French Creek near Union City	221	99	1972-91	3,530	4,040	4,400	4,740
03022554	Woodcock Creek at Woodcock Creek Dam	45.6	100	1978-93	872	990	1,070	1,150
03027500	East Branch Clarion River at East Branch Clarion River Dam	73.2	99	1953-91	1,170	1,570	1,910	2,310
03036000	Mahoning Creek at Mahoning Creek Dam	344	99	1939-91	7,800	9,400	10,700	12,000
[1]03039000	Crooked Creek at Crooked Creek Dam	278	99	1941-91	5,470	6,210	6,730	7,220
03042280	Yellow Creek near Homer City	57.4	91	1971-97	3,960	6,320	8,730	11,800

Table 4. *Streamflow-gaging stations in Pennsylvania with drainage areas less than 2,000 square miles and streamflow significantly affected by upstream regulation—Continued*

[Data from these streamflow-gaging stations was not included in the regression analysis; mi^2, square miles; water year, 12-month period October 1-September 30; ft^3/s, cubic feet per second]

U.S. Geological Survey streamflow-gaging station	Station name	Drainage area (mi^2)	Controlled area (percent)	Period of record (water year)	Computed from streamflow-gaging-station data			
					10-year (ft^3/s)	25-year (ft^3/s)	50-year (ft^3/s)	100-year ft^3/s)
03044000	Conemaugh River at Tunnelton	1,358	100	1952-91	26,400	30,500	33,500	36,400
03047000	Loyalhanna Creek at Loyalhanna Dam	292	99	1942-91	5,440	6,190	6,730	7,250
03048500	Kiskiminetas River at Vandergrift	1,825	91	1971-97	28,000	31,800	34,400	36,900
03077500	Youghiogheny River at Youghiogheny River Dam	436	100	1944-91	7,860	9,200	10,200	11,100
03101500	Shenango River at Pymatuning Dam	167	95	1935-97	1,350	1,570	1,740	1,910
03103500	Shenango River at Sharpsville	584	100	1967-91	4,020	4,310	4,510	4,690
03106300	Muddy Creek near Portersville	51.2	98	1970-97	597	715	807	901

[1] Data collected from these stations prior to regulation by a reservoir are included in the analysis.

Table 5. *Streamflow-gaging stations in Pennsylvania with drainage areas less than 2,000 square miles and streamflow significantly affected by mining*

[Data from these streamflow-gaging stations was not included in the regression analysis; mi^2, square miles]

US Geological Survey streamflow-gaging station number	Station name	Drainage area (mi^2)
01467500	Schuylkill River at Pottsville	53.4
01468500	Schuylkill River at Landingville	133
01534500	Lackawanna River at Archbald	108
01535500	Lackawanna River at Moosic	264
01536000	Lackawanna River at Old Forge	332
01537000	Toby Creek at Luzerne	32.4
01537500	Solomon Creek at Wilkes-Barre	15.7
01541308	Bradley Run near Ashville	6.77
01542000	Moshannon Creek at Osceola Mills	68.8
01554500	Shamokin Creek near Shamokin	54.2

TECHNIQUES FOR ESTIMATING MAGNITUDE AND FREQUENCY OF PEAK FLOWS

Four methods for computing flood-flow frequency discharges are discussed below and are dependent on the location of the site: 1) not near a streamflow-gaging station, 2) at a streamflow-gaging station, 3) near a streamflow-gaging station, and 4) between two streamflow-gaging stations. The regression equations presented in this report are used if the site of interest is not near a streamflow-gaging station.

Not near a streamflow-gaging station

If the site is not near a streamflow-gaging station, the appropriate flood-frequency regression equation is used to compute the discharge.

Example 1. Not near a streamflow-gaging station

Calculate the 100-year flood frequency by use of the appropriate regional regression equation for an ungaged site on Middle Creek at latitude 40°12'36" and longitude 76°15'05". The drainage area is 23.3 mi^2, percentage of forest cover area is 58 percent, percentage of urban development is 1.8 percent, percentage of carbonate bedrock in the basin is 8.4 percent, and percentage of streamflow controlled by lakes, swamps, and reservoirs is 24 percent (computed previously).

1. From figure 2 and the latitude and longitude, the site is in region A.
2. Substituting the basin characteristics into the regression equation for the 100-year flood in Region A from table 1 produces:

$$\log Q_{100}=2.9665 + 0.7278*\log(23.3) - 1.1342*\log(1.58) + 0.4040*\log(1.018) - 1.2691*\log(1.084) - 0.4637*\log(1.24)$$

$$\log Q_{100} = 2.9665 + 0.9952 - 0.2253 + 0.0031 - 0.0445 - 0.0433$$

$$\log Q_{100} = 3.6517$$

$$Q_{100} = 4{,}480\ ft^3/s$$

At a streamflow-gaging station

When the site of interest is at a streamflow-gaging station, a weighting method is recommended by Flippo (1977), Choquette (1987), and Water Resources Council, Hydrology Committee (1981). Because peak-flow data reported for a streamflow-gaging station represents a specific time span, flood-frequency values computed from streamflow-gaging-station data may contain some bias. The period of record for the streamflow-gaging station may or may not include years when large floods occurred in Pennsylvania, such as 1936, 1955, 1972, 1977, and 1996. Inclusion of several large floods, or lack of any large floods, can change flood-frequency values for streamflow-gaging stations, especially those with short periods of record. Consequently, the flood-frequency discharge computed from streamflow data is weighted with the flood-frequency discharges computed from regression equations on the basis of number of years in operation for the streamflow-gaging station and equivalent period of record for the regression equations. To use this method, the streamflow-gaging station should have at least 10 years of operation.

To obtain a weighted flood frequency for a site at a streamflow-gaging station, the flood frequency for the station is multiplied by the years of record at the station (N), and the flood frequency computed from the appropriate regional regression equation is multiplied by the equivalent years of record (NE) for the regression equation from table 2. The two values are then added and divided by the sum of the years of record to obtain a weighted flood frequency for the stream at the streamflow-gaging station. This equation is shown below:

$$WtdQ_T = (Q_{T(G)} \times N + Q_{T(R)} \times NE) / (N + NE) \qquad (2)$$

where $WtdQ_T$ is the weighted discharge for return intervals T-years;
$Q_{T(G)}$ is the T-year discharge computed from streamflow data, in cubic feet per second;
$Q_{T(R)}$ is the T-year discharge computed from regression equations, in cubic feet per second;
N is the number of years of record at streamflow-gaging station; and
NE is the equivalent years of record for regional regression equations from table 2.

Example 2. At a streamflow-gaging station

Calculate the weighted flood frequency for streamflow-gaging station 01452300 on East Branch Monocacy Creek near Bath, Pa., at latitude 40°43'10" and longitude 75°22'10". The drainage area is 5.35 mi^2, percentage of forest cover area is 26 percent, percentage of urban development is 4.0 percent, percentage carbonate bedrock in the basin is 4.0 percent, and 7.5 percent of the basin is controlled by lakes, swamps, and reservoirs. The station was operated from 1963 to 1968 as a continuous-record station and 1969 to 1980 as a crest-stage station, for a total of 18 years. The reported Q_{100} determined from streamflow data is 1,540 ft^3/s.

1. The Q_{100} computed from regional regression equations is 2,260 ft^3/s (see *Example 1* for setup) and from table 2, the equivalent years of record for the regression equation is 10 years.
2. Substituting the discharges and number of years into equation 2 produces:

$WtdQ_{100}$ = (1,540*18 + 2,260*10) / (18+10)

$WtdQ_{100}$ = 1,800 ft^3/s

Near a streamflow-gaging station on the same stream

Once a weighted flood frequency has been computed for the streamflow-gaging station, the flood frequency can be applied to nearby sites within 0.5 to 1.5 times the drainage area of the streamflow-gaging station, provided there is no significant change in land use or hydrologic conditions between the ungaged site and streamflow-gaging station. This methodology is presented by Choquette (1987) for the state of Kentucky and is cited as an acceptable transfer technique by the Federal Emergency Management Agency (FEMA) (1995).

This method translates the weighted streamflow-gaging station flood discharges to the ungaged site of interest by the use of a linear correction factor for the difference in drainage areas between the gaged and ungaged sites. As the drainage area of the ungaged site nears either 0.5 or 1.5 times the drainage area of the gaged site, the translated flood frequency nears the result of the regression equation. Using this method prevents large changes in flood frequencies when going from a gage-regression weighted value to a regression equation value. The equation to calculate this translated flood frequency is shown below:

$$C_u = C_g - \left(\frac{2(|DA_g - DA_u|)}{DA_g}\right)(C_g - 1) \qquad (3)$$

where C_u is the correction factor for the ungaged site;

C_g is the weighted flood frequency for the gaged site (from equation 2) divided by the regression estimate of flood frequency for the gaged site;

DA_g is the drainage area at the streamflow gage, in square miles; and

DA_u is the drainage area at the ungaged site, in square miles.

Example 3. Near a streamflow-gaging station on the same stream

Calculate the Q_{100} for an ungaged site on West Branch Clarion Creek at a latitude 41°29'55" and longitude 78°40'52". The drainage area for the ungaged site is 85.4 mi^2. There is an upstream streamflow-gaging station at Wilcox (station number 03028000) at a latitude 41°34'45" and longitude 78°41'22". The streamflow-gaging station has 43 years of operational history and a drainage area of 63.0 mi^2. Neither site has any controlled area. The Q_{100} computed from streamflow-gage data for the streamflow-gaging station is 7,410 ft^3/s.

1. From the latitude and longitude and figure 2, both sites are in Region B.
2. Substituting the basin characteristics into the regression equations for Region B for the ungaged site produces:

   $\log Q_{100} = 2.6069 + 0.6932*\log(85.4) - 1.5677*\log(1)$

   $Q_{100} = 8{,}830\ ft^3/s$

   and for the gaged site:

   $\log Q_{100} = 2.6069 + 0.6932*\log(63.0) - 1.5677*\log(1)$

   $Q_{100} = 7{,}150\ ft^3/s$

3. Substituting the needed variables for the streamflow-gaging station into equation 2 results in a weighted discharge of $Q_{100} = 7{,}360\ ft^3/s$ (see *Example 2* for setup).
4. Substituting the needed variables into equation 3 produces:

   $C_u = (7{,}360/7{,}150) - (2*|63.0-85.4|)/63.0) * ((7{,}360/7{,}150)-1)$

   $C_u = 1.029 - (44.8/63.0)*0.029$

   $C_u = 1.008$

5. Multiplying the correction factor for the ungaged site by the regression estimate for the ungaged site produces:

   $Q_{100} = 1.008 * 8{,}830$

   $Q_{100} = 8{,}900\ ft^3/s$

Between two streamflow-gaging stations

If the ungaged site of interest is between two streamflow-gaging stations and within 0.5 to 1.5 times both drainage areas (an upstream streamflow gage A and a downstream streamflow gage B), weighted discharge data should be computed for each streamflow gage and moved from the streamflow gages to the ungaged site of interest (C). The moved data should then be weighted proportional to the ratio of drainage areas between the site and the two streamflow gages. The equation for weighting the transferred data at the ungaged site is shown below.

$$Q_{T(C)} = Q_{T(AC)} \times \frac{DA_B - DA_C}{DA_B - DA_A} + Q_{T(BC)} \times \frac{DA_C - DA_A}{DA_B - DA_A} \qquad (4)$$

where $Q_{T(C)}$ is the final weighted discharge at ungaged site C, in cubic feet per second;

$Q_{T(AC)}$ is the weighted and moved discharge from upstream streamflow-gaging station (gage A), in cubic feet per second;

$Q_{T(BC)}$ is the weighted and moved discharge from downstream streamflow-gaging station (gage B), in cubic feet per second;

DA_A is the drainage area of the upstream streamflow gage A;

DA_B is the drainage area of the downstream streamflow gage B; and

DA_C is the drainage area of ungaged site C.

Example 4. Between two streamflow-gaging stations

Compute the Q_{100} for an ungaged site on Wissahickon Creek at a latitude 40°01'41" and longitude 75°11'51" with a drainage area of 61.5 mi^2. The basin is underlain by 17 percent carbonate bedrock and has 41 percent forested area, 42 percent urban area, and has no controlled area. Data from two streamflow-gaging stations are available, Wissahickon Creek at Bells Mills Road (station number 01473950) at 40°04'50" 75°13'35" and Wissahickon Creek at mouth (station number 01474000) at 40°04'45" 75°13'43". The upstream station at Bells Mills Road drains 53.6 mi^2, has 16 years in operation, 20 percent of the basin underlain by carbonate bedrock, 39 percent forested area, 41 percent urban area, and no area controlled by lakes or swamps. The Q_{100} for station number 01473950 computed from streamflow-gage data is 8,620 ft^3/s. The downstream station at mouth drains 64.0 mi^2, has 34 years in operation, 16 percent of the basin underlain by carbonate bedrock, 40 percent forested area, 42 percent urban area, and no area controlled by lakes or swamps. The Q_{100} for station number 01474000 computed from streamflow-gage data is 13,900 ft^3/s.

1. From the latitudes and longitudes and figure 2, all three sites are in Region A
2. Substituting the basin characteristics into the regression equation for Region A results in: (See *Example 1* for setup)

   01473950 Q_{100} = 10,500 ft^3/s

   01474000 Q_{100} = 12,400 ft^3/s

   ungaged site Q_{100} = 11,900 ft^3/s
3. Substituting the regression estimates into equation 2 results in weighted discharges of: (See *Example 2* for setup)

   01473950 $wtdQ_{100}$ = 9,340 ft^3/s

   01474000 $wtdQ_{100}$ = 13,600 ft^3/s
4. Substitute these computed discharges into equation 3 and multiplying by the correction factor results in: (See *Example 3* for setup)

   $Q_{100(AC)}$ = 11,000 ft^3/s

   $Q_{100(BC)}$ = 13,000 ft^3/s
5. Substituting the variables into equation 4 to calculate the final discharge for the ungaged site produces:

   $Q_{T(C)}$ = (11,000*(64.0-61.5) / (64.0-53.6)+(13,000*(61.5-53.6)) / (64.0-53.6)

   $Q_{T(C)}$ = 2,644 + 9,875

   $Q_{T(C)}$ = 12,500 ft^3/s

SUMMARY AND CONCLUSIONS

Regression equations for estimating the magnitude and frequency of floods on ungaged streams in Pennsylvania were developed on the basis of peak-flow data collected at 313 streamflow-gaging stations. All stations used in the development of the equations had 10 or more years of peak-flow record and were either continuous-record or crest-stage stations. The equations were developed by dividing the State into two flood-frequency regions, A and B. Region A generally is east and south of the Allegheny and Ohio Rivers and region B generally is north and west of the Allegheny and Ohio Rivers. The reason for the division was due to differing seasonal flooding that resulted in the initial run of the regression model overestimating flood discharges in the northwestern part of the State. Equations were developed for flood flows expected every 10, 25, 50, 100, and 500 years by the use of a weighted multiple linear regression model. The regression equations were based on five variables—drainage area, percentage of forest cover, percentage of urban development, percentage of basin underlain by carbonate rock, and percentage of basin controlled by lakes, swamps, and reservoirs.

The regression equations developed for Region A produced residual standard errors that ranged from 0.18 to 0.27; for Region B, the standard errors ranged from 0.12 to 0.19. The R^2 values ranged from 0.93 to 0.82 for Region A and 0.96 to 0.89 for Region B. The equations should only be used if the drainage area is between 1.5 and 2,000 mi^2. The equations should not be used to estimate flood flows immediately below flood-control reservoirs, of for stream with upstream significant current or past surface-mining activity. The equations developed for Region B should not be used if the basin has more than 5 percent urban development.

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APPENDIXES

Appendix 1. *Basin characteristics for streamflow-gaging stations used in the development of the regional regression equations*

[ddmmss, degrees, minutes, and seconds; mi^2, square miles; water year, 12-month period October 1-September 30]

U.S. Geological Survey streamflow-gaging station	Latitude (ddmmss)	Longitude (ddmmss)	Station name	Drainage area (mi^2)	Period of record used in analysis (water year)	Number of years used in analysis	Percentage forested area (percent)	Percentage urban area (percent)	Percentage carbonate bedrock (percent)	Percentage controlled area (percent)
01427650	414157	750958	North Branch Calkins Creek near Damascus, Pa.	7.02	1962-81	20	78	0.2	0	7.1
01428750	414028	752235	West Branch Lackawaxen River near Aldenville, Pa.	40.6	1975-97	23	74	.1	0	24
01429000	413514	751938	West Branch Lackawaxen River at Prompton, Pa.	59.7	1945-60	16	70	.1	0	28
01429300	413926	751712	Dyberry Creek above Reservoir near Honesdale, Pa.	45.8	1975-97	23	85	.2	0	22
01429500	413626	751603	Dyberry Creek near Honesdale, Pa.	64.6	1944-59	16	75	.1	0	18
01430000	413343	751454	Lackawaxen River near Honesdale, Pa.	164	1949-59	11	70	.5	0	26
01430500	412910	751115	Lackawaxen River at West Hawley, Pa.	206	1922-42	21	72	.5	0	26
01431000	412905	751320	Middle Creek near Hawley, Pa.	78.4	1945-86	42	77	.2	0	33
01431500	412834	751021	Lackawaxen River at Hawley, Pa.	290	1909-59	51	72	.5	0	27
					1960-97	38	72	.8	0	59
01431680	412315	751420	Mill Brook near Paupack, Pa.	4.84	1960-80	20	93	1.7	0	33
01438300	411935	744750	Vandermark Creek at Milford, Pa.	5.36	1962-97	33	85	2.8	0	16
01439500	410515	750220	Bush Kill at Shoemakers, Pa.	117	1909-96	88	90	.2	0	58
01440300	410950	751600	Mill Creek at Mountainhome, Pa.	5.84	1961-97	37	94	2.2	0	9.6
01440400	410505	751254	Brodhead Creek near Analomink, Pa.	65.9	1958-96	39	95	.8	0	19
01441000	405845	751205	McMichael Creek near Stroudsburg, Pa.	65.3	1911-55	45	50	1.0	0	2.6
01442500	405955	750835	Brodhead Creek at Minisink Hill, Pa.	259	1951-96	46	83	4.5	0	15
01446600	405400	751208	Martins Creek near East Bangor, Pa.	10.4	1961-86	26	84	.1	0	55
01447500	410749	753733	Lehigh River at Stoddartsville, Pa.	91.7	1942-97	56	93	2.1	0	58
01447680	410355	753114	Tunkhannock Creek near Long Pond, Pa.	18	1965-96	32	86	.2	0	94
01447720	410505	753621	Tobyhanna Creek near Blakeslee, Pa.	118	1962-96	35	89	2.9	0	69
01448000	410225	754542	Lehigh River at Tannery, Pa.	322	1917-59	43	86	2.0	0	47
01448500	410208	753237	Dilldown Creek near Long Pond, Pa.	2.39	1949-96	48	98	.2	0	17
01449000	404945	754220	Lehigh River at Lehighton, Pa.	591	1982-97	16	83	2.3	0	50
01449360	405351	753010	Pohopoco Creek at Kresgeville, Pa.	49.9	1967-96	30	68	4.7	0	4.2
01449500	405522	753332	Wild Creek at Hatchery, Pa.	16.8	1941-58	18	70	.2	0	0
01450000	404954	754053	Pohopoco Creek near Parryville, Pa.	109	1941-70	29	70	.2	0	8.8
01450500	404822	753554	Aquashicola Creek at Palmerton, Pa.	76.7	1940-96	57	70	1.2	5.0	1.6
01451000	404525	753612	Lehigh River at Walnutport, Pa.	889	1947-60	14	80	.2	4.0	10
					1961-97	37	85	2.0	4.0	43
01451500	403456	752900	Little Lehigh Creek near Allentown, Pa.	80.8	1946-97	52	33	11	63	0

Appendix 1. *Basin characteristics for streamflow-gaging stations used in the development of the regional regression equations*—*Continued*

[ddmmss, degrees, minutes, and seconds; mi^2, square miles; water year, 12-month period October 1-September 30]

U.S. Geological Survey streamflow-gaging station	Latitude (ddmmss)	Longitude (ddmmss)	Station name	Drainage area (mi^2)	Period of record used in analysis (water year)	Number of years used in analysis	Percentage forested area (percent)	Percentage urban area (percent)	Percentage carbonate bedrock (percent)	Percentage controlled area (percent)
01451650	403547	752828	Little Lehigh Creek at 10th St Bridge at Allentown, Pa.	98.2	1987-97	11	29	18	70	0
01451800	403942	753738	Jordan Creek near Schnecksville, Pa.	53.0	1967-97	31	33	1.1	0	0
01452000	403723	752858	Jordan Creek at Allentown, Pa.	75.8	1945-97	53	34	3.7	11	0
01452300	404310	752210	East Branch Monocacy Creek near Bath, Pa.	5.35	1963-80	18	26	4.0	4.0	7.5
01452500	403828	752247	Monocacy Creek at Bethlehem, Pa.	44.5	1945-97	53	19	12	69	2.0
01453000	403655	752245	Lehigh River at Bethlehem, Pa.	1,279	1902-60	55	75	1.0	13	0
					1961-97	37	64	5.8	13	30
01454600	403405	751945	Polk Valley Run at Hellertown, Pa.	2.14	1965-80	16	84	1.0	0	0
01454700	404009	751412	Lehigh River at Glendon, Pa.	1,359	1967-97	31	66	6.6	16	28
01458900	402814	750813	Tinicum Creek near Ottsville, Pa.	14.7	1962-80	19	78	.6	0	0
01459500	402601	750701	Tohickon Creek near Pipersville, Pa.	97.4	1936-73	38	55	1.0	0	0
					1974-97	24	59	3.6	0	75
01460000	402525	750400	Tohickon Creek at Point Pleasant, Pa.	107	1884-1913	29	61	3.4	0	0
01465000	401518	750159	Neshaminy Creek at Rushland, Pa.	134	1885-34	32	39	19	2.4	0
01465500	401026	745726	Neshaminy Creek near Langhorne, Pa.	210	1933-96	64	39	18	2.3	7.4
01465770	400755	745940	Poquessing Creek at Trevose Rd, Philadelphia, Pa.	5.08	1965-81	17	20	73	4.0	0
01465785	400522	745937	Walton Run at Philadelphia, Pa.	2.17	1965-78	14	23	63	0	0
01465790	400501	745857	Byberry Creek at Chalfont Road, Philadelphia, Pa.	5.34	1966-78	13	17	66	0	0
01465798	400325	745908	Poquessing Creek at Grant Ave, Philadelphia, Pa.	21.4	1966-97	32	18	67	1.0	0
01467042	400523	750410	Pennypack Creek at Pine Rd, Philadelphia, Pa.	37.9	1965-81	17	20	71	0	0
01467043	400527	750315	Unnamed tributary to Pennypack Creek at Philadelphia, Pa.	1.20	1965-80	16	9.8	87	0	0
01467048	400300	750159	Pennypack Creek at Lower Rhawn St Bridge, Philadelphia, Pa.	49.8	1966-97	32	33	55	1.0	0
01467050	400319	750122	Wooden Bridge Run at Philadelphia, Pa.	3.35	1965-81	17	20	71	0	0
01467086	400247	750640	Tacony Creek above Adams Ave, Philadelphia, Pa.	16.6	1966-86	21	25	68	0	0
01467087	400057	750550	Frankford Creek at Castor Ave, Philadelphia, Pa.	30.4	1982-97	16	20	73	0	0
01467089	400025	750533	Frankford Creek at Torresdale Ave, Philadelphia, Pa.	33.8	1966-81	16	20	74	0	0
01469500	404825	755820	Little Schuylkill River at Tamaqua, Pa.	42.9	1920-97	78	77	2.4	0	0
01470500	403121	755955	Schuylkill River at Berne, Pa.	355	1948-97	50	72	3.8	0	0
01470720	403423	755234	Maiden Creek tributary at Lenhartsville, Pa.	7.46	1962-80	18	30	.6	0	0
01470756	403051	755300	Maiden Creek at Virginville, Pa.	159	1973-95	23	40	1.3	16	0

Appendix 1. *Basin characteristics for streamflow-gaging stations used in the development of the regional regression equations—Continued*

[ddmmss, degrees, minutes, and seconds; mi^2, square miles; water year, 12-month period October 1-September 30]

U.S. Geological Survey streamflow-gaging station	Latitude (ddmmss)	Longitude (ddmmss)	Station name	Drainage area (mi^2)	Period of record used in analysis (water year)	Number of years used in analysis	Percentage forested area (percent)	Percentage urban area (percent)	Percentage carbonate bedrock (percent)	Percentage controlled area (percent)
01470779	402448	761019	Tulpehocken Creek near Bernville, Pa.	66.5	1975-96	23	13	3.7	82	0
01470853	402024	760837	Furnace Creek at Robesonia, Pa.	4.18	1983-97	15	74	0	0	0
01470960	402200	760116	Tulpehocken Creek at Blue Marsh, Pa.	175	1965-78	14	30	3.0	42	0
01471000	402208	755846	Tulpehocken Creek near Reading, Pa.	211	1951-78	28	28	3.6	42	0
01471510	402005	755612	Schuylkill River at Reading, Pa.	880	1902-30	29	60	2.0	19	0
					1980-97	18	49	4.3	19	20
01471800	402443	754402	Pine Creek near Manatawny, Pa.	15.6	1961-82	20	85	0	6.7	0
01471980	401622	754049	Manatawny Creek near Pottstown, Pa.	85.5	1975-97	23	56	1.5	26	0
01472000	401430	753905	Schuylkill River at Pottstown, Pa.	1,147	1902-78	77	50	5.1	19	0
					1979-97	19	50	5.1	19	15
01472157	400905	753606	French Creek near Phoenixville, Pa.	59.1	1969-97	29	64	1.0	0	2.4
01472174	400522	753750	Pickering Creek near Chester Spring, Pa.	5.98	1967-83	17	63	.5	.2	0
01472198	402338	753057	Perkiomen Creek at East Greenville, Pa.	38.0	1982-97	16	54	2.0	3.0	0
01472199	402226	753122	West Branch Perkiomen Creek at Hillegass, Pa.	23.0	1982-97	16	61	1.9	4.0	0
01472500	401630	752720	Perkiomen Creek near Frederick, Pa.	152	1885-1913	29	20	3.0	1.6	0
01472620	402414	751405	East Branch Perkiomen Creek near Dublin, Pa.	4.05	1984-99	16	42	.4	0	0
01473000	401346	752707	Perkiomen Creek at Graterford, Pa.	279	1915-97	83	50	2.0	1.7	10
01473100	401226	752157	Zacharias Creek near Skippack, Pa.	7.27	1960-80	21	41	6.6	0	0
01473120	400952	752601	Skippack Creek near Collegeville, Pa.	53.7	1966-94	29	37	19	0	0
01473169	400445	752740	Valley Creek at Pa Turnpike Bridge near Valley Forge, Pa.	20.8	1983-99	17	48	28	65	0
01473470	400738	752043	Stony Creek at Norristown, Pa.	20.4	1971-94	21	30	38	0	0
01473880	400813	751121	Pine Run Trib at Fort Washington, Pa.	2.01	1962-79	18	33	51	0	0
01473950	400450	751335	Wissahickon Creek at Bells Mill Rd, Philadelphia, Pa.	53.6	1966-81	16	39	41	20	0
01474000	400445	751343	Wissahickon Creek at Mouth, Philadelphia, Pa.	64.0	1966-99	34	40	42	16	0
01474500	395804	751120	Schuylkill River at Philadelphia, Pa.	1,893	1932-97	66	48	10	14	3.0
01475300	400121	752520	Darby Creek at Waterloo Mills near Devon, Pa.	5.15	1972-97	26	52	39	0	0
01475510	395544	751622	Darby Creek near Darby, Pa.	37.4	1964-90	27	38	51	0	0
01475530	395829	751649	Cobbs Creek at U.S. 1 at Philadelphia, Pa.	4.78	1965-81	17	20	73	0	0
01475550	395502	751452	Cobbs Creek at Darby, Pa.	22.0	1964-90	27	15	77	0	0
01475850	395837	752610	Crum Creek near Newtown Square, Pa.	15.8	1981-97	17	61	15	0	0
01476480	395458	752413	Ridley Creek at Media, Pa.	30.5	1987-97	11	58	14	0	0

Appendix 1. *Basin characteristics for streamflow-gaging stations used in the development of the regional regression equations*—*Continued*

[ddmmss, degrees, minutes, and seconds; mi^2, square miles; water year, 12-month period October 1-September 30]

U.S. Geological Survey streamflow-gaging station	Latitude (ddmmss)	Longitude (ddmmss)	Station name	Drainage area (mi^2)	Period of record used in analysis (water year)	Number of years used in analysis	Percentage forested area (percent)	Percentage urban area (percent)	Percentage carbonate bedrock (percent)	Percentage controlled area (percent)
01476500	395410	752335	Ridley Creek at Moylan, Pa.	31.9	1932-55	24	58	15	0	0
01477000	395203	752431	Chester Creek near Chester, Pa.	61.1	1932-97	66	55	19	0	0
01478200	394654	754803	Middle Branch White Clay Creek near Landenberg, Pa.	12.7	1960-91	32	31	3.6	4.6	0
01480300	400422	755140	West Branch Brandywine Creek near Honey Brook, Pa.	18.7	1960-97	38	31	1.5	3.1	0
01480500	395908	754940	West Branch Brandywine Creek at Coatesville, Pa.	45.8	1944-97	37	42	2.2	1.0	0
01480610	395820	755106	Sucker Run near Coatesville, Pa.	2.57	1964-96	33	45	12	36	0
01480617	395742	754806	West Branch Brandywine Creek at Modena, Pa.	55.0	1970-97	28	42	2.2	1.0	0
01480675	400552	754431	Marsh Creek near Glenmoore, Pa.	8.57	1967-97	31	55	1.1	0	68
01480680	400358	754338	Marsh Creek near Lyndell, Pa.	17.8	1960-71	12	46	2.6	0	33
01480700	400205	754232	East Branch Brandywine Creek near Downingtown, Pa.	60.6	1974-99	26	46	1.8	.1	33
01480800	400020	754220	East Branch Brandywine Creek At Downingtown, Pa.	81.6	1958-68	11	46	5.4	6.0	0
01480870	395807	754025	East Branch Brandywine Creek below Downingtown, Pa.	89.9	1974-99	26	47	6.4	8.7	22
01481000	395211	753537	Brandywine Creek at Chadds Ford, Pa.	287	1912-97	78	35	3.0	7.6	3.5
01516350	414734	770444	Tioga River near Mansfield, Pa.	153	1972-96	21	74	.5	0	0
01516500	414727	770054	Corey Creek near Mainesburg, Pa.	12.2	1955-96	42	47	.1	0	0
01516800	414919	770550	Manns Creek near Mansfield, Pa.	3.01	1960-77	17	53	0	0	0
01517000	414854	765755	Elk Run near Mainesburg, Pa.	10.2	1955-78	24	52	0	0	0
01518000	415430	770747	Tioga River at Tioga, Pa.	282	1939-77	39	63	3.3	0	0
01518420	415033	771625	Crooked Creek below Catlin Hollow at Middlebury Center, Pa.	74.3	1985-97	13	55	.1	0	0
01518500	415408	770855	Crooked Creek at Tioga, Pa.	122	1954-74	21	60	.2	0	0
01518862	415523	773156	Cowanesque River at Westfield, Pa.	90.6	1984-96	12	64	.4	0	0
01519200	415915	771809	Cowanesque River at Elkland, Pa.	235	1980-97	18	63	.3	0	0
01520000	415948	770825	Cowanesque River near Lawrenceville, Pa.	298	1952-78	27	66	2.3	0	0
01532000	414225	762906	Towanda Creek near Monroeton, Pa.	215	1914-96	83	68	1.7	0	5.8
01532200	413525	762600	South Branch Towanda Creek at New Albany, Pa.	13.3	1963-95	30	55	.2	0	0
01532850	415145	760026	Middle Branch Wyalusing Creek Trib near Birchardsville, Pa.	5.67	1960-79	20	78	.1	0	0
01533250	414225	760710	Tuscarora Creek near Silvara, Pa.	11.8	1963-95	33	63	.2	0	13
01533500	413150	760922	North Branch Mehoopany Creek near Lovelton, Pa.	35.2	1941-58	18	60	0	0	7.6
01533800	414810	753840	Butler Creek at Gibson, Pa.	7.38	1963-79	15	68	.3	0	19

Appendix 1. *Basin characteristics for streamflow-gaging stations used in the development of the regional regression equations—Continued*

[ddmmss, degrees, minutes, and seconds; mi^2, square miles; water year, 12-month period October 1-September 30]

U.S. Geological Survey streamflow-gaging station	Latitude (ddmmss)	Longitude (ddmmss)	Station name	Drainage area (mi^2)	Period of record used in analysis (water year)	Number of years used in analysis	Percentage forested area (percent)	Percentage urban area (percent)	Percentage carbonate bedrock (percent)	Percentage controlled area (percent)
01533950	413429	753832	South Branch Tunkhannock Creek near Montdale, Pa.	12.6	1961-78	18	74	0.4	0	9.1
01534000	413330	755342	Tunkhannock Creek near Tunkhannock, Pa.	383	1914-96	83	68	.8	0	23
01538000	410333	760538	Wapwallopen Creek near Wapwallopen, Pa.	43.8	1920-96	77	83	5.8	0	13
01538800	411840	760850	Huntington Creek near Pikes Creek, Pa.	4.94	1960-80	21	96	0	0	0
01539000	410441	762553	Fishing Creek near Bloomsburg, Pa.	274	1939-96	58	71	.2	0	3.1
01539500	410450	763040	Little Fishing Creek at Eyers Grove, Pa.	56.5	1941-58	18	50	.1	0	0
01540000	410010	762750	Fishing Creek at Bloomsburg, Pa.	355	1914-31	18	45	.1	.1	2.3
01540200	405110	761648	Trexler Run near Ringtown, Pa.	1.77	1959-79	21	90	0	0	0
01541000	405349	784038	West Branch Susquehanna River at Bower, Pa.	315	1914-97	84	50	1.0	0	0
01541200	405741	783110	West Branch Susquehanna River at Curwensville, Pa.	367	1956-67	12	78	2.3	0	0
01541500	405818	782422	Clearfield Creek at Dimeling, Pa.	371	1914-97	84	84	1.5	0	12
01542000	405058	781605	Moshannon Creek at Osceola Mills, Pa.	68.8	1941-93	52	83	1.3	0	2.9
01542500	410703	780633	West Branch Susquehanna River at Karthaus, Pa.	1,462	1940-60	21	50	1.0	0	0
					1966-97	32	80	1.3	0	28
01542720	411258	783500	Wilson Run at Penfield, Pa.	8.34	1962-95	34	65	0	0	0
01542810	413444	781734	Waldy Run near Emporium, Pa.	5.24	1964-97	34	99	0	0	0
01543000	412448	781150	Driftwood Br Sinnemahoning Creek at Sterling Run, Pa.	272	1914-96	83	80	.1	0	0
01543500	411902	780612	Sinnemahoning Creek at Sinnemahoning, Pa.	685	1936-97	62	93	.3	0	0
01543700	413108	780140	First Fork Sinnemahoning Creek at Wharton, Pa.	182	1984-97	14	93	.1	0	0
01544450	413849	773922	Germania Branch at Germania, Pa.	2.40	1964-79	11	71	.1	0	0
01544500	412833	774934	Kettle Creek at Cross Fork, Pa.	136	1941-96	56	96	0	0	0
01545600	412322	774128	Young Womans Creek near Renovo, Pa.	46.2	1965-96	32	100	0	0	0
01546000	405630	774740	North Bald Eagle Creek at Milesburg, Pa.	119	1911-28	18	60	.1	7.0	0
01546400	405001	774940	Spring Creek at Houserville, Pa.	58.5	1985-96	12	37	8.6	76	0
01546500	405323	774740	Spring Creek near Axemann, Pa.	87.2	1936-96	57	37	8.3	83	0
01547100	405554	774713	Spring Creek at Milesburg, Pa.	142	1967-96	30	40	6.8	78	0
01547200	405635	774712	Bald Eagle Creek below Spring Creek at Milesburg, Pa.	265	1957-96	40	61	4.0	46	0
01547500	410306	773617	Bald Eagle Creek at Blanchard, Pa.	339	1955-69	15	60	7.1	45	0
01547700	410334	773622	Marsh Creek at Blanchard, Pa.	44.1	1956-96	41	78	.2	0	0
01547800	410126	775415	South Fork Beech Creek near Snow Shoe, Pa.	12.2	1959-81	23	97	2.2	0	0
01547950	410642	774209	Beech Creek at Monument, Pa.	152	1968-97	30	68	1.7	0	0

Appendix 1. *Basin characteristics for streamflow-gaging stations used in the development of the regional regression equations—Continued*

[ddmmss, degrees, minutes, and seconds; mi^2, square miles; water year, 12-month period October 1-September 30]

U.S. Geological Survey streamflow-gaging station	Latitude (ddmmss)	Longitude (ddmmss)	Station name	Drainage area (mi^2)	Period of record used in analysis (water year)	Number of years used in analysis	Percentage forested area (percent)	Percentage urban area (percent)	Percentage carbonate bedrock (percent)	Percentage controlled area (percent)
01548005	410451	773259	Bald Eagle Creek near Beech Creek Station, Pa.	562	1971-97	25	71	2.4	28	61
01548020	410030	771935	Bull Run near Loganton, Pa.	1.99	1963-81	19	99	.4	0	0
01548500	413118	772652	Pine Creek at Cedar Run, Pa.	604	1919-96	78	83	1.1	0	0
01549000	411845	772245	Pine Creek near Waterville, Pa.	750	1909-20	12	90	.2	0	0
01549500	412825	771352	Blockhouse Creek near English Center, Pa.	37.7	1941-97	57	78	.1	0	0
01549700	411625	771928	Pine Creek below Little Pine Creek near Waterville, Pa.	944	1958-96	39	98	1.1	0	18
01549780	412504	770946	Larrys Creek at Cogan House, Pa.	6.80	1960-78	19	75	0	0	0
01550000	412506	770159	Lycoming Creek near Trout Run, Pa.	173	1914-98	85	80	.1	0	0
01551000	411515	770040	Grafius Run at Williamsport, Pa.	3.14	1940-53	14	40	5.0	0	0
01552000	411930	765446	Loyalsock Creek at Loyalsockville, Pa.	443	1926-98	73	82	.8	0	9.0
01552100	412010	765745	Mill Creek near Warrensville, Pa.	11.9	1961-78	18	81	.2	0	0
01552500	412125	763206	Muncy Creek near Sonestown, Pa.	23.8	1941-96	56	92	0	0	8.6
01553050	410705	770400	White Deer Hole Creek near Elimsport, Pa.	18.2	1961-95	33	98	0	0	0
01553130	410331	770437	Sand Spring Run near White Deer, Pa.	4.93	1968-81	14	95	3.1	0	0
01553600	410457	763917	East Branch Chillisquaque Creek near Washingtonville, Pa.	9.48	1960-78	19	41	1.0	0	0
01553700	410342	764050	Chillisquaque Creek at Washingtonville, Pa.	51.3	1980-96	17	31	.5	6.0	5.8
01555000	405200	770255	Penns Creek at Penns Creek, Pa.	301	1930-97	68	67	1.0	24	0
01555500	403640	765444	East Mahantango Creek near Dalmatia, Pa.	162	1930-97	68	53	1.1	0	0
01555800	402235	782555	McDonald Run near East Freedom, Pa.	1.54	1959-78	20	73	2.5	0	0
01556000	402747	781200	Frankstown Br Juniata River at Williamsburg, Pa.	291	1889-1997	109	70	1.5	21	0
01556400	403347	782035	Sandy Run near Bellwood, Pa.	5.58	1962-81	20	75	14	17	0
01556500	403740	781738	Little Juniata River at Tipton, Pa.	93.7	1946-81	36	75	6.5	8.0	0
01557100	404000	781500	Schell Run at Tyrone, Pa.	1.68	1958-81	23	86	3.9	0	0
01557500	404101	781402	Bald Eagle Creek at Tyrone, Pa.	44.1	1940-97	58	91	1.5	4.6	0
01558000	403645	780827	Little Juniata River at Spruce Creek, Pa.	220	1936-97	60	77	6.3	21	0
01559000	402905	780109	Juniata River at Huntingdon, Pa.	816	1896-97	96	50	2.0	32	0
01559500	403125	775815	Standing Stone Creek near Huntingdon, Pa.	128	1930-58	29	65	.5	4.9	0
01559700	395840	783708	Sulphur Springs Creek near Manns Choice, Pa.	5.28	1962-78	17	80	0	1.0	0
01560000	400418	782934	Dunning Creek at Belden, Pa.	172	1936-97	62	56	1.0	6.7	0
01561000	395720	781515	Brush Creek at Gapsville, Pa.	36.8	1930-58	29	70	.5	0	0
01562000	401257	781556	Raystown Branch Juniata River at Saxton, Pa.	756	1912-97	86	60	.8	14	0

Appendix 1. *Basin characteristics for streamflow-gaging stations used in the development of the regional regression equations—Continued*

[ddmmss, degrees, minutes, and seconds; mi^2, square miles; water year, 12-month period October 1-September 30]

U.S. Geological Survey streamflow-gaging station	Latitude (ddmmss)	Longitude (ddmmss)	Station name	Drainage area (mi^2)	Period of record used in analysis (water year)	Number of years used in analysis	Percentage forested area (percent)	Percentage urban area (percent)	Percentage carbonate bedrock (percent)	Percentage controlled area (percent)
01562500	402100	780750	Great Trough Creek near Marklesburg, Pa.	84.6	1930-57	28	65	0.1	0	0
01563000	402535	780147	Raystown Branch Juniata River near Huntingdon, Pa.	957	1946-71	26	67	1.0	12	1.0
01563800	400520	780255	Elders Branch near Hustontown, Pa.	3.46	1960-78	19	40	0	0	0
01564500	401245	775532	Aughwick Creek near Three Springs, Pa.	205	1939-97	59	60	.4	5.8	0
01565000	403917	773500	Kishacoquillas Creek at Reedsville, Pa.	164	1936-98	63	63	1.2	25	0
01565700	403620	771840	Little Lost Creek at Oakland Mills, Pa.	6.52	1960-81	22	29	1.2	46	0
01565920	402115	773855	Lick Run near East Waterford, Pa.	8.38	1962-81	20	76	.2	11	0
01566000	403055	772510	Tuscarora Creek near Port Royal, Pa.	214	1912-90	50	70	.1	12	0
01566500	403355	770705	Cocolamus Creek near Millerstown, Pa.	57.2	1930-58	29	55	.1	5.0	0
01567500	402215	772409	Bixler Run near Loysville, Pa.	15.0	1954-97	44	49	.1	19	0
01568000	401924	771009	Sherman Creek at Shermans Dale, Pa.	207	1927-97	71	68	.9	12	0
01568500	402737	764506	Clark Creek near Carsonville, Pa.	22.5	1938-96	59	95	0	0	43
01569000	402246	765431	Stony Creek near Dauphin, Pa.	33.2	1938-74	16	90	.2	0	0
01569340	400740	773250	Newburg Run at Newburg, Pa.	5.29	1964-95	32	34	1.9	0	0
01569800	401405	770823	Letort Spring Run near Carlisle, Pa.	21.6	1976-97	22	8.1	21	98	0
01570000	401508	770117	Conodoguinet Creek near Hogestown, Pa.	470	1912-96	64	35	4.0	38	0
01571000	401830	765100	Paxton Creek near Penbrook, Pa.	11.2	1940-50	11	25	3.0	11	0
					1974-94	21	38	29	11	0
01571500	401329	765354	Yellow Breeches Creek near Camp Hill, Pa.	216	1910-97	55	55	9.6	34	0
01572000	403215	762240	Lower Little Swatara Creek at Pine Grove, Pa.	34.3	1920-84	18	59	.3	0	0
01572900	402425	763315	Reeds Creek near Ono, Pa.	8.63	1962-81	20	41	15	0	0
01573000	402409	763439	Swatara Creek at Harper Tavern, Pa.	337	1919-97	79	54	1.7	1.2	.8
01573086	401924	762900	Beck Creek near Cleona, Pa.	7.87	1964-81	18	17	1.1	82	0
01573160	402034	763346	Quittapahilla Creek near Bellegrove, Pa.	74.2	1975-93	19	17	13	74	0
01573500	402350	764235	Manada Creek at Manada Gap, Pa.	13.5	1938-58	21	89	.8	0	0
01573560	401754	764005	Swatara Creek near Hershey, Pa.	483	1975-97	23	40	8.5	13	.5
01574000	400456	764313	West Conewago Creek near Manchester, Pa.	510	1929-97	69	34	1.8	6.0	0
01574500	395243	765113	Codorus Creek at Spring Grove, Pa.	75.5	1930-66	37	15	3.0	19	0
					1967-97	31	28	3.5	19	31
01574800	394857	763759	East Branch Codorus Creek Trib near Winterstown, Pa.	5.17	1960-75	16	26	.5	0	0

Appendix 1. *Basin characteristics for streamflow-gaging stations used in the development of the regional regression equations—Continued*

[ddmmss, degrees, minutes, and seconds; mi^2, square miles; water year, 12-month period October 1-September 30]

U.S. Geological Survey streamflow-gaging station	Latitude (ddmmss)	Longitude (ddmmss)	Station name	Drainage area (mi^2)	Period of record used in analysis (water year)	Number of years used in analysis	Percentage forested area (percent)	Percentage urban area (percent)	Percentage carbonate bedrock (percent)	Percentage controlled area (percent)
01575000	395514	764457	South Branch Codorus Creek near York, Pa.	117	1928-71	44	20	1.0	1.0	2.7
					1972-95	24	29	2.2	1.0	5.7
01575500	395646	764520	Codorus Creek near York. Pa.	222	1947-97	51	28	5.9	13	46
01576085	400841	755920	Little Conestoga Creek near Churchtown, Pa.	5.82	1982-95	14	20	.1	23	0
01576320	401244	760730	Stony Run at Reamstown, Pa.	3.55	1964-95	32	34	16	14	0
01576500	400300	761639	Conestoga River at Lancaster, Pa.	324	1929-97	69	27	12	44	0
01576754	395647	762205	Conestoga River at Conestoga, Pa.	470	1985-97	13	23	17	59	0
01577500	394621	761858	Muddy Creek at Castle Fin, Pa.	133	1929-72	15	40	1.0	0	0
01578200	395035	761145	Conowingo Creek near Buck, Pa.	8.71	1963-97	33	20	.9	0	0
01578400	395341	760650	Bowery Run near Quarryville, Pa.	5.98	1963-81	19	22	0	26	0
01600700	395535	783940	Little Wills Creek at Bard, Pa.	10.2	1961-81	21	83	0	0	0
01601000	394843	784300	Wills Creek below Hyndman, Pa.	146	1952-86	35	87	.3	0	0
01603500	394723	783848	Evitts Creek near Centerville, Pa.	30.2	1933-82	50	74	.1	18	0
01613050	395354	780757	Tonoloway Creek near Needmore, Pa.	10.7	1963-96	33	70	0	0	0
01613500	394323	780338	Licking Creek near Sylvan, Pa.	158	1931-41	11	65	.2	16	0
01614090	395548	772623	Conococheague Creek near Fayetteville, Pa.	5.05	1961-81	21	97	0	0	0
01638900	394745	771150	White Run near Gettysburg, Pa.	12.4	1961-80	20	17	6.3	0	30
03007800	414907	781735	Allegheny River at Port Allegany, Pa.	248	1975-97	23	88	.6	0	.8
03009680	414835	782550	Potato Creek at Smethport, Pa.	160	1972-97	24	93	.4	0	1.0
03010655	415742	781154	Oswayo Creek at Shinglehouse, Pa.	98.7	1975-97	23	86	.1	0	1.2
03011020	420923	784256	Allegheny River at Salamanca, N.Y.	1,608	1904-95	92	86	.6	0	3.1
03011800	414559	784308	Kinzua Creek near Guffey, Pa.	46.4	1966-96	31	96	1.0	0	2.8
03015000	415617	790800	Conewango Creek at Russell, Pa.	816	1936-97	62	52	2.0	0	29
03015080	415555	790538	Ackley Run near Russell, Pa.	9.64	1962-81	20	87	.2	0	0
03015390	415629	793841	Hare Creek near Corry, Pa.	12.3	1964-85	21	58	.5	0	8.9
03015500	415109	791903	Brokenstraw Creek at Youngsville, Pa.	321	1910-96	87	45	.2	0	20
03017500	413607	790301	Tionesta Creek at Lynch, Pa.	233	1938-79	42	96	.7	0	0
03019000	412825	792305	Tionesta Creek at Nebraska, Pa.	469	1910-40	19	90	.1	0	0
03020440	414531	793408	West Branch Caldwell Creek near Grand Valley, Pa.	4.37	1964-81	17	77	.1	0	0
03020500	412854	794144	Oil Creek at Rouseville, Pa.	300	1910-96	87	40	.5	0	5.3
03021350	420055	794658	French Creek near Wattsburg, Pa.	92.0	1975-97	23	56	.4	0	17

Appendix 1. *Basin characteristics for streamflow-gaging stations used in the development of the regional regression equations—Continued*

[ddmmss, degrees, minutes, and seconds; mi^2, square miles; water year, 12-month period October 1-September 30]

U.S. Geological Survey streamflow-gaging station	Latitude (ddmmss)	Longitude (ddmmss)	Station name	Drainage area (mi^2)	Period of record used in analysis (water year)	Number of years used in analysis	Percentage forested area (percent)	Percentage urban area (percent)	Percentage carbonate bedrock (percent)	Percentage controlled area (percent)
03021410	420454	795102	West Branch French Creek near Lowville, Pa.	52.3	1975-94	20	57	0.8	0	5.5
03021700	415553	800502	Little Conneauttee Creek near Mckean, Pa.	3.60	1961-78	18	58	0	0	0
03022500	414250	800850	French Creek at Saegerstown, Pa.	629	1913-39	27	30	.2	0	15
03022540	414126	800226	Woodcock Creek at Blooming Valley, Pa.	31.1	1975-95	21	64	.2	0	9.9
03023000	414020	801255	Cussewago Creek near Meadville, Pa.	90.2	1911-38	28	20	.2	0	12
03024000	412615	795722	French Creek at Utica, Pa.	1,028	1933-71	39	52	1.4	0	21
					1972-97	26	52	1.4	0	44
03025000	412543	795248	Sugar Creek at Sugarcreek, Pa.	166	1933-79	47	71	.2	0	8.4
03025200	412520	795059	Patchel Run near Franklin, Pa.	5.69	1961-78	18	77	.2	0	0
03026400	411053	794125	Richey Run at Emlenton, Pa.	5.88	1963-81	19	61	2.9	0	0
03026500	413752	783437	Sevenmile Run near Rasselas, Pa.	7.84	1952-96	45	94	.1	0	0
03028000	413445	784122	West Branch Clarion River at Wilcox, Pa.	63.0	1954-96	43	91	.6	0	0
03028500	412910	784043	Clarion River at Johnsonburg, Pa.	204	1953-94	42	93	.6	0	36
03029200	411917	790439	Clear Creek near Sigel, Pa.	8.67	1960-81	22	95	.1	0	0
03029400	412016	791250	Toms Run at Cooksburg, Pa.	12.6	1960-78	19	94	.3	0	0
03029500	411950	791233	Clarion River at Cooksburg, Pa	807	1936-97	62	92	1.0	0	11
03030500	411133	792625	Clarion River near Piney, Pa.	951	1948-96	49	90	1.0	0	8.8
03031000	410857	793937	Clarion River at St. Petersburg, Pa.	1,246	1942-53	12	90	.5	0	1.0
03031780	411453	785008	Mill Creek near Brockway, Pa.	2.12	1965-81	17	50	.2	0	0
03031950	405930	790526	Big Run near Sprankle Mills, Pa.	7.38	1964-81	18	53	.4	0	0
03032500	405940	792340	Redbank Creek at St. Charles, Pa.	528	1910-97	88	40	.5	0	0
03034000	405621	790031	Mahoning Creek at Punxsutawney, Pa.	158	1936-96	61	71	2.1	0	0
03034500	405010	790637	Little Mahoning Creek at Mccormick, Pa.	87.4	1940-98	59	73	.3	0	0
03035000	405405	791335	Mahoning Creek near Dayton, Pa.	321	1917-40	24	40	.5	0	0
03038000	403917	792056	Crooked Creek at Idaho, Pa.	191	1936-97	62	68	.7	0	7.0
03039000	404313	793042	Crooked Creek at Crooked Creek Dam, Pa.	278	1910-39	30	50	.1	0	0
03039200	400249	785000	Clear Run near Buckstown, Pa.	3.68	1961-78	18	99	0	0	0
03039925	401558	790101	North Fork Bens Creek at North Fork Reservoir, Pa.	3.45	1985-97	11	99	.1	0	0
03040000	401708	785515	Stonycreek River at Ferndale, Pa.	451	1914-97	82	68	1.8	0	7.7
03041000	402037	785307	Little Conemaugh at East Conemaugh, Pa.	183	1936-97	62	77	3.5	0	6.6
03041500	402509	790135	Conemaugh River at Seward, Pa.	715	1936-97	62	72	3.4	0	1.7

Appendix 1. *Basin characteristics for streamflow-gaging stations used in the development of the regional regression equations—Continued*

[ddmmss, degrees, minutes, and seconds; mi^2, square miles; water year, 12-month period October 1-September 30]

U.S. Geological Survey streamflow-gaging station	Latitude (ddmmss)	Longitude (ddmmss)	Station name	Drainage area (mi^2)	Period of record used in analysis (water year)	Number of years used in analysis	Percentage forested area (percent)	Percentage urban area (percent)	Percentage carbonate bedrock (percent)	Percentage controlled area (percent)
03042000	402824	791101	Blacklick Creek at Josephine, Pa.	192	1952-96	45	77	1.4	0	0
03042170	403631	790949	Stoney Run at Indiana, Pa.	4.39	1964-76	13	34	52	0	0
03042200	403345	785644	Little Yellow Creek near Strongstown, Pa.	7.36	1961-87	19	88	.2	0	0
03042500	403102	791019	Two Lick Creek at Graceton, Pa.	171	1952-68	17	72	3.9	0	0
					1969-97	29	72	3.9	0	35
03043000	402825	791215	Blacklick Creek at Black Lick, Pa.	390	1905-51	47	50	.1	0	0
03045000	401733	792027	Loyalhanna Creek at Kingston, Pa.	172	1940-97	52	81	.8	0	2.1
03045500	402340	792555	Loyalhanna Creek at New Alexandria, Pa.	265	1920-40	19	50	.1	0	2.0
03047500	403205	792755	Kiskiminetas River at Avonmore, Pa.	1,723	1884-1937	48	50	.5	0	0
03049000	404257	794159	Buffalo Creek near Freeport, Pa.	137	1941-96	55	67	1.1	0	0
03049100	404557	794601	Little Buffalo Creek at Cabot, Pa.	4.66	1959-81	23	80	0	0	0
03049800	403113	795618	Little Pine Creek near Etna, Pa.	5.78	1963-96	33	80	8.9	0	0
03070420	394551	793514	Stony Fork Trib near Gibbon Glade, Pa.	.93	1978-89	12	77	.1	0	0
03072000	394533	795815	Dunkard Creek at Shannopin, Pa.	229	1941-96	56	78	.3	0	0
03072590	394744	794747	Georges Creek at Smithfield, Pa.	16.3	1964-78	15	60	4.3	0	0
03072840	395951	800231	Tenmile Creek near Clarksville, Pa.	133	1969-79	11	56	1.1	0	0
03072880	395627	801721	Browns Creek near Nineveh, Pa.	17.5	1963-85	23	59	.2	0	0
03073000	395523	800422	South Fork Tenmile Creek at Jefferson, Pa.	180	1932-95	64	63	1.4	0	0
03074300	395204	794140	Lick Run at Hopwood, Pa.	3.80	1959-78	20	97	.5	0	0
03074500	395848	794552	Redstone Creek at Waltersburg, Pa.	73.7	1943-96	54	58	8.4	0	0
03078500	394334	790255	Big Piney Run near Salisbury, Pa.	24.5	1933-86	51	68	.3	0	5.3
03079000	395135	791340	Casselman River at Markleton, Pa.	382	1915-96	82	40	.2	0	0
03080000	394913	791918	Laurel Hill Creek at Ursina, Pa.	121	1914-97	84	81	.4	0	5.3
03081000	394940	792225	Youghiogheny River below Confluence, Pa.	1,029	1942-97	56	68	.9	0	42
03082200	400059	792533	Poplar Run near Normalville, Pa.	9.27	1961-78	18	79	.4	0	0
03082500	400103	793538	Youghiogheny River at Connellsville, Pa.	1,326	1943-97	55	69	.9	0	33
03083000	400618	793001	Green Lick Run at Green Lick Reservoir, Pa.	3.07	1929-79	51	70	.1	0	0
03083500	401424	794824	Youghiogheny River at Sutersville, Pa.	1,715	1943-97	55	67	2.2	0	0
03083600	401359	794906	Gillespie Run near Sutersville, Pa.	4.04	1959-81	21	68	4.4	0	2.5
03084000	402701	794250	Abers Creek near Murrysville, Pa.	4.39	1949-93	45	59	27	0	0
03084500	402309	794555	Turtle Creek at Trafford, Pa.	55.9	1917-55	37	68	14	0	0

Appendix 1. *Basin characteristics for streamflow-gaging stations used in the development of the regional regression equations—Continued*

[ddmmss, degrees, minutes, and seconds; mi^2, square miles; water year, 12-month period October 1-September 30]

U.S. Geological Survey streamflow-gaging station	Latitude (ddmmss)	Longitude (ddmmss)	Station name	Drainage area (mi^2)	Period of record used in analysis (water year)	Number of years used in analysis	Percentage forested area (percent)	Percentage urban area (percent)	Percentage carbonate bedrock (percent)	Percentage controlled area (percent)
03085500	402402	800548	Chartiers Creek at Carnegie, Pa.	257	1916-96	71	50	2.5	0	1.5
03086100	403627	800949	Big Sewickley Creek near Ambridge, Pa.	15.6	1963-78	16	84	3.8	0	0
03100000	413045	802815	Shenango River near Turnersville, Pa.	152	1912-22	11	30	.2	0	63
03101000	412950	802755	Sugar Run at Pymatuning Dam, Pa.	9.34	1935-55	21	30	.2	0	2.3
03102500	412519	802235	Little Shenango River at Greenville, Pa.	104	1914-96	80	30	.2	0	17
03102850	412113	802353	Shenango River near Transfer, Pa.	337	1966-97	32	40	2.1	0	52
03103000	411840	802840	Pymatuning Creek near Orangeville, Pa.	169	1914-63	48	30	.2	0	89
03104000	411355	803035	Shenango River at Sharon, Pa.	608	1910-32	23	30	.2	0	44
03104500	410000	802105	Shenango River at New Castle, Pa.	792	1913-32	20	30	.2	0	33
03104760	411110	801938	Harthegig Run near Greenfield, Pa.	2.26	1969-80	12	28	1.8	0	13
03106000	404901	801433	Connoquenessing Creek near Zelienople, Pa.	356	1916-96	81	56	4.5	0	1.4
03106500	405302	801402	Slippery Rock Creek at Wurtemburg, Pa.	398	1912-69	58	25	.2	0	7.3
					1970-97	28	56	1.5	0	20
03108000	403740	802016	Raccoon Creek at Moffatts Mill, Pa.	178	1916-96	70	68	3.5	0	2.6
03111150	401154	802428	Brush Run near Buffalo, Pa.	10.3	1961-85	21	28	.2	0	0
04213000	415534	803618	Conneaut Creek at Conneaut, Ohio	175	1923-95	60	20	.5	0	10
04213040	415642	802651	Raccoon Creek near West Springfield, Pa.	2.53	1961-95	34	63	2.0	0	44
04213200	420554	800435	Mill Creek at Erie, Pa.	9.16	1969-85	17	51	4.5	0	0

Appendix 2. *Flood-flow frequencies computed from streamflow-gaging data and regression equations for streamflow-gaging stations used in analysis*

[All flood flows in cubic feet per second; water year, 12-month period October 1-September 30]

U.S. Geological Survey streamflow-gaging station	Period of record used in analysis (water year)	Flood-flow region	Computed from streamflow-gaging-station data					Predicted from regression equations				
			10-year	25-year	50-year	100-year	500-year	10-year	25-year	50-year	100-year	500-year
01427650	1962-81	A	990	1,310	1,580	1,890	2,730	841	1,210	1,540	1,940	3,130
01428750	1975-97	A	3,450	4,190	4,740	5,310	6,690	3,100	4,320	5,410	6,670	10,400
01429000	1945-60	A	4,820	6,010	6,990	8,030	10,800	4,180	5,800	7,250	8,920	13,800
01429300	1975-97	A	3,550	4,440	5,150	5,910	7,850	3,170	4,390	5,470	6,710	10,300
01429500	1944-59	A	8,540	12,600	16,600	21,400	37,500	4,540	6,270	7,790	9,530	14,600
01430000	1944-59	A	12,900	17,100	20,700	25,000	37,200	9,140	12,400	15,300	18,500	27,900
01430500	1922-42	A	14,800	22,100	29,300	38,300	68,600	10,700	14,400	17,700	21,300	31,800
01431000	1945-86	A	5,510	7,530	9,260	11,200	16,600	4,800	6,620	8,220	10,100	15,400
01431500	1909-59	A	17,200	23,800	29,800	36,900	58,600	14,000	18,700	22,800	27,400	40,500
	1960-97	A	11,300	13,900	15,800	17,900	22,900	12,300	16,600	20,400	24,700	37,100
01431680	1960-80	A	380	460	530	600	790	516	746	956	1,200	1,960
01438300	1962-97	A	310	400	480	570	800	639	919	1,170	1,470	2,370
01439500	1909-96	A	4,310	6,200	8,010	10,300	17,700	5,580	7,650	9,470	11,600	17,600
01440300	1961-97	A	880	1,290	1,650	2,080	3,370	673	962	1,220	1,530	2,430
01440400	1958-96	A	6,480	8,930	11,000	13,300	19,800	4,140	5,670	6,990	8,510	12,800
01441000	1911-55	A	2,910	3,730	4,410	5,150	7,110	5,620	7,780	9,690	11,900	18,300
01442500	1951-96	A	20,100	29,500	38,600	49,700	86,600	13,500	17,800	21,400	25,500	36,600
01446600	1961-86	A	1,130	1,640	2,120	2,700	4,520	883	1,280	1,640	2,060	3,370
01447500	1942-97	A	6,700	10,700	14,800	20,200	39,300	4,690	6,430	7,950	9,700	14,800
01447680	1965-96	A	565	681	770	860	1,080	1,190	1,710	2,200	2,770	4,540
01447720	1962-96	A	7,060	9,690	11,900	14,300	20,800	5,490	7,500	9,270	11,300	17,200
01448000	1917-59	A	17,500	26,800	36,000	47,700	88,200	13,300	17,700	21,500	25,800	37,900
01448500	1949-96	A	320	450	560	690	1,040	308	452	584	742	1,230
01449000	1982-97	A	23,900	30,400	35,600	41,100	55,000	21,400	28,300	34,100	40,600	58,700
01449360	1967-96	A	1,860	2,280	2,600	2,920	3,720	4,270	5,840	7,200	8,740	13,200
01449500	1941-58	A	1,620	2,520	3,390	4,470	8,000	1,810	2,550	3,210	3,990	6,290
01450000	1941-70	A	3,780	5,030	6,070	7,220	10,300	7,300	9,940	12,200	14,900	22,400
01450500	1940-96	A	5,100	7,190	9,080	11,300	18,000	5,390	7,400	9,160	11,200	17,000
01451000	1947-60	A	49,000	69,100	87,400	109,000	176,000	32,100	42,000	50,400	59,500	84,800
	1961-97	A	33,200	41,600	48,100	54,800	71,500	27,400	36,100	43,400	51,500	74,100

Appendix 2. *Flood-flow frequencies computed from streamflow-gaging data and regression equations for streamflow-gaging stations used in analysis*—*Continued*

[All flood flows in cubic feet per second; water year, 12-month period October 1-September 30]

U.S. Geological Survey streamflow-gaging station	Period of record used in analysis (water year)	Flood-flow region	Computed from streamflow-gaging-station data					Predicted from regression equations				
			10-year	25-year	50-year	100-year	500-year	10-year	25-year	50-year	100-year	500-year
01451500	1946-97	A	4,970	8,220	11,500	15,600	29,700	3,730	5,530	7,250	9,340	16,100
01451650	1987-97	A	5,830	9,560	13,400	18,400	36,400	4,360	6,400	8,320	10,600	18,000
01451800	1967-97	A	5,050	6,900	8,500	10,300	15,300	5,550	7,770	9,760	12,100	19,100
01452000	1945-97	A	6,910	10,000	12,900	16,300	26,900	6,210	8,700	10,900	13,600	21,400
01452300	1963-80	A	730	1,020	1,270	1,540	2,280	919	1,350	1,760	2,260	3,820
01452500	1945-97	A	1,740	2,790	3,860	5,240	10,100	2,390	3,630	4,830	6,310	11,300
01453000	1902-60	A	51,800	73,100	92,500	115,000	185,000	41,900	55,000	66,100	78,400	113,000
	1961-97	A	43,700	54,700	63,400	72,400	94,900	40,600	53,500	64,500	76,800	112,000
01454600	1965-80	A	340	530	720	970	1,800	337	496	642	816	1,350
01454700	1967-97	A	45,200	55,300	63,000	70,800	89,600	40,500	53,100	63,900	75,900	109,000
01458900	1962-80	A	4,910	6,980	8,860	11,100	17,700	1,550	2,190	2,760	3,420	5,380
01459500	1936-73	A	12,000	15,300	18,000	21,000	29,000	7,690	10,500	13,000	15,800	24,000
	1974-97	A	12,700	17,100	20,900	25,200	37,200	5,750	7,940	9,890	12,200	18,900
01460000	1884-1913	A	6,810	8,800	10,500	12,500	18,400	8,090	10,900	13,400	16,200	24,200
01465000	1885-34	A	7,310	9,080	10,500	12,200	16,600	12,800	16,800	20,100	23,900	34,200
01465500	1933-96	A	20,400	26,800	32,400	38,500	55,600	16,900	22,100	26,600	31,500	45,200
01465770	1965-81	A	1,320	1,710	2,040	2,420	3,520	1,620	2,090	2,480	2,910	4,070
01465785	1965-78	A	1,110	1,380	1,590	1,820	2,430	823	1,090	1,320	1,570	2,280
01465790	1966-78	A	1,420	1,790	2,110	2,450	3,390	1,770	2,300	2,730	3,220	4,530
01465798	1966-97	A	5,840	7,460	8,790	10,200	14,100	5,180	6,530	7,620	8,790	11,900
01467042	1965-81	A	4,270	5,200	5,940	6,720	8,700	8,110	10,000	11,500	13,100	17,300
01467043	1965-80	A	620	840	1,030	1,230	1,790	666	869	1,040	1,230	1,740
01467048	1966-97	A	6,100	7,580	8,750	9,980	13,100	8,370	10,500	12,100	13,900	18,600
01467050	1965-81	A	1,650	2,150	2,570	3,030	4,320	1,240	1,610	1,920	2,260	3,190
01467086	1966-86	A	4,080	5,000	5,700	6,410	8,160	3,980	5,020	5,860	6,760	9,130
01467087	1982-97	A	9,620	11,300	12,500	13,800	16,800	6,950	8,570	9,850	11,200	14,700
01467089	1966-81	A	9,670	11,200	12,300	13,400	16,100	7,600	9,350	10,700	12,200	16,000
01469500	1920-97	A	3,280	4,360	5,220	6,120	8,390	3,620	4,960	6,140	7,470	11,300
01470500	1948-97	A	22,500	29,400	35,200	41,500	58,300	19,600	25,600	30,700	36,200	51,200
01470720	1962-80	A	1,310	1,980	2,600	3,340	5,640	1,240	1,810	2,340	2,980	5,000

Appendix 2. *Flood-flow frequencies computed from streamflow-gaging data and regression equations for streamflow-gaging stations used in analysis—Continued*

[All flood flows in cubic feet per second; water year, 12-month period October 1-September 30]

U.S. Geological Survey streamflow-gaging station	Period of record used in analysis (water year)	Flood-flow region	Computed from streamflow-gaging-station data					Predicted from regression equations				
			10-year	25-year	50-year	100-year	500-year	10-year	25-year	50-year	100-year	500-year
01470756	1973-95	A	9,660	13,100	16,300	19,900	30,900	9,500	13,300	16,600	20,500	32,300
01470779	1975-96	A	5,070	7,440	9,570	12,000	19,400	2,910	4,520	6,140	8,180	15,200
01470853	1983-97	A	470	600	700	810	1,080	593	861	1,110	1,400	2,290
01470960	1965-78	A	11,000	16,300	21,100	26,800	44,000	8,130	11,800	15,200	19,300	32,300
01471000	1951-78	A	9,340	12,200	14,600	17,200	24,600	9,610	13,800	17,700	22,300	36,700
01471510	1902-30	A	36,400	47,400	56,600	66,900	95,600	30,700	41,200	50,300	60,500	89,900
	1980-97	A	30,700	40,100	48,000	56,500	79,800	30,300	40,800	50,100	60,700	91,400
01471800	1961-82	A	710	880	1,020	1,160	1,520	1,360	1,950	2,470	3,080	4,900
01471980	1975-97	A	5,780	7,310	8,530	9,830	13,200	4,760	6,780	8,620	10,800	17,400
01472000	1902-78	A	39,900	51,300	60,600	70,700	97,400	42,400	56,100	67,900	81,100	118,000
	1979-97	A	36,200	45,400	52,700	60,600	81,000	39,200	52,100	63,400	76,000	112,000
01472157	1969-97	A	5,850	8,630	11,200	14,400	24,400	4,790	6,600	8,190	10,000	15,300
01472174	1967-83	A	1,930	2,920	3,820	4,890	8,080	844	1,220	1,570	1,980	3,230
01472198	1982-97	A	5,370	7,320	8,980	10,800	15,900	3,630	5,060	6,330	7,800	12,100
01472199	1982-97	A	3,080	4,120	5,000	5,970	8,670	2,250	3,180	4,010	4,980	7,850
01472500	1885-1913	A	7,190	8,540	9,630	10,800	13,800	13,600	18,700	23,200	28,400	44,000
01472620	1984-99	A	1,870	2,490	3,000	3,550	5,030	712	1,050	1,360	1,740	2,920
01473000	1915-97	A	28,000	35,200	40,500	45,900	58,600	16,700	22,400	27,400	33,000	49,000
01473100	1960-80	A	5,110	7,360	9,410	11,800	19,200	1,200	1,710	2,170	2,720	4,380
01473120	1966-94	A	12,900	18,800	24,600	31,700	55,800	6,520	8,670	10,500	12,600	18,400
01473169	1983-99	A	2,620	3,830	4,990	6,450	11,300	1,320	1,920	2,490	3,160	5,280
01473470	1971-94	A	12,900	18,400	23,300	29,000	45,800	3,700	4,860	5,840	6,920	9,920
01473880	1962-79	A	470	620	730	860	1,190	668	900	1,100	1,320	1,950
01473950	1966-81	A	5,300	6,540	7,550	8,620	11,400	5,600	7,390	8,920	10,500	15,400
01474000	1966-99	A	6,760	9,140	11,300	13,900	22,000	6,580	8,600	10,300	12,400	17,400
01474500	1932-97	A	76,500	96,900	113,000	130,000	172,000	70,100	90,400	107,000	126,200	178,000
01475300	1972-97	A	1,420	1,880	2,250	2,660	3,750	1,110	1,480	1,810	2,170	3,170
01475510	1964-90	A	4,890	6,000	6,870	7,770	10,000	6,200	7,820	9,140	10,500	14,300
01475530	1965-81	A	2,160	3,380	4,610	6,180	11,600	1,660	2,130	2,520	2,940	4,060
01475550	1964-90	A	4,270	5,260	6,030	6,840	8,850	5,790	7,170	8,270	9,430	12,500

Appendix 2. *Flood-flow frequencies computed from streamflow-gaging data and regression equations for streamflow-gaging stations used in analysis—Continued*

[All flood flows in cubic feet per second; water year, 12-month period October 1-September 30]

U.S. Geological Survey streamflow-gaging station	Period of record used in analysis (water year)	Flood-flow region	Computed from streamflow-gaging-station data					Predicted from regression equations				
			10-year	25-year	50-year	100-year	500-year	10-year	25-year	50-year	100-year	500-year
01475850	1981-97	A	1,920	2,510	3,010	3,570	5,080	2,060	2,820	3,480	4,230	6,370
01476480	1987-97	A	2,950	4,400	5,780	7,480	13,000	3,480	4,700	5,750	6,940	10,300
01476500	1932-55	A	3,010	4,560	6,100	8,050	14,800	3,600	4,870	5,950	7,170	10,600
01477000	1932-97	A	6,910	10,200	13,400	17,400	30,500	6,340	8,400	10,100	12,100	17,500
01478200	1960-91	A	2,260	3,180	4,000	4,940	7,730	1,770	2,550	3,260	4,110	6,720
01480300	1960-97	A	4,360	7,680	11,400	16,600	38,000	2,440	3,490	4,440	5,570	9,040
01480500	1944-97	A	4,820	7,170	9,360	12,100	20,600	4,770	6,630	8,280	10,200	15,900
01480610	1964-96	A	840	1,240	1,610	2,050	3,380	327	499	664	868	1,540
01480617	1970-97	A	6,220	8,900	11,300	14,000	22,200	5,510	7,620	9,500	11,700	18,100
01480675	1967-97	A	560	790	990	1,230	1,930	864	1,270	1,650	2,120	3,590
01480680	1960-71	A	980	1,170	1,320	1,470	1,860	1,910	2,740	3,500	4,400	7,160
01480700	1974-99	A	4,450	5,870	7,020	8,250	11,500	4,830	6,730	8,430	10,400	16,300
01480800	1958-68	A	4,720	5,330	5,800	6,270	7,440	6,630	9,160	11,400	14,000	21,500
01480870	1974-99	A	5,940	7,710	9,180	10,800	15,000	6,090	8,440	10,500	13,000	20,200
01481000	1912-97	A	12,900	16,800	20,100	23,700	33,500	18,300	24,900	30,600	37,200	56,500
01516350	1972-96	A	20,300	31,400	42,400	56,100	102,000	9,660	13,000	15,900	19,100	28,200
01516500	1955-96	A	2,160	3,320	4,450	5,870	10,600	1,610	2,300	2,940	3,690	5,980
01516800	1960-77	A	560	690	790	890	1,140	528	779	1,010	1,290	2,170
01517000	1955-78	A	1,440	2,100	2,740	3,520	6,040	1,360	1,960	2,500	3,140	5,100
01518000	1939-77	A	25,500	37,700	49,100	62,700	106,000	17,100	22,700	27,500	32,800	47,600
01518420	1985-97	A	11,400	15,900	19,800	24,200	36,600	6,200	8,540	10,600	12,900	19,800
01518500	1954-74	A	8,560	12,200	15,600	19,700	32,700	8,990	12,200	15,000	18,200	27,400
01518862	1984-96	A	10,700	15,600	19,800	24,600	38,000	6,820	9,300	11,500	13,900	21,000
01519200	1980-97	A	20,600	26,500	31,200	36,000	48,300	14,500	19,400	23,700	28,400	41,800
01520000	1952-78	A	24,100	33,800	42,600	52,800	83,400	17,400	23,000	27,700	33,000	47,700
01532000	1914-96	A	24,400	36,100	47,200	60,700	104,000	12,900	17,200	20,800	24,900	36,300
01532200	1963-95	A	1,360	1,900	2,390	2,960	4,740	1,620	2,320	2,940	3,680	5,920
01532850	1960-79	A	1,020	1,430	1,770	2,150	3,190	732	1,050	1,350	1,690	2,740
01533250	1963-95	A	1,060	1,420	1,720	2,050	2,910	1,330	1,900	2,430	3,050	4,930
01533500	1941-58	A	6,640	10,700	14,800	20,000	37,500	3,290	4,610	5,780	7,140	11,200

Appendix 2. *Flood-flow frequencies computed from streamflow-gaging data and regression equations for streamflow-gaging stations used in analysis—Continued*

[All flood flows in cubic feet per second; water year, 12-month period October 1-September 30]

U.S. Geological Survey streamflow-gaging station	Period of record used in analysis (water year)	Flood-flow region	Computed from streamflow-gaging-station data					Predicted from regression equations				
			10-year	25-year	50-year	100-year	500-year	10-year	25-year	50-year	100-year	500-year
01533800	1963-79	A	1,120	1,700	2,270	2,980	5,350	853	1,240	1,590	2,000	3,280
01533950	1961-78	A	1,530	1,970	2,320	2,700	3,660	1,330	1,890	2,400	2,990	4,780
01534000	1914-96	A	24,100	29,500	33,500	37,400	46,300	17,900	23,900	29,100	34,800	51,100
01538000	1920-96	A	2,510	3,350	4,050	4,810	6,870	3,450	4,720	5,830	7,080	10,700
01538800	1960-80	A	1,030	1,430	1,760	2,130	3,110	601	864	1,100	1,380	2,210
01539000	1939-96	A	17,300	23,600	28,900	34,900	51,900	15,500	20,700	25,100	30,000	43,700
01539500	1941-58	A	3,150	3,700	4,100	4,510	5,470	5,120	7,100	8,850	10,900	16,800
01540000	1914-31	A	22,400	28,400	33,000	37,800	49,300	22,100	29,600	36,000	43,300	64,000
01540200	1959-79	A	190	320	460	640	1,290	280	411	533	677	1,120
01541000	1914-97	A	13,900	17,800	21,200	24,800	35,000	19,600	26,200	31,800	38,200	56,200
01541200	1956-67	A	14,500	17,700	20,200	22,700	28,600	19,100	25,000	30,000	35,500	50,500
01541500	1914-97	A	12,500	15,700	18,300	21,100	28,400	17,800	23,400	28,100	33,300	47,700
01542000	1941-93	A	2,430	3,110	3,670	4,270	5,850	5,080	6,900	8,470	10,200	15,300
01542500	1940-60	A	45,600	54,500	61,100	67,600	83,000	63,800	82,500	98,200	115,400	163,000
	1966-97	A	37,300	48,900	58,900	70,200	102,000	47,200	60,700	71,900	84,100	117,000
01542720	1962-95	A	390	470	540	605	770	563	866	1,160	1,530	2,730
01542810	1964-97	A	410	560	690	840	1,260	620	889	1,130	1,410	2,250
01543000	1914-96	A	18,700	25,900	32,300	39,700	61,100	14,400	19,200	23,100	27,600	39,800
01543500	1936-97	A	36,300	49,000	60,100	72,600	109,000	28,800	37,300	44,300	52,000	72,600
01543700	1984-97	A	9,770	13,000	15,700	18,800	27,400	9,970	13,300	16,100	19,200	27,700
01544450	1964-79	A	170	200	230	260	340	395	581	753	960	1,600
01544500	1941-96	A	7,790	10,800	13,400	16,400	25,400	7,900	10,600	12,900	15,400	22,500
01545600	1965-96	A	2,430	3,700	4,920	6,430	11,400	3,330	4,560	5,630	6,830	10,200
01546000	1911-28	A	13,100	16,900	20,200	23,800	33,700	7,850	10,800	13,400	16,400	25,200
01546400	1985-96	A	1,170	1,680	2,170	2,750	4,610	2,370	3,590	4,780	6,240	11,100
01546500	1936-96	A	1,940	3,050	4,170	5,630	10,800	3,020	4,580	6,100	7,980	14,200
01547100	1967-96	A	3,270	4,900	6,450	8,350	14,500	4,470	6,680	8,800	11,400	19,800
01547200	1957-96	A	11,100	15,200	18,800	22,800	34,600	8,830	12,500	15,800	19,700	31,500
01547500	1955-69	A	7,560	9,350	10,800	12,200	15,800	11,300	15,800	19,800	24,600	38,700
01547700	1956-96	A	3,100	4,640	6,120	7,940	13,900	3,600	4,960	6,160	7,530	11,500

Appendix 2. *Flood-flow frequencies computed from streamflow-gaging data and regression equations for streamflow-gaging stations used in analysis—Continued*

[All flood flows in cubic feet per second; water year, 12-month period October 1-September 30]

U.S. Geological Survey streamflow-gaging station	Period of record used in analysis (water year)	Flood-flow region	Computed from streamflow-gaging-station data					Predicted from regression equations				
			10-year	25-year	50-year	100-year	500-year	10-year	25-year	50-year	100-year	500-year
01547800	1959-81	A	690	950	1,180	1,440	2,220	1,260	1,760	2,210	2,720	4,210
01547950	1968-97	A	5,380	7,180	8,710	10,400	15,100	10,100	13,500	16,500	19,800	29,000
01548005	1971-97	A	10,530	13,500	16,100	19,000	27,100	13,800	19,200	24,100	29,800	47,000
01548020	1963-81	A	160	240	310	400	700	292	428	552	699	1,150
01548500	1919-96	A	25,800	35,600	44,300	54,300	84,200	27,000	35,200	42,100	49,500	69,900
01549000	1909-20	A	34,400	40,700	45,200	49,600	59,300	30,900	40,000	47,500	55,600	77,500
01549500	1941-97	A	3,920	5,340	6,560	7,930	11,800	3,230	4,470	5,560	6,810	10,400
01549700	1958-96	A	42,800	58,700	72,700	88,600	135,000	31,700	40,900	48,600	56,900	79,400
01549780	1960-78	A	570	810	1,040	1,300	2,110	863	1,240	1,580	1,990	3,210
01550000	1914-96	A	14,100	19,100	23,500	28,400	42,500	10,300	13,800	16,700	20,000	29,300
01551000	1940-53	A	710	1,000	1,240	1,500	2,190	613	897	1,160	1,470	2,450
01552000	1926-98	A	28,400	37,200	44,800	53,200	76,600	20,300	26,700	32,200	38,200	54,700
01552100	1961-78	A	990	1,470	1,920	2,480	4,280	1,290	1,830	2,310	2,870	4,520
01552500	1941-96	A	4,190	6,000	7,660	9,600	15,500	2,000	2,800	3,500	4,310	6,680
01553050	1961-95	A	1,640	2,400	3,070	3,840	6,070	1,630	2,270	2,840	3,490	5,380
01553130	1968-81	A	590	1,010	1,440	2,000	3,990	615	879	1,120	1,390	2,210
01553600	1960-78	A	2,220	3,400	4,550	5,970	10,700	1,380	2,000	2,560	3,230	5,310
01553700	1980-96	A	3,480	4,100	4,560	5,030	6,150	4,710	6,700	8,520	10,700	17,200
01555000	1930-97	A	12,300	17,300	21,900	27,200	43,300	12,100	16,700	20,800	25,600	39,500
01555500	1930-97	A	11,300	17,300	23,300	31,200	58,900	11,400	15,400	18,900	22,900	34,200
01555800	1959-78	A	220	300	370	450	680	281	415	538	686	1,140
01556000	1889-1997	A	12,700	16,800	20,100	23,900	34,100	12,200	16,600	20,600	25,000	38,000
01556400	1962-81	A	520	780	1,020	1,310	2,230	653	938	1,200	1,500	2,410
01556500	1946-81	A	5,030	6,450	7,580	8,780	11,800	6,320	8,560	10,500	12,700	18,800
01557100	1958-81	A	230	310	380	450	640	289	421	542	685	1,120
01557500	1940-97	A	2,930	3,820	4,560	5,350	7,420	3,180	4,380	5,430	6,630	10,100
01558000	1936-97	A	12,200	17,900	23,400	30,100	52,300	9,840	13,300	16,400	19,800	29,600
01559000	1896-1997	A	28,300	38,600	47,600	58,000	88,600	26,000	35,600	44,200	54,000	82,900
01559500	1930-58	A	4,610	5,920	7,010	8,210	11,500	8,240	11,200	13,900	16,900	25,500
01559700	1962-78	A	770	1,130	1,470	1,860	3,040	678	978	1,250	1,570	2,530

Appendix 2. *Flood-flow frequencies computed from streamflow-gaging data and regression equations for streamflow-gaging stations used in analysis—Continued*

[All flood flows in cubic feet per second; water year, 12-month period October 1-September 30]

U.S. Geological Survey streamflow-gaging station	Period of record used in analysis (water year)	Flood-flow region	Computed from streamflow-gaging-station data					Predicted from regression equations				
			10-year	25-year	50-year	100-year	500-year	10-year	25-year	50-year	100-year	500-year
01560000	1936-97	A	9,020	12,400	15,400	18,800	29,000	10,700	14,600	18,100	22,000	33,600
01561000	1930-58	A	2,610	4,110	5,620	7,540	14,200	3,320	4,610	5,740	7,050	10,900
01562000	1912-97	A	27,800	35,900	42,400	49,400	67,500	29,200	39,100	47,800	57,500	85,300
01562500	1930-57	A	3,610	5,020	6,290	7,770	12,200	6,460	8,830	10,900	13,200	20,000
01563000	1946-71	A	23,400	27,400	30,200	32,800	38,600	34,700	46,000	55,700	66,400	96,800
01563800	1960-78	A	340	460	550	660	940	643	951	1,240	1,590	2,690
01564500	1939-97	A	14,200	20,000	25,100	31,100	49,000	12,300	16,700	20,500	24,900	37,300
01565000	1936-98	A	6,540	9,560	12,400	15,800	26,700	7,510	10,500	13,200	16,400	25,700
01565700	1960-81	A	630	980	1,330	1,780	3,350	605	946	1,280	1,710	3,150
01565920	1962-81	A	960	1,550	2,150	2,920	5,620	814	1,190	1,530	1,950	3,210
01566000	1912-90	A	11,300	14,400	17,000	19,800	27,200	10,600	14,500	17,900	21,800	33,000
01566500	1930-58	A	4,610	5,810	6,740	7,700	10,000	4,710	6,570	8,230	10,200	15,800
01567500	1954-97	A	3,300	6,060	9,300	14,000	34,200	1,380	2,030	2,650	3,400	5,760
01568000	1927-97	A	15,900	22,500	28,600	35,600	57,100	10,600	14,600	18,000	22,000	33,400
01568500	1938-96	A	1,030	1,700	2,380	3,260	6,400	1,590	2,240	2,830	3,520	5,560
01569000	1938-74	A	2,760	4,880	7,260	10,600	24,100	2,710	3,750	4,660	5,690	8,670
01569340	1964-95	A	890	1,460	2,060	2,860	5,950	928	1,360	1,750	2,220	3,700
01569800	1976-97	A	670	1,060	1,460	1,980	3,880	1,240	1,950	2,660	3,570	6,710
01570000	1912-96	A	13,000	16,900	20,300	24,100	35,000	17,900	25,100	31,600	39,200	62,300
01571000	1940-50	A	1,900	2,270	2,540	2,810	3,440	1,470	2,170	2,820	3,610	6,140
	1974-94	A	3,350	4,640	5,760	7,040	10,700	1,700	2,350	2,920	3,570	5,490
01571500	1910-97	A	5,960	8,660	11,300	14,500	25,300	9,280	12,900	16,100	19,900	31,000
01572000	1920-84	A	2,700	3,750	4,700	5,820	9,210	3,360	4,700	5,880	7,250	11,300
01572900	1962-81	A	2,650	3,580	4,370	5,250	7,700	1,480	2,070	2,590	3,200	4,990
01573000	1919-97	A	17,900	23,700	28,900	34,700	51,700	19,900	26,400	32,100	38,400	56,100
01573086	1964-81	A	1,320	3,150	5,710	9,990	33,000	511	840	1,180	1,630	3,260
01573160	1975-93	A	2,200	3,280	4,320	5,620	10,000	3,530	5,320	7,060	9,200	16,300
01573500	1938-58	A	1,780	2,810	3,820	5,080	9,280	1,350	1,900	2,390	2,960	4,620
01573560	1975-97	A	20,000	26,400	32,100	38,600	57,600	26,100	34,600	41,900	50,100	73,300
01574000	1929-97	A	29,400	40,100	49,900	61,600	98,700	29,000	38,900	47,500	57,200	85,300

Appendix 2. *Flood-flow frequencies computed from streamflow-gaging data and regression equations for streamflow-gaging stations used in analysis—Continued*

[All flood flows in cubic feet per second; water year, 12-month period October 1-September 30]

U.S. Geological Survey streamflow-gaging station	Period of record used in analysis (water year)	Flood-flow region	Computed from streamflow-gaging-station data					Predicted from regression equations				
			10-year	25-year	50-year	100-year	500-year	10-year	25-year	50-year	100-year	500-year
01574500	1930-66	A	4,620	6,670	8,610	11,000	18,500	6,560	9,410	12,100	15,200	25,100
	1967-97	A	4,930	8,040	11,400	15,900	33,100	5,010	7,220	9,270	11,700	19,500
01574800	1960-75	A	1,070	2,230	3,740	6,130	18,300	952	1,410	1,830	2,340	3,970
01575000	1928-71	A	5,410	8,060	10,700	13,900	24,700	11,200	15,500	19,400	23,900	37,300
	1972-95	A	11,900	18,600	25,300	34,000	64,400	10,600	14,500	18,000	22,000	33,900
01575500	1947-97	A	9,250	13,400	17,300	22,000	37,700	12,200	17,000	21,400	26,500	42,000
01576085	1982-95	A	1,550	2,060	2,480	2,930	4,120	763	1,170	1,570	2,060	3,720
01576320	1964-95	A	1,030	1,320	1,560	1,810	2,450	622	906	1,170	1,480	2,460
01576500	1929-97	A	16,000	22,000	27,300	33,400	51,000	14,200	20,000	25,300	31,400	50,300
01576754	1985-97	A	18,500	22,800	26,300	29,900	39,000	17,300	24,300	30,700	38,200	61,200
01577500	1929-72	A	12,100	17,500	22,600	28,800	49,200	10,600	14,500	17,900	21,800	33,300
01578200	1963-97	A	1,240	1,950	2,660	3,580	6,840	1,500	2,200	2,850	3,630	6,100
01578400	1963-81	A	2,000	3,440	5,040	7,270	16,300	743	1,140	1,530	2,020	3,650
01600700	1961-81	A	1,170	1,770	2,350	3,060	5,390	1,140	1,620	2,050	2,550	4,040
01601000	1952-86	A	8,660	11,300	13,600	16,100	23,000	8,720	11,700	14,200	17,100	25,000
01603500	1933-82	A	2,120	2,940	3,640	4,430	6,670	2,090	3,010	3,840	4,820	7,790
01613050	1963-96	A	900	1,230	1,520	1,830	2,680	1,260	1,800	2,280	2,850	4,550
01613500	1931-41	A	12,200	18,800	25,300	33,400	61,400	8,260	11,400	14,200	17,500	26,900
01614090	1961-81	A	300	470	630	840	1,560	612	879	1,120	1,400	2,250
01638900	1961-80	A	3,350	5,000	6,570	8,490	14,700	1,870	2,690	3,460	4,380	7,270
03007800	1975-97	B	8,740	10,400	11,700	13,000	16,100	11,000	13,800	15,900	18,200	24,200
03009680	1972-97	B	7,000	8,810	10,300	11,900	16,400	8,020	10,100	11,700	13,400	17,900
03010655	1975-97	B	3,530	4,180	4,640	5,090	6,100	5,640	7,120	8,300	9,580	12,900
03011020	1904-95	B	37,000	44,600	50,500	56,700	72,200	41,700	50,400	57,300	64,400	82,400
03011800	1966-96	B	3,110	4,300	5,340	6,500	9,800	3,200	4,070	4,780	5,540	7,500
03015000	1936-97	B	11,900	13,800	15,100	16,500	19,600	19,200	22,800	25,500	28,200	34,500
03015080	1962-81	B	930	1,040	1,120	1,200	1,380	1,060	1,380	1,650	1,950	2,720
03015390	1964-85	B	1,330	1,660	1,920	2,200	2,940	1,140	1,460	1,730	2,020	2,750
03015500	1910-96	B	11,900	14,100	15,600	17,100	20,600	10,700	13,000	14,800	16,600	21,000
03017500	1938-79	B	10,600	13,200	15,200	17,300	22,500	10,700	13,300	15,400	17,700	23,500

Appendix 2. *Flood-flow frequencies computed from streamflow-gaging data and regression equations for streamflow-gaging stations used in analysis—Continued*

[All flood flows in cubic feet per second; water year, 12-month period October 1-September 30]

U.S. Geological Survey streamflow-gaging station	Period of record used in analysis (water year)	Flood-flow region	Computed from streamflow-gaging-station data					Predicted from regression equations				
			10-year	25-year	50-year	100-year	500-year	10-year	25-year	50-year	100-year	500-year
03019000	1910-40	B	13,900	16,100	17,800	19,400	23,000	17,700	21,900	25,200	28,700	37,800
03020440	1964-81	B	470	560	630	690	860	596	789	948	1,120	1,590
03020500	1910-96	B	12,800	15,400	17,500	19,600	24,700	12,000	14,900	17,100	19,400	25,400
03021350	1975-97	B	5,940	6,810	7,420	7,980	9,200	4,500	5,580	6,430	7,310	9,510
03021410	1975-94	B	6,120	8,060	9,700	11,500	16,600	3,380	4,280	5,000	5,780	7,760
03021700	1961-78	B	540	680	800	920	1,240	518	687	828	983	1,390
03022500	1913-39	B	17,500	21,100	23,900	26,700	33,700	18,400	22,300	25,200	28,300	35,800
03022540	1975-95	B	2,280	2,860	3,320	3,780	4,900	2,200	2,800	3,270	3,780	5,070
03023000	1911-38	B	2,540	3,130	3,610	4,130	5,500	4,640	5,790	6,700	7,650	10,000
03024000	1933-71	B	19,600	22,100	23,800	25,500	29,200	24,800	29,500	33,100	36,800	45,700
	1972-97	B	16,500	18,300	19,400	20,500	22,700	19,900	23,100	25,500	27,900	33,200
03025000	1933-79	B	8,580	10,100	11,200	12,200	14,500	7,540	9,370	10,800	12,300	16,200
03025200	1961-78	B	620	920	1,210	1,560	2,680	722	952	1,140	1,350	1,900
03026400	1963-81	B	640	710	760	810	900	739	974	1,170	1,380	1,940
03026500	1952-96	B	1,140	1,710	2,240	2,890	4,950	911	1,200	1,430	1,690	2,360
03028000	1954-96	B	4,180	5,390	6,370	7,410	10,100	4,130	5,260	6,170	7,150	9,690
03028500	1953-94	B	6,900	8,660	10,100	11,600	15,800	6,630	7,980	8,990	10,000	12,400
03029200	1960-81	B	690	1,030	1,350	1,740	3,020	980	1,280	1,530	1,810	2,530
03029400	1960-78	B	620	760	860	970	1,220	1,280	1,670	1,990	2,340	3,260
03029500	1936-97	B	32,000	41,100	48,600	56,800	78,900	23,200	28,100	31,900	35,800	45,600
03030500	1948-96	B	40,100	50,600	59,100	68,200	91,800	26,600	32,200	36,600	41,100	52,400
03031000	1942-53	B	41,700	48,800	54,000	59,000	70,400	35,600	43,300	49,300	55,700	71,900
03031780	1965-81	B	230	300	350	400	520	353	472	571	681	974
03031950	1964-81	B	900	1,120	1,270	1,420	1,780	871	1,150	1,370	1,620	2,270
03032500	1910-97	B	23,200	31,100	38,000	46,000	69,300	19,300	23,800	27,400	31,200	40,900
03034000	1936-96	B	8,920	12,200	15,300	18,800	29,700	8,050	10,100	11,800	13,500	18,100
03034500	1940-98	B	5,300	6,470	7,380	8,320	10,700	5,240	6,630	7,760	8,970	12,100
03035000	1917-40	B	12,200	15,000	17,200	19,700	26,200	13,500	16,700	19,300	22,100	29,200
03038000	1936-97	B	8,890	11,300	13,300	15,400	21,300	8,490	10,500	12,200	13,900	18,200
03039000	1910-39	B	15,200	17,900	19,800	21,700	25,700	12,100	15,100	17,500	20,000	26,500

Appendix 2. *Flood-flow frequencies computed from streamflow-gaging data and regression equations for streamflow-gaging stations used in analysis*—*Continued*

[All flood flows in cubic feet per second; water year, 12-month period October 1-September 30]

U.S. Geological Survey streamflow-gaging station	Period of record used in analysis (water year)	Flood-flow region	Computed from streamflow-gaging-station data					Predicted from regression equations				
			10-year	25-year	50-year	100-year	500-year	10-year	25-year	50-year	100-year	500-year
03039200	1961-78	A	260	340	400	470	650	474	685	875	1,100	1,770
03039925	1985-97	A	170	220	270	320	440	449	650	831	1,050	1,690
03040000	1914-97	A	22,800	30,700	37,400	44,800	65,500	22,500	29,600	35,500	42,100	60,300
03041000	1936-97	A	12,900	18,500	23,600	29,700	48,600	10,700	14,300	17,400	20,800	30,300
03041500	1936-97	A	39,800	55,800	70,000	86,400	135,000	33,100	42,900	51,200	60,200	84,700
03042000	1952-96	A	13,800	19,200	24,200	30,000	48,000	11,600	15,400	18,600	22,200	32,200
03042170	1964-76	A	460	530	580	630	740	1,200	1,590	1,910	2,280	3,280
03042200	1961-87	A	1,150	1,760	2,360	3,120	5,710	867	1,240	1,570	1,970	3,130
03042500	1952-68	A	8,980	11,200	12,900	14,800	19,700	11,100	14,700	17,800	21,200	30,600
	1969-97	A	11,300	18,000	24,800	33,400	64,000	9,330	12,500	15,300	18,400	27,300
03043000	1905-51	A	22,300	30,000	36,800	44,700	67,900	23,000	30,600	37,100	44,400	65,000
03045000	1940-97	A	12,200	16,400	20,100	24,400	36,800	10,200	13,600	16,500	19,800	29,000
03045500	1920-40	A	16,000	22,400	28,300	35,100	55,900	16,800	22,500	27,400	33,000	49,000
03047500	1884-1937	A	74,900	97,900	117,000	139,000	202,000	73,600	94,800	113,000	132,000	185,000
03049000	1941-96	A	7,360	9,390	11,100	12,900	17,600	9,410	12,700	15,600	18,800	28,000
03049100	1959-81	A	340	380	400	430	480	620	896	1,150	1,440	2,340
03049800	1963-96	A	1,160	2,160	3,310	4,930	11,700	818	1,150	1,450	1,790	2,790
03070420	1978-89	A	110	140	160	180	250	181	271	356	458	779
03072000	1941-96	A	12,200	14,700	16,600	18,500	22,900	13,000	17,400	21,000	25,200	36,600
03072590	1964-78	A	1,210	1,520	1,770	2,030	2,700	1,950	2,740	3,440	4,250	6,650
03072840	1969-79	A	10,800	15,800	20,600	26,300	44,300	9,700	13,200	16,200	19,700	29,600
03072880	1963-85	A	2,320	3,250	4,040	4,900	7,240	1,970	2,790	3,520	4,390	6,970
03073000	1932-95	A	10,200	12,000	13,300	14,500	17,300	12,200	16,300	19,900	23,800	35,000
03074300	1959-78	A	350	490	610	750	1,160	494	713	913	1,150	1,850
03074500	1943-96	A	3,900	4,830	5,570	6,340	8,300	6,670	8,940	10,900	13,100	19,300
03078500	1933-86	A	2,500	3,610	4,630	5,820	9,460	2,340	3,290	4,130	5,110	7,990
03079000	1915-96	A	20,600	27,200	32,900	39,400	58,000	24,200	32,300	39,300	47,200	69,800
03080000	1914-97	A	7,090	8,690	9,910	11,100	14,100	7,520	10,200	12,400	15,000	22,200
03081000	1942-97	A	28,400	36,100	42,400	49,400	68,300	35,800	47,000	56,500	67,100	96,800
03082200	1961-78	A	1,150	1,460	1,730	2,010	2,790	1,080	1,550	1,960	2,450	3,900

Appendix 2. *Flood-flow frequencies computed from streamflow-gaging data and regression equations for streamflow-gaging stations used in analysis—Continued*

[All flood flows in cubic feet per second; water year, 12-month period October 1-September 30]

U.S. Geological Survey streamflow-gaging station	Period of record used in analysis (water year)	Flood-flow region	Computed from streamflow-gaging-station data					Predicted from regression equations				
			10-year	25-year	50-year	100-year	500-year	10-year	25-year	50-year	100-year	500-year
03082500	1943-97	A	46,000	60,000	71,800	84,800	121,000	45,300	59,000	70,600	83,300	119,000
03083000	1929-79	A	590	870	1,120	1,430	2,390	480	704	909	1,150	1,910
03083500	1943-97	A	57,300	74,600	89,000	105,000	147,000	67,700	86,200	102,000	118,000	162,000
03083600	1959-81	A	490	750	1,000	1,310	2,340	616	887	1,130	1,420	2,300
03084000	1949-93	A	900	1,160	1,370	1,590	2,120	850	1,170	1,450	1,760	2,670
03084500	1917-55	A	4,260	5,380	6,260	7,180	9,460	5,390	7,170	8,670	10,300	15,000
03085500	1916-96	A	10,100	12,400	14,100	15,900	19,900	16,800	22,500	27,300	32,800	48,200
03086100	1963-78	A	1,320	1,790	2,180	2,630	3,870	1,650	2,290	2,860	3,510	5,400
03100000	1912-22	B	6,170	8,100	9,710	11,500	16,400	4,260	5,030	5,570	6,110	7,270
03101000	1935-55	B	1,430	2,050	2,610	3,230	5,020	1,010	1,310	1,560	1,840	2,550
03102500	1914-96	B	4,510	5,610	6,470	7,340	9,490	4,900	6,080	6,990	7,940	10,300
03102850	1966-97	B	5,360	5,720	5,950	6,140	6,520	8,270	9,740	10,800	11,800	14,100
03103000	1914-63	B	5,010	5,970	6,650	7,290	8,680	3,840	4,440	4,840	5,230	6,010
03104000	1910-32	B	15,700	19,800	22,900	26,200	34,200	13,600	16,000	17,800	19,500	23,400
03104500	1913-32	B	16,500	21,300	25,300	29,700	41,600	18,100	21,400	23,900	26,300	32,000
03104760	1969-80	B	340	430	500	580	760	316	416	497	585	812
03106000	1916-96	B	12,600	15,100	17,000	19,000	23,800	14,300	17,700	20,400	23,200	30,600
03106500	1912-69	B	13,200	16,100	18,400	20,600	26,000	14,400	17,700	20,300	23,000	29,800
	1970-97	B	8,900	9,930	10,600	11,300	12,600	12,600	15,200	17,200	19,300	24,400
03108000	1916-96	A	6,820	8,490	9,770	11,100	14,300	11,800	15,800	19,100	22,800	33,200
03111150	1961-85	A	1,240	1,670	2,010	2,380	3,310	1,590	2,310	2,980	3,770	6,260
04213000	1923-95	B	11,100	13,600	15,500	17,400	21,900	7,680	9,510	11,000	12,500	16,300
04213040	1961-95	B	280	370	440	520	710	256	326	380	437	572
04213200	1969-85	B	1,380	1,700	1,940	2,190	2,780	1,020	1,340	1,590	1,880	2,620