# TECHNIQUE FOR ESTIMATING MAGNITUDE AND FREQUENCY OF FLOODS IN DELAWARE

U.S. GEOLOGICAL SURVEY

WATER-RESOURCES INVESTIGATIONS 78-93
OPEN-FILE REPORT



Prepared in cooperation with

STATE OF DELAWARE
DEPARTMENT OF TRANSPORTATION
and the
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

# TECHNIQUE FOR ESTIMATING MAGNITUDE AND FREQUENCY OF FLOODS IN DELAWARE

By R. H. Simmons and D. H. Carpenter

---

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations 78-93
Open-File Report

Prepared in cooperation with

State of Delaware
Department of Transportation
and the
U.S. Department of Transportation
Federal Highway Administration

September 1978

UNITED STATES DEPARTMENT OF THE INTERIOR

CECIL D. ANDRUS, Secretary

GEOLOGICAL SURVEY

H. William Menard, Director

---

Open-File Report

For additional information write to:

U.S. Geological Survey
208 Carroll Building
8600 La Salle Road
Towson, Maryland 21204

CONTENTS

Page



COVER PHOTOGRAPH--Meredith Branch near Sandtown, flood of August 4, 1967. Photograph furnished by Delaware Department of Transportation

## ILLUSTRATIONS



## TABLES

TECHNIQUE FOR ESTIMATING MAGNITUDE

AND FREQUENCY OF FLOODS IN DELAWARE

by R. H. Simmons and D. H. Carpenter

ABSTRACT

A flood-estimating method is presented which applies to drainage basins without urban development and covers selected recurrence intervals from 2 to 100 years. The method was developed by multiple-regression techniques.

The State is divided into two regions and sets of equations for calculating peak discharges based on physical basin characteristics are provided for each region. The boundary between regions generally corresponds with the division between the Piedmont and Coastal Plain provinces. In the northern region, flood-peak discharges were related to basin drainage area and storage. In the southern region, flood peaks were related to drainage area, slope, storage, forest cover, and two composite soil categories. Standard errors of estimate for the regression equations in the northern region ranged from 30 to 39 percent. For the southern region, the standard errors of estimate varied from 38 to 40 percent. Without using the two soil parameters in the southern region, the standard errors of estimate varied from 57 to 70 percent.

Annual flood peaks, basin characteristics, and flood-frequency distributions are tabulated for the 60-gaged sites used in the regression analysis. At 23 of these sites, a rainfall-runoff model generated additional flood-peak data which were used in defining the flood-frequency distributions.

## INTRODUCTION

The purpose of this report is to provide a convenient and reliable technique for estimating the magnitude and frequency of floods for Delaware streams. Such flood information is required for efficient design of bridges, culverts, embankments, and flood-protection structures, and is a prerequisite for effective flood-plain management.

Relatively little flood-discharge data were available for small streams in Delaware prior to 1964. To obtain this information and to develop the flood-estimating technique, a small-streams flood investigation was initiated in 1964 in cooperation with the Delaware Department of Transportation and the Federal Highway Administration.

Flood-discharge records at 60 gaging stations (including 32 sites in nearby Maryland and Pennsylvania) were included in the analysis used to develop the flood-estimating method. Flood magnitude and frequency characteristics were determined for these sites using U.S. Water Resources Council (WRC) Bulletin 17 guidelines. (See table 3.) Annual maximum flood-peak data for 74 gaging stations (including stations not used in the analysis) are given in table 5.

The technique for estimating floods was developed by relating flood magnitude/frequency characteristics to basin characteristics such as drainage area and forest cover at the 60 sites mentioned above. Generalized relationships were determined by multiple-regression analyses. These relationships between the flood-frequency characteristics and basin characteristics were considered to apply to ungaged drainage basins and their applicability was statistically tested. The northern region of the State (see pl. 1), which generally coincides with the Piedmont province, was found to have a set of generalized flood-frequency relationships different from the southern region, which generally coincides with the Coastal Plain.

Large-stream flood data were included with the small-stream data used in the analysis. Combining the data strengthened the technique and provided continuity for its use throughout a wide range in drainage area sizes.

A rainfall-runoff model developed by the U.S. Geological Survey was used to generate long-term records of flood peaks at 23 sites used in the analysis. The generated data were combined with observed peak data to develop flood magnitude/frequency distributions utilized in the multiple-regression analysis.

Previous reports by Tice (1968), and Cushing, Kantrowitz, and Taylor (1973) presented methods for estimating flood magnitudes, but these methods were based on considerably fewer data within the study area and did not apply to small drainage basins.

Special acknowledgment is made to the U.S. Soil Conservation Service for their assistance in providing natural soil group maps. The maps of Delaware were prepared by the Soil Conservation Service in cooperation with the Delaware Agricultural Experiment Station. The maps of the Eastern Shore of Maryland were prepared by the Maryland Department of State Planning from information furnished by and with the assistance of the Soil Conservation Service in cooperation with the Maryland Agricultural Experiment Station. Long-term daily precipitation data and storm rainfall at 5-minute intervals were obtained from the National Oceanic and Atmospheric Administration. The technical support of the Surface Water Branch of the Water Resources Division of the U.S. Geological Survey is appreciated. The assistance of W. O. Thomas was especially helpful in the analysis phase of the study.

## Conversion of Measurement Units

The following factors may be used to convert the U.S. customary units appearing in this report to SI metric units.

| To convert from | Multiply by | To obtain |
|---|---|---|
| foot (ft) | 0.305 | meter (m) |
| mile (mi) | 1.61 | kilometer (km) |
| foot per mile (ft/mi) | 0.189 | meter per kilometer (m/km) |
| $mile^2$ ($mi^2$) | 2.59 | $kilometer^2$ ($km^2$) |
| $foot^3$ per second ($ft^3/s$) | 0.0283 | $meter^3$ per second ($m^3/s$) |

## Ungaged Streams

Peak discharges may be estimated for ungaged streams (with the separation between northern and southern regions shown on plate 1) by the following equations:

### Northern Region

$$Q_2 = 13{,}600\ A^{0.742} St^{-1.948}, \quad (1)$$

$$Q_5 = 23{,}700\ A^{0.703} St^{-1.914}, \quad (2)$$

$$Q_{10} = 33{,}200\ A^{0.675} St^{-1.893}, \quad (3)$$

$$Q_{25} = 52{,}000\ A^{0.640} St^{-1.887}, \quad (4)$$

$$Q_{50} = 68{,}200\ A^{0.616} St^{-1.868}, \quad (5)$$

$$Q_{100} = 89{,}300\ A^{0.591} St^{-1.853}, \quad (6)$$

### Southern Region

$$Q_2 = 28.6\ A^{0.910} Sl^{0.681} St^{-0.148} F^{-0.647} S_a^{-0.309} S_d^{0.560}, \quad (7)$$

$$Q_5 = 119\ A^{0.989} Sl^{0.843} St^{-0.533} F^{-0.731} S_a^{-0.369} S_d^{0.577}, \quad (8)$$

$$Q_{10} = 306\ A^{1.016} Sl^{0.911} St^{-0.820} F^{-0.804} S_a^{-0.367} S_d^{0.624}, \quad (9)$$

$$Q_{25} = 936\ A^{1.039} Sl^{0.974} St^{-1.114} F^{-0.868} S_a^{-0.384} S_d^{0.655}, \quad (10)$$

$$Q_{50} = 2{,}120\ A^{1.051} Sl^{1.009} St^{-1.321} F^{-0.916} S_a^{-0.396} S_d^{0.676}, \quad (11)$$

$$Q_{100} = 4{,}800\ A^{1.060} Sl^{1.035} St^{-1.519} F^{-0.963} S_a^{-0.410} S_d^{0.695}, \quad (12)$$

where

$Q_2$, $Q_5$....$Q_{100}$ = peak discharges for floods with recurrence intervals of 2 years, 5 years....100 years;

A = drainage area, in $mi^2$;

Sl = main channel slope (10-85 percent points), in ft/mi;

St = storage (lakes, ponds and swamps), in percent plus 10;

F = forest cover, in percent plus 10;

$S_a$ = type A soils, in percent plus 10; and

$S_d$ = type D soils, in percent plus 10.

These characteristics may be determined from topographic maps and the soils maps included with this report. See table 4 for detailed definition of basin characteristics and explanation of how they are determined. Basin characteristics expressed in percent (St, F, $S_a$, and $S_d$) must have a constant of 10.0 added before being entered into the estimating equations. If the value of one of these characteristics is zero before adding the constant, the characteristic still must be included in the equation (as $10^x$).

An alternate set of equations for estimating peak discharges in the southern region is presented below.

<u>Southern Region (Alternate)</u>

$$Q_2 = 1{,}450\ A^{0.757} St^{-0.229} F^{-0.849}, \quad (13)$$

$$Q_5 = 14{,}300\ A^{0.784} St^{-0.642} F^{-1.056}, \quad (14)$$

$$Q_{10} = 53{,}100\ A^{0.791} St^{-0.926} F^{-1.132}, \quad (15)$$

$$Q_{25} = 2.29 \times 10^5\ A^{0.795} St^{-1.226} F^{-1.222}, \quad (16)$$

$$Q_{50} = 6.34x10^5 A^{0.799} St^{-1.437} F^{-1.284} , \quad (17)$$

$$Q_{100} = 1.66x10^6 A^{0.801} St^{-1.639} F^{-1.341} . \quad (18)$$

The alternate method requires fewer basin characteristics as input data. However, the resulting flood estimates are less accurate than those computed by equations 7 to 12.

The equations apply to basins under natural conditions (not significantly affected by urbanization or other manmade changes). (See section on "Accuracy and Limitations" for further details.)

The equations will not work with metric units. To obtain answers in cubic meters per second, peak discharges must be computed first in cubic feet per second and then multiplied by 0.0283.

A drainage basin under study may lie partly in both the northern and southern regions. If the overlap is significant, the discharge may be computed twice, as though the basin were entirely in each region, using the alternate method for the southern region. The two results are then combined, weighted by the percentages of the total basin area falling in each region.

The following step by step example shows how to use the estimating equations to determine a peak discharge at a site on an ungaged stream.

<u>Problem</u>: Estimate the 50-year flood on Murderkill River at U.S. Hwy. 13, near Felton, Del.

1. Determine drainage area. Outline the drainage basin above U.S. Hwy. 13 on best available topographic maps and planimeter area.
   $A = 13.6 \ mi^2$.

2. Determine slope. Measure length, in miles, of main channel (L) on topographic map from U.S. Hwy. 13 to basin rim; L = 6.10 mi. Obtain channel elevation from topographic map at distances of 0.10L and 0.85L upstream from U.S. Hwy. 13;

$$Elev_{0.10} = 29 \text{ ft.} \quad Elev_{0.85} = 58 \text{ ft.}$$

$$Sl = \frac{Elev_{0.85} - Elev_{0.10}}{0.75L} = 6.3 \text{ ft/mi.}$$

3. Determine storage. On the topographic map, planimeter the area of lakes, ponds, and swamps within the drainage basin. Planimetered area = 0.0880 $mi^2$. A = 13.6 $mi^2$ from step 1 above.

$$St = (\frac{0.088}{A})\ 100 + 10 = 10.6 \text{ percent.}$$

4. Determine forest cover. On the topographic map, measure the forested area within the drainage basin (shaded green on U.S. Geological Survey maps) by grid method = 4.76 $mi^2$.

$$F = (\frac{4.76}{A})\ 100 + 10 = 45 \text{ percent.}$$

5. Determine type A soils. Outline the drainage basin on soils map (pl. 2) provided with this report. Planimeter the area of type A soil = 0.95 $mi^2$.

$$S_a = (\frac{0.95}{A})\ 100 + 10 = 17 \text{ percent.}$$

6. Determine type D soils. Planimeter the area of type D soil within the drainage basin on soils map (pl. 2) = 5.85 mi$^2$.

$$S_d = (\frac{5.85}{A})\,100 + 10 = 53 \text{ percent.}$$

7. Determine peak discharge. Using equation 11 (southern region),

$$Q_{50} = 2{,}120\,A^{1.051}\,Sl^{1.009}\,St^{-1.321}\,F^{-0.916}\,S_a^{-0.396}\,S_d^{0.676}.$$

By substitution,

$$Q_{50} = 2{,}120\,(13.6)^{1.051}\,(6.3)^{1.009}\,(10.6)^{-1.321}\,(45)^{-0.916}\,(17)^{-0.396}\,(53)^{0.676}$$

$$Q_{50} = 2{,}120 \times 15.5 \times 6.41 \times 0.0442 \times 0.0306 \times 0.326 \times 14.6$$

$$Q_{50} = 1{,}360 \text{ ft}^3/\text{s}.$$

## Gaged Streams

Peak discharges may be estimated for gaged streams (fig. 1) in the following manner: (1) If the estimate is needed directly at a gaged location, use data from table 3. (2) If the estimate is needed away from a gaged site, transfer the gaged-site discharge value (table 3) upstream or downstream to the location in question by the following equation:

$$Q_u = Q_g\,(\frac{A_u}{A_g})^n\,, \qquad (19)$$

and then, combine the above transferred "gaged" value with a value from the estimating equations by the following equation:

$$Q_w = Q_r\left(\frac{2\Delta A}{A_g}\right) + Q_u\left(1-\frac{2\Delta A}{A_g}\right). \quad (20)$$

where

$Q_u$ = discharge at the ungaged site transferred from a gaged site by drainage area ratio;

$Q_g$ = discharge at the nearby gaged site for a selected recurrence interval from table 3;

$Q_w$ = weighted discharge at the site in question determined by combining the transferred gaged discharge ($Q_u$) with the estimating equation discharge ($Q_r$);

$Q_r$ = discharge at the ungaged site determined by the regional estimating equations;

n = regional drainage area exponent

northern region = 0.66
southern region = 0.62;

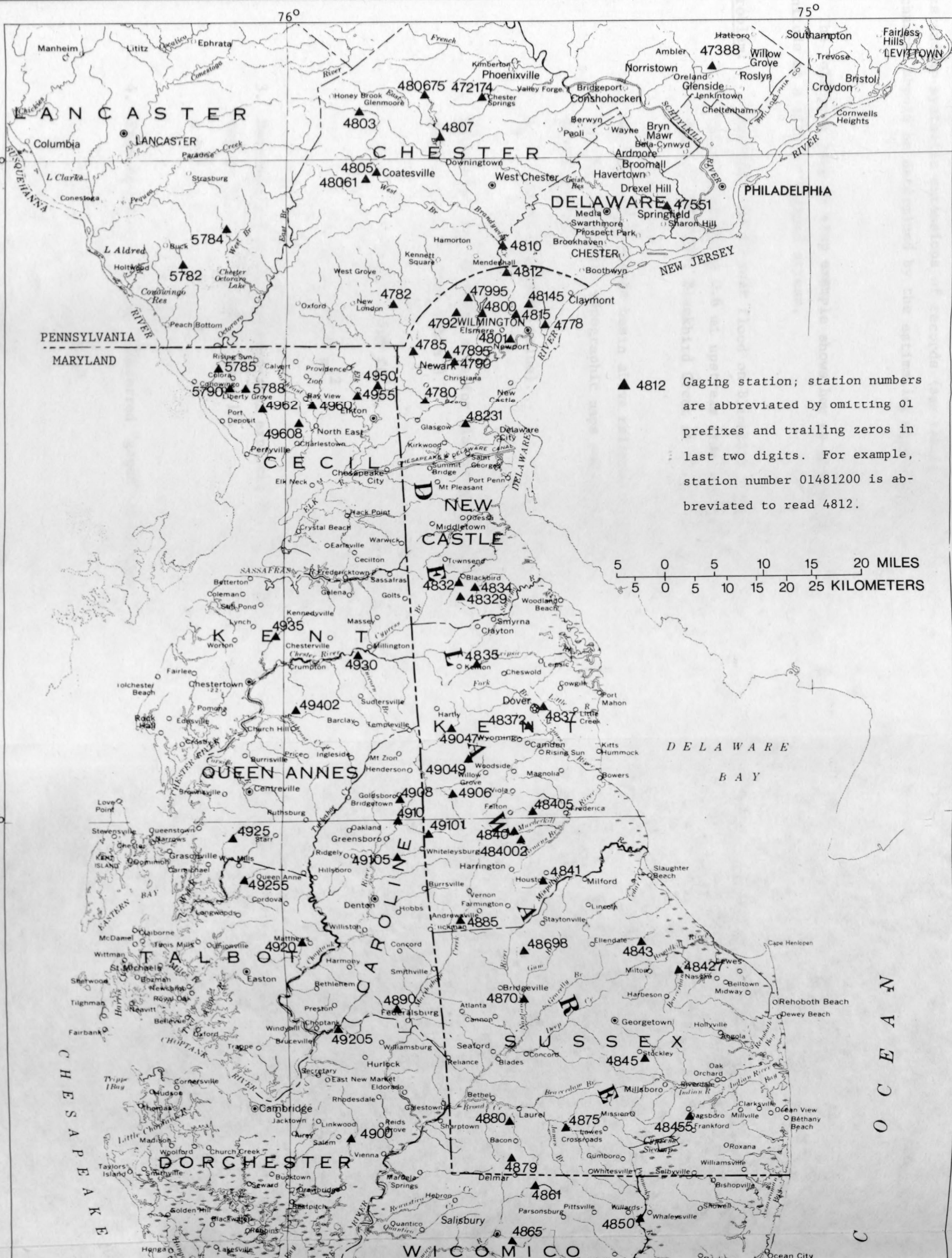
$A_u$ = drainage area at the ungaged site;

$A_g$ = drainage area at the nearby gaged site; and

$\Delta A$ = difference between the drainage areas at the gaged and ungaged sites (absolute value).

The drainage-area exponents (n values in eq. 19) were determined by using the multiple-regression technique to relate drainage areas alone to $Q_2$, $Q_5$....$Q_{100}$, and averaging the results for each region.

In equation 20, the weighting effect of the transferred "gaged" peak discharge value ($Q_u$) is phased out as $\Delta A$ increases to 50 percent of $A_g$. Therefore, if the drainage area at the site where the discharge is to be determined differs by more than 50 percent from the nearest gaged site, the estimating equations (eqs. 1-18) alone should be used to determine the peak.




BASE FROM U.S. GEOLOGICAL SURVEY,1978; 1:500,000

**Figure 1. Location of gaging stations in Delaware, Maryland, and Pennsylvania.**

For streams where there are less than 15 years of recorded annual peaks and no synthetic extensions of records (see tables 3 and 5), peak discharges should be determined by the estimating equations alone (p. 5-7).

The following step by step example shows how to estimate a flood magnitude at a site on a gaged stream.

Problem: Estimate the 10-year flood on Blackbird Creek at railroad crossing 0.6 mi upstream from gaging station 01483200, Blackbird Creek at Blackbird, Del.

1. Outline the drainage basin above railroad crossing on the best available topographic maps and planimeter drainage area.

   $A_u = 3.60 \text{ mi}^2$ (assumed value).

2. Obtain $Q_{10}$ and drainage area for Blackbird Creek at gaging station, from table 3.

$$Q_{10} = 408 \text{ ft}^3/\text{s},$$

$$A_g = 3.85 \text{ mi}^2.$$

3. Determine regional drainage-area exponent for southern region from definition on page 10.

   $n = 0.62.$

4. From equation 19, the transferred "gaged" discharge is:

$$Q_u = Q_g \left(\frac{A_u}{A_g}\right)^n.$$

By substitution,

$$Q_u = 408 \left(\frac{3.60}{3.85}\right)^{0.62}.$$

$$Q_u = 391 \text{ ft}^3/\text{s}.$$

5. Determine $Q_r$ by same procedure as shown in example for ungaged streams on page 7.

$$Q_r = 300 \text{ ft}^3/\text{s} \quad \text{(assumed value)}.$$

6. Compute $\Delta A = A_u - A_g$,

By substitution,

$$\Delta A = 3.85\text{-}3.60.$$

$$\Delta A = 0.25 \text{ mi}^2.$$

7. From equation 20, the weighted estimated discharge is:

$$Q_w = Q_r\left(\frac{2\Delta A}{A_g}\right) + Q_u\left(1- \frac{2\Delta A}{A_g}\right).$$

By substitution,

$$Q_w = 300 \left(\frac{2\text{x}0.25}{3.85}\right) + 391 \left(1- \frac{2\text{x}0.25}{3.85}\right).$$

$$Q_w = 379 \text{ ft}^3/\text{s}.$$

## Accuracy and Limitations

The accuracy of results that may be expected when using the flood-peak estimating technique is indicated to some extent by the standard error of estimate of the equations. The standard error of estimate is a measure of how well the computed peaks agree with the observed peaks used to derive the estimating equations. The observed values for approximately two out of three data points used to define a relationship (as done in this study) fall within one standard error of estimate of the computed values. In other words, the standard error of estimate is computed in such a way that for a statistically defined "normal distribution", two out of three points fall within one standard error of estimate. The observed values for approximately 19 out of 20 points fall within 2 standard errors of estimate of the computed values. Figure 2 illustrates how the standard error of estimate envelops the data points defining a relationship.

Standard errors of estimate have been computed for the flood-magnitude estimating equations and are listed in table 1.

TABLE 1.--Standard errors of estimate for regression equations, in percent.

| Flood peak | Northern region | Southern region | Southern region (alternate) |
|---|---|---|---|
| $Q_2$ | 30 | 38 | 57 |
| $Q_5$ | 28 | 37 | 61 |
| $Q_{10}$ | 29 | 37 | 63 |
| $Q_{25}$ | 32 | 38 | 66 |
| $Q_{50}$ | 35 | 38 | 68 |
| $Q_{100}$ | 39 | 40 | 70 |

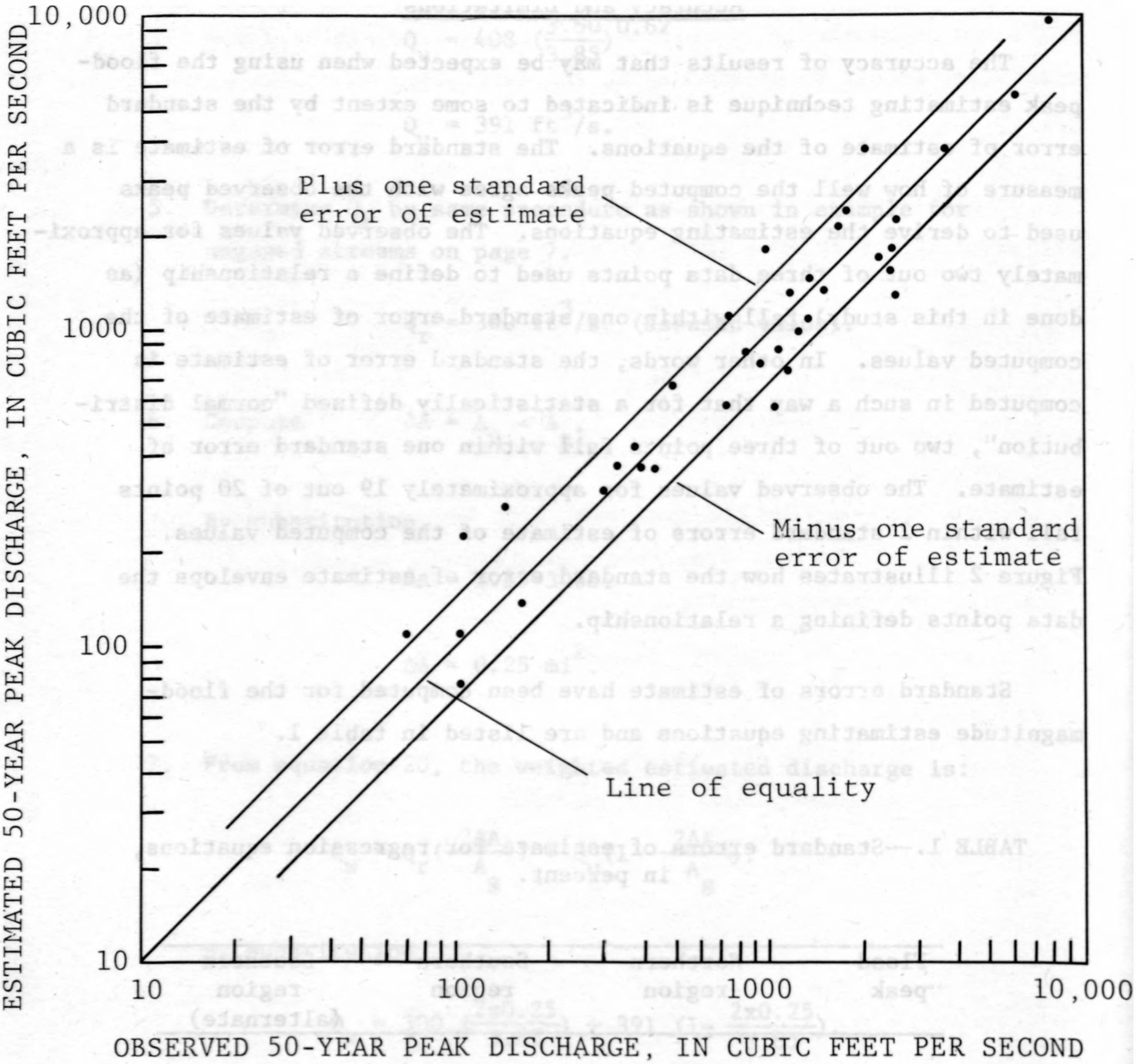



FIGURE 2.- Observed and estimated 50-year peak discharges for southern region.

The standard errors of estimate indicate that estimating equations 7 to 12 for the southern region give much better results than the alternate set of equations, 13 to 18. The improvement comes from evaluating the effects of soils and main channel slope. In general, it should be worth the effort to determine the soils' characteristics and use equations 7 to 12. In particular, use of these equations should greatly reduce the probability of an occasional estimate being "out of the ballpark." However, the alternate method may be desirable for some purposes.

The estimating equations should give satisfactory results, as generally reflected by the standard errors of estimate, within the range of basin characteristics used in developing the estimating equations. The basin characteristics' ranges are as follows:

| Basin characteristic | Northern region | Southern region |
|---|---|---|
| Drainage area | 0.4 to 87.8 ($mi^2$) | 0.6 to 113 ($mi^2$) |
| Slope | - | 1.5 to 36.6 (ft/mi) |
| Storage | 0 to 6.1 (percent) | 0 to 15.8 (percent) |
| Forest cover | - | 8 to 85 (percent) |
| Type A soil | - | 0 to 96 (percent) |
| Type D soil | - | 4 to 100 (percent) |

At stream sites where drainage areas exceed the ranges above, the reliability of the estimating equations is diminished. On these streams, however, nearby observed flood data generally are available and peak discharge estimates may be computed from equation 19 (p. 9). Refinement with equation 20 in these cases is not warranted because of the reduced reliability of the estimating equations.

The estimating equations were developed from data on natural streams. The equations therefore are not considered reliable for streams where flood peaks are affected significantly by urban development or regulation by dams, etc. The equations are not applicable where significant portions of the drainage basins are tidal marshes or have been created or altered by dredging spoil. In addition, the equations may not be reliable for drainage basins where abnormally high infiltration conditions are apparent. Such conditions are believed rare and were observed at only one (01488000) of the 74 gaging stations studied. Further information on this site is presented on page 33.

Caution should be exercised in using the equations to determine flood peaks for basins that overlap the divide between the northern and southern regions. An acceptable solution under these conditions is described on page 7.

## Remarks

The frequencies of the flood peaks determined by the design method are expressed in terms of recurrence intervals. A recurrence interval is defined as the average interval of years during which a given peak discharge can be expected to be exceeded once. It is inversely related to the probability of the peak being exceeded in any single year. Thus, a 25-year flood would have 1 chance in 25, or a 4-percent probability of being exceeded in any given year. Though unlikely, such a flood could occur 2 years in a row.

A graph for raising the basin characteristics' values to decimal powers (fig. 3) is provided for convenience in solving the estimating equations.

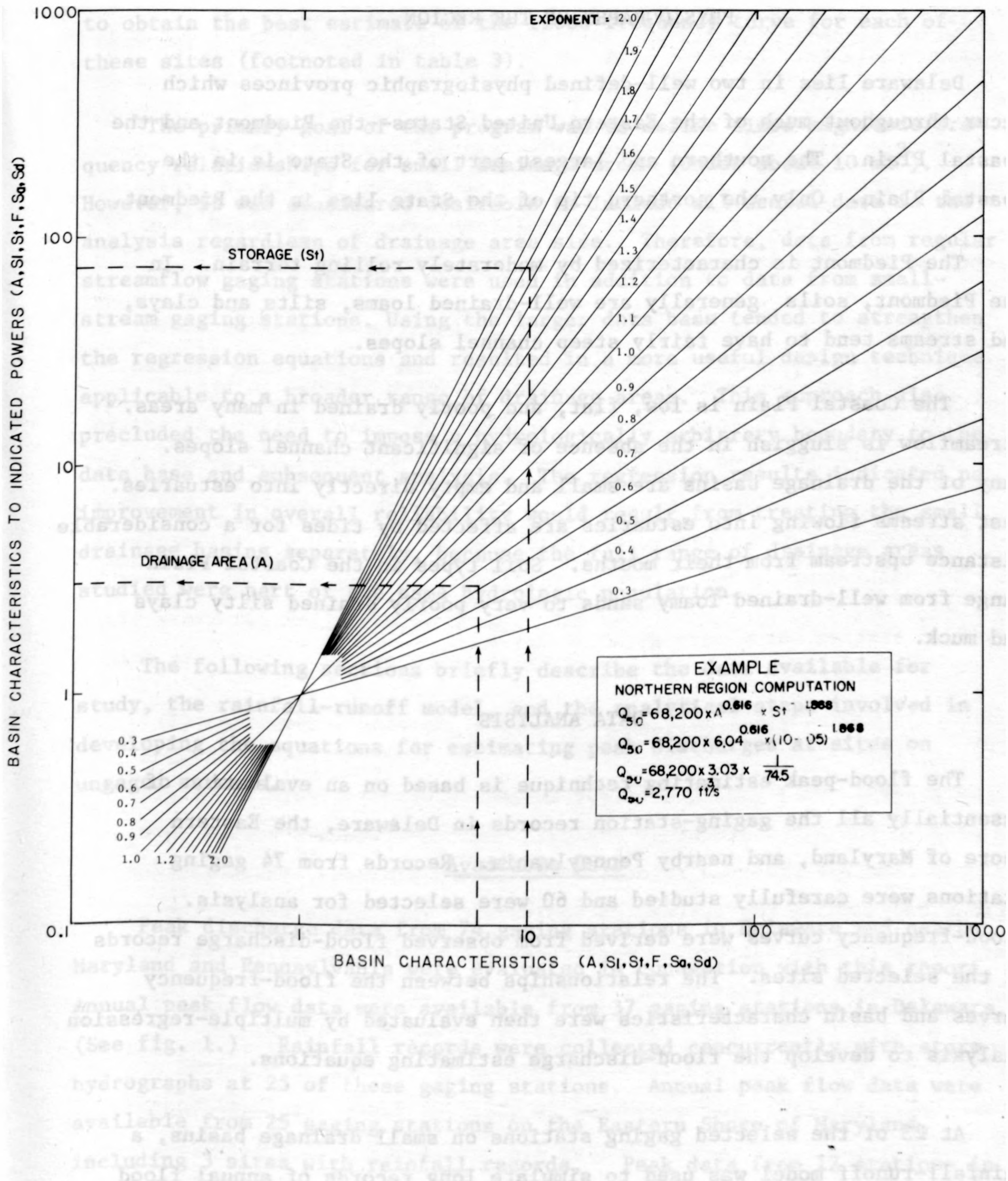



FIGURE 3.- Graphical method for raising basin characteristics' values to decimal powers.

## PHYSIOGRAPHY OF THE REGION

Delaware lies in two well-defined physiographic provinces which occur throughout much of the Eastern United States--the Piedmont and the Coastal Plain. The southern and largest part of the State is in the Coastal Plain. Only the northern tip of the State lies in the Piedmont.

The Piedmont is characterized by moderately rolling terrain. In the Piedmont, soils generally are well-drained loams, silts and clays, and streams tend to have fairly steep channel slopes.

The Coastal Plain is low, flat, and poorly drained in many areas. Streamflow is sluggish in the absence of significant channel slopes. Many of the drainage basins are small and empty directly into estuaries. Most streams flowing into estuaries are affected by tides for a considerable distance upstream from their mouths. Soil types in the Coastal Plain range from well-drained loamy sands to very poorly drained silty clays and muck.

## DATA ANALYSIS

The flood-peak estimating technique is based on an evaluation of essentially all the gaging-station records in Delaware, the Eastern Shore of Maryland, and nearby Pennsylvania. Records from 74 gaging stations were carefully studied and 60 were selected for analysis. Flood-frequency curves were derived from observed flood-discharge records at the selected sites. The relationships between the flood-frequency curves and basin characteristics were then evaluated by multiple-regression analysis to develop the flood-discharge estimating equations.

At 23 of the selected gaging stations on small drainage basins, a rainfall-runoff model was used to simulate long records of annual flood peaks to supplement the observed flood-discharge data. Flood-frequency curves were derived from the simulated flood data and also from the observed flood data. The simulated and observed curves were then combined to obtain the best estimate of the flood-frequency curve for each of these sites (footnoted in table 3).

The primary goal of the program was to define flood magnitude/frequency relationships for small drainage areas (under about 10 $mi^2$). However, it was considered desirable to include all useful data in the analysis regardless of drainage area size. Therefore, data from regular streamflow gaging stations were used in addition to data from small-stream gaging stations. Using the larger data base tended to strengthen the regression equations and resulted in a more useful design technique applicable to a broader range of drainage areas. This approach also precluded the need to impose a hydrologically arbitrary boundary to the data base and subsequent analysis. The regression results indicated no improvement in overall reliability would result from treating the small drainage basins separately, because the full range of drainage areas studied were part of the same hydrologic population.

The following sections briefly describe the data available for study, the rainfall-runoff model, and the analytical steps involved in developing the equations for estimating peak discharges at sites on ungaged streams.

## Available Data

Peak discharge data from 74 gaging stations in Delaware and nearby Maryland and Pennsylvania were evaluated in connection with this report. Annual peak flow data were available from 37 gaging stations in Delaware. (See fig. 1.) Rainfall records were collected concurrently with storm hydrographs at 25 of these gaging stations. Annual peak flow data were available from 25 gaging stations on the Eastern Shore of Maryland, including 3 sites with rainfall records. Peak data from 12 stations in nearby Pennsylvania were evaluated along with the Maryland and Delaware data. The annual peak data are presented in table 5 along with the locations of the gaging stations.

Sixty of the seventy-four stations available were used in the regression analysis. Fourteen stations were excluded for a variety of reasons which are discussed on page 33.

Long-term daily and continuous storm rainfall records from two National Weather Service sites were used in the study: Baltimore City, Md., and Atlantic City, N.J. Daily evaporation data were obtained from National Weather Service stations at Newark and Georgetown, Del.

A number of basin characteristics which intuitively appeared to be related to flood magnitudes were determined for the basins being studied. These characteristics were: Drainage area, channel slope, channel length, basin elevation, area of lakes and ponds, forest cover, annual precipitation, intensity of precipitation, and extent of different soils types grouped by runoff potential. The soils types are discussed in detail in the section on "Regression Analysis." The basin characteristics that were used in the estimating equations are described in table 4 and individual station values are given in table 3.

## Station Flood-Frequency Analysis

In general, only gaging stations having 10 or more years of record were used in the flood-frequency analysis. Flood-frequency curves were developed from the observed records at 63 gaging stations, including 3 stations not used in the regression analysis. The curves define the relationship between flood-peak magnitudes and recurrence intervals. Flood magnitudes were determined for recurrence intervals of 2, 5, 10, 25, 50, and 100 years. The flood-frequency curves were derived by fitting the log-Pearson type III distribution to records of observed annual peak discharges as recommended in the U.S. Water Resources Council (WRC) Bulletin 17. A log-Pearson type III distribution is defined by three parameters: (1) Mean, (2) standard deviation, and (3) coefficient of skewness.

A generalized skew of 0.7 was used for stations having less than 25 years of observed record. This skew value was obtained from the generalized skew map in WRC Bulletin 17. For stations having more than 25 years of observed record, the generalized skew was weighted with the station skew.

Historical flood information and outliers were treated following guidelines outlined in WRC Bulletin 17. Outliers are flood events that depart significantly from the trend of the rest of the data.

## Rainfall-Runoff Model

A rainfall-runoff model was used to simulate flood-peak data at 23 of the 28 peak flow stations where concurrent rainfall data were collected in Delaware and Maryland. These generated data were analyzed along with the observed flood-peak data. The rainfall-runoff model was developed by the U.S. Geological Survey to generate flood hydrographs for small drainage basins using daily rainfall, daily evaporation and unit storm-rainfall data as input. The model consists of three components which are briefly described as follows:

(1) Antecedent moisture - component to simulate moisture redistribution in the soil column and evapotranspiration from the soil.

(2) Infiltration - component to deal with entry into the soil of water available at the soil surface.

(3) Surface runoff (routing) - component to distribute precipitation excess by time to produce the flood hydrograph.

The model has seven parameters which deal with volume of surface runoff and three parameters which control the shape of the flood hydrograph.

There are two phases involved in using the model--calibration and synthesis. In the calibration phase, concurrent rainfall and runoff data collected directly at the gaged sites and evaporation data from nearby locations are used to fit the model to the hydrologic conditions at the gaged basins. The model uses the observed storm rainfall as input to simulate flood hydrographs which are compared with the observed flood hydrographs. An optimization process keeps revising the model parameter values and then recomputing the discharges to minimize the scatter between the actual and computed runoff. The final values of several parameters are determined by this optimization process. In the synthesis phase, long-term rainfall and evaporation data are used as input to the calibrated model to generate a long-term series of flood peaks. A more detailed discussion of the rainfall-runoff model is given by Dawdy, Lichty, and Bergmann (1972).

An adequate calibration of the model was obtained at 25 of the 28 small-stream gaging stations where concurrent rainfall and runoff data were collected. However, 2 of the 25 calibrated sites were urbanized basins and were not included in the final regression analysis. Evaporation data from the National Weather Service station at Newark, Del., were used with the northern sites and from the station at Georgetown, Del., with the southern sites. At each modeled site, an average of 18 storm events was used for calibration.

## Flood-Peak Synthesis

Synthesized peak discharges were generated for 23 calibrated sites using long-term daily and unit rainfall and daily evaporation data as input to the model in conjunction with the optimized parameters. Seventy-two years of rainfall records from Baltimore, Md., and 55 years of records from Atlantic City, N.J., were used to generate long-term synthetic records of annual peaks. The long-term evaporation data used were generated values based on averaged data from short-term actual records. Newark, Del., evaporation data were used with the calibrated sites in the north, and Georgetown, Del., data were used with sites in the south.

Continuous records of rainfall available at Baltimore and Atlantic City were translated into unit values at 5-minute intervals for the more significant storm periods each year. These unit data (about four storms per year on the average) were used as input to the model, along with daily rainfall and evaporation data, to produce the arrays of simulated annual peak discharges.

The rainfall-runoff model does not treat base flow. Base flow is considered to be that part of streamflow which comes from ground-water storage. Base flow is subtracted from the storm hydrographs used to calibrate the model. For some streams in the Coastal Plain, base flow is a significant part of the total discharge even at flood stage. Therefore, when the model was used to generate peaks on those streams, it was necessary to add in a base-flow component of discharge. Analysis indicated that for some of the calibrated sites, the base flows were fairly constant regardless of flood magnitudes, while at other sites base flow varied with peak magnitude. Adjustments were made to the generated peaks based on the results of this analysis. No adjustments were made unless, on the average, base flow amounted to more than 5 percent of total peak flow.

Flood magnitude/frequency curves were developed from the arrays of simulated annual peaks in the same manner as for the observed station data using the log-Pearson type III distribution. The flood curves generated from the Atlantic City rainfall had significantly larger peaks in general than those from Baltimore, especially at the higher recurrence intervals.

## Combining Flood-Frequency Curves

Since considerable variation was observed between the synthetic flood-frequency curves derived from Baltimore and Atlantic City rainfall, a weighting procedure was needed to combine the two sets of curves. To determine the best procedure to use, rainfall intensities were investigated for various recurrence intervals and storm durations at three recording rainfall gages in Delaware, each with about 15 years of record, and also at the gages in Baltimore and Atlantic City. The analysis indicated the rainfall distributions on the Delmarva Peninsula were much more similar to Baltimore than Atlantic City. The final weighting procedure was based on the 100-year 6-hour rainfall distribution shown in U.S. Weather Bureau Technical Paper No. 29, July 1958. The synthetic flood-frequency curves were combined using weighting factors of 2/3 and 1/3 for Baltimore and Atlantic City, respectively.

The weighted synthetic flood-frequency curves were then combined with the observed flood-frequency curves based on an analysis of variance of the two distributions. The following paragraphs briefly describe the procedure (Lichty and Liscum, 1978) used to determine the final combined synthetic/observed curves.

The average variance of synthetic estimates of discharge for different recurrence intervals was computed for the network by the following equation:

$$\overline{V}_{model} = V_{total} - \overline{V}_{Ti}\ (1-r)$$

where

$\overline{V}_{model}$ = average variance of synthetic estimates of discharge for recurrence interval T,

$V_{total}$ = variance of differences between observed and synthetic estimates of discharge for recurrence interval T,

$\overline{V}_{Ti}$ = average time-sampling variance of the observed annual peak discharges, and

$r$ = average interstation correlation coefficient for annual peaks.

The final combined weighted estimates of the flood peaks at each site were then determined by the following equation:

$$Q_T = \frac{Q_o\ (\overline{V}_{model}) + Q_s\ (V_{Ti})}{\overline{V}_{model} + V_{Ti}}$$

where

$Q_T$ = weighted estimated discharge for recurrence interval T,

$Q_o$ = observed estimated discharge for recurrence interval T,

$Q_s$ = synthetic estimated discharge for recurrence interval T, and

$V_{Ti}$ = individual station time sampling variance.

For a more detailed description of time-sampling variance and inter-station correlation coefficient, refer to Hardison (1971).

This procedure was applied individually to the modeled gaged sites in the northern part of the peninsula. However, in order to dampen out effects of an apparent significant variation in time-sampling error south of Dover, Del., average weighting factors for combining the observed and synthetic frequency curves were used. These weighting factors were based on individual station results using the above procedure, and are listed below:

| Recurrence interval (years) | Weighting factors | |
|---|---|---|
| | Observed | Synthetic |
| 2 | 0.9 | 0.1 |
| 5 | .8 | .2 |
| 10 | .7 | .3 |
| 25 | .7 | .3 |
| 50 | .6 | .4 |
| 100 | .6 | .4 |

Flood-frequency characteristics for gaging stations where long-term synthesized flood data were utilized are included in table 3.

## Regression Analysis

The flood-estimating method presented in this report was developed by multiple-regression analysis. To obtain long-term observed flood data at all streams in any region is economically impractical. Therefore, a method is needed for transferring flood information from sites where observed data are available to ungaged locations. Multiple regression is a useful technique for determining transferable flood-frequency relationships (Riggs 1973).

The regression analysis defines the relationships which exist between different basin characteristics such as drainage area and slope, and flood magnitudes ($Q_2$, $Q_5$....$Q_n$) within a region, and determines how significant those relationships are. The regression analysis quantifies the relationships in mathematical expressions (regression equations) of the form

$$Q_T = KA^a \cdot B^b \cdot C^c \ldots . I^i$$

where

$Q_T$ = peak discharge with recurrence interval of T years,

K = the constant of the equation,

A,B,C....I = related basin characteristics, and

a,b,c....i = exponents applied to the basin characteristics.

The reliability of the regression equations can be determined to some extent by the standard error of estimate (described on page 13). The standard errors of estimate for the regression equations presented in this report vary from 30 to 40 percent for the primary sets of relationships for the northern and southern regions, and from 57 to 70 percent for the southern region alternate method. (See table 1.) Hardison (1971) relates reliability of regression equations to standard errors of estimate.

Both step-backward and step-forward regression techniques (Riggs 1973) were used in the analysis to determine the final estimating (regression) equations.

In this study, numerous multiple regressions were run testing the effects of a broad range of physical basin and climatic characteristics utilizing nearly all of the gaging-station records which reflected natural conditions in Delaware, the Eastern Shore of Maryland, and nearby Pennsylvania.

Sixty of the seventy-four gaging stations evaluated were used as the data base (table 3) for the final regression equations. All of the stations included in the final regressions either had 10 or more years of annual peak data or had records extended by the rainfall-runoff model, except for two Pennsylvania sites with 9 years of data each.

A summary of the sizes of the drainage areas and average years of observed record for the stations used is given in the following table.

| Drainage area ($mi^2$) | Number of gaged basins | Average years of observed record |
|---|---|---|
| 0-1 | 4 | 10 |
| 1-2 | 5 | 10 |
| 2-5 | 12 | 12 |
| 5-10 | 19 | 17 |
| 10-20 | 5 | 20 |
| 20-50 | 9 | 24 |
| 50-120 | 6 | 29 |

The 14 gaging stations excluded from the data base for the regression equations are discussed on page 33.

Twelve basin characteristics were analyzed by the regression technique for possible effect on flood magnitudes. They were: Drainage area, main channel slope, main channel length, basin elevation, storage (lakes, swamps, and ponds), forest cover, mean annual precipitation, 2-year 24-hour rainfall, and the extent of four different types of soils.

The soils types investigated were classified by the U.S. Soil Conservation Service in a system which groups soils according to various physical and chemical properties (Maryland Department of State Planning, 1973). The following qualitative groupings, arranged by runoff potential, were delineated on natural soil group maps obtained from the U.S. Soil Conservation Service and were studied in detail.

Type A. Low runoff potential.

Type B. Moderately low runoff potential.

Type C. Moderately high runoff potential.

Type D. High runoff potential.

Type A soils (low runoff potential) and type D soils (high runoff potential) were found to be highly related to flood magnitudes and their outlines were transferred to base maps (pls. 1 through 3) for use with the design method.

Only those basin characteristics which were determined to be significant at a 95-percent confidence level appear in the final estimating equations. The storage characteristic did not prove significant for recurrence intervals under 10 years in the southern region equations and under 25 years in the southern region alternate equations. Storage was included, however, throughout the range of recurrence intervals in the southern region because it was highly significant at the higher recurrence intervals. Each basin characteristic included in the final estimating equations effectively reduced the standard errors of estimate for the equations. The basin characteristics used in the estimating equations are described in detail in table 4 and the individual station values are given in table 3. The soil characteristics are of particular interest because the soils are analyzed in groupings not believed to have been investigated before in relation to floods, and in the southern region, basically Coastal Plain, they were found to be highly related to flood peaks. Previous studies in the East have, in general, encountered considerable difficulty in identifying any significant relationships between soil characteristics and flood peaks in Coastal Plain areas.

The relationships between flood magnitudes and basin characteristics were evaluated to see if the entire area could be modeled effectively as a single region by one set of regression equations, or whether it should be separated into two areas roughly coinciding with the Piedmont and the Coastal Plain. The two-region approach was selected as more realistic and probably more reliable with the dividing line reflecting a rather abrupt change in topography generally agreeing with the Fall Line.

The area was divided because of two indications of the existence of hydrologically different regions. The soil characteristics were found to be not significant in the northern region, and a graph of the residuals for an area-wide trial model plotted against forest cover exhibited two clusters of data points corresponding to the two regions under consideration. The separate clusters were considered a strong indication of separate populations.

The stability of the two primary sets of final regionalized regression equations was tested by informal split-sampling techniques. Rigorous split-sample tests were not appropriate because of the relatively small number of data sets available. The northern region was tested by modeling the 14 stations in Delaware and Maryland separately from the final 24-station regression which included Pennsylvania sites. The 14-station model agreed very closely with the 24-station model.

The southern region was tested by running a regression with 20 sites and using the results to compute flood peaks for the remaining 16 stations to compare with observed peaks. The 20-station regression model was similar to the final 36 station regression and did a reasonable job of estimating flood peaks at the other 16 sites ($Q_{50}$ residuals: mean = 0.035 log units, standard deviation $\cong$ 0.20 log units).

Because of the large number of basin characteristics in the regression equations for the southern region, it was decided to analyze the region without the soils factors in order to provide another set of estimating equations which would be easier to use. Therefore, the alternate set of regression equations for the southern region was developed, but, as it turned out, at a considerable sacrifice in accuracy. The standard errors of estimate for the alternate model ranged from 57 to 70 percent as opposed to 38 to 40 percent for the model including soils characteristics. (See table 1.) The slope parameter did not prove significant in the alternate model apparently because of a high negative intercorrelation (-0.67) between slope and type D soil. Type D soil which was not treated in this model appears to have masked much of the direct relationship between slope and discharge.

Along with the higher standard errors accompanying the simpler alternate model, the extreme values of observed flood data were much more widely scattered about the line of relationship than with the model including soils. For example, the maximum departures of the observed peaks from the $Q_{100}$ regression for the southern region alternate model were +0.43 and -0.78 log units as opposed to +0.33 and -0.34 log units for the primary southern region model. It can be inferred from this scatter that a gross error in estimating a design flood is much more likely to occur when the alternate set of equations is used. The southern region alternate equations are particularly unreliable for small drainage areas. (See table 2.) Although the alternate regression equations may be useful under some circumstances, it is strongly recommended that, in general, the primary set of equations be used for the southern region.

Standard errors of estimate were computed for the drainage basins used in the final regression equations separated into two classes--less than 10 $mi^2$ and more than 10 $mi^2$. The results (listed in table 2) indicate the larger basins fit the regression relationships better.

TABLE 2.--Standard errors of estimate for estimating equations for drainage areas less than and more than 10 $mi^2$.

| Estimating equations | Flood recurrence interval (years) | Standard error of estimate (percent) | | |
|---|---|---|---|---|
| | | Sites under 10 $mi^2$ | Sites over 10 $mi^2$ | All sites |
| Northern region | 10 | 36 | 16 | 29 |
| | 100 | 43 | 38 | 39 |
| Southern region | 10 | 45 | 28 | 37 |
| | 100 | 48 | 31 | 40 |
| Southern region alternate | 10 | 74 | 40 | 63 |
| | 100 | 83 | 43 | 70 |

These results are not surprising. In general, the records of flood data available for the larger basins are considerably longer. Therefore, there probably is less time-sampling error in the flood-frequency curves for those basins which would account in part for their having a better fit. Also, the larger basins generally have a more evenly distributed and better balanced mixture of basin characteristics which tends to reduce the scatter.

Use of the multiple-regression analysis carries the assumption of linearity between the dependent and independent variables. Previous hydrologic investigations (Thomas and Benson, 1970) have determined that most basin characteristics when transformed into log units are linearly related to flood magnitudes. All characteristics used in the analysis were transformed into logs. The transformation requires adding a constant to the characteristics for which values can go to zero in order for the equations to function. Previous studies generally have used a constant of 1.0 for convenience in using the estimating equations. However, in this study, with several characteristics expressed in percent, a constant of 10.0 gave better results.

The table on page 32 illustrates the smoother and more reasonable transitions in the evaluated expressions for the basin characteristics throughout their ranges when using a constant of 10. For comparison purposes, the values of the expressions are converted to a common base with the expanded expression equaling 1.00 when the characteristic percentage equals zero. All the other values are given in proportional relation to the base values which were set at unity.

All the significant basin characteristics were plotted against the residuals ($\log Q_{observed} - \log Q_{computed}$) for the stations used in the final regression equations to test for nonlinearity. The relations appeared to be linear. The residuals at the gaged sites used were also plotted on a map to test for areal bias in the regression equations. No areal bias was indicated.

| Basin characteristic value (percent) | Expanded basin characteristic expressions (converted to relative values) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Storage | | Forest | | Type A soil | | Type D soil | |
| | C* = 10 | C = 1 | C = 10 | C = 1 | C = 10 | C = 1 | C = 10 | C = 1 |
| 0 | 1.00 | 1.00 | †1.00 | †1.00 | 1.00 | 1.00 | †1.00 | †1.00 |
| 1 | .87 | .73 | † .91 | † .66 | .96 | .89 | †1.07 | †1.48 |
| 5 | .54 | .45 | † .68 | † .34 | .85 | .74 | 1.33 | 2.78 |
| 8 | .41 | .38 | .57 | .27 | .79 | .69 | 1.50 | 3.50 |
| 10 | .35 | .34 | .51 | .23 | .75 | .67 | 1.62 | 3.92 |
| 15 | .25 | .29 | .41 | .19 | .69 | .63 | 1.89 | 4.86 |
| 20 | † .19 | † .26 | .35 | .16 | .64 | .60 | 2.15 | 5.67 |
| 40 | † .09 | † .19 | .21 | .11 | .52 | .53 | 3.06 | 8.30 |
| 60 | † .05 | † .16 | .15 | .08 | .45 | .50 | 3.87 | 10.41 |
| 80 | † .04 | † .14 | .12 | .07 | .41 | .48 | 4.60 | 12.24 |
| 100 | † .03 | † .13 | .10 | .06 | .37 | .46 | 5.29 | 13.88 |

* C = constant added to basin characteristic values.
† Outside of range used in calibration.
Data are from southern region $Q_{100}$ estimating equations derived with C = 10 and C = 1.

Fourteen of the seventy-four gaging stations evaluated for use in the regression analysis were excluded from the final regression equations. Of the 14 stations (see table 5), 4 had less than 10 years of record, and 3 had extensive regulation of peak flows by dams. The remaining seven stations were excluded for the following reasons:

| Station Number | Remarks |
| --- | --- |
| 01475510, 01477800 and 01481450 | - significant urban development, |
| 01481000 and 01481500 | - oversize drainage areas (see below), |
| 01478500 | - nearly duplicate of Station 01490000, on same stream, included in analysis, |
| 01488000 | - abnormally high infiltration (see below). |

Stations 0148100 and 01481500 on Brandywine Creek were considered outliers and excluded because their drainage areas (287 and 314 $mi^2$) far exceeded the rest of the sites in the northern region analysis (next largest drainage area = 87.8 $mi^2$). Reliable estimates of peak discharges for sites on Brandywine Creek may be made with equation 19 (p. 9) alone, without weighting results by estimating equations which would be unreliable for such large drainage areas (see discussion on p. 15).

Station 01488000, Holly Ditch near Laurel, Del., was excluded from the regression equations because of pronounced attenuation of the lower recurrence interval peaks. This dampening effect probably resulted from excessive soil infiltration or perhaps from drainage from the streambed. In any event, the phenomenon was observed at only 1 of the 74 sites studied and is believed to be rare. Comparative observed and computed peak discharge values for different recurrence intervals at Holly Ditch are presented in the following table.

| Station | Recurrence intervals (years) | Peak discharges ($ft^3/s$) | |
|---|---|---|---|
| | | Computed (Model with soils) | Observed |
| 01488000 | 2 | 54 | 8.1 |
| | 5 | 88 | 25 |
| | 10 | 126 | 48 |
| | 25 | 193 | 104 |
| | 50 | 259 | 178 |
| | 100 | 345 | 297 |

The tendency of the values to converge at the higher recurrence interval floods is particularly interesting.

## SUMMARY

Prior to 1964, relatively little flood-discharge data were available for small drainage basins in Delaware. The U.S. Geological Survey, in cooperation with the Delaware Department of Transportation and the Federal Highway Administration, began a small-streams flood investigation in 1964 to fill the data gap and to develop a method to predict flood magnitudes and frequencies. The design method in this report is the result of that investigation.

A thorough evaluation has been made of flood-flow records from 74 gaging stations on the Delmarva Peninsula and in nearby Pennsylvania. The estimating equations presented herein are based on data from 60 of those stations and provide a convenient means to estimate flood discharges for selected recurrence intervals from 2 to 100 years. The estimating equations apply to natural basins and were calibrated over a range in drainage areas from 0.4 to 110 $mi^2$.

The State has been divided into two regions, each with a set of estimating equations. The boundary between the regions generally follows the Fall Line. In the northern region, a significant relationship was found between peak discharges and two basin characteristics. In the southern region, six basin characteristics were found to be significant, including the areal extent of two soils groupings which were highly related to the peak discharges.

Standard errors of estimate which varied from 30 to 40 percent, along with other evaluations of the estimating equations, indicate the equations should give satisfactory results within the range of parameters used in their derivation.

## SELECTED REFERENCES

Benson, M. A., 1962, Factors influencing the occurrence of floods in a humid region of diverse terrain: U.S. Geol. Survey Water-Supply Paper 1580-B, 64 p.

Cushing, E. M., Kantrowitz, I. H., and Taylor, K. R., 1973, Water resources of the Delmarva Peninsula: U.S. Geol. Survey Prof. Paper 822, 58 p.

Dawdy, D. R., Lichty, R. W., and Bergmann, J. M., 1972, A rainfall-runoff simulation model for estimation of flood peaks for small drainage basins: U.S. Geol. Survey Prof. Paper 506-B, 28 p.

Hardison, C. H., 1969, Accuracy of streamflow characteristics: U.S. Geol. Survey Prof. Paper 650-D, p. D210-D214.

______1971, Prediction error of regression estimates of streamflow characteristics at ungaged sites: U.S. Geol. Survey Prof. Paper 750-C, p. C228-C236.

Lichty, R. W., and Liscum, Fred, 1978, A rainfall-runoff modeling procedure for improving estimates of T-year (annual) floods for small drainage basins: U.S. Geol. Survey Water-Resources Inv. 78-7, 44 p.

Maryland Department of State Planning, 1973, Natural soil groups technical report: Maryland Dept. of State Plan., pub. no. 199, 153 p.

Riggs, H. C., 1973, Regional analyses of streamflow characteristics: U.S. Geol. Survey Techniques of Water-Resources Inv., book 4, chap. B3, 15 p.

Thomas, D. M., and Benson, M. A., 1970, Generalization of streamflow characteristics from drainage basin characteristics: U.S. Geol. Survey Water-Supply Paper 1975, 55 p.

Tice, R. H., 1968, Magnitude and frequency of floods in the United States, pt. 1-B, North Atlantic slope basins, New York to York River: U.S. Geol. Survey Water-Supply Paper 1672, 585 p.

U.S. Soil Conservation Service [1976], Natural soil group map, [New Castle County, Delaware]: scale 1:48,000.

______[1976], Natural soil group map, [Kent County, Delaware]: scale 1:63,360.

______[1976], Natural soil group map, [Sussex County, Delaware]: scale 1:63,360.

U.S. Water Resources Council, 1976, Guidelines for determining flood flow frequency: Water Resources Council Bull. no. 17, 26 p.

U.S. Weather Bureau, 1958, Rainfall intensity-frequency regime, pt. 3, the middle Atlantic region: U.S. Weather Bur. Tech. Paper no. 29, 38 p.

# SUPPLEMENTAL DATA

TABLE 3.--Basin characteristics and flood-frequency characteristics for selected gaging stations.

| Identification No. | Basin characteristics | | | | | | Flood-frequency characteristics | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Drainage area | Channel slope | Storage | Forest cover | Soil Type A | Soil Type D | Peak discharge, in cubic feet per second, for indicated recurrence interval, in years | | | | | |
| | ($mi^2$) | (ft/mi) | (Percent) | | | | 2 | 5 | 10 | 25 | 50 | 100 |
| 01472174 | 5.98 | 39.6 | 0 | 14 | - | - | 530 | 1,170 | 1,880 | 3,280 | 4,820 | 6,950 |
| 01473880 | 2.01 | 86.0 | 0 | 14 | - | - | 182 | 355 | 530 | 846 | 1,170 | 1,590 |
| 01478000 | 20.5 | 22.7 | 0.07 | 19 | 0 | 7 | 1,710 | 2,400 | 2,940 | 3,720 | 4,370 | 5,100 |
| 01478200 | 12.7 | 29.0 | 0 | 11 | - | - | 994 | 1,770 | 2,510 | 3,760 | 4,980 | 6,500 |
| 01478500* | 66.7 | 18.4 | .07 | 19 | 0 | 7 | 2,970 | 4,370 | 5,500 | 7,210 | 8,690 | 10,400 |
| 01478950† | 6.04 | 54.0 | .05 | 25 | 0 | 6 | 844 | 1,630 | 2,340 | 3,420 | 4,370 | 5,460 |
| 01479000 | 87.8 | 15.0 | .09 | 23 | 0 | 8 | 3,750 | 5,270 | 6,440 | 8,130 | 9,560 | 11,100 |
| 01479200† | 4.19 | 40.9 | 0 | 9 | 0 | 13 | 550 | 953 | 1,240 | 1,920 | 2,460 | 3,070 |
| 01479950† | 0.38 | 154 | 0 | 27 | 0 | 2 | 43 | 79 | 121 | 197 | 277 | 383 |
| 01480000 | 47.0 | 16.6 | .82 | 18 | 0 | 7 | 2,250 | 3,100 | 3,760 | 4,710 | 5,510 | 6,390 |
| 01480100 | 6.70 | 44.5 | .16 | 14 | 0 | 15 | 849 | 1,560 | 2,240 | 3,430 | 4,610 | 6,100 |
| 01480300 | 18.7 | 28.2 | 0 | 30 | - | - | 1,220 | 2,220 | 3,170 | 4,800 | 6,380 | 8,360 |
| 01480500‡ | 45.8 | 22.9 | .35 | 18 | - | - | 1,910 | 3,890 | 5,920 | 9,640 | 13,500 | 18,500 |
| 01480610 | 2.57 | 67.2 | 0 | 23 | - | - | 282 | 565 | 854 | 1,380 | 1,920 | 2,620 |
| 01480675 | 8.57 | 24.8 | 6.07 | 27 | - | - | 299 | 534 | 753 | 1,120 | 1,480 | 1,920 |
| 01480700 | 60.6 | 24.3 | 0 | 19 | - | - | 2,890 | 4,690 | 6,250 | 8,720 | 11,000 | 13,600 |
| 01481000* | 287 | 14.5 | .16 | - | - | - | 6,810 | 10,400 | 13,200 | 17,500 | 21,200 | 25,300 |
| 01481200† | 0.97 | 136 | .31 | 43 | 0 | 7 | 100 | 208 | 321 | 526 | 741 | 1,030 |
| 01481500* | 314 | 14.5 | .17 | - | - | - | 7,800 | 12,000 | 15,600 | 21,100 | 26,000 | 31,700 |
| 01482310† | 1.07 | 36.6 | .96 | 9 | 0 | 5 | 141 | 260 | 371 | 543 | 696 | 869 |
| 01483200† | 3.85 | 15.8 | 1.90 | 43 | 8 | 43 | 134 | 273 | 408 | 632 | 842 | 1,100 |

* Site not used in regression analysis.
† Flood-frequency data are weighted estimates based on observed and synthetic flood-frequency curves.
‡ Flood-frequency data adjusted for historical flood information.

TABLE 3.--Basin characteristics and flood-frequency characteristics for selected gaging stations--Continued.

| Identification No. | Basin characteristics | | | | | | Flood-frequency characteristics | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Drainage area | Channel slope | Storage | Forest cover | Soil Type A | Soil Type D | Peak discharge, in cubic feet per second, for indicated recurrence interval, in years | | | | | |
| | ($mi^2$) | (ft/mi) | (Percent) | | | | 2 | 5 | 10 | 25 | 50 | 100 |
| 01483290† | 1.30 | 11.1 | 0 | 17 | 0 | 40 | 143 | 261 | 372 | 569 | 762 | 1,020 |
| 01483400† | 0.6 | 26.4 | 5.2 | 26 | 0 | 36 | 24 | 35 | 46 | 66 | 85 | 108 |
| 01483500† | 9.35 | 10.4 | .10 | 21 | 0 | 40 | 223 | 456 | 696 | 1,110 | 1,530 | 2,040 |
| 01483700 | 31.9 | 3.86 | 2.27 | 46 | 1 | 50 | 500 | 826 | 1,110 | 1,580 | 2,020 | 2,540 |
| 01483720† | 2.3 | 18.4 | 0 | 20 | 0 | 7 | 158 | 289 | 420 | 644 | 855 | 1,110 |
| 01484000‡ | 13.6 | 6.26 | 0.65 | 35 | 7 | 43 | 284 | 559 | 828 | 1,290 | 1,760 | 2,340 |
| 01484002†‡ | 0.97 | 17.6 | 0 | 28 | 96 | 4 | 18 | 29 | 40 | 60 | 80 | 105 |
| 01484050† | 3.29 | 12.6 | 0 | 16 | 1 | 15 | 64 | 139 | 214 | 356 | 510 | 733 |
| 01484100† | 2.83 | 7.12 | 0.36 | 45 | 30 | 70 | 53 | 86 | 119 | 176 | 231 | 300 |
| 01484270† | 6.10 | 7.73 | 2.20 | 57 | 82 | 5 | 27 | 36 | 43 | 53 | 61 | 69 |
| 01484300 | 7.08 | 7.89 | 3.95 | 54 | 88 | 10 | 37 | 59 | 77 | 107 | 134 | 165 |
| 01484500† | 5.24 | 4.87 | .04 | 51 | 27 | 69 | 62 | 86 | 147 | 226 | 302 | 397 |
| 01484550† | 8.78 | 5.43 | .15 | 46 | 5 | 94 | 273 | 405 | 541 | 785 | 1,020 | 1,320 |
| 01485000 | 60.5 | 1.49 | 15.8 | 30 | 4 | 95 | 613 | 770 | 881 | 1,030 | 1,150 | 1,280 |
| 01485500 | 44.9 | 3.56 | 6.20 | 85 | 8 | 84 | 495 | 698 | 856 | 1,090 | 1,280 | 1,500 |
| 01486000 | 4.80 | 5.47 | 0 | 57 | 0 | 100 | 124 | 234 | 342 | 532 | 723 | 967 |
| 01486100† | 4.1 | 8.47 | 2.90 | 77 | 6 | 71 | 90 | 143 | 191 | 272 | 347 | 439 |
| 01486980† | 5.28 | 3.49 | .21 | 68 | 10 | 66 | 41 | 58 | 73 | 97 | 117 | 141 |
| 01487000‡ | 75.4 | 3.23 | 1.70 | 40 | 18 | 48 | 551 | 966 | 1,350 | 1,980 | 2,590 | 3,330 |
| 01487900† | 3.47 | 4.23 | 0 | 44 | 0 | 65 | 77 | 106 | 140 | 207 | 278 | 370 |
| 01488500‡ | 44.8 | 2.65 | .30 | 29 | 0 | 79 | 674 | 1,360 | 2,040 | 3,250 | 4,460 | 6,020 |

† Flood-frequency data are weighted estimates based on observed and synthetic flood-frequency curves.
‡ Flood-frequency data adjusted for historical flood information.

TABLE 3.--Basin characteristics and flood-frequency characteristics for selected gaging stations--Continued.

| Identification No. | Basin characteristics | | | | | | Flood-frequency characteristics | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Drainage area | Channel slope | Storage | Forest cover | Soil Type A | Soil Type D | Peak discharge, in cubic feet per second, for indicated recurrence interval, in years | | | | | |
| | ($mi^2$) | (ft/mi) | (Percent) | | | | 2 | 5 | 10 | 25 | 50 | 100 |
| 01489000‡ | 7.10 | 7.65 | 0.47 | 33 | 0 | 50 | 172 | 401 | 656 | 1,150 | 1,690 | 2,430 |
| 01490000 | 15.0 | 4.53 | .10 | 50 | 5 | 35 | 210 | 342 | 458 | 643 | 814 | 1,020 |
| 01490600†‡ | 8.4 | 5.98 | 1.20 | 48 | 2 | 88 | 208 | 350 | 487 | 714 | 928 | 1,190 |
| 01490800 | 3.9 | 7.67 | .71 | 29 | 0 | 69 | 184 | 338 | 486 | 745 | 1,000 | 1,330 |
| 01491000‡ | 113 | 3.01 | 1.91 | 35 | 5 | 76 | 1,670 | 2,770 | 3,730 | 5,260 | 6,670 | 8,340 |
| 01491010†‡ | 1.9 | 10.9 | .14 | 28 | 0 | 36 | 70 | 151 | 233 | 376 | 524 | 717 |
| 01491050‡ | 3.8 | 6.06 | .07 | 25 | 0 | 35 | 65 | 120 | 173 | 266 | 361 | 483 |
| 01492000 | 5.85 | 14.8 | 0 | 26 | 6 | 24 | 276 | 542 | 813 | 1,300 | 1,810 | 2,470 |
| 01492050 | 8.4 | 9.81 | 0 | 23 | 0 | 14 | 98 | 200 | 305 | 501 | 706 | 978 |
| 01492500 | 8.09 | 8.80 | 0 | 32 | 0 | 15 | 198 | 441 | 713 | 1,250 | 1,840 | 2,670 |
| 01492550 | 4.6 | 16.9 | .34 | 14 | 5 | 20 | 131 | 286 | 456 | 788 | 1,150 | 1,650 |
| 01493000 | 22.3 | 6.06 | 1.54 | 43 | 3 | 40 | 281 | 497 | 699 | 1,040 | 1,370 | 1,790 |
| 01493500‡ | 12.7 | 9.15 | .20 | 8 | 0 | 7 | 374 | 756 | 1,150 | 1,900 | 2,680 | 3,720 |
| 01495000‡ | 52.6 | 17.9 | .05 | 14 | 0 | 8 | 3,030 | 5,000 | 6,690 | 9,340 | 11,700 | 14,500 |
| 01495500 | 26.8 | 23.7 | .06 | 23 | 0 | 7 | 1,720 | 2,550 | 3,230 | 4,260 | 5,170 | 6,200 |
| 01496000 | 24.3 | 24.0 | .09 | 22 | 0 | 11 | 1,560 | 2,480 | 3,270 | 4,510 | 5,650 | 6,980 |
| 01496080 | 1.7 | 125 | .03 | 96 | 0 | 0 | 300 | 460 | 595 | 803 | 989 | 1,200 |
| 01578200 | 8.71 | 74.2 | 0 | 23 | – | – | 516 | 915 | 1,290 | 1,910 | 2,510 | 3,240 |
| 01578400 | 5.98 | 108 | 0 | 22 | – | – | 607 | 1,010 | 1,360 | 1,930 | 2,450 | 3,080 |
| 01578800† | 1.3 | 69.8 | .18 | 12 | 0 | 10 | 364 | 556 | 725 | 1,030 | 1,340 | 1,750 |
| 01579000† | 5.31 | 37.0 | .08 | 22 | 0 | 3 | 720 | 1,350 | 1,980 | 3,130 | 4,350 | 6,000 |

† Flood-frequency data are weighted estimates based on observed and synthetic flood-frequency curves.

‡ Flood-frequency data adjusted for historical flood information.

TABLE 4.--Basin characteristics significant in regression analysis.

1. Drainage area (A), in square miles: Planimetered from best available topographic maps.

2. Main channel slope (Sl), in feet per mile: Determined from topographic maps as follows.

   A. Measure length of main channel from site in question (catch point) to basin rim with dividers, electronic distance measuring device, etc. Above a confluence, the branch draining the largest area is considered the main channel regardless of its name.

   B. Determine the channel elevation by interpolation at locations 10 percent and 85 percent of the channel length upstream from the catch point.

   C. Compute slope by taking the elevation at the 85-percent point minus the elevation at the 10-percent point and dividing by the horizontal distance between the two points.

3. Storage (St), in percent: Determined from topographic maps as follows. Planimeter area of lakes, ponds, and swamps: Express that area in percent (to nearest 0.1 percent) of total drainage area and increase its value by 10.0. It is recommended that St be expressed to nearest 0.1 percent because the discharge is very sensitive to this parameter.

4. Forest cover (F), in percent: Determined from topographic maps as follows. Measure the area of the basin covered by forests (shaded green on U.S. Geological Survey maps) by the grid method (a minimum of 100 grid intersections is recommended): Express that area in percent of the total drainage area and increase its value by 10.

5. Type A soils ($S_a$), classified as having "low runoff potential." Determine $S_a$ in percent from soils maps (pls. 1-3) as follows. Planimeter area of the drainage basin covered by type A soil: Express that area in percent of the total drainage area and increase its value by 10.

6. Type D soils ($S_d$), classified as having "high runoff potential." Determine $S_d$ in percent from soils maps (pls. 1-3) as follows. Planimeter area of the drainage basin covered by type D soil: Express that area in percent of the total drainage area and increase its value by 10.

TABLE 5.--Annual maximum discharges at gaging stations
(Discharges in cubic feet per second)

01472174 Pickering Creek near Chester Springs, Pa.

Location.--Lat 40°05'22", long 75°37'50", Chester County, at bridge on Horseshoe Trail Road, 0.75 mi southwest of Chester Springs.

Drainage Area.--5.98 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1967 | 385 | 1970 | 222 | 1972 | 2,410 | 1974 | 412 |
| 1968 | 267 | 1971 | 1,640 | 1973 | 580 | 1975 | 1,340 |
| 1969 | 282 | | | | | | |

01473880 Pine Run Tributary at Fort Washington, Pa.

Location.--Lat 40°08'13", long 75°11'21", Montgomery County, at culvert on Delaware Road in Fort Washington Industrial Park at Fort Washington.

Drainage Area.--2.01 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1962 | 147 | 1966 | 206 | 1970 | 83 | 1973 | 1,580 |
| 1963 | 88 | 1967 | 300 | 1971 | 198 | 1974 | 152 |
| 1964 | 243 | 1968 | 120 | 1972 | 128 | 1975 | 400 |
| 1965 | 163 | 1969 | 190 | | | | |

01475510 Darby Creek near Darby, Pa.*

Location.--Lat 39°55'44", long 75°16'22", Delaware County, 30 ft upstream from Providence Road Bridge, and 1.1 mi northwest of Upper Darby.

Drainage Area.--37.4 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1965 | 1,480 | 1968 | 4,610 | 1971 | 4,370 | 1974 | 5,920 |
| 1966 | 2,690 | 1969 | 2,910 | 1972 | 4,370 | 1975 | 3,330 |
| 1967 | 2,550 | 1970 | 3,640 | 1973 | 4,940 | | |

* Not used in final regression model.

TABLE 5.--Annual maximum discharges at gaging stations--Continued
(Discharges in cubic feet per second)

01477800 Shellpot Creek at Wilmington, Del.*

Location.--Lat 39°45'39", long 75°31'10", New Castle County, in Clifton Park, 700 ft downstream from North Market Street in Wilmington.

Drainage Area.--7.46 mi².

Remarks.--Peak flow affected by urban development.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1946 | 1,340 | 1954 | 830 | 1962 | 730 | 1969 | 1,080 |
| 1947 | 2,140 | 1955 | 2,280 | 1963 | 560 | 1970 | 1,970 |
| 1948 | 1,440 | 1956 | 1,330 | 1964 | 1,020 | 1971 | 6,850 |
| 1949 | 715 | 1957 | 1,000 | 1965 | 990 | 1972 | 2,240 |
| 1950 | 565 | 1958 | 1,140 | 1966 | 695 | 1973 | 2,030 |
| 1951 | 1,290 | 1959 | 1,540 | 1967 | 4,650 | 1974 | 3,300 |
| 1952 | 4,080 | 1960 | 1,930 | 1968 | 1,220 | 1975 | 1,390 |
| 1953 | 785 | 1961 | 1,210 | | | | |

01478000 Christina River at Coochs Bridge, Del.

Location.--Lat 39°38'14", long 75°43'43", New Castle County, at highway bridge, 0.5 mi southeast of Coochs Bridge.

Drainage Area.--20.5 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1943 | 2,150 | 1952 | 2,730 | 1960 | 3,300 | 1968 | 2,190 |
| 1944 | 1,280 | 1953 | 1,590 | 1961 | 1,220 | 1969 | 1,190 |
| 1945 | 2,620 | 1954 | 1,170 | 1962 | 1,250 | 1970 | 1,680 |
| 1946 | 1,680 | 1955 | 3,250 | 1963 | 638 | 1971 | 2,110 |
| 1947 | 4,330 | 1956 | 1,950 | 1964 | 1,570 | 1972 | 3,320 |
| 1948 | 1,170 | 1957 | 1,310 | 1965 | 978 | 1973 | 2,400 |
| 1949 | 1,680 | 1958 | 1,390 | 1966 | 1,650 | 1974 | 1,920 |
| 1950 | 1,000 | 1959 | 955 | 1967 | 2,610 | 1975 | 2,500 |
| 1951 | 1,500 | | | | | | |

* Not used in final regression model.

TABLE 5.--Annual maximum discharges at gaging stations--Continued
(Discharges in cubic feet per second)

01478200 Middle Branch White Clay Creek near Landenberg, Pa.

Location.--Lat 39°46'54", long 75°48'03", Chester County, at bridge on Legislative Route 15017, 1.8 mi west of Landenberg.

Drainage Area.--12.7 $mi^2$.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1960 | 1,900 | 1964 | 1,250 | 1968 | 794 | 1972 | 3,860 |
| 1961 | 360 | 1965 | 672 | 1969 | 784 | 1973 | 826 |
| 1962 | 510 | 1966 | 1,420 | 1970 | 1,160 | 1974 | 874 |
| 1963 | 489 | 1967 | 1,540 | 1971 | 1,820 | 1975 | 2,570 |

01478500 White Clay Creek above Newark, Del.*

Location.--Lat 39°42'52", long 75°45'34", New Castle County, 1.7 mi southeast of Delaware-Maryland-Pennsylvania State corner, and 2.2 mi north of Newark.

Drainage Area.--66.7 $mi^2$.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1953 | 2,620 | 1958 | 2,830 | 1966 | 3,910 | 1971 | 4,320 |
| 1954 | 1,840 | 1959 | 3,160 | 1967 | 4,540 | 1972 | 10,200 |
| 1955 | 4,050 | 1963 | 2,060 | 1968 | 1,930 | 1973 | 2,800 |
| 1956 | 1,930 | 1964 | 3,480 | 1969 | 2,430 | 1974 | 2,690 |
| 1957 | 2,960 | 1965 | 2,410 | 1970 | 2,560 | 1975 | 6,330 |

01478950 Pike Creek near Newark, Del.

Location.--Lat 39°42'11", long 75°41'41", New Castle County, at bridge on State Highway 2, 2.6 mi northeast of Newark.

Drainage Area.--6.04 $mi^2$.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1969 | 2,550 | 1971 | 494 | 1973 | 1,160 | 1975 | 745 |
| 1970 | 427 | 1972 | 942 | 1974 | 494 | | |

* Not used in final regression model.

TABLE 5.--Annual maximum discharges at gaging stations--Continued
(Discharges in cubic feet per second)

01479000 White Clay Creek near Newark, Del.

Location.--Lat 39°42'01", long 75°41'00", New Castle County, 300 ft upstream from Baltimore & Ohio Railroad bridge, and 3.5 mi east of Newark.

Drainage Area.--87.8 $mi^2$.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1932 | 3,030 | 1947 | 3,170 | 1956 | 3,250 | 1967 | 6,640 |
| 1933 | 6,230 | 1948 | 3,310 | 1957 | 3,800 | 1968 | 2,360 |
| 1934 | 3,870 | 1949 | 2,850 | 1960 | 6,340 | 1969 | † |
| 1935 | 3,790 | 1950 | 4,590 | 1961 | 2,300 | 1970 | 3,000 |
| 1936 | 6,030 | 1951 | 3,310 | 1962 | 1,970 | 1971 | 5,170 |
| 1943 | 3,020 | 1952 | 5,750 | 1963 | 2,160 | 1972 | 9,080 |
| 1944 | 4,050 | 1953 | 3,020 | 1964 | 3,610 | 1973 | 4,340 |
| 1945 | 3,870 | 1954 | 2,550 | 1965 | 2,640 | 1974 | 4,760 |
| 1946 | 5,960 | 1955 | 6,010 | 1966 | 3,770 | 1975 | 6,900 |

01479200 Mill Creek at Hockessin, Del.

Location.--Lat 39°46'31", long 75°41'26", New Castle County, at bridge on Brackenville Road, 0.9 mi southeast of Hockessin.

Drainage Area.--4.19 $mi^2$, of which 0.15 $mi^2$ is probably noncontributing.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1966 | 504 | 1969 | 2,100 | 1972 | 687 | 1974 | 372 |
| 1967 | 727 | 1970 | 579 | 1973 | 444 | 1975 | 625 |
| 1968 | 272 | 1971 | 524 | | | | |

01479950 Red Clay Creek Tributary near Yorklyn, Del.

Location.--Lat 39°47'50", long 75°39'33", New Castle County, at culvert on private road, 1.1 mi southeast of Yorklyn.

Drainage Area.--0.38 $mi^2$.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1966 | 22 | 1969 | 200 | 1972 | 56 | 1974 | 23 |
| 1967 | 49 | 1970 | 69 | 1973 | 43 | 1975 | 62 |
| 1968 | 24 | 1971 | 64 | | | | |

† Discharge not determined.

TABLE 5.--Annual maximum discharges at gaging stations--Continued
(Discharges in cubic feet per second)

01480000 Red Clay Creek at Wooddale, Del.

Location.--Lat 39°45'52", long 75°38'08", New Castle County, at bridge on State Highway 48, 0.3 mi south of Wooddale.

Drainage Area.--47.0 $mi^2$.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1943 | 1,730 | 1952 | 2,750 | 1960 | 4,780 | 1968 | 1,750 |
| 1944 | 1,670 | 1953 | 1,800 | 1961 | 1,390 | 1969 | 4,500 |
| 1945 | 2,810 | 1954 | 1,260 | 1962 | 1,870 | 1970 | 2,100 |
| 1946 | 2,510 | 1955 | 3,650 | 1963 | 1,560 | 1971 | 3,520 |
| 1947 | 2,030 | 1956 | 1,520 | 1964 | 2,620 | 1972 | 4,120 |
| 1948 | 1,730 | 1957 | 2,520 | 1965 | 2,070 | 1973 | 2,040 |
| 1949 | 1,880 | 1958 | 2,370 | 1966 | 2,730 | 1974 | 1,870 |
| 1950 | 1,570 | 1959 | 2,020 | 1967 | 2,910 | 1975 | 5,010 |
| 1951 | 2,740 | | | | | | |

01480100 Little Mill Creek at Elsmere, Del.

Location.--Lat 39°44'05", long 75°35'14", New Castle County, at highway bridge on North Du Pont Road at Elsmere.

Drainage Area.--6.70 $mi^2$.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1964 | 735 | 1967 | 3,960 | 1970 | 652 | 1973 | 714 |
| 1965 | 478 | 1968 | 500 | 1971 | 2,650 | 1974 | 1,070 |
| 1966 | 567 | 1969 | 562 | 1972 | 1,380 | 1975 | 882 |

01480300 West Branch Brandywine Creek near Honey Brook, Pa.

Location.--Lat 40°04'22", long 75°51'40", Chester County, at bridge on Legislative Route 15185, at Birdell, and 3.0 mi southeast of Honey Brook.

Drainage Area.--18.7 $mi^2$.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1960 | 1,870 | 1964 | 1,180 | 1968 | 704 | 1972 | 8,140 |
| 1961 | 810 | 1965 | 1,130 | 1969 | 1,150 | 1973 | 3,140 |
| 1962 | 810 | 1966 | 1,080 | 1970 | 673 | 1974 | 848 |
| 1963 | 810 | 1967 | 990 | 1971 | 1,820 | 1975 | 2,480 |

TABLE 5.--Annual maximum discharges at gaging stations--Continued
(Discharges in cubic feet per second)

01480500 West Branch Brandywine Creek at Coatesville, Pa.*

Location.--Lat 39°59'08", long 75°49'40", Chester County, 1,200 ft upstream from bridge on old Lincoln Highway, and 0.6 mi downstream from Rock Run.

Drainage Area.--45.8 $mi^2$.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1942 | 8,600 | 1947 | 675 | 1951 | 3,330 | 1973 | 8,100 |
| 1944 | 1,340 | 1948 | 1,170 | 1970 | 996 | 1974 | 1,770 |
| 1945 | 3,670 | 1949 | 1,170 | 1971 | 2,850 | 1975 | 2,370 |
| 1946 | 1,570 | 1950 | 835 | 1972 | 7,770 | | |

01480610 Sucker Run near Coatesville, Pa.

Location.--Lat 39°58'20", long 75°51'06", Chester County, at bridge on State Highway 372, 2 mi west of Coatesville.

Drainage Area.--2.57 $mi^2$.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1964 | 224 | 1967 | 312 | 1970 | 590 | 1973 | 1,010 |
| 1965 | 126 | 1968 | 90 | 1971 | 300 | 1974 | 195 |
| 1966 | 208 | 1969 | 422 | 1972 | 926 | | |

01480675 Marsh Creek near Glenmoore, Pa.

Location.--Lat 40°05'52", long 75°44'31", Chester County, 300 ft north of Pennsylvania Turnpike, and 3 mi northeast of Glenmoore.

Drainage Area.--8.57 $mi^2$.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1967 | 292 | 1970 | 201 | 1972 | 946 | 1974 | 190 |
| 1968 | 158 | 1971 | 586 | 1973 | 659 | 1975 | 277 |
| 1969 | 201 | | | | | | |

TABLE 5.--Annual maximum discharges at gaging stations--Continued
(Discharges in cubic feet per second)

01480700 East Branch Brandywine Creek near Downingtown, Pa.

Location.--Lat 40°02'05", long 75°42'32", Chester County, at bridge on Dowlin Forge Road, 2.2 mi north of Downingtown.

Drainage Area.--60.6 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1966 | 3,530 | 1969 | 1,620 | 1972 | 8,070 | 1974 | 2,090 |
| 1967 | 3,240 | 1970 | 2,050 | 1973 | 5,820 | 1975 | 2,540 |
| 1968 | 1,740 | 1971 | 4,440 | | | | |

01481000 Brandywine Creek at Chadds Ford, Pa.*

Location.--Lat 39°52'11", long 75°35'37", Delaware County, at Penn Central Railroad bridge at Chadds Ford and 1,200 ft downstream from U.S. Highway 1.

Drainage Area.--287 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1912 | 10,600 | 1926 | 5,900 | 1940 | 6,190 | 1955 | 16,400 |
| 1913 | 3,900 | 1927 | 7,010 | 1941 | 5,060 | 1963 | 5,900 |
| 1914 | 4,320 | 1928 | 8,620 | 1942 | 16,800 | 1964 | 7,110 |
| 1915 | 16,500 | 1929 | 6,520 | 1943 | 5,360 | 1965 | 6,470 |
| 1916 | 4,790 | 1930 | 4,670 | 1944 | 7,880 | 1966 | 8,600 |
| 1917 | 4,430 | 1931 | 8,240 | 1945 | 8,240 | 1967 | 7,700 |
| 1918 | 10,200 | 1932 | 5,460 | 1946 | 8,810 | 1968 | 6,840 |
| 1919 | 7,180 | 1933 | 14,800 | 1947 | 2,500 | 1969 | 7,270 |
| 1920 | 17,200 | 1934 | 4,670 | 1948 | 6,190 | 1970 | 5,310 |
| 1921 | 2,560 | 1935 | 7,000 | 1949 | 5,360 | 1971 | 14,300 |
| 1922 | 4,100 | 1936 | 9,000 | 1950 | 4,690 | 1972 | 23,800 |
| 1923 | 3,220 | 1937 | 3,790 | 1951 | 11,600 | 1973 | 11,400 |
| 1924 | 6,840 | 1938 | 9,400 | 1952 | 6,050 | 1974 | 6,790 |
| 1925 | 7,700 | 1939 | 8,060 | 1953 | 6,200 | 1975 | 9,600 |

01481200 Brandywine Creek Tributary near Centerville, Del.

Location.--Lat 39°50'08", long 75°35'57", New Castle County, at culvert on State Highway 100, 1.4 mi northeast of Centerville.

Drainage Area.--0.97 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1966 | 43 | 1969 | 333 | 1972 | 170 | 1974 | 78 |
| 1967 | 64 | 1970 | 154 | 1973 | 57 | 1975 | 195 |
| 1968 | 37 | 1971 | 405 | | | | |

* Not used in final regression model.

TABLE 5.--Annual maximum discharges at gaging stations--Continued
(Discharges in cubic feet per second)

01481450 Willow Run at Rockland, Del.*

Location.--Lat 39°47'32", long 75°33'16", New Castle County, at culvert on Country Club Drive, 1.0 mi east of Rockland.

Drainage Area.--0.37 $mi^2$.

Remarks.--Peak flow affected by urban development.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1966 | 144 | 1969 | 177 | 1972 | 263 | 1974 | 296 |
| 1967 | 372 | 1970 | 375 | 1973 | 209 | 1975 | 204 |
| 1968 | 146 | 1971 | 620 | | | | |

01481500 Brandywine Creek at Wilmington, Del.*

Location.--Lat 39°46'09", long 75°34'25", New Castle County, 0.2 mi downstream from Henry Clay Bridge, in Wilmington.

Drainage Area.--314 $mi^2$.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1947 | 4,730 | 1955 | 17,800 | 1962 | 9,750 | 1969 | 8,730 |
| 1948 | 5,160 | 1956 | 5,020 | 1963 | 7,990 | 1970 | 7,120 |
| 1949 | 4,940 | 1957 | 9,620 | 1964 | 9,050 | 1971 | 21,300 |
| 1950 | 4,610 | 1958 | 7,790 | 1965 | 8,740 | 1972 | 29,000 |
| 1951 | 11,500 | 1959 | 4,950 | 1966 | 10,900 | 1973 | 10,400 |
| 1952 | 6,960 | 1960 | 15,600 | 1967 | 9,510 | 1974 | 5,890 |
| 1953 | 5,820 | 1961 | 7,660 | 1968 | 7,500 | 1975 | 8,400 |
| 1954 | 3,780 | | | | | | |

01482310 Doll Run at Red Lion, Del.

Location.--Lat 39°35'53", long 75°39'43", New Castle County, at culvert on secondary road, 0.7 mi south of Red Lion.

Drainage Area.--1.07 $mi^2$.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1966 | 28 | 1969 | 134 | 1972 | 215 | 1974 | 79 |
| 1967 | 97 | 1970 | 117 | 1973 | 360 | 1975 | 243 |
| 1968 | 83 | 1971 | 140 | | | | |

* Not used in final regression model.

01483200 Blackbird Creek at Blackbird, Del.

Location.--Lat 39°21'58", long 75°40'10", New Castle County, at highway bridge 0.5 mi upstream from Barlow Branch, and 0.6 mi southwest of Blackbird.

Drainage Area.--3.85 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1952 | 195 | 1959 | 49 | 1965 | 30 | 1971 | 194 |
| 1953 | 115 | 1960 | 510 | 1966 | 82 | 1972 | 712 |
| 1955 | 202 | 1961 | 131 | 1967 | 97 | 1973 | 222 |
| 1956 | 95 | 1962 | 56 | 1968 | 158 | 1974 | 83 |
| 1957 | 231 | 1963 | 70 | 1969 | 229 | 1975 | 277 |
| 1958 | 152 | 1964 | 72 | 1970 | 129 | | |

01483290 Paw Paw Branch Tributary near Clayton, Del.

Location.--Lat 39°18'41", long 75°40'08", New Castle County, at culverts on road No. 483, 2.4 mi northwest of Clayton.

Drainage Area.--1.3 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1966 | 92 | 1969 | 350 | 1972 | 760 | 1974 | 89 |
| 1967 | 91 | 1970 | 99 | 1973 | 163 | 1975 | 197 |
| 1968 | 131 | 1971 | 207 | | | | |

01483400 Sawmill Branch Tributary near Blackbird, Del.

Location.--Lat 39°20'57", long 75°38'31", New Castle County, at culvert on U.S. Highway 13, 1.8 mi southeast of Blackbird.

Drainage Area.--0.6 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1966 | 25 | 1969 | 39 | 1972 | 37 | 1974 | 18 |
| 1967 | 17 | 1970 | 7 | 1973 | 17 | 1975 | 35 |
| 1968 | 23 | 1971 | 28 | | | | |

TABLE 5.--Annual maximum discharges at gaging stations--Continued
(Discharges in cubic feet per second)

01483500 Leipsic River near Cheswold, Del.

Location.--Lat 39°13'58", long 75°37'57", Kent County, at highway bridge on road No. 91, 2.6 mi northwest of Cheswold.

Drainage Area.--9.35 $mi^2$.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1943 | 250 | 1952 | 730 | 1960 | 1,340 | 1968 | 197 |
| 1944 | 316 | 1953 | 185 | 1961 | 306 | 1969 | 301 |
| 1945 | 136 | 1954 | 103 | 1962 | 118 | 1970 | 186 |
| 1946 | 144 | 1955 | 334 | 1963 | 167 | 1971 | 424 |
| 1947 | 100 | 1956 | 131 | 1964 | 111 | 1972 | 785 |
| 1948 | 250 | 1957 | 1,120 | 1965 | <53 | 1973 | 432 |
| 1949 | 215 | 1958 | 640 | 1966 | 88 | 1974 | 181 |
| 1950 | 144 | 1959 | 107 | 1967 | 233 | 1975 | 203 |
| 1951 | 215 | | | | | | |

01483700 St. Jones River at Dover, Del.

Location.--Lat 39°09'49", long 75°31'10", Kent County, 150 ft upstream from Division Street in Dover.

Drainage Area.--31.9 $mi^2$.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1958 | 1,260 | 1963 | 285 | 1968 | 404 | 1972 | 996 |
| 1959 | 217 | 1964 | 498 | 1969 | 505 | 1973 | 720 |
| 1960 | 1,900 | 1965 | 107 | 1970 | 440 | 1974 | 310 |
| 1961 | 602 | 1966 | 93 | 1971 | 852 | 1975 | 718 |
| 1962 | 276 | 1967 | 652 | | | | |

01483720 Puncheon Branch at Dover, Del.

Location.--Lat 39°08'25", long 75°32'20", Kent County, at culvert on New Burton Road in Dover.

Drainage Area.--2.3 $mi^2$.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1966 | 129 | 1969 | 136 | 1972 | 183 | 1974 | 99 |
| 1967 | 284 | 1970 | 70 | 1973 | 205 | 1975 | 520 |
| 1968 | 36 | 1971 | 172 | | | | |

TABLE 5.--Annual maximum discharges at gaging stations--Continued
(Discharges in cubic feet per second)

01484000 Murderkill River near Felton, Del.

Location.--Lat 38°58'33", long 75°34'03", Kent County, at bridge on U.S. Highway 13, 2.2 miles south of Felton.

Drainage Area.--13.6 $mi^2$.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1932 | 346 | 1963 | 370 | 1968 | 192 | 1972 | 370 |
| 1933 | 490 | 1964 | 278 | 1969 | 388 | 1973 | 265 |
| 1960 | 805 | 1965 | 64 | 1970 | 388 | 1974 | 204 |
| 1961 | 292 | 1966 | 69 | 1971 | 260 | 1975 | 1,150 |
| 1962 | 219 | 1967 | 2,090 | | | | |

01484002 Murderkill River Tributary near Felton, Del.

Location.--Lat 38°58'19", long 75°33'31", Kent County, at culvert on road No. 426, 2.9 mi south of Felton.

Drainage Area.--0.97 $mi^2$.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1966 | 37 | 1969 | 27 | 1972 | 15 | 1974 | 19 |
| 1967 | 360 | 1970 | 25 | 1973 | 14 | 1975 | 15 |
| 1968 | 10 | 1971 | 19 | | | | |

01484050 Pratt Branch near Felton, Del.

Location.--Lat 39°00'37", long 75°31'46", Kent County, at bridge on road No. 33, 2.6 mi east of Felton.

Drainage Area.--3.29 $mi^2$.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1966 | <7 | 1969 | 157 | 1972 | 54 | 1974 | 60 |
| 1967 | 459 | 1970 | 72 | 1973 | 43 | 1975 | 162 |
| 1968 | 33 | 1971 | 65 | | | | |

TABLE 5.--Annual maximum discharges at gaging stations--Continued
(Discharges in cubic feet per second)

01484100 Beaverdam Branch at Houston, Del.

Location.--Lat 38°54'20", long 75°30'49", Kent County at bridge on State Highway 384, 0.8 mi south of Houston.

Drainage Area.--2.83 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1958 | 79 | 1963 | 80 | 1968 | 37 | 1972 | 50 |
| 1959 | 45 | 1964 | 45 | 1969 | 60 | 1973 | 55 |
| 1960 | 176 | 1965 | 16 | 1970 | 59 | 1974 | 31 |
| 1961 | 60 | 1966 | 26 | 1971 | 35 | 1975 | 115 |
| 1962 | 63 | 1967 | 76 | | | | |

01484270 Beaverdam Creek near Milton, Del.

Location.--Lat 38°45'41", long 75°16'03", Sussex County, at culvert on road No. 88, 2.5 mi east of Milton.

Drainage Area.--6.10 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1966 | 21 | 1969 | 25 | 1972 | 43 | 1974 | 23 |
| 1967 | 20 | 1970 | 24 | 1973 | 42 | 1975 | 32 |
| 1968 | 21 | 1971 | 34 | | | | |

01484300 Sowbridge Branch near Milton, Del.

Location.--Lat 38°48'51", long 75°19'39", Sussex County, at highway bridge, 2.5 mi north of Milton.

Drainage Area.--7.08 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1957 | 28 | 1962 | 26 | 1967 | 134 | 1972 | 85 |
| 1958 | 80 | 1963 | 30 | 1968 | 37 | 1973 | 46 |
| 1959 | 44 | 1964 | 26 | 1969 | 32 | 1974 | 24 |
| 1960 | 38 | 1965 | 17 | 1970 | 46 | 1975 | 40 |
| 1961 | 41 | 1966 | 22 | 1971 | 58 | | |

TABLE 5.--Annual maximum discharges at gaging stations--Continued
(Discharges in cubic feet per second)

01484500 Stockley Branch at Stockley, Del.

Location.--Lat 38°38'19", long 75°20'31", Sussex County, at highway bridge in Stockley.

Drainage Area.--5.24 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1943 | 44 | 1952 | 53 | 1960 | 46 | 1968 | 65 |
| 1944 | 54 | 1953 | 60 | 1961 | 75 | 1969 | 85 |
| 1945 | 64 | 1954 | 30 | 1962 | 92 | 1970 | 96 |
| 1946 | 77 | 1955 | 51 | 1963 | 71 | 1971 | 75 |
| 1947 | 34 | 1956 | 27 | 1964 | 68 | 1972 | 65 |
| 1948 | 132 | 1957 | 36 | 1965 | 38 | 1973 | 105 |
| 1949 | 49 | 1958 | 118 | 1966 | 73 | 1974 | 51 |
| 1950 | 45 | 1959 | 58 | 1967 | 107 | 1975 | 97 |
| 1951 | 30 | | | | | | |

01484550 Pepper Creek at Dagsboro, Del.

Location.--Lat 38°32'50", long 75°14'39", Sussex County, at bridge on State Highway 26 at Dagsboro.

Drainage Area.--8.78 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1960 | <36 | 1964 | 280 | 1968 | 137 | 1972 | 545 |
| 1961 | 215 | 1965 | 182 | 1969 | 330 | 1973 | 403 |
| 1962 | 292 | 1966 | 54 | 1970 | 479 | 1974 | 303 |
| 1963 | 156 | 1967 | 346 | 1971 | 259 | 1975 | 521 |

01485000 Pocomoke River near Willards, Md.

Location.--Lat 38°23'20", long 75°19'30", Worcester County, at bridge on State Highway 346, 1.3 mi east of Willards.

Drainage Area.--60.5 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1950 | 502 | 1957 | 559 | 1964 | 796 | 1970 | 492 |
| 1951 | 391 | 1958 | 882 | 1965 | 503 | 1971 | 452 |
| 1952 | 830 | 1959 | 562 | 1966 | 445 | 1972 | 924 |
| 1953 | 816 | 1960 | 565 | 1967 | 586 | 1973 | 710 |
| 1954 | 679 | 1961 | 709 | 1968 | 560 | 1974 | 522 |
| 1955 | 645 | 1962 | 884 | 1969 | 541 | 1975 | 1,000 |
| 1956 | 670 | 1963 | 690 | | | | |

01485500 Nassawango Creek near Snow Hill, Md.

Location.--Lat 38°13'44", long 75°28'19", Worcester County at bridge on State Highway 12, 5.5 mi northwest of Snow Hill.

Drainage Area.--44.9 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1950 | 215 | 1957 | 542 | 1964 | 597 | 1970 | 437 |
| 1951 | 258 | 1958 | 761 | 1965 | 121 | 1971 | 347 |
| 1952 | 486 | 1959 | 597 | 1966 | 200 | 1972 | 1,320 |
| 1953 | 988 | 1960 | 361 | 1967 | 452 | 1973 | 760 |
| 1954 | 430 | 1961 | 653 | 1968 | 434 | 1974 | 365 |
| 1955 | 920 | 1962 | 669 | 1969 | 480 | 1975 | 615 |
| 1956 | 348 | 1963 | 615 | | | | |

01486000 Manokin Branch near Princess Anne, Md.

Location.--Lat 38°12'50", long 75°40'18", Somerset County, 45 ft downstream from bridge on private road, 1.4 mi northeast of Princess Anne.

Drainage Area.--4.80 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1951 | 97 | 1957 | 154 | 1963 | 224 | 1968 | 126 |
| 1952 | 84 | 1958 | 174 | 1964 | 140 | 1969 | 547 |
| 1953 | 210 | 1959 | 111 | 1965 | 38 | 1970 | 311 |
| 1954 | 41 | 1960 | 184 | 1966 | 46 | 1971 | 194 |
| 1955 | 237 | 1961 | 152 | 1967 | 72 | 1975 | 265 |
| 1956 | 54 | 1962 | 218 | | | | |

01486100 Andrews Branch near Delmar, Md.

Location.--Lat 38°26'15", long 75°31'46", Wicomico County, at culvert on Rum Ridge Road, 2.8 mi southeast of Delmar.

Drainage Area.--4.1 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1967 | 155 | 1970 | 70 | 1973 | 191 | 1975 | 118 |
| 1968 | 77 | 1971 | 93 | 1974 | 58 | 1976 | 42 |
| 1969 | 147 | 1972 | 112 | | | | |

TABLE 5.--Annual maximum discharges at gaging stations--Continued
(Discharges in cubic feet per second)

01486500 Beaverdam Creek near Salisbury, Md.*

Location.--Lat 38°21'05", long 75°34'11", Wicomico County, at Schumaker Dam, 2 mi southeast of Salisbury.

Drainage Area.--19.5 mi².

Remarks.--Peak flow affected by Schumaker Dam.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1930 | 76 | 1943 | 86 | 1954 | 502 | 1965 | 317 |
| 1931 | 36 | 1944 | 260 | 1955 | 338 | 1966 | 135 |
| 1932 | 115 | 1945 | 115 | 1956 | 209 | 1967 | 296 |
| 1933 | † | 1946 | 252 | 1957 | 300 | 1968 | 175 |
| 1936 | 234 | 1947 | 69 | 1958 | 337 | 1969 | 303 |
| 1937 | 334 | 1948 | 1,480 | 1959 | 733 | 1970 | 366 |
| 1938 | 443 | 1949 | 217 | 1960 | 214 | 1971 | 212 |
| 1939 | 283 | 1950 | 95 | 1961 | 337 | 1972 | 469 |
| 1940 | 234 | 1951 | 143 | 1962 | 487 | 1973 | 417 |
| 1941 | 111 | 1952 | 207 | 1963 | 239 | 1974 | 254 |
| 1942 | 392 | 1953 | 653 | 1964 | 631 | 1975 | 339 |

01486980 Toms Dam Branch near Greenwood, Del.

Location.--Lat 38°48'04", long 75°33'28", Sussex County, at bridge on State Highway 16, 1.5 mi east of Greenwood.

Drainage Area.--5.28 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1966 | 54 | 1969 | 34 | 1972 | 52 | 1974 | 14 |
| 1967 | 88 | 1970 | 28 | 1973 | 39 | 1975 | 56 |
| 1968 | 42 | 1971 | 26 | | | | |

01487000 Nanticoke River near Bridgeville, Del.

Location.--Lat 38°43'42", long 75°33'44", Sussex County, at highway bridge, 2.5 mi southeast of Bridgeville.

Drainage Area.--75.4 mi².

* Not used in final regression model.
† Discharge not determined.

TABLE 5.--Annual maximum discharges at gaging stations--Continued
(Discharges in cubic feet per second)

01487000 Nanticoke River near Bridgeville, Del.--Continued

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1943 | 400 | 1952 | 776 | 1960 | 1,620 | 1968 | 526 |
| 1944 | 420 | 1953 | 468 | 1961 | 728 | 1969 | 227 |
| 1945 | 435 | 1954 | 248 | 1962 | 985 | 1970 | † |
| 1946 | 730 | 1955 | 680 | 1963 | 867 | 1971 | 700 |
| 1947 | 386 | 1956 | 270 | 1964 | 572 | 1972 | 522 |
| 1948 | 830 | 1957 | 635 | 1965 | 229 | 1973 | 828 |
| 1949 | 590 | 1958 | 2,300 | 1966 | 435 | 1974 | 490 |
| 1950 | 216 | 1959 | 930 | 1967 | 2,360 | 1975 | 1,730 |
| 1951 | 290 | | | | | | |

01487500 Trap Pond Outlet near Laurel, Del.*

Location.--Lat 38°31'40", long 75°28'58", Sussex County, 200 ft downstream from Trap Pond Dam, and 5 mi southeast of Laurel.

Drainage Area.--16.7 mi$^2$.

Remarks.--Peak flow affected by Trap Pond Dam.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1952 | 200 | 1958 | 315 | 1964 | 265 | 1970 | 161 |
| 1953 | 181 | 1959 | 133 | 1965 | 43 | 1971 | 172 |
| 1954 | 148 | 1960 | 223 | 1966 | 259 | 1972 | 315 |
| 1955 | 172 | 1961 | 265 | 1967 | 608 | 1973 | 473 |
| 1956 | 94 | 1962 | 462 | 1968 | 138 | 1975 | 560 |
| 1957 | 150 | 1963 | 192 | 1969 | 341 | | |

01487900 Meadow Branch near Delmar, Del.

Location.--Lat 38°29'05", long 75°35'16", Sussex County, at culverts on road No. 503B, 2.1 mi northwest of Delmar.

Drainage Area.--3.47 mi$^2$.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1967 | 99 | 1970 | 52 | 1972 | 100 | 1974 | 68 |
| 1968 | 34 | 1971 | 61 | 1973 | 112 | 1975 | 89 |
| 1969 | 76 | | | | | | |

* Not used in final regression model.
† Discharge not determined.

TABLE 5.--Annual maximum discharges at gaging stations--Continued
(Discharges in cubic feet per second)

01488000 Holly Ditch near Laurel, Del.*

Location.--Lat 38°32'20", long 75°35'55", Sussex County, at culverts on road No. 494, 1.5 mi southwest of Laurel.

Drainage Area.--2.19 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1951 | 2 | 1960 | 31 | 1965 | † | 1971 | 4 |
| 1952 | 12 | 1961 | 62 | 1967 | 26 | 1972 | 41 |
| 1953 | 8 | 1962 | † | 1968 | 14 | 1973 | 28 |
| 1954 | 2 | 1963 | † | 1969 | 8 | 1974 | 4 |
| 1955 | 3 | 1964 | † | 1970 | 8 | 1975 | 35 |
| 1956 | 1 | | | | | | |

01488500 Marshyhope Creek near Adamsville, Del.

Location.--Lat 38°50'59", long 75°40'24", Kent County, 45 ft upstream from highway bridge, 1.6 mi northeast of Adamsville.

Drainage Area.--43.9 mi² (area at site prior to Oct. 1, 1971, 44.8 mi²).

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1943 | 486 | 1951 | 325 | 1959 | 597 | 1966 | 126 |
| 1944 | 626 | 1952 | 1,020 | 1960 | 1,440 | 1967 | 3,060 |
| 1945 | 678 | 1953 | 635 | 1961 | 805 | 1968 | 452 |
| 1946 | 1,040 | 1954 | 328 | 1962 | 762 | 1972 | 1,430 |
| 1947 | 404 | 1955 | 743 | 1963 | 1,200 | 1973 | 1,480 |
| 1948 | 933 | 1956 | 310 | 1964 | 618 | 1974 | 1,390 |
| 1949 | 730 | 1957 | 1,440 | 1965 | 162 | 1975 | 3,700 |
| 1950 | 232 | 1958 | 2,270 | | | | |

01489000 Faulkner Branch at Federalsburg, Md.

Location.--Lat 38°42'44", long 75°47'34", Caroline County, at highway bridge on Nichols Road, 1.6 mi northwest of Federalsburg.

Drainage Area.--7.10 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1950 | 38 | 1952 | 175 | 1954 | 45 | 1956 | 94 |
| 1951 | 39 | 1953 | 58 | 1955 | 433 | 1957 | 198 |

* Not used in final regression model.
† Discharge not determined.

01489000 Faulkner Branch at Federalsburg, Md.--Continued

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1958 | 440 | 1963 | 283 | 1968 | 205 | 1972 | 283 |
| 1959 | 250 | 1964 | 138 | 1969 | 192 | 1973 | 211 |
| 1960 | 672 | 1965 | 492 | 1970 | 199 | 1974 | 130 |
| 1961 | 298 | 1966 | 33 | 1971 | 156 | 1975 | 1,680 |
| 1962 | 203 | 1967 | 792 | | | | |

01490000 Chicamacomico River near Salem, Md.

Location.--Lat 38°30'43", long 75°52'51", Dorchester County, 30 ft downstream from Big Mill Pond Dam, and 1.6 mi east of Salem.

Drainage Area.--15.0 $mi^2$.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1951 | 85 | 1958 | 285 | 1964 | 176 | 1970 | 218 |
| 1952 | 326 | 1959 | 202 | 1965 | 182 | 1971 | 210 |
| 1953 | 152 | 1960 | 419 | 1966 | 128 | 1972 | 300 |
| 1954 | 106 | 1961 | 470 | 1967 | 518 | 1973 | 542 |
| 1955 | 314 | 1962 | 157 | 1968 | 226 | 1974 | 168 |
| 1956 | 78 | 1963 | 230 | 1969 | 169 | 1975 | 478 |
| 1957 | 260 | | | | | | |

01490470 Tappahanna Ditch near Hartly, Del.*

Location.--Lat 39°08'07", long 75°41'30", Kent County, at bridge on road No. 103, 2.7 mi southeast of Hartly.

Drainage Area.--5.93 $mi^2$.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1966 | 32 | 1968 | † | 1970 | 117 | 1972 | 127 |
| 1967 | 80 | 1969 | 86 | 1971 | 119 | 1973 | 120 |

* Not used in final regression model.
† Discharge not determined.

01490490 Beachy Neidig Ditch near Willow Grove, Del.*

Location.--Lat 39°04'57", long 75°39'27", Kent County, at culverts on road No. 226, 1.8 mi northwest of Willow Grove.

Drainage Area.--2.43 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1966 | 13 | 1969 | 67 | 1972 | † | 1974 | <31 |
| 1967 | 67 | 1970 | 76 | 1973 | † | 1975 | † |
| 1968 | 45 | 1971 | † | | | | |

01490600 Meredith Branch near Sandtown, Del.

Location.--Lat 39°02'23", long 75°41'52", Kent County, at bridge on State Highway 10, 1.2 mi east of Sandtown.

Drainage Area.--8.4 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1966 | 16 | 1969 | 226 | 1972 | 242 | 1974 | 169 |
| 1967 | 2,140 | 1970 | 191 | 1973 | 233 | 1975 | 431 |
| 1968 | 210 | 1971 | 210 | | | | |

01490800 Oldtown Branch at Goldsboro, Md.

Location.--Lat 39°01'23", long 75°47'16", Caroline County, at culvert on State Highway 313, 0.7 mi south of Goldsboro.

Drainage Area.--3.9 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1967 | 690 | 1970 | 170 | 1973 | 350 | 1975 | 200 |
| 1968 | 125 | 1971 | 235 | 1974 | 68 | 1976 | 170 |
| 1969 | 100 | 1972 | 340 | | | | |

* Not used in final regression model.
† Discharge not determined.

TABLE 5.--Annual maximum discharges at gaging stations--Continued
(Discharges in cubic feet per second)

01491000 Choptank River near Greensboro, Md.

Location.--Lat 38°59'50", long 75°47'09", Caroline County, at highway bridge, 2 mi northeast of Greensboro.

Drainage Area.--113 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1948 | 1,600 | 1955 | 1,140 | 1962 | 1,580 | 1969 | 1,620 |
| 1949 | 1,700 | 1956 | 989 | 1963 | 1,890 | 1970 | 1,650 |
| 1950 | 1,050 | 1957 | 4,140 | 1964 | 1,890 | 1971 | 1,570 |
| 1951 | 840 | 1958 | 4,380 | 1965 | 525 | 1972 | 2,760 |
| 1952 | 3,640 | 1959 | 758 | 1966 | 150 | 1973 | 2,660 |
| 1953 | 1,330 | 1960 | 5,040 | 1967 | 6,970 | 1974 | 944 |
| 1954 | 1,180 | 1961 | 2,400 | 1968 | 1,620 | 1975 | 2,860 |

01491010 Sangston Prong near Whiteleysburg, Del.

Location.--Lat 38°58'25", long 75°43'32", Kent County, at culvert on road No. 269, 1.2 mi north of Whiteleysburg.

Drainage Area.--1.9 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1966 | 35 | 1969 | 51 | 1972 | 68 | 1974 | 36 |
| 1967 | 765 | 1970 | 66 | 1973 | 62 | 1975 | 484 |
| 1968 | 52 | 1971 | 70 | | | | |

01491050 Spring Branch near Greensboro, Md.

Location.--Lat 38°56'34", long 75°47'25", Caroline County, at culvert on Knife Box Road, 2.2 mi southeast of Greensboro.

Drainage Area.--3.8 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1967 | 965 | 1970 | 95 | 1973 | 80 | 1975 | 150 |
| 1968 | 42 | 1971 | 82 | 1974 | 41 | 1976 | 60 |
| 1969 | 33 | 1972 | 70 | | | | |

TABLE 5.--Annual maximum discharges at gaging stations--Continued
(Discharges in cubic feet per second)

01492000 Beaverdam Branch at Matthews, Md.

Location.--Lat 38°48'41", long 75°58'15", Talbot County, at bridge on State Highway 328, 1 mi west of Matthews.

Drainage Area.--5.85 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1950 | 181 | 1957 | 1,020 | 1964 | 116 | 1970 | 238 |
| 1951 | 148 | 1958 | 1,050 | 1965 | 545 | 1971 | 562 |
| 1952 | 276 | 1959 | 231 | 1966 | 181 | 1972 | 357 |
| 1953 | 222 | 1960 | 2,200 | 1967 | 693 | 1973 | 441 |
| 1954 | 133 | 1961 | 251 | 1968 | 269 | 1974 | 150 |
| 1955 | 476 | 1962 | 162 | 1969 | 180 | 1975 | 301 |
| 1956 | 109 | 1963 | 307 | | | | |

01492050 Gravel Run at Beulah, Md.

Location.--Lat 38°40'54", long 75°53'53", Dorchester County, at culvert on State Highway 16, 0.3 mi north of Beulah.

Drainage Area.--8.4 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1966 | 53 | 1969 | 97 | 1972 | 120 | 1975 | 690 |
| 1967 | 220 | 1970 | 145 | 1973 | 85 | 1976 | 36 |
| 1968 | 95 | 1971 | 81 | 1974 | 71 | | |

01492500 Sallie Harris Creek near Carmichael, Md.

Location.--Lat 38°57'55", long 76°06'30", Queen Annes County, at bridge on U.S. Highway 50, 2 mi northeast of Carmichael

Drainage Area.--8.09 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1952 | 327 | 1958 | 577 | 1964 | 71 | 1970 | 219 |
| 1953 | 214 | 1959 | 75 | 1965 | 51 | 1971 | 220 |
| 1954 | 116 | 1960 | 1,240 | 1966 | 71 | 1972 | 290 |
| 1955 | 1,030 | 1961 | 154 | 1967 | 1,180 | 1973 | 502 |
| 1956 | 91 | 1962 | 135 | 1968 | 304 | 1974 | 202 |
| 1957 | 155 | 1963 | 286 | 1969 | 136 | 1975 | 233 |

01492550 Mill Creek near Skipton, Md.

Location.--Lat 38°55'00", long 76°03'42", Talbot County, at culvert on U.S. Highway 50, 1.5 mi north of Skipton.

Drainage Area.--4.6 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1966 | 99 | 1969 | 88 | 1972 | 105 | 1975 | 165 |
| 1967 | 1,520 | 1970 | 165 | 1973 | 135 | 1976 | 72 |
| 1968 | 190 | 1971 | 140 | 1974 | 59 | | |

01493000 Unicorn Branch near Millington, Md.

Location.--Lat 39°14'59", long 75°51'40", Kent County, at bridge on State Highway 313, 1.4 mi southwest of Millington.

Drainage Area.--22.3 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1949 | 277 | 1956 | 167 | 1963 | 840 | 1970 | 296 |
| 1950 | 222 | 1957 | 630 | 1964 | 226 | 1971 | 524 |
| 1951 | 282 | 1958 | 370 | 1965 | 106 | 1972 | 1,020 |
| 1952 | 383 | 1959 | 116 | 1966 | 85 | 1973 | 467 |
| 1953 | 253 | 1960 | 1,060 | 1967 | 582 | 1974 | 168 |
| 1954 | 157 | 1961 | 429 | 1968 | 266 | 1975 | 365 |
| 1955 | 359 | 1962 | 246 | 1969 | 430 | | |

01493500 Morgan Creek near Kennedyville, Md.

Location.--Lat 39°16'48", long 76°00'54", Kent County, 200 ft upstream from highway bridge, 2 mi southwest of Kennedyville.

Drainage Area.--12.7 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1951 | 208 | 1958 | 834 | 1964 | 160 | 1970 | 340 |
| 1952 | 622 | 1959 | 446 | 1965 | 86 | 1971 | 760 |
| 1953 | 428 | 1960 | 1,530 | 1966 | 129 | 1972 | 7,500 |
| 1954 | 269 | 1961 | 625 | 1967 | 823 | 1973 | 912 |
| 1955 | 630 | 1962 | 198 | 1968 | 397 | 1974 | 466 |
| 1956 | 291 | 1963 | 301 | 1969 | 426 | 1975 | 376 |
| 1957 | 293 | | | | | | |

TABLE 5.--Annual maximum discharges at gaging stations--Continued
(Discharges in cubic feet per second)

01494020 Browns Branch Tributary near Church Hill, Md.*

Location.--Lat 39°10'05", long 75°58'41", Queen Annes County, at culvert on John Powell Road, 1.8 mi north of Church Hill.

Drainage Area.--1.7 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1971 | 890 | 1973 | 230 | 1975 | 130 | 1976 | 70 |
| 1972 | 450 | 1974 | 255 | | | | |

01495000 Big Elk Creek at Elk Mills, Md.

Location.--Lat 39°39'26", long 75°49'20", Cecil County, at highway bridge at Elk Mills.

Drainage Area.--52.6 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1884 | 18,000 | 1943 | 2,860 | 1954 | 1,340 | 1965 | 2,020 |
| 1932 | 3,020 | 1944 | 2,380 | 1955 | 5,860 | 1966 | 3,690 |
| 1933 | 7,530 | 1945 | 6,030 | 1956 | 1,540 | 1967 | 6,120 |
| 1934 | 2,620 | 1946 | 7,080 | 1957 | 2,880 | 1968 | 1,570 |
| 1935 | 4,720 | 1947 | 5,220 | 1958 | 2,590 | 1969 | 1,050 |
| 1936 | † | 1948 | 2,120 | 1959 | 3,420 | 1970 | 2,640 |
| 1937 | 10,600 | 1949 | 1,720 | 1960 | 6,180 | 1971 | 4,030 |
| 1938 | 2,310 | 1950 | 3,400 | 1961 | 1,610 | 1972 | 8,720 |
| 1939 | 2,620 | 1951 | 2,620 | 1962 | 2,180 | 1973 | 2,010 |
| 1940 | 2,700 | 1952 | 3,280 | 1963 | 1,620 | 1974 | 2,040 |
| 1941 | 5,680 | 1953 | 2,740 | 1964 | 3,030 | 1975 | 4,540 |
| 1942 | 3,380 | | | | | | |

01495500 Little Elk Creek at Childs, Md.

Location.--Lat 39°38'30", long 75°52'00", Cecil County, at highway bridge, 0.2 mi southeast of Childs.

Drainage Area.--26.8 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1949 | 1,120 | 1952 | 2,420 | 1955 | 5,400 | 1957 | 1,890 |
| 1950 | 1,700 | 1953 | 1,600 | 1956 | 1,520 | 1958 | 1,620 |
| 1951 | 1,540 | 1954 | 1,280 | | | | |

* Not used in final regression model.
† Discharge not determined.

TABLE 5.--Annual maximum discharges at gaging stations--Continued
(Discharges in cubic feet per second)

01496000 Northeast Creek at Leslie, Md.

Location.--Lat 39°37'38", long 75°56'40", Cecil County, at highway bridge, 0.7 mi northeast of Leslie.

Drainage Area.--24.3 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1949 | 1,340 | 1956 | 858 | 1963 | 814 | 1970 | 1,770 |
| 1950 | 1,640 | 1957 | 1,850 | 1964 | 1,020 | 1971 | 2,040 |
| 1951 | 1,460 | 1958 | 3,220 | 1965 | 1,050 | 1972 | 4,800 |
| 1952 | 2,410 | 1959 | 1,210 | 1966 | 2,000 | 1973 | 1,560 |
| 1953 | 1,870 | 1960 | 2,790 | 1967 | 4,060 | 1974 | 2,120 |
| 1954 | 834 | 1961 | 1,020 | 1968 | 912 | 1975 | 3,410 |
| 1955 | 2,590 | 1962 | 838 | 1969 | 1,440 | | |

01496080 Northeast River Tributary near Charlestown, Md.

Location.--Lat 39°35'53", long 75°58'37", Cecil County, at culvert on U.S. Highway 40, 1.6 mi north of Charlestown.

Drainage Area.--1.7 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1967 | 260 | 1970 | 480 | 1973 | 150 | 1975 | 700 |
| 1968 | <125 | 1971 | 395 | 1974 | 215 | 1976 | 320 |
| 1969 | <125 | 1972 | 615 | | | | |

01496200 Principio Creek near Principio Furnace, Md.*

Location.--Lat 39°37'34", long 76°02'27", Cecil County, at highway bridge on Belvedere Road, 3.5 mi north of Principio Furnace.

Drainage Area.--9.03 mi².

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1967 | 4,260 | 1970 | 896 | 1972 | 3,020 | 1974 | 934 |
| 1968 | 634 | 1971 | 1,260 | 1973 | 1,210 | 1975 | 3,050 |
| 1969 | 7,060 | | | | | | |

* Not used in final regression model.

TABLE 5.--Annual maximum discharges at gaging stations--Continued
(Discharges in cubic feet per second)

01578200 Conowingo Creek near Buck, Pa.

Location.--Lat 39°50'35", long 76°11'45", Lancaster County at bridge on Legislative Route 36135, 2.5 mi southeast of Buck.

Drainage Area.--8.71 $mi^2$.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1963 | 456 | 1967 | 340 | 1970 | 693 | 1973 | 3,780 |
| 1964 | 643 | 1968 | 285 | 1971 | 533 | 1974 | 427 |
| 1965 | 245 | 1969 | 391 | 1972 | 1,270 | 1975 | 936 |
| 1966 | 498 | | | | | | |

01578400 Bowery Run near Quarryville, Pa.

Location.--Lat 39°53'41", long 76°06'50", Lancaster County, at single-span bridge, 1.1 mi upstream from mouth and 2.5 mi east of Quarryville.

Drainage Area.--5.98 $mi^2$.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1963 | 305 | 1967 | 724 | 1970 | 842 | 1973 | 660 |
| 1964 | 2,220 | 1968 | 344 | 1971 | 720 | 1974 | 629 |
| 1965 | 291 | 1969 | 629 | 1972 | 1,050 | 1975 | 955 |
| 1966 | 430 | | | | | | |

01578500 Octoraro Creek near Rising Sun, Md.*

Location.--Lat 39°41'24", long 76°07'43", Cecil County, at Porter Bridge, 3.5 mi west of Rising Sun.

Drainage Area.--193 $mi^2$.

Remarks.--Peak flow regulated by Chester-Octoraro Reservoir since Feb. 22, 1951.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1884 | 60,000 | 1934 | 2,910 | 1938 | 5,970 | 1942 | 35,000 |
| 1918 | 27,700 | 1935 | 17,200 | 1939 | 4,250 | 1943 | 2,780 |
| 1932 | 980 | 1936 | 9,340 | 1940 | 5,080 | 1944 | 8,300 |
| 1933 | 34,500 | 1937 | 2,280 | 1941 | 3,630 | 1945 | 7,820 |

* Not used in final regression model.

TABLE 5.--Annual maximum discharges at gaging stations--Continued
(Discharges in cubic feet per second)

01578500 Octoraro Creek near Rising Sun, Md.--Continued

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1946 | 5,900 | 1953 | 6,400 | 1963 | 7,370 | 1970 | 2,830 |
| 1947 | 3,550 | 1954 | 1,930 | 1965 | 568 | 1971 | 11,800 |
| 1948 | 4,040 | 1955 | 7,960 | 1966 | 1,980 | 1972 | 29,000 |
| 1949 | 3,550 | 1956 | 2,090 | 1967 | 6,870 | 1973 | 4,880 |
| 1950 | 2,900 | 1957 | 1,450 | 1968 | 2,220 | 1974 | 5,460 |
| 1951 | 5,600 | 1958 | 6,870 | 1969 | 1,580 | 1975 | 17,300 |
| 1952 | 9,240 | | | | | | |

01578800 Basin Run at West Nottingham, Md.

Location.--Lat 39°39'23", long 76°04'30", Cecil County, at culvert on State Highway 276, 0.9 mi south of West Nottingham.

Drainage Area.--1.3 $mi^2$.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1967 | 820 | 1970 | 335 | 1973 | 640 | 1975 | 710 |
| 1968 | 310 | 1971 | 420 | 1974 | 220 | 1976 | 160 |
| 1969 | 700 | 1972 | 660 | | | | |

01579000 Basin Run at Liberty Grove, Md.

Location.--Lat 39°39'30", long 76°06'10", Cecil County, at highway bridge, 0.9 mi east of Liberty Grove.

Drainage Area.--5.31 $mi^2$.

| Water Year | Discharge | Water Year | Discharge | Water Year | Discharge | Water Year | Discharge |
|---|---|---|---|---|---|---|---|
| 1949 | 354 | 1955 | 967 | 1967 | 3,500 | 1972 | 2,600 |
| 1950 | 511 | 1956 | 176 | 1968 | 645 | 1973 | 1,770 |
| 1951 | 1,440 | 1957 | 724 | 1969 | 2,800 | 1974 | 460 |
| 1952 | 596 | 1958 | 1,560 | 1970 | 790 | 1975 | 2,120 |
| 1953 | 425 | 1965 | 625 | 1971 | 1,200 | 1976 | 435 |
| 1954 | 460 | 1966 | 660 | | | | |