PROBABLE MAGNITUDE AND FREQUENCY OF FLOODS ON SMALL STREAMS IN VIRGINIA

by

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I. INTRODUCTION

This paper is an attempt to provide a simple and effective method of estimating the magnitude and frequency of recurrence of floods on small streams in Virginia.

The uses of such information is manifold. In the design of engineering projects such as dams, bridges, channel improvements, sewage disposal plants, and industrial buildings, knowledge of the magnitude and frequency of floods that are likely to be equaled or exceeded within the life of the project is necessary. If the estimate of the maximum discharge is not correct the project cannot be economically and efficiently designed. If the estimate is too high, funds will be unnecessarily wasted providing for floods which are not likely to occur until the project is obsolete. Likewise, if the estimate is too low, the project may prove ineffective for the purpose for which it was designed or cause great economic damage and loss of life.

The recent activities in flood plain zoning and flood insurance also requires a knowledge of flood frequency. Without such knowledge these endeavors would have little basis. The economic importance of these problems make the development of sound flood frequency methods imperative.

This paper is essentially an extension and refinement of previously published reports of the U.S. Geological Survey. Several analyses applicable to Virginia have been made by this agency from stream flow data available at the time and were released as reports on the magnitude and frequency of floods. Tice [16] prepared a flood-frequency report for the North Atlantic Slope Basins, New York to York River using stream flow records to October 1962. Speer and Gamble [13, 14, 15] prepared similar reports for the South Atlantic Slope Basins, James River to Savannah River, using data through water year 1959, for the Cumberland and Tennessee River basins in 1964, and for the Ohio River basin except Cumberland and Tennessee basins in 1965. Each of these reports are applicable to a part of Virginia.

Application of the relations represented in the foregoing reports gives results which are generally reliable for streams that drain basins larger than 150 square miles in Virginia. The relationships in this paper should, in general, give more reliable results for smaller basins. This refinement is possible because data from 47 crest-stage stations were used in the analysis. These stations, not used in previous analyses, were established during the period 1955-1960 to gage peak flows from drainage basins mostly smaller than 50 square miles and to provide better geographic sampling.

II. REVIEW OF LITERATURE

In 1924 Foster [7] introduced the use of the Flexible Pearson distributions to solve flood frequency problems. These empirical distributions had been set up by Karl Pearson to enable statisticians to deal with a wide variety of data. The use of this distribution requires the calculation of the mean, standard deviation, and skewness in order to determine the frequency curve. Gumbel [9] applied the distribution of maximum values proposed by Fisher and Tippett to flood frequency analysis. Hazen [10] transformed natural flood data to their logarithms and used the Pearson curves to determine the magnitude and frequency of floods.

Beard [1] proposed the use of the median plotting position formula to determine the exceedance interval of floods. Gumbel [8] recommended the use of the mode as the measure of central tendency to be used in determining plotting positions. Powell [12], using the theory of maximum values, devised a time scale that tends to make frequency curves plot as a straight line. Kimball [11] is credited with the introduction of the widely used plotting position formula, $T = \frac{n+1}{m}$. This formula uses the mean as a measure of central tendency and has been adopted by the U.S. Geological Survey.

As with most hydrologic techniques, the theories proposed by these writers are not standard. Most of the disagreement has centered on the type of statistical distribution that may be used to fit the data and the plotting position formula used to determine recurrence intervals.

III. DESCRIPTION OF THE STATE

Physiography

The physiographic divisions of Virginia fall into two broad categories according to Fenneman [6], the Atlantic Plain and the Appalachian Highlands. The Coastal Plain constitutes the Atlantic Plain of the eastern part of the state, and the Piedmont, Blue Ridge, and Ridge and Valley provinces, and the Allegheny Plateau constitute the Appalachian Highlands of the western part of the state. Boundaries between these divisions are not everywhere clearly defined, many falling in zones of transition. The boundaries are oriented in a general northeast-southwest direction, roughly parallel to the Atlantic coastline.

Climate

The climate of Virginia is generally mild and humid but is one of the most varied of any Eastern State. The variations are due to differences in altitude and distance from the coast [3].

Streams

Stream basins of the state are within the larger drainage-basin systems of the United States and each system forms an area termed a "part" by the U.S. Geological Survey. These parts are the basis for divisions of reports on water supply of the United States into volumes. The four parts in Virginia are Part 1-B (North Atlantic slope basins, New York to York River), Part 2-A (South Atlantic slope basins, James River to Savannah River), Part 3-A (Ohio River basin except Cumberland and Tennessee River basins), and Part 3-B (Cumberland and Tennessee River basins).

Although headwaters of principal streams of the Piedmont and mountains originate in the higher altitudes of the state, smaller streams originate in any locality. Streams originating in the mountains generally have narrow valleys and steep slopes, whereas streams originating in the Coastal Plain and lower Piedmont province have wide flood plains and flat slopes. The eastern part of the Coastal Plain has swampy areas with very flat stream slopes.

Flood Frequency Regions

No rigorous statistical test to determine homogeneous flood-frequency regions is feasible using the log-Pearson Type III distribution. Because of the general nature of the distribution each station frequency curve has a different distribution depending on the value of its mean, standard deviation, and skewness.

A general breakdown into homogeneous regions was arrived at by considering the relationship of the mean annual flood with drainage area. In regions 2-A and 1-B respectively, all points with the exception of those in the Coastal Plain plotted in a fairly tight band. The points in the Coastal Plain of both regions 2-A and 1-B also defined a fairly straight line. Points in regions 3-A and 3-B were combined because of the sparsity of data in region 3-B and because no unusual disparity was observed when the regions were combined.

The four flood-frequency regions used in this report are region 2-A except Coastal Plain, region 1-B except Coastal Plain, regions 3-A and 3-B combined, and the Coastal Plain of regions 2-A and 1-B combined.

Obviously a more rigorous determination of homogeneous regions is desirable. From a physiographic and climatologic standpoint however, the regions used in this report are not entirely without basis. Also, the breakdown is generally consistent with past reports published by the U.S. Geological Survey.

IV. GENERAL CONSIDERATIONS

The two major considerations in any flood frequency analysis is the type of statistical distribution used to fit the data and the plotting position formula used to determine recurrence intervals.

Statistical Distributions

In flood frequency analysis the concept of theoretical populations or distributions is employed. A distribution is a set of values that would occur under fixed conditions in an infinite amount of time. Those that have occurred are presumed to constitute a random sample and accordingly are used to make inferences regarding the distribution from which they were derived. Such inferences are necessarily attended by considerable uncertainty, because a given set of observations could result from any of many distributions.

There is no agreement as to the "best" distribution to which annual flood data should be fitted. The two most widely used are reviewed below.

Pearson Type III Distribution

The Pearson Type III method was originally applied to flood frequency analysis by H. A. Foster [7] in 1924. This distribution has little theoretical justification but it covers a wide range of possibilities and experience has shown that it can be made to fit a large proportion of flood-flow data. As originally used by Foster, the method required the use of the natural data in computations of the mean standard deviation, and skew coefficient of the distribution. The current practice is first to transform the natural data to their logarithms and then to compute the statistical parameters. Because of this transformation the method is now called the log-Pearson Type III method.

Type I Extremal Distribution

Gumbel [8] first proposed the application of this distribution to flood frequency studies. Working with Fisher and Tippett's theory of largest values, Gumbel used as the sample of largest values the maximum flow value from each water year, or the series of annual floods. This distribution is presently used by the U.S. Geological Survey and many state agencies for flood frequency studies.

Plotting Position Formulas

Based on considerations of probability, several methods have been proposed to compute plotting positions.

"California" Method [5]

This is the simplest form of computation, in which the recurrence interval, $T_r = \frac{n}{m}$, where "n" is the number of years of record and "m" is the rank starting with the highest as 1. A minor objection to this method, where considering the probability of the event, is the reciprocal of the recurrence interval. The probability of the lowest flood occurring is computed as 1, which precludes the occurrence of any flood lower than this. Also, this method gives no weight to the probability that the highest flood of record has a recurrence interval of something over "n" years.

Hazen Method [10]

Hazen computed the "return period" T_p, as $\frac{2n}{(2m-1)}$. This equation results in a recurrence interval of 2n for the highest flood of record, which is an artificial lengthening of the return period.

Gumbel Method [8]

The theoretical plotting by Gumbel,

$$T = 1 - \frac{m^{\frac{1}{n}}}{e},$$

is based on the assumption that the observed "m"th value is the most probable, or modal, value of this rank of flood. Its return period is therefore skewed towards the mode of the theoretical distribution.

According to Dalrymple [5] the Gumbel theory does not apply strictly to floods for the following reasons:

1. "It is assumed that the same treatment derived for daily discharges can be applied to peaks."

2. "The daily discharges are not independent events."

3. "The 365 daily discharges in a year do not constitute a "large" number as predicated by the theory."

4. "The annual peaks under consideration do not come from the same statistical population. Some peaks are caused by ordinary seasonal rains, some by snowmelt, others by hurricane conditions. Entirely different physical factors influence each type. Therefore, although other considerations fitted the assumptions, the different peaks at one station would not lie on a straight line."

Beard Method [2]

This method is based on the assumption that the "m"th value is the median value of this rank of flood, or that the probability of this value occurring is 50 percent. Beard's method is based on the premise that if they are used repeatedly in a great number of random samples, they will prove to be too low in half of the cases and too high in the other half, compared with the theoretically true values that cannot be determined because of random variations in data. Of the formulas generally used, use of the median plotting position will most nearly duplicate results obtained by analytical methods of frequency analysis that do not require plotting positions.

Geological Survey Method [5]

The formula used by the Geological Survey is:

$$T = \frac{n+1}{m}$$

where

T = recurrence interval, in years

n = number of years of record, and

m = magnitude of flood, the highest being 1.

This formula gives essentially the same results as Gumbel's computed values, and is much simpler to use.

The statistical distribution and plotting position formula used in this paper is the log-Pearson Type III and the Beard method respectively.

V. REGIONAL FLOOD FREQUENCY

Flood records at gaging stations are nearly always short in a statistical sense, the sampling error is correspondingly large, and the records represent different periods of time. In addition it is only rarely that flood-frequency information is required at a gaging-station site. Generally it is required at an ungaged site.

The U.S. Geological Survey [5] has developed a method of combining records within a region which reduces the sampling error and produces flood-frequency relations generally applicable within the region. Experience has proved that such a procedure is not only possible but leads to results of acceptable accuracy for design and planning.

Regional flood-frequency study consists of two major parts. The first is the development of basic, dimensionless frequency curves representing the ratio of the flood of any frequency to an index flood (the mean annual flood). The second part is the development of a relationship between drainage area size and the mean annual flood, to enable the mean annual flood to be predicted at any point within the region. This second part can also be extended to the development of relationships between drainage area size and physiographic and meteorologic factors. These factors do not lend themselves well to rigorous analysis and are often interdependent. Furthermore, these factors usually vary widely within a drainage basin. The relationships of the discharge in this report are expressed as a function of drainage area only. The basic element of discharge used is the mean annual flood, Q_m. Consequently the general equation relating discharge and drainage area is,

$$Q_m = CA^x \tag{1}$$

in which A is the drainage area in square miles, and C is an empirical coefficient expressing the effect of other factors.

The curves presented in Figures 1 through 4 are expressions of this equation. To determine the equation for any of these curves, the constant C is the figure for Q_m at which the curve intercepts 1 on the drainage area scale. The exponent "x" is the slope of the curve. Equations for curves 1 through 4 respectively are:

$$\text{Curve 1:} \quad Q_m = 239A^{0.543} \tag{2}$$

$$\text{Curve 2:} \quad Q_m = 181A^{0.620} \tag{3}$$

$$\text{Curve 3:} \quad Q_m = 24.2A^{1.105} \tag{4}$$

$$\text{Curve 4:} \quad Q_m = 17.6A^{0.943} \tag{5}$$

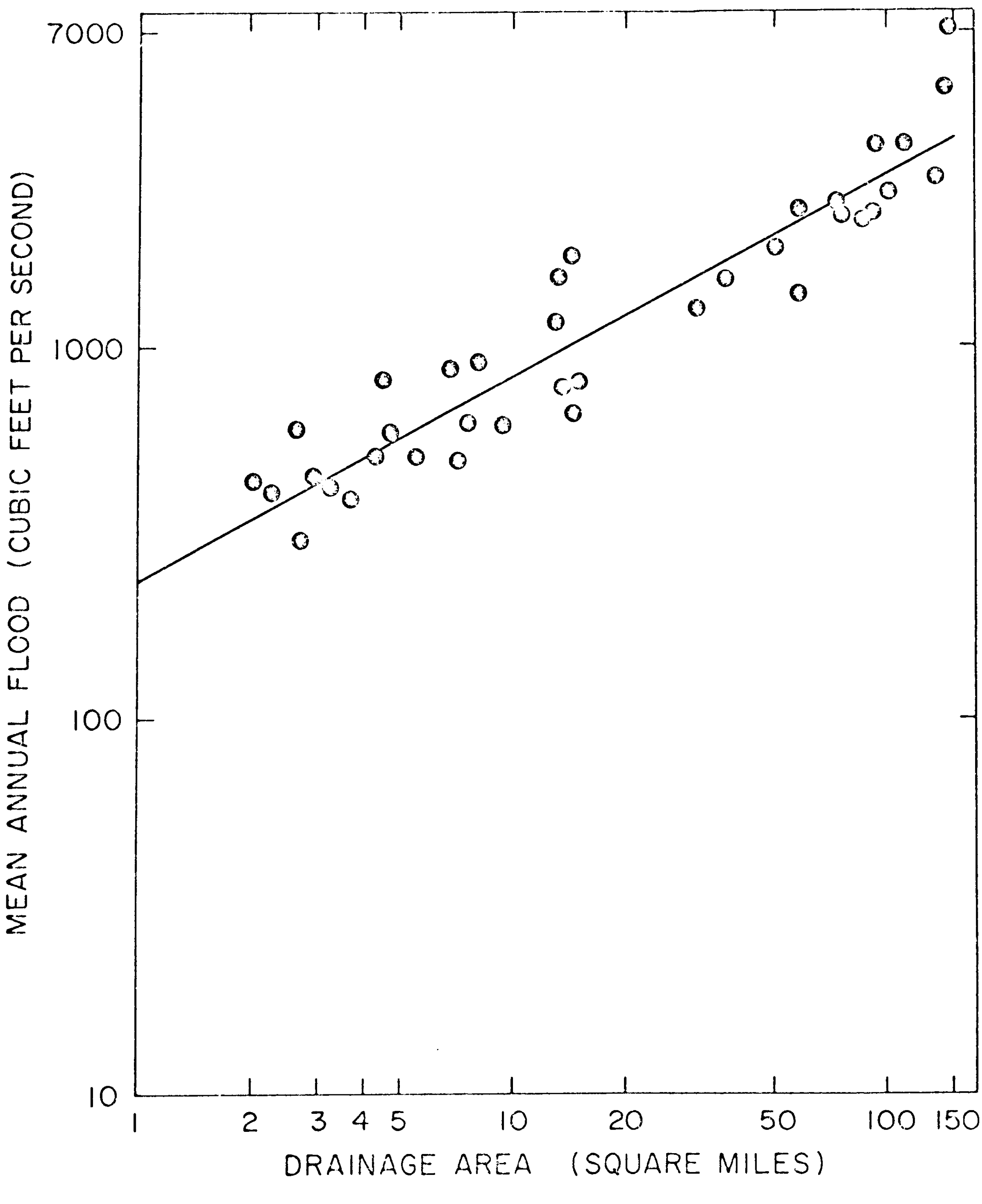

FIGURE 1: VARIATION OF MEAN ANNUAL FLOOD WITH DRAINAGE AREA IN REGION 1-B (EXCEPT COASTAL PLAIN)

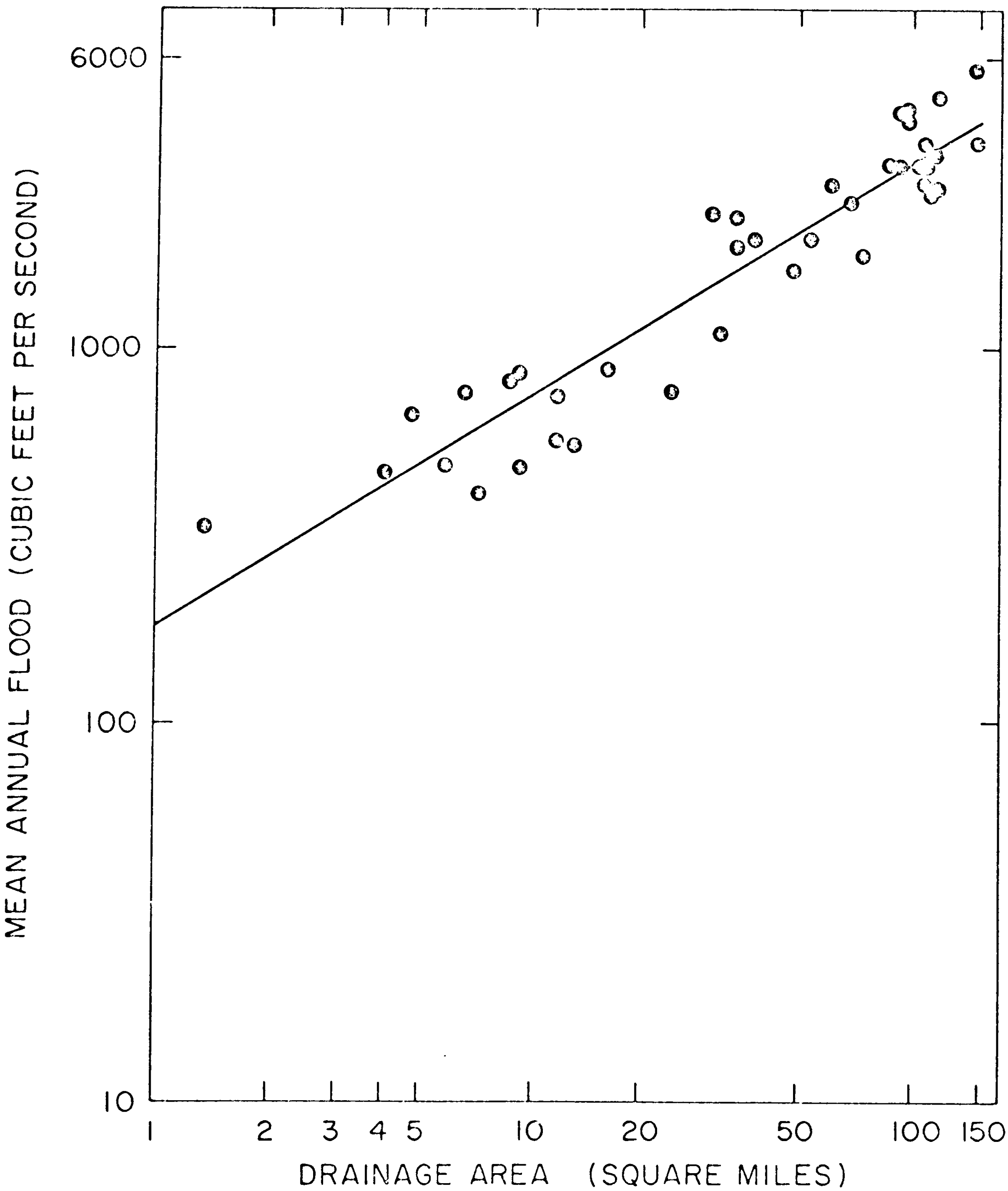

FIGURE 2: VARIATION OF MEAN ANNUAL FLOOD WITH DRAINAGE AREA IN REGION 2-A (EXCEPT COASTAL PLAIN)

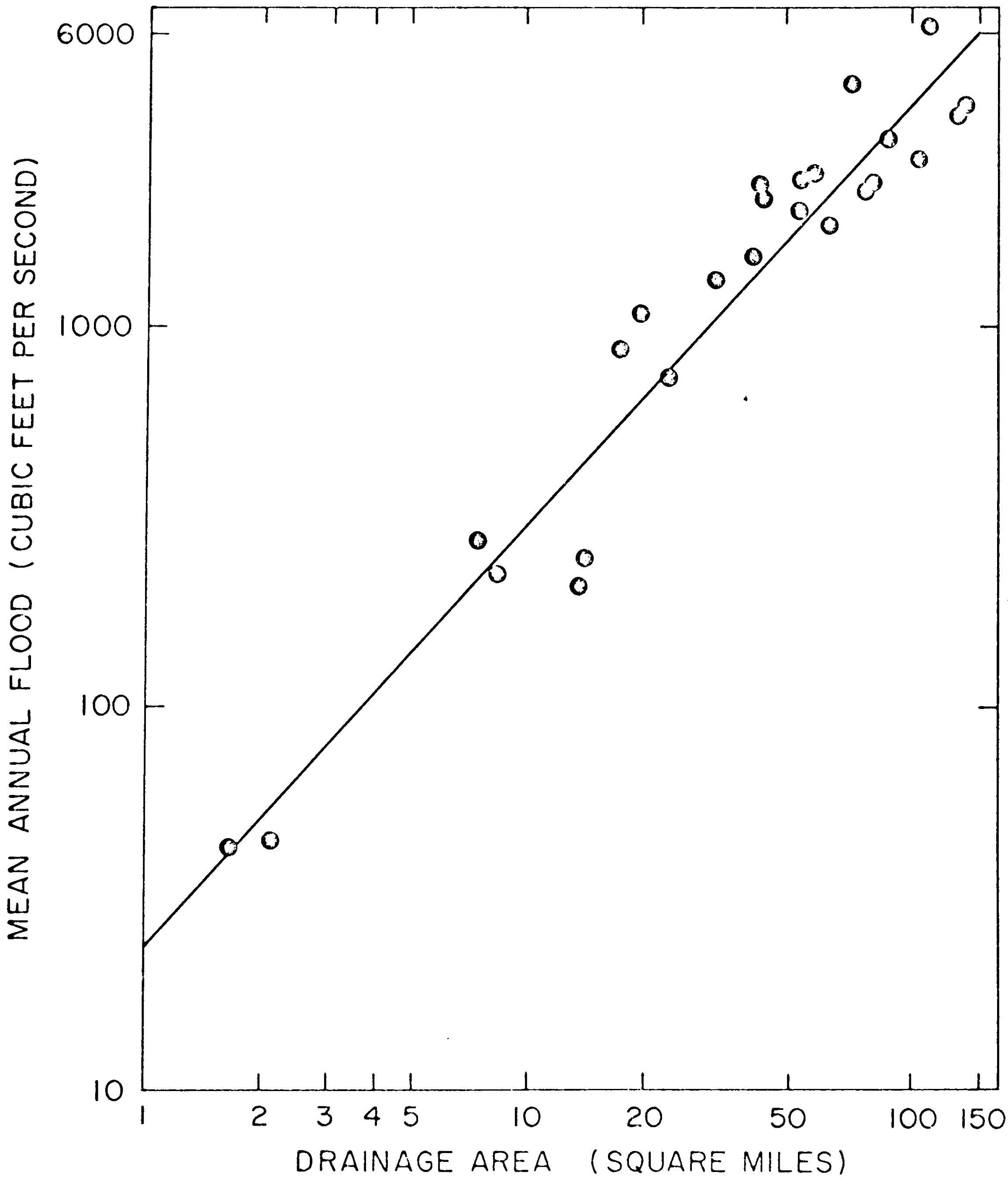

FIGURE 3 : VARIATION OF MEAN ANNUAL FLOOD WITH DRAINAGE AREA IN REGIONS 3-A AND 3-B

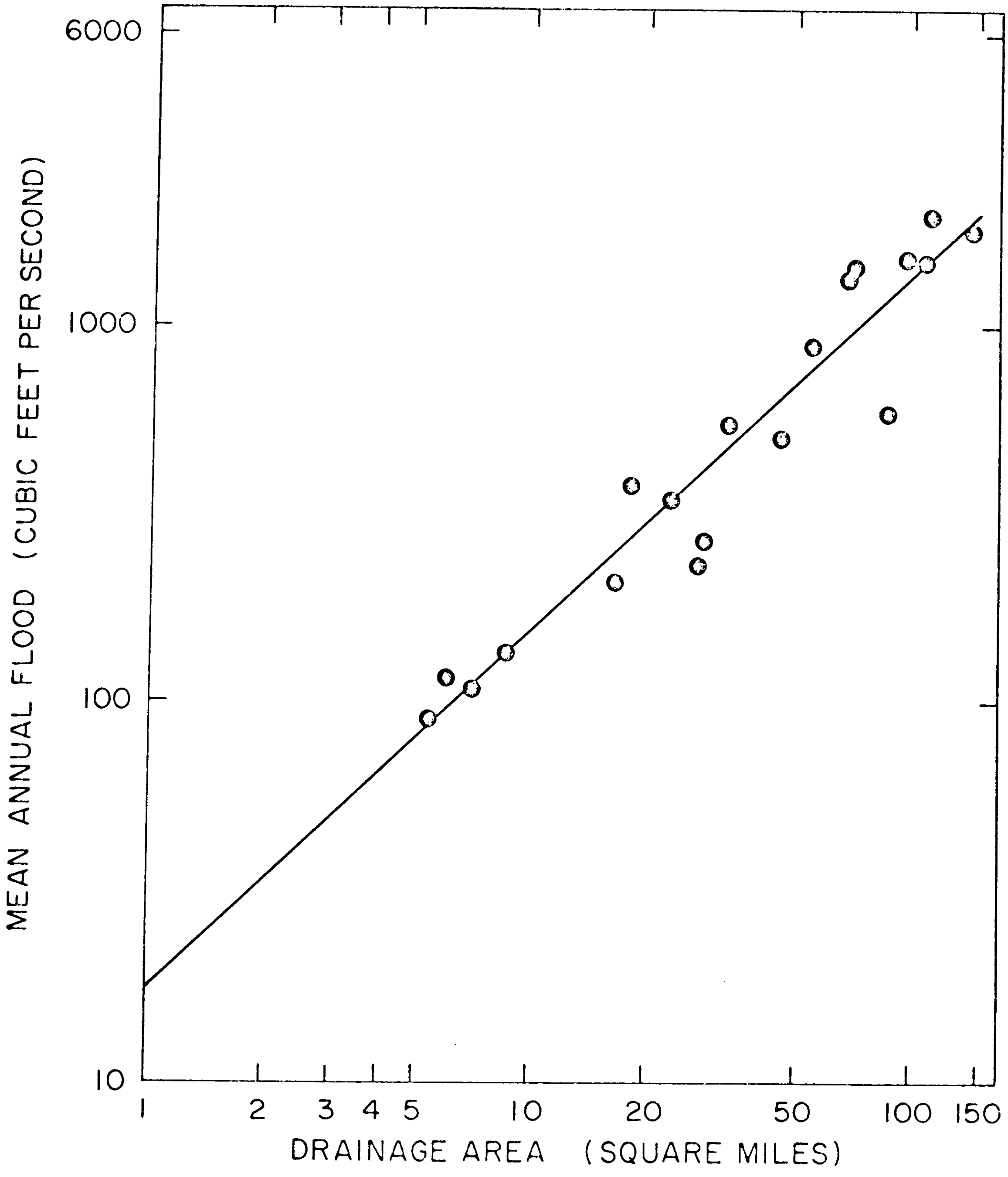

FIGURE 4: VARIATION OF MEAN ANNUAL FLOOD WITH DRAINAGE AREA IN COASTAL PLAIN

VI. FLOOD-FREQUENCY RELATIONS

Data Used

The basic data used in this report are the records of annual maximum discharge collected at gaging stations operated by the U.S. Geological Survey and other agencies, mainly the Virginia Division of Water Resources. Records from 161 gaging stations were used. These data are published in annual reports of the Geological Survey, and compilations have been made in several reports. Streamflow records used in this report were restricted to gaging stations with less than 150 square miles of drainage area and with annual peaks for 5 or more years. Available records through the 1967 water year were used.

The basic data are fairly uniformly distributed with respect to geographic location, length of record, and drainage area size. The longer records are generally from the Piedmont and Blue Ridge provinces; however, the collective records of the Coastal Plain province are sufficient for flood-frequency definition except for areas adjacent to the coast, which are under the influence of tidal effects.

Station Frequency

A flood-frequency relation defining the variation of annual peak discharge with recurrence interval was prepared for each station used. For this purpose a computer program [17] was used. Generally this program correlated short record stations with long record stations. The shorter records were extended based on this correlation. The mean, standard deviation, and skew for each extended record was computed and a frequency curve was computed using the log-Pearson Type III method and the median plotting position formula as proposed by Beard [1]. The flood-frequency relation for each station represents a statistical sample with respect to geography and time, and forms the basis for the regional analysis.

The flood frequency relation for each gaging station was defined by drawing a smooth curve through the plotted points for annual peak discharges on log-probability paper. The abscissa is the annual peak discharge and the ordinate is the probability of exceedance.

The term "exceedance interval" or "recurrence interval" is defined as the average interval of time within which a flood of a given magnitude is equaled or exceeded once. A flood with a recurrence interval of 25 years is the annual flood that is equaled or exceeded once in 25 years on the long-term average. The concept implies no regularity in the time of recurrence of a given magnitude of flood. For example, floods having recurrence intervals of 25 years or greater might occur either in two consecutive years or at intervals much longer than 25 years. Another concept of frequency is in terms of probability. The probability of occurrence of a 25-year flood in any given year is 1 in 25, or 0.04.

The Composite Frequency Curve

The station flood-frequency curve is only a sample at one particular site for a specific time period, and in all probability does not represent the long-term average flood experience for the general area. This is particularly true for frequency curves based on short records. Unfortunately, most streamflow records are considered short in a statistical sense. Because of the limitations of single-station curves, a composite curve was defined for each of the four flood-frequency regions. Each curve is applicable to all points in its respective region.

In order for individual frequency curves to be combined, it was first necessary that they be expressed in comparable terms; therefore, discharges for selected recurrence intervals were expressed as ratios to the mean annual flood. The mean annual flood in this report is simply the mean of the annual floods and should not be confused with the mean annual flood used by the U.S. Geological Survey which is by definition the flood having a recurrence interval of 2.33 years.

The mean ratio of discharge to the mean annual flood for each category of recurrence interval in each region was computed and plotted on semi-logarithmic paper to form the composite curve for that region. The composite curves for the flood-frequency regions in Virginia are shown in Figures 5 through 8.

The composite curves are applicable within a region to estimate flood-frequency relations for any site (drainage area, less than 150 square miles), gaged or ungaged, not materially affected by manmade changes. Results from the use of the composite curve should be more reliable than results from the use of individual station frequency curves, even for gaged sites.

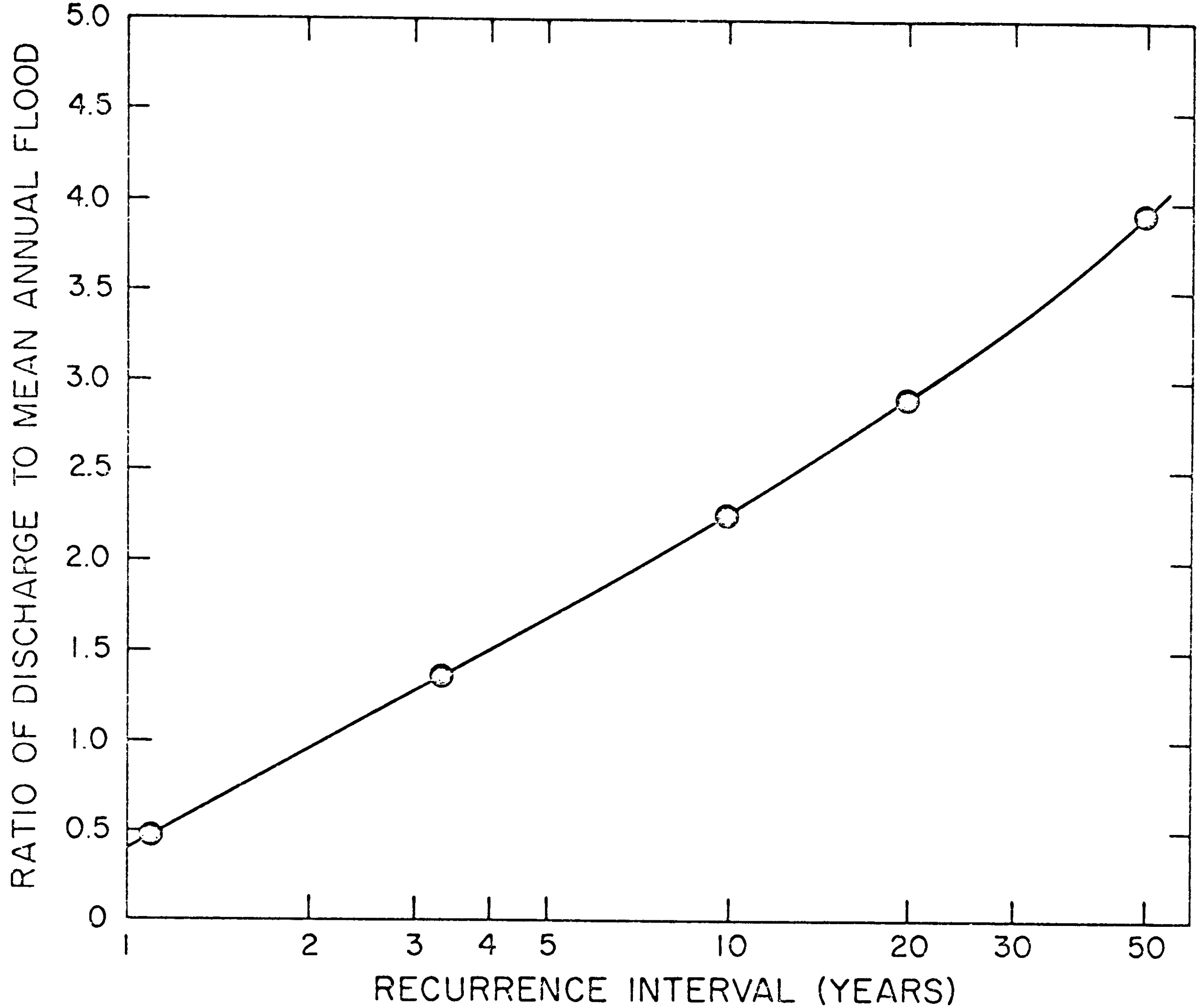

FIGURE 5 : COMPOSITE FREQUENCY CURVE FOR REGION I - B
(EXCEPT COASTAL PLAIN)

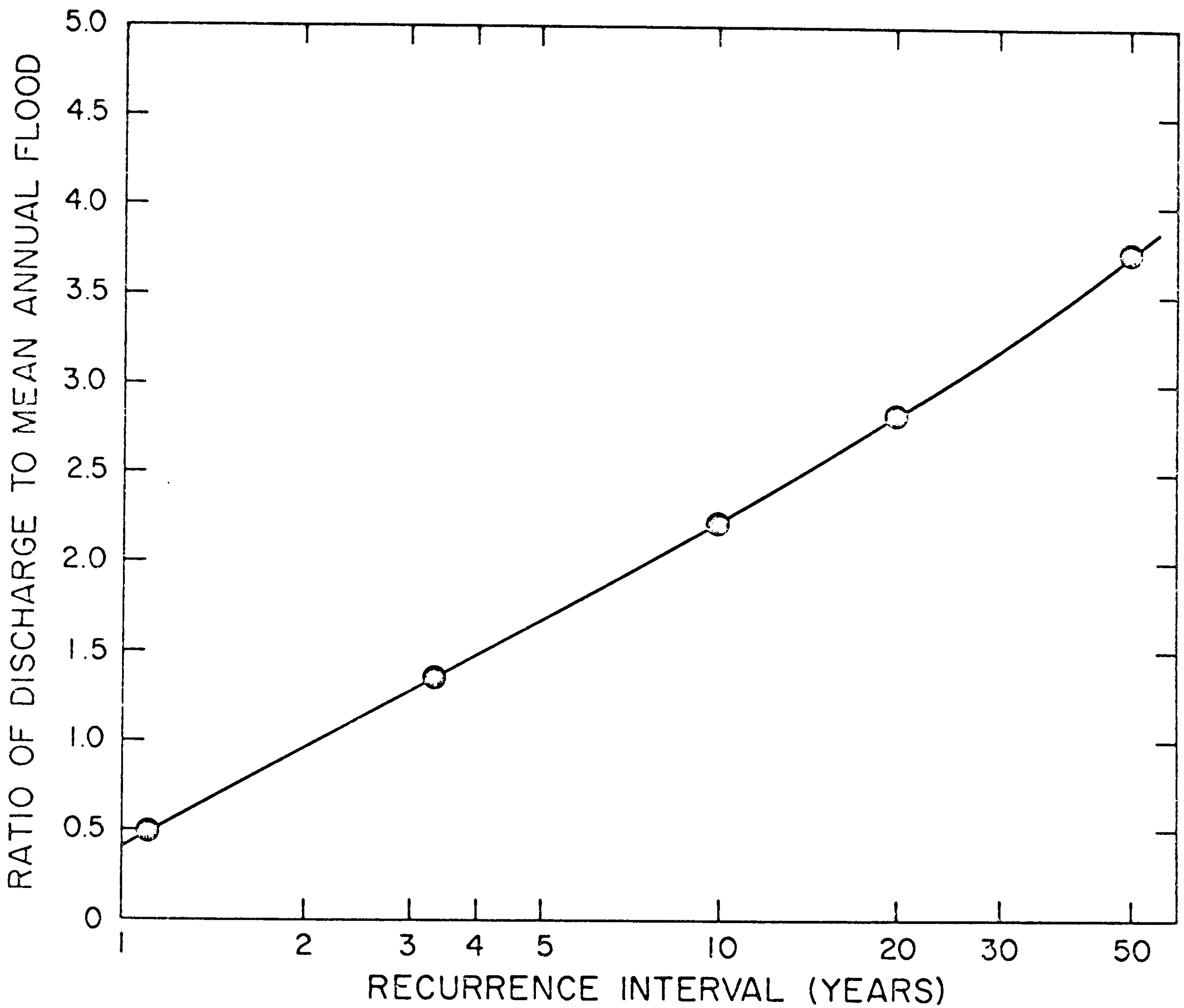

FIGURE 6: COMPOSITE FREQUENCY CURVE FOR REGION 2-A (EXCEPT COASTAL PLAIN)

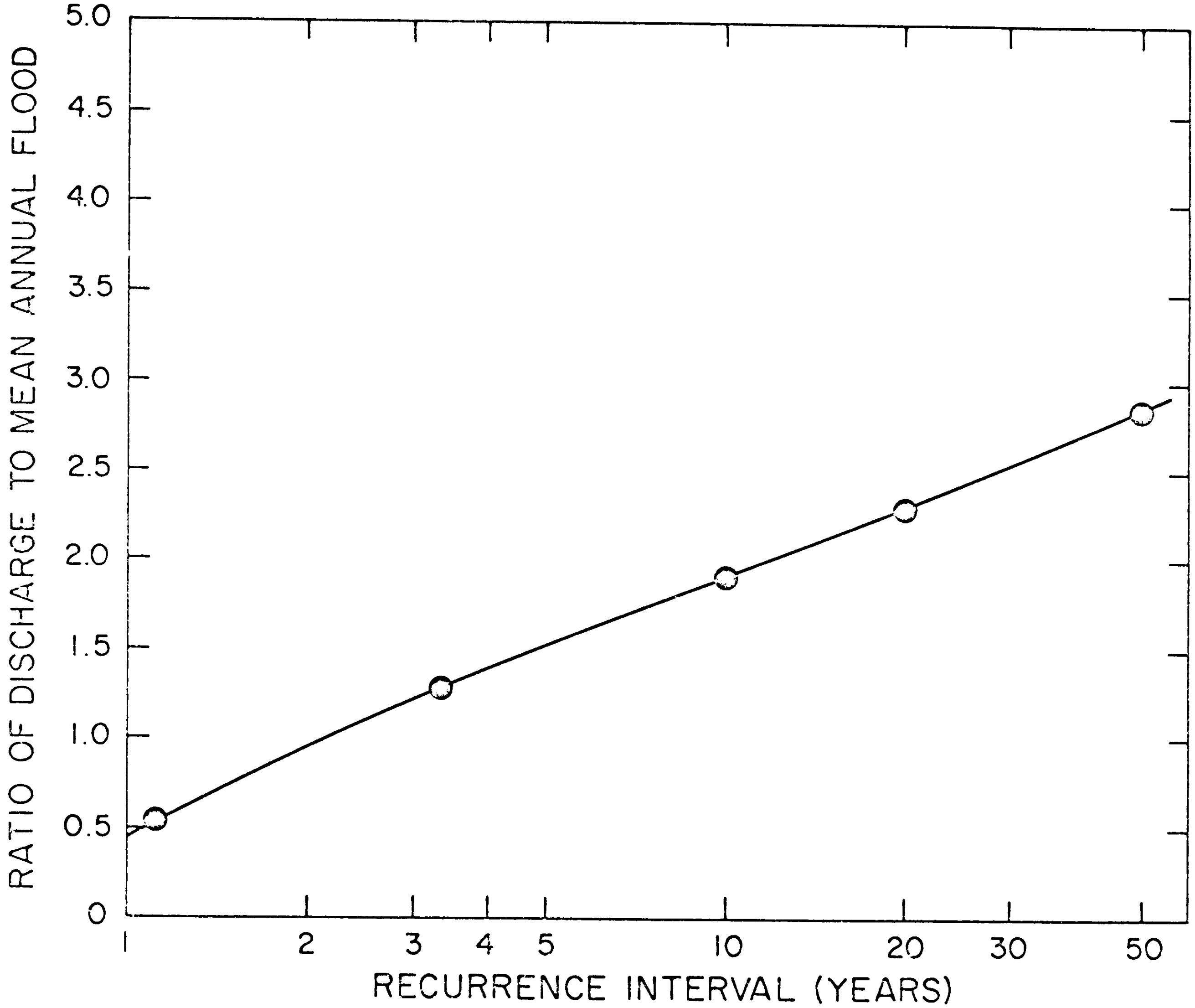

FIGURE 7: COMPOSITE FREQUENCY CURVE FOR REGIONS 3-A AND 3-B

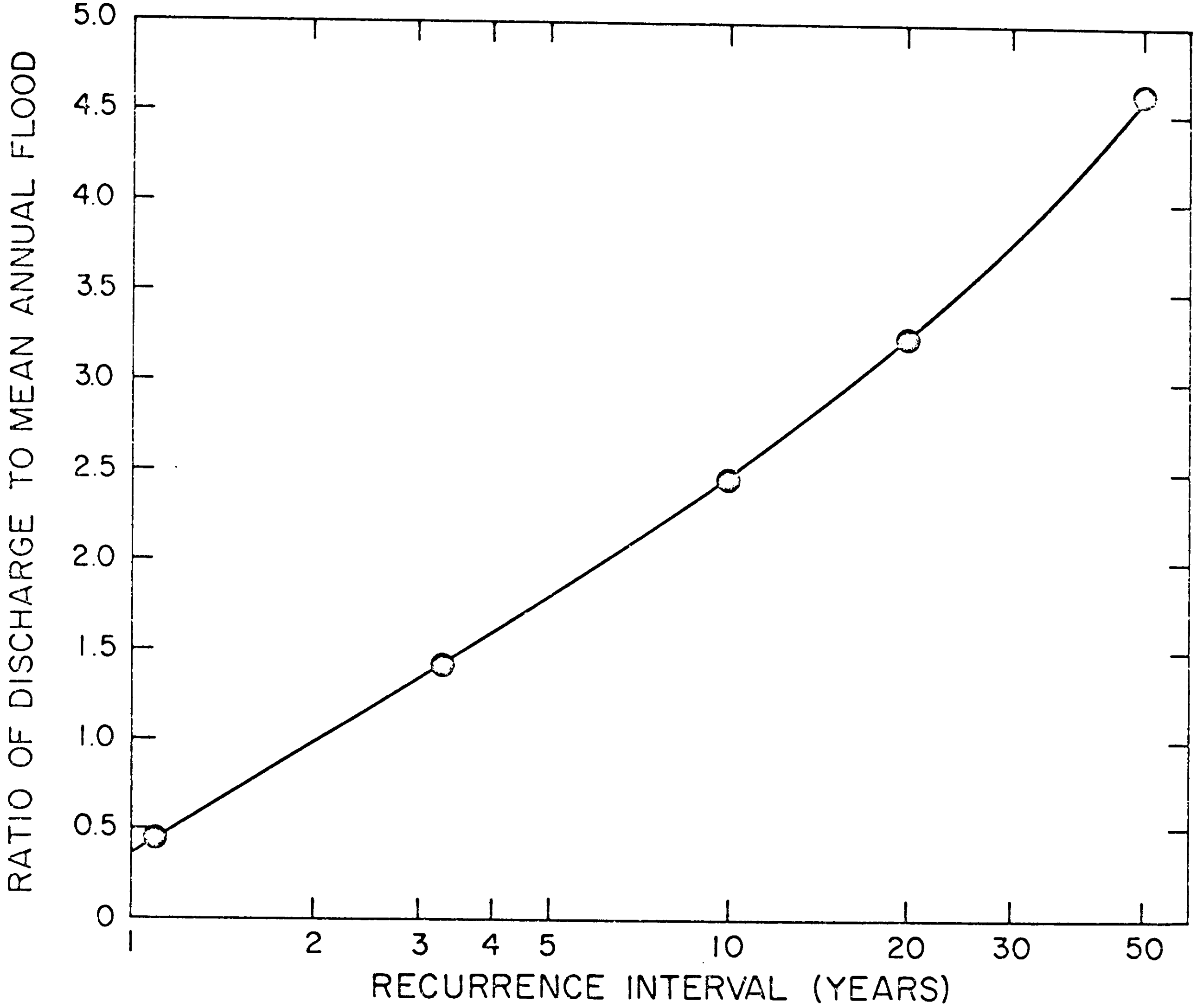

FIGURE 8 : COMPOSITE FREQUENCY CURVE FOR COASTAL PLAIN

VII. LIMITATIONS AND APPLICATION OF RESULTS

This paper was an attempt to examine individual flood records in Virginia for small drainage basins to develop generalized relationships that apply anywhere in the State, including ungaged sites. While this approach may overcome many of the uncertainties due to sampling error at individual sites there remains certain deficiencies in the method and some limitations on the use of the results.

As with any flood-frequency study the selection of a frequency distribution and plotting position formula has to be somewhat arbitrary. The selection of the log-Pearson Type III distribution and Beard plotting position formula was made entirely for convenience. Both, however, give good results and considering the state of the art with respect to flood flow frequency methods, neither require further justification.

The decision to divide the State into four flood-frequency regions, while not entirely arbitrary, is subject to question. Other than the fact that the data seems to fall into these four divisions and the fact that these divisions seem to be logical and consistent with other flood frequency reports no justification can be given.

Limitations

Of the many small streams in the State, those gaged afford a limited statistical sample of the magnitude and frequency of floods. Average relations of streams having only natural flows are used. The relations for streams draining less than 1 square mile are not defined. Regional frequency curves cannot be extrapolated with confidence beyond 50 years, and composite flood-frequency curve 8 is not well defined beyond 25 years because of the scarcity of long-term records for small streams in the Coastal Plain. Relations as defined in this report should not be used for areas immediately adjacent to the sounds.

Local influences on floods, such as regulation, urbanization, unusual geology, or ground cover, may not be represented by the average natural-flow condition of the streams used in this analysis. Special consideration is necessary for streams having predominant characteristics differing from those for the general area.

Application of Results

Detailed procedures are given below for determining the magnitudes of floods having recurrence intervals ranging from 1 to 50 years at sites having drainage areas between 1 and 150 square miles in Virginia

1. Ascertain that the selected site is not materially affected by manmade regulation or control, channel improvement, or extensive diversion of flood waters.

2. Determine the drainage area above the selected site to insure it is less than or equal to 150 square miles.

3. Determine the flood-frequency region in which the drainage area is located. Region 1-B covers the northern portion of Virginia south to the James River with the exception of streams draining into the Ohio River basin and streams in the Coastal Plain. Region 2-A covers the area south of the James River with the exception of streams draining into the Tennessee and Cumberland River basins and streams in the Coastal Plain. Streams draining into the Ohio, Tennessee and Cumberland basins are in the composite area 3-A and 3-B. Locations in the

Coastal Plain of either regions 1-B and 2-A are in the Coastal Plain region.

4. Use the appropriate Figure 1-4 to determine the mean annual flood for the selected site.

5. From Figures 5-8, use the appropriate curve and determine the ratio of discharge to the mean annual flood for the selected recurrence interval.

6. Multiply the ratio by the mean annual flood to determine the peak discharge for the selected recurrence interval.

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IX. APPENDIX

COMPUTER PROGRAM FOR

REGIONAL FREQUENCY ANALYSIS

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C      23-X6-268 REGIONAL FREQUENCY COMPUTATION, HEC, C OF E , OCT 1969
C      LIBRARY SUBROUTINES USED ALOG,SIN -- SEE COMMENTS IN FUNCTION RNGEN
C      INDEXES I=DURATION  J=YEAR  K=STATION  L=RELATED STA M=SEQUENCE NO
       DIMENSION
     1AA(8),AB(8),ANYR(8,10),AV(8,10),B(10),DQ(8,10),IQ(8),IRCRD(100),
     2ISTA(10),NCAB(8,10,20),NLOG(8,10),P(8),PLOT(100),XQ(8),
     3Q(400,10),QM(400),QR(400,10),R(10,11),RA(8,10,20),SD(8,10),
     4SKEW(8,10),SKW(8),SQA(8,10,20),SQB(8,10,20),SUMA(8,10,20),SUMB(8,
     510,20),X(400),XPAB(8,10,20),AAA(8,10,20),AAB(8,10,20),
     6KEEP(4),IKEEP(10),QMIN(8,10),XINCR(8)
       DIMENSION ISTN(10),ISTY(10),SDA(8,10,20),SDB(8,10,20)
       COMMON DTRMC,NINDP,B
       DATA LTRA/1HA/,BLANK/1H /,E/1HE/
       KSTA=10
       KDUR=8
       KYRS=50
     1 FORMAT(1X,I7,9I8)
     2 FORMAT(1X,F7.0,9F8.0)
     3 FORMAT(A1,A3,9A4,10A4)
     4 FORMAT(1X,A3,9A4,10A4)
     5 FORMAT(1H1)
     6 FORMAT(1X,I7,I8,8F8.0)
     7 FORMAT (2X,A3,A4,F9.3)
     8 FORMAT (1X,2A4,F9.3)
     9 FORMAT (20F6.3)
       DO 2009 K=1,KSTA
  2009 ISTA(K)=-1
       IYRSV=0
C                WASTE CARDS UNTIL AN A IN COL 1, FIRST TITLE CARD
    10 READ(5,3)IA,(QR(J,1),J=1,20)
       IF (IA.NE.LTRA) GO TO 10
       READ(5,4)((QR(J,K),J=1,20),K=2,3)
       READ(5,1)NDUR,IYRA,ISKEW,NSTAT,NSMTH,INCAD,(KEEP(I),I=1,4)
C                TERMINATE WITH 4 BLANK CARDS, AN A IN COL 1 OF FIRST
       IF(NDUR.LT.1)STOP
       WRITE(6,5)
       WRITE(6,4)((QR(J,K),J=1,20),K=1,3)
       IF(NDUR.LE.KDUR)GO TO 40
    20 WRITE(6,30) NSTA,NDUR,NYRS
    30 FORMAT(/19H DIMENSION EXCEEDED ,5X,5HNSTA=,I3,5X,5HNDUR=,I2,5X,5HN
     1YRS=,I4)
       GO TO 10
    40 WRITE(6,50)NDUR,IYRA,ISKEW,NSTAT,NSMTH,INCAD
    50 FORMAT(/5H NDURI2,6H  IYRAI5,7H  ISKEWI2,7H  NSTAT I3,7H  NSMTH I3
     1,7H  INCAD,I3)
       IF(KEEP(1).LE.0) GO TO 52
       WRITE(6,51)(KEEP(I),I=1,4)
    51 FORMAT(/31H  STATION(S) KEPT FROM LAST RUN ,5(I6,1H,))
    52 READ(5,4)(AA(I),AB(I),I=1,NDUR)
       READ (5,2)(P(I),I=1,NDUR)
       IF (P(1).LE.0.) GO TO 56
       WRITE (6,55)
    55 FORMAT (/30H RATIOS TO OBTAIN RATE OF FLOW)
       WRITE (6,7) AA(1),AB(1),P(1)
       IF (NDUR.GT.1) WRITE (6,8)(AA(I),AB(I),P(I),I=2,NDUR)
```

```
          GO TO 58
       56 DO 57 I=1,NDUR
          P(I)= 1.
       57 CONTINUE
       58 AVGSK=0.
          IF(ISKEW.LE.0)GO TO 59
          READ(5,2)(SKW(I),I=1,NDUR)
          DO 2058 I=1,NDUR
     2058 AVGSK=AVGSK+SKW(I)
          TEMP=NDUR
          AVGSK=AVGSK/TEMP
C                   SET CONSTANTS
       59 T=99999999.
          IXX=0
          IYRA=IYRA-1
          NSTA=NSTAT
          IF (NSTAT.GT.0) GO TO 1131
          NSTA=0
C                   SAVE STATIONS FROM PREVIOUS RUN IF NECESSARY
          INDC=0
          ITP=KDUR*KYRS
          DO 12059 K=1,KSTA
          IKEEP(K)=0
          DO 12059 N=1,ITP
          QR(N,K)=(-1.)
    12059 CONTINUE
          IF(KEEP(1).LE.0) GO TO 2060
          DO 8059 K=1,KSTA
          DO 6059 L=1,4
          IF(KEEP(L).NE.ISTA(K)) GO TO 6059
          INDC=1
          NSTA=NSTA+1
          IKEEP(NSTA)=1
          ISTA(NSTA)=ISTA(K)
          DO 10059 I=1,NDUR
          NLOG(I,NSTA)=0
          DQ(I,NSTA)=0.
    10059 CONTINUE
          M=0
          ITP=1
          MM=(IYRSV-IYRA)*NDUR
          IF(MM.GE.0) GO TO 16059
          M=-MM
          MM=0
          ITP=IYRA-IYRSV+1
          IF(ITP.LE.0) ITP=1
    16059 DO 4059 J=ITP,NYRS
          DO 2059 I=1,NDUR
          M=M+1
          MM=MM+1
          IF(IRCRD(J).LE.0) GO TO 2059
          QR(MM,NSTA)=Q(M,K)
          NLOG(I,NSTA)=NLOG(I,NSTA)+1
          DQ(I,NSTA)=DQ(I,NSTA)+QR(MM,NSTA)
     2059 CONTINUE
```

```
 4059 CONTINUE
 6059 CONTINUE
 8059 CONTINUE
 2060 IF(INDC.LT.1) NYRS=0
      ITP= NSTA+1
      DO 4060 K=ITP,KSTA
      ISTA(K)=-1
 4060 CONTINUE
      IYRSV=IYRA
C                 INITIATE -1, NO RECORD FOR ALL FLOWS
      ITP=KDUR*KYRS/NDUR
      DO 80 K=1,KSTA
      DO 70 I=1,NDUR
      IF(IKEEP(K).EQ.1) GO TO 6060
      NLOG(I,K)=0
      DQ(I,K)=0.
 6060 DO 60 J=1,ITP
      N=NDUR*(J-1)+I
      Q(N,K)=QR(N,K)
   60 CONTINUE
   70 CONTINUE
   80 CONTINUE
C  * * * * * * READ AND PROCESS ONE STATION-YEAR OF DATA * * * * * * * * * * * * *
   90 READ(5,6)ISTAN,IYR,(QM(I),I=1,NDUR)
C                 BLANK CARD INDICATES END OF FLOW DATA
      IF(ISTAN.LT.1)GO TO 160
      IF(NSTA.LT.1)GO TO 110
      DO 100 K=1,NSTA
C                 IDENTIFY STATION SUBSCRIPT
      IF(ISTAN.EQ.ISTA(K))GO TO 120
  100 CONTINUE
  110 NSTA=NSTA+1
C                 ASSIGN SUBSCRIPT TO NEW STATION
      IF(NSTA.GT.KSTA) GO TO 20
      K=NSTA
      ISTA(K)=ISTAN
C                 ASSIGN SUBSCRIPT TO YEAR
  120 J=IYR-IYRA
      IF(NYRS.LT.J)NYRS=J
      IF(J.GT.0)GO TO 140
      WRITE(6,130)IYR
  130 FORMAT(/18H UNACCEPTABLE YEAR I5)
      GO TO 10
C                 STORE FLOWS IN STATION AND DURATION ARRAY
  140 M=(J-1)*NDUR
      DO 150 I=1,NDUR
      M=M+1
      IF(QM(I).LT.0)GO TO 150
      NLOG(I,K)=NLOG(I,K)+1
      DQ(I,K)=DQ(I,K)+QM(I)
      Q(M,K)=QM(I)
  150 CONTINUE
      GO TO 90
  160 IF(NYRS*NDUR.GT.KYRS*KDUR) GO TO 20
C  * * * * * * COMPUTE FREQUENCY STATISTICS * * * * * * * * * * * * * * * * * *
```

```
          WRITE(6,170)
      170 FORMAT(/21H FREQUENCY STATISTICS)
          WRITE(6,180)(AA(I),AB(I),I=1,NDUR)
      180 FORMAT(5X,12HSTA     ITEM 3X,A3,A4,7(3X,2A4))
          DO 183 J=1,NYRS
      183 IRCRD(J)=0
          KRCRD=1
          ICORL=1
          IF(NDUR.EQ.1.AND.NSTA.EQ.1) ICORL=0
          INDC=0
          DO 262 K=1,NSTA
      185 DO 186 I=1,NDUR
          TEMP=T
          M=I-NDUR
          DO 2185 J=1,NYRS
          M=M+NDUR
          TMP=Q(M,K)
          IF(TMP.LT.0.) GO TO 2185
          IF(TMP.LT.TEMP) TEMP=TMP
     2185 CONTINUE
          QMIN(I,K)=TEMP
          TEMP=NLOG(I,K)
          IF (TEMP.LT.0.1) GO TO 186
          DQ(I,K)=DQ(I,K)*.001/TEMP
          IF(DQ(I,K).LT..0001) DQ(I,K)=.0001
      186 CONTINUE
          XMIN=T
          DO 187 I=1,NDUR
          IF(DQ(I,K).LT.0001) GO TO 187
          TEMP=(QMIN(I,K)+DQ(I,K))/DQ(I,K)
          IF(TEMP.LT.XMIN) XMIN=TEMP
      187 CONTINUE
          DO 2187 I=1,NDUR
          XINCR(I)=XMIN/16.*DQ(I,K)
     2187 CONTINUE
          N=0
      188 DO 190 I=1,NDUR
          ANYR(I,K)=0.
          AV(I,K)=0.
          SD(I,K)=0.
          SKEW(I,K)=0.
      190 CONTINUE
          M=0
          DO 220 J=1,NYRS
          DO 210 I=1,NDUR
          M=M+1
          IF(Q(M,K).LT.0.) GO TO 200
          IRCRD(J)=1
          QR(M,K)=BLANK
          ANYR(I,K)=ANYR(I,K)+1.
C                   REPLACE FLOW ARRAY WITH LOG ARRAY
          TEMP=ALOG(Q(M,K)+DQ(I,K))*.4342945
          IF(ICORL.EQ.1) Q(M,K)=TEMP
C                   SUM, SQUARES AND CUBES
          AV(I,K)=AV(I,K)+TEMP
```

```
            SD(I,K)=SD(I,K)+TEMP*TEMP
            SKEW(I,K)=SKEW(I,K)+TEMP*TEMP*TEMP
            GO TO 210
C                     MISSING FLOWS EQUATED TO T
        200 Q(M,K)=T
            QR(M,K)=E
            KRCRD=0
        210 CONTINUE
        220 CONTINUE
            SUM=0.
            DO 240 I=1,NDUR
            TEMP=NLOG(I,K)
            IF (TEMP.LT.0.5) GO TO 240
            TMP=AV(I,K)
            AV(I,K)=TMP/TEMP
            IF (SD(I,K).LE.0.0.OR.TEMP.LT.2.5) GO TO 230
            TMPA=SD(I,K)
            SD(I,K)=((SD(I,K)-AV(I,K)*TMP)/(TEMP-1.))**.5
            SKEW(I,K)=(TEMP*TEMP*SKEW(I,K)-3.*TEMP*TMP*TMPA+2.*TMP*TMP*TMP)/
           1(TEMP*(TEMP-1.)*(TEMP-2.)*SD(I,K)**3)
            GO TO 235
        230 SD(I,K)=0.
            SKEW(I,K)=0.
        235 SUM=SUM+SKEW(I,K)
        240 CONTINUE
            TEMP=NDUR
            SUM=SUM/TEMP
            N=N+1
            IF(N.GT.1)GO TO 241
C                     PRINT FREQUENCY STATISTICS
            WRITE(6,342)ISTA(K),(AV(I,K),I=1,NDUR)
            WRITE(6,344)(SD(I,K),I=1,NDUR)
            WRITE(6,346)(SKEW(I,K),I=1,NDUR)
            WRITE(6,348)(DQ(I,K),I=1,NDUR)
            WRITE(6,349)(ANYR(I,K),I=1,NDUR)
            IF(ISKEW.LE.0.OR.INCAD.LE.0) GO TO 262
        241 IF(N.GE.16) GO TO 262
            IF(SUM.GT.(AVGSK-.1).AND.SUM.LT.(AVGSK+.1)) GO TO 262
            INDC=1
            M=0
            DO 244 J=1,NYRS
            DO 243 I=1,NDUR
            M=M+1
            IF(Q(M,K).EQ.T)  GO TO 242
            TEMP=Q(M,K)
            Q(M,K)=10.**TEMP-DQ(I,K)
            GO TO 243
        242 Q(M,K)=-1.
        243 CONTINUE
        244 CONTINUE
            IF(SUM-AVGSK) 2244,262,250
       2244 DO 245 I=1,NDUR
        245 DQ(I,K)=DQ(I,K)*1.5
            GO TO 188
        250 DO 260 I=1,NDUR
```

```
0248          DQ(I,K)=DQ(I,K)-XINCR(I)
0249      260 CONTINUE
0250          GO TO 188
0251      262 CONTINUE
0252          NSTAX=NSTA+NSTA
0253          IF (NDUR.EQ.1) NSTAX=NSTA
        C               OMIT CORRELATIONS IF ONLY 1 STA AND 1 DURATION
0254      351 ITRNS=0
0255          IF(ICORL.EQ.1) GO TO 358
0256          M=0
0257          ANYRS=0.
0258          DO 354 J=1,NYRS
0259          M=M+1
0260          IF (Q(J,1).EQ.T) GO TO 354
0261          ANYRS=ANYRS+1.
0262          QR(M,1)=BLANK
0263          IRCRD(M)=1
0264      354 CONTINUE
0265          GO TO 925
        C               OMIT CORRELATIONS IF NO MISSING FLOWS
0266      358 IF(KRCRD.EQ.1) GO TO 308
        C  * * * * * * COMPUTE SUMS OF SQUARES AND CROSS PRODUCTS * * * * * * * * * * * *
0267      360 DO 2392 K=1,NSTA
0268          DO 370 I=1,NDUR
0269          DO 370 L=1,NSTAX
0270          RA(I,K,L)=-4.
0271          SUMA(I,K,L)=0.
0272          SUMB(I,K,L)=0.
0273          SQA(I,K,L)=0.
0274          SQB(I,K,L)=0.
0275          XPAB(I,K,L)=0.
0276          NCAB(I,K,L)=0
0277          AAA(I,K,L)=0.
0278          AAB(I,K,L)=0.
0279      370 CONTINUE
0280     2392 CONTINUE
0281          DO 490 K=1,NSTA
0282          KX=K+1
0283          IF(KX.GT.NSTAX) GO TO 448
0284          M=0
0285          DO 445 J=1,NYRS
0286          DO 440 I=1,NDUR
0287          M=M+1
0288          TEMP=Q(M,K)
0289          IF(TEMP.EQ.T)GO TO 440
0290          IF(ITRNS.EQ.1) TEMP=ALOG(TEMP)*.4342945
0291          DO 400 L=K,NSTAX
        C               SUBSCRIPTS EXCEEDING NSTA RELATE TO ADJACENT DURATION
0292          IF(L.LE.NSTA)GO TO 393
0293          LX=L-NSTA
0294          IF (I.EQ.1) TMP=Q(M+1,LX)
0295          IF(I.GT.1)TMP=Q(M-1,LX)
0296          IF(TMP.EQ.T)GO TO 400
0297          IF(ITRNS.EQ.1) TMP=ALOG(TMP)*.4342945
0298          GO TO 395
```

```
  393 TMP=Q(M,L)
      IF(ITRNS.EQ.1) TMP=ALOG(TMP)*.4342945
      IF(TMP.EQ.T)GO TO 400
C               COUNT AND USE ONLY RECORDED PAIRS
  395 NCAB(I,K,L)=NCAB(I,K,L)+1
      SUMA(I,K,L)=SUMA(I,K,L)+TEMP
      SUMB(I,K,L)=SUMB(I,K,L)+TMP
      SQA (I,K,L)=SQA (I,K,L)+TEMP*TEMP
      SQB (I,K,L)=SQB (I,K,L)+TMP*TMP
      XPAB(I,K,L)=XPAB(I,K,L)+TEMP*TMP
      IF(L.GT.NSTA) GO TO 400
      NCAB(I,L,K)=NCAB(I,K,L)
      SUMA(I,L,K)=SUMB(I,K,L)
      SUMB(I,L,K)=SUMA(I,K,L)
      SQA (I,L,K)=SQB (I,K,L)
      SQB (I,L,K)=SQA (I,K,L)
      XPAB(I,L,K)=XPAB(I,K,L)
  400 CONTINUE
  440 CONTINUE
  445 CONTINUE
C  * * * * * * COMPUTE CORRELATION COEFFICIENTS  * * * * * * * * * * * * * * * *
      ITMP=0
  448 DO 480 I=1,NDUR
C               SEARCH FOR DURATION WITH LONGEST RECORD
      ITEMP=NLOG(I,K)
      IF(ITEMP.LE.ITMP) GO TO 450
      ITMP=ITEMP
      IX=I
  450 IF(KX.GT.NSTAX) GO TO 2478
      DO 470 L=KX,NSTAX
C               ELIMINATE PAIRS WITH LESS THAN 3 YRS DATA
      IF(NCAB(I,K,L).LE.2) GO TO 469
      TEMP=NCAB(I,K,L)
      AAA(I,K,L)=SUMA(I,K,L)/TEMP
      AAB(I,K,L)=SUMB(I,K,L)/TEMP
      TMP=(SQA(I,K,L)-SUMA(I,K,L)*SUMA(I,K,L)/TEMP)*(SQB(I,K,L)-SUMB
     1(I,K,L)*SUMB(I,K,L)/TEMP)
      IF(TMP.LE.0.) GO TO 468
      TMPB=1.
      TMPA=XPAB(I,K,L)-SUMA(I,K,L)*SUMB(I,K,L)/TEMP
      IF(TMPA.LT.0.)TMPB=-TMPB
      TMPA=TMPA*TMPA/TMP
      TMPA=1.-(1.-TMPA)*(TEMP-1.)/(TEMP-2.)
      IF(TMPA.LT.0.)TMPA=0.
      RA(I,K,L)=TMPB*TMPA**.5
      TMP=(SQA(I,K,L)-SUMA(I,K,L)*AAA(I,K,L))/(TEMP-1.)
      IF(TMP.LT.0.) TMP=0.
      SDA(I,K,L)=TMP**.5
      TMP=(SQB(I,K,L)-SUMB(I,K,L)*AAB(I,K,L))/(TEMP-1.)
      IF(TMP.LT.0.) TMP=0.
      SDB(I,K,L)=TMP**.5
  469 IF(L.GT.NSTA) GO TO 470
      RA(I,L,K)=RA(I,K,L)
      AAB(I,L,K)=AAA(I,K,L)
      AAA(I,L,K)=AAB(I,K,L)
```

```
            SDA(I,L,K)=SDB(I,K,L)
            SDB(I,L,K)=SDA(I,K,L)
            GO TO 470
        468 RA(I,K,L)=0.
        470 CONTINUE
C                    ELIMINATE NEGATIVE GROSS CORRELATIONS
       2478 DO 478 L=1,NSTAX
            TEMP=RA(I,K,L)
            IF (TEMP.LT.0.0.AND.TEMP.GE.(-1.0)) RA(I,K,L)=0.
        478 CONTINUE
            RA(I,K,K)=1.
        480 CONTINUE
        490 CONTINUE
            IF(ITRNS.NE.0) GO TO 725
C * * * * * *  ADJUSTMENT OF FREQUENCY STATISTICS TO LONG TERM
            DO 16490 II=1,NDUR
            I=IX+II-1
            IF(I.GT.NDUR)I=NDUR-II+1
            DO 2490 K=1,NSTA
            ISTN(K)=K
            ISTY(K)=NLOG(I,K)
       2490 CONTINUE
C                    ARRAY STATIONS - LONGEST RECORD FIRST,ETC
            ITMP=NSTA-1
            DO 6490 KX=1,ITMP
            ITP=KX+1
            DO 4490 K=ITP,NSTA
            IF(ISTY(KX).GT.ISTY(K)) GO TO 4490
            ITEMP=ISTN(KX)
            ISTN(KX)=ISTN(K)
            ISTN(K)=ITEMP
            ITEMP=ISTY(KX)
            ISTY(KX)=ISTY(K)
            ISTY(K)=ITEMP
       4490 CONTINUE
       6490 CONTINUE
            DO 14490 KX=1,NSTA
            K=ISTN(KX)
            TMPB=NLOG(I,K)
            INDC=0
            DO 12490 LX=1,KX
            IF(LX.EQ.KX) GO TO 8490
            ITP=I
            L=ISTN(LX)
            TMP=NLOG(I,L)
            TMPP=NCAB(I,K,L)
            GO TO 10490
       8490 IF(NDUR.EQ.1) GO TO 12490
            ITP=I-1
            IF(ITP.LE.0)ITP=I+1
            L=K+NSTA
            TMP=NLOG(ITP,K)
            TMPP=NCAB(I,K,L)
      10490 TP=RA(I,K,L)
            IF(TP.LT.(-1.)) GO TO 12490
```

```
            TMPA=TMPP/(1.-(TMP-TMPP)*TP/TMP)
            IF(TMPA.LT.TMPB) GO TO 12490
            INDC=1
            ANYR(I,K)=TMPA
            TMPB=TMPA
            ITMP=L
            ITPP=ITP
      12490 CONTINUE
            IF(INDC.LE.0) GO TO 14490
            L=ITMP
            ITP=ITPP
            LX=L
            IF(LX.GT.NSTA) LX=LX-NSTA
            TP=RA(I,K,L)
            TEMP=SDA(I,K,L)/SDB(I,K,L)
            AV(I,K)=AAA(I,K,L)+(AV(ITP,LX)-AAB(I,K,L))*TP*TEMP
            SD(I,K)=SDA(I,K,L)+(SD(ITP,LX)-SDB(I,K,L))*TP**2*TEMP
      14490 CONTINUE
      16490 CONTINUE
        341 WRITE(6,2341)
       2341 FORMAT(/52H FREQUENCY STATISTICS AFTER CONSISTENCY COMPUTATIONS)
            WRITE(6,180)(AA(I),AB(I),I=1,NDUR)
            DO 350 K=1,NSTA
            WRITE(6,342)ISTA(K),(AV(I,K),I=1,NDUR)
        342 FORMAT(/I8,8H    MEAN 10F11.3)
            WRITE(6,344)(SD(I,K),I=1,NDUR)
        344 FORMAT(9X,7HSTD DEV 10F11.3)
            WRITE(6,346)(SKEW(I,K),I=1,NDUR)
        346 FORMAT(12X,4HSKEW 10F11.3)
            WRITE(6,348)(DQ(I,K),I=1,NDUR)
        348 FORMAT(10X,6HINCRMT F10.2,9F11.2)
            WRITE (6,349)(ANYR(I,K),I=1,NDUR)
        349 FORMAT (11X,5HYEARS 10F11.0)
        350 CONTINUE
C     * * * * * * TRANSFORM TO STANDARDIZED VARIATES  * * * * * * * * * * * * * * * *
        308 DO 2340 K=1,NSTA
            M=0
            DO 340 J=1,NYRS
            DO 330 I=1,NDUR
            M=M+1
            IF(Q(M,K).EQ.T)GO TO 330
            IF(SD(I,K).EQ.0.)GO TO 320
            Q(M,K)=(Q(M,K)-AV(I,K))/SD(I,K)
C                    PEARSON TYPE III TRANSFORM
            TMPP=SKEW(I,K)
            IF(ISKEW.GT.0) TMPP=SKW(I)
            IF(TMPP.EQ.0.) GO TO 330
            TEMP=.5*TMPP*Q(M,K)+1.
            TMP=1.
            IF(TEMP.GE.0.)GO TO 310
            TEMP=-TEMP
            TMP=-TMP
        310 Q(M,K)=6.*(TMP*TEMP**(1./3.)-1.)/SKEW(I,K)+SKEW(I,K)/6.
            GO TO 330
        320 Q(M,K)=0.
```

```
  330 CONTINUE
  340 CONTINUE
 2340 CONTINUE
      ITRNS=-1
      GO TO 360
C  * * * * * * ESTIMATE MISSING CORRELATION COEFFICIENTS * * * * * * * * * * * *
  491 IF(NSTA.LE.1) GO TO 810
      DO 560 I=1,NDUR
      IX=I-1
      IF(I.EQ.1)IX=I+1
      DO 550 K=1,NSTA
      ANYR(I,K)=NLOG(I,K)
      KX=K+1
      IF (KX.GT.NSTAX) GO TO 550
      DO 540 L=KX,NSTAX
C               L AND K CORRELATION POSSIBLY MISSING
      IF(RA(I,K,L).GE.(-1.))GO TO 540
      RMAX=1.
      RMIN=-1.
C               LX SEARCHES ALL DIRECTLY RELATED CORRELATIONS
      DO 530 LX=1,NSTAX
      IF(LX.EQ.K)GO TO 530
      IF(LX.EQ.L)GO TO 530
      TEMP=RA(I,K,LX)
      IF(L.LE.NSTA)GO TO 500
      IF(LX.LE.NSTA)GO TO 510
C               BOTH L AND LX REPRESENT ADJACENT DURATIONS
      ITMP=L-NSTA
      ITEMP=LX-NSTA
      TMP=RA(IX,ITMP,ITEMP)
      GO TO 520
C               L REPRESENTS CURRENT DURATION
  500 TMP=RA(I,L,LX)
      GO TO 520
C               LX AND NOT L REPRESENTS CURRENT DURATION
  510 TMP=RA(I,LX,L)
  520 IF(TMP+TEMP.LT.(-2.))GO TO 530
      TMPA=((1.-TEMP*TEMP)*(1.-TMP*TMP))**.5
      TMPB=TMP*TEMP+TMPA
      IF(TMPB.LT.RMAX)RMAX=TMPB
      TMPB=TMPB-TMPA-TMPA
      IF(TMPB.GT.RMIN)RMIN=TMPB
  530 CONTINUE
C               AVERAGE SMALLEST MAX AND LARGEST MIN CONSISTENT VALUE
      RA(I,K,L)=(RMAX+RMIN)*.5
      IF (RA(I,K,L).LT.0.0) RA(I,K,L)=0.
      IF(L.LE.NSTA)RA(I,L,K)=RA(I,K,L)
  540 CONTINUE
  550 CONTINUE
  560 CONTINUE
      GO TO 810
C  * * * * * * PRINT CORRELATION MATRIX  * * * * * * * * * * * * * * * * * * * *
  725 DO 800 I = 1,NDUR
      IF(ITRNS.LT.1) WRITE(6,729)AA(I),AB(I)
  729 FORMAT(//33H RAW CORRELATION COEFFICIENTS FOR 2A4,9H DURATION)
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          IF(ITRNS.GT.0) WRITE(6,730)AA(I),AB(I)
      730 FORMAT(//34H CONSISTENT CORRELATION MATRIX FOR 2A4,9H DURATION)
          WRITE(6,740)(ISTA(K),K=1,NSTA)
      740 FORMAT(/3X,3HSTA 18I7)
          WRITE(6,750)
      750 FORMAT(20X,18HWITH SAME DURATION)
          DO 760 K=1,NSTA
          WRITE(6,770)ISTA(K),(RA(I,K,L),L=1,NSTA)
      760 CONTINUE
      770 FORMAT(1X,I5,18F7.3/6X,18F7.3)
          IF (NDUR.EQ.1) GO TO 800
          WRITE(6,780)
      780 FORMAT(20X,39HWITH ADJACENT DURATION AT ABOVE STATION)
          ITP=NSTA+1
          DO 790 K=1,NSTA
          WRITE(6,770)ISTA(K),(RA(I,K,L),L=ITP,NSTAX)
      790 CONTINUE
      800 CONTINUE
          IF(KRCRD.EQ.1) GO TO 925
          IF(ITRNS) 491,491,1022
C * * * * * * RECONSTITUTE MISSING DATA * * * * * * * * * * * * * * * * * * * * * *
      810 M=0
          NVAR=NSTA+1
          DO 920 J=1,NYRS
          IF (IRCRD(J).EQ.1) GO TO 815
          M=M+NDUR
          GO TO 920
      815 DO 910 I=1,NDUR
          MX=M
          M=M+1
          IF(I.EQ.1)MX=M+1
          DO 900 K=1,NSTA
          KX=NSTA+K
          IF (Q(M,K).NE.T.OR.NLOG(I,K).LT.3) GO TO 900
          NINDP=0
          IPREV=0
C                   FORM CORRELATION MATRIX FOR EACH MISSING FLOW
          DO 870 L=1,NSTA
          LA = NINDP
          IF(L.EQ.K)GO TO 840
          IF(Q(M,L).EQ.T)GO TO 870
          NINDP=NINDP+1
          X(NINDP)=Q(M,L)
          DO 830 LX = L,NSTA
          IF(LX.EQ.K)GO TO 820
          IF(Q(M,LX).EQ.T)GO TO 830
          LA=LA+1
          R(NINDP,LA)=RA(I,L,LX)
          GO TO 825
      820 IF (NDUR.EQ.1) GO TO 830
          IF(Q(MX,LX).EQ.T)GO TO 830
          LA=LA+1
          R(NINDP,LA) = RA(I,L,KX)
      825 R(LA,NINDP) = R(NINDP,LA)
      830 CONTINUE
```

```
            R(NINDP,NVAR)=RA(I,L,K)
            GO TO 870
        840 IF (NDUR.EQ.1) GO TO 870
            IF(Q(MX,K).EQ.T)GO TO 870
            NINDP=NINDP+1
            IPREV=NINDP
            X(NINDP)=Q(MX,L)
            DO 860 LX = L,NSTA
            IF(LX.EQ.K)GO TO 850
            IF(Q(M,LX).EQ.T)GO TO 860
            LA=LA+1
            R(NINDP,LA) = RA(I,LX,KX)
            R(LA,NINDP)=R(NINDP,LA)
            GO TO 860
        850 LA=LA+1
            R(NINDP,LA)=1.
        860 CONTINUE
            R(NINDP,NVAR)=RA(I,L,KX)
        870 CONTINUE
      C                 CASE NUMBER 1 RESULTS WHEN NO FLOWS ARE FOUND FOR CORRELATION
            ICSE=1
            IF(NINDP.LE.0) GO TO 8874
            ITMP=NINDP+1
            DO 871 IX=1,NINDP
        871 R(IX,ITMP)=R(IX,NVAR)
      C     ==========
        873 CALL CROUT(R)
      C     ==========
            ITEMP=NINDP+1
            TEMP=1.
            INDC=0
            DO 4873 L=1,NINDP
            TMP=ABS(R(L,ITEMP))
            IF(TMP.GT.TEMP) GO TO 2873
            IF(L.EQ.IPREV.AND.TMP.GE..9) GO TO 2873
            TEMP=TMP
            ITP=L
       2873 IF(R(L,ITEMP).LT.0..AND.B(L).GT.(-1.5).AND.B(L).LT..5) GO TO 4873
            IF(R(L,ITEMP).GT.0..AND.B(L).GT.(-.5).AND.B(L).LT.1.5) GO TO 4873
            INDC=1
       4873 CONTINUE
            IF(INDC.GT.0) GO TO 2874
            IF(DTRMC.LE.1..AND.DTRMC.GE.0.) GO TO 880
      C                 IF MATRIX INCONSISTENT, OMIT VARIABLE WITH LEAST CORRELATION
       2874 ITMP=NINDP-1
            IF(ITMP.GT.0) GO TO 6874
      C                 CASE NUMBER 2 RESULTS WHEN ALL CORRELATIONS ARE ZERO
            ICSE=2
      C                 POSSIBLE BRANCH FROM 870+2
       8874 IYR=IYRA+J
            WRITE(6,4874) ISTA(K),I,IYR,ICSE
       4874 FORMAT(/25H ZERO CORRELATION FOR STA ,I6,10H  DURATION ,I2,6H  YEA
           1R ,I5,6H  CASE ,I2/)
            B(1)=0.
            X(1)=0.
```

```
           DTRMC=0.
           GO TO 880
      6874 IF(ITP.GT.ITMP) GO TO 877
           DO 876 L=ITP,ITMP
           DO 875 LA=1,ITEMP
       875 R(L,LA)=R(L+1,LA)
       876 X(L)=X(L+1)
       877 DO 879 L=1,ITMP
           DO 878 LA=ITP,NINDP
       878 R(L,LA)=R(L,LA+1)
       879 CONTINUE
           NINDP=ITMP
           GO TO 873
C                  ADD RANDOM COMPONENT TO PRESERVE VARIANCE
       880 TMP=RNGEN(IXX)
           TEMP=RNGEN(IXX)
           TEMP=(-2.*ALOG(TEMP))**.5*SIN(6.2832*TMP)
C                  COMPUTE FLOW
           AL=(1.-DTRMC)**.5
           TEMP=TEMP*AL
           DO 890 L=1,NINDP
           TEMP=TEMP+B(L)*X(L)
       890 CONTINUE
           Q(M,K)=TEMP
           ANYR(I,K)=ANYR(I,K)+DTRMC
           TP=Q(M,K)
C                  ADD NEW VALUE TO SUMS OF SQUARES AND CROSS PRODUCTS
           DO 899 L=1,NSTAX
C                  SUBSCRIPTS EXCEEDING NSTA RELATE TO PRECEDING MONTH
     10890 IF(L.LE.NSTA) GO TO 2890
           LX=L-NSTA
           IF (I.EQ.1) TMP=Q(M+1,LX)
           IF(I.GT.1) TMP=Q(M-1,LX)
           GO TO 891
      2890 TMP=Q(M,L)
       891 IF(TMP.EQ.T) GO TO 899
C                  COUNT AND USE ONLY RECORDED PAIRS
           NCAB(I,K,L)=NCAB(I,K,L)+1
           SUMA(I,K,L)=SUMA(I,K,L)+TP
           SUMB(I,K,L)=SUMB(I,K,L)+TMP
           SQA (I,K,L)=SQA (I,K,L)+TP*TP
           SQB (I,K,L)=SQB (I,K,L)+TMP*TMP
           XPAB(I,K,L)=XPAB(I,K,L)+TP*TMP
           IF(L.GT.NSTA) GO TO 892
           NCAB(I,L,K)=NCAB(I,K,L)
           SUMA(I,L,K)=SUMB(I,K,L)
           SUMB(I,L,K)=SUMA(I,K,L)
           SQA (I,L,K)=SQB (I,K,L)
           SQB (I,L,K)=SQA (I,K,L)
           XPAB(I,L,K)=XPAB(I,K,L)
C                  RECOMPUTE CORRELATION COEFFICIENTS TO INCLUDE NEW DATA
C                  ELIMINATE PAIRS WITH LESS THAN 3 YRS DATA
       892 IF(NCAB(I,K,L).LE.2) GO TO 899
           TEMP=NCAB(I,K,L)
           TMP=(SQA(I,K,L)-SUMA(I,K,L)*SUMA(I,K,L)/TEMP)*(SQB(I,K,L)-SUMB
```

```
     1(I,K,L)*SUMB(I,K,L)/TEMP)
C              ELIMINATE PAIRS WITH ZERO VARIANCE PRODUCT
      IF(TMP.LE.0.) GO TO 897
      TMPB=1.
      TMPA=XPAB(I,K,L)-SUMA(I,K,L)*SUMB(I,K,L)/TEMP
C              RETAIN ALGEBRAIC SIGN
      IF(TMPA.LT.0.)TMPB=-TMPB
      TMPA=TMPA*TMPA/TMP
      RA(I,K,L)=TMPB*TMPA**.5
      IF(RA(I,K,L).GE.0.) GO TO 898
  897 RA(I,K,L)=0.
  898 IF(L.GT.NSTA) GO TO 899
      RA(I,L,K)=RA(I,K,L)
  899 CONTINUE
      IF(NDUR.EQ.1)GO TO 900
      DO 8899 L=1,NSTA
      ITP=0
      IX=I+1
      IF(IX.GT.NDUR) GO TO 2899
      TMP=Q(M+1,L)
      GO TO 4899
 2899 IF(I.GT.2) GO TO 900
 3899 TMP=Q(M-1,L)
      IX=I-1
      ITP=1
 4899 IF(TMP.EQ.T) GO TO 8899
      NCAB(IX,L,KX)=NCAB(IX,L,KX)+1
      SUMA(IX,L,KX)=SUMA(IX,L,KX)+TMP
      SUMB(IX,L,KX)=SUMB(IX,L,KX)+TP
      SQA (IX,L,KX)=SQA (IX,L,KX)+TMP**2
      SQB (IX,L,KX)=SQB (IX,L,KX)+TP**2
      XPAB(IX,L,KX)=XPAB(IX,L,KX)+TMP*TP
      IF(NCAB(IX,L,KX).LE.2) GO TO 8899
      TEMP=NCAB(IX,L,KX)
      TMP=(SQA(IX,L,KX)-SUMA(IX,L,KX)**2/TEMP)*(SQB(IX,L,KX)-
     1SUMB(IX,L,KX)**2/TEMP)
      IF(TMP.LE.0.) GO TO 6899
      TMPB=1.
      TMPA=XPAB(IX,L,KX)-SUMA(IX,L,KX)*SUMB(IX,L,KX)/TEMP
      IF(TMPA.LT.0.) TMPB=-TMPB
      TMPA=TMPA**2/TMP
      RA(IX,L,KX)=TMPB*TMPA**.5
      IF(RA(IX,L,KX).GE.0.) GO TO 8899
 6899 RA(IX,L,KX)=0.
      IF(I.EQ.2.AND.ITP.LT.1) GO TO 3899
 8899 CONTINUE
  900 CONTINUE
  910 CONTINUE
  920 CONTINUE
  925 WRITE(6,5)
      WRITE(6,930)
  930 FORMAT(33H RECORDED AND RECONSTITUTED FLOWS)
      DO 1000 K=1,NSTA
      WRITE(6,940)(AA(I),AB(I),I=1,NDUR)
  940 FORMAT(/2X,10H STA  YEAR 4X,A3,A4,9(3X,2A4))
```

```
0701            M=0
          C              CONVERT STANDARD DEVIATES TO FLOWS
0702        942 ANYRS=NYRS
0703            DO 970 J=1,NYRS
0704            IF (IRCRD(J).EQ.1) GO TO 943
0705            M=M+NDUR
0706            ANYRS=ANYRS-1.
0707            GO TO 970
0708        943 DO 950 I=1,NDUR
0709            M=M+1
0710            B(I)=QR(M,K)
0711            XQ(I)=Q(M,K)
0712            IF(ICORL.EQ.0)GO TO 950
0713            IF (NLOG(I,K).LT.3) GO TO 947
0714            TEMP=Q(M,K)
0715            TMP=SKEW(I,K)
          C              USE ADOPTED SKEW FOR RECONSTITUTING
0716            IF(ISKEW.GT.0) TMP=SKW(I)
0717            IF(TMP.EQ.0.) GO TO 948
0718            TEMP=((TMP*(TEMP-TMP/6.)/6.+1.)**3-1.)*2./TMP
0719            IF(QR(M,K).NE.E) GO TO 948
0720            TMPP=(-2.)/TMP
0721            IF(TMP) 941,948,944
0722        941 IF(TEMP.GT.TMPP) TEMP=TMPP
0723            GO TO 948
0724        944 IF(TEMP.LT.TMPP) TEMP=TMPP
0725        948 TMP=TEMP*SD(I,K)+AV(I,K)
0726            TEMP=10.**TMP-DQ(I,K)
0727            IF(TEMP.LT.0.) TEMP=0.
0728            IF(TEMP.LT.QMIN(I,K)) QMIN(I,K)=TEMP
0729            Q(M,K)=TEMP
0730            IF(I.EQ.1) GO TO 946
0731            TMP=Q(M-1,K)*P(I)/P(I-1)
0732            IF(Q(M,K).LT.TMP) GO TO 946
0733            IF(QR(M,K).EQ.E) GO TO 4944
0734            ITP=I-1
0735            DO 2944 L=1,ITP
0736            TMP=Q(M-L,K)*P(I)/P(I-L)
0737            IF(TMP.LT.Q(M,K).AND.QR(M-L,K).EQ.E)Q(M-L,K)=Q(M,K)*P(I-L)/P(I)
0738            IF(NLOG(I-L,K).GT.2) XQ(I-L)=Q(M-L,K)
0739       2944 CONTINUE
0740            GO TO 946
0741       4944 Q(M,K)=TMP
0742        946 XQ(I)=Q(M,K)
0743            GO TO 950
0744        947 XQ(I)=-1.
0745        950 CONTINUE
0746            IYR=IYRA+J
0747            WRITE(6,960)ISTA(K),IYR,(XQ(I),B(I),I=1,NDUR)
0748        960 FORMAT(2I6,F11.0,A1,F10.0,A1,8(F10.0,A1))
0749        970 CONTINUE
0750            IF(ICORL.EQ.0.OR.KRCRD.GE.1) GO TO 1000
0751            INDC=0
0752        971 DO 972 I=1,NDUR
0753            IF(QMIN(I,K)+DQ(I,K).GT..0001) GO TO 972
```

```
          INDC=1
      972 CONTINUE
          IF(INDC.LT.1) GO TO 974
          DO 973 I=1,NDUR
          DQ(I,K)=DQ(I,K)+XINCR(I)
      973 CONTINUE
          GO TO 971
    C * * * * * * RECOMPUTE FREQUENCY STATISTICS * * * * * * * * * * * * * * * * *
      974 DO 990 I=1,NDUR
          IF (NLOG(I,K).LT.3) GO TO 985
          TMP=0.
          TEMP=0.
          TMPA=0.
          M=I
          DO 980 J=1,NYRS
          IF (IRCRD(J).EQ.0) GO TO 975
          TP=ALOG(Q(M,K)+DQ(I,K))
          TMP=TMP+TP
          TEMP=TEMP+TP*TP
          TMPA=TMPA+TP*TP*TP
      975 M = M + NDUR
      980 CONTINUE
          AV(I,K)=TMP*.4342945/ANYRS
          SD(I,K)=((TEMP-TMP*TMP/ANYRS)/(ANYRS-1.))**.5
          SKEW(I,K)=(ANYRS*ANYRS*TMPA-3.*ANYRS*TMP*TEMP+2.*TMP**3)/
         1 (ANYRS*(ANYRS-1.)*(ANYRS-2.)*SD(I,K)**3)
          IF (SKEW(I,K).GT.1.) SKEW(I,K)=1.
          IF (SKEW(I,K).LT.(-1.)) SKEW(I,K)=(-1.)
          SD(I,K)=SD(I,K)*.4342945
          GO TO 990
      985 ANYR(I,K)=0.
      990 CONTINUE
     1000 CONTINUE
          IF(ICORL.EQ.0.OR.KRCRD.GE.1) GO TO 1022
          WRITE(6,5)
          WRITE(6,1010)
     1010 FORMAT(//30H ADJUSTED FREQUENCY STATISTICS)
          WRITE(6,180)(AA(I),AB(I),I=1,NDUR)
          DO 1020 K=1,NSTA
          WRITE(6,342)ISTA(K),(AV(I,K),I=1,NDUR)
          WRITE(6,344)(SD(I,K),I=1,NDUR)
          WRITE(6,346) (SKEW(I,K),I=1,NDUR)
          WRITE (6,1015) (ANYR(I,K),I=1,NDUR)
     1015 FORMAT (7X,9HEQUIV YRS 10F11.1)
     1020 CONTINUE
    C               RECOMPUTE CORRELATION MATRIX
          ITRNS=1
          GO TO 358
    C * * * * * * ARRANGE FLOWS IN ORDER * * * * * * * * * * * * * * * * * * * *
     1022 ITMP=ANYRS+.1
    C               COMPUTE MEDIAN PLOTTING POSITIONS
          TEMP=1./ANYRS
          PLOT(1)=(1.-.5**TEMP)*100.
          TEMP=(100.-PLOT(1)-PLOT(1))/(ANYRS-1.)
          DO 1025 J=2,ITMP
```

```
            PLOT(J)=PLOT(J-1)+TEMP
       1025 CONTINUE
            WRITE(6,1027)
       1027 FORMAT(//17H FREQUENCY ARRAYS)
            DO 1130 K=1,NSTA
            DO 1070 I=1,NDUR
            M=I
            QM(I)=Q(M,K)
            IF(QM(I).EQ.T) QM(I)=-T
            X(I)=QR(M,K)
            JA=1
            DO 1050 J=2,NYRS
            M=M+NDUR
            IF (IRCRD(J).EQ.0) GO TO 1050
            JA=JA+1
            TEMP=Q(M,K)
            JX=JA*NDUR+I
            DO 1030 L=2,JA
            LX=JX-L*NDUR
            ITP=LX+NDUR
            IF(QM(LX).GE.TEMP)GO TO 1040
            QM(ITP)=QM(LX)
            X(ITP)=X(LX)
       1030 CONTINUE
            QM(I)=TEMP
            X(I)=QR(M,K)
            GO TO 1050
       1040 QM(ITP)=TEMP
            X(ITP)=QR(M,K)
       1050 CONTINUE
       1070 CONTINUE
            WRITE(6,1250)ISTA(K)
       1090 FORMAT(/10H NO  PLOT 3X,A3,A4,9(3X,2A4))
            WRITE(6,1090)(AA(I),AB(I),I=1,NDUR)
            M=0
            DO 1110 J=1,ITMP
            DO 1100 I=1,NDUR
            M=M+1
            X(I)=X(M)
            XQ(I)=QM(M)
            IF(NLOG(I,K).LT.3) XQ(I)=-1.
       1100 CONTINUE
            WRITE(6,1120)J,PLOT(J),(XQ(I),X(I),I=1,NDUR)
       1120 FORMAT(I3,F6.2,F11.0,A1,9(F10.0,A1))
       1110 CONTINUE
       1130 CONTINUE
      C  * * * * * * SMOOTH STATISTICS * * * * * * * * * * * * * * * * * * * * * * * *
       1131 DO 1160 K=1,NSTA
            IF (NSTAT.LT.1) GO TO 1138
      C                 READ STATISTICS, IF SUPPLIED
            READ(5,1132) ISTA(K),TEMP
       1132 FORMAT (1X,I7,F8.0)
            DO 1136 I=1,NDUR
       1136 ANYR(I,K)=TEMP
            READ(5,2) (AV(I,K),I=1,NDUR)
```

```
              READ(5,2) (SD(I,K),I=1,NDUR)
              IF (ISKEW.LE.0) READ(5,2) (SKEW(I,K),I=1,NDUR)
              READ(5,2) (DQ(I,K),I=1,NDUR)
         1138 IF (NSMTH.LE.(-1)) GO TO 1152
              IF(NDUR.LT.3)GO TO 1152
C                     SUMS, SQUARES AND CROSS PRODUCTS
              SA=0.
              SB=0.
              SC=0.
              SAA=0.
              SAB=0.
              SAC=0.
              ITMP=NDUR
              DO 1140 I=1,NDUR
              IF (NLOG(I,K).LT.3) GO TO 1139
              TP=AV(I,K)-P(I)
              TMP=SD(I,K)
              TEMP=SKEW(I,K)
              SA=SA+TP
              SB=SB+TMP
              SC=SC+TEMP
              SAA=SAA+TP*TP
              SAB=SAB+TP*TMP
              SAC=SAC+TP*TEMP
              GO TO 1140
         1139 ITMP=ITMP-1
         1140 CONTINUE
              IF (ITMP.LT.3) GO TO 1152
C                     LINEAR REGRESSION, STD DEV AND SKEW VS MEAN
              TP=ITMP
              SAA=SAA-SA*SA/TP
              SAB=SAB-SA*SB/TP
              SAC=SAC-SA*SC/TP
C                     LIMIT REGRESSION COEFFICIENT FOR CONSISTENCY
              BB=SAB/SAA
              IF(BB.GT..25)BB=.25
              IF(BB.LT.(-.25))BB=-.25
              BC=SAC/SAA
              IF(BC.GT.1.)BC=1.
              IF(BC.LT.(-1.))BC=-1.
C                     REGRESSION CONSTANTS
              SA=SA/TP
              SB=SB/TP
              CB=SB-BB*SA
              SC=SC/TP
              CC=SC-BC*SA
C                     COMPUTE SMOOTHED STATISTICS
              DO 1150 I=1,NDUR
              IF (NLOG(I,K).LT.3) GO TO 1150
              TEMP=AV(I,K)-P(I)
              SD(I,K)=CB+BB*TEMP
              IF (SD(I,K).LT.0.) SD(I,K)=0.
              SKEW(I,K)=CC+BC*TEMP
         1150 CONTINUE
         1152 IF (ISKEW.LE.0) GO TO 1160
```

```
      DO 1154 I=1,NDUR
      SKEW(I,K)=SKW(I)
 1154 CONTINUE
 1160 CONTINUE
      IF (NDUR.LT.3.AND.ISKEW.LE.0) GO TO 1185
      WRITE(6,5)
      WRITE(6,1170)
 1170 FORMAT(29H ADOPTED FREQUENCY STATISTICS)
      WRITE(6,180)(AA(I),AB(I),I=1,NDUR)
      DO 1180 K=1,NSTA
      WRITE(6,342)ISTA(K),(AV(I,K),I=1,NDUR)
      WRITE(6,344)(SD(I,K),I=1,NDUR)
      WRITE(6,346)(SKEW(I,K),I=1,NDUR)
      WRITE(6,348) (DQ(I,K),I=1,NDUR)
 1180 CONTINUE
C  * * * * * * COMPUTE FREQUENCY CURVES  * * * * * * * * * * * * * * * * * * * *
 1185 TMPA=100.
      X(1)=3.73
      X(2)=3.09
      X(3)=2.33
      X(4)=1.64
      X(5)=1.28
      X(6)=.52
      WRITE(6,5)
      WRITE(6,1190)
 1190 FORMAT(26H COMPUTED FREQUENCY CURVES)
      DO 1280 K=1,NSTA
      TMPB=0.
      TMPP=0.
      DO 1240 II=1,NDUR
      I=NDUR-II+1
      IF(NLOG(I,K).LT.3) GO TO 1195
      TMPP=TMPP+1.
      TP=SKEW(I,K)
      TMPB=TMPB+ANYR(I,K)
 1195 DO 1230 J=1,13
      IF (NLOG(I,K).LT.3.AND.NSTAT.LT.1) GO TO 1225
      TEMP=0.
      IF(J-7)1200,1220,1210
 1200 TEMP=X(J)
      GO TO 1220
 1210 TEMP=-X(14-J)
C                  PEARSON TYPE III TRANSFORM
 1220 IF(TP.EQ.0.) GO TO 1223
      TEMP=2./TP*((TP/6.*(TEMP-TP/6.)+1.)**3-1.)
      TMP=(-2.)/TP
      IF(TP)         1221,1223,1222
 1221 IF(TEMP.GT.TMP) TEMP=TMP
      GO TO 1223
 1222 IF(TEMP.LT.TMP)   TEMP=TMP
 1223 TMP=AV(I,K)+TEMP*SD(I,K)
      QR(J,I)=10.**TMP-DQ(I,K)
      IF(QR(J,I).LT.0.) QR(J,I)=0.
      IF(II.EQ.1.OR.J.LE.8) GO TO 1230
      TMP=QR(J,I+1)*P(I)/P(I+1)
```

```
      IF(QR(J,I).LT.TMP)QR(J,I)=TMP
      GO TO 1230
 1225 QR(J,I)=-1.
 1230 CONTINUE
 1240 CONTINUE
      IF(TMPP.LE.0.) GO TO 1280
      PLOT(1)=.01
      PLOT(2)=.1
      PLOT(3)=1.
      PLOT(4)=5.
      PLOT(5)=10.
      PLOT(6)=30.
      PLOT(7)=50.
      PLOT(8)=TMPA-PLOT(6)
      PLOT(9)=TMPA-PLOT(5)
      PLOT(10)=TMPA-PLOT(4)
      PLOT(11)=TMPA-PLOT(3)
      PLOT(12)=TMPA-PLOT(2)
      PLOT(13)=TMPA-PLOT(1)
C                 PLOT VALUES EXCEEDING 13 ARE EXPECTED PROBABILITY
      TMP=TMPB/TMPP
      PLOT(14)=.01*(1.+1600./TMP**1.72)
      PLOT(15)= .1*(1.+280./TMP**1.55)
      PLOT(16)= 1.*(1.+26./TMP**1.16)
      PLOT(17)= 5.*(1.+6./TMP**1.04)
      PLOT(18)=10.*(1.+3./TMP**1.04)
      PLOT(19)=30.*(1.+.46/TMP**.925)
      PLOT(20)=50.
      PLOT(21)=TMPA-PLOT(19)
      PLOT(22)=TMPA-PLOT(18)
      PLOT(23)=TMPA-PLOT(17)
      PLOT(24)=TMPA-PLOT(16)
      PLOT(25)=TMPA-PLOT(15)
      PLOT(26)=TMPA-PLOT(14)
      WRITE(6,1250)ISTA(K)
 1250 FORMAT(/8H STATION I8)
      WRITE(6,1260)(AA(I),AB(I),I=1,NDUR)
 1260 FORMAT(4X,16H  PLOT  EXP PROB 4X,A3,A4,9(3X,2A4))
      DO 1270 J=1,13
      WRITE(6,1275) PLOT(J),PLOT(J+13),(QR(J,I),I=1,NDUR)
 1275 FORMAT(2F10.2,9F11.0)
 1270 CONTINUE
 1280 CONTINUE
      GO TO 10
      END
```

```
      SUBROUTINE CROUT(RX)
      DIMENSION B(10),R(10,11),RX(10,11)
      COMMON DTRMC,NINDP,B
      NVAR=NINDP+1
      DO 5 J=1,NINDP
      DO 4 K=1,NVAR
    4 R(J,K)=RX(J,K)
    5 CONTINUE
      IF(NINDP.GT.1)GO TO 10
      B(1)=R(1,2)/R(1,1)
      DTRMC=B(1)*B(1)
      RETURN
C * * * * * * DERIVED MATRIX * * * * * * * * * * * * * * * * * * * * * * * *
   10 DO 20 K=2,NVAR
   20 R(1,K)=R(1,K)/R(1,1)
      DO 60 K=2,NINDP
      ITP=K-1
      DO 40 J=K,NINDP
      DO 30 I=1,ITP
      L=K-I
   30 R(J,K)=R(J,K)-R(J,L)*R(L,K)
      IF(J.EQ.K) GO TO 40
      R(K,J)=R(J,K)/R(K,K)
   40 CONTINUE
      DO 50 I=1,ITP
      L=K-I
   50 R(K,NVAR)=R(K,NVAR)-R(L,NVAR)*R(K,L)
   60 R(K,NVAR)=R(K,NVAR)/R(K,K)
C * * * * * * BACK SOLUTION * * * * * * * * * * * * * * * * * * * * * * * * *
      B(NINDP)=R(NINDP,NVAR)
      DO 80 I=2,NINDP
      J=NVAR-I
      IX=I-1
      B(J)=R(J,NVAR)
      DO 70 L=1,IX
      K=J+L
   70 B(J)=B(J)-B(K)*R(J,K)
   80 CONTINUE
      DTRMC=0.
      DO 90 J=1,NINDP
   90 DTRMC=DTRMC+B(J)*RX(J,NVAR)
      RETURN
      END
```

```
0001            FUNCTION RNGEN(IX)
          C     RANDOM NUMBER SUBROUTINE FOR A BINARY MACHINE
          C     GENERATES UNIFORM RANDOM NUMBERS IN THE INTERVAL 0 TO 1
          C     GENERAL USAGE IS AS FOLLOWS
          C     A=RNGEN(IX)
          C     IX SHOULD BE INITIALIZED TO ZERO IN THE PROGRAM
          C     IARG CAN BE ANY LARGE, ODD INTEGER
          C
0002            DATA IARG/759821/
0003            IF(IARG.EQ.IX) GO TO 3
0004            IX=IARG
0005            IY=IX
          C
          C     * * * *  CONSTANT ONE=(2**((B+1)/2))+3   * * * *
          C     WHERE B= NUMBER OF BITS IN THE INTEGER WORD
          C
0006          3 IY=IY*65539
          C
          C     * * * *  CONSTANT TWO=(2**B)-1   * * * *
          C
0007            IF(IY.LT.0) IY=IY+2147483647+1
0008            RNGEN=IY
          C
          C     * * * *  CONSTANT THREE=1.0/(2.**B)   * * * *
          C
0009            RNGEN=RNGEN*.465661287E-09
0010            RETURN
0011            END
```

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the scanned document

PROBABLE MAGNITUDE AND FREQUENCY OF FLOODS

ON SMALL STREAMS IN VIRGINIA

by

Randall Clayton Miller

Abstract

The magnitude and frequency of floods are defined regionally for small streams (drainage area, 1 to 150 square miles) in Virginia. Curves are defined which show the relationship between the drainage area and the mean annual flood in four regions. Composite frequency curves for each region relate the magnitude of the annual flood, in ratio to the mean annual flood, to recurrence intervals of 1 to 50 years.

These two relationships are based upon annual peak flows at gaging stations with drainage areas less than 150 square miles and with records greater than 5 years. Gaging-stations which were materially affected by storage or diversion were not used.