U.S. DEPARTMENT OF THE INTERIOR
MARCH 3, 1849

Floods in Indiana:
Technical Manual for Estimating
Their Magnitude and Frequency

Floods in Indiana: Technical Manual for Estimating Their Magnitude and Frequency

By L. G. Davis

GEOLOGICAL SURVEY CIRCULAR 710

1974

United States Department of the Interior
ROGERS C. B. MORTON, *Secretary*

Geological Survey
V. E. McKelvey, *Director*

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GLOSSARY

Annual peak discharge. The highest peak discharge in a water year.

Cubic feet per second (ft³/s). The rate of discharge representing a volume of 1 cubic foot of water passing a given point during 1 second and is equivalent to 7.48 gallons per second, 448.8 gallons per minute, or 0.028 cubic metres per second.

Discharge. The rate of flow of water in a stream at a given place and within a given period of time.

Drainage area. An area from which surface runoff is carried away by a single drainage system. Also called water shed, drainage basin.

Evapotranspiration. The amount of precipitation that returns to the atmosphere as vapor by the combined action of evaporation and transpiration by plants.

Flood. A relatively high flow, as measured by either gage height or discharge, which usually overtops the natural banks along some reaches of a stream.

Flood peak. The maximum rate of flow, usually expressed in cubic feet per second, that occurred during a flood.

Frequency. The number of occurrences of a certain phenomenon in a given period of time.

Gaging station. A particular site on a stream where systematic observations of gage height and discharge are obtained. The station usually has a recording gage for continuous measurement of the elevation of the water surface in the channel.

Geomorphic factors. Physical characteristics of watersheds that are the result of fluvial processes and have a direct effect on the magnitudes of floods.

Geomorphology. The study of landform development and fluvial processes in various climatic regions.

Physiographic region. Areas where soils and drainage have been developed on geologically similar materials.

Precipitation index. An amount of precipitation that directly affects peak discharge. In this study it is the average annual precipitation minus the sum of average annual evapotranspiration and mean annual snowfall (water equivalent).

Probability. The likelihood or chance that a flood or storm will occur or that the magnitude of a flood or storm will be equaled or exceeded.

Q_t. The discharge for a recurrence interval of t-years. It is the annual maximum peak flow that will be exceeded every t-number of years on the average.

Recurrence interval. The average interval of time within which a given flood will be exceeded once. Also called return period.

Regression equation. An equation derived by methods of regression. It is a mathematical relationship between a dependent variable and one or more independent variables.

Regulated stream. A stream that has been subjected to control by reservoirs, diversions, or other manmade hydraulic structures.

Return period. See recurrence interval.

Standard error of regression. Refers to the standard error of estimate of the dependent variable. It is the standard deviation of the residual errors about a regression line used to predict the dependent variable converted to an average percentage. Approximately two-thirds of the data values for the dependent variable are included within one standard error of estimate.

Time of concentration. The time required for storm runoff from the most remote part of a watershed to reach the outlet or point of discharge on the stream, after the beginning of runoff.

Water year. A continuous 12-month period from October 1 to September 30, during which streamflow data are collected, compiled, and reported.

Watershed. See drainage area.

FACTORS FOR CONVERTING ENGLISH UNITS TO INTERNATIONAL SYSTEM (SI) UNITS

The following factors may be used to convert the English units published herein to the International System of Units (SI):

English units	Multiply by	To obtain SI units
inches (in.)	25.4	millimetres (mm)
feet (ft)	.305	metres (m)
miles (mi)	1.61	kilometres (km)
feet per mile (ft/mi)	.189	metres per kilometre (m/km)
square miles (mi^2)	2.59	square kilometres (km^2)
miles per square mile (mi/mi^2)	.621	kilometres per square kilometre (km/km^2)
cubic feet per second (ft^3/s)	.028	cubic metres per second (m^3/s)

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By L. G. Davis

ABSTRACT

This manual provides methods for estimating the magnitude and frequency of floods on unregulated and unurbanized streams in Indiana that drain at least 15 square miles (38.8 square kilometres). The methods provide the design engineer with a means of estimating flood frequencies without having to analyze the records at individual streamflow sites.

The estimating equations in this manual are based on relations between floods of specific return periods and selected watershed characteristics. The most significant factors for estimating flood peaks in Indiana were found to be drainage area and precipitation index. The shape of a watershed was also found very significant in development of the regional equations. Other variables used in the regional equations are physical characteristics that further explain differences in the magnitudes of floods from the watersheds.

The regional equations are multivariate regression equations that relate peak discharges of 2-, 5-, 10-, 25-, 50-, and 100-year recurrence intervals to watershed characteristics and are essentially for natural streams. In this study, if 25 percent or more of the drainage area of a stream is above a reservoir, it was considered to be regulated, and flood peaks from it were not included in the analysis unless it could be determined that flood peaks were not materially affected, as in the case of several streams below small water-supply reservoirs. The equations also do not apply to streams that are affected by a high degree of urbanization.

INTRODUCTION

PURPOSE AND SCOPE

Adequate regulatory, planning, and design activities along rivers and streams depend upon the ability to define the magnitude and frequency of floods that are apt to occur. The purpose of this manual is to present and illustrate a method for estimating flood discharges at ungaged sites on natural flowing streams in the State of Indiana. The method may also be applied to compute peak-discharge frequency curves at gaged sites where an insufficient number of flood peaks have been observed.

Flood discharges at gaged sites where an adequate number of flood peaks have been observed are shown in table 6. Values from the station frequency curves, in general, are the most reliable estimators of future floods at those sites.

The log-Pearson Type III distribution function, which was used to fit log-probability frequency curves to observed peak discharges at the gaging stations, is described in the report. Frequency-discharge data, watershed characteristics, and other pertinent data are tabulated in tables 6 and 7 for each of the 149 gaging stations used in the study.

Relations from this study are better defined than those from previous studies because of the improvement in techniques of regional analyses and the expansion of the flood-peak data base. Data deficiencies are identified, and needs for further studies are included in the summary.

BASIC DATA
PEAK-DISCHARGE DATA

Peak discharges from 149 gaging stations in Indiana having at least 10 years of record were used as the basic data from which the flood-frequency relations in this manual were developed. Locations of these gaging stations are shown in figure 1, and the geographic coordinates for each station are listed in table 6. Annual peak discharges through the 1971 water year were used in the analysis of the flood data. Annual peaks that were affected by regulation were omitted based on the criteria that if 25 percent or more of the drainage area at a gage was above a reservoir, flood peaks at that gage were considered to be affected.

In accordance with recommendations of the U.S. Water Resources Council, Hydrology Committee (1967), the log-Pearson Type III distribution function was used to fit observed data to log-probability frequency curves. This distribution is defined by three statistical parameters in equation form:

Log $Q = M + KS$, where M is the mean of the logs of the annual peaks at a gaging station, K is a function of the skew of the computed frequency curve, and S is the standard deviation about the mean of the logs.

The log-Pearson Type III computation and frequency plot was done by computer for each gaging station. The computer operation is performed in the following manner:

1. An array of N annual flood peaks at a gaging station are transformed into an array of corresponding logarithmic values.
   $$X_1, X_2, \dots \dots \dots \dots \dots X_N.$$

2. The mean of the logarithms is computed
   $$M = \frac{\Sigma X}{N}.$$

3. The standard deviation is computed
   $$S = \frac{\Sigma X^2 - (\Sigma X)^2 / N}{N-1}.$$

4. The skew coefficient is computed
   $$g = \frac{N \Sigma (X - M^3)}{(N-1)(N-2) S}.$$

5. The logarithms of discharges at selected recurrence intervals are computed
   Log $Q = M + KS$ (U.S. Water   (1)

Resources Council, Hydrology Committee, 1967.)

K is taken from tables that relate computed values of g to selected recurrence intervals.

6. The antilog of log Q is computed to get the flood discharge of Q.

FLOOD-FREQUENCY CURVES

The flood-frequency curves for the individual gaging stations are then obtained by plotting the discharges computed from equation (1) for the selected recurrence intervals on log-probability coordinates. The actual curve is a continuous line that averages the plotted discharges.

The frequency curve at a gaging station is used to determine floods of specific recurrence intervals or probabilities, such as the 50-year flood or its equivalent, the 0.02 probability. At stations where one or more floods of a rare frequency have been observed, the computed frequency curve may not conform to the array of observed peaks. This is the so-called outlier problem. At stations where this problem occurred, the outlier was removed and the frequency curve was recomputed. The outlier was assigned a realistic recurrence interval based on historical data at the site or nearby sites and plotted on the recomputed curve, and the curve was adjusted, if necessary, by graphical inspection.

Extension and definition of the station frequency curves were based on the following minimum years of record needed to define floods of selected recurrence interval:

			Years	
Recurrence interval _____	10	25	50	100
Minimum length of record ___	10	15	20	25

The recurrence interval is the average interval of time in which the given flood (50-year in this case) will be exceeded once. However, a flood of this magnitude could occur in consecutive years. The relationship of recurrence interval to probability is shown in table 1. The table shows that there is a 40 percent probability that a flood greater than a 50-year flood could occur in any 25-year period.

The probability that a 50-year flood will be exceeded in the next 10 years is computed by:

$$P = 1 - (1 - 1/t)^n \text{ where } n = 10, t = 50$$

$$P = 1 - (1 - \frac{1}{50})^{10} = 1 - (0.82) = 18 \text{ percent.}$$

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TABLE 1.—*Probability of a flood of given recurrence interval being exceeded during the indicated time periods*

Recurrence interval (years)	Probabilities for indicated time periods, in years				
	5	10	25	50	100
5 ------	0.67	0.89	0.996	[1] 1.0	[1] 1.0
10 ------	.41	.65	.94	.995	[1] 1.0
25 ------	.18	.34	.64	.87	.983
50 ------	.10	.18	.40	.64	.87
100 ------	.05	.10	.22	.40	.63

[1] These probabilities are less than 1, but for all practical purposes may be taken as unity.

REGIONAL ANALYSIS

Because streamflow records are not available at most sites where information is needed, data from gaging stations must be interpreted and applied to these sites. Since flood-frequency data at individual gaging stations have very limited transfer capability, estimates of flood characteristics at ungaged sites should be based on a regional analysis of gage data. A regional analysis has the advantage of developing flood-frequency relations that are applicable to an entire region, rather than to a single station, by considering records for all stations in a region.

The watershed characteristics that produce floods are analyzed, and relations that define flood characteristics are then developed and may be applied to ungaged sites. In this study it was found that flood characteristics of most streams in Indiana are highly related to differences in hydrology of the three general physiographic regions of the State. In addition to drainage area and precipitation, specific geomorphic parameters such as drainage density and relief are the dominant factors that influence floods on small streams. On large streams, the geomorphic factors are less pronounced because of the integrated effect of drainage from many small streams with dissimilar geomorphology. Floods on the large streams are more influenced by channel control, and factors such as channel slope and length are dominant factors.

In addition to the physical characteristics, climatic variations influence flood characteristics. The total amount of precipitation, when adjusted for evapotranspiration and snowmelt, was found to be very significant in explaining differences in flood characteristics of large areas. Rainfall intensity, when combined with soil permeability, was found to be more important in producing floods from small areas.

MULTIPLE-REGRESSION METHOD

Flood-frequency analysis by the multiple-regression method identified the most significant watershed and climatic factors that produce floods. A frequency curve for each gaging station having at least 10 years of record was developed by using the log-Pearson Type III distribution function, and discharges corresponding to the 2-, 5-, 10-, 25-, 50-, and 100-year recurrence intervals were compiled for each station. Each set of discharges was then regressed against various watershed and climatic variables using the model:

$$Q_t = b \, A^x B^y \ldots \ldots \ldots \ldots D^u,$$

where

Q is the discharge for a recurrence interval of t-years,

A, B, D are watershed and climatic variables,

x, y, u are regression coefficients,

b is the regression constant.

The model relates flood discharges of a specified frequency of occurrence to physical and climatic parameters. The independent variables $(A, B \ldots D)$ in the model are not the only ones that influence flood peaks in Indiana; however, in this study they were found to be the most effective in estimating peak flows with the smallest standard error and the least number of variables.

The flood data used in the regression model were from natural flowing streams. In addition to removing periods of regulation from the station records, some stations were omitted from the regression analyses because of effects of urbanization and size of drainage area (stations with drainage areas less than 15 mi² (38.8 km²) were excluded). Only independent variables that could be contained in the report or determined from available maps were considered. The number of stations used to develop the regression equations were:

Model 1_____81 stations.
Model 2_____43 stations.
Model 3____144 stations.
Model 4_____20 stations.

FIGURE 1.—Location of gaging stations used in this study.
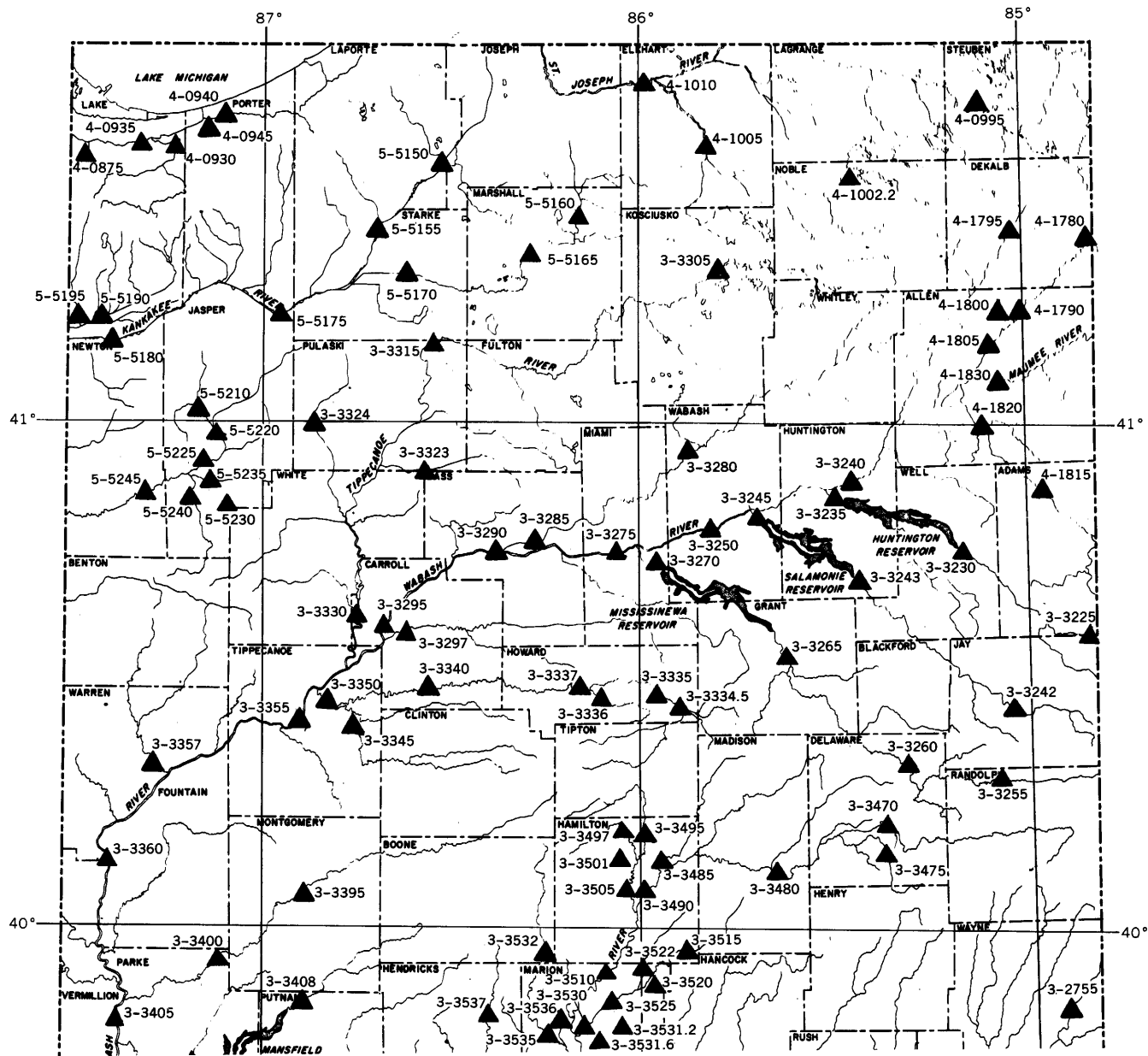
The log-Pearson frequency discharges are shown in table 6 for each station according to the minimum length of record for selected recurrence intervals (see page 2). Corresponding discharge values computed from the regional equations presented in this manual are shown up to the 100-year recurrence interval.

WATERSHED CHARACTERISTICS

The watershed and climatic variables in the regression equations in this manual may be determined from standard 7½-minute series U.S. Geological Survey topographic maps and from included maps and graphs. Because an insufficient record of peak discharges is available from gaging stations on small streams, the equations should not be applied to watersheds smaller than 15 mi² (38.8 km²). The following watershed and climatic variables were found to be significant in the regression models:

Channel length (L).—Distance along a stream, in miles, from a gaging station (or point of discharge) to the watershed divide. It is measured with dividers spaced at 0.1 mile (0.16 km) on the Geological Survey 7½-minute series topographic maps.

Channel slope (S).—The difference in elevation at points, 10 percent and 85 percent of the distance along the channel from a gaging station (or point of discharge) to the watershed divide, divided by the distance between the two points. Expressed in feet per mile and determined from 7½-minute series topographic maps or from stream profiles available from the Indiana Department of Natural Resources.

Drainage area (A).—Area of the watershed, in square miles, as planimetered from Geological Survey 7½-minute series topographic maps, and tabulated in a report in preparation by the Geological Survey. Index map showing maps available from the Geological Survey can be obtained free of charge from Distribution Branch, U.S. Geological Survey, 1200 South Eads Street, Arlington, Virginia 22202. Maps listed in the index can be purchased from this address.

Drainage density (D).—Total stream length in a watershed, in miles, divided by the drainage area, expressed in miles per square mile. Drainage density was measured from county drainage maps (Purdue University, 1959) with dividers spaced at 0.25 mile (0.40 km). It is a geomorphic parameter that is related to the physiography of a region. Figure 2 shows the three general physiographic regions of Indiana and the principal watershed divides in the State. Drainage densities measured for small watersheds in this study relate closely to drainage areas within the different physiographic regions as shown in figure 3. Because measurement of drainage density from the county maps is a rather tedious procedure, figures 2 and 3 are provided for estimating drainage densities for ungaged sites. Actual variation of measured drainage densities from the maps to those interpolated from the curves in figure 3 is 28 percent. To obtain design discharges, drainage density should be measured from the county drainage maps.

Precipitation index (Pi).—The areal variation in average annual excess precipitation, in inches, which is the mean annual precipitation minus the sum of average annual evapotranspiration and mean annual snowfall (water equivalent). This is the average annual amount of precipitation that is available for runoff. Snowfall is removed from the annual total because in flat terrain typical of Indiana, snowmelt is usually slow, resulting in low peak discharges. It may be determined from figure 4. The lines of equal average annual excess precipitation are based on data furnished by the National Weather Service. Where a stream crosses a line of equal precipitation, a weighted average should be estimated and rounded to the nearest one-half inch.

Soil runoff coefficient (Rc).—A coefficient that related storm runoff to soil permeability by major hydrologic soil groups as defined by the Agronomy Department, Purdue University, and the U.S. Soil Conservation Service (fig. 5). *Rc* is defined as the ratio of the volume of rainfall, *Px*, to the total volume of runoff, *R*, occurring after the beginning of runoff:

$$Rc = \frac{Px}{R}$$

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The soil runoff coefficient was compiled by principal soil types and then grouped by hydrologic soil groups as shown by the map. If a stream crosses a soil group boundary, an areally weighted average should be rounded to the nearest one-tenth.

Watershed relief (R).—The difference in elevation, in feet, between the highest point on the watershed perimeter and the stream at a gaging station (or point of discharge). Determined from Geological Survey 7½-minute topographic maps.

Watershed shape factor (f).—The ratio of stream length to the diameter of a circle having the same area as the watershed. It is not an independent variable to use in the regression equations, but is a qualitative parameter that is combined with drainage area to determine which set of watershed characteristics best estimate the flood characteristics for particular streams. The time of concentration is usually greater and resulting flood peaks are lower for elongated watersheds than for fan or pear-shaped watersheds. The shape is determined by dividing the channel length, in miles, by the diameter of a circle, in miles, having the same area as the watershed, and is computed by:

$$\text{Watershed shape } (f) = 0.89\, LA^{-1/2}$$

REGRESSION MODELS

The best models for estimating flood discharges in Indiana were developed by using the combination of drainage area and watershed shape as an index to determine which factors have the most influence on flood peaks for each watershed. Generally, for streams that drain areas less than 100 mi² (259 km²), the shape factor (f) is less than 2.0 and drainage area, watershed relief, drainage density, and soil runoff coefficient were the most important factors. For streams draining more than 200 mi² (518 km²) (f) is greater than 2.0, and drainage area, channel slope, channel length, and the precipitation index were the factors that had the most influence on flood characteristics. For streams draining between 100 and 200 mi² (259 and 518 km²), if (f) was greater than 2.0, factors for the large streams applied. If (f) was less than 2.0, factors for the small streams applied.

For estimating flood discharges for streams with drainage areas between 100 and 200 mi² (259 and 518 km²), an adjustment technique is recommended based upon size of drainage area. This adjustment is expressed by:

$$\left(\frac{A-100}{100}\right) Q_t \text{ model 1} + \left(\frac{200-A}{100}\right) Q_t \text{ model 2}$$

where Q_t model 1 is computed from the regression model shown for large streams (greater than 200 mi² or 518 km²) and Q_t model 2 is computed from the regression model shown for small streams (less than 100 mi² or 259 km²) and A is drainage area.

Model 1 is the regression equation for large streams and has the form:

$$Q_t = b\, A^x\, S^y\, L^z\, Pi^u$$

where

Q_t is the discharge for a recurrence interval of t-years

b is the regression constant,

A is the drainage area (mi²),

S is the channel slope (ft/mi),

L is the channel length (mi),

Pi is the precipitation index (in.),

x, y, z, and u are regression coefficients.

TABLE 2.—*Regression coefficients for model 1*

t-years	b	x	y	z	u	Standard error (percent)
2	1.16	0.734	0.729	0.277	0.891	26
5	1.19	.701	.792	.348	.982	26
10	1.19	.678	.815	.393	1.037	26
25	1.16	.654	.841	.443	1.103	27
50	1.12	.632	.858	.489	1.153	28
100	1.06	.620	.876	.521	1.198	29

Model 2 is the regression equation for small streams and has the form:

$$Q_t = b\, A^x\, R^y\, D^z\, R_c^u$$

where

Q_t is the discharge for a recurrence interval of t-years,

b is the regression constant,

A is the drainage area (mi²),

R is the watershed relief (ft),

D is the drainage density (mi/mi²),

R_c is the soil runoff coefficient,

x, y, z, and u are regression coefficients.

Model 3 was developed for all streams draining at least 15 mi² (38.8 km²), using the two factors that have the greatest influence on

INDIANA WATERSHED AREAS		Curve in figure 3
1	Lake Michigan	D
2	St Joseph	D
3	Kankakee	D
4	Maumee	D
5	Tippecanoe	D
6	Upper Wabash, Logansport	C
7	Mid-Wabash, Logansport	C
8	Wabash, below Terre Haute	A
9	Upper White, West Fork	C
10	Lower White West Fork	B
11	Upper White, East Fork	C
12	Muscatatuck	B
13	Lower White, East Fork	B
14	Patoka	A
15	Whitewater	B
16	Upper Ohio	B
17	Mid-Ohio	B
18	Lower Ohio	B

EXPLANATION

▬ ▪ ▬ ▪ ▬
Watershed boundary

▬ ▬ ▬ ▬
Physiographic boundary

10
Watershed number

FIGURE 2.—Principal watersheds and major physiographic regions.

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TABLE 3.—*Regression coefficients for model 2*

t-years	b	x	y	z	u	Standard error (percent)
2 ------	18.7	0.591	0.351	0.574	1.47	34
5 ------	29.2	.552	.327	.725	1.55	33
10 ------	38.5	.529	.309	.803	1.60	33
25 ------	50.7	.508	.289	.888	1.66	34
50 ------	59.6	.494	.281	.949	1.70	35
100 ------	70.6	.480	.270	1.002	1.74	37

flood characteristics—drainage area and the precipitation index. This model is presented for making quick estimates, but estimates are not as reliable as those computed from models 1 and 2.

Model 3 is of the equation form:

$$Q_t = b\,A^x Pi^y$$

where

Q_t is the discharge for a recurrence interval of t-years,

b is the regression constant,

A is the drainage area (mi^2),

Pi is the precipitation index (in.),

x and y are regression coefficients.

TABLE 4.—*Regression coefficients for model 3*

t-years	b	x	y	Standard error (percent)
2 --------	1.42	0.688	1.832	50
5 --------	1.44	.685	2.001	54
10 --------	1.42	.684	2.094	56
25 --------	1.38	.684	2.200	58
50 --------	1.32	.684	2.281	60
100 --------	1.27	.685	2.353	63
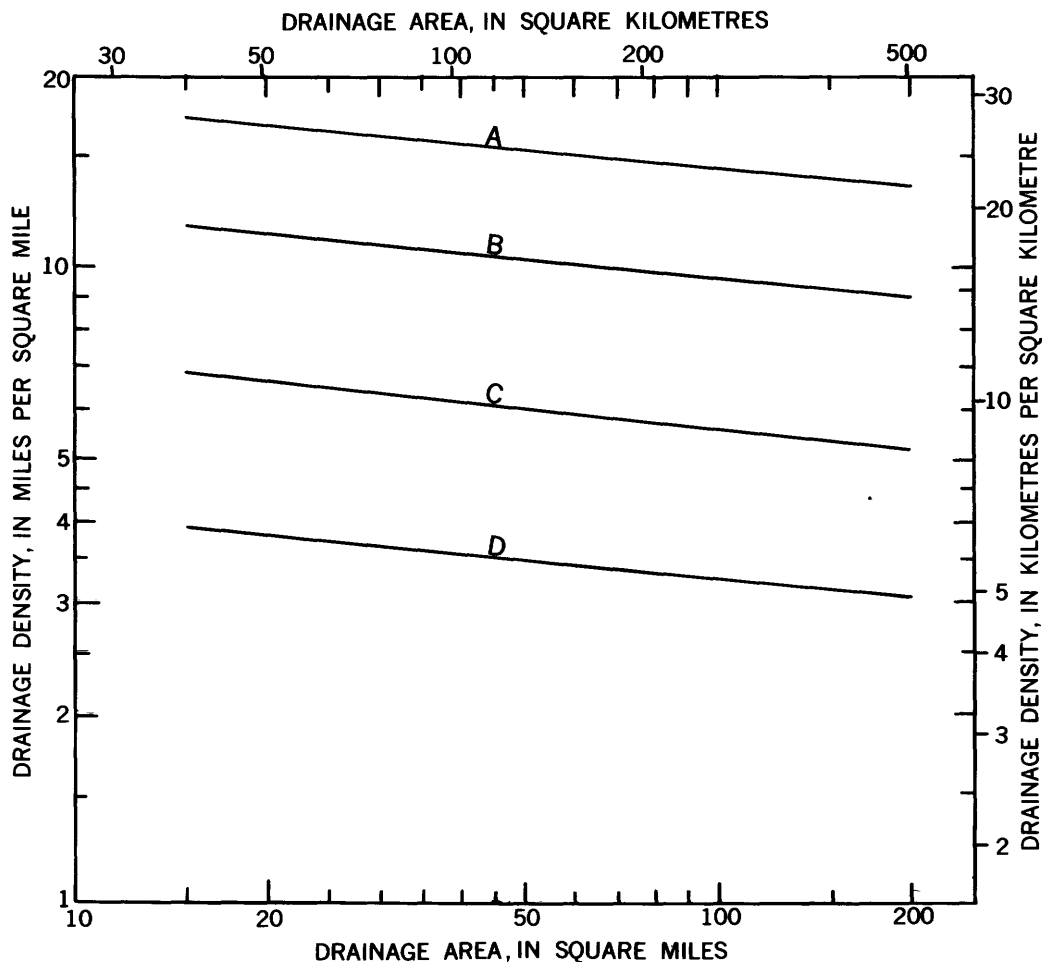
FIGURE 3.—Relationship of drainage density to drainage area by physiographic region for streams having drainage areas between 15 and 200 mi² (38.8 and 322 km²). See figure 2 for location of streams.

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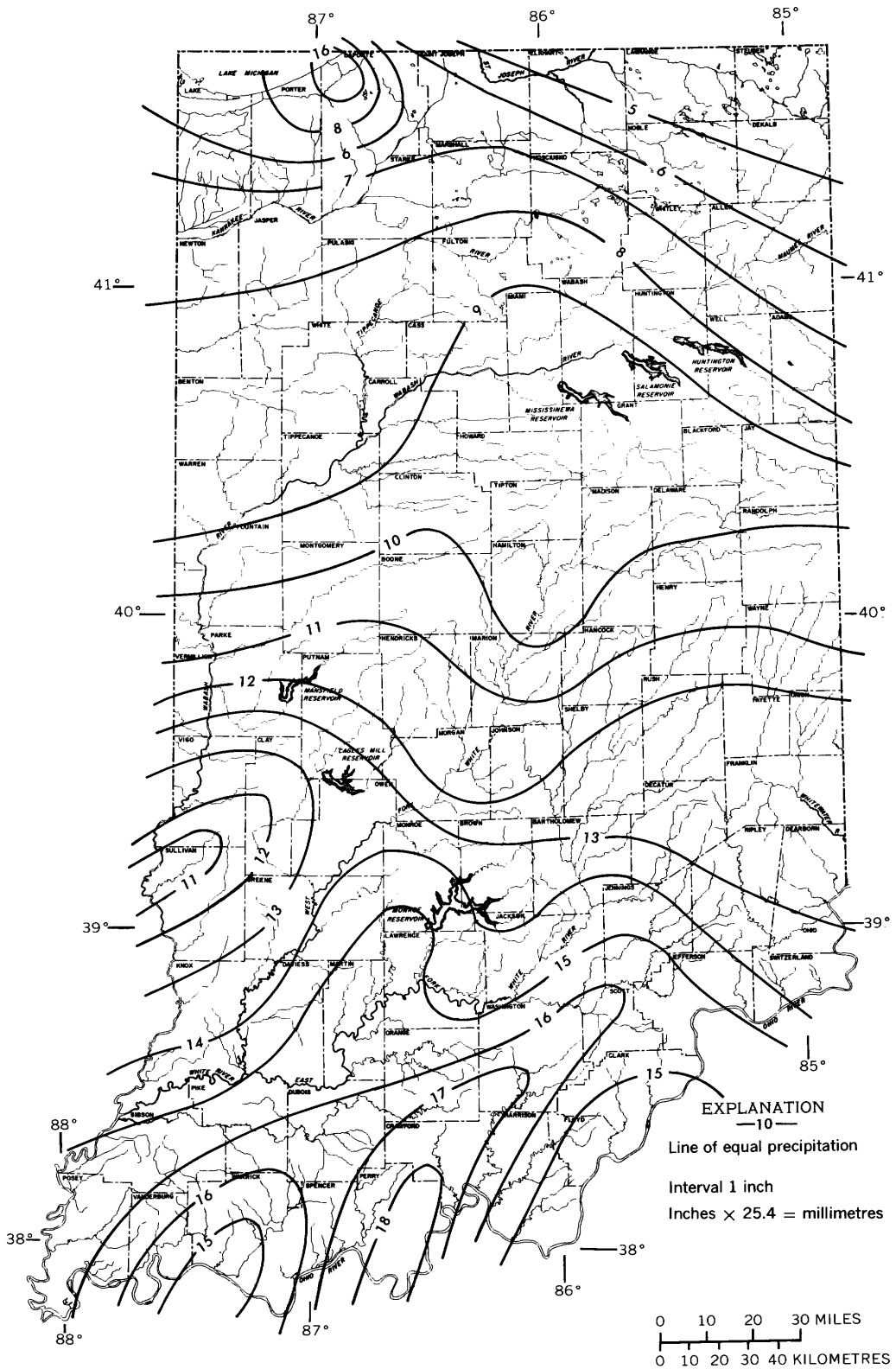
FIGURE 4.—Average annual excess precipitation. Based on data from U.S. Weather Service.

Hydrologic soil group	Soil runoff coefficient
A	0.30
B	0.50
C	0.70
D	0.80
E	1.00

Hydrologic soil group boundary
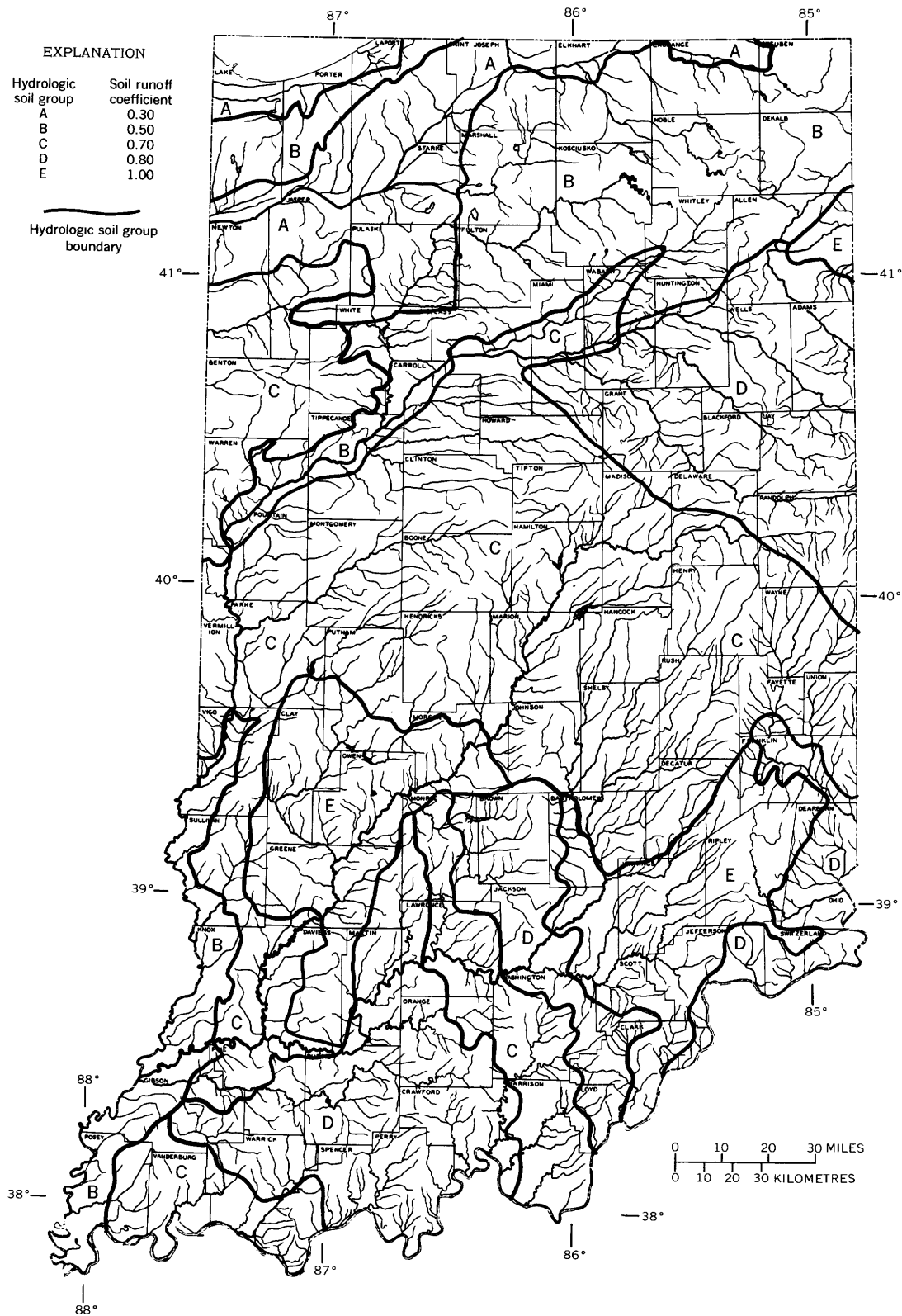
FIGURE 5.—Major hydrologic soil groups. Based on data by the Agronomy Department, Purdue University, and the U.S. Soil Conservation Service.

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Model 4 was developed for the Wabash and White Rivers using the watershed factors: drainage area, channel slope, and stream length. The precipitation index was not found to be significant. The model is of the form:

$$Q_t = b\, A^x S^y L^z$$

where

Q_t is a peak discharge with a recurrence interval of t-years,

b is the regression constant,

A is the drainage area (mi^2),

S is the channel slope (ft/mi),

L is the stream length (mi),

x, y, and z are the regression coefficients.

This equation should be used to estimate regional flood-frequency discharges on the Wabash and White Rivers:

1. Wabash River—from Wabash to the mouth.

2. White River—from Indianapolis to the mouth.

3. East Fork White River—from Columbus to the mouth.

Computed values from model 4 compare closely with the t-year discharges from frequency curves for stations on these rivers (see table 6), and t-year peaks computed from model 4 for points between the gaging stations on these streams should be used. Figures 6–8 show t-year peak discharges versus distance for these streams.

Model 4 should *not* be used on the Wabash River above Montezuma, because of the effects of the flood-control reservoirs that have been developed since 1968.
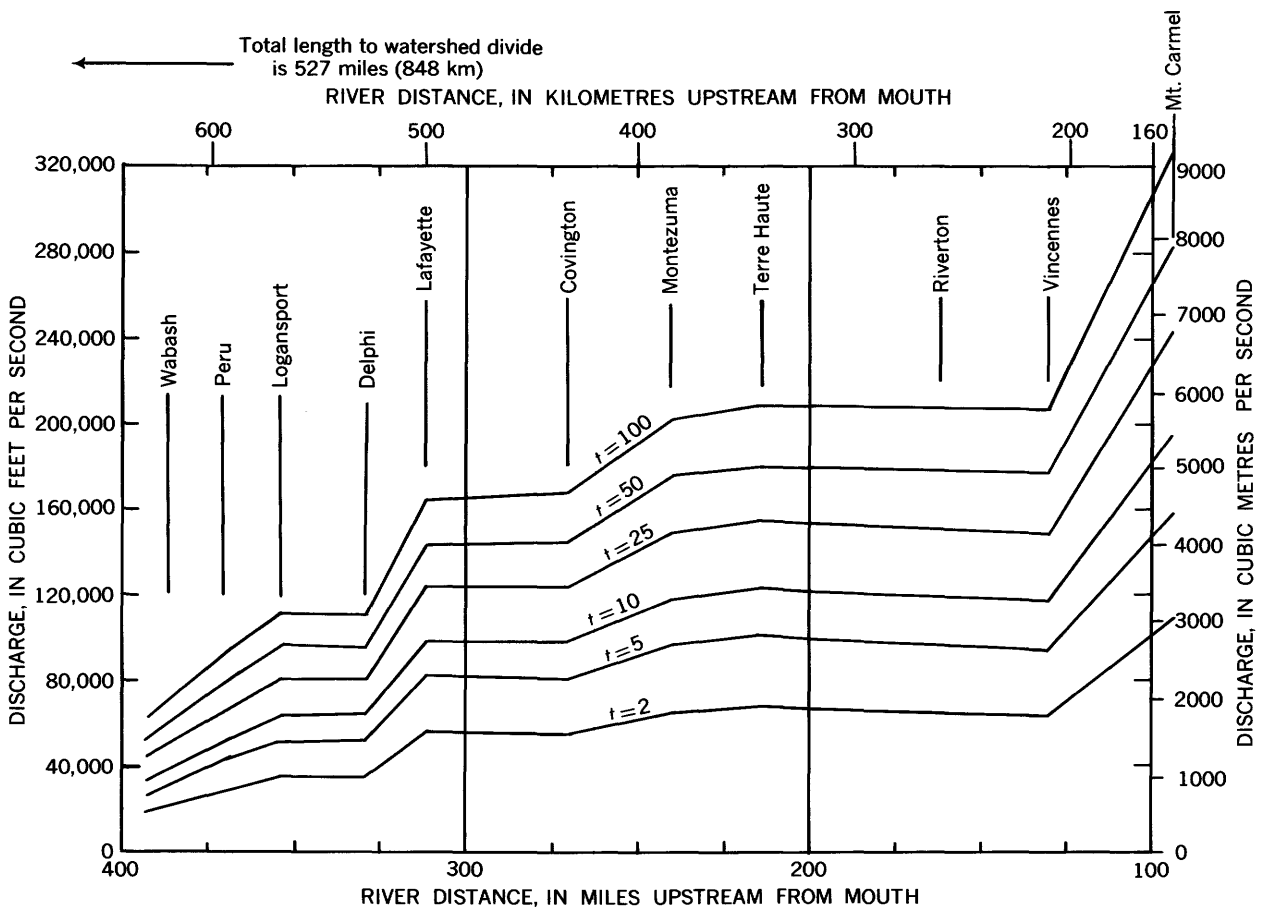
FIGURE 6.—Q_t peak discharges on main stem of Wabash River computed from the regression equation for model 4.

TABLE 5.—*Regression coefficients for model 4*

t year	b	x	y	z	Standard error (percent)
2	144	0.902	0.382	−0.435	9
5	279	.870	.311	−.423	11
10	494	.832	.203	−.418	10
25	1,114	.826	.077	−.499	10
50	2,197	.777	−.058	−.499	9
100	2,838	.751	−.099	−.473	9

Graphic solutions for the regression equations for models 1, 2, and 3 are shown in figures 11 to 28.

Figure 9 shows the standard error that can be expected from computing *t*-year discharges from the regression models. Generally this error means that for about 67 percent of the estimates, the difference between computed and observed discharges are within plus or minus one standard error of estimate. It is an approximate measure of the accuracy of the discharges computed using the regression equations. Users of this manual should recognize from figure 9 that

model 3 does not provide estimates as reliable as models 1 or 2.

ILLUSTRATIVE EXAMPLES

Example 1.—Estimate the 100-year peak discharge of the Eel River at State Road 5 in South Whitley, an ungaged site.

1. The following quadrangles for determining drainage area are South Whitley West, South Whitley East, Laud, Columbia City, Churubusco, Ege, and Merriam. From the topographic maps or from the drainage area report, the drainage area is 284 mi².

2. From the maps, the channel length is 28.8 miles to the watershed divide (Huntertown quadrangle).

3. The channel slope is computed by the difference in elevation at mile 2.9 (0.10×28.8) and mile 24.5 (0.85×28.8) divided by 21.6 (24.5−2.9) the distance between the two points:

    Elevation at mile 24.5 is 825 ft.
    (Huntertown quadrangle)
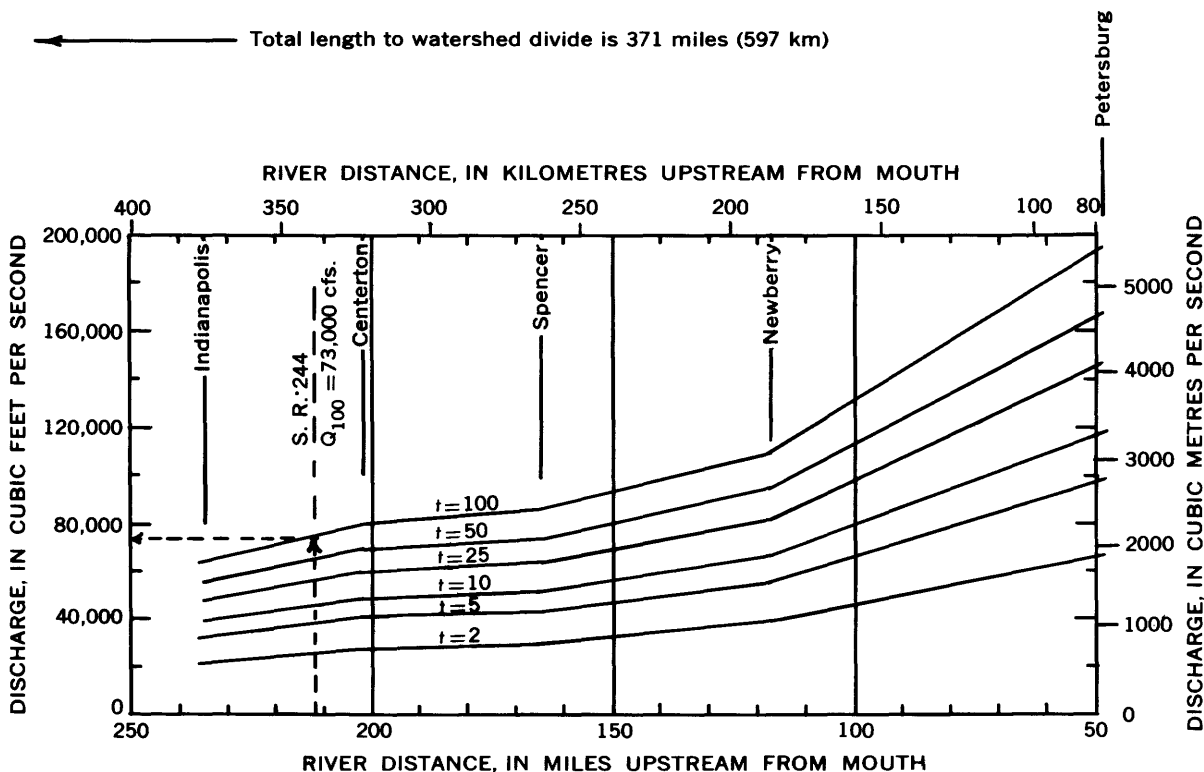

FIGURE 7.—Q_t peak discharges on main stem of White River computed from the regression equation for model 4.
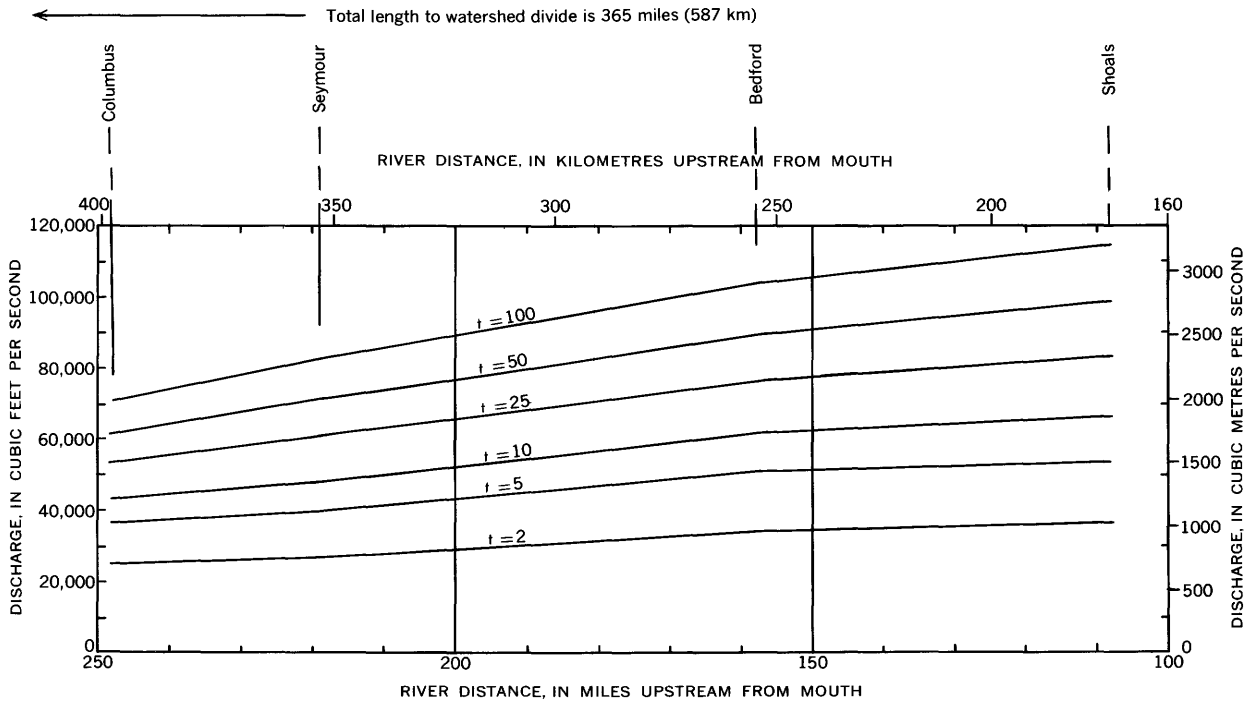
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FIGURE 8.—Q_t peak discharges on main stem of East Fork White River computed from the regression equation for model 4.
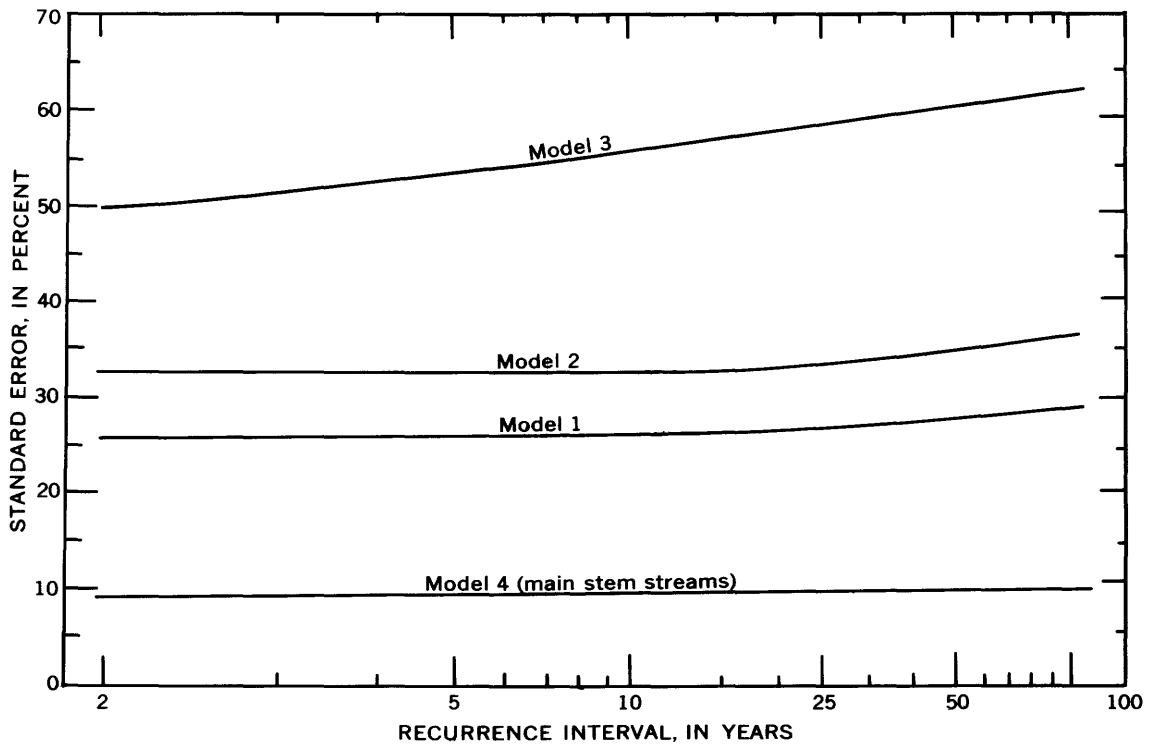

FIGURE 9.—Standard error versus recurrence interval for t-year peak discharge computed from regression equations.

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Elevation at mile 2.9 is 783 ft.
(South Whitley East quadrangle)

$$\text{Channel slope} = \frac{(825-783)\text{ feet}}{21.6\text{ miles}} = 1.9\text{ ft/mi.}$$

4. From figure 4, the precipitation index is 7.0 in.

5. From model 1:
$$Q_{100} = 1.06\, A^{0.620} S^{0.876} L^{0.521} Pi^{1.198}$$

6. Substituting the proper variables:
$$Q_{100} = 1.06\,(284)^{0.620}(1.9)^{0.876}(28.8)^{0.521}(7.0)^{1.198}$$
Solving the equation:
$$Q_{100} = 3{,}660\text{ ft}^3/\text{s }(102\text{ m}^3/\text{s}).$$

7. Solving the equation graphically (fig. 16)
$$Q_{100} = 3{,}600\text{ ft}^3/\text{s }(101\text{ m}^3/\text{s}).$$

Example 2.—Determine the discharge needed for selecting the size of culvert pipe on Willow Creek at State Road 3 in Allen County, a tributary to Cedar Creek, for the 25-year recurrence interval.

1. The drainage area as determined from the Ege, Garrett, and Huntertown quadrangles is 18.0 mi².

2. The watershed relief is 125 feet (945–820).

3. The drainage density estimated from figures 2 and 3 is 3.9 mi/mi². Measured from the Allen and Noble County drainage maps, the drainage density is 3.0 mi/mi².

4. From figure 5, the soil runoff coefficient (Hydrologic Soil Group B) is 0.50.

5. From model 2:
$$Q_{25} = 50.7\, A^{0.508} R^{0.289} D^{0.888} Rc^{1.66}.$$

6. Substituting the proper variables:
$$Q_{25} = 50.7\,(18.0)^{0.508}(125)^{0.289}(3.9)^{0.888}(0.50)^{1.66}.$$
Solving the equation:
$$Q_{25} = 940\text{ ft}^3/\text{s }(26.3\text{ m}^3/\text{s}).$$

7. Solving the equation, using the measured drainage density:
$$Q_{25} = 745\text{ ft}^3/\text{s }(20.9\text{ m}^3/\text{s}).$$

8. Solving the equation graphically (fig. 22)
$$Q_{100} = 988\text{ ft}^3/\text{s }(27.7\text{ m}^3/\text{s}).$$

Example 3.—Using model 4, compute the 100-year peak discharge for White River at State Road 244 in Morgan County.

1. From the drainage area report, the drainage area at S. R. 244 is 2,026 mi².

2. From the topographic maps, the river distance at S. R. 244 is 212 miles above the mouth. The stream length at S. R. 244 is

determined by: total river length minus the distance above the mouth at S. R. 244—371 miles – 212 miles = 159 miles.

From model 4, the computed discharge is:
$$Q_{100} = 2{,}838\,(2{,}026)^{0.751}(3.2)^{-0.099}(159)^{-0.473}.$$
$$Q_{100} = 70{,}000\text{ ft}^3/\text{s }(1{,}960\text{ m}^3/\text{s}).$$

3. Solving the equation graphically (fig. 7) the estimated Q_{100} discharge is 73,000 ft³/s (2,044 m³/s).

Example 4.—What is the probable recurrence interval of the 1970 flood (13,000 ft³/s) at South Hogan Creek near Dillsboro (03–2767) with 12 years of record? From the data in table 7:

Drainage area is 38.2 mi².
Watershed relief is 449 ft.
Drainage density is 11.0 mi/mi².
Soil runoff coefficient is 0.90

Solve the equations for *t*-year peaks from model 2:

$$Q_2 = 4{,}680\text{ ft}^3/\text{s}$$
$$Q_5 = 7{,}790$$
$$Q_{10} = 10{,}100$$
$$Q_{25} = 13{,}300$$
$$Q_{50} = 16{,}200$$
$$Q_{100} = 19{,}400$$

Plotting the discharges on log-probability coordinates, figure 10, the 1970 flood has an expected recurrence interval of 25 years.

What is the probability that this discharge will be exceeded in the next 12 years? From the laws of probability, *P*, of a peak flow to be exceeded in *n* years is:
$$P_n = 1 - (1 - 1/t)^n$$

Solving for *P*:
$$P_{12} = 1 - (1 - 1/25)^{12} = 1 - (0.96)^{12} = 39\text{ percent.}$$

Example 5.—Using the probability equation and figure 10, compute the magnitude of a flood on South Hogan Creek at Dillsboro that has a 10-percent probability of being exceeded in the next 10 years.

$$P_n = 0.10\text{ and } n = 10\text{ years}$$
$$0.10 = 1 - (1 - 1/t)^n$$
$$1 - 1/t = 0.989$$
$$1/t = 0.011$$
$$t = 90\text{ years}$$

And from figure 10, the discharge corresponding to a recurrence interval of 90 years is 19,000 ft³/s. Table 1 may be used to determine

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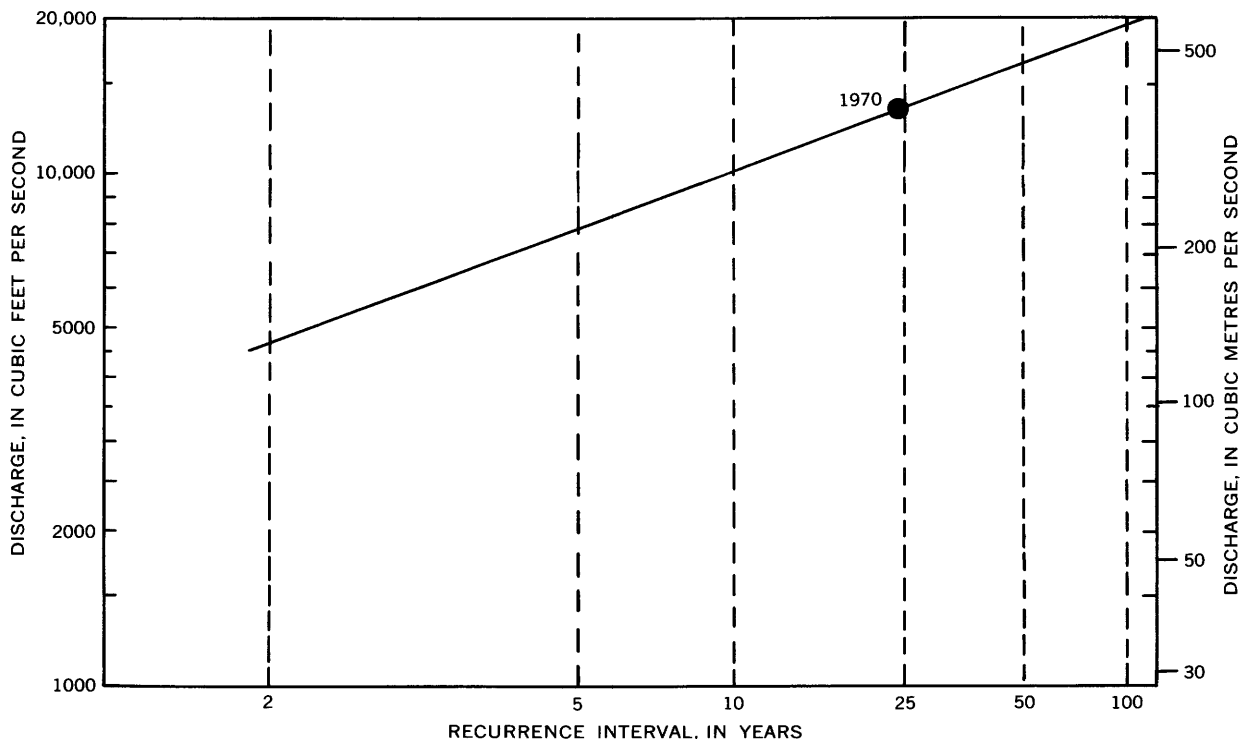
FIGURE 10.—Log-probability plot of computed t-year discharges for South Hogan Creek near Dillsboro.

the probability of a flood of a given recurrence interval being exceeded during an indicated time period.

Example 6.—It is desired to estimate the 100-year peak discharge for Deer Creek at S. R. 29 in Carroll County (an ungaged site).

1. From the Geological Survey 7.5-minute topographic maps:

   Drainage area is 122 mi²
   Channel slope is 4.9 ft/mi
   Channel length is 32.3 miles
   Relief is 182 ft

2. From figure 4:
   Precipitation index is 9.5 in.

3. From figures 2 and 3:
   Drainage density is 5.5 mi/mi²

4. From figure 5:
   Soil runoff coefficient is 0.70

5. Using the regression equation for model 1:
$$Q_{100} = 1.06 \ (122)^{0.620} (4.9)^{0.876} (32.3)^{0.521} (9.5)^{1.198}$$
$$Q_{100} = 7,600 \text{ ft}^3/\text{s} \ (213 \text{ m}^3/\text{s})$$

6. Using the regression equation for model 2:
$$Q_{100} = 70.6 \ (122)^{0.480} (182)^{0.270} (5.5)^{1.002} (0.70)^{1.74}$$
$$Q_{100} = 8,570 \text{ ft}^3/\text{s} \ (240 \text{ m}^3/\text{s})$$

7. Since the drainage area at the site is between 100 and 200 mi², the adjustment factor is applied:
$$Q_{100} = (\frac{A-100}{100}) \ Q_{100} \text{ model 1}$$
$$+ (\frac{200-A}{100}) \ Q_{100} \text{ model 2}$$
$$Q_{100} = 0.22 \ (7,600) + 0.78 \ (8,570)$$
$$= 8,360 \text{ ft}^3/\text{s} \ (234 \text{ m}^3/\text{s})$$

8. The solution is shown graphically in figures 16 and 22.

LIMITS OF APPLICATION

Relations in this manual should not be applied to streams affected by regulation or urbanization, nor to streams that drain less than 15 mi² (38.8 km²). A current project to obtain peak discharges for streams between 0.1 and 20 mi² (0.25 and 50 km²) will provide data for a future flood-frequency analysis for small streams. At present, however, sufficient data have not been collected at these sites to develop meaningful flood-frequency relationships.

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Flood-peak data are also deficient in the areas of urbanized streams and streams affected by flood-control reservoirs. Future studies are needed to define flood-frequency relationships for these streams.

SUMMARY

The maps, equations, tables, and graphs presented in this manual provide a means of estimating flood-frequency analysis. The watershed characteristics presented in the regression equations are not the only factors that influence floods in Indiana; however, they represent the most effective combination found for explaining peak flows with the smallest standard error and the least number of variables.

The regression equations should be used only within the stated limits of application. Additional studies will be necessary in the future as flood data become available for regulated streams and streams affected by urbanization.

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TABLES 6 and 7; FIGURES 11-28

The upper numbers are values of Q_t from individual station frequency curves. The lower numbers are values of Q_t computed using regression equations.

Values of Q_t from individual station frequency curves are shown according to the following minimum length of record at a gaging station: Recurrence interval _____Q_{10} Q_{25} Q_{50} Q_{100}
   Minimum length of record in years _____10   15   20   25

Values of Q_t are computed from the regression equations shown for: a, Model 1 for drainage areas greater than 200 mi². b, Model 2 for drainage areas less than 100 mi². c, Model 1 and model 2 by the weighted average $(A-100/100)Q_t$ model $1 + (200-A/100)Q_t$ model 2 for drainage areas between 100 and 200 mi² $(A$ is drainage area.) d, Model 4 for main stem gaging stations (noted by an *).

Station No.	Station name and location	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}
03–2750.00	Whitewater River near Alpine, Ind. Lat 39°34'23", long 85°09'27", in SW¼SE¼ sec. 14, T. 13 N., R. 12 E., Fayette County.	12,600 / 14,400	22,000 / 22,500	28,000 / 27,900	37,000 / 35,300	44,000 / 41,400	52,000 / 48,000
03–2755.00	East Fork Whitewater River at Richmond, Ind. Lat 39°48'24", long 84°54'26", in NW¼SW¼ sec. 8, T. 13 N., R. 1 W., Wayne County.	6,100 / 6,150	10,300 / 9,590	13,300 / 11,900	16,800 / 15,200	19,800 / 17,900	----- / 20,800
03–2760.00	East Fork Whitewater River at Brookville, Ind. Lat 39°26'02", long 85°00'12", in NE¼NE¼ sec. 20, T. 9 N., R. 2 W., Franklin County.	9,800 / 11,200	16,200 / 17,600	21,000 / 22,000	28,500 / 28,100	----- / 33,200	----- / 38,700
03–2765.00	Whitewater River at Brookville, Ind. Lat 39°24'24", long 85°00'46", in NE¼NW¼ sec. 32, T. 9 N., R. 2 W., Franklin County.	29,000 / 25,500	46,000 / 39,200	56,000 / 48,300	68,000 / 60,700	78,000 / 70,900	89,000 / 82,100
03–2767.00	South Hogan Creek near Dillsboro, Ind. Lat 39°01'47", long 85°02'17", in SW¼NW¼ sec. 7, T. 4 N., R. 2 W., Dearborn County.	5,900 / 4,680	10,300 / 7,790	12,600 / 10,100	----- / 13,300	----- / 16,200	----- / 19,400
03–2770.00	Laughery Creek near Farmers Retreat, Ind. Lat 38°57'08", long 85°04'15", in NW¼SE¼ sec. 2, T. 4 N., R. 3 W., Ohio County.	10,500 / 7,920	17,200 / 12,800	22,000 / 16,300	29,500 / 21,300	36,400 / 25,800	44,000 / 30,400
03–2940.00	Silver Creek near Sellersburg. Ind. Lat 38°22'15", long 85°43'35", in SW¼SW¼ Lot 68, Clark Military Grant, Clark County.	7,000 / 5,670	11,200 / 8,800	14,100 / 10,900	18,000 / 13,900	----- / 16,300	----- / 18,800
03–3025.00	Indian Creek near Corydon, Ind. Lat 38°16' 35", long 86°06'35", in SW¼SE¼ sec. 6, T. 3 S., R. 4 E., Harrison County.	7,000 / 6,380	10,400 / 8,410	13,100 / 12,200	17,000 / 15,500	20,300 / 18,300	----- / 21,200
03–3030.00	Blue River near White Cloud, Ind. Lat 38°14'15", long 86°13'42", in NW¼SE¼ sec. 19, T. 3 S., R. 3 E., Harrison County.	13,200 / 8,070	19,000 / 13,200	22,300 / 16,900	26,000 / 22,400	29,000 / 27,500	31,500 / 32,500
03–3033.00	Middle Fork Anderson River at Bristow, Ind. Lat 38°08'19", long 86°43'16", in SW¼NE¼ sec. 27, T. 4 S., R. 3 W., Perry County.	2,350 / 4,330	4,050 / 7,200	5,500 / 9,300	----- / 12,300	----- / 15,000	----- / 17,900
03–3221.00	Pigeon Creek at Evansville, Ind. Lat 38°00'14", long 87°32'19", in NE¼NW¼ sec. 16, T. 6 S., R. 10 W., Vanderburg County.	4,200 / 4,710	6,200 / 6,970	7,700 / 8,530	----- / 10,700	----- / 12,400	----- / 14,200
03–3225.00	Wabash River near New Corydon, Ind. Lat 40° 33'50", long 84°48'10", in NE¼SE¼ sec. 3, T. 24 N., R. 15 E., Jay County.	4,100 / 3,260	5,700 / 5,410	6,600 / 6,650	7,700 / 8,330	8,600 / 9,760	----- / 11,200
03–3230.00	Wabash River at Bluffton, Ind. Lat 40°44'30", long 85°10'19", in NW¼NE¼ sec. 4, T. 26 N., R. 12 W., Wells County.	5,700 / 4,820	8,200 / 7,020	10,300 / 8,550	13,200 / 10,600	16,000 / 12,300	19,000 / 14,300
03–3235.00	Wabash River at Huntington, Ind. Lat 40°51'20", long 85°29'53", in SW¼NE¼ sec. 27, T. 28 N., R. 9 E., Huntington County.	7,500 / 6,410	10,300 / 9,400	12,400 / 11,500	15,300 / 14,300	17,900 / 16,700	----- / 19,100
03–3240.00	Little River near Huntington, Ind. Lat. 40°54'14", long 85°24"22, in NE¼NW¼ sec. 9, T. 28 N., R. 10 E., Huntington County.	3,300 / 2,910	4,300 / 4,120	4,700 / 4,850	5,400 / 5,770	5,800 / 6,500	6,300 / 7,170
03–3242.00	Salamonie River at Portland, Ind. Lat 40°25'40", long 85°02'20", in NE¼SE¼ sec. 23, T. 23 N., R. 13 E., Jay County.	2,250 / 1,610	2,900 / 2,300	3,200 / 2,730	----- / 3,310	----- / 3,770	----- / 4,250
03–3243.00	Salamonie River near Warren, Ind. Lat 40°42'25", long 85°27'13", in SE¼SE¼ sec. 12, T. 26 N., R. 9 E., Huntington County.	6,700 / 4,290	9,200 / 6,200	10,600 / 7,480	13,400 / 9,180	----- / 10,600	----- / 12,000
03–3245.00	Salamonie River at Dora, Ind. Lat 40°48'42", long 85°41'02", in NE¼NE¼ sec. 12, T. 27 N., R. 7 E., Wabash County.	7,400 / 6,040	10,500 / 8,900	12,200 / 10,900	14,300 / 13,500	16,000 / 15,700	17,300 / 18,000
*03–3250.00	Wabash River at Wabash, Ind. Lat 40°47'25", long 85°49'13", in SE¼NW¼ sec. 14, T. 27 N., R. 6 E., Wabash County.	21,000 / 20,300	31,400 / 30,500	38,800 / 38,100	49,000 / 48,900	58,000 / 59,100	68,000 / 69,200
03–3255.00	Mississinewa River near Ridgeville, Ind. Lat 40° 16'49", long 84°59'44", in SE¼SE¼ sec. 7, T. 21 N., R. 14 E., Randolph County.	3,400 / 3,730	5,800 / 5,390	7,700 / 6,920	10,700 / 8,700	13,400 / 10,200	16,500 / 11,700
03–3260.00	Mississinewa River near Eaton, Ind. Lat 40°19'08", long 85°19'10", in NW¼NE¼ sec. 31, T. 22 N., R. 11 E., Delaware County.	6,200 / 4,160	10,000 / 6,120	13,000 / 7,450	17,500 / 9,250	21,200 / 10,700	----- / 12,200
03–3265.00	Mississinewa River at Marion, Ind. Lat 40°34'34", long 85°39'34", in SE¼NE¼ sec. 31, T. 25 N., R. 8 E., Grant County.	11,300 / 7,720	16,800 / 11,400	20,000 / 13,900	24,000 / 17,000	27,400 / 20,100	31,000 / 23,000

Station No.	Station name and location	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}
03–3270.00	Mississinewa River at Peoria, Ind. Lat 40°43'24", long 85°57'27", in SW¼SW¼ sec. 3, T. 26 N., R. 5 E., Miami County.	10,500 10,400	17,200 15,800	21,000 19,500	25,500 24,500	----- 28,900	----- 33,400
*03–3275.00	Wabash River at Peru, Ind. Lat 40°44'35", long 86°05'45", in SE¼NE¼ sec. 32, T. 27 N., R. 4 E., Miami County.	27,500 27,700	41,000 41,200	50,500 50,800	65,000 64,800	77,000 77,200	89,000 89,800
03–3280.00	Eel River at North Manchester, Ind. Lat 40°59'55", long 85°45'50", in NE¼NE¼ sec. 5, T. 29 N., R. 7 E., Wabash County.	4,050 2,840	5,600 3,900	6,600 4,560	7,600 5,400	8,400 6,050	9,200 6,700
03–3285.00	Eel River near Logansport, Ind. Lat 40°46'55". long 86°15'50", in NE¼SE¼ sec. 14, T. 27 N., R. 2 E., Cass County.	7,400 6,850	10,400 9,870	12,400 11,900	14,900 14,600	16,500 16,800	18,200 19,000
*03–3290.00	Wabash River at Logansport, Ind. Lat 40°44'47", long 86°22'39", in SW¼NE¼ sec. 35, T. 27 N., R. 1 E., Cass County.	37,000 34,800	52,000 51,600	64,000 63,400	81,000 80,900	96,000 95,600	111,000 110,000
03–3295.00	Wabash River at Delphi, Ind. Lat 40°35'26" long 86°41'54", in SE¼SE¼ sec. 24, T. 25 N. R. 3 W., Carroll County.	36,000 35,300	52,000 52,300	64,000 64,100	81,000 80,900	96,000 95,600	111,000 110,000
03–3297.00	Deer Creek near Delphi, Ind. Lat 40°35'25" long 86°37'15", in NE¼NE¼ sec. 27, T. 25 N., R. 2 W., Carroll County.	3,800 5,540	6,400 8,470	8,600 10,500	12,400 13,200	16,000 15,400	20,300 17,800
03–3305.00	Tippecanoe River at Oswego, Ind. Lat 41°19'14", long 85°47'21", in NE¼NE¼ sec. 14, T. 33 N., R. 6 E., Kosciusko County.	350 620	500 810	600 910	740 1,050	860 1,150	----- 1,250
03–3315.00	Tippecanoe River near Ora, Ind. Lat 41°09'26", long 86°33'49", in SE¼SE¼ sec. 6, T. 31 N., R. 1 W., Pulaski County.	3,800 5,400	5,400 7,620	6,400 9,120	7,700 11,100	8,800 12,700	9,900 15,000
03–3323.00	Little Indian Creek near Royal Center, Ind. Lat 40°52'53", long 86°35'26", in NE¼NW¼ sec. 13, T. 28 N., R. 2 W., White County.	360 190	430 230	460 260	----- 290	----- 310	----- 330
03–3324.00	Big Monon Creek near Francesville, Ind. Lat 40° 59'03", long 86°51'43", in NW¼NE¼ sec. 10, T. 29 N., R. 4 W., Pulaski County.	1,750 1,360	2,160 1,780	2,350 2,030	----- 2,350	----- 2,590	----- 2,820
03–3330.00	Tippecanoe River near Delphi, Ind. Lat 40°37'02", long 86°45'39", in NW¼NE¼ sec. 16, T. 25 N., R. 3 W., Carroll County.	11,600 11,000	16,000 15,600	19,000 18,800	22,000 23,000	24,700 26,600	27,000 30,200
03–3334.50	Wildcat Creek near Jerome, Ind. Lat 40°26'29", long 85°55'08", in NE¼SE¼ sec. 14, T. 23 N., R. 5 E., Howard County.	2,600 2,110	3,600 2,880	4,100 3,360	----- 3,990	----- 4,480	----- 4,960
03–3335.00	Wildcat Creek at Greentown, Ind. Lat 40°27'00", long 85°57'00", on line between secs. 9 and 10, T. 23 N., R. 5 E., Howard County.	2,400 2,320	3,800 3,210	4,800 3,830	6,050 4,590	----- 5,220	----- 5,700
03–3336.00	Kokomo Creek near Kokomo, Ind. Lat 40°26'28", long 86°05'20", in NW¼SW¼ sec. 16, T. 23 N., R. 4 E., Howard County.	430 790	610 1,190	740 1,480	----- 1,870	----- 2,190	----- 2,530
03–3337.00	Wildcat Creek at Kokomo, Ind. Lat 40°28'24", long 86°09'26", in NE¼NW¼ sec. 2, T. 23 N., R. 3 E., Howard County.	3,600 2,730	5,700 3,950	7,000 4,770	8,600 5,850	----- 6,730	----- 7,610
03–3340.00	Wildcat Creek at Owasco, Ind. Lat 40°27'50", long 86°38'15", in SE¼SE¼ sec. 4, T. 23 N., R. 2 W., Carroll County.	4,500 5,680	6,900 8,610	8,500 10,700	10,500 13,500	12,200 15,900	14,000 18,300
03–3345.00	South Fork Wildcat Creek near Lafayette, Ind. Lat 40°25'04", long 86°46'05", in SW¼SW¼ sec. 21, T. 23 N., R. 3 W., Tippecanoe County.	4,500 6,260	7,600 9,790	10,000 12,200	13,400 15,500	16,700 18,300	20,300 21,300
03–3350.00	Wildcat Creek near Lafayette, Ind. Lat 40°26'26", long 86°49'46", in SE¼NE¼ sec. 14, T. 23 N., R. 4 W., Tippecanoe County.	9,000 10,500	14,000 15,700	18,000 19,400	23,000 24,300	----- 28,600	----- 32,900
*03–3355.00	Wabash River at Lafayette, Ind. Lat 40°25'19", long 86°53'49", in NE¼SW¼ sec. 20, T. 23 N., R. 4 W., Tippecanoe County.	50,000 56,000	70,000 81,700	86,000 98,600	110,000 124,000	130,000 143,000	150,000 164,000
03–3357.00	Big Pine Creek near Williamsport, Ind. Lat 40° 19'03", long 87°17'26", in SW¼SE¼ sec. 26, T. 22 N., R. 8 W., Warren County.	5,200 4,950	8,200 7,360	10,200 8,960	12,300 11,100	----- 12,900	----- 14,700
*03–3360.00	Wabash River at Covington, Ind. Lat 40°08'24", long 87°24'20", in NE¼NW¼ sec. 35, T. 20 N., R. 9 W., on Fountain-Warren County line.	51,000 54,600	76,000 80,400	92,000 98,300	114,000 124,000	135,000 145,000	157,000 168,000
03–3395.00	Sugar Creek at Crawfordsville, Ind. Lat 40°02'56", long 86°53'58", in SW¼NW¼ sec. 32, T. 19 N., R. 4 W., Montgomery County.	10,400 9,610	16,500 14,600	20,400 17,900	24,700 22,400	28,000 26,000	31,500 30,000
03–3400.00	Sugar Creek near Byron, Ind. Lat 39°55'52", long 87°07'33", in NW¼SW¼ sec. 8, T. 17 N., R. 6 W., Parke County.	14,000 13,100	20,400 20,200	24,000 25,000	28,500 31,600	32,000 37,200	35,500 43,100

Station No.	Station name and location	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}
*03–3405.00	Wabash River at Montezuma, Ind. Lat 39°47'33", long 87°22'26", in SE¼NE¼ sec. 35, T. 16 N., R. 9 W., Parke County.	62,000 65,200	92,000 96,000	110,000 118,000	138,000 149,000	162,000 175,000	188,000 202,000
03–3408.00	Big Raccoon Creek near Fincastle, Ind. Lat 39° 48'45", long 86°57'14", in NW¼SW¼ sec. 22, T. 16 N., R. 5 W., Putnam County.	5,100 3,870	9,300 5,730	13,100 6,990	----- 8,650	----- 10,100	----- 11,500
03–3410.00	Raccoon Creek at Mansfield, Ind. Lat 39°41'00", long 87°07'00", in sec. 8, T. 14 N., R 6 W., Parke County.	6,400 7,730	10,500 12,400	13,700 15,800	18,400 20,500	----- 24,700	----- 29,000
03–3412.00	Little Raccoon Creek near Catlin, Ind. Lat 39° 40'38", long 87°13'38", in NE¼NW¼ sec. 7, T. 14 N., R. 7 W., Parke County.	5,700 4,770	11,500 7,170	16,800 8,790	----- 10,900	----- 12,800	----- 14,600
*03–3415.00	Wabash River at Terre Haute, Ind. Lat 39°28'00", long 87°25'08", in NE¼SW¼ sec. 21, T. 12 N., R. 9 W., Vigo County.	64,000 68,400	94,000 101,000	115,000 123,000	145,000 154,000	170,000 180,000	196,000 209,000
*03–3420.00	Wabash River at Riverton, Ind. Lat 39°01'13", long 87°34'07", in NE¼SW¼ sec. 30, T. 7 N., R. 10 W., Sullivan County.	62,000 64,800	96,000 96,200	121,000 119,000	155,000 150,000	185,000 178,000	215,000 208,000
03–3425.00	Busseron Creek near Carlisle, Ind. Lat 38°58'26", long 87°35'23", in NW¼, survey 17, Vincennes Tract, Sullivan County.	3,500 3,100	5,100 4,490	6,200 5,420	7,700 6,660	9,200 7,650	10,500 8,660
*03–3430.00	Wabash River at Vincennes, Ind. Lat 38°42'26", long 87°31'10", in NW¼SW¼ sec. 10, T. 3 N., R. 10 W., Knox County.	56,000 63,100	84,000 94,000	108,000 117,000	140,000 148,000	170,000 177,000	206,000 207,000
03–3470.00	White River at Muncie, Ind. Lat 40°12'15", long 85°23'14", in SE¼NW¼ Hackley Reserve Delaware County.	5,200 5,030	7,900 7,740	9,800 9,610	12,300 12,200	14,700 14,400	16,800 16,600
03–3475.00	Buck Creek near Muncie, Ind. Lat 40°08'05", long 85°22'25", in SW¼SE¼ sec. 34, T. 20 N., R. 10 E., Delaware County.	850 1,490	1,300 2,250	1,580 2,820	1,970 3,540	----- 4,150	----- 4,800
03–3480.00	White River at Anderson, Ind. Lat 40°06'22" long 85°40'20", in SW¼SW¼ sec. 7, T. 19 N., R. 8 E., Madison County.	6,700 7,810	10,800 12,100	13,600 15,000	17,300 19,200	20,700 22,700	24,000 26,400
03–3485.00	White River near Noblesville, Ind. Lat 40°07'46", long 85°57'46", in NE¼NE¼ sec. 4, T. 19 N., R. 5 E., Hamilton County.	10,800 13,500	16,500 20,600	20,600 25,500	26,000 32,300	30,000 38,100	34,000 44,200
03–3490.00	White River at Noblesville, Ind. Lat 40°02'50". long 86°01'00", in SE¼SE¼ sec. 36, T. 19 N., R. 4 E., Hamilton County.	10,300 13,600	15,500 20,900	19,500 26,000	25,500 33,000	31,000 39,000	36,000 45,300
03–3495.00	Cicero Creek near Arcadia, Ind. Lat 40°10'34", long 85°59'43", in NW¼NW¼ sec. 20, T. 20 N., R. 5 E., Hamilton County.	1,850 2,620	2,850 3,800	3,540 4,430	4,600 5,590	----- 6,520	----- 7,380
03–3497.00	Little Cicero Creek near Arcadia, Ind. Lat 40° 10'32", long 86°02'45", in NE¼NW¼ sec. 23, T. 20 N., R. 4 E., Hamilton County.	1,260 1,250	1,900 1,840	2,400 2,250	3,100 2,790	----- 3,230	----- 3,700
03–3501.00	Hinkle Creek near Cicero, Ind. Lat 40°06'05", long 86°05'10", in NW¼NW¼ sec. 16, T. 19 N., R. 4 E., Hamilton County.	1,520 960	2,800 1,540	3,750 1,980	5,100 2,580	----- 3,080	----- 3,630
03–3505.00	Cicero Creek at Noblesville, Ind. Lat 40°03'20", long 86°02'30", in NW¼NE¼ sec. 35, T. 19 N., R. 4 E., Hamilton County.	3,650 3,780	5,500 5,730	6,800 6,970	8,900 8,730	10,900 10,200	----- 11,700
03–3510.00	White River near Nora, Ind. Lat 39°54'35", long 86°06'20", in NW¼NW¼ sec. 20, T. 17 N., R. 4 E., Marion County.	13,000 16,200	20,000 24,500	25,000 30,200	33,000 38,000	40,000 44,600	47,000 51,500
03–3515.00	Fall Creek near Fortville, Ind. Lat 39°57'15", long 85°52'05", in NW¼NE¼ sec. 5, T. 17 N., R. 6 E., Hamilton County.	2,900 4,690	4,550 7,080	5,800 8,700	7,600 10,900	9,200 12,700	11,000 14,600
03–3520.00	Lawrence Creek at Fort Benjamin Harrison, Ind. Lat. 39°52'09", long 86°01'25", in S½ sec. 36, T. 17 N., R. 4 E., Marion County. (Not included in regression analysis.)	500	780	980	1,300	-----	-----
03–3522.00	Mud Creek at Indianapolis, Ind. Lat 39°53'30" long 86°00'57", in SE¼NE¼ sec. 25, T. 17 N., R. 4 E., Marion County.	860 1,320	1,300 1,930	1,600 2,350	----- 2,900	----- 3,350	----- 3,820
03–3525.00	Fall Creek at Millersville, Ind. Lat 39°51'07", long 86°05'15", in NE¼NE¼ sec. 9, T. 16 N., R. 4 E., Marion County.	4,250 6,660	7,000 10,300	8,900 12,800	11,800 16,200	14,700 19,100	17,500 22,000
*03–3530.00	White River at Indianapolis, Ind. Lat 39°45'05", long 86°10'30", in NW¼NW¼ sec. 14, T. 15 N., R 3 E., Marion County.	19,500 21,900	28,000 32,200	34,000 38,800	42,000 47,900	48,000 55,500	56,000 64,200
03–3531.20	Pleasant Run at Arlington Ave. at Indianapolis, Ind. Lat 39°46'33", long 86°03'50", in SW¼NW¼ sec. 2, T. 15 N., R. 4 E., Marion County. (Not included in regression analysis.)	880	1,300	1,600	-----	-----	-----

Station No.	Station name and location	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}
03–3531.60	Pleasant Run at Brookville Road at Indianapolis. Ind. Lat 39°45′52″, long 86°05′43″, in NE¼NW¼ sec. 9, T. 15 N., R. 4 E., Marion County. (Not included in regression analysis.)	1,150	1,670	2,030	-----	-----	-----
03–3532.00	Eagle Creek at Zionsville, Ind. Lat. 39°56′56″, long 86°15′22″, in SW¼NW¼ sec. 1, T. 17 N., R. 2 E., Boone County.	4,800 3,240	7,100 4,930	9,000 6,090	----- 7,680	----- 9,010	----- 10,400
03–3535.00	Eagle Creek at Indianapolis, Ind. Lat 39°46′33″, long 86°15′01″, in NW¼NW¼ sec. 6, T. 15 N., R. 3 E., Marion County.	5,200 4,760	8,600 7,270	11,200 8,980	14,900 11,300	18,300 13,200	22,000 15,200
03–3536.00	Little Eagle Creek at Speedway, Ind. Lat 39°47′15″, long 86°13′41″, NE¼SW¼ sec. 32, T. 16 N., R. 3 E., Marion County.	1,160 1,080	1,560 1,600	1,820 1,960	----- 2,400	----- 2,820	----- 3,230
03–3537.00	West Fork Whitelick Creek at Danville, Ind. Lat 39°45′36″, long 86°30′47″, in NW¼NE¼ sec. 10, T. 15 N., R. 1 W., Hendricks County.	1,740 1,260	2,900 1,940	3,900 2,440	----- 3,110	----- 3,670	----- 4,270
03–3538.00	Whitelick Creek at Mooresville, Ind. Lat 39°36′28″, long 86°22′56″, in NE¼SE¼ sec. 35, T. 14 N., R. 1 E., Morgan County.	9,900 6,690	13,500 10,500	15,600 13,100	----- 16,700	----- 19,600	----- 22,700
*03–3540.00	White River near Centerton, Ind. Lat 39°30′02″, long 86°24′24″, in SW¼SE¼ sec. 3, T. 12 N., R. 1 E., Morgan County.	26,000 27,500	37,000 40,300	44,000 48,500	54,000 59,600	63,000 69,000	72,000 79,700
03–3545.00	Beanblossom Creek at Beanblossom, Ind. Lat 39°15′45″, long 86°14′55″, in SW¼NW¼ sec. 31, T. 10 N., R. 3 E., Brown County.	1,750 2,000	3,100 3,470	4,150 4,560	5,700 6,200	7,100 7,670	----- 9,270
03–3550.00	Bear Creek near Trevlac, Ind. Lat 39°16′40″, long 86°20′45″, in NE¼NE¼ sec. 30, T. 10 N., R. 2 E., Brown County. (Not included in regression analysis.)	610	1,140	1,560	2,220	2,870	-----
03–3560.00	Beanblossom Creek at Dolan, Ind. Lat 39°14′30″, long 86°29′57″, in NW¼SW¼ sec. 2, T. 9 N., R. 1 W., Brown County.	2,850 6,480	5,200 10,300	7,200 13,000	10,500 16,700	13,600 20,100	17,200 23,500
*03–3570.00	White River at Spencer, Ind. Lat 39°16′49″ long 86°45′42″, in NE¼NE¼ sec. 29, T. 10 N., R. 3 W., Owen County.	29,000 29,000	43,000 42,700	51,000 51,600	62,000 63,200	72,000 73,300	83,000 85,100
03–3575.00	Big Walnut Creek near Reelsville, Ind. Lat 39°32′11″, long 86°58′35″, in NW¼SW¼ sec. 28, T. 13 N., R. 5 W., Putnam County.	10,400 9,460	15,400 15,100	18,400 19,000	22,500 24,600	26,000 29,400	----- 34,500
03–3580.00	Mill Creek near Cataract, Ind. Lat 39°26′00″, long 86°45′48″, in NE¼SE¼ sec. 32, T. 12 N., R. 3 W., Owen County.	5,900 5,770	8,500 8,760	10,000 10,800	11,900 13,500	13,300 15,700	----- 18,000
03–3590.00	Mill Creek near Manhattan, Ind. Lat 39°29′22″, long 86°55′50″, in SW¼SE¼ sec. 11, T. 12 N., R. 5 W., Putnam County.	4,300 6,750	5,800 10,400	6,800 12,900	8,200 16,400	9,500 19,400	10,700 22,500
03–3595.00	Deer Creek near Putnamville, Ind. Lat 39°34′04″, long 86°52′00″, in SW¼NW¼ sec. 16, T. 13 N., R. 4 W., Putnam County.	5,800 2,750	8,000 4,160	9,600 5,110	11,900 6,410	----- 7,500	----- 8,650
03–3600.00	Eel River at Bowling Green, Ind. Lat 39°23′02″, long 87°01′12″, in NE¼NE¼ sec. 24, T. 11 N., R. 6 W., Clay County.	13,600 19,000	19,700 29,700	24,000 37,100	30,500 47,500	36,000 56,200	42,000 65,700
*03–3605.00	White River at Newberry, Ind. Lat 38°55′42″, long 87°01′00″, in NE¼NE¼ sec. 25, T. 6 N., R. 6 W., Greene County.	36,000 37,300	53,000 54,800	64,000 66,300	78,000 81,200	90,000 94,100	103,000 109,000
03–3610.00	Big Blue River at Carthage, Ind. Lat 39°44′38″, long 85°34′33″, in SW¼SW¼ sec. 18, T. 15 N., R. 9 E., Rush County.	4,100 4,520	6,200 6,830	7,800 8,390	9,900 10,500	11,700 12,300	----- 14,100
03–3615.00	Big Blue River at Shelbyville, Ind. Lat 39°31′45″, long 85°46′55″, in SE¼SE¼ sec. 31 T. 13 N., R. 7 E., Shelby County.	7,800 9,000	11,000 13,900	13,000 17,300	15,600 22,000	17,500 26,000	19,300 30,300
03–3620.00	Youngs Creek near Edinburg, Ind. Lat 39°25′08″, long 86°00′18″, in SE¼SW¼ sec. 5, T. 11 N., R. 5 E., Johnson County.	4,000 3,340	6,600 5,000	8,200 6,160	10,300 7,650	11,800 8,970	13,100 10,200
03–3625.00	Sugar Creek near Edinburg, Ind. Lat 39°21′39″, long 85°59′51″, in SW¼SE¼ sec. 29, T. 11 N., R. 5 E., Johnson County.	8,900 9,930	14,300 15,500	18,000 19,500	22,500 25,100	26,500 29,900	30,000 35,000
03–3630.00	Driftwood River near Edinburg, Ind. Lat 39°20′21″, long 85°59′11″, in NW¼SW¼ sec. 4, T. 10 N., R. 5 E., Bartholomew County.	16,700 21,500	26,000 33,000	32,800 40,700	41,000 51,400	47,000 60,100	54,000 69,600
03–3635.00	Flatrock River at St. Paul, Ind. Lat 39°25′03″, long 85°38′03″, in SE¼NE¼ sec. 9, T. 11 N., R. 8 E., Shelby County.	6,800 8,130	11,400 12,900	14,600 16,300	18,300 21,000	21,500 25,100	24,600 29,500
*03–3640.00	East Fork White River at Columbus, Ind. Lat 39°12′00″, long 85°55′32″, in NE¼NW¼ sec. 25, T. 9 N., R. 5 E., Bartholomew County.	26,000 25,000	39,000 36,400	47,000 43,400	59,000 53,600	69,000 61,400	79,000 70,400

Station No.	Station name and location	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}
03-3645.00	Clifty Creek at Hartsville, Ind. Lat 39°16'25", long 85°42'10", in NW¼NW¼ sec. 36, T. 10 N., R. 7 E., Bartholomew County.	4,000 4,150	6,700 6,170	8,200 7,480	10,600 9,280	12,500 10,800	----- 12,400
03-3650.00	Sand Creek near Brewersville, Ind. Lat 39°05'03", long 85°39'32", in NW¼NE¼ sec. 5, T. 7 N., R. 5 E., Jennings County.	7,700 8,010	11,700 12,700	14,200 16,200	17,900 20,800	20,800 25,000	----- 29,200
*03-3655.00	East Fork White River at Seymour, Ind. Lat 38°58'57", long 85°53'57", in NW¼NE¼ sec. 7, T. 6 N., R. 6 E., Jackson County	30,000 26,900	49,000 39,700	59,000 48,300	74,000 60,900	85,000 71,500	98,000 82,800
03-3660.00	Graham Creek near Vernon, Ind. Lat 38°55'47", long 85°33'45", in NW¼SE¼ sec. 30, T. 6 N., R. 9 E., Jennings County.	6,400 5,890	10,500 9,150	14,000 11,400	19,300 14,600	----- 17,400	----- 20,300
03-3665.00	Muscatatuck River near Deputy, Ind. Lat 38°48'15", long 85°40'26", in SW¼NE¼ sec. 7, T. 4 N., R. 8 E., Jefferson County.	15,500 10,800	22,500 17,600	28,000 22,500	35,500 29,500	42,500 35,500	----- 42,000
03-3670.00	Muscatatuck River near Austin, Ind. Lat 38°46'13", long 85°49'21", in NW¼SE¼ sec. 23, T. 4 N., R. 6 E., Scott County.	13,300 11,600	20,500 18,800	26,500 23,900	35,500 31,400	43,500 38,000	54,000 44,900
03-3680.00	Brush Creek near Nebraska, Ind. Lat 39°04'13", long 85°29'10", in NW¼NE¼ sec. 11, T. 7 N., R. 9 E., Jennings County. (Not included in regression analysis.)	2,000	2,600	3,000	3,460	-----	-----
03-3690.00	Vernon Fork near Butlersville, Ind. Lat 39°02'55", long 85°32'40", in NW¼SE¼ sec. 17, T. 7 N., R. 9 E., Jennings County.	6,800 7,500	10,400 11,900	13,400 14,900	18,000 19,300	22,000 23,100	27,000 27,100
03-3695.00	Vernon Fork at Vernon, Ind. Lat 38°58'34", long 85°37'13", in NW¼SE¼ sec. 10, T. 6 N., R. 8 E., Jennings County.	14,200 8,580	23,000 13,400	29,000 17,800	39,000 23,400	47,000 28,200	56,000 33,300
*03-3715.00	East Fork White River near Bedford, Ind. Lat 38°46'10", long 86°24'30", in SW¼NE¼ sec. 21, T. 4 N., R. 1 E., Lawrence County.	39,500 34,700	57,500 51,100	70,000 61,900	86,000 76,700	102,000 89,200	118,000 104,000
03-3716.00	South Fork Salt Creek at Kurtz, Ind. Lat 38°57'46", long 86°12'12", in SW¼SW¼ sec. 9, T. 6 N., R. 3 E., Jackson County.	3,760 3,280	5,000 5,380	5,700 6,910	----- 9,060	----- 11,000	----- 13,000
03-3716.50	North Fork Salt Creek at Nashville, Ind. Lat 39°12'06", long 86°14'51", in NW¼SW¼ sec. 19, T. 9 N., R. 3 E., Brown County.	4,800 3,900	6,500 5,900	7,400 7,240	----- 9,080	----- 10,600	----- 12,300
03-3720.00	North Fork Salt Creek near Belmont, Ind. Lat 39°09'00", long 85°20'14", in SW¼NW¼ sec. 5, T. 8 N., R. 2 E., Brown County.	6,000 5,660	9,500 8,770	11,700 10,900	14,700 13,700	17,000 16,400	19,000 18,900
03-3727.00	Clear Creek near Harrodsburg, Ind. Lat 39°02'03", long 86°34'01", in NE¼NW¼ sec. 19, T. 7 N., R. 1 W., Monroe County.	4,550 3,460	6,700 5,340	8,400 6,650	----- 8,430	----- 9,970	----- 11,600
03-3730.00	Salt Creek near Peerless, Ind. Lat 38°56'36", long 86°30'36", in SE¼NW¼ sec. 22, T. 6 N., R. 1 W., Lawrence County.	11,700 6,620	17,400 9,690	20,700 11,800	24,300 14,700	27,500 17,100	30,000 19,600
03-3732.00	Indian Creek near Springsville, Ind. Lat 38°57'01", long 86°40'30", in SE¼SW¼ sec. 18, T. 6 N., R. 2 W., Lawrence County.	4,260 3,810	5,600 5,770	6,300 7,100	----- 8,910	----- 10,500	----- 12,100
*03-3735.00	East Fork White River at Shoals, Ind. Lat 38°40'02", long 86°47'32", in sec. 30, T. 3 N., R. 3 W., Martin County.	38,000 36,300	55,000 53,900	68,000 66,400	86,000 83,100	104,000 98,500	122,000 115,000
*03-3740.00	White River at Petersburg, Ind. Lat 38°30'39", long 87°17'22", in SE¼SW¼ sec. 15, T. 1 N., R. 8 W., Pike County.	70,000 67,700	103,000 98,500	127,000 118,000	157,000 146,000	172,000 167,000	208,000 193,000
03-3745.00	Patoka River near Ellsworth, Ind. Lat 38°26'39", long 86°43'31", in SW¼SE¼ sec. 10, T. 2 S., R. 3 W., Dubois County.	2,940 5,650	4,460 9,080	5,600 11,400	----- 14,700	----- 17,700	----- 20,700
03-3755.00	Patoka River at Jasper, Ind. Lat 38°24'49", long 86°52'36", in NW¼SE¼ sec. 20, T. 1 S., R. 4 W., Dubois County.	3,900 5,090	6,400 7,960	8,500 10,100	12,000 13,100	15,400 15,800	----- -----
03-3765.00	Patoka River near Princeton, Ind. Lat 38°23'30", long 87°32'55", in Location 107, T. 1 S., R. 10 W., Gibson County.	5,400 8,350	8,800 12,600	11,500 15,700	15,600 20,200	19,000 24,200	23,000 28,300
*03-3775.00	Wabash River at Mt. Carmel, Ill. Lat 38°24'07", long 87°45'10", in SE¼NW¼ sec. 28, T. 1 S., R. 12 W., Wabash County.	132,000 108,000	192,000 158,000	226,000 194,000	274,000 242,000	315,000 282,000	350,000 327,000
04-0875.00	Hart Ditch at Munster, Ind. Lat 41°33'40", long 87°28'50", in SE¼NW¼ sec. 20, T. 36 N., R. 9 W., Lake County.	1,220 1,090	1,860 1,490	2,300 1,730	2,900 2,050	3,400 2,300	4,000 2,540
04-0930.00	Deep River at Lake George Outlet at Hobart, Ind. Lat 41°32'10", long 87°15'25", in NW¼NW¼ sec. 32, T. 36 N., R. 7 W., Lake County.	1,340 1,320	2,150 1,760	2,700 2,040	3,500 2,380	4,100 2,650	----- 2,910

Station No.	Station name and location	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}
04–0935.00	Burns Ditch at Gary, Ind. Lat 41°34'30", long 87° 17'20", in SE¼NW¼ sec. 13, T. 36 N., R. 8 W., Lake County.	1,360 / 1,620	2,000 / 2,250	2,400 / 2,660	2,900 / 3,190	3,300 / 3,610	----- / 4,020
04–0940.00	Little Calumet River at Porter, Ind. Lat 41°37'18", long 87°05'13", in NE¼NE¼ sec. 34, T. 37 N., R. 6 W., Porter County.	1,020 / 1,310	1,640 / 1,920	2,080 / 2,360	2,680 / 2,900	3,190 / 3,340	3,700 / 3,800
04–0945.00	Salt Creek near McCool, Ind. Lat 41°35'48", long 87°08'40", in SE¼SE¼ sec. 6, T. 36 N., R. 6 W., Porter County.	900 / 1,240	1,430 / 1,760	1,800 / 2,090	2,350 / 2,520	2,800 / 2,870	3,300 / 3,230
04–0995.00	Pigeon Creek at Hogback Lake Outlet near Angola, Ind. Lat 41°37'24", long 85°05'44", in NE¼NW¼ sec. 36, T. 37 N., R. 12 E., Steuben County.	340 / 450	460 / 560	530 / 630	620 / 700	700 / 760	780 / 820
04–1002.20	North Branch Elkhart River near Cosperville, Ind. Lat 41°29'32", long 85°26'54", in SW¼NE¼ sec. 14, T. 35 N., R. 9 E., Noble County.	420 / 960	560 / 1,290	650 / 1,470	770 / 1,710	860 / 1,890	----- / 2,060
04–1005.00	Elkhart River at Goshen, Ind. Lat 41°35'36", long 85°50'55", in NE¼NE¼ sec. 8, T. 36 N., R. 6 E., Elkhart County.	2,700 / 4,220	3,800 / 5,890	4,400 / 6,940	5,200 / 8,290	5,800 / 9,340	6,300 / 10,400
04–1010.00	St. Joseph River at Elkhart, Ind. Lat 41°41'30", long 85°58'30", in SW¼NE¼ sec. 5, T. 37 N., R. 5 E., Elkhart County.	9,000 / 13,000	12,800 / 17,500	15,100 / 20,200	18,200 / 23,500	20,800 / 26,000	----- / 28,600
04–1780.00	St. Joseph River near Newville, Ind. Lat 41°23'08", long 84°48'06", in SW¼SW¼ sec. 18, T. 5 N., R. 1 E., Defiance County, Ohio.	4,100 / 3,790	5,800 / 5,240	7,000 / 6,120	8,600 / 7,240	9,800 / 8,100	11,200 / 8,950
04–1790.00	St. Joseph River at Cedarville, Ind. Lat 41°11'46", long 85°01'27", in J. Hackley Res., T. 32 N., R. 13 E., Allen County.	4,400 / 4,140	6,000 / 5,690	7,200 / 6,640	8,700 / 7,840	----- / 8,770	----- / 9,690
04–1795.00	Cedar Creek at Auburn, Ind. Lat 41°21'57", long 85°03'08", in NE¼NW¼ sec. 32, T. 34 N., R. 13 E., Dekalb County.	860 / 1,540	1,120 / 2,150	1,270 / 2,520	1,440 / 3,020	1,560 / 3,410	1,670 / 3,810
04–1800.00	Cedar Creek near Cedarville, Ind. Lat 41°13'08", long 85°04'35", in NW¼NW¼ sec. 19, T. 32 N., R. 13 E., Allen County.	2,900 / 2,960	3,900 / 4,190	4,400 / 4,930	5,000 / 5,870	5,400 / 6,560	5,800 / 7,270
04–1805.00	St. Joseph River near Fort Wayne, Ind. Lat 41° 10'00", long 85°04'00", in NW¼SE¼ sec. 4, T. 31 N., R. 13 E., Allen County.	7,600 / 4,840	9,700 / 6,550	10,800 / 7,600	----- / 8,910	----- / 9,920	----- / 10,900
04–1815.00	St. Marys River at Decatur, Ind. Lat 40°50'55", long 84°56'16", in SW¼SW¼ sec. 27, T. 28 N., R. 14 E., Adams County.	5,200 / 4,540	7,500 / 6,430	8,900 / 7,760	10,700 / 9,300	12,000 / 10,600	13,300 / 12,000
04–1820.00	St. Marys River near Fort Wayne, Ind. Lat 40° 59'16", long 85°06'03", in A. LaFontaine Res. T. 29 N., R. 12 E., Allen County.	6,100 / 4,800	8,500 / 6,760	10,000 / 8,070	11,700 / 9,780	13,000 / 11,200	14,300 / 12,600
04–1830.00	Maumee River at New Haven, Ind. Lat 41°05'06", long 85°01'19", in SE¼NE¼ sec. 2, T. 30 N., R. 13 E., Allen County.	12,300 / 11,500	15,400 / 16,000	17,400 / 18,800	19,800 / 22,400	----- / 25,300	----- / 28,200
05–5150.00	Kankakee River near North Liberty, Ind. Lat 41° 33'50", long 86°29'50", in NW¼NE¼ sec. 23, T. 36 N., R. 1 W., St. Joseph County.	510 / 500	600 / 630	640 / 690	680 / 770	700 / 840	----- / 890
05–5155.00	Kankakee River at Davis, Ind. Lat 41°24'00", long 86°42'04", in SE¼NE¼ sec. 13, T. 34 N., R. 3 W., Starke County.	1,160 / 1,790	1,320 / 2,380	1,410 / 2,760	1,530 / 3,230	1,620 / 3,590	1,700 / 3,940
05–5160.00	Yellow River near Bremen, Ind. Lat 41°25'11", long 86°10'14", in NW¼NW¼ sec. 10, T. 34 N., R. 3 E., Marshall County.	1,130 / 1,100	1,310 / 1,460	1,420 / 1,660	1,570 / 1,910	----- / 2,090	----- / 2,270
05–5165.00	Yellow River at Plymouth, Ind. Lat 41°20'25", long 86°18'16", in SE¼NW¼ sec. 13, T. 33 N., R. 2 E., Marshall County.	1,980 / 2,070	2,600 / 2,810	3,000 / 3,260	3,500 / 3,840	3,900 / 4,260	----- / 4,690
05–5170.00	Yellow River at Knox, Ind. Lat 41°18'10", long 86°37'14", in SW¼SW¼ sec. 14, T. 33 N., R. 2 W., Starke County.	2,220 / 3,510	3,010 / 4,950	3,520 / 5,890	4,150 / 7,120	4,620 / 8,100	5,080 / 9,080
05–5175.00	Kankakee River at Dunns Bridge, Ind. Lat 41° 13'17", long 86°57'52", in NE¼SE¼ sec. 15, T. 32 N., R. 5 W., Jasper County.	3,380 / 3,520	4,060 / 4,550	4,470 / 5,200	4,970 / 6,000	5,330 / 6,450	----- / 7,210
05–5180.00	Kankakee River at Shelby, Ind. Lat 41°10'58", long 87°20'33", in SW¼NE¼ sec. 33, T. 32 N., R. 8 W., Lake County.	4,010 / 4,270	4,820 / 5,470	5,310 / 6,220	5,880 / 7,130	6,300 / 7,810	6,710 / 8,500
05–5190.00	Singleton Ditch at Schneider, Ind. Lat 41°12'44", long 87°26'44", in SW¼NW¼ sec. 22, T. 32 N., R. 9 W., Lake County.	990 / 920	1,110 / 1,180	1,150 / 1,330	1,180 / 1,520	1,190 / 1,670	----- / 1,800
05–5195.00	West Creek near Schneider, Ind. Lat 41°12'52", long 87°29'36", in NW¼NE¼ sec. 19, T. 32 N., R. 9 W., Lake County.	960 / 780	1,360 / 1,140	1,600 / 1,380	1,860 / 1,700	2,040 / 1,950	----- / 2,220

TABLE 6—*T-year peak discharges at gaging stations, in cubic feet per second*—Continued

Station No.	Station name and location	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}
05–5210.00	Iroquois River at Rosebud, Ind. Lat 41°02′00″, long 87°10′49″, in NW¼SW¼ sec. 24, T. 30 N., R. 7 W., Jasper County.	230 180	300 340	340 390	390 460	420 500	----- 550
05–5220.00	Iroquois River near North Marion, Ind. Lat 40°58′12″, long 87°06′50″, in NE¼NW¼ sec. 16, T. 29 N., R. 6 W., Jasper County.	850 1,020	1,060 1,370	1,220 1,580	1,420 1,840	1,580 2,040	----- 2,220
05–5225.00	Iroquois River at Rensselaer, Ind. Lat 40°56′00″, long 87°07′44″, in NW¼SE¼ sec. 29, T. 29 N., R. 6 W., Jasper County.	1,240 1,150	1,500 1,540	1,670 1,760	1,900 2,070	2,100 2,300	----- 2,530
05–5230.00	Bice Ditch near South Marion, Ind. Lat 40°52′00″, long 87°05′32″, in NE¼NW¼ sec. 22, T. 28 N., R. 6 W., Jasper County.	460 650	630 950	750 1,160	900 1,430	1,010 1,640	----- 1,870
05–5235.00	Slough Creek near Collegeville, Ind. Lat 40°53′30″, long 87°09′17″, in SE¼NE¼ sec. 12, T. 28 N., R. 7 W., Jasper County.	1,240 1,270	1,780 1,670	2,100 1,910	2,480 2,230	2,740 2,460	----- 2,710
05–5240.00	Carpenter Creek at Egypt, Ind. Lat 40°51′58″, long 87°12′20″, in SE¼SW¼ sec. 15, T. 28 N., R. 7 W., Jasper County.	940 1,260	1,480 1,700	1,970 1,990	2,760 2,350	3,550 2,630	----- 2,930
05–5245.00	Iroquois River near Foresman, Ind. Lat 40°52′14″, long 87°18′24″, in NE¼SE¼ sec. 15, T. 28 N., R. 8 W., Newton County.	2,570 2,830	3,540 3,790	4,220 4,380	5,100 5,110	5,790 5,650	----- 6,200

TABLE 7.—*Selected watershed characteristics and maximum floods at gaging stations*

Length of record: Years of continuous record since gaging station was established:
A is the drainage area, in square miles, that contributes directly to surface runoff. *S* is the main channel slope, in feet per mile. *L* is the main channel length, in miles *Pi* is the precipitation index, in inches. *R* is the watershed relief, in feet. *D* is the drainage intensity, in miles per square mile. *Rc* is the soil runoff coefficient.
Where the maximum flood at a gaging station exceeds the Q_{100} computed from the regression equation, it is shown as a ratio to the computed Q_{100} and noted by an *.
Values for relief, drainage density, and soil runoff coefficient are shown only for drainage areas as much as 200 mi².
The precipitation index is not shown for main stem gaging stations.
Gaging stations 03–3520.00, 03–3531.20, 03–3531.60, 03–3550.00, and 03–3680.00 were not used in the regression analyses and are not included in this table.

Station No.	Length of record	A	S	L	Pi	R	D	Rc	Year	Maximum flood Discharge (ft³/s)	R.I. (years)	Remarks
03–2750.00 _____	43	529	8.7	47.4	11.5	---	---	---	1937	37,100	25	
03–2755.00 _____	23	121	12.8	19.5	11.0	341	9.5	0.80	1969	15,000	25	
03–2760.00 _____	18	380	9.2	52.1	10.5	---	---	---	1959	36,100	80	
03–2765.00 _____	50	1,224	7.3	72.9	11.0	---	---	---	1959	81,800	99	
03–2767.00 _____	11	38.2	26.0	16.6	13.0	449	11.0	.90	1959	16,300	51	
03–2770.00 _____	31	248	6.6	63.8	12.5	---	---	---	1959	47,800	*1.6	
03–2940.00 _____	17	188	5.5	25.1	15.0	265	10.5	.90	1959	19,600	*1.0	
03–3025.00 _____	28	129	6.3	33.2	16.0	438	8.7	.80	1964	26,700	*1.3	
03–3030.00 _____	41	284	3.8	77.1	17.0	---	---	---	1959	28,500	60	
03–3033.00 _____	10	41.9	15.4	14.0	17.5	435	12.0	.80	1959	15,000	50	
03–3221.00 _____	11	326	2.4	42.0	14.5	---	---	---	1961	12,100	43	
03–3225.00 _____	21	262	3.2	63.1	9.0	---	---	---	1959	8,720	28	
03–3230.00 _____	41	532	2.0	93.3	9.0	---	---	---	1913	25,000	*1.8	Discontinued in 1971.
03–3235.00 _____	21	721	2.0	117	9.0	---	---	---	1959	14,900	28	Regulate since 1969 by Huntington Reservoir.
03–3240.00 _____	28	263	4.4	28.0	7.0	---	---	---	1950	5,990	29	
03–3242.00 _____	12	85.6	4.7	15.6	9.5	182	5.8	.50	1963	3,460	29	
03–3243.00 _____	15	425	2.4	58.1	9.5	---	---	---	1959	13,200	*1.1	
03–3245.00 _____	48	557	2.7	85.0	9.0	---	---	---	1943	16,500	68	Regulated since 1968 by Salamonie Reservoir.
03–3250.00 _____	48	1,768	2.5	140	---	---	---	---	1913	90,000	*1.3	Regulated since 1968 by upstream reservoirs.
03–3255.00 _____	25	133	4.6	20.1	10.0	150	7.5	.80	1958	13,900	*1.2	
03–3260.00 _____	20	310	3.0	48.0	10.5	---	---	---	1958	19,400	*1.6	Discontinued in 1971.
03–3265.00 _____	48	682	2.9	83.8	9.5	---	---	---	1927	25,000	*1.1	
03–3270.00 _____	19	808	3.3	113	9.5	---	---	---	1958	28,000	45	Regulated since 1968 by Mississinewa Reservoir.
03–3275.00 _____	28	2,686	2.4	158	---	---	---	---	1913	115,000	*1.3	Regulated since 1968 by upstream reservoirs.
03–3280.00 _____	42	417	2.1	41.9	7.5	---	---	---	1967	7,940	*1.2	
03–3285.00 _____	28	789	2.4	87.1	8.5	---	---	---	1943	17,000	52	
03–3290.00 _____	48	3,779	2.2	176	---	---	---	---	1913 1913	140,000 145,000	*1.3 *1.3	Do. Regulated since 1968. Discontinued in 1971.
03–3295.00 _____	32	4,072	2.2	199	---	---	---	---				
03–3297.00 _____	28	274	5.6	50.2	9.5	---	---	---	1943	18,000	*1.0	
03–3305.00 _____	22	113	3.6	22.7	7.0	95	3.4	.30	1954	700	3	

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Station No.	Length of record	A	S	L	Pi	R	D	Rc	Year	Maximum flood Discharge (ft³/s)	R.I. (years)	Remarks
03–3315.00 -----	28	856	1.6	105	8.0	---	---	---	1950	7,800	5	
03–3323.00 -----	12	35.0	5.5	9.6	8.5	77	2.2	.30	1963	500	*1.3	
03–3324.00 -----	12	152	2.0	19.1	8.0	82	2.3	.70	1965	2,750	86	
03–3330.00 -----	32	1,865	1.5	168	8.5	---	---	---	1959	22,600	23	
03–3334.50 -----	10	146	3.3	24.1	9.0	100	2.8	.80	1964	4,160	33	
03–3335.00 -----	17	162	3.3	29.6	9.0	111	3.0	.80	1950	6,320	*1.1	Discontinued in 1961.
03–3336.00 -----	12	24.7	4.5	12.7	9.5	72	4.5	.70	1964	1,040	4	
03–3337.00 -----	16	242	2.7	44.1	9.5	---	---	---	1959	8,100	*1.1	
03–3340.00 -----	28	396	3.3	83.5	9.5	---	---	---	1950	10,200	8	
03–3345.00 -----	28	243	7.1	48.8	10.0	---	---	---	1943	17,900	45	
03–3350.00 -----	17	794	3.5	102	9.5	---	---	---	1958	25,000	27	
03–3355.00 -----	48	7,267	2.1	220	---	---	---	---	1913	190,000	*1.2	Regulated since 1968 by upstream reservoirs.
03–3357.00 -----	16	323	4.4	48.5	9.0	---	---	---	1959	12,600	45	
03–3360.00 -----	32	8,208	1.8	262	---	---	---	---	1913	200,000	*1.2	Do.
03–3395.00 -----	33	509	5.3	51.2	11.0	---	---	---	1913	36,000	*1.2	
03–3400.00 -----	31	670	5.4	72.0	11.0	---	---	---	1957	32,000	27	
03–3405.00 -----	44	11,100	1.6	294	---	---	---	---	1913	230,000	*1.1	
03–3408.00 -----	14	132	7.2	35.9	12.0	252	5.4	.70	1957	39,900	*3.5	
03–3410.00 -----	19	240	6.7	54.1	13.0	---	---	---	1957	38,400	*1.3	Discontinued in 1958.
03–3412.00 -----	14	133	11.4	29.1	13.0	344	5.4	.70	1957	53,400	*3.7	Discontinued in 1971.
03–3415.00 -----	44	12,200	1.6	320	---	---	---	---	1913	245,000	*1.2	
03–3420.00 -----	33	13,100	1.4	373	---	---	---	---	1913	250,000	*1.2	
03–3425.00 -----	28	228	2.9	30.6	11.5	---	---	---	1950	8,800	*1.0	
03–3430.00 -----	42	13,700	1.3	409	---	---	---	---	1913	255,000	*1.2	
03–3470.00 -----	40	241	4.7	49.4	11.0	---	---	---	1913	20,000	*1.2	
03–3475.00 -----	17	35.5	10.2	12.5	10.5	165	5.7	.70	1964	1,780	3	
03–3480.00 -----	41	406	4.4	72.0	11.0	---	---	---	1913	28,000	*1.1	
03–3485.00 -----	54	828	4.1	93.4	11.0	---	---	---	1927	27,200	12	
03–3490.00 -----	25	858	3.9	102	11.0	---	---	---	1964	26,800	11	
03–3495.00 -----	17	131	4.0	27.1	10.0	121	5.4	.70	1957	6,720	60	
03–3497.00 -----	16	40.4	6.2	15.0	9.5	110	4.6	.70	1957	3,980	*1.1	
03–3501.00 -----	16	18.5	18.7	6.4	9.5	110	6.6	.70	1957	3,920	*1.1	
03–3505.00 -----	21	216	4.0	41.6	10.5	---	---	---	1957	9,800	40	
03–3510.00 -----	42	1,219	3.7	117	10.0	---	---	---	1913	58,500	*1.1	
03–3515.00 -----	30	169	7.2	31.8	11.5	273	5.3	.70	1964	8,750	10	
03–3522.00 -----	13	42.4	6.7	19.3	10.0	127	4.5	.70	1964	2,010	6	
03–3525.00 -----	42	298	5.3	48.8	11.5	---	---	---	1913	22,000	*1.0	
03–3530.00 -----	42	1,635	3.5	135	---	---	---	---	1913	70,000	*1.1	
03–3532.00 -----	14	103	15.2	17.4	10.5	153	7.5	.70	1964	12,400	*1.2	
03–3535.00 -----	32	174	6.8	35.1	10.5	264	7.9	.70	1957	28,800	*1.9	Regulated since 1969 by Eagle Creek Reservoir.
03–3536.00 -----	12	23.9	18.8	9.2	11.0	189	4.5	.70	1961	1,940	10	
03–3537.00 -----	13	28.8	10.6	11.5	11.0	131	6.0	.70	1962	3,330	31	
03–3538.00 -----	14	212	9.0	35.1	11.0	---	---	---	1963	18,000	32	
03–3540.00 -----	26	2,444	3.1	166	---	---	---	---	1913	90,000	*1.1	
03–3545.00 -----	20	14.6	19.8	7.6	13.0	291	11.5	.80	1960	8,140	65	
03–3560.00 -----	25	100	6.2	28.1	13.0	---	---	---	1947	9,420	4	
03–3570.00 -----	46	2,988	2.8	203	---	---	---	---	1913	100,000	*1.2	Discontinued in 1971.
03–3575.00 -----	22	326	6.6	58.8	12.5	---	---	---	1957	27,400	37	
03–3580.00 -----	22	245	5.8	29.5	12.5	---	---	---	1960	11,400	12	
03–3590.00 -----	33	294	5.1	45.0	12.5	---	---	---	1950	8,960	4	Regulated since 1953 by Cagles Mill Reservoir.
03–3595.00 -----	15	59.0	12.6	18.3	12.5	283	7.0	.70	1963	10,700	*1.2	
03–3600.00 -----	40	830	5.8	75.7	13.0	---	---	---	1950	34,000	7	Regulated since 1953 by Cagles Mill Reservoir.
03–3605.00 -----	43	4,688	2.4	253	---	---	---	---	1913	130,000	*1.2	
03–3610.00 -----	21	184	5.8	30.8	12.0	251	5.2	.70	1963	12,900	60	
03–3615.00 -----	28	421	4.8	57.6	12.5	---	---	---	1963	15,800	7	
03–3620.00 -----	29	107	4.3	30.1	12.0	195	7.0	.70	1952	10,700	*1.0	
03–3625.00 -----	29	474	4.5	81.1	12.0	---	---	---	1956	27,600	34	
03–3630.00 -----	31	1,060	5.9	67.3	12.5	---	---	---	1963	40,500	10	
03–3635.00 -----	41	303	5.7	60.6	12.5	---	---	---	1949	18,500	15	
03–3640.00 -----	24	1,707	3.8	117	---	---	---	---	1963	52,300	*1.2	
03–3645.00 -----	23	91.4	10.3	33.7	12.5	401	7.4	.70	1959	11,300	63	
03–3650.00 -----	23	155	8.9	42.3	13.5	410	9.8	.90	1959	19,900	20	
03–3655.00 -----	44	2,341	2.8	146	---	---	---	---	1913	120,000	*1.4	
03–3660.00 -----	16	77.2	9.4	32.6	14.0	318	1.5	1.00	1960	18,600	67	
03–3665.00 -----	23	293	7.6	54.7	14.5	---	---	---	1959	52,200	*1.2	
03–3670.00 -----	39	359	6.2	68.8	14.5	---	---	---	1959	53,900	*1.2	Discontinued in 1971.
03–3690.00 -----	29	85.9	12.2	29.1	13.5	391	9.0	1.00	1959	26,200	85	

| Station No.	Length of record	A	S	L	Pi	R	D	Rc	Year	Maximum flood Discharge (ft³/s)	R.I. (years)	Remarks
03–3695.00	32	198	9.2	43.2	14.0	448	9.1	1.00	1959	56,800	*1.7	
03–3715.00	32	3,861	2.5	207	---	---	---	---	1913	155,000	*1.5	
03–3716.00	11	38.2	13.0	10.6	14.0	312	10.0	.80	1968	6,400	8	Discontinued in 1971.
03–3716.50	10	76.1	11.6	17.7	13.5	400	8.0	.70	1963	7,500	12	Do.
03–3720.00	25	120	9.0	34.7	13.5	436	9.5	.70	1960	13,300	5	Do.
03–3727.00	11	48.8	19.1	13.7	14.5	383	7.5	.80	1968	8,280	23	
03–3730.00	25	573	2.0	58.2	14.0	---	---	---	1961	25,100	*1.3	Regulated since 1963 by Monroe Res. Disc. 1971.
03–3732.00	10	60.7	12.7	16.5	15.0	390	7.0	.80	1964	6,450	7	
03–3735.00	57	4,927	2.0	255	---	---	---	---	1913	160,000	*1.4	
03–3740.00	44	11,125	1.9	315	---	---	---	---	1913	235,000	*1.2	
03–3745.00	10	171	2.6	52.8	15.5	466	13.7	.80	1964	14,700	25	
03–3755.00	23	262	2.4	72.6	16.0	---	---	---	1913	16,000	56	
03–3765.00	37	822	1.2	143	15.5	---	---	---	1937	18,700	18	
03–3775.00	44	28,600	1.2	509	---	---	---	---	1913	428,000	*1.3	
04–0875.00	29	69.2	7.4	22.6	6.5	159	4.0	.50	1959	2,670	*1.0	
04–0930.00	24	125	3.6	29.8	7.0	131	3.2	.50	1954	3,880	*1.3	
04–0935.00	23	160	3.2	36.0	8.0	173	3.1	.40	1954	3,430	35	
04–0940.00	26	62.9	6.2	14.8	12.0	262	8.0	.40	1954	3,110	35	
04–0945.00	26	78.7	4.7	22.5	8.0	206	6.6	.40	1954	3,180	90	
04–0995.00	26	80.5	5.2	22.9	4.5	120	3.2	.30	1950	744	43	
04–1002.20	21	142	3.9	26.6	5.5	130	3.5	.30	1956	717	2	Discontinued in 1971.
04–1005.00	40	594	2.8	65.9	6.0	---	---	---	1950	5,440	4	
04–1010.00	24	3,339	2.2	135	5.0	---	---	---	1950	18,400	6	
04–1780.00	25	609	3.2	74.4	4.5	---	---	---	1950	9,710	*1.1	
04–1790.00	16	762	2.7	88.2	4.5	---	---	---	1956	10,100	*1.0	
04–1795.00	28	87.3	8.0	20.1	4.5	193	5.1	.50	1950	1,520	2	
04–1800.00	25	270	6.0	35.8	5.0	---	---	---	1950	4,870	9	
04–1805.00	14	1,060	2.3	98.2	4.5	---	---	---	1913	16,500	*1.5	
04–1815.00	25	621	2.1	79.4	7.5	---	---	---	1959	11,300	80	
04–1820.00	41	762	1.7	98.2	7.5	---	---	---	1959	13,600	*1.1	
04–1830.00	15	1,967	2.9	124	5.5	---	---	---	1950	19,100	11	
05–5150.00	20	116	1.2	23.2	5.5	100	3.0	.30	1954	686	10	
05–5155.00	47	400	1.3	49.6	6.5	---	---	---	1927	1,700	2	
05–5160.00	16	132	5.0	12.9	7.0	65	2.5	.50	1965	1,650	10	
05–5165.00	23	284	2.2	26.6	8.0	---	---	---	1954	5,390	*1.2	
05–5170.00	28	425	2.3	54.4	8.0	---	---	---	1954	5,660	9	
05–5175.00	23	1,160	.9	69.6	7.0	---	---	---	1954	5,300	11	
05–5180.00	49	1,578	.9	78.6	6.5	---	---	---	1927	7,200	28	
05–5190.00	23	123	3.2	22.2	7.5	137	2.5	.40	1970	1,160	5	
05–5195.00	20	54.7	2.3	21.1	7.0	102	6.5	.40	1954	1,840	35	
05–5210.00	23	35.6	2.5	8.9	7.5	44	2.5	.40	1950	422	15	
05–5220.00	22	144	2.9	15.7	8.0	58	3.5	.40	1958	2,040	50	
05–5225.00	23	203	2.5	18.6	8.0	63	4.5	.40	1958	2,550	*1.0	
05–5230.00	22	21.8	6.4	10.4	8.5	82	3.4	.70	1967	958	5	
05–5235.00	22	83.7	2.2	13.2	8.5	95	2.5	.70	1967	2,390	40	
05–5240.00	22	44.8	6.4	21.4	8.5	193	3.0	.70	1958	3,720	*1.3	
05–5245.00	22	452	2.0	30.7	8.0	---	---	---	1958	5,930	70	

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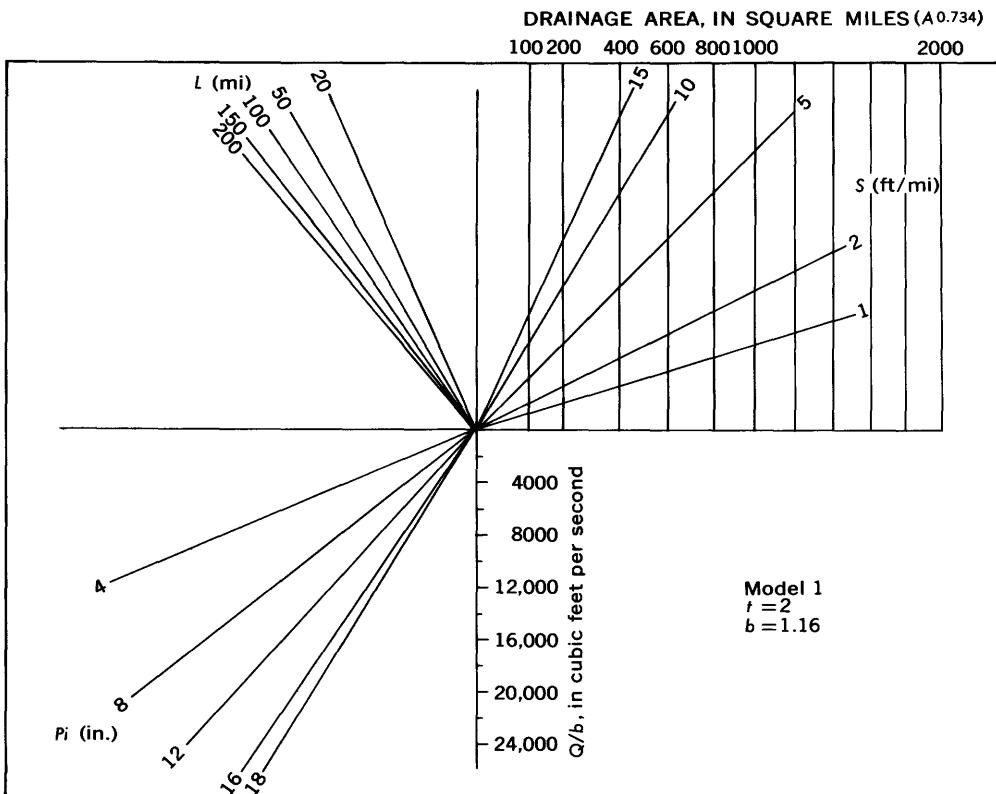
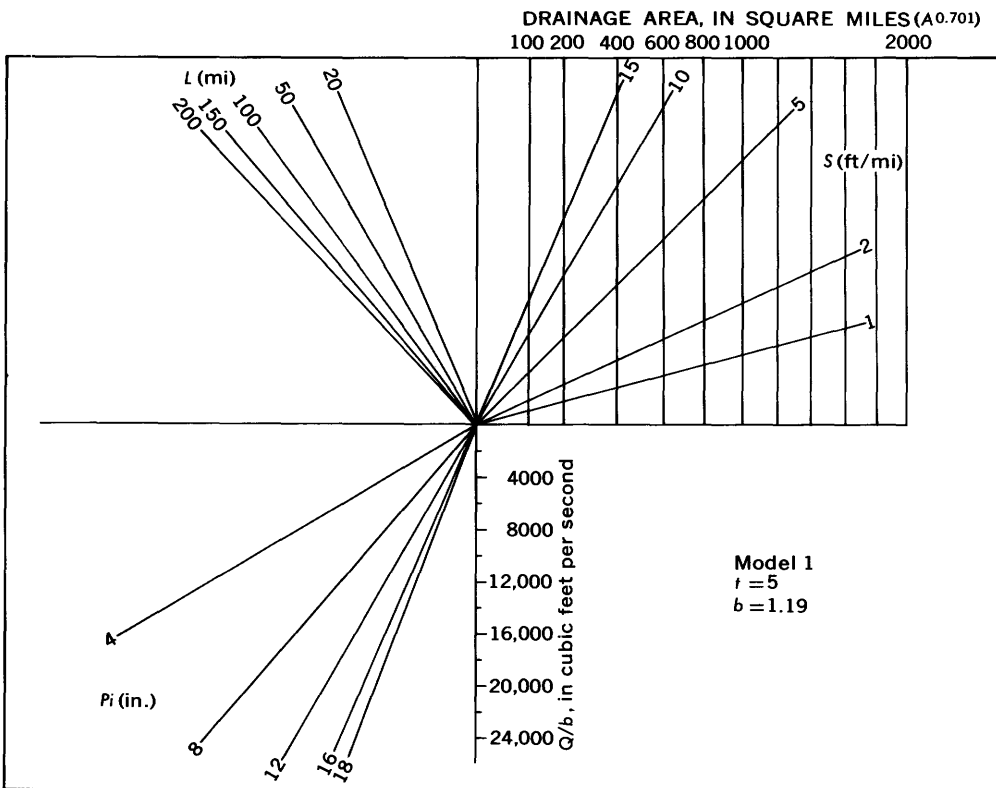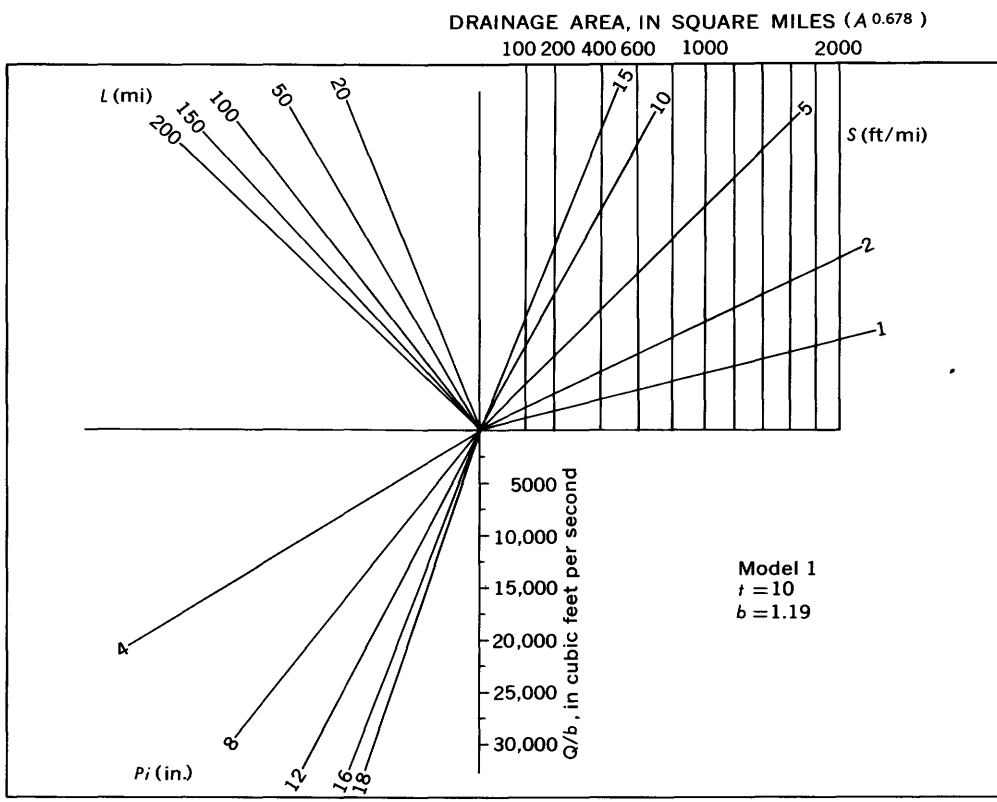FIGURE 11.—Graphical solutions for regression equations for model 1.

FIGURE 12.—Graphical solutions for regression equations for model 1.

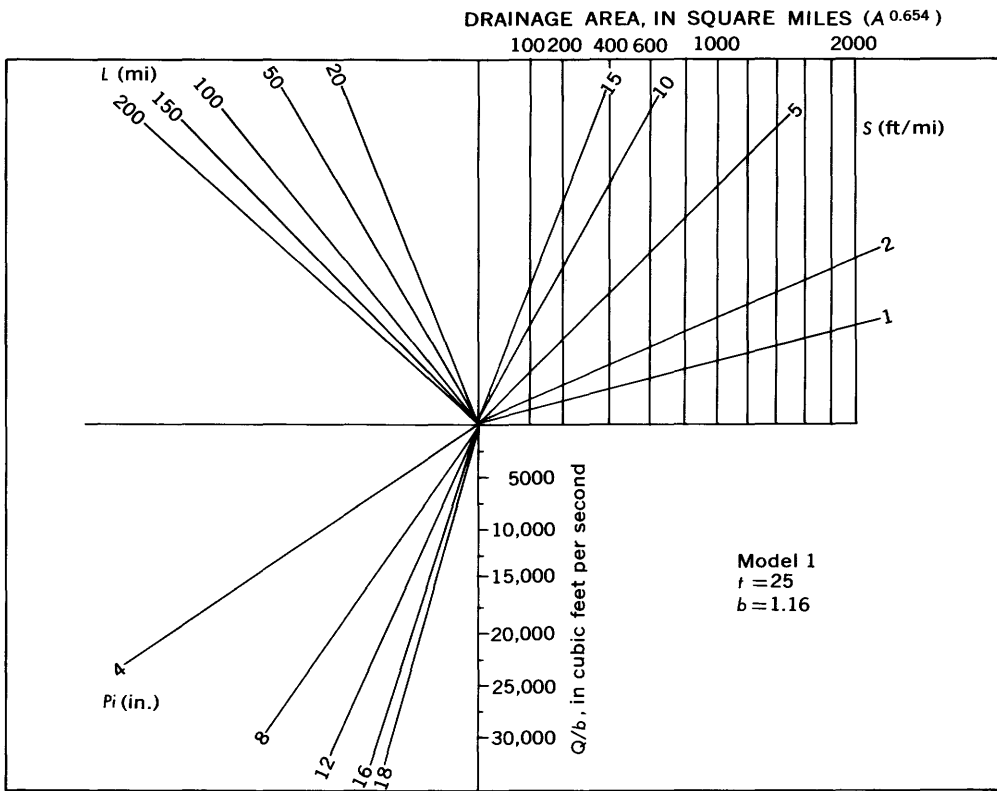FIGURE 13.—Graphical solutions for regression equations for model 1.

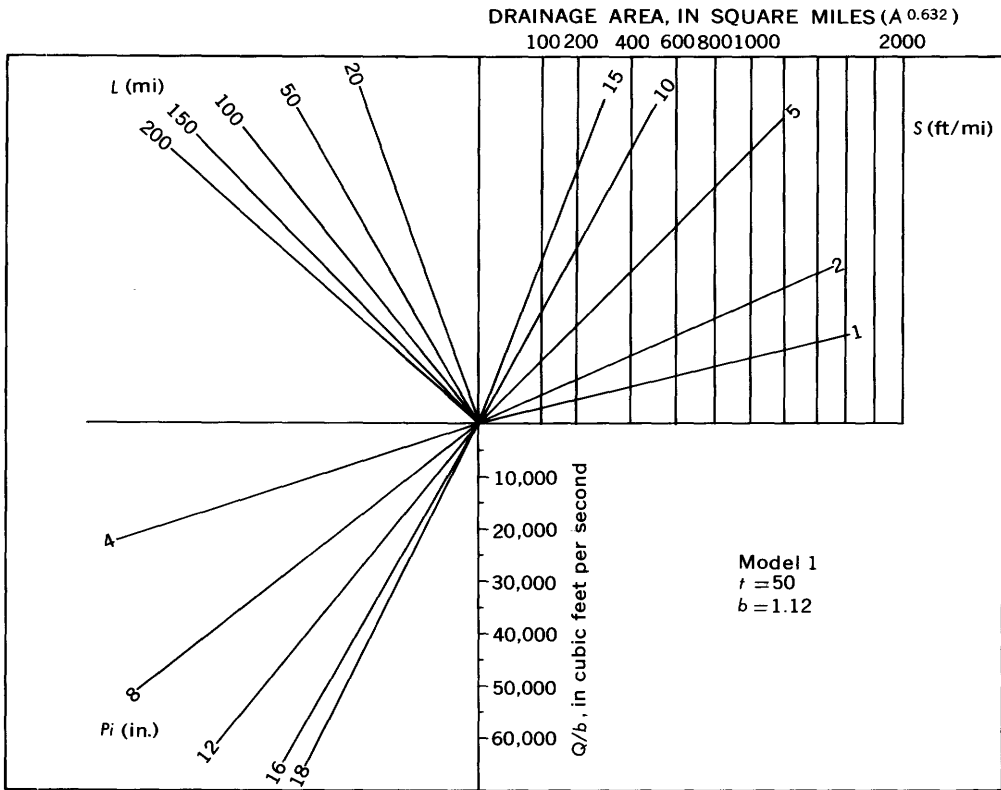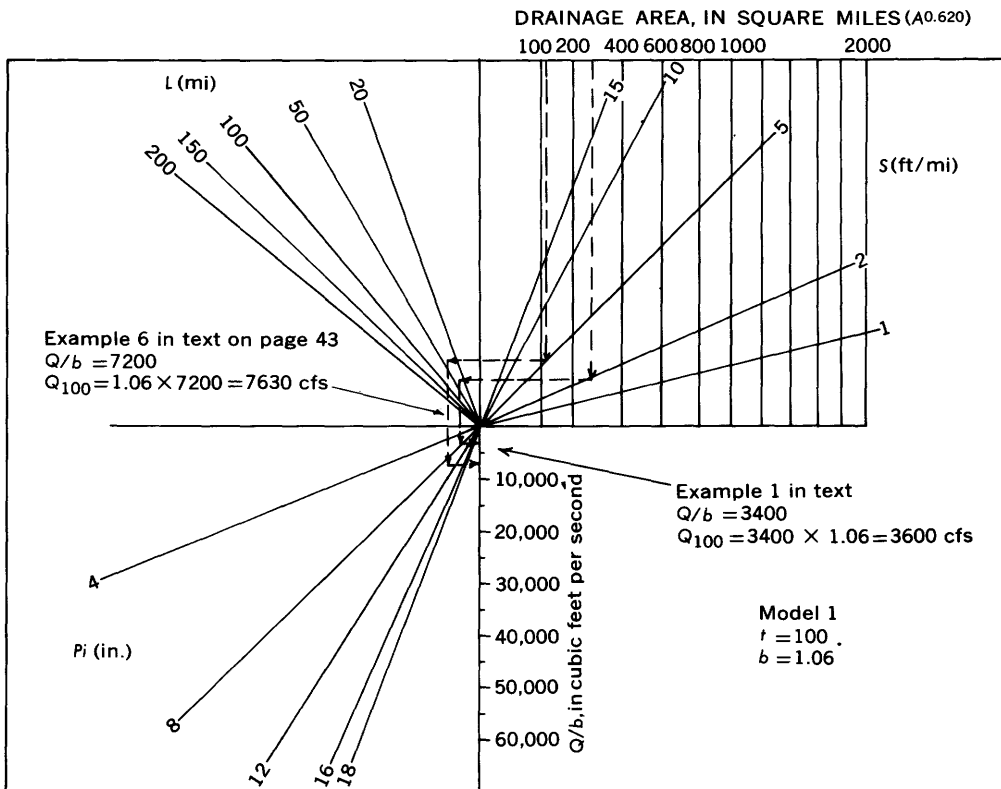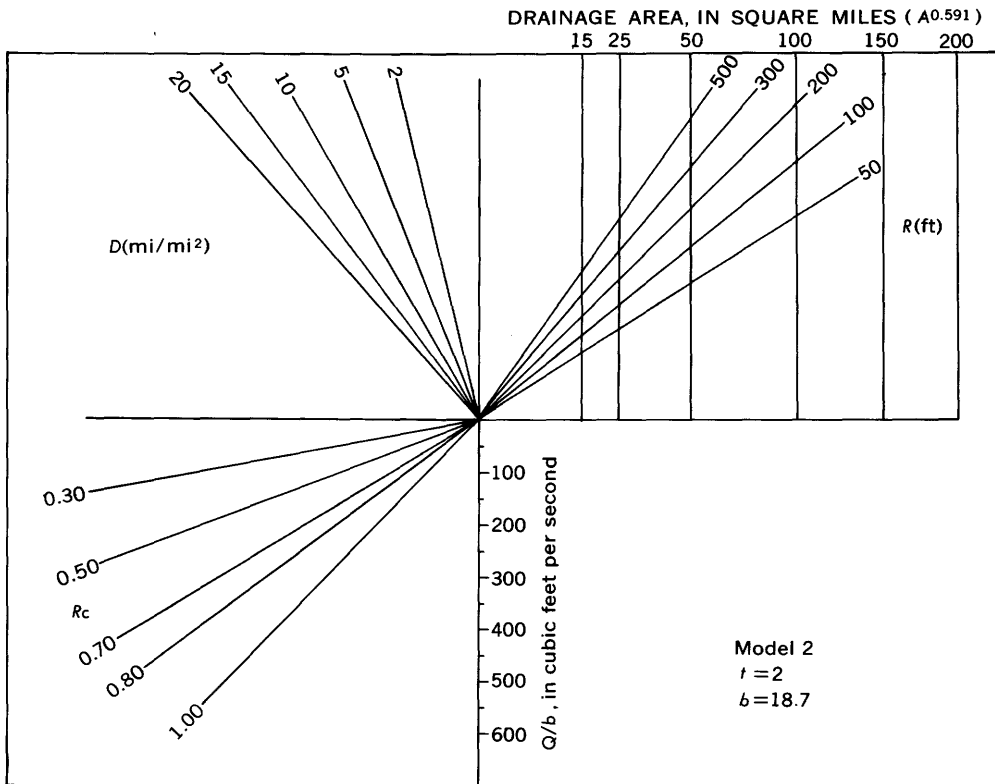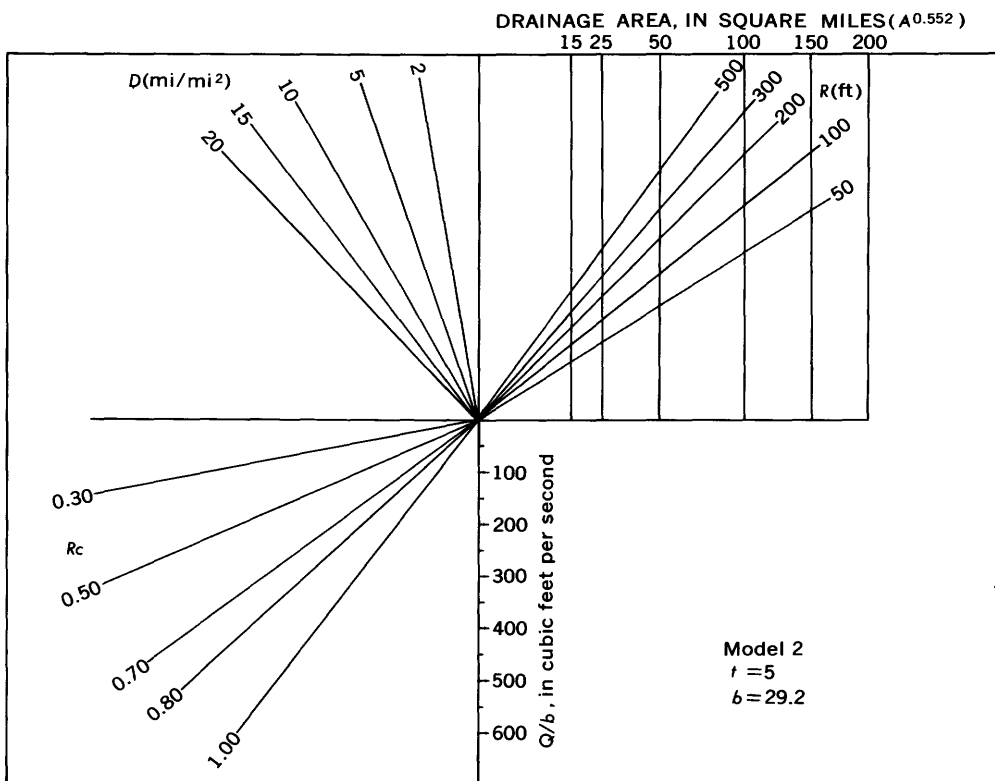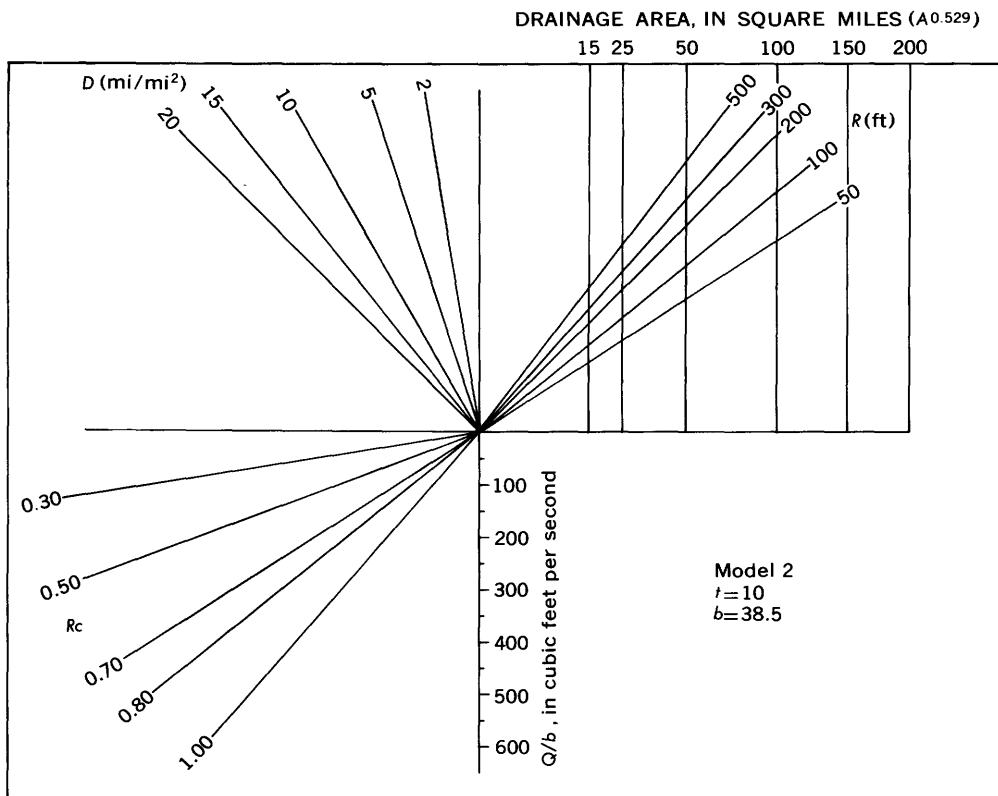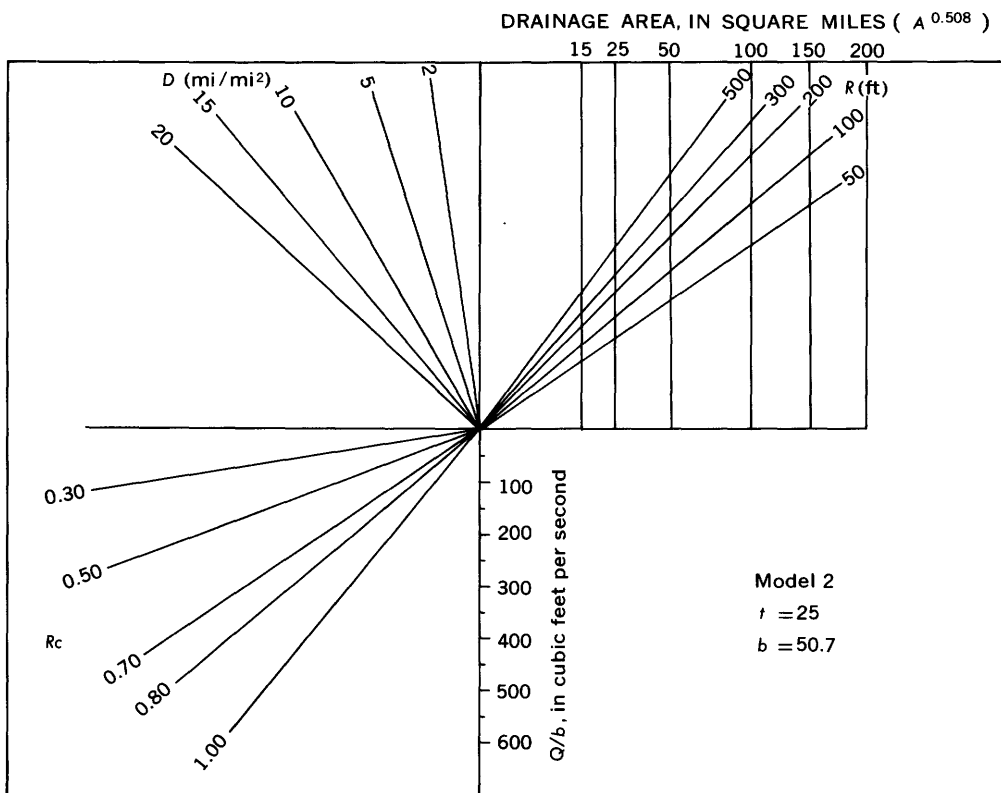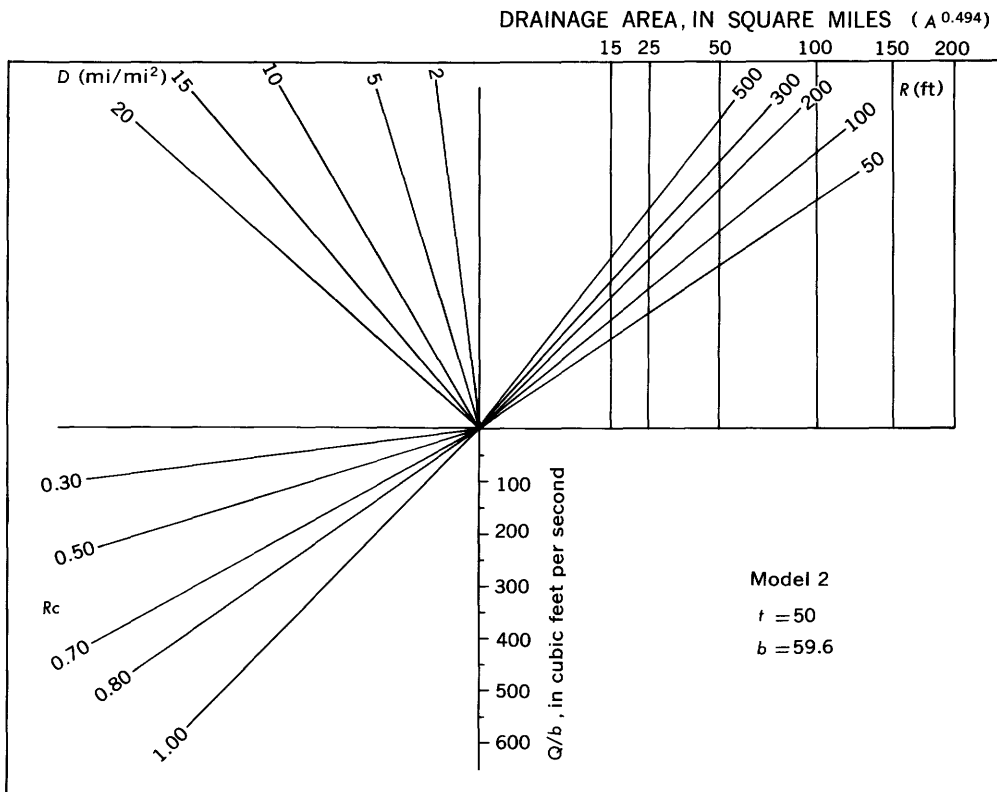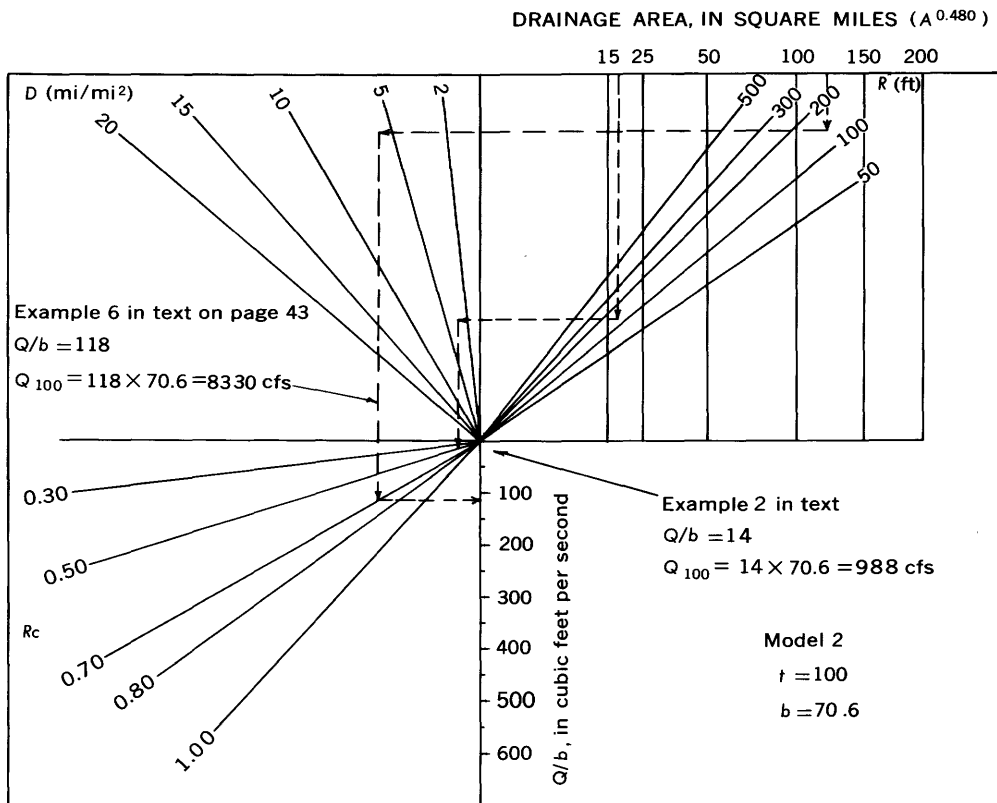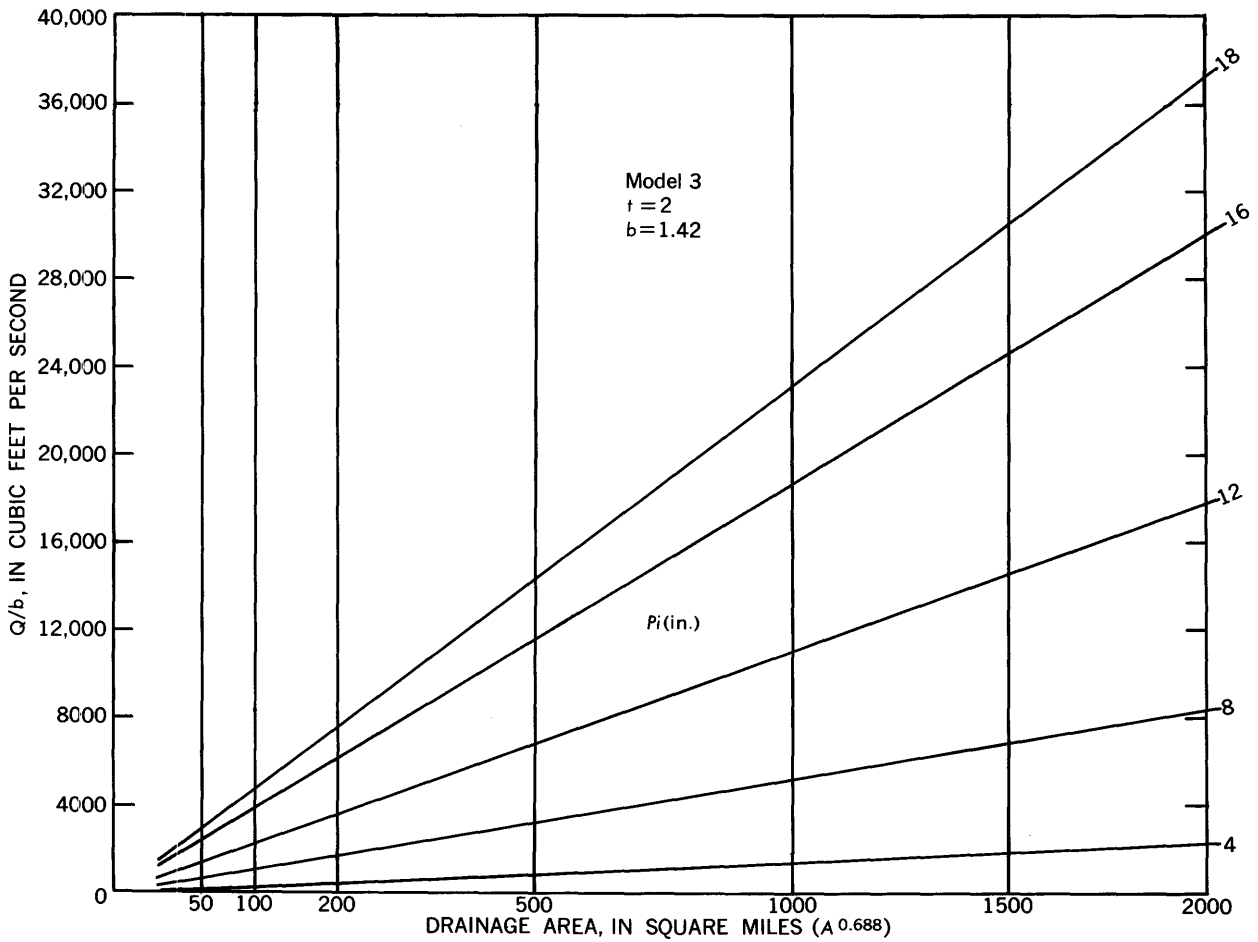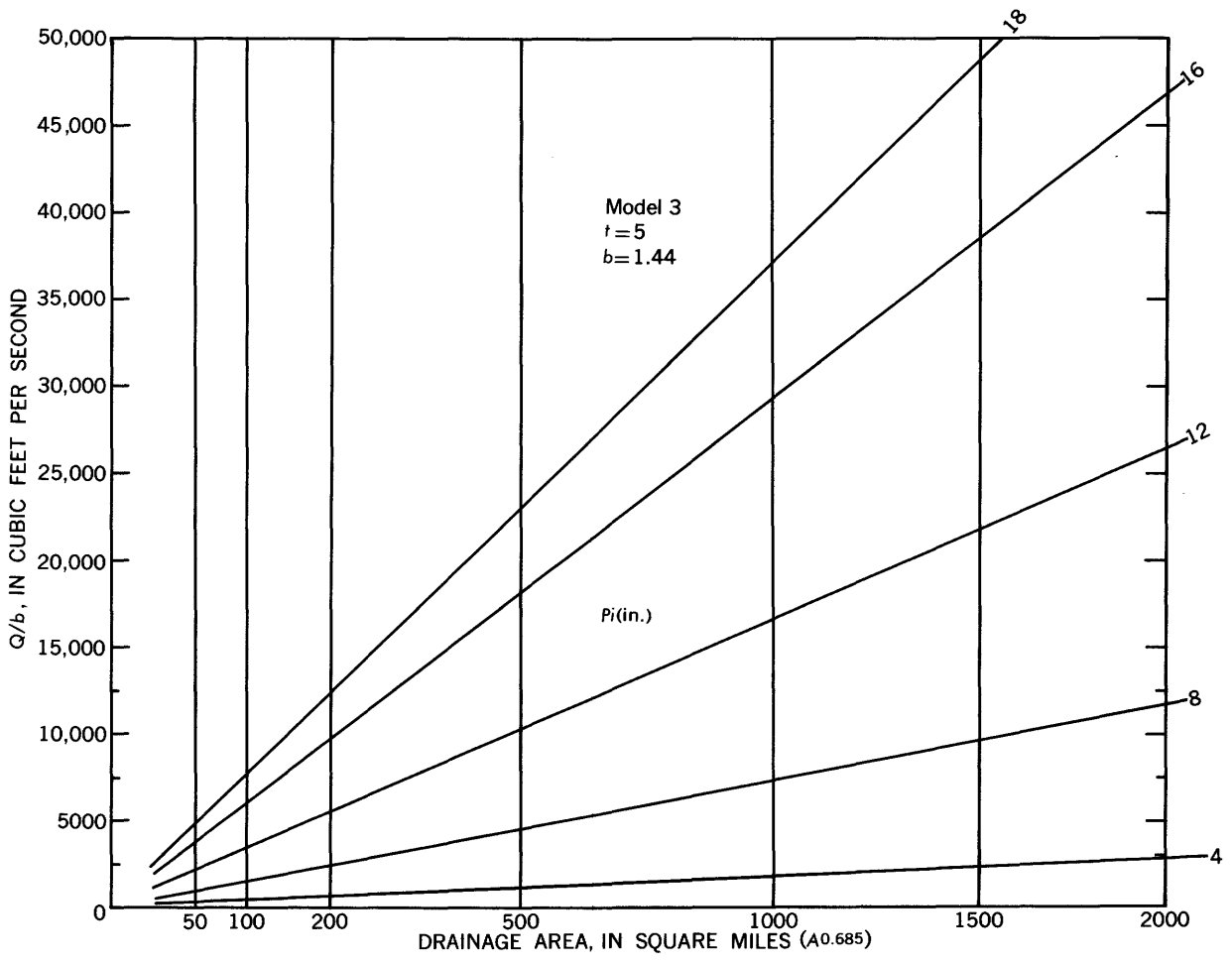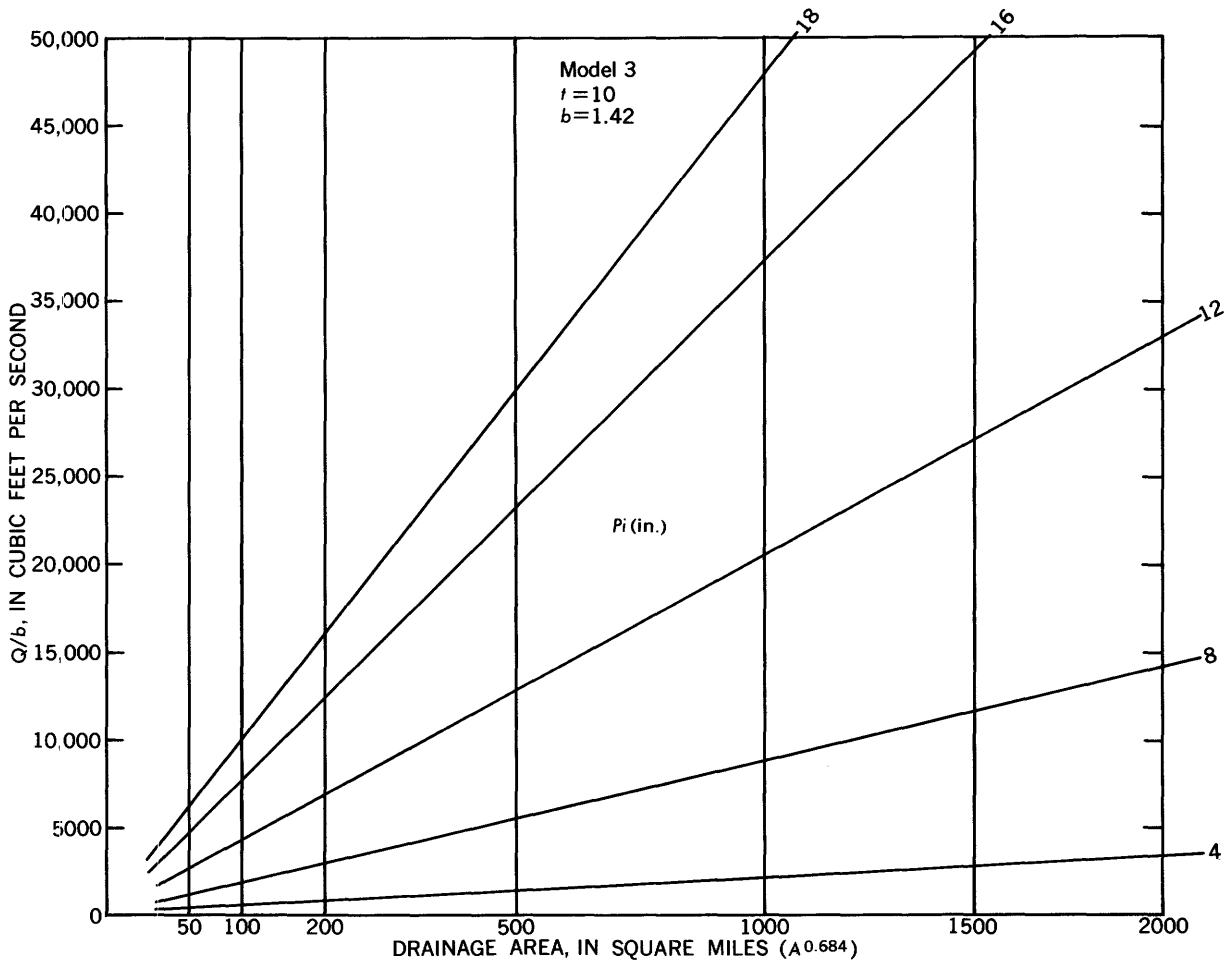FIGURE 14.—Graphical solutions for regression equations for model 1.

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FIGURE 15.—Graphical solutions for regression equations for model 1.

FIGURE 16.—Graphical solutions for regression equations for model 1.

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FIGURE 17.—Graphical solutions for regression equations for model 2.

FIGURE 18.—Graphical solutions for regression equations for model 2.

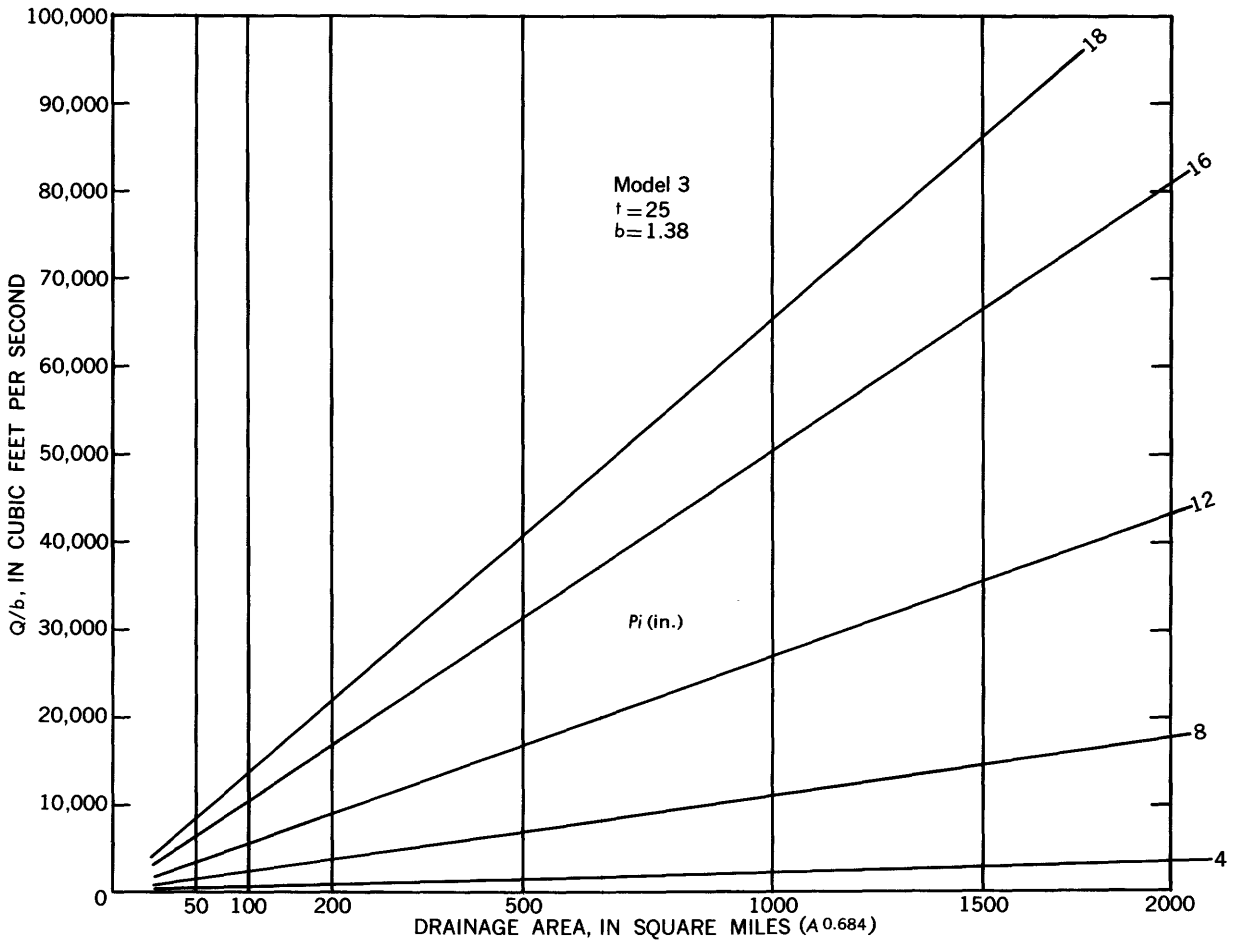FIGURE 19.—Graphical solutions for regression equations for model 2.

FIGURE 20.—Graphical solutions for regression equations for model 2.

FIGURE 21.—Graphical solutions for regression equations for model 2.

FIGURE 22.—Graphical solutions for regression equations for model 2.

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FIGURE 23.—Graphical solutions for regression equations for model 3.

FIGURE 24.—Graphical solutions for regression equations for model 3.

FIGURE 25.—Graphical solutions for regression equations for model 3.

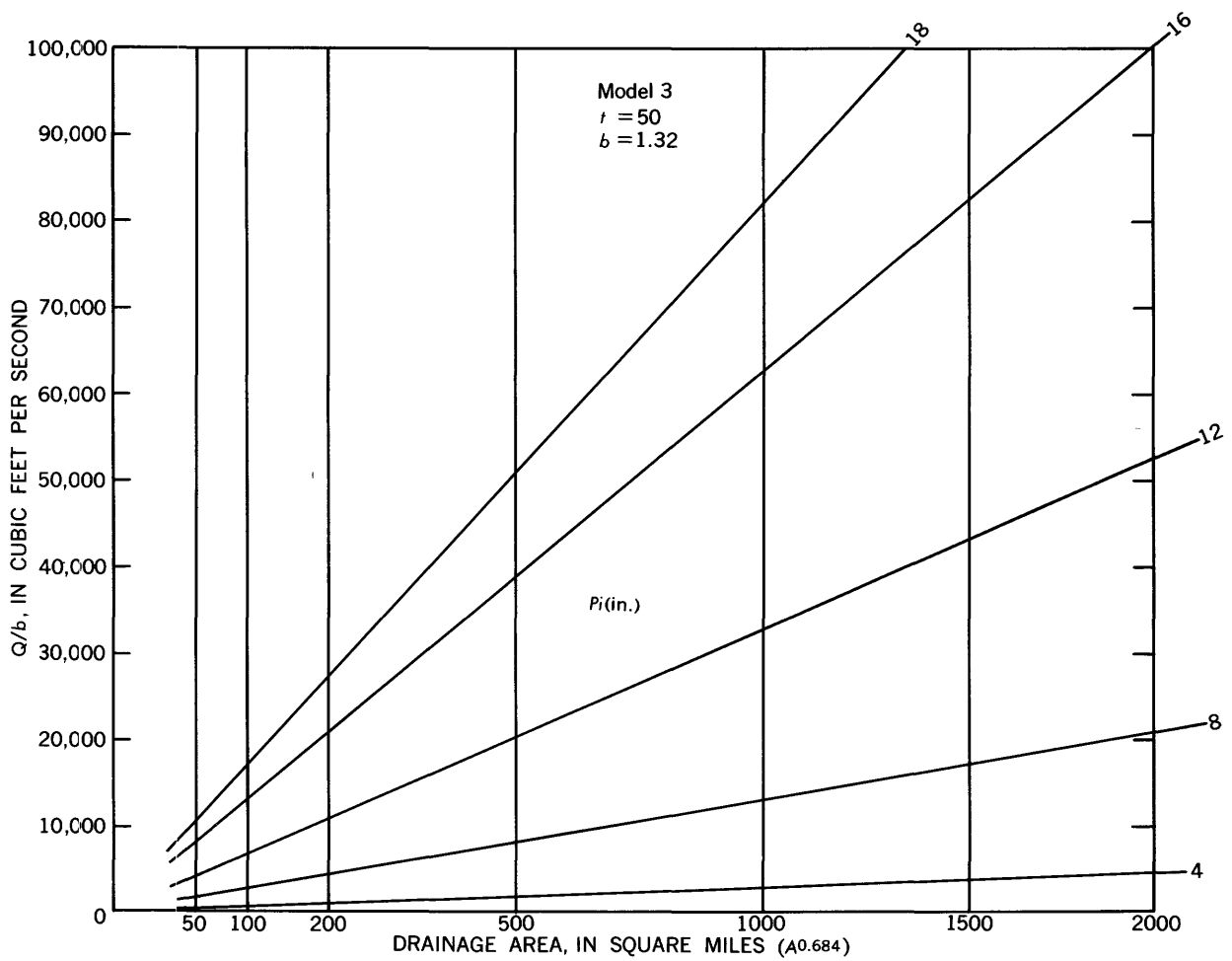FIGURE 26.—Graphical solutions for regression equations for model 3.

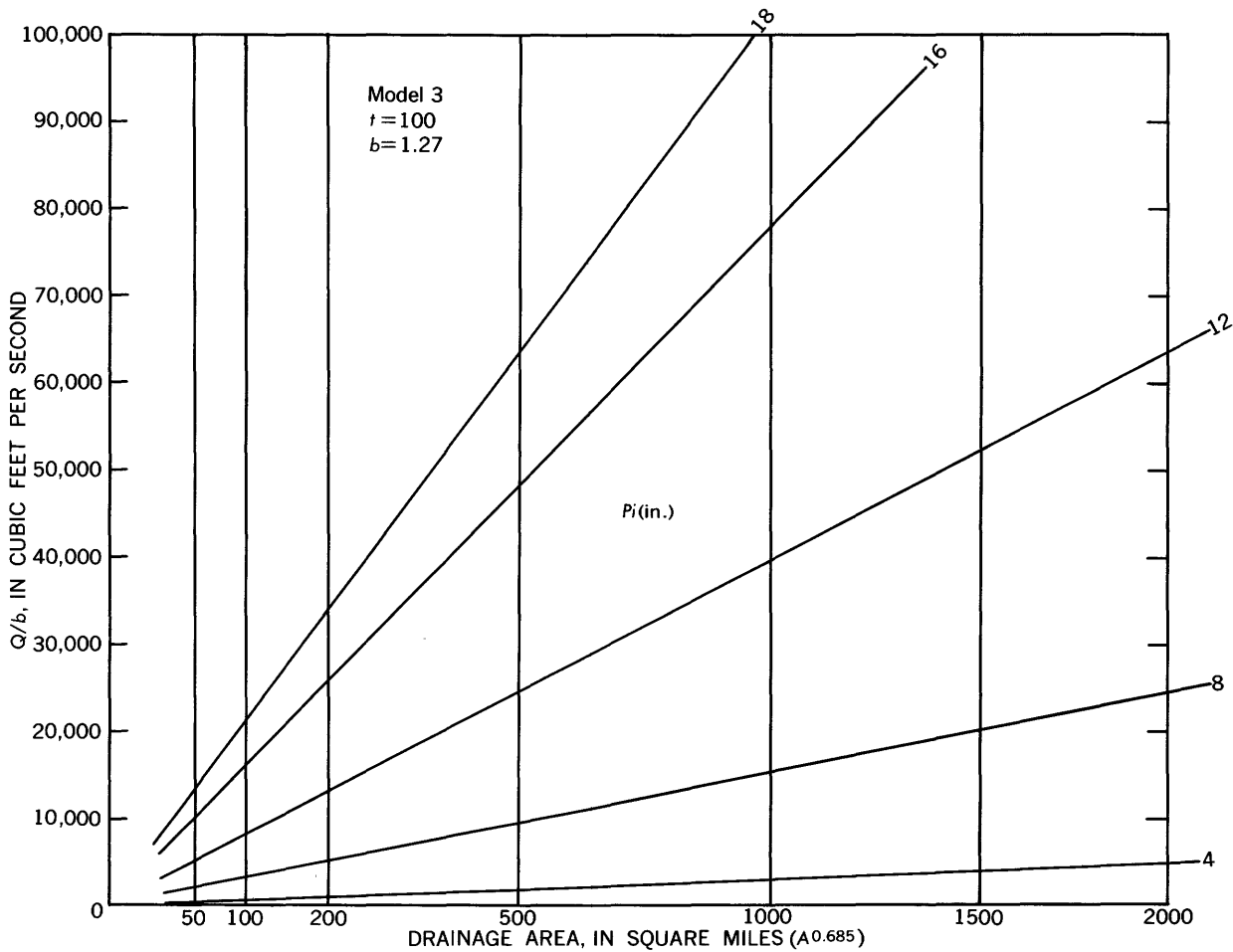FIGURE 27.—Graphical solutions for regression equations for model 3.

FIGURE 28.—Graphical solutions for regression equations for model 3.