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Effects of Urbanization on the Magnitude and Frequency of Floods in Northeastern Illinois

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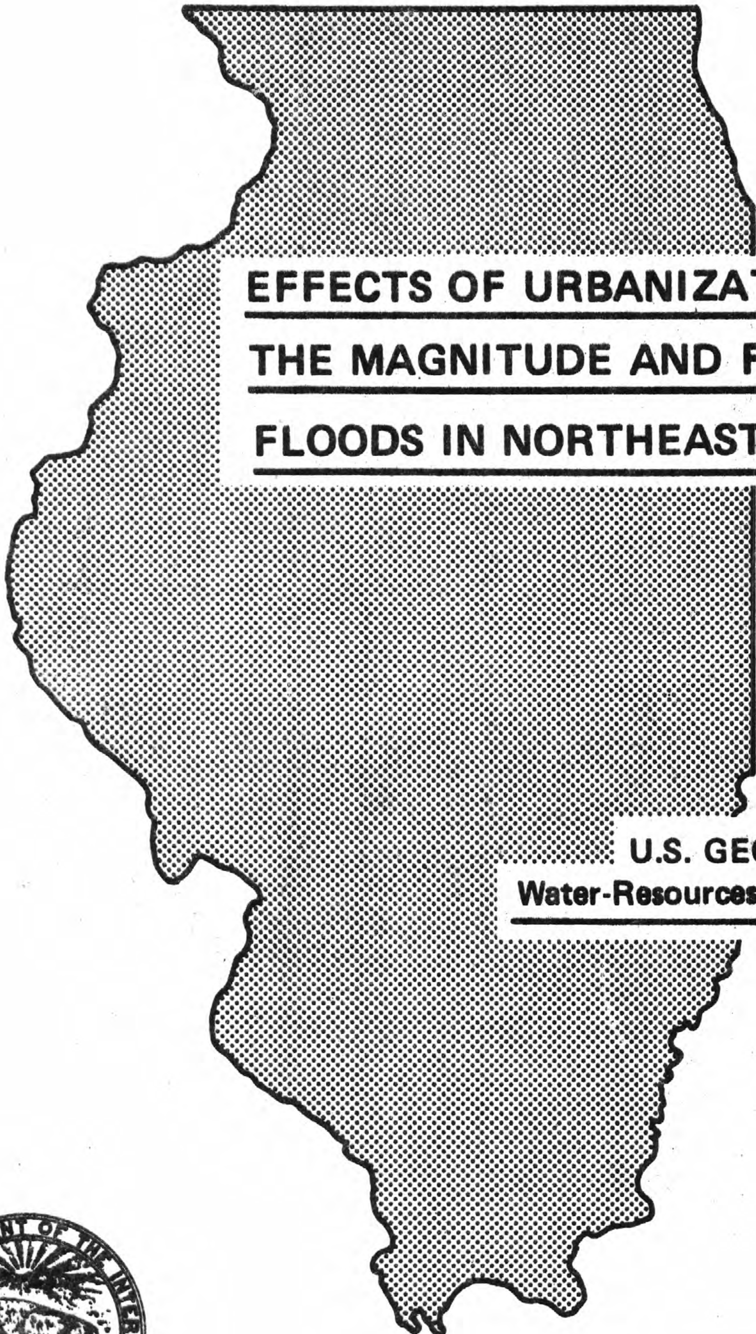

EFFECTS OF URBANIZATION ON THE MAGNITUDE AND FREQUENCY OF FLOODS IN NORTHEASTERN ILLINOIS

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations 79–36

Prepared in cooperation with

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Three variables, drainage area, channel slope, and percent imperviousness (an urbanization factor), are used to estimate flood magnitudes for frequencies ranging from 2 to 500 years. Multiple regression analyses were used to relate flood-discharge data to the above watershed characteristics for 103 gaged watersheds. These watersheds ranged in drainage area from 0.07 to 630 square miles, in channel slope from 1.1 to 115 feet per mile, and in imperviousness from 1 to 39 percent.

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STATE OF ILLINOIS
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1979
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GLOSSARY

Annual peak discharge. The maximum momentary peak discharge in a water year.

Cubic feet per second (ft^3/s). A unit expressing rates of discharge. One cubic foot per second represents a volume of 1 cubic foot of water passing a given point during 1 second and is equivalent to approximately 7.48 gallons per second, 448.8 gallons per minute, or 0.02832 cubic meters per second.

Continuous-record gaging station. A site on a stream where stage and discharge are obtained continuously over a period of time.

Crest-stage gaging station. A site on a stream where flood peak data are collected systematically over a period of years.

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

Exceedance probability. The likelihood or chance that a random flood peak will exceed a specified magnitude in a given time period.

Floodflow. A relatively high streamflow which generally overtops the natural or artificial banks along some reaches of a stream.

Flood peak. The highest value of the stage or discharge attained by a flood.

Flood plain. The lowland that borders a stream, usually dry but subject to flooding.

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

Housing unit. A house, an apartment, a ground of rooms, or a single room occupied or intended for occupancy as a separate living quarters.

Imperviousness. A quality of the land surface characterized by the inability of water to penetrate those areas of land surface covered with asphalt, concrete, buildings, or other manmade coverings.

Percent chance. A probability multiplied by 100.

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

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

Recurrence interval. The average time interval 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.

Standard error of estimate. A measure of the reliability of a regression. It is a measure of the distribution of the residuals about a regression line.

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

Watershed. See drainage area.

Weighted mean. A value obtained by multiplying each of a series of values by its assigned weight and dividing the sum of those products by the sum of the weights.

FACTORS FOR CONVERTING INCH-POUND UNITS TO INTERNATIONAL SYSTEM (SI) UNITS

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

Multiply inch-pound unit	By	To obtain SI (metric) unit
inch (in)	25.4	millimeter (mm).
	2.54	centimeter (cm).
foot (ft)	0.3048	meter (m).
mile (mi)	1.609	kilometer (km).
square mile (mi^2)	2.590	square kilometer (km^2).
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km).
mile per square mile (mi/mi^2)	0.6214	kilometer per square kilometer (km/km^2).
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s).

EFFECTS OF URBANIZATION ON THE MAGNITUDE AND FREQUENCY OF FLOODS IN NORTHEASTERN ILLINOIS

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ABSTRACT

Changes in land use associated with urbanization have increased flood-peak discharges in northeastern Illinois by factors ranging up to 3.2.

Techniques are presented for estimating the magnitude and frequency of floods in the urban environment of northeastern Illinois, and for estimating probable changes in flood characteristics that may be expected to accompany progressive urbanization. Suggestions are also offered for estimating the effects of urbanization on flood characteristics in areas other than northeastern Illinois.

Three variables, drainage area, channel slope, and percent imperviousness (an urbanization factor), are used to estimate flood magnitudes for frequencies ranging from 2 to 500 years. Multiple-regression analyses were used to relate flood-discharge data to the above watershed characteristics for 103 gaged watersheds. These watersheds ranged in drainage area from 0.07 to 630 square miles, in channel slope from 1.1 to 115 feet per mile, and in imperviousness from 1 to 39 percent.

INTRODUCTION

Urban expansion in northeastern Illinois has been rapid in recent years. Farms, wetlands, and woods are continually being replaced by highways, streets, parking lots, and buildings. These changes in land use have created and will continue to create many complex problems.

It is generally recognized that floodflows from urbanized watersheds increase as the result of increased imperviousness and modifications in the drainage system. Flood damages also increase due to urban encroachment on once-open natural flood plains. This problem is becoming more acute as urban pressures force development of more and more of the natural flood plains.

Purpose and Scope

The purpose of this report is to define the effects of urban development on flood-peak discharges and to provide techniques and procedures for estimating the probable magnitude and frequency of floods from ungaged watersheds in northeastern Illinois. Streamflow and relevant basin characteristics from 103 gaged watersheds are defined and analyzed to evaluate the hydrologic impact of urban development on floodflows.

The report presents a summary of observed flood data, flood-frequency characteristics at gaged sites, and analyses showing the relative effect of several physical basin characteristics on flood peaks. The results of the analyses are presented as mathematical and graphical relations that may be used to estimate the magnitude and frequency of floods from drainage basins with various degrees of development. Knowledge of the magnitude and frequency of floods is essential if planning and engineering efforts are to result in effective, efficient, and orderly use of waterways.

Previous Work

Flood-frequency studies in Illinois have been confined to rural streams. Mitchell (1954), Ellis (1968), Carns (1973), and Curtis (1977a, 1977b) all presented techniques and procedures for estimating the probable magnitude and frequencies of floods on ungaged rural streams. Of these, Curtis (1977b) utilized the longest periods of record, extension of records by rainfall-runoff relationships, and the greatest range in drainage areas to give the most comprehensive techniques for ungaged rural streams on a statewide basis.

Sheaffer, Ellis, and Spieker (1970) described a flood-hazard mapping program in Metropolitan Chicago. The program they described resulted in the mapping of historical floods on maps at a scale of 1 to 24,000 for most of the six-county metropolitan area of northeastern Illinois. Three hundred and ninety-four crest-stage gages were established for that project.

Many investigators (Wiitala, 1961; Martens, 1968; Anderson, 1970; Putnam, 1972; and Espey and Winslow, 1974) have suggested that the increase in impervious surfaces during urbanization is one of the principal causes of increases in flood-peak flow and that percentage of imperviousness may be used as an index of urbanization for flood-frequency prediction.

Other investigators (Stankowski, 1972; McCuen, 1975) have shown that certain demographic characteristics such as population density and housing density can be used as indirect indicators of land-surface modifications affecting urban runoff.

Acknowledgments

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DESCRIPTION OF THE STUDY AREA

The study area includes about 2,640 mi^2 in all or parts of Cook, Du Page, Kane, Kendall, Lake, McHenry, and Will Counties, Illinois (fig. 1). In 1970, the population of the area was about 6,800,000, of which 48.3 percent was within the city of Chicago. Between 1960 and 1970 the increase in population for the entire study area was about 12 percent, as opposed to an increase of 35 percent for suburban areas.

The climate is humid continental, with warm to hot summers and fairly cold winters with a slight moderating effect by Lake Michigan. The average annual temperature is about 50°F (10°C), with average monthly mean temperatures ranging from 23°F (-5°C) in January to 74°F (23°C) in July. Average annual precipitation is 34 inches, of which about 10 percent is in the form of snow. The area is subject to very intense storms of short duration.

The major part of the study area is located in physiographic subdivisions of the Chicago lake plain and the Wheaton morainal country, with the extreme southwestern part of the area situated in the Bloomington ridged plain and the Kankakee plain (Leighton, Ekblaw, and Horberg, 1948).

Topographic features in northeastern Illinois were formed primarily as the result of glacial and related activity of Pleistocene Age. The Chicago lake plain, the result of glaciolacustrine action, extends northerly from the Indiana–Illinois line to about Winnetka and as far west as La Grange. The lake plain has a relatively flat surface sloping gradually towards Lake Michigan, interrupted by only a few low ridges and knolls and by two drainageways, the Des Plaines River and the Calumet Sag Channel. The Wheaton morainal country, which includes most of Du Page, Lake, McHenry, and Will Counties, is noted for its broad, parallel morainic ridges, numerous lakes and swamps, and hilly topography.

The surficial geology of northeastern Illinois consists of a mantle of unconsolidated glacial deposits overlying bedrock. These deposits, known as drift, consist of till, silt, clay, sand, gravel, and peat. They average about 100 feet in thickness but range from 0 to about 400 feet.

Bedrock formations in the study area consist of dolomite, limestone, sandstone, shale, and claystone of Paleozoic Age. Natural bedrock outcrops occur only in the southern part of the area where glacial drainage and present rivers have cut through the glacial deposits.

Most of the area drains to the Mississippi River via the Des Plaines, Fox, and Illinois Rivers, while a small part of the area drains eastward to the St. Lawrence River basin via Lake Michigan. The natural drainage divide which separates the St. Lawrence River basin and the Mississippi River basin is a few miles west of Lake Michigan. Most of the original drainage to Lake Michigan is now diverted to the Mississippi basin through the Chicago Sanitary and Ship Canal and the Calumet Sag Channel. During extreme floods some of the peak flow from the Chicago and Calumet Rivers is reversed to Lake Michigan to avoid serious flooding problems in the Chicago metropolitan area.

The natural drainage system is poorly developed with numerous lakes and swamps, many shallow streams with low streambanks, and wide, flat flood plains. The larger streams flow generally south along the sags between moraines.

WATERSHED SELECTION AND ANALYSIS

Gaging Station Selection

Data used in this study were selected from 453 gaging stations in northeastern Illinois where hydrologic information was collected for periods of several years. Several criteria were used in the selection of the stations. The primary criterion was that annual peak discharges could be obtained for determining station flood-frequency relationships. The annual peak discharge was available for all continuous-record stations and for some of the crest-stage stations where relationships of stage to discharge were established and maintained during the period of station record. At most of the stations established for flood-hazard mapping (Sheaffer and others, 1970) only annual peak stages were available. The flood-hazard mapping stations were considered for use in this study only if indirect methods could be used to relate the peak stages to discharge.

These indirect rating methods included step-backwater analyses, width constrictions, and flow through culverts (Shearman, 1976; Matthai, 1967; and Bodhaine, 1968, respectively). Not all the stations that could possibly have been rated by indirect methods were selected. Records at some of the stations indicated changes had been made in the channel characteristics during the period of record. Channel dredging and new bridges and culverts at some stations precluded use of the stage to discharge relationship for the complete period of stage record. These stations were not used.

Time constraints prevented development of a stage to discharge relationship for all the stations. The stage to discharge relationships developed by indirect methods were verified at most stations by current-meter measurements. Selection of stations was further guided by the need to obtain an even geographic distribution, a range in drainage areas, and a range in the types and degrees of urban development.

The report is based on streamflow data obtained at 103 gaging stations (fig. 1) selected by the above procedures. Seventy of these stations are crest-stage gages and 33 are continuous-record gages. Information regarding the location, type of station, period of record, channel slope, and percent imperviousness for each station is given in table 1.

The annual peak discharges for the period of record at all crest-stage stations used in this study were published in the water resources data report for Illinois, water year 1977 (U.S. Geological Survey, 1978). The maximum recorded discharge for the period of record at each gaging station is presented in table 1.

Flood-Frequency Curves

Flood-frequency curves relate flood-peak discharges to exceedance probabilities or recurrence intervals. Flood-frequency curves for the gaging stations were defined using guidelines recommended by the U.S. Water Resources Council (1977). These guidelines describe the procedures for fitting a log-Pearson Type III distribution to the observed annual flood data.

The log-Pearson Type III distribution is defined by three statistical parameters: mean, standard deviation, and skew of the data array. The method of fitting the log-Pearson Type III distribution to an array of flood data is as follows:

A. The N annual flood peaks at a gaging station are transformed into corresponding logarithmic values;

$$X_1, X_2, \ldots X_N.$$

B. Mean of the logarithms is computed;

$$\overline{X} = \frac{\Sigma X}{N}.$$

C. Standard deviation (S) and skew coefficient (G) are computed;

$$S = \sqrt{\frac{\Sigma X^2 - (\Sigma X)^2/N}{N-1}},$$

$$G = \frac{N\Sigma(X-\overline{X})^3}{(N-1)(N-2)S^3}.$$

D. Logarithms of discharges at selected exceedance probabilities are computed;

$$\text{Log } Q = \overline{X} + KS \tag{1}$$

where $\overline{X}$ is the mean of the logs of the annual flood peaks at a gaging station, and K is a factor from tables in the guidelines by U.S. Water Resources Council (1977) that relates the computed value of the skew coefficient (G) to the selected exceedance probability.

E. The antilog of log Q is the flood discharge, Q.

Frequency curves for individual stations are obtained by plotting the discharges computed from equation 1 for the selected exceedance probabilities on log-probability coordinates and drawing a continuous line that averages the plotted discharges.

A base period of record at gaging stations used in the study was needed for which changing conditions of urbanization in the watersheds would have minimal effect on flood-frequency curves. The most recent census data for which indices of urbanization could be developed were for 1970. A period was required for those watersheds affected by urbanization for which urban development in 1970 would be an average.

The period of record at many of the crest-stage stations used in the study was from 1960 to 1976. Urbanization indices based on 1970 census statistics were used to represent an approximate average for the period from 1960 to 1976. Therefore, this period was selected as the base period of record for all gaging stations with more than 5 percent imperviousness in the watershed.

The skew coefficient computed from station records is very sensitive to extremes of the data array. As recommended by the U.S. Water Resources Council (1977), a generalized skew of -0.4 for northeastern Illinois was used directly for computing the frequency relations for all stations having less than 25 years of record. They also give (p. 10) procedures for weighting the station skew with the generalized skew, which were used for those stations with gage records longer than 25 years and with less than 5 percent imperviousness in the watershed.

The peak discharge-frequency data for the gaging stations used in the study are presented in table 2.

Impervious Areas

Evaluating the effects of urban development on flood peaks requires a quantitative measure of the degree of urbanization. Several studies (Wiitala, 1961; Martens, 1968; Anderson, 1970; Putnam, 1972; and Espey and Winslow, 1974) have suggested that the percentage of impervious area may be useable as a measure of urbanization.

Impervious areas may be measured directly from aerial photographs, large scale maps, or by field surveys. These methods are usually very expensive and laborious, and the lack of aerial photography or detailed maps may restrict the measurement of imperviousness for many watersheds.

Some researchers (Stankowski, 1972; McCuen, 1975) have used demographic statistics (population density, housing density), as indirect indicators of imperviousness. These statistics are included in census data and projections of the statistics are made by planning agencies. They can therefore be used as an index of future urban conditions.

Three relationships between demographic statistics and imperviousness were determined for this study. Aerial photographs flown in 1970 (scale 1″ = 400′) were obtained for 15 watersheds with drainage areas ranging from 1.34 to 23.5 mi^2. These watersheds were selected based on considerations of both geographic location and varying urban densities. The impervious areas of each watershed were measured directly from aerial photographs using a grid sampling technique. The grid used had 900 points per square mile.

The drainage divides of the watersheds were outlined on maps in the metropolitan map series (U.S. Bureau of Census, 1972). The population density, housing density, and street density for each watershed were computed based on information as compiled from the metropolitan maps and census block statistics. The location, size, population density, housing density, street density, and percentage of imperviousness for each of the 15 watersheds are presented in table 3.

Regression analyses were used to relate the percentage of imperviousness to population density (persons/mi^2), housing density (units/mi^2), and street density (miles/mi^2). The results of these analyses indicate a high degree of correlation between imperviousness and each of the three independent variables (figs. 2, 3, and 4). The quadratic relationships (figs. 2, 3, and 4) between percentage of imperviousness and population density, housing density, and street density were defined by the least squares method.

Watershed divides for all gaging stations used in the study were transferred to the metropolitan map series, and the population density for each watershed was computed based on the block statistics (U.S. Bureau of Census, 1971, 1972). The percent imperviousness for each gaged watershed was determined from a relation between percentage of imperviousness and population density (fig. 2), except for 15 watersheds where percent imperviousness was measured directly. For basins not fully covered by the metropolitan map series, housing units were counted on topographic maps and the percent imperviousness determined from a relationship between imperviousness and housing density (fig. 3). The percent imperviousness determined for each watershed in the study is shown in table 1.

REGIONALIZATION

Needs and Methods

Floodflow information is often needed at sites where gaging stations are not located. Flood-frequency data from individual gaging stations have limited transferability, therefore, estimates of flood magnitudes and frequencies at ungaged sites should be determined from a regional analysis of data from gaged sites. Regional analyses relate flood peaks to the watershed characteristics affecting floodflows. In addition to providing a method of estimating floods at ungaged sites, regional analyses often improve flood-frequency estimates at gaging stations.

Multiple-regression techniques were used to develop the regional flood-frequency relations in this report. Flood discharges corresponding to the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year recurrence intervals were computed at all stations using the log-Pearson Type III analysis and regressed against basin and climatic variables using the model:

$$Q_T = cA^xB^y \ldots D^z \tag{2}$$

where Q_T is the peak discharge with a recurrence interval of T-years,

A, B, . . . D are basin and climatic variables,

x, y, . . . z are regression coefficients, and c is the regression constant.

The computer program used for the regression computations evaluated the statistical significance of each independent variable, defined the regression coefficients and constant, and provided the standard error of estimate of the regression equations. Many independent variables, such as drainage area, main channel length, main channel slope, channel slope of a reach from a gage to one-fifth of the channel length upstream from the gage, storage (percentage of watershed in lakes, ponds, and swamps), a channel improvement factor, percent imperviousness, and rainfall intensity were originally used as independent variables. The significance on flood magnitudes of each variable was evaluated. The combination of independent variables most useful in predicting flood magnitudes included drainage area (A), main channel slope (S), and percent imperviousness (If). The regression equations defined with these variables have the smallest standard errors and the least number of variables.

Flood-Frequency Estimating Equations

The flood-frequency estimating equations developed using regression analyses are:

$$Q_2 = 14.7\, A^{0.698}\, S^{0.241}\, If^{0.313} \quad (3)$$

$$Q_5 = 23.8\, A^{0.682}\, S^{0.284}\, If^{0.255} \quad (4)$$

$$Q_{10} = 29.8\, A^{0.675}\, S^{0.305}\, If^{0.228} \quad (5)$$

$$Q_{25} = 37.2\, A^{0.668}\, S^{0.325}\, If^{0.202} \quad (6)$$

$$Q_{50} = 42.7\, A^{0.664}\, S^{0.338}\, If^{0.186} \quad (7)$$

$$Q_{100} = 48.0\, A^{0.660}\, S^{0.349}\, If^{0.172} \quad (8)$$

$$Q_{500} = 60.5\, A^{0.651}\, S^{0.366}\, If^{0.145} \quad (9)$$

The Q_2, Q_5, Q_{10}, Q_{25}, Q_{50}, Q_{100}, Q_{500} are the discharges, in cubic feet per second, corresponding to the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year recurrence interval floods (Q_T), respectively. The independent variables in the equations are drainage area (A), main channel slope (S), and percent imperviousness (If).

Drainage area of the watershed, in square miles, and the main channel slope, in feet per mile, may be determined from U.S. Geological Survey topographic maps or other equivalent maps. Ogata (1975) has tabulated the drainage areas for numerous sites in Illinois where water data have been collected, and for many other selected locations.

Main channel slope is the difference in elevation at points 10 and 85 percent of the distance along the channel from the site to the watershed divide, divided by the distance between the two points. U.S. Geological Survey 7½-minute series topographic maps are generally sufficient for this determination.

Percent imperviousness is the impervious area of a watershed expressed as a percentage (If = 100 x impervious area/drainage area). This factor is used to quantify the degree of present urbanization, or that projected for future conditions.

The percentage of imperviousness for watersheds may be estimated from the curves in figures 2, 3, and 4. Population and housing data can be obtained from publications of census statistics by the U.S. Bureau of Census. Population estimates or projections may be obtained for specific areas from city, county, and State planning agencies. Street densities can be determined with the use of maps which depict all the streets and roads in an area. Imperviousness may also be directly measured by field survey, or with the use of aerial photographs or maps.

Due to the exponential nature of the regression equations, use of If values less than 1.0 has the effect of decreasing computed discharge values. Even though the equations are relatively insensitive to If in this range, values of If less than 1.0 should be considered as 1.0 for use in the estimating equations.

Reliability of Estimating Equations

The standard error of estimate expresses the reliability of an equation developed by regression. It is a measure of the dispersion of the observed values about the regression line. The standard error in this report is expressed as a percentage, and signifies that for about 68 percent of the estimates made by the regression equation the difference between the computed and actual discharge should be within plus or minus one standard error of estimate.

The reliability of the estimating equations may also be expressed as equivalent years of record. Equivalent years are the actual years of record needed at an ungaged site for the reliability of an estimate to be equal in accuracy to the standard error of estimate. Equivalent years of record for the regression were determined using the techniques developed by Hardison (1971).

The standard error of estimate (in percent) and equivalent years of record for regression equations 3 to 9 are summarized in table 4.

The reliability of flood-frequency estimates for large recurrence interval floods is comparatively poor. Because of this fact the 500-year flood discharges are not included in table 2. The 500-year flood estimating equation is included in this report only for special purposes, such as flood-insurance studies.

Limitations of Estimating Equations

The flood-frequency equations presented may be used to estimate the magnitude and frequency of floods on most (see exceptions below) of the streams in the study area (fig. 1). The estimating equations are based on data from watersheds with drainage areas ranging from 0.07 to 630 mi^2, channel slopes from 1.1 to 115 ft/mi, and impervious areas from 1 to 39 percent. Use of the equations outside of the observed range of data could result in solutions less reliable than indicated by the standard errors.

The equations are not designed to estimate flood discharges from watersheds completely served by underground drainage systems, or to predict floodflows from airports, parking lots, or other highly impervious areas. The equations are also not applicable to locations on streams where flood detention or retention reservoirs substantially affect the flood peaks.

The main stem of the Fox River has also been excluded from this study. Techniques for flood-frequency estimates on the Fox River are described by Curtis (1977a).

Weighting of Independent Estimates

The following procedures are suggested for weighting flood estimates at gaged sites and flood estimates at ungaged sites on gaged streams. The weighted mean values obtained from these procedures are the best estimates of flood discharges at either gaged or ungaged sites. Judgment must be used to determine if the location of the gaging station justifies the use of station data to adjust estimates at an ungaged site. A rule of thumb on gaged streams is to weight flood estimates at an ungaged site where the drainage area is between 50 and 200 percent of the drainage area at the gaging station.

The T-year flood discharge estimated from log-Pearson Type III frequency distribution and the corresponding estimate using a regional equation are considered independent. A weighted mean estimate of the flood discharge at a gaging station is obtained as follows:

$$\text{Log } Q_T = \frac{(\text{Yrs of record})(\log \text{sta } Q_T) + (\text{Eq yrs record})(\log \text{regional } Q_T)}{\text{Yrs of record} + \text{Eq yrs record}} . \tag{10}$$

The years of record for each station may be obtained from table 1. Station Q_T is obtained from the first line of discharge values for each station tabulated in table 2 and converted to a logarithm. The equivalent years of record for each recurrence interval corresponding to the Q_T obtained using regional equations 3 to 9 are listed in table 5. The regional Q_T is computed using the desired regional equations (second line of the discharge values for each station in table 2) and then transformed into logs. The anti-log of the solution obtained from equation 10 is the weighted mean estimate of the flood discharge at a gaging station. The weighted mean discharge values for each station have been computed and are the third line of values for each station in table 2. Equation 10 may be used to update the weighted mean discharge values as additional years of record become available.

The weighted station Q_T from equation 10, or line 3 in table 2, can be used to weight a flood estimate of Q_T at an ungaged site located on the same stream as the gaging station. A weighted Q_T at an ungaged site may be determined as follows:

$$\text{Weighted } Q_T \text{ (ungaged)} = \frac{Q_T \text{ (weighted at gage)}}{Q_T \text{ (regional equation at gage)}} \times Q_T \text{ (regional equation at ungaged site)}. \tag{11}$$

APPLICATION OF REGIONAL EQUATIONS

Flood-Frequency Estimating Technique

The magnitude of floods at sites where the equations are applicable may be estimated at desired frequencies for most types of urban development within the study area. A flow chart giving the proper sequence of the flood magnitude estimating technique is shown in figure 5.

Illustrative Examples

Flood-frequency estimating techniques for the study area are illustrated by the following three examples:

Example 1. Estimate the 100-year flood at a site located on an ungaged stream with a completely undeveloped watershed.

(a) Determine the size of drainage area (A), in square miles. The drainage area is measured on maps with sufficient features to accurately delineate the watershed boundary. For this example, assume $A = 5.0\ mi^2$.

(b) Determine the slope (S), in feet per mile. Slope is computed as the difference in elevation at points 10 percent and 85 percent of the distance along the channel from the site to the watershed divide, divided by the distance between the two points as measured along the stream. For this example, assume S = 5 ft/mi.

(c) Determine the percent imperviousness (If). This factor is the impervious area of the watershed expressed as a percentage of the total area. In this example, because the watershed is undeveloped, If is set at 1.

(d) Use equation 8 from page 7 to compute the flood magnitude.

$$Q_{100} = 48.0\ A^{0.660}\ S^{0.349}\ If^{0.172}$$

$$= (48.0)\ (5)^{0.660}\ (5)^{0.349}\ (1)^{0.172}$$

$$= (48.0)\ (2.89)\ (1.75)\ (1)$$

$$= 243\ ft^3/s.$$

Example 2. Determine the 50-year flood discharge for use in the design of a bridge opening on Winfield Creek at Gary Avenue in Wheaton, Du Page County, SW¼SE¼ sec.8, T.39 N., R.10 E.

(a) Site is ungaged and not on a gaged stream.

(b) The drainage area and slope are determined as described in example 1. The drainage area (A) and slope (S) for this example site are $4.54\ mi^2$ and 15.0 ft/mi, respectively.

(c) Determine the percent imperviousness (If). Using the techniques outlined in the section "Impervious Areas," an impervious value of 20 percent was computed for this site. The watershed divides were outlined on the metropolitan map series (U.S. Bureau of Census, 1972). The population of the watershed was estimated at 12,300 based on block statistics data for the watershed as compiled by the U.S. Bureau of Census (1972). The population density therefore is 2,709 (12,300/4.54) persons per square mile. From figure 2, watershed imperviousness for this example site is 20 percent.

(d) Substitute into equation 7 on page 7,

$$Q_{50} = 42.7\, A^{0.664}\, S^{0.338}\, If^{0.186}$$

$$= (42.7)\,(4.54)^{0.664}\,(15.0)^{0.338}\,(20.0)^{0.186}$$

$$= (42.7)\,(2.73)\,(2.50)\,(1.75)$$

$$= 510 \text{ ft}^3/\text{s}.$$

Example 3. Determine the 100-year flood discharge on Silver Creek at Grand Avenue in Franklin Park, Cook County, SW¼NE¼ sec.2, T.40 N., R.12 E., for use in a channel conveyance study.

(a) Site is on a gaged stream but not at a gaging station.

(b) The watershed characteristics A, S, and If are determined as in examples 1 and 2. At this site on Silver Creek $A = 6.91$ mi^2; $S = 7.76$ ft/mi; $If = 14.0$.

(c) Q_{100} at site on Silver Creek at Grand Avenue by equation 8 = 553 ft^3/s.

(d) From table 2, select from the third line of discharge values the weighted mean estimate (Q_{100}) for the gaging station on Silver Creek (05530700), Q_{100} = 793 ft^3/s.

(e) From table 2, select from the second line of discharge values the station frequency value computed using regional equation 8, Q_{100} = 723 ft^3/s.

(f) From table 1, obtain the drainage area for station 05530700, A = 11.2 mi^2.

(g) The drainage area ratio,

$$\frac{\text{A at ungaged site}}{\text{A at gaged site}} = \frac{6.91}{11.2} = 0.62, \text{ or}$$

62 percent which is within the weighting technique rule of thumb (50 to 200 percent).

(h) The weighted mean discharge at the ungaged site on Silver Creek is computed by equation 11,

$$\text{Weighted } Q_T \text{ (ungaged)} = \frac{Q_T \text{ (weighted at gage)}}{Q_T \text{ (regional equation at gage)}} \times Q_T \begin{array}{l}\text{(regional equation}\\ \text{at ungaged site)}\end{array}$$

$$= \frac{793}{723} \times 553$$

$$= 607 \text{ ft}^3/\text{s}.$$

EFFECT OF URBAN DEVELOPMENT

Flood Magnitudes

Estimating equations 3 to 9 show that urbanization causes an increase in peak flows for all frequencies. The curves in figure 6 were developed using equations 3 to 8 to compute flood magnitudes at various levels of imperviousness or urbanization. Computed flood magnitudes were plotted as their ratio to flood magnitudes for rural watersheds or one percent imperviousness.

Figure 6 indicates that an urbanized watershed (about 40 percent imperviousness) will increase the magnitude of the 100-year flood by a factor of 1.9 and the 2-year flood by a factor of 3.2 over that for undeveloped areas. This is in line with the results of urban hydrology studies shown in a report by Espey and Winslow (1974), which indicated that flood peaks in urbanized areas could be expected to range from 2 to 5 times that expected for undeveloped areas.

Transferability of Urban Effect

The effects of urbanization on flood magnitudes described in this report are based on data from northeastern Illinois and therefore are applicable solely to the study area. Other factors, such as rainfall intensity, might be significant in other areas, although they were not significant in this study.

In other parts of Illinois and surrounding areas with similar climatic and physiographic characteristics, the effects of urbanization on flood magnitudes may also be expected to be similar. Based on this assumption, figure 6 can be used to estimate the increase in floodflows caused by urbanization, provided a flood-frequency equation for rural streams is available.

Curtis (1977a) presents flood-frequency equations for rural streams in Illinois. These equations, along with figure 6, can be used to estimate the effects of urbanization on many streams in Illinois outside the study area. These estimates should be checked by other methods, when and if available.

SUMMARY AND CONCLUSIONS

Change in land use from rural to urban has increased flood-peak discharges in northeastern Illinois by factors ranging up to 3.2.

A technique for estimating the magnitude and frequency of floods from watersheds with various degrees of urban development is presented. Drainage area, channel slope,and percent imperviousness are required to use the procedure. Methods are given to estimate the percent imperviousness from demographic statistics.

The equations used to estimate flood peaks at various recurrence intervals were developed using multiple regression analyses, which related flood-discharge data to the above watershed characteristics for 103 gaged watersheds. These watersheds ranged in drainage area from 0.07 to 630 mi^2, in channel slope from 1.1 to 115 ft/mi, and in imperviousness from 1.0 to 39.0 percent.

The information presented provides engineers and planners with a predictive tool to aid in flood-plain management and in solving other hydrologic problems associated with urban development.

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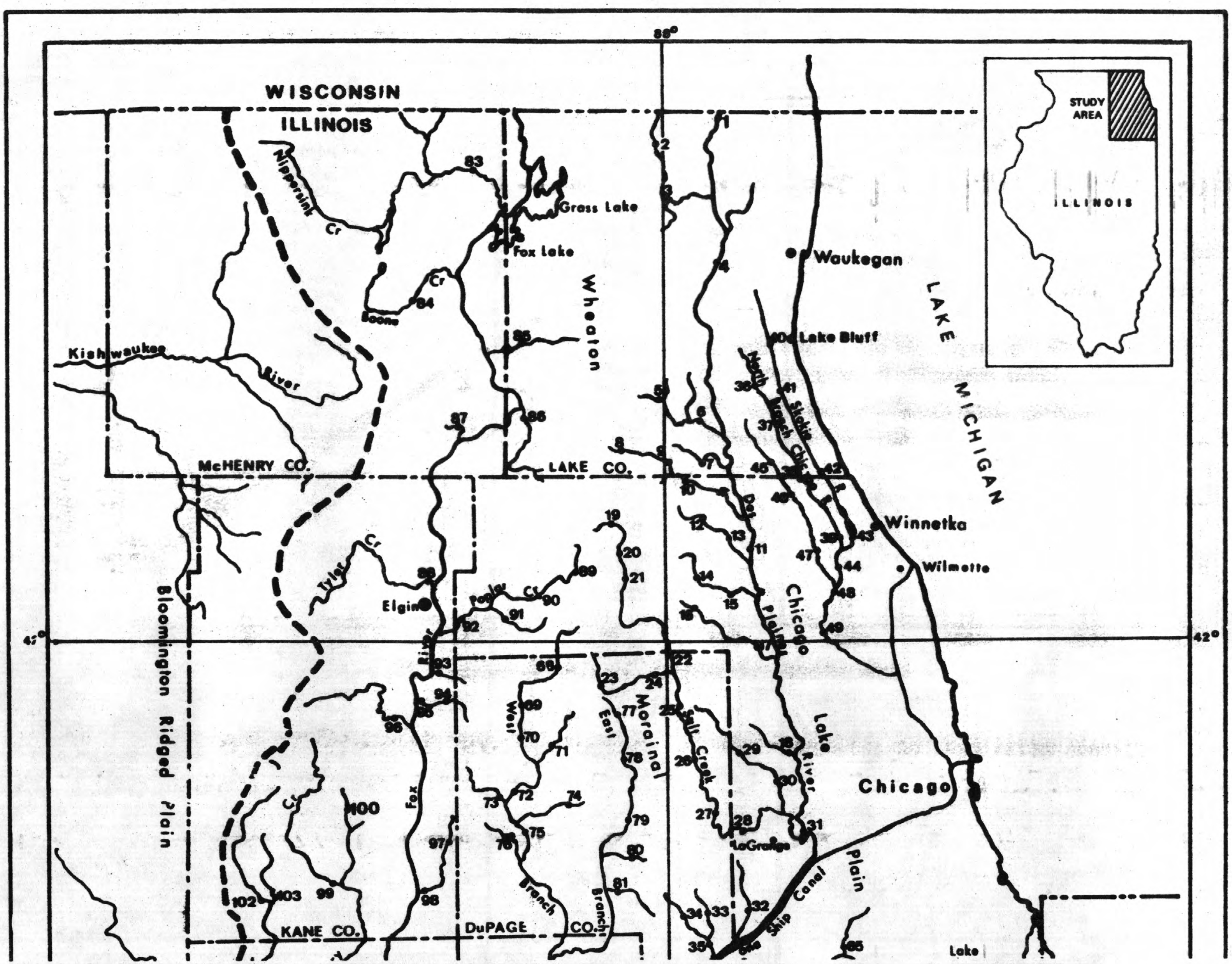
FIGURES 1 to 6; TABLES 1 to 4



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Grass Lake
Fox Lake
Boone Cr
Kishwaukee River
Wheaton
Waukegan
Lake Bluff
LAKE MICHIGAN
North Branch Chicago R
Skokie R
McHENRY CO.
LAKE CO.
Des Plaines
Winnetka
Wilmette
Tyler Cr
Poplar Cr
Elgin
Bloomington Ridged Plain
Chicago
42°
Fox River
West Branch
East Branch
Morainal
Salt Creek
Lake River
Chicago
LaGrange
Ship Canal
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KANE CO.
DuPAGE CO.
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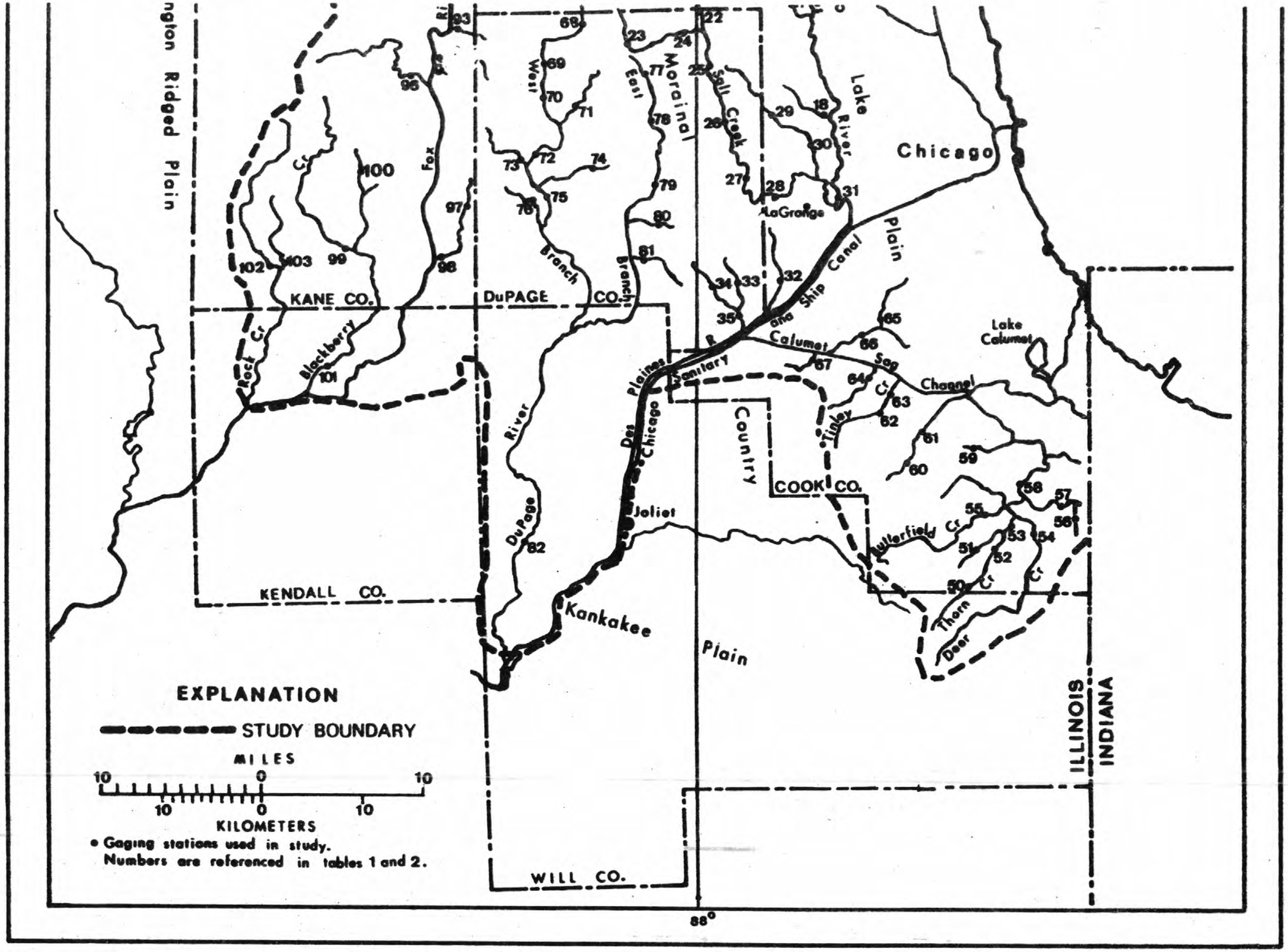

Figure 1.--Location of study area and gaging stations.

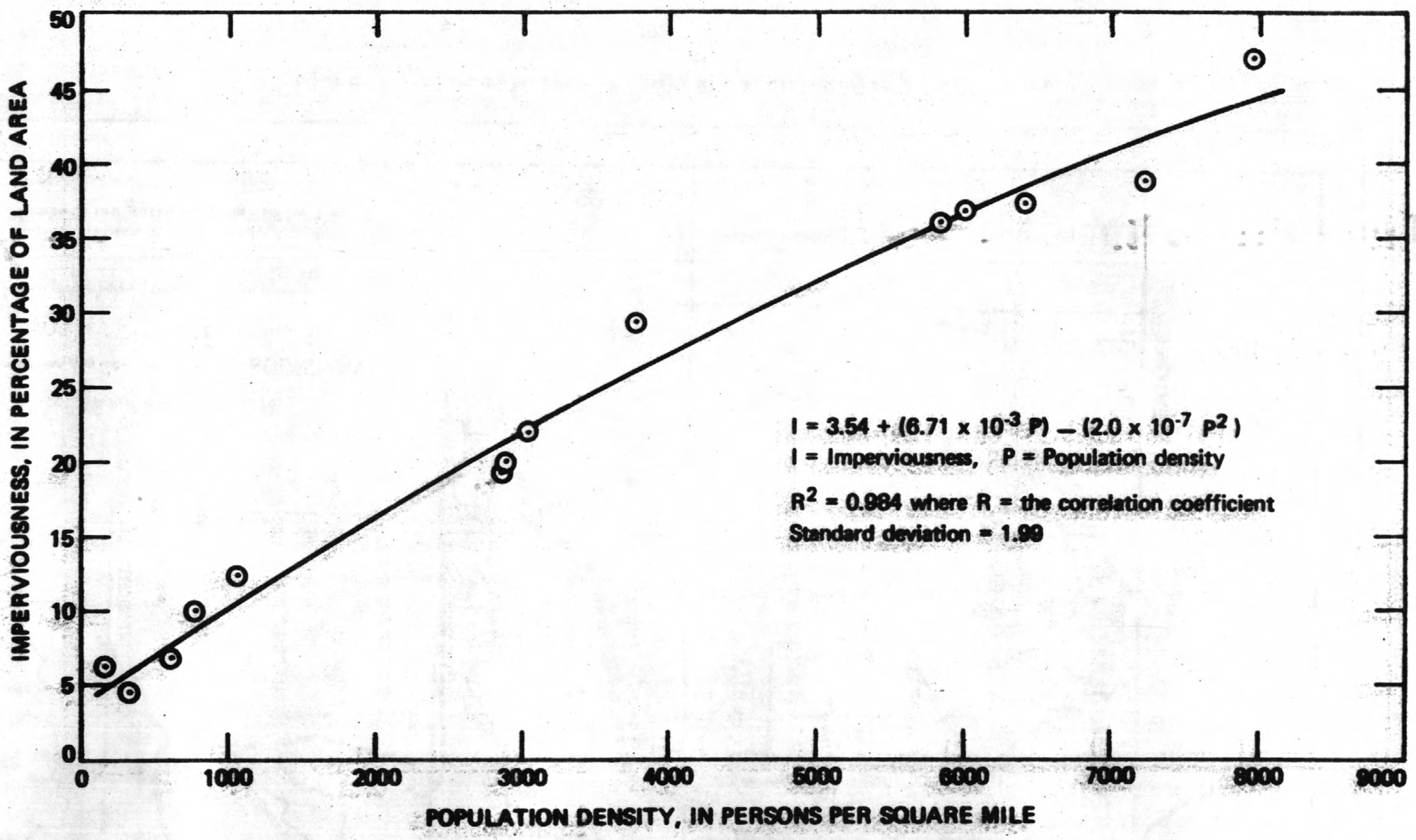

Figure 2.--Relationship between percentage of imperviousness and population density.

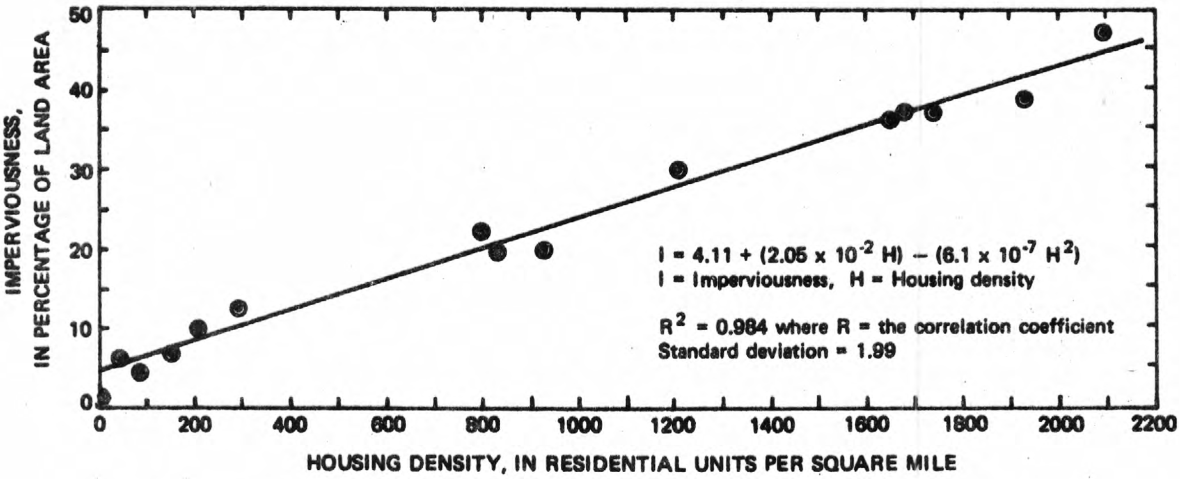

Figure 3.--Relationship between percentage of imperviousness and housing density.

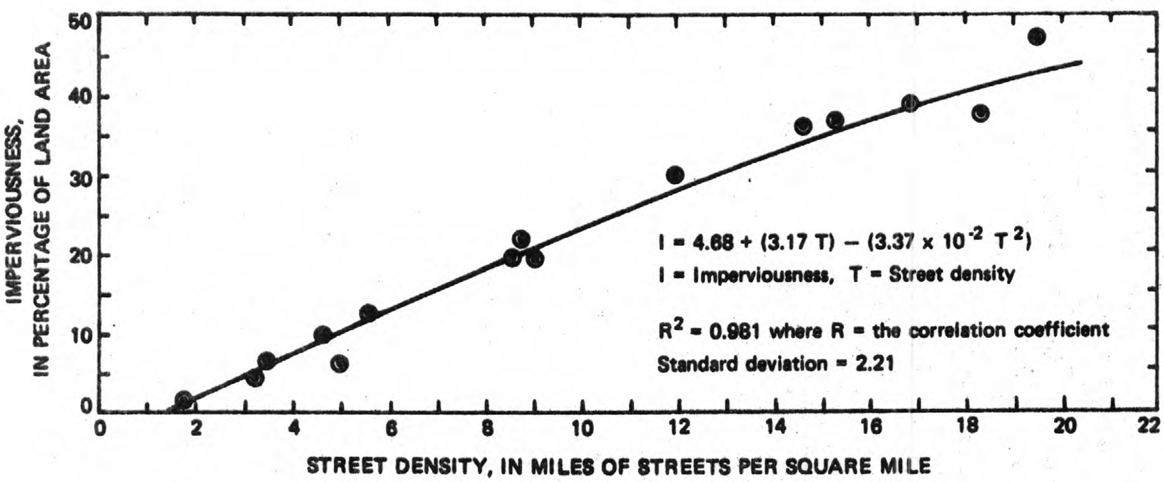

Figure 4.--Relationship between percentage of imperviousness and street density.

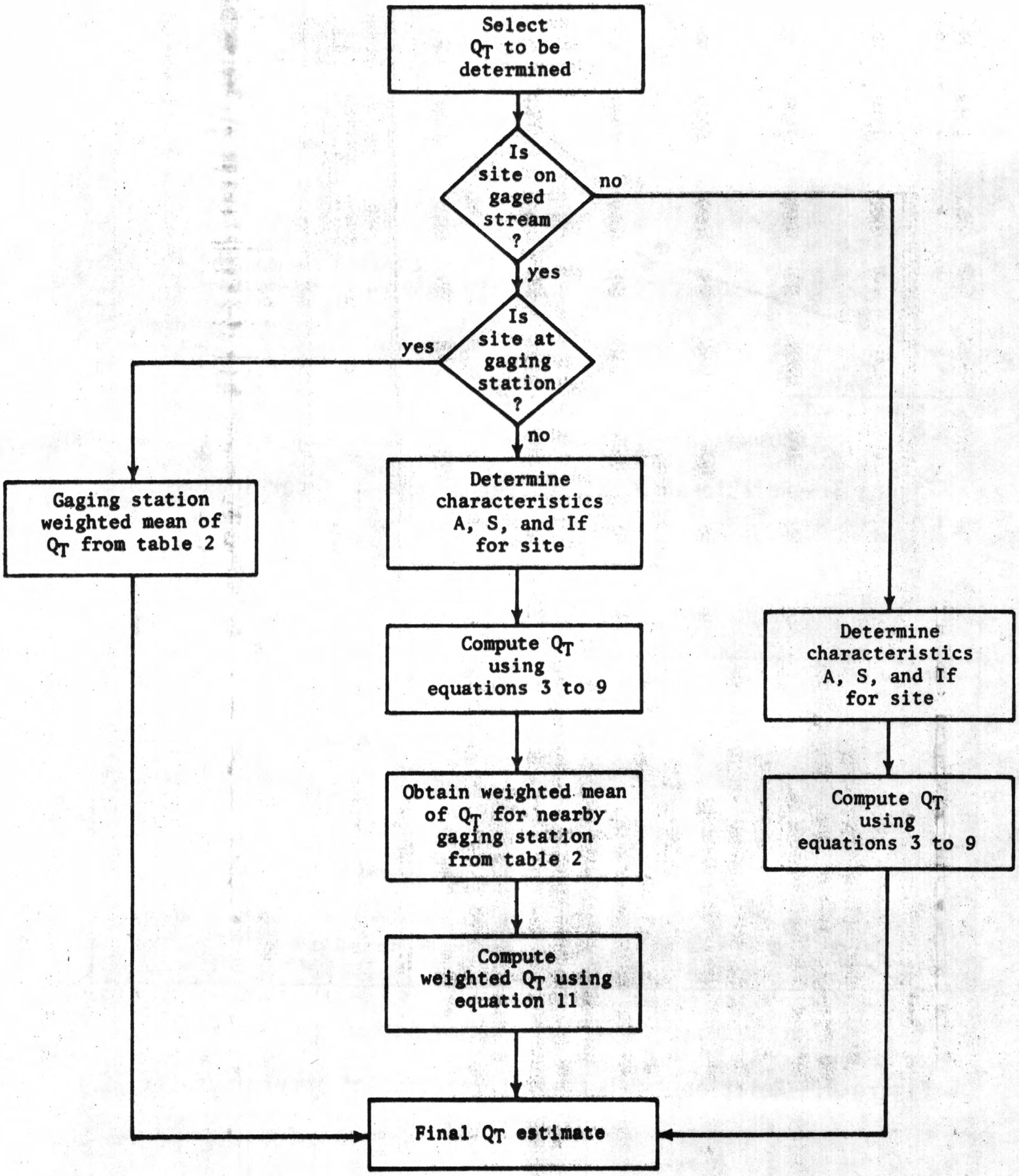

Figure 5.--Flow chart for estimating flood magnitude.

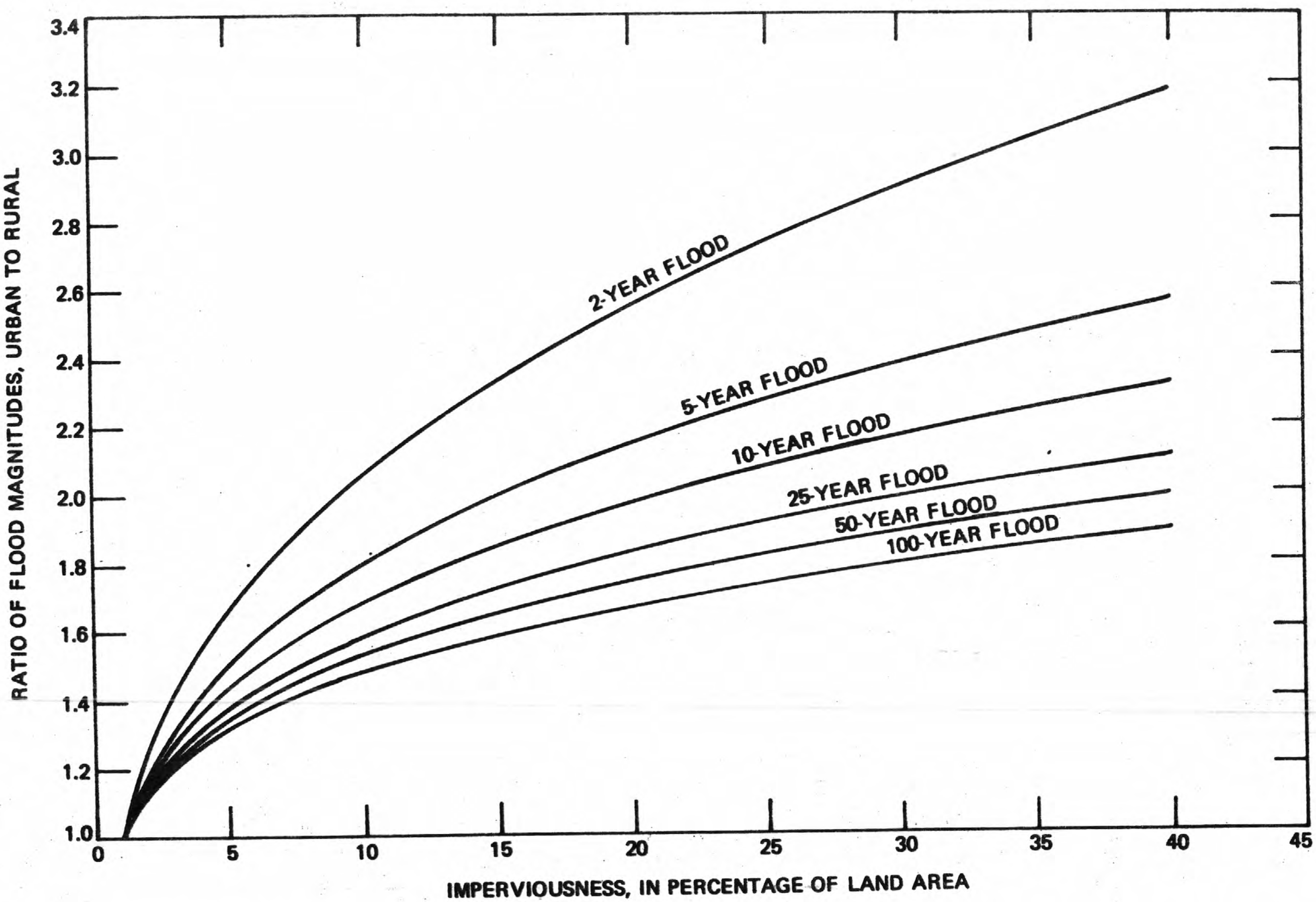

Figure 6.--Effect of urbanization on flood magnitudes in northeastern Illinois.

Table 1.–Watershed characteristics and maximum floods at gaging stations

Type of gage: (R) continuous-record station; (C) crest-stage station.

Years of record: Years of annual peak discharge data used in regression analysis.

(A) is drainage area in square miles. (S) is main channel slope, in feet per mile, determined between the 10 and 85 percent distance along the channel. (If) is imperviousness expressed as a percentage of the watershed. (R.I.) is the recurrence interval.

When the maximum flood of record at a gaging station exceeds the weighted mean Q_{100} (see table 2), the recurrence interval associated with that flood is shown as a ratio to the weighted Q_{100} and noted with an asterisk, *.

Map No.	Station No.	Station Name and Location	Type of Gage	Years of Record	A	S	If	Maximum flood of record		
								Water Year	Discharge (ft^3/s)	R.I. (years)
1	05527800	Des Plaines River at Russell, Ill. Lat 42°29′22″, long 87°55′32″, in SE¼ sec.3, T.46 N., R.11 E., Lake County.	R	17	123	1.76	2.0	1976	1,990	27
2	05527900	North Mill Creek at Hickory Corners, Ill. Lat 42°27′58″, long 88°00′32″, in SW¼NE¼ sec. 13, T.46 N., R.10 E., Lake County.	C	16	21.4	1.80	2.8	1960	510	37
3	05527950	Mill Creek at Old Mill Creek, Ill. Lat 42°24′55″, long 87°58′08″, in SW¼SE¼ sec. 32, T.46 N., R.11 E., Lake County.	C	16	60.9	7.13	4.6	1976	1,050	11
4	05528000	Des Plaines River near Gurnee, Ill. Lat 42°20′39″, long 87°56′18″, in SE¼SW¼ sec. 27, T.45 N., R.11 E., Lake County.	R	29	232	1.27	2.4	1960	3,070	26
5	05528150	Indian Creek at Diamond Lake, Ill. Lat 42°13′27″, long 88°00′17″, in NW¼NW¼ sec.7, T.43 N., R.11 E., Lake County.	C	17	10.6	18.03	4.5	1960	1,150	75
6	05528230	Indian Creek at Prairie View, Ill. Lat 42°12′34″, long 87°57′18″, in NW¼NE¼ sec.16, T.43 N., R.11 E., Lake County.	C	14	35.7	13.64	7.6	1960	1,410	43
7	05528360	Aptakisic Creek at Aptakisic, Ill. Lat 42°10′05″, long 87°56′58″, in SE¼SE¼ sec. 28, T.43 N., R.11 E., Lake County.	C	16	2.85	11.34	4.5	1972	390	80

Table 1.–Watershed characteristics and maximum floods at gaging stations—Continued

Map No.	Station No.	Station Name and Location	Type of Gage	Years of Record	A	S	If	Maximum flood of record		
								Water Year	Discharge (ft^3/s)	R.I. (years)
8	05528440	Buffalo Creek near Lake Zurich, Ill. Lat 42°10′58″, long 88°03′02″, in NW¼NE¼ sec.27, T.43 N., R.10 E., Lake County.	C	16	1.03	38.34	7.2	1972	203	28
9	05528470	Buffalo Creek at Long Grove, Ill. Lat 42°10′38″, long 87°59′57″, in SE¼NW¼ sec. 30, T.43 N., R.11 E., Lake County.	C	16	7.88	19.83	5.9	1972	539	19
10	05528500	Buffalo Creek near Wheeling, Ill. Lat 42°09′05″, long 87°57′25″, in NE¼NW¼ sec.4, T.42 N., R.11 E., Cook County.	R	[1]17	19.6	15.42	8.4	1972	802	14
11	05529000	Des Plaines River near Des Plaines, Ill. Lat 42°04′55″, long 87°53′25″, in SE¼SE¼ sec. 25, T.42 N., R.11 E., Cook County.	R	35	360	1.11	4.4	1938	[2]5,000	79
12	05529300	McDonald Creek near Wheeling, Ill. Lat 42°07′14″, long 87°56′47″, in NW¼NW¼ sec.15, T.42 N., R.11 E., Cook County.	C	16	4.58	17.51	22.0	1972	485	23
13	05529500	McDonald Creek near Mount Prospect, Ill. Lat 42°05′42″, long 87°54′46″, in NW¼NE¼ sec.26, T.42 N., R.11 E., Cook County.	R	[1]17	7.93	9.66	19.6	1972	664	23
14	05529900	Weller Creek at Mount Propsect, Ill. Lat 42°03′32″, long 87°57′23″, in NE¼SW¼ sec. 11, T.41 N., R.11 E., Cook County.	C	16	9.02	14.05	36.8	1972	1,190	23
15	05530000	Weller Creek at Des Plaines, Ill. Lat 42°02′58″, long 87°55′05″, in NW¼NW¼ sec.18, T.41 N., R.12 E., Cook County.	R	[1]17	13.2	10.60	36.0	1967	1,590	26
16	05530400	Higgins Creek near Mount Prospect, Ill. Lat 42°02′04″, long 87°57′35″, in NW¼NW¼ sec.23, T.41 N., R.11 E., Cook County.	C	16	2.24	14.87	12.6	1972	463	21

[1] Base period (1960-76).
[2] Historical flood.

Table 1.–Watershed characteristics and maximum floods at gaging stations—Continued

Map No.	Station No.	Station Name and Location	Type of Gage	Years of Record	A	S	If	Maximum flood of record: Water Year	Discharge (ft³/s)	R.I. (years)
17	05530480	Willow Creek at Orchard Place, Ill. Lat 41°59′49″, long 87°52′47″, in SE¼SW¼ sec. 33, T.41 N., R.12 E., Cook County.	C	16	18.1	7.16	12.2	1967	2,100	*1.0
18	05530700	Silver Creek at Melrose Park, Ill. Lat 41°54′18″, long 87°50′40″, in NW¼NW¼ sec.2, T.39 N., R.12 E., Cook County.	C	16	11.2	5.02	25.2	1972	752	55
19	05530940	Salt Creek at Palatine, Ill. Lat 42°06′38″, long 88°03′47″, in SW¼SW¼ sec. 15, T.42 N., R.10 E., Cook County.	C	16	6.26	26.37	7.7	1972	513	75
20	05530960	Salt Creek near Palatine, Ill. Lat 42°04′26″, long 88°02′38″, in NW¼SW¼ sec.35, T.42 N., R.10 E., Cook County.	C	16	16.0	16.07	11.8	1967	744	35
21	05531000	Salt Creek near Arlington Heights, Ill. Lat 42°03′02″, long 88°00′37″, in NE¼NW¼ sec.17, T.41 N., R.11 E., Cook County.	R	[1,2]17	32.1	13.04	15.5	1967, 1972	1,060	14
22	05531050	Salt Creek near Wood Dale, Ill. Lat 41°59′34″, long 87°59′44″, in NW¼NW¼ sec.4, T.40 N., R.11 E., Du Page County.	C	17	53.6	8.64	14.2	1972	1,510	70
23	05531080	Spring Brook at Bloomingdale, Ill. Lat 41°57′31″, long 88°04′14″, in NW¼NW¼ sec.14, T.40 N., R.10 E., Du Page County.	C	16	5.08	22.13	11.8	1972	645	*1.2
24	05531130	Spring Brook at Walnut Avenue at Itasca, Ill. Lat 41°58′16″, long 88°00′47″, in SE¼NW¼ sec. 8, T.40 N., R.11 E., Du Page County.	C	16	13.7	18.05	11.1	1972	770	*1.3
25	05531200	Salt Creek at Addison, Ill. Lat 41°55′44″, long 87°58′40″, in SW¼NW¼ sec.27, T.40 N., R.11 E., Du Page County.	C	17	83.2	5.03	14.1	1972	2,110	*1.1

[1] Base period (1960-76).
[2] Three years of record (1974-76) transferred from station 0.9 mile upstream.

Table 1.–Watershed characteristics and maximum floods at gaging stations—Continued

Map No.	Station No.	Station Name and Location	Type of Gage	Years of Record	A	S	If	Maximum flood of record		
								Water Year	Discharge (ft^3/s)	R.I. (years)
26	05531300	Salt Creek at Elmhurst, Ill. Lat 41°53′20″, long 87°57′41″, in NE¼NE¼ sec. 10, T.39 N., R.11 E., Du Page County.	C	17	90.6	4.13	15.5	1972	2,230	*1.1
27	05531380	Salt Creek at Oak Brook, Ill. Lat 41°51′39″, long 87°56′52″, in SW¼SE¼ sec. 14, T.39 N., R.11 E., Du Page County.	C	17	100	3.54	17.3	1972	1,790	32
28	05531500	Salt Creek at Western Springs, Ill. Lat 41°49′35″, long 87°54′00″, in NE¼SE¼ sec. 31, T.39 N., R.12 E., Cook County.	R	[1]17	114	2.85	16.4	1948	[2]1,920	25
29	05531800	Addison Creek at Northlake, Ill. Lat 41°54′37″, long 87°54′10″, in SW¼SW¼ sec. 32, T.40 N., R.12 E., Cook County.	C	15	6.79	10.23	15.6	1966	449	15
30	05532000	Addison Creek at Bellwood, Ill. Lat 41°52′48″, long 87°52′07″, in SW¼SE¼ sec. 9, T.39 N., R.12 E., Cook County.	R	[1]17	17.9	6.21	30.4	1972	706	18
31	05532500	Des Plaines River at Riverside, Ill. Lat 41°49′20″, long 87°49′15″, in SW¼SW¼ sec. 36, T.39 N., R.12 E., Cook County.	R	33	630	1.06	7.7	1919	[3]7,450	85
32	05533000	Flag Creek near Willow Springs, Ill. Lat 41°44′20″, long 87°53′48″, in SE¼NE¼ sec. 31, T.38 N., R.12 E., Cook County.	R	[1]17	16.5	14.04	20.2	1961	2,680	*1.1
33	05533200	Sawmill Creek tributary near Tiedtville, Ill. Lat 41°44′05″, long 87°58′00″, in NE¼SW¼ sec. 34, T.38 N., R.11 E., Du Page County.	C	16	2.33	34.33	17.3	1976	315	15
34	05533300	Wards Creek near Woodridge, Ill. Lat 41°43′32″, long 87°59′19″, in SW¼NW¼ sec.4, T.37 N., R.11 E., Du Page County.	C	15	3.21	16.93	7.2	1966	151	9

[1] Base period (1960-76).
[2] Occurred prior to base period.
[3] Historical flood.

Table 1.–Watershed characteristics and maximum floods at gaging stations—Continued

Map No.	Station No.	Station Name and Location	Type of Gage	Years of Record	A	S	If	Maximum flood of record: Water Year	Maximum flood of record: Discharge (ft^3/s)	Maximum flood of record: R.I. (years)
35	05533400	Sawmill Creek near Lemont, Ill. Lat 41°42′28″, long 87°57′45″, in NE¼SW¼ sec. 10, T.37 N., R.11 E., Du Page County.	C	16	13.0	14.59	10.3	1966, 1975	984	7
36	05534300	North Branch Chicago River at Lake Forest, Ill. Lat 42°14′24″, long 87°52′50″, in NE¼NW¼ sec.6, T.43 N., R.12 E., Lake County.	C	16	10.8	5.15	5.3	1969	299	8
37	05534400	North Branch Chicago River at Bannockburn, Ill. Lat 42°12′00″, long 87°51′10″, in SW¼SE¼ sec. 17, T.43 N., R.12 E., Lake County.	C	17	15.8	3.88	5.2	1967	355	8
38	05534500	North Branch Chicago River at Deerfield, Ill. Lat 42°09′10″, long 87°49′07″, in SW¼SE¼ sec. 34, T.43 N., R.12 E., Lake County.	R	[1]17	19.7	3.24	8.5	1976	550	36
39	05534600	North Branch Chicago River at Northfield, Ill. Lat 42°06′05″, long 87°46′26″, in NE¼SE¼ sec. 24, T.42 N., R.12 E., Cook County.	C	17	23.8	3.29	9.3	1976	481	8
40	05534900	Skokie River at Lake Bluff, Ill. Lat 42°16′46″, long 87°51′46″, in NW¼ sec.20, T.44 N., R.12 E., Lake County.	C	15	8.17	6.85	19.6	1976	395	11
41	05535000	Skokie River at Lake Forest, Ill. Lat 42°13′57″, long 87°50′41″, in NW¼SW¼ sec.4, T.43 N., R.12 E., Lake County.	R	[1]17	13.0	5.58	15.0	1972	367	11
42	05535070	Skokie River near Highland Park, Ill. Lat 42°09′34″, long 87°47′52″, in NW¼SE¼ sec. 35, T.43 N., R.12 E., Lake County.	R	10	21.1	5.29	15.9	1972	570	13
43	05535150	Skokie River at Northfield, Ill. Lat 42°06′05″, long 87°45′33″, in NW¼SE¼ sec. 19, T.42 N., R.13 E., Cook County.	C	17	29.1	3.92	16.4	1967	567	20

[1] Base period (1960-76).

Table 1.–Watershed characteristics and maximum floods at gaging stations—Continued

Map No.	Station No.	Station Name and Location	Type of Gage	Years of Record	A	S	If	Maximum flood of record: Water Year	Discharge (ft^3/s)	R.I. (years)
44	05535200	North Branch Chicago River at Glenview, Ill. Lat 42°04′08″, long 87°46′28″, in SE¼SE¼ sec. 36, T.42 N., R.12 E., Cook County.	C	17	60.5	3.52	14.7	1976	1,200	42
45	05535400	West Fork of North Branch Chicago River at Deerfield, Ill. Lat 42°10′02″, long 87°51′24″, in NW¼NE¼ sec.32, T.43 N., R.12 E., Lake County.	C	16	6.50	5.09	9.9	1967	571	65
46	05535500	West Fork of North Branch Chicago River at Northbrook, Ill. Lat 42°08′18″, long 87°50′04″, in SW¼SE¼ sec. 4, T.42 N., R.12 E., Cook County.	R	[1]17	11.5	3.69	11.6	1957	[2]930	*1.1
47	05535700	West Fork of North Branch Chicago River at Glenview, Ill. Lat 42°05′13″, long 87°48′08″, in NE¼SW¼ sec. 26, T.42 N., R.12 E., Cook County.	C	17	21.6	4.31	14.3	1967	1,140	48
48	05535800	North Branch Chicago River at Morton Grove, Ill. Lat 42°03′00″, long 87°46′50″, in SE¼NW¼ sec. 17, T.41 N., R.13 E., Cook County.	C	17	92.2	3.31	15.9	1967	2,130	*1.0
49	05536000	North Branch Chicago River at Niles, Ill. Lat 42°00′44″, long 87°47′45″, in SW¼SE¼ sec. 30, T.41 N., R.13 E., Cook County.	R	[1]17	100	2.94	17.9	1967	2,210	*1.1
50	05536201	Thorn Creek at Park Forest, Ill. Lat 41°28′19″, long 87°40′26″, in SW¼SW¼ sec. 31, T.35 N., R.14 E., Cook County.	C	15	6.28	19.92	8.8	1974	1,460	*1.0
51	05536207	Thorn Creek tributary at Chicago Heights, Ill. Lat 41°30′22″, long 87°39′36″, in SW¼NE¼ sec. 19, T.35 N., R.14 E., Cook County.	C	15	3.87	12.31	35.1	1968	1,090	*1.2

[1] Base period (1960-76).
[2] Occurred prior to base period.

Table 1.–Watershed characteristics and maximum floods at gaging stations—Continued

Map No.	Station No.	Station Name and Location	Type of Gage	Years of Record	A	S	If	Maximum flood of record		
								Water Year	Discharge (ft^3/s)	R.I. (years)
52	05536210	Thorn Creek near Chicago Heights, Ill. Lat 41°30′50″, long 87°38′07″, in SE¼SE¼ sec. 17, T.35 N., R.14 E., Cook County.	R	12	17.2	17.51	21.5	1974	2,220	65
53	05536215	Thorn Creek at Glenwood, Ill. Lat 41°31′50″, long 87°36′20″, in SW¼SE¼ sec. 9, T.35 N., R.14 E., Cook County.	R	[1]17	24.7	15.68	23.1	1968	2,600	*1.0
54	05536235	Deer Creek near Chicago Heights, Ill. Lat 41°31′15″, long 87°35′25″, in SE¼NW¼ sec. 14, T.35 N., R.14 E., Cook County.	R	[1]17	23.1	9.72	8.3	1957	[2]1,380	*1.1
55	05536255	Butterfield Creek at Flossmoor, Ill. Lat 41°32′25″, long 87°38′55″, in NE¼NW¼ sec.8, T.35 N., R.14 E., Cook County.	R	[1]17	23.5	6.34	12.4	1957	[2]2,550	*1.4
56	05536265	Lansing ditch near Lansing, Ill. Lat 41°31′40″, long 87°31′45″, in NE¼ sec.17, T.35 N., R.15 E., Cook County.	R	[1]17	8.84	8.71	10.2	1948	[2]461	60
57	05536270	North Creek near Lansing, Ill. Lat 41°32′45″, long 87°33′30″, in SE¼SE¼ sec. 1, T.35 N., R.14 E., Cook County.	R	[1]17	16.8	6.34	10.7	1948	[3]730	*1.1
58	05536275	Thorn Creek at Thornton, Ill. Lat 41°34′05″, long 87°36′30″, in SW¼NW¼ sec.34, T.36 N., R.14 E., Cook County.	R	[1]17	104	10.82	13.5	1957	[2]4,700	*1.1
59	05536310	Calumet Union Drainage Canal near Markham, Ill. Lat 41°35′48″, long 87°39′59″, in SE¼NW¼ sec. 19, T.36 N., R.14 E., Cook County.	C	16	12.6	17.18	19.2	1968	502	14
60	05536335	Midlothian Creek near Tinley Park, Ill. Lat 41°35′18″, long 87°44′52″, in NE¼NW¼ sec.28, T.36 N., R.13 E., Cook County.	C	[1]17	9.13	6.39	10.2	1973	580	*1.1

[1] Base period (1960-76).
[2] Occurred prior to base period.
[3] Historical flood.

Table 1.–Watershed characteristics and maximum floods at gaging stations—Continued

Map No.	Station No.	Station Name and Location	Type of Gage	Years of Record	A	S	If	Maximum flood of record: Water Year	Maximum flood of record: Discharge (ft^3/s)	Maximum flood of record: R.I. (years)
61	05536340	Midlothian Creek at Oak Forest, Ill. Lat 41°36′51″, long 87°43′46″, in SE¼NW¼ sec. 15, T.36 N., R.13 E., Cook County.	R	[1]17	12.6	8.33	12.6	1973	627	*1.1
62	05536460	Tinley Creek near Oak Forest, Ill. Lat 41°37′49″, long 87°47′05″, in NW¼NE¼ sec.7, T.36 N., R.13 E., Cook County.	C	16	7.95	12.52	5.9	1970	999	62
63	05536500	Tinley Creek near Palos Park, Ill. Lat 41°38′48″, long 87°45′59″, in SW¼SE¼ sec. 32, T.37 N., R.13 E., Cook County.	R	[1]17	11.2	11.46	7.4	1970	1,270	*1.0
64	05536510	Navajo Creek at Palos Heights, Ill. Lat 41°39′39″, long 87°47′38″, in SW¼SW¼ sec. 30, T.37 N., R.13 E., Cook County.	C	16	1.69	35.75	16.9	1976	434	65
65	05536560	Melvina ditch near Oak Lawn, Ill. Lat 41°43′09″, long 87°47′07″, in NW¼NE¼ sec.7, T.37 N., R.13 E., Cook County.	C	15	5.58	5.60	37.2	1976	408	*1.0
66	05536570	Stony Creek (West) at Worth, Ill. Lat 41°42′00″, long 87°47′52″, in SE¼NE¼ sec. 13, T.37 N., R.12 E., Cook County.	C	15	18.0	8.60	38.7	1976	1,570	*1.0
67	05536620	Mill Creek near Palos Park, Ill. Lat 41°39′09″, long 87°50′23″, in NW¼SE¼ sec. 34, T.37 N., R.12 E., Cook County.	C	16	6.39	8.19	9.3	1966	330	44
68	05539870	West Branch Du Page River at Ontarioville, Ill. Lat 41°58′42″, long 88°07′59″, in NW¼SE¼ sec. 6, T.40 N., R.10 E., Du Page County.	C	16	10.1	6.81	16.6	1972	630	12
69	05539890	West Branch Du Page River near Wayne, Ill. Lat 41°56′37″, long 88°10′51″, in NW¼NW¼ sec.23, T.40 N., R.9 E., Du Page County.	C	16	23.9	7.00	11.0	1967	760	12

[1] Base period (1960-76).

Table 1.–Watershed characteristics and maximum floods at gaging stations––Continued

Map No.	Station No.	Station Name and Location	Type of Gage	Years of Record	A	S	If	Maximum flood of record: Water Year	Maximum flood of record: Discharge (ft^3/s)	Maximum flood of record: R.I. (years)
70	05539900	West Branch Du Page River near West Chicago, Ill. Lat 41°54′39″, long 88°10′44″, in SE¼NW¼ sec. 35, T.40 N., R.9 E., Du Page County.	R	16	28.5	6.58	10.0	1967	805	21
71	05539950	Klein Creek at Carol Stream, Ill. Lat 41°54′24″, long 88°08′32″, in NE¼SW¼ sec. 31, T.40 N., R.10 E., Du Page County.	C	16	8.81	6.32	6.9	1972	888	*1.3
72	05540030	West Branch Du Page River at West Chicago, Ill. Lat 41°51′41″, long 88°11′33″, in NW¼SE¼ sec. 15, T.39 N., R.9 E., Du Page County.	C	16	60.2	5.48	10.6	1972	1,670	*1.1
73	05540060	Kress Creek at West Chicago, Ill. Lat 41°51′23″, long 88°12′15″, in NW¼NW¼ sec.22, T.39 N., R.9 E., Du Page County.	C	16	18.1	5.84	6.9	1964	637	95
74	05540080	Spring Brook at Wheaton, Ill. Lat 41°51′02″, long 88°06′53″, in NE¼SE¼ sec. 20, T.39 N., R.10 E., Du Page County.	C	16	2.10	15.40	30.0	1972	552	*1.5
75	05540095	West Branch Du Page River near Warrenville, Ill. Lat 41°49′22″, long 88°10′23″, in SW¼NE¼ sec. 35, T. 39 N., R.9 E., Du Page County.	R	[1]16	90.4	4.97	10.0	1972	1,980	20
76	05540110	Ferry Creek at Warrenville, Ill. Lat 41°49′13″, long 88°11′35″, in SW¼NE¼ sec. 34, T.39 N., R.9 E., Du Page County.	C	16	4.27	11.18	3.7	1964	214	65
77	05540140	East Branch Du Page River near Bloomingdale, Ill. Lat 41°56′06″, long 88°03′29″, in SW¼SE¼ sec. 23, T.40 N., R.10 E., Du Page County.	C	16	3.03	25.99	4.7	1972	204	65
78	05540150	East Branch Du Page River at Glen Ellyn, Ill. Lat 41°53′24″, long 88°03′01″, in SW¼SW¼ sec. 1, T.39 N., R.10 E., Du Page County.	C	15	14.2	5.27	17.0	1972	912	*1.0

[1] Eight years of record (1961-68) transferred from crest-stage station, 0.3 mile downstream.

Table 1.–Watershed characteristics and maximum floods at gaging stations—Continued

Map No.	Station No.	Station Name and Location	Type of Gage	Years of Record	A	S	If	Maximum flood of record: Water Year	Maximum flood of record: Discharge (ft^3/s)	Maximum flood of record: R.I. (years)
79	05540160	East Branch Du Page River near Downers Grove, Ill. Lat 41°49′54″, long 88°02′51″, in SE¼SW¼ sec. 25, T.39 N., R.10 E., Du Page County.	C	15	27.2	4.61	19.8	1972	1,720	*1.1
80	05540190	St. Joseph Creek at Belmont, Ill. Lat 41°47′31″, long 88°02′15″, in NW¼SE¼ sec. 12, T.38 N., R.10 E., Du Page County.	C	16	8.80	9.38	29.3	1972	642	11
81	05540240	Prentiss Creek near Lisle, Ill. Lat 41°46′17″, long 88°04′11″, in SW¼SW¼ sec. 14, T.38 N., R.10 E., Du Page County.	C	16	6.48	20.30	16.6	1961	532	25
82	05540500	Du Page River at Shorewood, Ill. Lat 41°31′20″, long 88°11′35″, in SE¼SW¼ sec. 10, T.35 N., R.9 E., Will County.	R	35	324	4.38	6.0	1954	12,000	*1.1
83	05548280	Nippersink Creek near Spring Grove, Ill. Lat 42°26′37″, long 88°14′51″, in NE¼NW¼ sec.25, T.46 N., R.8 E., McHenry County.	R	10	192	7.68	2.0	1971	3,980	15
84	05549000	Boone Creek near McHenry, Ill. Lat 42°19′15″, long 88°18′45″, in NW¼SW¼ sec.4, T.44 N., R.8 E., McHenry County.	R	28	15.5	7.34	1.0	1970	276	13
85	05549700	Mutton Creek at Island Lake, Ill. Lat 42°17′05″, long 88°10′47″, in NE¼NE¼ sec. 21, T.44 N., R.9 E., Lake County.	C	16	10.8	8.28	2.6	1960	378	53
86	05549850	Flint Creek near Fox River Grove, Ill. Lat 42°12′40″, long 88°10′23″, in NW¼ sec.15, T.43 N., R.9 E., Lake County.	C	16	37.0	7.99	5.4	1960	492	60
87	05549900	Fox River tributary near Cary, Ill. Lat 42°11′48″, long 88°15′54″, in NW¼NE¼ sec.23, T.43 N., R.8 E., McHenry County.	C	20	.07	115	1.0	1972	59	36

Table 1.–Watershed characteristics and maximum floods at gaging stations—Continued

Map No.	Station No.	Station Name and Location	Type of Gage	Years of Record	A	S	If	Maximum flood of record		
								Water Year	Discharge (ft^3/s)	R.I. (years)
88	05550300	Tyler Creek at Elgin, Ill. Lat 42°03′31″, long 88°18′14″, in SE¼SE¼ sec. 3, T.41 N., R.8 E., Kane County.	C	14	38.9	9.36	4.2	1973	488	11
89	05550430	East Branch Poplar Creek near Palatine, Ill. Lat 42°04′02″, long 88°06′41″, in SW¼SE¼ sec. 31, T.42 N., R.10 E., Cook County.	C	16	2.63	19.24	13.2	1967	275	*1.0
90	05550450	Poplar Creek near Ontarioville, Ill. Lat 42°02′48″, long 88°09′20″, in NE¼NW¼ sec.13, T.41 N., R.9 E., Cook County.	C	16	16.7	11.93	4.9	1967	410	19
91	05550470	Poplar Creek tributary near Bartlett, Ill. Lat 42°01′28″, long 88°12′10″, in SE¼NE¼ sec. 21, T.41 N., R.9 E., Cook County.	C	16	4.55	10.59	23.4	1967	565	*1.2
92	05550500	Poplar Creek at Elgin, Ill. Lat 42°01′35″, long 88°15′20″, in SE¼NW¼ sec. 19, T.41 N., R.9 E., Cook County.	R	[1]17	35.2	9.08	8.1	1973	896	37
93	05551030	Brewster Creek at Valley View, Ill. Lat 41°58′22″, long 88°16′50″, in SW¼SW¼ sec. 1, T.40 N., R.8 E., Kane County.	C	15	14.0	10.91	3.4	1967	687	23
94	05551050	Norton Creek near Wayne, Ill. Lat 41°56′54″, long 88°16′17″, in NW¼SE¼ sec. 13, T.40 N., R.8 E., Kane County.	C	15	7.35	9.36	4.3	1967	617	*1.5
95	05551060	Norton Creek near St. Charles, Ill. Lat 41°56′42″, long 88°18′22″, in SW¼SE¼ sec. 15, T.40 N., R.8 E., Kane County.	C	15	11.5	10.61	3.8	1967	954	*1.6
96	05551200	Ferson Creek near St. Charles, Ill. Lat 41°56′00″, long 88°20′30″, in NE¼SE¼ sec. 20, T.40 N., R.8 E., Kane County.	R	16	51.7	13.31	3.1	1971	1,620	10

[1] Base period (1960-76).

Table 1.--Watershed characteristics and maximum floods at gaging stations---Continued

Map No.	Station No.	Station Name and Location	Type of Gage	Years of Record	A	S	If	Maximum flood of record Water Year	Discharge (ft^3/s)	R.I. (years)
97	05551520	Indian Creek near North Aurora, Ill. Lat 41°48'50", long 88°16'26", in SE¼SW¼ sec. 36, T.39 N., R.8 E., Kane County.	C	16	5.21	11.96	3.4	1966	262	19
98	05551530	Indian Creek at Aurora, Ill. Lat 41°45'59", long 88°18'24", in NW¼NE¼ sec.22, T.38 N., R.8 E., Kane County.	C	16	16.7	9.82	8.3	1972	742	20
99	05551620	Blackberry Creek near Kaneville, Ill. Lat 41°48'17", long 88°27'34", in SW¼NE¼ sec. 5, T.38 N., R.7 E., Kane County.	C	14	21.6	12.04	2.5	1974	640	23
100	05551650	Lake Run tributary near Batavia, Ill. Lat 41°50'45", long 88°24'20", near center of sec.23, T.39 N., R.7 E., Kane County.	C	16	2.11	28.83	2.0	1970	346	83
101	05551700	Blackberry Creek near Yorkville, Ill. Lat 41°40'18", long 88°26'29", in SE¼NW¼ sec. 21, T.37 N., R.7 E., Kendall County.	R	16	70.2	5.60	3.4	1974	1,320	19
102	05551900	East Branch Big Rock Creek near Big Rock, Ill. Lat 41°46'04", long 88°34'11", in NE¼SE¼ sec. 17, T.38 N., R.6 E., Kane County.	C	12	32.6	8.79	1.7	1974	1,580	80
103	05551930	Welch Creek near Big Rock, Ill. Lat 41°45'36", long 88°30'38", in SE¼NE¼ sec. 23, T.38 N., R.6 E., Kane County.	C	12	22.1	10.04	2.7	1974	694	38

Table 2.–T-year peak discharges at gaging stations, in cubic feet per second

The upper values of the Q_T's listed for each station are from individual station frequency curves. The middle values are computed using the regression equations. The lower values are the weighted means obtained using equation 10.

Map No.	Station No.	Station Name	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}
1	05527800	Des Plaines River at Russell, Ill.	603	1,140	1,540	2,080	2,500	2,930
			602	888	1,070	1,280	1,440	1,580
			603	1,110	1,480	1,930	2,300	2,670
2	05527900	North Mill Creek at Hickory Corners, Ill.	205	318	392	483	547	610
			198	295	356	429	482	531
			204	315	388	474	536	597
3	05527950	Mill Creek at Old Mill Creek, Ill.	406	735	972	1,280	1,510	1,740
			670	1,010	1,230	1,490	1,690	1,870
			429	761	998	1,310	1,540	1,760
4	05528000	Des Plaines River near Gurnee, Ill.	1,190	1,970	2,500	3,170	3,650	4,130
			917	1,310	1,550	1,820	2,030	2,210
			1,170	1,920	2,420	3,010	3,450	3,890
5	05528150	Indian Creek at Diamond Lake, Ill.	283	522	698	933	1,110	1,300
			246	397	499	625	720	810
			279	507	674	879	1,040	1,210
6	05528230	Indian Creek at Prairie View, Ill.	500	803	1,010	1,260	1,440	1,630
			631	960	1,170	1,430	1,620	1,790
			515	821	1,030	1,290	1,470	1,660
7	05528360	Aptakisic Creek at Aptakisic, Ill.	112	193	250	322	377	431
			88	142	179	223	257	290
			109	187	241	304	355	405
8	05528440	Buffalo Creek near Lake Zurich, Ill.	82	131	163	203	232	260
			67	113	145	185	216	245
			80	129	161	200	229	258

Table 2.–T-year peak discharges at gaging station, in cubic feet per second—Continued

Map No.	Station No.	Station Name	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}
9	05528470	Buffalo Creek at Long Grove, Ill.	227	367	461	580	667	751
			222	357	448	558	642	722
			226	366	460	576	663	746
10	05528500	Buffalo Creek near Wheeling, Ill.	399	606	740	902	1,020	1,130
			442	678	831	1,020	1,150	1,280
			403	613	749	919	1,040	1,150
11	05529000	Des Plaines River near Des Plaines, Ill.	2,100	3,080	3,690	4,410	4,920	5,400
			1,460	1,980	2,290	2,650	2,900	3,130
			2,060	3,010	3,600	4,240	4,720	5,170
12	05529300	McDonald Creek near Wheeling, Ill.	176	301	389	502	587	670
			223	333	403	487	548	606
			181	304	391	500	581	659
13	05529500	McDonald Creek near Mount Prospect, Ill.	229	405	532	697	822	947
			273	397	475	565	632	693
			233	404	526	675	790	904
14	05529900	Weller Creek at Mount Prospect, Ill.	528	836	1,040	1,300	1,480	1,660
			399	567	670	791	879	958
			512	801	990	1,200	1,360	1,520
15	05530000	Weller Creek at Des Plaines, Ill.	827	1,210	1,450	1,740	1,950	2,140
			483	674	791	926	1,020	1,110
			781	1,140	1,360	1,580	1,770	1,940
16	05530400	Higgins Creek near Mount Prospect, Ill.	134	276	389	548	674	806
			109	169	208	256	291	324
			131	261	363	486	590	698
17	05530480	Willow Creek at Orchard Place, Ill.	523	952	1,270	1,680	2,000	2,320
			390	568	679	809	905	992
			506	899	1,180	1,500	1,760	2,030

Table 2.—T-year peak discharges at gaging stations, in cubic feet per second—Continued

Map No.	Station No.	Station Name	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}
18	05530700	Silver Creek at Melrose Park, Ill.	440	562	631	708	760	807
			321	445	520	606	668	723
			425	548	618	691	745	793
19	05530940	Salt Creek at Palatine, Ill.	218	305	358	420	462	502
			220	354	444	554	638	717
			218	310	367	439	486	531
20	05530960	Salt Creek near Palatine, Ill.	291	443	542	662	748	830
			430	651	793	962	1,090	1,210
			304	462	565	702	794	881
21	05531000	Salt Creek near Arlington Heights, Ill.	529	793	962	1,170	1,310	1,450
			725	1,060	1,270	1,510	1,690	1,860
			547	818	991	1,220	1,360	1,510
22	05531050	Salt Creek near Wood Dale, Ill.	627	890	1,050	1,240	1,370	1,500
			913	1,310	1,550	1,830	2,040	2,230
			652	927	1,090	1,310	1,450	1,590
23	05531080	Spring Brook at Bloomingdale, Ill.	187	276	333	401	449	494
			209	326	403	496	566	632
			189	281	340	415	466	514
24	05531130	Spring Brook at Walnut Avenue at Itasca, Ill.	246	355	422	502	558	611
			390	596	730	890	1,010	1,120
			259	376	448	550	613	672
25	05531200	Salt Creek at Addison, Ill.	854	1,150	1,330	1,530	1,660	1,790
			1,090	1,510	1,760	2,060	2,270	2,460
			876	1,180	1,370	1,600	1,740	1,880
26	05531300	Salt Creek at Elmhurst, Ill.	995	1,300	1,480	1,690	1,830	1,950
			1,130	1,550	1,800	2,080	2,290	2,470
			1,010	1,320	1,510	1,740	1,890	2,020

Table 2.–T-year peak discharges at gaging stations, in cubic feet per second—Continued

Map No.	Station No.	Station Name	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}
27	05531380	Salt Creek at Oak Brook, Ill.	1,000	1,290	1,460	1,650	1,770	1,890
			1,210	1,630	1,880	2,160	2,370	2,550
			1,020	1,320	1,500	1,720	1,850	1,980
28	05531500	Salt Creek at Western Springs, Ill.	1,130	1,470	1,660	1,880	2,030	2,170
			1,240	1,650	1,900	2,180	2,380	2,550
			1,140	1,490	1,680	1,920	2,080	2,220
29	05531800	Addison Creek at Northlake, Ill.	332	396	431	469	494	516
			231	343	413	496	557	614
			320	389	429	473	504	531
30	05532000	Addison Creek at Bellwood, Ill.	434	557	628	707	760	809
			498	683	794	922	1,010	1,100
			440	569	644	736	793	847
31	05532500	Des Plaines River at Riverside, Ill.	3,830	5,150	5,920	6,780	7,360	7,890
			2,540	3,300	3,750	4,240	4,600	4,900
			3,740	5,020	5,770	6,520	7,080	7,580
32	05533000	Flag Creek near Willow Springs, Ill.	744	1,270	1,650	2,130	2,490	2,840
			504	734	878	1,050	1,170	1,290
			714	1,200	1,540	1,920	2,220	2,520
33	05533200	Sawmill Creek tributary near Tiedtville, Ill.	224	272	299	328	346	363
			152	239	297	367	420	471
			215	268	299	334	357	378
34	05533300	Wards Creek near Woodridge, Ill.	77	117	144	176	199	221
			122	195	243	303	348	391
			81	124	153	193	218	243
35	05533400	Sawmill Creek near Lemont, Ill.	492	925	1,250	1,690	2,020	2,370
			330	503	615	749	849	942
			471	864	1,160	1,490	1,760	2,050

Table 2.–T-year peak discharges at gaging stations, in cubic feet per second—Continued

Map No.	Station No.	Station Name	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}
36	05534300	North Branch Chicago River at Lake Forest, Ill.	191	262	304	353	386	417
			194	294	358	435	492	545
			191	265	310	365	401	435
37	05534400	North Branch Chicago River at Bannockburn, Ill.	245	320	364	413	446	477
			234	350	423	510	574	632
			244	323	370	426	463	498
38	05534500	North Branch Chicago River at Deerfield, Ill.	294	392	449	514	558	600
			305	438	520	615	685	748
			295	397	456	528	575	620
39	05534600	North Branch Chicago River at Northfield, Ill.	348	437	487	542	579	612
			360	512	605	714	793	865
			349	444	498	565	607	645
40	05534900	Skokie River at Lake Bluff, Ill.	204	314	385	472	535	595
			257	368	436	516	574	627
			210	320	391	479	541	600
41	05535000	Skokie River at Lake Forest, Ill.	216	295	342	397	434	469
			311	445	527	624	694	757
			224	308	358	425	466	504
42	05535070	Skokie River near Highland Park, Ill.	433	492	523	555	576	594
			439	619	729	857	950	1,030
			434	511	553	614	647	674
43	05535150	Skokie River at Northfield, Ill.	383	454	492	534	561	585
			516	713	832	970	1,070	1,160
			395	476	520	584	618	648
44	05535200	North Branch Chicago River at Glenview, Ill.	718	885	978	1,080	1,150	1,210
			809	1,110	1,290	1,490	1,640	1,770
			727	906	1,010	1,130	1,210	1,280

Table 2.–T-year peak discharges at gaging stations, in cubic feet per second—Continued

Map No.	Station No.	Station Name	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}
45	05535400	West Fork of North Branch Chicago River at Deerfield, Ill.	366	454	502	557	592	625
			165	243	292	350	393	432
			335	424	473	518	555	590
46	05535500	West Fork of North Branch Chicago River at Northbrook, Ill.	464	596	672	757	813	865
			239	341	403	477	530	578
			433	562	637	706	762	814
47	05535700	West Fork of North Branch Chicago River at Glenview, Ill.	653	858	978	1,110	1,210	1,290
			410	577	679	797	883	960
			622	823	941	1,060	1,150	1,230
48	05535800	North Branch Chicago River at Morton Grove, Ill.	1,100	1,400	1,560	1,740	1,860	1,980
			1,100	1,480	1,710	1,970	2,160	2,320
			1,100	1,410	1,580	1,770	1,900	2,030
49	05536000	North Branch Chicago River at Niles, Ill.	1,170	1,460	1,620	1,800	1,920	2,030
			1,170	1,560	1,790	2,050	2,240	2,400
			1,170	1,470	1,640	1,840	1,960	2,080
50	05536201	Thorn Creek at Park Forest, Ill.	319	621	853	1,170	1,420	1,670
			215	339	421	521	596	666
			305	578	785	1,020	1,230	1,430
51	05536207	Thorn Creek tributary at Chicago Heights, Ill.	289	470	592	746	859	969
			211	303	360	426	475	519
			279	446	558	679	778	873
52	05536210	Thorn Creek near Chicago Heights, Ill.	1,010	1,490	1,800	2,160	2,420	2,660
			558	817	980	1,170	1,310	1,440
			928	1,370	1,650	1,910	2,140	2,350
53	05536215	Thorn Creek at Glenwood, Ill.	1,020	1,500	1,810	2,180	2,450	2,700
			715	1,030	1,230	1,460	1,630	1,790
			983	1,440	1,740	2,050	2,300	2,540

Table 2.–T-year peak discharges at gaging stations, in cubic feet per second—Continued

Map No.	Station No.	Station Name	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}
54	05536235	Deer Creek near Chicago Heights, Ill.	449	684	836	1,020	1,160	1,280
			441	663	804	973	1,100	1,210
			448	682	833	1,010	1,150	1,270
55	05536255	Butterfield Creek at Flossmoor, Ill.	556	917	1,160	1,480	1,700	1,930
			457	658	783	929	1,040	1,130
			545	886	1,110	1,380	1,580	1,780
56	05536265	Lansing ditch near Lansing, Ill.	151	240	300	375	429	482
			235	352	426	515	581	642
			158	250	311	393	449	503
57	05536270	North Creek near Lansing, Ill.	282	385	446	517	566	612
			345	504	603	720	807	885
			288	396	460	543	597	647
58	05536275	Thorn Creek at Thornton, Ill.	1,700	2,490	2,980	3,570	3,980	4,380
			1,510	2,160	2,560	3,040	3,380	3,700
			1,680	2,450	2,930	3,480	3,880	4,270
59	05536310	Calumet Union Drainage Canal near Markham, Ill.	302	393	446	506	547	584
			431	638	770	925	1,040	1,150
			314	415	474	557	605	650
60	05536335	Midlothian Creek near Tinley Park, Ill.	222	316	374	441	489	533
			223	329	396	476	535	589
			222	317	376	446	496	541
61	05536340	Midlothian Creek at Oak Forest, Ill.	249	333	383	440	478	514
			317	467	561	672	753	828
			255	345	399	469	512	552
62	05536460	Tinley Creek near Oak Forest, Ill.	426	644	783	954	1,070	1,190
			200	315	391	484	553	618
			392	595	725	857	964	1,070

Table 2.–T-year peak discharges at gaging stations, in cubic feet per second––Continued

Map No.	Station No.	Station Name	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}
63	05536500	Tinley Creek near Palos Park, Ill.	480	721	876	1,060	1,200	1,320
			267	412	505	618	703	781
			451	680	827	978	1,110	1,220
64	05536510	Navajo Creek at Palos Heights, Ill.	235	310	354	403	436	467
			122	193	241	299	343	385
			218	294	339	384	420	453
65	05536560	Melvina ditch near Oak Lawn, Ill.	119	190	237	297	340	382
			229	315	367	426	469	507
			129	202	250	315	359	400
66	05536570	Stony Creek (West) at Worth, Ill.	418	711	916	1,180	1,380	1,570
			583	800	930	1,080	1,190	1,290
			435	721	918	1,160	1,350	1,520
67	05536620	Mill Creek near Palos Park, Ill.	125	190	233	285	322	358
			179	271	329	399	451	499
			130	198	242	301	340	377
68	05539870	West Branch Du Page River at Ontarioville, Ill.	300	490	618	781	900	1,020
			282	407	484	574	640	699
			298	480	601	744	853	961
69	05539890	West Branch Du Page River near Wayne, Ill.	434	614	725	854	944	1,030
			456	664	794	947	1,060	1,160
			436	619	732	868	961	1,050
70	05539900	West Branch Du Page River near West Chicago, Ill.	435	598	696	809	887	960
			493	718	859	1,020	1,150	1,260
			441	610	712	839	924	1,000
71	05539950	Klein Creek at Carol Stream, Ill.	203	332	420	532	615	696
			192	290	353	428	484	535
			202	327	412	514	592	668

Table 2.–T-year peak discharges at gaging stations, in cubic feet per second—Continued

Map No.	Station No.	Station Name	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}
72	05540030	West Branch Du Page River at West Chicago, Ill.	741	982	1,120	1,280	1,390	1,490
			810	1,150	1,360	1,610	1,790	1,950
			748	999	1,140	1,330	1,450	1,560
73	05540060	Kress Creek at West Chicago, Ill.	260	367	433	510	563	613
			311	463	560	675	760	838
			265	377	446	533	590	644
74	05540080	Spring Brook at Wheaton, Ill.	160	224	263	308	340	370
			138	204	246	295	332	365
			157	222	261	306	339	369
75	05540095	West Branch Du Page River near Warrenville, Ill.	1,110	1,520	1,770	2,060	2,250	2,430
			1,030	1,460	1,720	2,020	2,240	2,440
			1,100	1,510	1,760	2,050	2,250	2,430
76	05540110	Ferry Creek at Warrenville, Ill.	86	123	145	172	191	208
			109	177	223	280	323	364
			88	128	152	186	208	227
77	05540130	East Branch Du Page River near Bloomingdale, Ill.	52	90	116	150	176	201
			113	190	242	307	358	406
			57	98	126	168	197	225
78	05540150	East Branch Du Page River at Glen Ellyn, Ill.	240	408	526	678	791	903
			339	480	566	666	739	804
			249	415	530	676	783	887
79	05540160	East Branch Du Page River near Downers Grove, Ill.	576	883	1,080	1,320	1,500	1,670
			543	748	872	1,010	1,120	1,210
			572	866	1,050	1,260	1,430	1,580
80	05540190	St. Joseph Creek at Belmont, Ill.	354	533	648	788	887	982
			331	469	553	651	723	787
			351	525	637	765	859	948

Table 2.–T-year peak discharge at gaging station, in cubic feet per second—Continued

Map No.	Station No.	Station Name	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}
81	05540240	Prentiss Creek near Lisle, Ill.	224	344	423	519	588	654
			270	410	500	608	689	764
			229	351	431	532	603	670
82	05540500	Du Page River at Shorewood, Ill.	3,660	5,690	7,050	8,770	10,000	11,300
			2,080	2,950	3,480	4,100	4,560	4,960
			3,550	5,490	6,790	8,260	9,400	10,600
83	05548280	Nippersink Creek near Spring Grove, Ill.	1,510	2,850	3,860	5,220	6,280	7,350
			1,170	1,830	2,260	2,780	3,180	3,540
			1,450	2,650	3,530	4,510	5,370	6,210
84	05549000	Boone Creek near McHenry, Ill.	128	201	250	310	353	396
			161	272	348	444	517	587
			130	205	256	321	366	411
85	05549700	Mutton Creek at Island Lake, Ill.	80	155	213	291	352	415
			174	280	352	440	506	569
			87	166	225	311	373	436
86	05549850	Flint Creek near Fox River Grove, Ill.	254	313	346	381	405	426
			511	775	944	1,150	1,300	1,440
			275	346	387	454	487	516
87	05549900	Fox River tributary near Cary, Ill.	12	27	39	56	71	86
			7	15	21	29	36	43
			11	26	37	51	65	79
88	05550300	Tyler Creek at Elgin, Ill.	327	399	439	483	512	538
			508	786	968	1,190	1,350	1,500
			346	434	485	566	608	645
89	05550430	East Branch Poplar Creek near Palatine, Ill.	86	133	164	201	228	254
			132	206	254	312	356	398
			90	140	172	215	245	273

Table 2.--T-year peak discharges at gaging stations, in cubic feet per second----Continued

Map No.	Station No.	Station Name	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}
90	05550450	Poplar Creek near Ontarioville, Ill.	221	296	341	392	427	459
			314	492	610	753	860	961
			230	313	364	435	477	516
91	05550470	Poplar Creek tributary near Bartlett, Ill.	167	248	300	363	406	449
			201	292	349	417	466	511
			170	253	305	371	415	458
92	05550500	Poplar Creek at Elgin, Ill.	407	573	675	794	876	953
			578	861	1,040	1,250	1,410	1,560
			422	598	706	850	941	1,030
93	05551030	Brewster Creek at Valley View, Ill.	234	420	555	732	866	1,000
			242	388	485	604	694	779
			235	416	546	709	835	959
94	05551050	Norton Creek near Wayne, Ill.	93	167	220	291	344	398
			160	254	316	392	448	502
			99	175	230	306	359	414
95	05551060	Norton Creek near St. Charles, Ill.	143	252	332	436	515	593
			217	346	432	536	616	690
			150	262	342	451	531	608
96	05551200	Ferson Creek near St. Charles, Ill.	832	1,340	1,680	2,110	2,420	2,720
			613	977	1,220	1,510	1,740	1,950
			804	1,290	1,620	2,000	2,300	2,580
97	05551520	Indian Creek near North Aurora, Ill.	129	190	229	275	308	338
			124	203	256	321	371	419
			128	191	232	282	317	350
98	05551530	Indian Creek at Aurora, Ill.	516	637	704	778	827	872
			353	533	648	786	888	983
			495	625	698	779	836	889

Table 2.--T-year peak discharges at gaging stations, in cubic feet per second---Continued

Map No.	Station No.	Station Name	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}
99	05551620	Blackberry Creek near Kaneville, Ill.	426	519	570	626	663	697
			305	496	624	783	903	1,020
			409	516	576	651	700	745
100	05551650	Lake Run tributary near Batavia, Ill.	53	117	171	248	312	380
			69	123	161	210	248	286
			55	118	170	242	301	363
101	05551700	Blackberry Creek near Yorkville, Ill.	615	931	1,140	1,380	1,560	1,730
			635	963	1,170	1,430	1,610	1,790
			617	935	1,140	1,390	1,570	1,740
102	05551900	East Branch Big Rock Creek near Big Rock, Ill.	652	978	1,190	1,440	1,620	1,790
			334	544	686	860	993	1,120
			593	899	1,100	1,300	1,470	1,630
103	05551930	Welch Creek near Big Rock, Ill.	336	462	538	626	687	743
			303	487	610	761	875	983
			331	465	548	651	721	786

Table 3.–Location, drainage area, population density, housing density, street density, and imperviousness for 15 watersheds

Watershed Location	Drainage area (mi^2)	Population density (persons per mi^2)	Housing density (units per mi^2)	Street density (miles per mi^2)	Imperviousness (percentage of land area)
McDonald Creek upstream from Schoenbeck Road, NW¼ sec. 15, T.42 N., R.11 E., Cook County.	4.58	3,045	798	8.71	22.0
McDonald Creek upstream from Camp McDonald Road, NE¼ sec.26, T.42 N., R.11 E., Cook County.	7.93	2,883	827	9.04	19.6
Weller Creek upstream from Lincoln Street, SW¼ sec.11, T.41 N., R.11 E., Cook County.	9.02	6,000	1,745	15.24	36.8
Weller Creek upstream from State Highway 58 (Gulf Road), NW¼ sec.18, T.41 N., R.12 E., Cook County.	13.2	5,840	1,650	14.63	36.0
Butterfield Creek upstream from U.S. Highway 30, SE¼ sec. 18, T.35 N., R.13 E., Cook County.	1.77	17	5.6	1.69	1.6
Butterfield Creek upstream from Governor's Highway, NW¼ sec.23, T.35 N., R.13 E., Cook County.	9.44	333	85.6	3.17	4.5
Butterfield Creek tributary upstream from Sauk Trail, SE¼ sec.27, T.35 N., R.13 E., Will County.	1.34	160	46.3	4.92	6.3
Butterfield Creek upstream from Vollmer Road, SE¼ sec.12, T.35 N., R.13 E., Cook County.	19.2	782	210	4.61	10.0
Butterfield Creek upstream from Reigle Road, NW¼ sec.8, T.35 N., R.14 E., Cook County.	23.5	1,062	289	5.62	12.4
Stony Creek (West) tributary upstream from Edison Avenue, NW¼ sec.9, T.37 N., R.13 E., Cook County.	3.00	7,972	2,095	19.43	47.0

Table 3.--Location, drainage area, population density, housing density, street density, and imperviousness for 15 watersheds—Continued

Watershed Location	Drainage area (mi^2)	Population density (persons per mi^2)	Housing density (units per mi^2)	Street density (miles per mi^2)	Imperviousness (percentage of land area)
Melvina ditch upstream from 95th Street, NE¼ sec.7, T.37 N., R.13 E., Cook County.	5.58	6,417	1,674	18.30	37.2
Stony Creek (West) upstream from Harlem Avenue, NE¼ sec. 13, T.37 N., R.13 E., Cook County.	18.0	7,237	1,926	16.86	38.7
Klein Creek upstream from State Highway 64, SW¼ sec.31, T.40 N., R.10 E., Du Page County.	8.81	616	151	3.44	6.9
St. Joseph Creek upstream from Blodgett Avenue, SE¼ sec.8, T.38 N., R.11 E., Du Page County.	3.28	2,899	921	8.60	19.9
St. Joseph Creek upstream from Belmont Avenue, SE¼ sec.12, T.38 N., R.10 E., Du Page County.	8.80	3,768	1,205	11.99	29.3

Table 4.—Reliability of estimating equations,
$$Q_T = cA^x S^y If^z$$

Recurrence interval, in years	Standard error of estimate, in percentage	Equivalent years of record
2	36	2
5	38	2
10	40	2
25	43	3
50	45	3
100	48	3
500	52	4

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