REGIONAL FLOOD-FREQUENCY RELATIONS FOR WEST-CENTRAL FLORIDA

By M. A. Seijo, R. F. Giovannelli, and J. F. Turner, Jr.

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations

Open-File Report 79-1293

Prepared in cooperation with the

SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT

1979

UNITED STATES DEPARTMENT OF THE INTERIOR

CECIL D. ANDRUS, Secretary

GEOLOGICAL SURVEY

H. William Menard, Director

For additional information write to:

U.S. Geological Survey
Water Resources Division
325 John Knox Road, Suite F-240
Tallahassee, Florida 32303

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CONVERSION FACTORS

For use of those readers who may prefer to use metric (SI) units rather than inch-pound units, the conversion factors for the terms used in this report are listed below:

Multiply inch-pound unit	By	To obtain metric (SI) unit
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.59	square kilometer (km^2)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

GLOSSARY

Some of the technical terms used in this report are defined here for convenience. See Dalrymple (1960) and Langbein and Iseri (1960) for additional information regarding flood-frequency analyses and associated hydrologic terminology. Statistical terms are defined with respect to flood analysis applications described in this report.

Annual maximum discharge.--The highest instantaneous peak discharge for a water year.

Basin characteristics.--Parameters that describe the physical and climatic factors of a drainage basin. Parameters used in this study include drainage area, channel length and slope, lake area, forested area and soils index.

Correlation.--Linear dependence between two or more hydrologic variables.

Correlation coefficient.--The degree of linear dependence of two hydrologic variables. The correlation coefficient can range from plus one (perfect correlation) or minus one (perfect inverse correlation) to zero (no correlation).

Equivalent years of record.--Number of years of streamflow record that would be necessary to produce a frequency distribution with accuracy equal to that of the regression analysis.

Exceedance probability.--The probability that a flood will exceed a specified magnitude in any water year. Recurrence interval is computed as the inverse of exceedance probability.

Frequency distribution.--A graph showing flood magnitudes that will, on the average, be exceeded once within a specified number of years (Riggs, 1968).

Mean.--The arithmetic mean of the sample.

Multiple correlation coefficient.--A measure of the explanatory power of a regression involving three or more hydrologic variables.

Outlier.--A nonrepresentative annual flood event.

Recurrence interval.--The average interval of time within which a specified flood magnitude will be exceeded once.

Residual.--The difference between a station value and a value predicted by a regression equation.

Significance (level of).--The specified probability level at which a statistical test is made to determine whether or not the explained variation in the dependent variable resulting from introduction of an independent variable in the regression analysis could have occurred by chance alone.

Skew coefficient.--Relative measure of the asymmetry of a flood-frequency distribution.

Standard deviation.--A measure of the amount of variation in a sample. The standard deviation is determined by taking the square root of the average squared deviations of the observations from the mean.

Standard error of estimate.--A measure of the reliability of a regression equation. In this report, the standard error is given as an average percent value representing the average range about the regression equation that includes about 68 percent of all regression data points. More technically, the standard error is the standard deviation of the residuals about the regression equation.

T-year event.--Specified recurrence interval, in years.

Water year.--The 12-month period beginning October 1 and ending September 30, and is designated by the calender year in which it ends.

SYMBOLS

The following symbols have been adopted for use in this report.

A_G	Drainage area, in square miles, for the gaged site;
A_U	Drainage area, in square miles, for the ungaged site;
B_0-B_4	Partial regression coefficients;
C_G	Geographic zone coefficient;
C_R	Regression constant;
DA	Drainage area, in square miles;
FO	Forested area, in percent of drainage area;
G	WRC weighted skew coefficient;
$\overline{G}$	Generalized skew coefficient;
$\hat{G}$	Estimate of station skew coefficient;
K	Scale factor for the log-Pearson Type III distribution;
LE	Channel length, in miles;
LK	Lake area, in percent of drainage area;
M	Arithmetic mean of a sample;
N	Accuracy for a flood estimate, in equivalent years of record;

N_1	Number of annual flood events for a gaged site, in years;
N_2	Accuracy of a regional flood estimate, in equivalent years;
N_T	Transferred accuracy, in equivalent years, for the estimate Q_G;
Q_G	Estimate of the T-year flood at a gaged site from the adjusted station frequency distribution, in cubic feet per second;
Q_R	Estimate of the T-year flood from the regression equation, in cubic feet per second;
Q_{RG}	Regional flood estimate for a gaged site from regression equation, in cubic feet per second;
Q_{RU}	Regional flood estimate for an ungaged site from regression equation, in cubic feet per second;
Q_T	Estimate of the T-year flood from log-Pearson Type III distribution, in cubic feet per second;
Q_U	Adjusted flood estimate for an ungaged site, in cubic feet per second;
Q_W	Weighted estimate of the T-year flood at a gaged site, in cubic feet per second;
r	Drainage area ratio;
R	Multiple correlation coefficient;
R^2	Coefficient of determination;
S	Standard deviation of the logarithms of annual peaks;
SL	Channel slope, in feet per mile;
SO	Soil infiltration index, in inches;
ST	Total area of lakes, ponds, and swamps, in percent of drainage area;
T	Recurrence interval, years;
X_1, X_2, X_3....	Independent variables of the regression.

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ABSTRACT

This report presents regional relations for estimating the magnitude and frequency of floods on streams in west-central Florida. Flood prediction equations derived cover 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year recurrence intervals.

Annual floods for three geographic areas of west-central Florida were found to relate significantly to basin characteristics. Basin characteristics include drainage area, soils index, channel slope, and lake area. The average standard error of estimate for regional flood relations ranged from 38.4 percent to 52.1 percent with a mean of 43.5 percent. The average multiple correlation coefficient is 0.94. Regional relations apply to gaged and ungaged sites whose drainage areas are greater than 10 but less than 2,500 square miles.

Tables of maximum known floods for 64 streamflow stations used in the analysis are included. Tables comparing station, weighted, and regional flood-peak discharges are also included.

INTRODUCTION

Regional flood-frequency information covering recurrence intervals as great as 500 years is needed for flood evaluation and control in west-central Florida. Knowledge of the magnitude and frequency of floods is also necessary for the proper design and location of structures such as dams, bridges, and highways. Design of a structure on any basis less than maximum possible flood infers an element of risk. In practice, the design imposes economic constraints where it is desirable to include an element of risk. Usually the planner arrives at an intermediate design that would result in the lowest average annual cost for a specified design period. An accurate estimate of the flood damage potential or flood frequency, therefore, is essential for sound economic design.

At sites where long-term systematic streamflow records are available, reliable flood-frequency information can be determined. Unfortunately, long-term records are not generally available at or near stream sites where flood information is needed. Planning requirements and cost considerations make it impossible to maintain and operate streamflow stations at all sites where flood data are needed. The problem expands then to one of not only defining flood frequency at gaged sites but also ungaged sites. Thus, a consistent and uniformly applicable procedure is needed for estimating flood-frequency information for streams in west-central Florida.

Regional flood-frequency information covering the west-central Florida area is available from earlier studies, including Barnes and Golden (1966) and Rabon (1971). There are significant differences between flood-frequency information provided in these two reports. The Barnes and Golden (1966) study covers Florida and parts of Georgia, Alabama, and Mississippi. The study is based on the index-flood method of analysis (Dalrymple, 1960) using records through the 1966 water year. Regional flood-frequency relations are provided for recurrence intervals up to and including 50 years. The Rabon (1971) report uses records through the 1970 water year. Regional flood relations are provided that also cover recurrence intervals up to and including 50 years. Rabon's flood-frequency relations were developed in a regression analysis of flood discharges and basin characteristics. The regional flood relations presented in this report should be used in preference to those found in both Barnes and Golden (1966) and Rabon (1971) for the west-central Florida area. A flood profile report for the Alafia River (Robertson, 1978) in which the methods described in Barnes and Golden (1966) were used in the determination of the frequency distribution is no longer applicable. Flood discharges provided in this report should be used in preference to Robertson (1978).

Areal flood-frequency relations covering recurrence intervals of 2 through 500 years, using 20 stations having more than 20 years of record through the 1975 water year, were recently developed. These relations were used exclusively in a series of flood studies (Murphy, 1978a, 1978b, Murphy and others, 1978, Hammett and others, 1978, Turner and others, 1979). The results and method of determining these relations were similar to those presented in this report but were limited in scope and area. However, regional flood relations presented in this report should be used in preference to those found in the flood profile reports.

This report describes the development of regional flood frequency relations for streams in west-central Florida. Illustrated examples for determining flood estimates at gaged and ungaged sites are also presented.

PURPOSE AND SCOPE

The purpose of this study is to develop regional flood-frequency relations for the Southwest Florida Water Management District area of responsibility, including revised District boundaries effective January 1, 1977 (fig. 1). These relations cover flood-peak discharges having recurrence intervals of 2, 5, 10, 25, 50, 100, 200, and 500 years. Sixty-four streamflow stations located in and near the study area were included in the study. Flood data available for these stations through September 1976 were used in the regional analysis.

Regional relations were developed in a multiple linear-regression analysis of station flood-frequency data and basin characteristics. These relations are provided in mathematical form supported by illustrated examples to facilitate their use. Accuracy of the regression estimates is provided in terms of equivalent years of record and standard error of estimate.

Regional relations obtained are applicable to streams having drainage areas greater than 10 mi^2 and less than 2,500 mi^2. Basins having drainage areas of less than 10 mi^2 were not used in the regional analysis because of insufficient flood data. Results from a preliminary study on small drainage basins (Bridges, 1977) were not sufficiently advanced to be incorporated in this study. Results of this study do not apply to urbanized areas, tidally affected stream reaches, or sites significantly affected by regulation or diversion.

DESCRIPTION OF THE AREA

The study area covers approximately 10,000 mi^2 and includes all or part of 15 counties of west-central Florida (fig. 1). Included are all basins draining into the Gulf of Mexico from the Withlacoochee River on the north to the Peace River on the south. A description of the study area is found in Florida Board of Conservation (1966). The following description of west-central Florida summarizes topographic, geologic, and climatic factors that influence flooding in the study area.

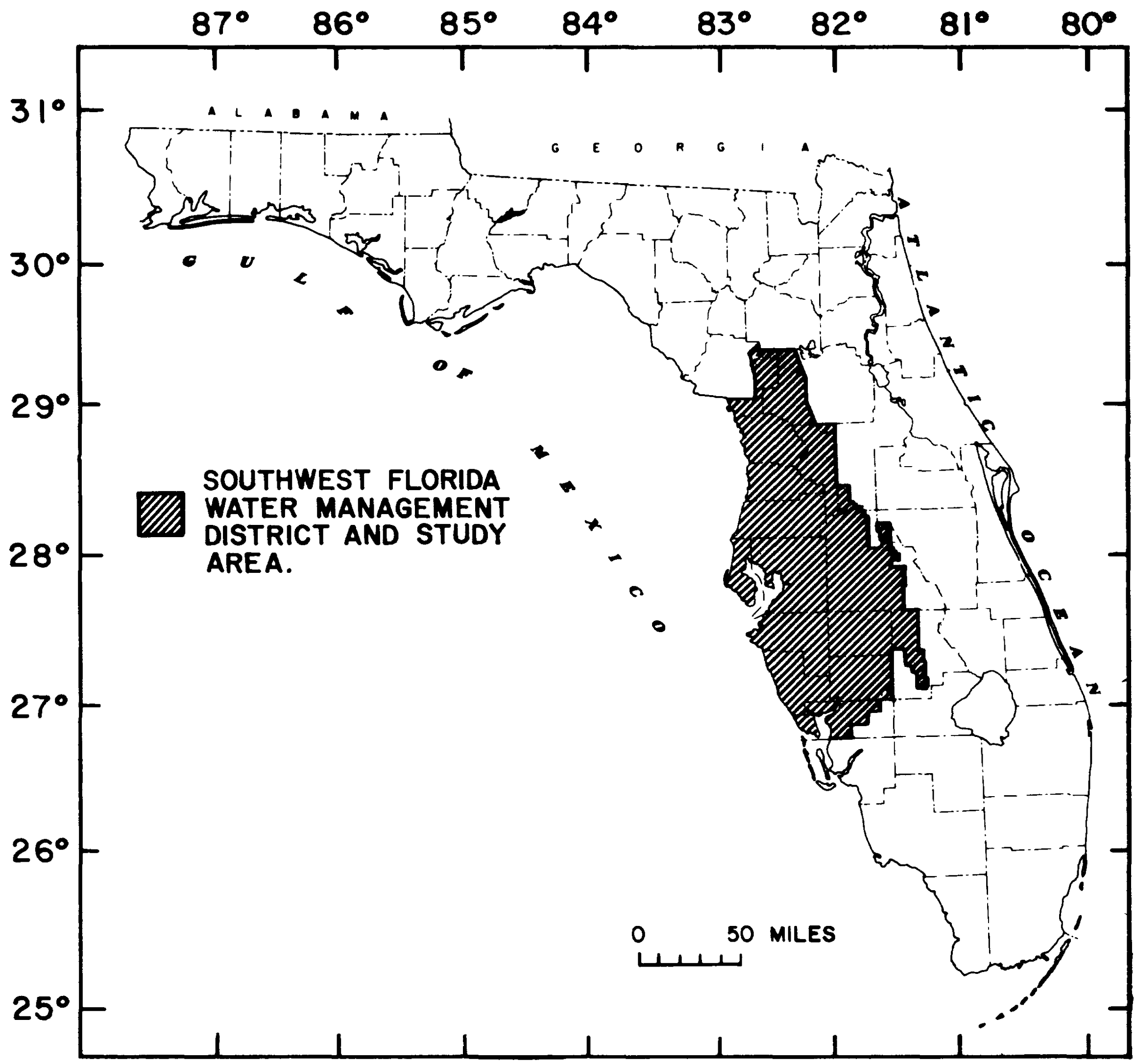

Figure 1.--Location of the study area.

Topography

The west-central Florida area lies within two of the five natural topographic regions of Florida; the Coastal Lowlands and the Central Highlands (Pride, 1958) (fig. 2). Land-surface elevations in the study area range from the National Geodetic Vertical Datum of 1929 (NGVD of 1929) in the Coastal Lowlands to just over 300 ft above the datum in the Central Highlands. The two regions consist of low, nearly level plains and gently undulating to rolling areas with many ponds, swamps, and marshes as well as numerous lakes and perennial streams. A topographic high, which contains the headwaters of several major rivers, exists in the central part of the study area.

The study area is drained primarily by three major rivers: the Withlacoochee, the Hillsborough, and the Peace. The Withlacoochee River basin includes about 2,000 mi^2 of the northeastern part of the study area, where it flows northwestward to the Gulf of Mexico. The Withlacoochee River overflows at flood stage into the upper Hillsborough River through an overflow channel. Numerous large springs sustain base flow of the river from near the overflow channel to the mouth. In lower reaches of the river, about 50 percent of base flow is from the Floridan aquifer, a major artesian aquifer underlying the west-central Florida area.

The Hillsborough River basin drains about 800 mi^2 in the central part of the study area. The river originates south of the Withlacoochee River and flows generally southwestward into Hillsborough Bay. Base flow of the river is sustained by a large spring located in the upper reaches. Large swampy areas, which tend to retain flood waters resulting in reduced flood peaks, are characteristic of both the upper Hillsborough and the Withlacoochee River basins.

The Peace River basin covers approximately 2,500 mi^2 located in the southern part of the study area. The river flows southward from Polk County through Hardee and DeSoto Counties and discharges into Charlotte Harbor. The headwater region has many sinkhole lakes which diminish surface runoff in the upper reaches of the river. The main stem of the Peace River is relatively shallow and narrow with the basin having a moderately steep slope. These conditions offer little opportunity for flood storage or reduction of flood peaks which cause the runoff rate of the Peace River to be generally greater than that of the Hillsborough or Withlacoochee Rivers.

Smaller river basins in the southern part of the study area include the Myakka, Manatee, Little Manatee, and Alafia Rivers. These smaller basins generally provide drainage to coastal areas having poorly defined stream channels, especially in the low-lying areas. Many basin divides are not distinct, and well defined stream drainage patterns are almost nonexistent.

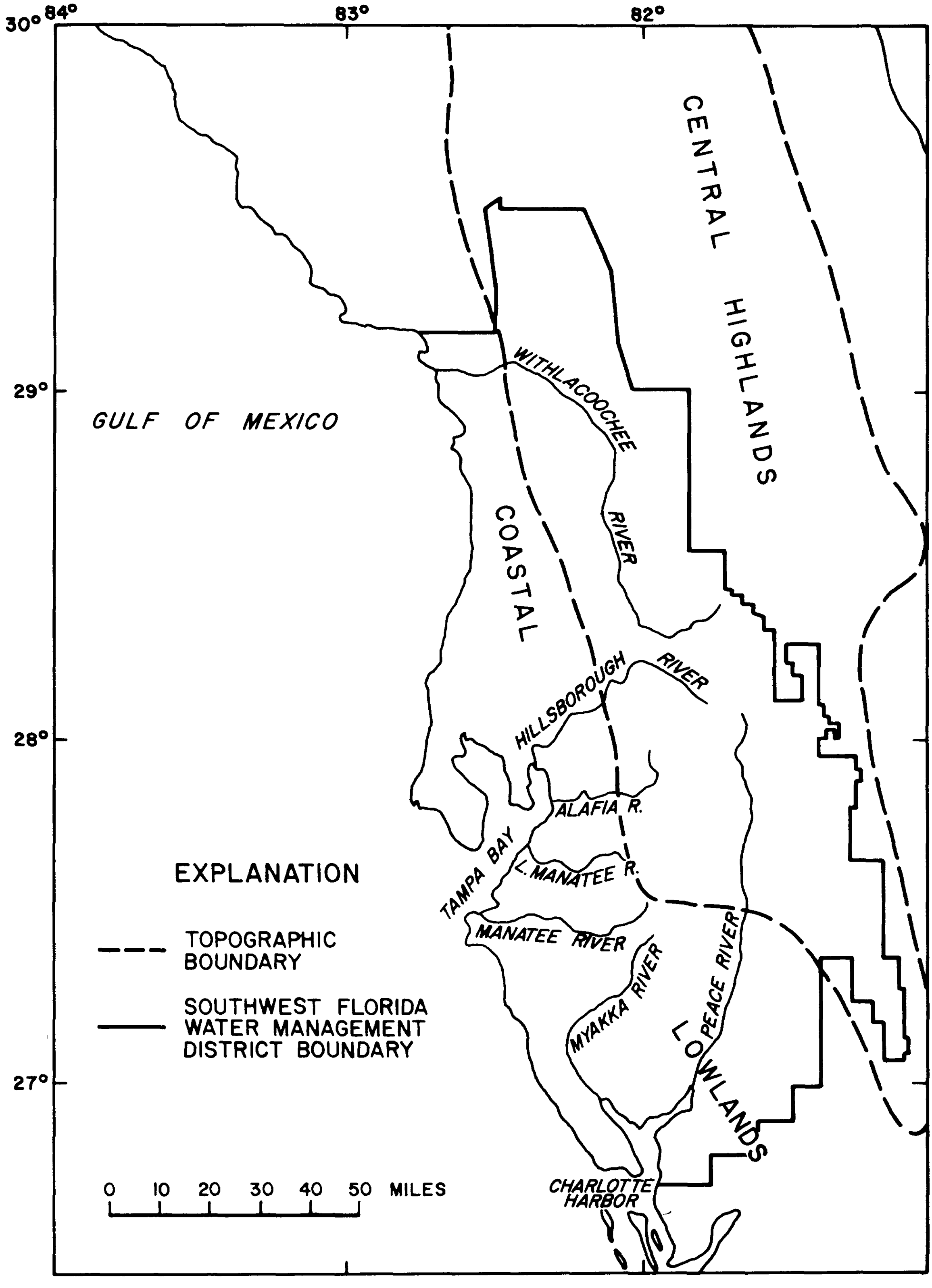

Figure 2.--Topographic divisions and major streams of the study area (modified from Pride, 1958).

Geology

The Floridan aquifer underlies the west-central Florida area and is a major water-supply source. The aquifer is composed primarily of limestone and dolomite rocks of Eocene, Oligocene, and Miocene ages (fig. 3).

In the central part of the study area, the limestones and dolomites of the Oligocene Series are exposed at ground surface or are covered by highly permeable sands. Much of the rainfall in this part of the study area infiltrates rapidly, and sinkholes retain a large part of the surface drainage.

In the northern and southern part of the study area, clays, marls, sands, and phosphates of the Eocene and Miocene Series overlie the limestones. The surface distribution of the rocks and soils tends to be less pervious; therefore, surface runoff responds more quickly to rainfall.

In the most southern part of the study area lie the more recent deposits of the Pleistocene Series, composed mostly of shell hash limestones and clay. The distribution of clays in this area reduces infiltration which results in higher runoff.

Climate

The climate is characterized by warm, humid summers and mild, moderately dry winters. Variation in land-surface elevation has little effect on the overall climate of the study area. The proximity to the sea and numerous wet-land areas contributes to the humid, temperate climate.

The average annual rainfall of the study area varies from 50 to 56 in., with the State average being 53 in. Rainfall also varies seasonally with amounts equal to more than half the annual total occurring from June to September. Most of the summer rain comes from short-duration, high intensity, afternoon or evening showers or thundershowers. Rainfall in the fall, winter, and spring seasons generally occurs from less frequent, longer duration, frontal type storms.

Hurricanes, tropical storms, and depressions affect the area at irregular intervals. These storms, which occur during the summer and fall months, are the main causes of widespread heavy rainfall and flooding.

RECORDS AVAILABLE

Streamflow records used in this study were obtained from the U.S. Geological Survey National Water Data Storage and Retrieval System. Records are collected by the U.S. Geological Survey in cooperation with state, local, and federal agencies.

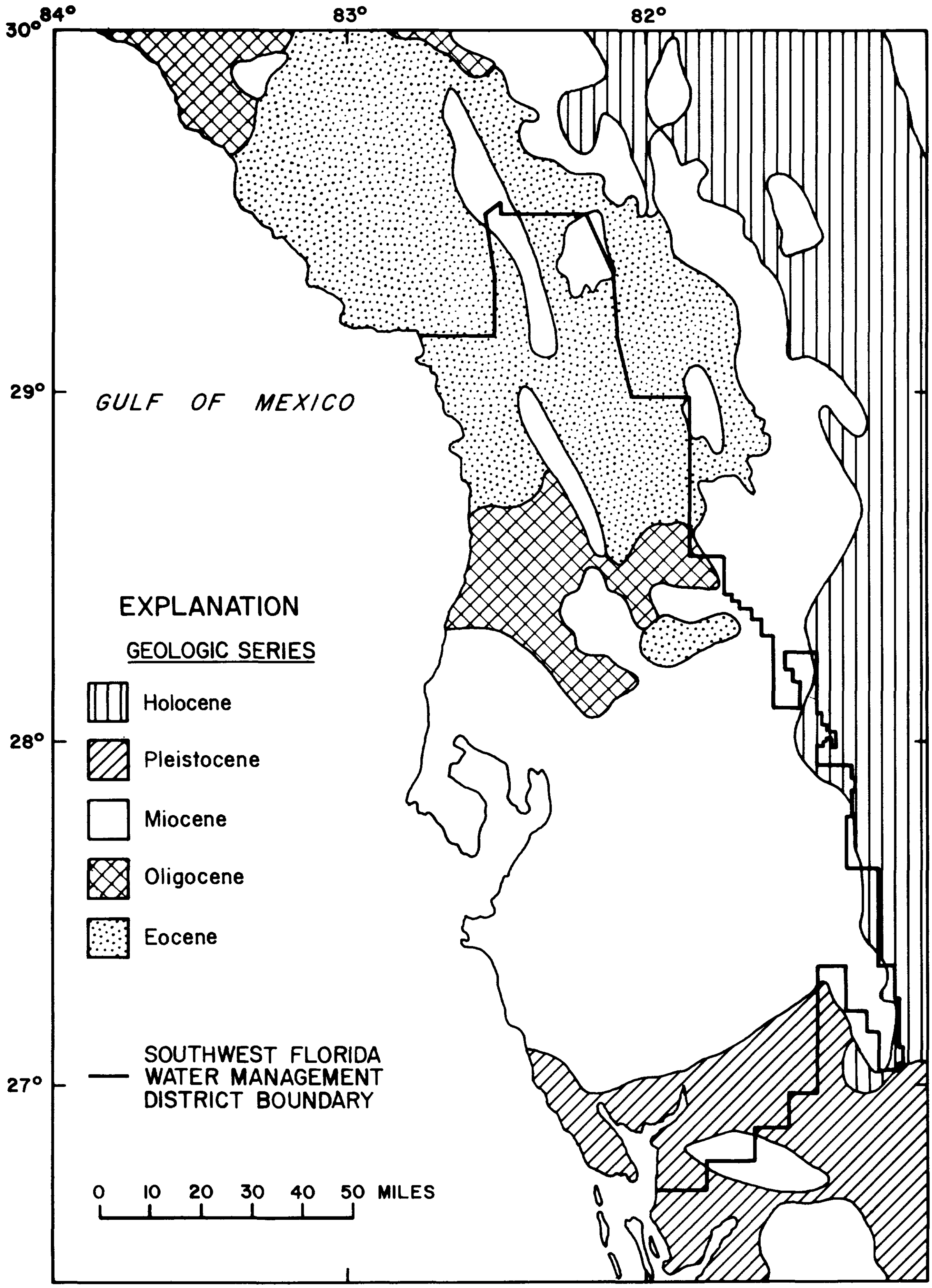

Figure 3.--Geology of the study area (modified from Geologic map of Florida, Florida Bureau of Geology, Map Series No. 18, 1965).

Streamflow records at gaged sites were selected on the basis of length, quality, and station location. Sites with less than 10 years of record and sites significantly affected by regulation or diversion were excluded from the analysis. These sites are summarized in table 1. All sites located within the study area that met selection criteria were used in the analysis. In addition, a small number of sites located along the periphery of the study area were included to provide continuity to the analysis. Location of 64 selected streamflow sites are shown in figure 4 and keyed to an identification number listed in table 2.

Available data for sites not included in this report can be obtained from U.S. Geological Survey publications "Water Resources Data for Florida" (1961-76) and Water Supply Papers 1304, 1674, and 1724 (1960, 1966 and 1963).

FLOOD-FREQUENCY ANALYSIS

Station flood-frequency distributions were determined for all stations using U.S. Geological Survey guidelines and procedures outlined by the Water Resources Council. The "Guidelines for Determining Flood Flow Frequency," Bulletin 17 of the U.S. Water Resources Council (1976), is a major extension of the work previously completed by the Council to promote a consistent approach to flood flow frequency determination. Suggested procedures are provided in Bulletin 17 for defining flood-frequency distributions for gaged sites. These procedures form the basis for the station data analysis methods incorporated in this report. A brief summary of the procedure used is outlined below.

1. A Pearson Type III distribution was fitted to logarithms of observed annual flood peaks for each station;
2. A generalized skew coefficient was used as an estimate of station skew for stations with less than 25 annual flood peaks. A weighted skew coefficient was used as an estimate of station skew for stations with at least 25 annual flood peaks;
3. Frequency distributions were adjusted for missing record, zero flows, outliers, and historic peaks;
4. Regional comparisons based on annual peak correlations of short-term to long-term stations were made to improve the final station distributions for short-term stations.

Log-Pearson Type III Analysis

The Pearson Type III distribution with base 10 logarithmic transformation of annual flood peaks was used to define station flood-frequency distributions. For this distribution, the peak discharge at selected

Table 1.--Streamflow stations not used in regional analysis

Station number	Station name
02293500	Peace Creek Drainage Canal near Dundee, Fla.1/
02294068	Lake Lulu outlet at Eloise, Fla.2/
02294898	Peace River at Fort Meade, Fla.3/
02296191	Little Charley Bowlegs Creek at South Fence Line Road near Sebring, Fla.1/
02296207	Little Charley Bowlegs Creek at Cottage Road near Sebring, Fla.1/
02296223	Little Charley Bowlegs Creek near Sebring, Fla.1/
02298123	Prairie Creek near Fort Ogden, Fla.3/
02301350	Little Alafia River near Hopewell, Fla.4/
02301990	Hillsborough River above Crystal Springs near Zephyrhills, Fla.5/
02303350	Trout Creek near Sulphur Springs, Fla.3/
02303990	Cow House Creek near Temple Terrace, Fla.3/
02304000	Hillsborough River at Fowler Avenue near Tampa, Fla.1/
02304500	Hillsborough River near Tampa, Fla.1/
02309000	Brooker Creek near Odessa, Fla.1/
02301280	Pithlachascotee River near Fivay Junction, Fla.3/
02310750	Crystal River near Crystal River, Fla.6/
02310947	Withlacoochee River near Cumpressco, Fla.7/
02311000	Withlacoochee-Hillsborough overflow near Richland, Fla.8/
02311500	Withlacoochee River near Dade City, Fla.3/
02312140	Bayroot Slough headwaters near Bay Lake, Fla.3/
02312180	Little Withlacoochee River near Tarrytown, Fla.8/
02312600	Withlacoochee River near Florida City, Fla.3/
02312700	Outlet River at Panacoochee Retreats, Fla.2/
02313200	Withlacoochee River at Dunnelon, Fla.2/

1/ Flow affected by regulation or control.
2/ Flow affected by a lake.
3/ Miscellaneous measurements only.
4/ Flow affected by backwater.
5/ Flow from spring.
6/ Tidally affected.
7/ Flow diversion.
8/ Indeterminate drainage area.

Table 2.--Streamflow sites used in regional study and maximum known floods

Identification number	Station number	Name and location	Maximum stage[1] (ft)	Discharge (ft^3/s)	Year	Recurrence interval[2] (years)
		STATIONS WITHIN THE SWFWMD STUDY AREA				
1	2293400	Alligator Creek near Punta Gorda	11.30	3,370	1962	>100
2	2293986	Peace Creek Drainage Canal near Alturas	13.30	2,540	1928	40
3	2294650	Peace River at Bartow	6.45	4,140	1947	32
4	2295637	Peace River at Zolfo Springs	25.05	26,300	1933	>100
5	2296500	Charlie Creek near Gardner	18.77	8,160	1960	24
6	2296750	Peace River at Arcadia	20.55	43,000	1912	>100
7	2297100	Joshua Creek at Nocatee	18.80	8,670	1953	32
8	2297310	Horse Creek near Arcadia	17.94	11,700	1960	56
9	2298830	Myakka River near Sarasota	11.58	8,670	1960	49
10	2299800	Phillippi Creek at Sarasota	14.20*	6,740	1962	>100
11	2299950	Manatee River near Myakka Head	15.33	3,130	1976	8
12	2300000	Manatee River near Bradenton	25.79	9,420	1962	40
13	2300100	Little Manatee River near Fort Lonesome	10.20	1,310	1973	4
14	2300200	South Fork Little Manatee River near Duette	6.96	1,040	1960	47
15	2300500	Little Manatee River near Wimauma	19.76*	14,000	1960	62
16	2300700	Bullfrog Creek near Wimauma	20.59*	5,200	1960	35
17	2301000	North Prong Alafia River at Keysville	15.86	9,570	1960	>100
18	2301300	South Prong Alafia River near Lithia	17.83	2,600	1967	6
19	2301500	Alafia River at Lithia	28.50	45,900	1933	>100
20	2301800	Sixmile Creek at Tampa	11.47*	1,290	1960	28
21	2301900	Fox Branch near Socrum	6.81	454	1967	4
22	2302500	Blackwater Creek near Knights	9.70	5,400	1960	>100
23	2303000	Hillsborough River near Zephyrhills	15.33	12,600	1960	>100
24	2303100	New River near Zephyrhills	8.48	261	1971	4
25	2303400	Cypress Creek near San Antonio	5.23	717	1974	7
26	2303420	Cypress Creek at Worthington Gardens	12.56	1,210	1974	7
27	2303800	Cypress Creek near Sulphur Springs	34.13*	2,660	1960	22
28	2307000	Rocky Creek near Sulphur Springs	17.03	2,840	1960	44
29	2307359	Brooker Creek near Tarpon Springs	13.32*	1,600	1960	35
30	2307697	Alligator Creek at Safety Harbor	7.52*	1,030	1974	33

Footnotes are at end of table.

Table 2.--Streamflow sites used in regional study and maximum known floods - continued

Identification number	Station number	Name and location	Maximum stage[1/] (ft)	Discharge (ft^3/s)	Year	Recurrence interval[2/] (years)
31	2308889	Seminole Lake outlet near Largo	7.17*	642	1971	21
32	2310000	Anclote River near Elfers	27.70*	5,000	1945	56
33	2310240	Jumping Gully at Loyce	6.80	920	1964	73
34	2310300	Pithlachascotee River near New Port Richey	11.91	1,410	1964	18
35	2310800	Withlacoochee River near Eva	6.10	2,160	1960	47
36	2312000	Withlacoochee River at Trilby	---	8,840	1934	89
37	2312200	Little Withlacoochee River near Rerdell	12.32	3,400	1960	87
38	2312500	Withlacoochee River at Croom	13.78	8,650	1960	90
39	2312640	Jumper Creek Canal near Bushnell	6.06	227	1970	9
40	2313000	Withlacoochee River near Holder	13.28	8,660	1960	48
		PERIPHERY STATIONS				
41	2236500	Big Creek near Clermont	6.23	691	1960	37
42	2237000	Palatlakaha River near Mascotte	96.60*	458	1945	5
43	2239000	Oklawaha River near Ocala	5.68	2,270	1960	22
44	2240950	Hogtown Creek near Gainesville	11.29	1,600	1970	41
45	2241900	Lochloosa Creek at Grove Park	9.45	1,520	1964	20
46	2243500	Oklawaha River near Orange Springs	11.60	9,760	1933	64
47	2244000	Oklawaha River at Riverside Lodge near Orange Springs	9.73*	8,760	1964	22
48	2256500	Fisheating Creek at Palmdale	12.44	31,400	1951	>100
49	2262900	Boggy Creek near Taft	13.64	3,680	1960	63
50	2263800	Shingle Creek at Airport near Kissimmee	---	1,600	1960	9
51	2264000	Cypress Creek near Vineland	4.66	354	1960	40
52	2266500	Reedy Creek near Loughman	4.25	790	1969	20
53[3/]	2269000	Kissimmee River below Lake Kissimmee	---	8,820	1948	24
54	2270500	Arbuckle Creek near DeSoto City	8.71	7,380	1948	24
55	2271500	Josephine Creek near DeSoto City	---	1,780	1948	25

Table 2.--Streamflow sites used in regional study and maximum known floods - continued

Identification number	Station number	Name and location	Maximum stage 1/ (ft)	Discharge (ft^3/s)	Year	Recurrence interval 2/ (years)
56	2293000	Orange River near Fort Myers	13.40	5,300	1936	>100
57	2313400	Waccasassa River near Bronson	5.49	1,090	1964	11
58	2314200	Tenmile Creek at Lebanon Station	12.38	4,290	1964	>100
59	2321000	New River near Lake Butler	15.33	11,400	1964	47
60 3/	2321700	Swift Creek near Lake Butler	10.62	1,580	1964	57
61	2322000	Santa Fe River near High Springs	18.96	20,000	1964	46
62	2322500	Santa Fe River near Fort White	15.34	17,000	1964	77
63	2323000	Suwannee River near Bell	27.43	82,300	1948	>100
64	2323500	Suwannee River near Wilcox	22.32*	84,700	1948	>100

1/ All stage values are referenced to a local datum with the exception of those marked with an asterisk which indicates elevation in feet, National Geodetic Vertical Datum of 1929.

2/ Weighted frequency estimate using equation 6 and table 7.

3/ Station does not appear in figure 4.

T-year recurrence intervals can be computed using equation 1 as follows:

$$\log Q_T = M + K_T S \qquad (1)$$

where Q_T = Estimate of the T-year flood from log-Pearson Type III distribution, in cubic feet per second;

M = Mean of the logarithms of the annual peaks;

K_T = A scale factor that is a function of the skew coefficient and recurrence interval;

S = Standard deviation of the logarithms of the annual peaks.

U.S. Geological Survey computer program J407, described by Carrigan and Kirby (1976), was used to fit the log-Pearson Type III distribution to the station flood data. Program J407 includes many of the features described in Bulletin 17, but requires the user to use hydrologic judgment when providing data on historic peaks, specifying screening levels for outliers, and interpreting the frequency distribution.

Generalized Skew Coefficient

The accuracy of the station skew coefficient, as an estimate of the true skew of the frequency distribution, is generally a function of the length of record. The station skew is a measure of the past history of annual flood events and is extremely sensitive to extreme events for short records. For these reasons, Bulletin 17 recommends the use of a generalized skew, as an estimate of the station skew for short-term records less than 25 years. For records of 25 to 100 years, a weighted skew is recommended and is calculated by equation 2 as follows:

$$G = \frac{N-25}{75} \cdot \hat{G} + \frac{100-N}{75} \bar{G} \qquad (2)$$

where G = WRC weighted skew coefficient;

N = Number of annual peaks;

$\hat{G}$ = Estimate of station skew coefficient, based on observed records;

$\bar{G}$ = Generalized skew coefficient.

A generalized skew coefficient for the study area was estimated from a group of stations having 25 or more years of record whose values ranged from -0.81 to 1.02. The generalized skew coefficient of 0.14 was determined as the mean of the station skew coefficients, giving equal weight to each station. Attempts were made to determine a better estimate of the generalized skew coefficient, including relating station skew and deviates from an isoline plot to basin characteristics. Basin characteristics used are discussed in a following section entitled "Peak Flow Regionalization." None of these attempts provided useable results.

The effect of the generalized skew coefficient on a frequency distribution computed from a record of 18 annual flood events is shown in figure 5. Because the number of peaks is less than 25, the generalized skew defines the final frequency distribution for the station used in figure 5.

Regional Comparisons

Regional comparisons of flood events between similar basins can be used to improve the reliability of the analysis. Two-way station comparisons, described in Bulletin 17, were used to reduce time sampling errors inherent in records for short-term stations by adjusting their frequency distributions to reflect experience at a nearby longer term station. A regression technique was used to adjust the mean and standard deviation for the short record. The generalized skew coefficient was then used in equation 1 to compute the adjusted distribution. This procedure was limited to pairs of stations in similar hydrologic watersheds having 10 or more years of concurrent record. Records for the long-term stations were at least twice as long as those of the short-term station.

In several cases, the criteria described in Bulletin 17 to obtain 10-percent reduction in the standard error of the estimate was not met. In these cases, adjustment produced improved frequency distributions, but with somewhat less than a 10-percent reduction in the standard error. In all cases the cross-correlation coefficient between short-term and long-term sites was 0.7 or greater.

PEAK FLOW REGIONALIZATION

Regional flood-frequency relations were determined for the study area by using multiple linear-regression analysis methods to relate flood-peak discharge to selected basin characteristics. This was in agreement with the major objective of the study; a need for the transfer of flood-frequency relations to sites where no records or insufficient records exist. Results of the regression analysis consisted of statistical equations along with additional data describing accuracy and reliability. Residual errors of the initial regression analysis were evaluated with respect to geographic zones of the study area. Coefficients for each geographic zone, resulting from this evaluation, were introduced into a final regression analysis to develop the regional flood-frequency relations.

Regression Model

The Statistical Analysis System (SAS) computer package was used for regression analysis in the U.S. Geological Survey computer system (Barr, 1976). The use of SAS facilitated the organization and entry of data and

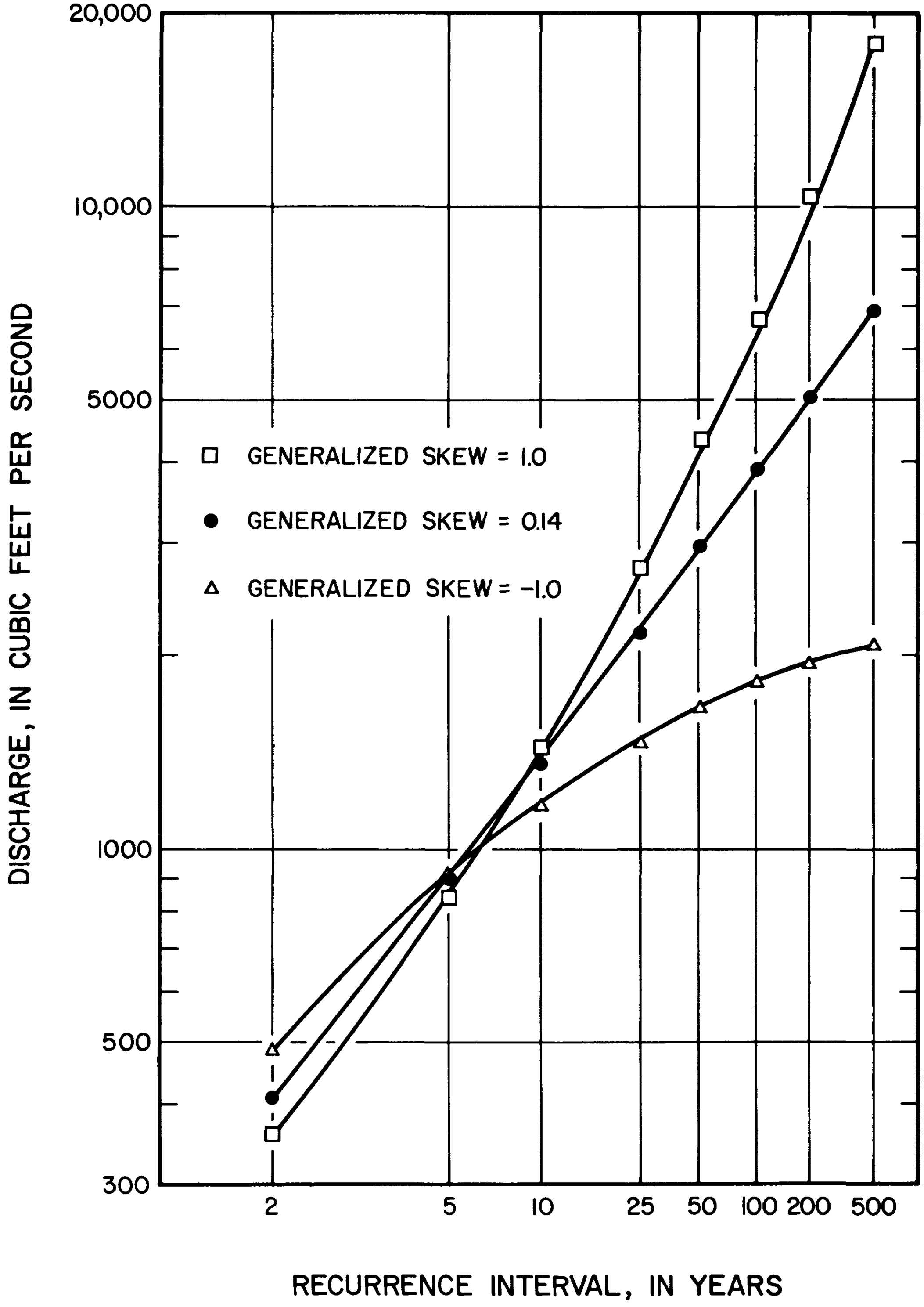

Figure 5.--Example showing effect of skew coefficient on station flood-frequency distribution.

provided comprehensive editing, analysis, and plotting procedures. The regression procedure selected consisted of a variation of the step forward regression analysis method (Wesolowsky, 1976) for selecting independent variables, MAXR, which essentially tests all combinations of independent variables. The significant variables are selected as those inducing the greatest improvement of the R^2 statistic (square of the multiple correlation coefficient). In this manner, the best one, two, three, and so forth, parameter models are obtained. For each recurrence interval, the choice of a final prediction equation depends on both the significance of the parameters and the degree of improvement in the standard error of estimate.

The hydrologic model used is of the form

$$Q_R = B_0 X_1^{B_1} X_2^{B_2} X_3^{B_3} \ldots\ldots\ldots \quad (3)$$

where, Q_R represents the T-year flood discharge or dependent regression variable; B_0, B_1, B_2, B_3, are partial regression coefficients; and, X_1, X_2, X_3 are the basin characteristics or independent variables. Equation 3 has a linear form given by equation 4 as follows:

$$\log Q_T = \log B_0 + B_1 \log X_1 + B_2 \log X_2 + B_3 \log X_3 \ldots\ldots \quad (4)$$

The multiple relation given by equation 4 is the form that was used in the linear regression study.

Basin Characteristics

The basin characteristics data were entered as the independent variables of the regression and are discussed below. All variables were not significant, and, subsequently, all do not appear in the final prediction equations. To avoid difficulties associated with the use of zeros in the regression analysis, all basin characteristics with zero values in terms of percentage of the contributing drainage area were increased by 0.01 percent.

1. Drainage area (DA), in square miles: area that contributes to surface runoff. Determined by outlining the basin boundary on topographic maps and planimetering the area within the boundary.
2. Channel slope (SL), in feet per mile: measured along the main channel between points 10 and 85 percent of the distance from the streamflow station to the basin divide. Elevations for the two points are taken directly from a topographic map or a profile of the stream channel.
3. Channel length (LE), in miles: measured along the main channel from the gage to the basin boundary.

4. Storage (ST), in percentage of contributing drainage area (DA); the area shown as lakes, ponds, and swamps on topographic maps.

5. Lake area (LK), in percentage of contributing drainage area (DA); the area shown as lakes and ponds on topographic maps.

6. Forest cover (FO), in percentage of contributing drainage area (DA); forested area shown on topographic maps.

7. Soil infiltration index (SO), in inches: value of potential maximum infiltration during an annual flood, under average soil moisture conditions. Determined from Soil Conservation Service runoff curve number, using land use and soil type, Chow (1964). Soil infiltration index values for the study area are shown in figure 6.

Regression Analysis

Flood magnitudes for recurrence intervals of 2, 5, 10, 25, 50, 100, 200, and 500 years were regressed using the model given by equation 4 against the basin characteristics. All 64 stations were included in the initial analysis. For all recurrence intervals, drainage area, DA, exhibited the greatest significance. The order of significance of the remainder of the parameters varied with recurrence interval, but in general the geographic coefficient, C_G, defined below, was second followed by soils index, SO, channel slope, LS, and lake area, LK. All of these parameters proved to be significant at the 5 percent level. Length was eliminated from the analysis because of high correlation with drainage area. Standard errors of estimate for the initial regression ranged from 53 to 67 percent, indicating that the basin parameters did not adequately explain the flood-peak variation over the entire study area.

Residual errors for each station, or the difference between a station value and a value from the regression, were plotted on a base map of the study area to evaluate areal variations with respect to topographic and surface geologic features. Distinct residual error patterns were noted. Geographic zone boundaries were drawn (fig. 4) giving considerable weight to residual patterns, basin divides, soils index maps, and general geologic and topographic features. Three geographic zones were identified. Zone 1 includes the central highlands area lying north of the Withlacoochee River basin. Zone 2 includes the Hillsborough and Withlacoochee River basins and north coastal area. Zone 3 includes the coastal area surrounding Tampa Bay area and the Peace River basin.

The mean of the residual errors in each of the three geographic zones was calculated and used as a new independent variable in the regression analysis. Examination of each of the geographic zones indicated that zone 1 and zone 3 had similar characteristics and mean residuals; therefore, only two independent geographic coefficients were used in the final regression analysis. Results from this analysis succeeded in meeting established accuracy goals as set forth in Rabon (1971) for areal streams (drainage area less than 500 mi^2). For the 50-year recurrence interval, the accuracy goals for planning and design on areal streams are 43 percent standard error for 10 years of record. However, results from the final analysis failed in meeting established accuracy goals for all recurrence intervals for main stem streams. The accuracy goals for planning and design on main stem streams are 26 percent standard error for 25 years of record.

Use of geographic zone coefficients significantly reduced the standard error of estimate from the initial to final regression analysis. For example, the average standard error of estimate for the 50-year flood-frequency relation was reduced from 57.9 to 42.6 percent.

The final regional estimating equation for peak flows is as follows:

$$Q_R = C_R \cdot C_G \cdot DA^{B_1} \, SL^{B_2} \, LK^{B_3} \, SO^{B_4} \qquad (5)$$

where Q_R = Estimate of the T-year flood from the regression equation, in cubic feet per second;

C_R = Regression constant which varies with T, from table 4;

C_G = Geographic zone coefficient, from table 5;

DA = Drainage area, in square miles;

SL = Channel slope, in feet per mile;

LK = Lake area, in percent;

SO = Soils index, in inches;

B_1, B_2, B_3, B_4 are exponents of the regression, which vary with T from table 4.

Values of the basin characteristics used in the regional analysis are listed in table 3. Regional flood-frequency relations are summarized in table 4. Values of C_G for various recurrence intervals and geographic zones are listed in table 5.

Accuracy of the Regression Estimates

The standard error of estimate is one index of the accuracy of the estimates obtained from the regional relation. However, the accuracy of the prediction is often expressed in terms of "equivalent years of record" that would be required to give results of equal accuracy (Hardison, 1971). In order to remove this variability, equivalent years of record can be determined using the average index of variability and the standard error of prediction. The regional average index of variability (I_v) is computed as the average standard deviation of the logarithms of the annual flood-peak discharges for all station records used in the analysis and is 0.3137 log units. Standard errors of estimate used are those determined

Table 3.--Basin characteristics used in regional analysis

Identification number [1/]	Station number	Station name	Drainage area [2/] (mi^2)	Slope (ft/mi)	Percent lakes	Soil index
1	2293400	Alligator Creek near Punta Gorda	31.1	2.46	5.31	1.90
2	2293986	Peace Creek Drainage Canal near Alturas	160	1.26	12.80	3.88
3	2294650	Peace River near Bartow	390	1.25	13.30	4.05
4	2295637	Peace River at Zolfo Springs	826	1.38	7.15	4.05
5	2296500	Charlie Creek near Gardner	330	1.68	0.10	2.08
6	2296750	Peace River at Arcadia	1,370	1.30	4.35	3.04
7	2297100	Joshua Creek at Nocatee	132	4.06	0.14	2.03
8	2297310	Horse Creek near Arcadia	218	2.79	0.12	2.05
9	2298830	Myakka River near Sarasota	235	2.14	1.81	1.90
10	2299600	Phillippi Creek at Sarasota	45.0	3.24	5.79	2.05
11	2299950	Manatee River near Myakka Head	64.7	5.83	0.17	2.05
12	2300000	Manatee River near Bradenton	80.0	4.93	0.22	2.05
13	2300100	Little Manatee River near Fort Lonesome	31.4	5.70	0.01	2.05
14	2300200	South Fork Little Manatee River near Duette	9.4	5.76	0.12	5.38
15	2300500	Little Manatee River near Wimauma	149	5.03	0.40	2.55
16	2300700	Bullfrog Creek near Wimauma	29.1	6.93	0.52	2.05
17	2301000	North Prong Alafia River at Keysville	135	4.96	3.09	2.70
18	2301300	South Prong Alafia River near Lithia	107	3.60	6.30	2.05
19	2301600	Alafia River at Lithia	335	3.45	1.16	2.14
20	2301800	Sixmile Creek at Tampa	28.0	2.07	0.99	5.38
21	2301900	Fox Branch near Socrum	9.5	6.70	0.01	2.05
22	2302500	Blackwater Creek near Knights	110	3.52	2.58	2.72
23	2303000	Hillsborough River near Zephyrhills	220	3.87	1.81	2.77
24	2303100	New River near Zephyrhills	15.0	12.90	4.33	3.69
25	2303400	Cypress Creek near San Antonio	56.0	4.00	1.61	2.47
26	2303420	Cypress Creek at Worthington Gardens	117	2.00	1.71	2.73
27	2303800	Cypress Creek near Sulphur Springs	160	2.53	1.56	2.64
28	2307000	Rocky Creek near Sulphur Springs	35.0	4.12	3.74	2.23
29	2307359	Brooker Creek near Tarpon Springs	3.0	2.81	6.02	2.05
30	2307397	Alligator Creek at Safety Harbor	9.0	9.64	2.67	2.05
31	2308889	Seminole Lake Outlet near Largo	14.0	1.71	4.33	2.05
32	2310000	Anclote River near Elfers	72.5	3.54	3.20	2.42
33	2310240	Jumping Gully at Loyce	43.0	1.50	4.35	4.11
34	2310300	Pithlachascotee River near New Port Richey	182	1.97	5.52	4.11
35	2310800	Withlacoochee River near Eva	130	1.90	4.36	2.52

Footnotes are at end of table.

Table 3.--Basin characteristics used in regional analysis - continued

Identification number [1/]	Station number	Station name	Drainage area [2/] (mi^2)	Slope (ft/mi)	Percent lakes	Soil index
36	2312000	Withlacoochee River at Trilby	580	1.35	1.71	2.70
37	2312200	Little Withlacoochee River near Rerdell	160	1.75	4.40	2.71
38	2312500	Withlacoochee River at Croom	880	1.24	2.40	5.37
39	2312640	Jumper Creek Canal near Bushnell	40.0	2.10	2.75	5.38
40	2313000	Withlacoochee River near Holder	1,710	0.86	4.95	3.89
41	2236500	Big Creek near Clermont	68.0	0.75	4.64	2.52
42	2237000	Palatlakaha River near Mascotte	180	0.93	11.90	2.66
43	2239000	Oklawaha River near Ocala	1,070	0.91	19.00	4.56
44	2240950	Hogtown Creek near Gainesville	18.5	23.50	0.55	12.20
45	2241900	Lochlousa Creek at Grove Park	34.7	6.83	6.57	3.89
46	2243500	Oklawaha River near Orange Springs	2,000	0.85	14.20	4.83
47	2244000	Oklawaha River at Riverside Lodge near Orange Springs	2,160	0.83	26.30	4.88
48	2235500	Fisheating Creek at Palmdale	311	1.33	0.15	2.15
49	2262900	Boggy Creek near Taft	83.6	2.04	8.79	3.08
50	2263800	Shingle Creek at Airport near Kissimmee	89.2	1.78	6.72	2.28
51	2264000	Cypress Creek near Vineland	30.3	0.41	27.50	5.31
52	2266590	Reedy Creek near Loughman	110	2.46	8.07	4.21
53 [3/]	2269000	Kissimmee River below Lake Kissimmee	1,610	0.21	17.20	4.58
54	2270500	Arbuckle Creek near DeSoto City	379	1.40	8.99	2.88
55	2271500	Josephine Creek near DeSoto City	109	3.81	19.30	5.14
56	2293000	Orange River near Fort Myers	60.0	1.64	2.64	2.01
57	2313400	Waccasassa River near Bronson	220	1.10	6.10	7.20
58	2314200	Tenmile Creek at Lebanon	26.0	5.90	7.19	2.00
59	2321000	New River near Lake Butler	193	2.95	0.03	3.65
60 [3/]	2321700	Swift Creek near Lake Butler	46.0	1.85	8.67	2.87
61	2322000	Santa Fe River near High Springs	950	2.33	1.90	4.97
62	2322500	Santa Fe River near Fort White	1,080	1.48	1.73	5.60
63	2323000	Suwannee River near Bell	9,490	0.55	0.49	4.78
64	2323500	Suwannee River near Wilcox	9,730	0.51	0.54	4.83

1/ Refers to station location shown in figure 4.

2/ Basin parameters obtained from Rabon (1971), the U.S. Geological Survey streamflow/basin characteristic file (1977), and U.S. Geological Survey 7.5 minute series topographic quadrangles.

3/ Station does not appear in figure 4.

Table 4.--Regional flood relations

Recurrence interval T, in years	Annual exceedance probability	Geographic coefficient C_G [1/]	Regression constant C_R	Regression coefficients DA B_1	SL B_2	LK B_3	SO B_4	Multiple correlation coefficient R	Standard error Log units	Percent Positive	Negative	Average
2	0.5	--	11.7	0.91	0.65	-0.11	-0.56	0.95	0.179	51.0	33.8	42.4
5	0.2	--	31.7	0.86	0.57	-0.11	-0.61	.95	.163	45.5	31.3	38.4
10	0.1	--	54.1	0.84	0.53	-0.11	-0.64	.95	.163	45.5	31.3	38.4
25	0.04	--	96.3	0.81	0.49	-0.10	-0.68	.95	.171	48.3	32.5	40.4
50	0.02	--	140	0.79	0.46	-0.10	-0.70	.94	.180	51.4	33.9	42.6
100	0.01	--	198	0.77	0.44	-0.10	-0.73	.93	.190	54.9	35.4	45.2
200	0.005	--	273	0.76	0.42	-0.10	-0.75	.92	.202	59.2	37.2	48.2
500	0.002	--	403	0.75	0.39	-0.10	-0.78	.91	.217	64.8	39.3	52.1

1/ See table 5 for values of C_G.

Table 5.--Variation of geographic zone coefficient, C_G, with recurrence interval

Geographic zone	Recurrence interval, in years 2	5	10	25	50	100	200	500
1 or 3	1.26	1.27	1.27	1.28	1.28	1.28	1.28	1.29
2	.62	.61	.60	.60	.60	.59	.59	.59

in the regression analysis Table 6 lists the accuracy, in equivalent years of record, for various recurrence intervals. The accuracy appraisals shown define the weight given to the regression estimates when adjusting flood-frequency estimates at gaged sites and can be used to improve the estimate of flood magnitude based on the weighting of two independent estimates.

DETERMINATION OF FLOOD MAGNITUDE AND FREQUENCY

Regional relations can be used to estimate flood data for ungaged sites and improve flood estimates for gaged sites. An adjusted station frequency distribution at a gaged site can be computed by the use of the WRC weighted skew. Flood discharges computed using station skew, generalized (WRC weighted) skew, and the regional equations are summarized in table 7. For gaged sites, the weighted or best estimate of the T-year flood event, also listed in table 7, is determined by weighting the regional estimate with the estimate from the adjusted station frequency distribution. Accuracy, in equivalent years, for the weighted estimate is equivalent to the sum of the accuracy of each estimate, assuming the two estimates are independent. For ungaged sites, the regional estimate can be improved if the site is located near a gaged site with at least 10 years of record. In this case, the accuracy of the weighted estimate depends on the location of the gaged site. Gaged sites with less than 10 years of record are treated as ungaged sites.

Gaged Sites

Flood estimates for gaged sites can be determined from equation 6 suggested by the Water Resources Council (1976) as follows:

$$\text{Log } Q_W = \frac{N_1 \, (\text{Log } Q_G) + N_2 \, (\text{Log } Q_{RG})}{N_1 + N_2} \qquad (6)$$

where Q_W = Weighted estimate of the T-year flood at a gaged site, in cubic feet per second;

Q_G = Estimate of the T-year flood at a gaged site from the adjusted station frequency distribution using the generalized skew, in cubic feet per second;

N_1 = Number of annual floods for the gaged site, in years;

Q_{RG} = Regional flood estimate for the gaged site, computed from equation 5, or from table 7, in cubic feet per second;

N_2 = Accuracy of the regional flood estimate, in equivalent years from table 6.

Table 6.--Accuracy of regional flood relations in equivalent years of record

Recurrence interval, T, in years	Exceedence probability, in percent	Accuracy, in equivalent years
2	0.5	3
5	0.2	7
10	0.1	9
25	0.04	12
50	0.02	13
100	0.01	14
200	0.005	15
500	0.002	15

Table 7.--Comparison of station, regional, and weighted peak discharges

Station number and name	Period of record	Number of peaks	Method of discharge computation	Skew coeffi-cient	Recurrence interval, in years: 2	5	10	25	50	100	200	500
					DISCHARGE IN CUBIC FEET PER SECOND							
2293400	1960-72	11	Station skew[1]	1.46	644	1,130	1,660	2,710	3,870	5,490	7,750	12,200
Alligator Creek near Punta Gorda			Generalized skew[2]	0.14	[5] 720	1,240	1,670	2,300	2,840	3,450	4,120	5,130
			Regional equation[3]		338	742	1,100	1,690	2,240	2,900	3,680	4,930
			Weighted[4]		620	1,020	1,380	1,960	2,500	3,130	3,860	5,020
2293986	1948-71	24	Station skew	0.39	513	922	1,280	1,850	2,360	2,970	3,670	4,790
Peace Creek Drainage Canal near			Generalized skew	0.20	539	983	1,360	1,950	2,480	3,080	3,780	4,850
Alturas			Regional equation		628	1,220	1,750	2,570	3,320	4,190	5,200	6,770
			Weighted		548	1,030	1,460	2,140	2,750	3,450	4,270	5,520
2294650	1940-76	37	Station skew	0.24	975	1,770	2,460	3,520	4,480	5,590	6,860	8,850
Peace River at Bartow			Generalized skew	0.16	985	1,780	2,440	3,460	4,350	5,360	6,500	8,250
			Regional equation		1,370	2,550	3,550	5,110	6,480	8,060	9,860	12,600
			Weighted		1,010	1,890	2,630	3,810	4,830	6,000	7,330	9,330
2295637	1933-76	44	Station skew	0.78	4,660	8,330	11,800	17,900	24,000	31,600	41,100	57,700
Peace River at Zolfo Springs			Generalized skew	0.30	4,900	8,550	11,600	16,400	20,700	25,600	31,200	40,000
			Regional equation		3,110	5,510	7,500	10,500	13,100	16,100	19,400	24,400
			Weighted		4,760	8,050	10,800	14,900	18,700	22,900	27,700	35,300
2296500	1951-76	26	Station skew	0.77	2,200	3,720	5,110	7,430	9,650	12,400	15,700	21,300
Charlie Creek near Gardner			Generalized skew	0.15	2,330	3,820	5,000	6,680	8,090	9,630	11,300	13,800
			Regional equation		3,550	6,650	9,330	13,500	17,200	21,500	26,400	34,000
			Weighted		2,430	4,300	5,870	8,340	10,400	12,800	15,400	19,200
2296750	1932-76	45	Station skew	0.87	6,940	11,700	16,100	23,400	30,500	39,000	49,600	67,200
Peace River at Arcadia			Generalized skew	0.53	7,270	12,500	17,200	24,700	31,700	40,000	49,800	65,800
			Regional equation		5,890	10,400	14,100	19,700	24,600	30,000	36,200	45,600
			Weighted		7,180	12,200	16,600	23,600	30,000	37,400	46,000	60,100
2297100	1951-76	26	Station skew	0.40	1,890	3,660	5,320	8,120	10,800	14,100	18,000	24,700
Joshua Creek at Nocatee			Generalized skew	0.14	1,960	3,710	5,240	7,630	9,770	12,200	15,100	19,500
			Regional equation		2,670	4,900	6,800	9,730	12,300	15,300	18,700	23,900
			Weighted		2,020	3,940	5,600	8,240	10,600	13,200	16,300	21,000
2297310	1951-76	26	Station skew	0.21	2,100	4,010	5,710	8,430	10,900	13,800	17,200	22,500
Horse Creek near Arcadia			Generalized skew	0.14	2,110	4,020	5,690	8,300	10,600	13,300	16,400	21,200
			Regional equation		3,340	6,160	8,560	12,300	15,500	19,300	23,600	30,200
			Weighted		2,210	4,400	6,320	9,400	12,000	15,200	18,700	24,100
2298830	1937-76	40	Station skew	0.37	2,040	3,520	4,790	6,770	8,540	10,600	13,000	16,700
Myakka River near Sarasota			Generalized skew	0.19	2,080	3,550	4,750	6,530	8,060	9,770	11,700	14,600
			Regional equation		2,330	4,410	6,230	9,080	11,600	14,600	18,100	23,400
			Weighted		2,100	3,670	4,990	7,050	8,820	10,800	13,200	16,600

Footnotes are at end of table.

Table 7.--Comparison of station, regional, and weighted peak discharges - continued

Station number and name	Period of record	Number of peaks	Method of discharge computation	Skew coefficient	Recurrence interval, in years							
					2	5	10	25	50	100	200	500
2299800	1960-75	12	Station skew	1.31	940	1,990	3,300	6,150	9,680	15,100	23,200	40,800
Phillippi Creek at Sarasota			Generalized skew	0.14	5/ 1,160	2,350	3,430	5,180	6,800	8,720	11,000	14,600
			Regional equation		570	1,130	1,640	2,450	3,200	4,090	5,120	6,760
			Weighted		1,010	1,790	2,500	3,560	4,600	5,800	7,190	9,520
2299950	1967-76	10	Station skew	0.57	1,870	2,360	2,690	3,140	3,490	3,860	4,240	4,780
Manatee River near Myakka Head			Generalized skew	0.14	1,910	2,380	2,670	3,040	3,300	3,570	3,830	4,180
			Regional equation		1,720	3,170	4,420	6,350	8,060	10,000	12,300	15,800
			Weighted		1,860	2,680	3,390	4,540	5,470	6,510	7,720	9,290
2300000	1940-66	27	Station skew	-0.09	2,430	4,530	6,230	8,730	10,800	13,100	15,600	19,200
Manatee River near Bradenton			Generalized skew	0.13	2,360	4,490	6,340	9,230	11,800	14,800	18,200	23,500
			Regional equation		1,810	3,360	4,690	6,760	8,600	10,700	13,100	16,900
			Weighted		2,300	4,230	5,880	8,390	10,700	13,300	16,200	20,900
2300100	1964-76	13	Station skew	-0.31	697	1,000	1,190	1,430	1,590	1,750	1,910	2,110
Little Manatee River near Fort Lonesome			Generalized skew	0.14	5/ 825	1,340	1,740	2,320	2,800	3,330	3,900	4,750
			Regional equation		1,190	2,270	3,210	4,690	6,010	7,540	9,310	12,000
			Weighted		884	1,610	2,240	3,250	4,100	5,090	6,220	7,810
2300200	1960-75	16	Station skew	-0.01	214	453	669	1,010	1,320	1,690	2,100	2,740
South Fork Little Manatee River near Duette			Generalized skew	0.14	5/ 217	463	698	1,090	1,460	1,910	2,450	3,320
			Regional equation		176	342	486	710	912	1,140	1,410	1,820
			Weighted		210	422	613	907	1,180	1,500	1,880	2,480
2300500	1940-76	37	Station skew	0.20	2,730	5,280	7,570	11,200	14,600	18,500	23,100	30,300
Little Manatee River near Wimauma			Generalized skew	0.15	2,750	5,290	7,540	11,100	14,300	18,000	22,300	29,000
			Regional equation		2,690	4,780	6,520	9,160	11,500	14,100	17,000	21,500
			Weighted		2,750	5,210	7,270	10,600	13,500	16,800	20,600	26,600
2300700	1958-74	16	Station skew	0.23	1,210	2,620	4,000	6,370	8,670	11,500	15,000	20,800
Bullfrog Creek near Wimauma			Generalized skew	0.14	1,210	2,650	4,030	6,370	8,600	11,300	14,600	19,900
			Regional equation		818	1,560	2,200	3,220	4,130	5,190	6,420	8,330
			Weighted		1,140	2,260	3,240	4,760	6,190	7,860	9,810	13,100
2301000	1951-76	26	Station skew	0.60	1,490	2,830	4,140	6,410	8,670	11,500	15,100	21,300
North Prong Alafia River at Keysville			Generalized skew	0.15	1,570	2,900	4,040	5,800	7,350	9,120	11,100	14,300
			Regional equation		1,890	3,370	4,620	6,530	8,200	10,100	12,200	15,500
			Weighted		1,600	2,990	4,180	6,020	7,630	9,450	11,500	14,700
2301300	1964-76	13	Station skew	-0.06	944	1,570	1,980	2,530	2,970	3,420	3,890	4,540
North Prong Alafia River near Lithia			Generalized skew	0.14	5/ 1,300	2,460	3,460	5,010	6,400	8,000	9,830	12,700
			Regional equation		1,340	2,520	3,500	5,170	6,630	8,320	10,300	13,300
			Weighted		1,310	2,480	3,550	5,090	6,520	8,170	10,100	13,000

Table 7.--Comparison of station, regional, and weighted peak discharges - continued

Station number and name	Period of record	Number of peaks	Method of discharge computation	Skew coefficient	Recurrence interval, in years							
					2	5	10	25	50	100	200	500
2301500 Alafia River at Lithia	1933-76	44	Station skew	1.02	2,890	6,420	10,700	19,600	30,400	46,200	69,500	117,000
			Generalized skew	0.36	3,170	6,780	10,400	16,800	23,300	31,400	41,600	59,200
			Regional equation		4,350	7,720	10,500	14,800	18,600	22,900	27,700	35,100
			Weighted		3,240	6,900	10,400	16,400	22,100	29,100	37,500	51,900
2301800 Sixmile Creek at Tampa	1957-74	18	Station skew	-0.95	619	937	1,110	1,290	1,390	1,480	1,560	1,640
			Generalized skew	0.14	557	926	1,220	1,640	2,000	2,390	2,820	3,450
			Regional equation		195	388	561	836	1,080	1,380	1,710	2,240
			Weighted		480	726	942	1,250	1,540	1,880	2,250	2,840
2301900 Fox Branch near Socrum	1965-76	12	Station skew	-0.66	5/ 223	363	451	554	624	687	746	817
			Generalized skew	0.14	270	579	872	1,360	1,830	2,390	3,060	4,160
			Regional equation		217	426	611	905	1,170	1,480	1,840	2,400
			Weighted		259	517	749	1,110	1,450	1,850	2,310	3,070
2302500 Blackwater Creek near Knights	1952-76	25	Station skew	0.85	1,080	1,720	2,300	3,230	4,110	5,170	6,440	8,540
			Generalized skew	0.14	1,150	1,780	2,250	2,910	3,440	4,010	4,630	5,510
			Regional equation		621	1,130	1,560	2,220	2,810	3,470	4,220	5,380
			Weighted		1,080	1,610	2,040	2,670	3,210	3,810	4,480	5,460
2303000 Hillsborough River near Zephyrhills	1940-76	37	Station skew	0.35	2,140	3,810	5,260	7,550	9,630	12,100	14,900	19,400
			Generalized skew	0.17	2,180	3,840	5,210	7,280	9,080	11,100	13,400	16,900
			Regional equation		1,280	2,230	3,010	4,190	5,200	6,340	7,620	9,550
			Weighted		8,100	3,520	4,680	6,360	7,860	9,520	11,400	14,300
2303100 New River near Zephyrhills	1965-75	11	Station skew	-0.77	5/ 165	233	270	309	334	355	374	395
			Generalized skew	0.14	174	264	331	424	499	578	663	784
			Regional equation		187	334	457	645	809	993	1,200	1,520
			Weighted		177	289	383	528	648	783	934	1,150
2303400 Cypress Creek near San Antonio	1964-76	13	Station skew	0.13	5/ 154	340	518	822	1,110	1,460	1,890	2,580
			Generalized skew	0.14	193	497	827	1,440	2,080	2,900	3,950	5,770
			Regional equation		405	757	1,060	1,540	1,960	2,440	3,000	3,860
			Weighted		222	576	916	1,490	2,020	2,650	3,410	4,650
2303420 Cypress Creek at Worthington Gardens	1964-76	11	Station skew	0.15	5/ 529	878	1,150	1,550	1,890	2,260	2,660	3,260
			Generalized skew	0.14	636	1,150	1,590	2,260	2,840	3,500	4,260	5,400
			Regional equation		474	898	1,270	1,840	2,360	2,950	3,630	4,690
			Weighted		597	1,040	1,440	2,030	2,570	3,180	3,890	4,980
2303800 Cypress Creek near Sulphur Springs	1965-76	12	Station skew	0.20	5/ 585	1,030	1,410	2,000	2,510	3,100	3,760	4,790
			Generalized skew	0.14	728	1,410	2,020	2,980	3,860	4,870	6,050	7,900
			Regional equation		757	1,390	1,930	2,750	3,480	4,310	5,260	6,720
			Weighted		734	1,400	1,980	2,860	3,660	4,560	5,600	7,220

Table 7.--Comparison of station, regional, and weighted peak discharges - continued

Station number and name	Period of record	Number of peaks	Method of discharge computation	Skew coeffi-cient	Recurrence interval, in years							
					2	5	10	25	50	100	200	500
2307000 Rocky Creek near Sulphur Springs	1954-76	23	Station skew	-0.36	467	965	1,370	1,940	2,410	2,900	3,410	4,130
			Generalized skew	0.14	433	948	1,440	2,290	3,090	4,070	5,250	7,170
			Regional equation		530	1,040	1,500	2,230	2,890	3,670	4,590	6,020
			Weighted		443	969	1,460	2,270	3,020	3,910	4,980	6,690
2307359 Brooker Creek near Tarpon Springs	1951-76	26	Station skew	0.03	225	512	787	1,250	1,690	2,210	2,840	3,840
			Generalized skew	0.14	222	509	795	1,290	1,780	2,380	3,120	4,340
			Regional equation		357	731	1,080	1,640	2,170	2,790	3,530	4,710
			Weighted		233	550	860	1,390	1,900	2,520	3,270	4,470
2307697 Alligator Creek near Safety Harbor	1950-74	23	Station skew	-0.44	181	356	489	670	811	954	1,100	1,300
			Generalized skew	0.14	167	349	519	800	1,060	1,380	1,750	2,350
			Regional equation		290	572	826	1,230	1,610	2,050	2,560	3,370
			Weighted		178	392	592	927	1,230	1,600	2,030	2,710
2308289 Seminole Lake Outlet near Largo	1950-71	22	Station skew	-0.68	197	344	441	557	636	710	799	863
			Generalized skew	0.14	178	338	478	698	894	1,120	1,380	1,780
			Regional equation		133	295	451	717	971	1,280	1,660	2,270
			Weighted		172	327	470	705	922	1,180	1,490	1,960
2310000 Anclote River near Elfers	1945-76	32	Station skew	0.34	950	1,840	2,660	4,020	5,300	6,860	8,720	11,800
			Generalized skew	0.16	972	1,850	2,630	3,840	4,940	6,210	7,680	9,960
			Regional equation		908	1,730	2,450	3,590	4,610	5,790	7,160	9,300
			Weighted		967	1,830	2,590	3,770	4,840	6,080	7,510	9,750
2310240 Jumping Gully at Loyce	1964-76	13	Station skew	0.93	[5/] 65	185	354	768	1,330	2,250	3,750	7,800
			Generalized skew	0.14	84	226	324	686	1,000	1,420	1,960	2,910
			Regional equation		113	225	327	488	635	807	1,010	1,320
			Weighted		89	226	360	560	797	1,060	1,370	1,910
2310300 Pithlachascotee River near New Port Richey	1964-76	13	Station skew	0.32	[5/] 352	680	981	1,480	1,940	2,500	3,180	4,270
			Generalized skew	0.14	393	760	1,080	1,600	2,060	2,600	3,230	4,200
			Regional equation		491	894	1,230	1,750	2,210	2,720	3,310	4,200
			Weighted		410	805	1,140	1,670	2,130	2,660	3,270	4,200
2310800 Withlacoochee River near Eva	1959-76	18	Station skew	0.02	362	783	1,170	1,810	2,390	3,080	3,880	5,140
			Generalized skew	0.14	356	778	1,190	1,880	2,540	3,340	4,300	5,880
			Regional equation		331	659	954	1,430	1,860	2,360	2,950	3,880
			Weighted		352	743	1,110	1,690	2,230	2,870	3,620	4,870
2312000 Withlacoochee River at Trilby	1931-76	46	Station skew	0.13	1,400	2,730	3,910	5,770	7,450	9,390	11,600	15,200
			Generalized skew	0.14	1,400	2,730	3,910	5,780	7,470	9,430	11,700	15,300
			Regional equation		1,590	2,880	3,960	5,600	7,050	8,680	10,500	13,400
			Weighted		1,410	2,750	3,920	5,740	7,380	9,250	11,400	14,800

Table 7.--Comparison of station, regional, and weighted peak discharges - continued

Station number and name	Period of record	Number of peaks	Method of discharge computation	Skew coefficient	Recurrence interval, in years							
					2	5	10	25	50	100	200	500
2312200	1959-76	18	Station skew	0.48	389	883	1,410	2,420	3,480	4,700	6,770	10,100
Little Withlacoochee River near			Generalized skew	0.14	410	903	1,380	2,190	2,970	3,920	5,070	6,940
Rerdell			Regional equation		524	989	1,390	2,030	2,590	3,240	3,990	5,150
			Weighted		425	927	1,380	2,130	2,810	3,610	4,550	6,060
2312560	1940-76	37	Station skew	0.03	1,650	3,090	4,300	6,130	7,720	9,500	11,500	14,500
Withlacoochee River at Croom			Generalized skew	0.12	1,630	3,080	4,330	6,270	7,990	9,970	12,200	15,700
			Regional equation		1,450	2,480	3,320	4,560	5,610	6,770	8,670	10,000
			Weighted		1,620	2,980	4,110	5,800	7,290	8,970	10,800	13,800
2312640	1964-76	13	Station skew	-0.51	107	160	193	231	258	283	306	335
Juniper Creek Canal near Bushnell			Generalized skew	0.14	101	158	201	261	310	362	419	500
			Regional equation		119	229	325	474	608	762	938	1,210
			Weighted		104	180	245	348	434	533	645	803
2313000	1932-76	45	Station skew	-0.11	2,400	4,000	5,200	6,840	8,140	9,510	10,900	13,000
Withlacoochee River near Holder			Generalized skew	0.07	2,350	3,980	5,260	7,110	8,660	10,300	12,200	14,900
			Regional equation		2,310	4,030	5,430	7,530	9,340	11,300	13,600	17,000
			Weighted		2,350	3,990	5,290	7,200	8,810	10,500	21,800	15,400
2236500	1959-75	17	Station skew	0.42	99	219	344	575	814	1,120	1,520	2,230
Big Creek near Clermont			Generalized skew	0.14	103	223	338	531	714	937	1,200	1,640
			Regional equation		143	302	451	697	928	1,200	1,530	2,060
			Weighted		108	244	374	594	800	1,050	1,350	1,830
2237000	1946-55	10	Station skew	-0.61	173	362	506	695	837	976	1,110	1,290
Palatlakaha River near Mascotte			Generalized skew	0.14	153	354	556	908	1,250	1,680	2,210	3,080
			Regional equation		350	692	1,000	1,490	1,940	2,460	3,080	4,040
			Weighted		185	467	734	1,190	1,600	2,100	2,700	3,630
2239000	1931-68	38	Station skew	-0.40	977	1,430	1,660	1,890	2,010	2,120	2,200	2,290
Oklawaha River near Ocala			Generalized skew	0.05	946	1,350	1,630	2,000	2,280	2,560	2,860	3,260
			Regional equation		1,230	2,180	2,960	4,130	5,150	6,280	7,560	9,500
			Weighted		945	1,450	1,830	2,380	2,810	3,260	3,770	4,410
2240950	1959-76	18	Station skew	0.61	519	879	1,200	1,720	2,200	2,780	3,470	4,590
Hogtown Creek near Gainesville			Generalized skew	0.14	543	897	1,180	1,580	1,910	2,280	2,690	3,280
			Regional equation		439	707	912	1,200	1,440	1,700	1,980	2,390
			Weighted		527	839	1,080	1,420	1,700	2,010	2,340	2,840
2241900	1958-76	17	Station skew	-0.03	408	795	1,120	1,620	2,060	2,540	3,090	3,900
Lochloosa Creek at Grove Park			Generalized skew	0.14	408	782	1,110	1,620	2,090	2,620	3,240	4,190
			Regional equation		479	884	1,230	1,760	2,240	2,780	3,400	4,350
			Weighted		418	811	1,150	1,680	2,150	2,690	3,520	4,270

Table 7.--Comparison of station, regional, and weighted peak discharges - continued

Station number and name	Period of record	Number of peaks	Method of discharge computation	Skew coefficient	Recurrence interval, in years							
					2	5	10	25	50	100	200	500
2243500 Okalwaha River near Orange Springs	1931-52	22	Station skew	-0.15	3,800	5,530	6,690	8,150	9,230	10,300	11,400	12,800
			Generalized skew	0.14	3,720	5,500	6,780	8,530	9,920	11,400	12,900	15,100
			Regional equation		2,170	3,700	4,950	6,790	8,360	10,100	12,000	14,900
			Weighted		3,490	5,000	6,190	7,870	9,310	10,900	12,900	15,000
2244000 Okalawaha River at Riverside Lodge near Orange Springs	1944-68	25	Station skew	-0.81	4,410	6,500	7,660	8,900	9,680	10,300	10,900	11,600
			Generalized skew	0.14	4,050	6,420	8,230	10,800	12,900	15,100	17,500	21,100
			Regional equation		2,050	3,510	4,690	6,450	7,940	9,590	11,400	14,200
			Weighted		3,770	5,630	7,090	9,140	10,900	12,800	14,900	18,200
2256500 Fisheating Creek at Palmdale	1932-75	44	Station skew	-0.18	3,450	7,040	10,100	14,600	18,400	22,600	27,200	33,900
			Generalized skew	0.06	3,330	6,970	10,300	15,700	20,600	26,400	33,200	43,700
			Regional equation		2,710	5,180	7,350	10,700	13,800	17,300	21,400	27,800
			Weighted		3,290	6,690	9,730	14,500	18,800	23,800	29,700	39,000
2262900 Boggy Creek near Taft	1960-74	15	Station skew	0.40	5/515	1,090	1,680	2,710	3,750	5,070	6,740	9,620
			Generalized skew	0.14	588	1,240	1,850	2,870	3,830	4,970	6,350	8,560
			Regional equation		564	1,100	1,580	2,340	3,040	3,850	4,790	6,260
			Weighted		584	1,190	1,740	2,620	3,440	4,390	5,520	7,320
2263800 Shingle Creek at Airport near Kissimmee	1959-75	17	Station skew	0.13	548	1,090	1,580	2,360	3,070	3,900	4,870	6,390
			Generalized skew	0.14	547	1,090	1,580	2,360	3,080	3,900	4,910	6,460
			Regional equation		668	1,330	1,940	2,920	3,810	4,870	6,110	8,080
			Weighted		564	1,160	1,700	2,580	3,380	4,320	5,440	7,180
2264000 Cypress Creek near Vineland	1946-75	30	Station skew	-0.59	40	93	137	198	245	294	342	407
			Generalized skew	0.09	35	91	151	260	371	513	690	993
			Regional equation		51	115	179	287	390	517	670	918
			Weighted		36	95	157	267	377	514	683	968
2266500 Reedy Creek near Loughman	1940-69	21	Station skew	-0.44	434	560	603	633	645	652	656	659
			Generalized skew	0.14	413	527	600	692	760	828	896	987
			Regional equation		339	622	862	1,230	1,550	1,920	2,340	2,980
			Weighted		403	549	669	853	998	1,160	1,340	1,560
2269000 Kissimmee River below Lake Kissimmee	1934-69	36	Station skew	-0.43	2,400	4,690	6,430	8,800	10,600	12,500	14,400	17,000
			Generalized skew	0.06	2,250	4,620	6,770	10,200	13,300	17,000	21,200	27,800
			Regional equation		1,420	2,800	4,040	6,000	7,780	9,860	12,300	16,000
			Weighted		2,170	4,260	6,110	8,940	11,500	14,600	18,100	23,600
2270500 Arbuckle Creek near DeSoto City	1940-74	35	Station skew	-0.18	1,850	3,610	5,050	7,150	8,900	10,800	12,900	15,800
			Generalized skew	0.10	1,790	3,570	5,180	7,730	10,000	12,700	15,900	20,700
			Regional equation		1,820	3,410	4,780	6,930	8,840	11,000	13,600	17,500
			Weighted		1,790	3,540	5,100	7,520	9,670	12,200	15,200	19,700

Table 7.--Comparison of station, regional, and weighted peak discharges - continued

Station number and name	Period of record	Number of peaks	Method of discharge computation	Skew coefficient	Recurrence interval, in years							
					2	5	10	25	50	100	200	500
2271500 Josephine Creek near DeSoto City	1947-75	29	Station skew	-0.42	396	740	995	1,340	1,600	1,860	2,120	2,480
			Generalized skew	0.11	368	728	1,050	1,560	2,020	3,550	3,170	4,130
			Regional equation		744	1,330	1,830	2,570	3,220	3,960	4,790	6,060
			Weighted		393	819	1,200	1,810	2,330	2,940	3,650	4,710
2293000 Orange River near Fort Myers	1936-74	15	Station skew	0.84	735	1,440	2,190	3,580	5,070	7,050	9,690	14,600
			Generalized skew	0.14	801	1,510	2,120	3,080	3,930	4,910	6,030	7,760
			Regional equation		524	1,080	1,590	2,440	3,220	4,160	5,270	7,040
			Weighted		746	1,360	1,900	2,780	3,580	4,530	5,640	7,390
2313400 Waccasassa River near Bronson	1964-76	9	Station skew	-0.43	253	534	760	1,080	1,330	1,600	1,870	2,250
			Generalized skew	0.14	253	501	723	1,080	1,400	1,780	2,220	2,920
			Regional equation		590	1,100	1,540	2,210	2,800	3,480	4,250	5,420
			Weighted		313	707	1,060	1,630	2,110	2,680	3,330	4,300
2314200 Tenmile Creek at Lebanon Station	1964-76	13	Station skew	1.04	658	1,310	2,040	3,470	5,070	7,310	10,400	16,500
			Generalized skew	0.14	735	1,400	1,970	2,870	3,670	4,600	5,660	7,310
			Regional equation		506	985	1,410	2,100	2,730	3,460	4,320	5,660
			Weighted		685	1,240	1,720	2,470	3,170	3,970	4,900	6,380
2321000 New River near Lake Butler	1950-71	22	Station skew	-0.61	2,840	5,670	7,370	9,150	10,200	11,100	11,700	12,400
			Generalized skew	0.14	2,780	4,980	6,810	9,580	12,000	14,700	17,800	22,400
			Regional equation		2,610	4,660	6,360	8,910	11,100	13,600	16,400	20,600
			Weighted		2,760	4,900	6,680	9,340	11,700	14,300	17,200	21,700
2321700 Swift Creek near Lake Butler	1958-75	17	Station skew	0.60	497	797	1,050	1,450	1,810	2,230	2,720	3,490
			Generalized skew	0.14	497	823	1,080	1,450	1,760	2,100	2,480	3,030
			Regional equation		319	650	954	1,450	1,900	2,440	3,080	4,080
			Weighted		465	768	1,030	1,450	1,820	2,250	2,750	3,480
2322000 Santa Fe River near High Springs	1931-71	41	Station skew	-0.51	3,640	7,310	10,100	13,900	16,700	19,600	22,500	26,300
			Generalized skew	0.00	3,370	7,210	10,700	16,400	21,600	27,600	34,600	45,500
			Regional equation		5,130	8,540	11,300	15,200	18,500	22,200	26,300	32,300
			Weighted		3,470	7,390	10,800	16,100	20,800	26,100	32,200	41,500
2322500 Santa Fe River near Fort White	1928-75	45	Station skew	-0.14	4,260	7,100	9,210	12,100	14,300	16,700	19,100	22,600
			Generalized skew	0.07	4,170	7,060	9,340	12,600	15,400	18,300	21,600	26,400
			Regional equation		4,050	6,900	9,200	12,600	15,400	18,600	22,100	27,400
			Weighted		4,160	7,040	9,320	12,600	15,400	18,400	21,700	26,700
2323000 Suwannee River near Bell	1932-56	26	Station skew	0.87	15,900	27,500	38,600	57,800	76,800	101,000	131,000	183,000
			Generalized skew	0.15	17,100	28,600	37,700	50,900	62,100	74,500	88,100	108,000
			Regional equation		19,400	32,300	42,400	57,100	69,500	83,000	98,000	120,000
			Weighted		17,300	29,400	38,900	52,800	64,500	77,400	91,600	112,000

Table 7.--Comparison of station, regional, and weighted peak discharges - continued

Station number and name	Period of record	Number of peaks	Method of discharge computation	Skew coefficient	Recurrence interval, in years							
					2	5	10	25	50	100	200	500
2323500 Suwannee River near Wilcox	1944-75	34	Station skew	0.24	19,800	31,500	40,600	53,700	64,600	76,600	89,900	109,000
			Generalized skew	0.15	20,000	31,600	40,400	52,900	63,100	74,200	86,200	104,000
			Regional equation		18,600	31,000	40,900	55,200	67,300	80,400	95,100	117,000
			Weighted		19,900	31,500	40,500	53,500	64,300	76,000	88,900	108,000

1/ Station frequency distribution computed from skew of annual peaks.

2/ Adjusted station frequency distribution computed from generalized (weighted) skew, WRC Bulletin 17.

3/ Regional frequency distribution computed from regression equation.

4/ Weighted frequency distribution computed from equation for weighting of independent estimates, WRC Bulletin 17, Appendix 8 (equation 6 in this report).

5/ Frequency distribution adjusted by two-station comparison, WRC Bulletin 17, Appendix 7.

The accuracy of the weighted estimate, Q_W, in equivalent years of record, is equal to N_1 plus N_2 provided the estimate Q_{RG} and the estimate Q_G are independent. A flood discharge estimated by regional regression tends to be independent of the estimate obtained from the station frequency distribution. For situations where the estimates are not independent, accuracy is reduced in proportion to the degree of correlation of the estimates. The stations used in this analysis cover a very large area, therefore, estimates are assumed to be independent.

Regional estimates, Q_{RG}, computed by use of equation 5, along with estimates of the adjusted station frequency distribution using the generalized skew, Q_G, are provided as a convenience in table 7 for the 64 selected streamflow stations used in the study.

Ungaged Sites

Flood magnitudes for ungaged sites are determined by using the appropriate values of drainage area, slope, lake area, and soils index in the regional estimating equation (equation 5). Inspection of figure 4 is also required to determine the correct geographic zone.

The regional estimate for the ungaged site can be improved if the site is located near a gaging station with at least 10 years of record. A constant obtained by using the ratio of Q_W to Q_{RG} (as defined for gaged sites) is used to adjust the regional estimates. This procedure should only be applied to sites on the same stream where gaged sites have drainage area ratios (r) of more than half or less than twice the drainage area of the ungaged site. Otherwise, the regional estimate at the ungaged site is the best estimate available.

The adjusted estimate, Q_U, for an ungaged site can be determined from equation 7 as follows:

$$Q_U = Q_{RU}\left[\left(\frac{Q_W}{Q_{RG}} - 1\right) \cdot \left(\frac{2A_U - A_G}{A_U}\right) + 1\right]$$ For gaged sites downstream from ungaged sites

(7)

$$Q_U = Q_{RU}\left[\left(\frac{Q_W}{Q_{RG}} - 1\right) \cdot \left(\frac{2A_G - A_U}{A_U}\right) + 1\right]$$ For gaged sites upstream from ungaged sites

where Q_{RU} = Regional estimate for the ungaged site from the regression equation, in cubic feet per second;

Q_W = Weighted estimate of the T-year flood at the gaged site, in cubic feet per second;

Q_{RG} = Regional flood estimate for the gaged site from the regression equation, in cubic feet per second;

A_U = Drainage area for the ungaged site, in square miles;

A_G = Drainage area for the gaged site, in square miles.

For ungaged sites the accuracy of the adjusted estimate, Q_U, in equivalent years of record, is not the sum of the accuracy of each estimate. Intuition suggests some figure of accuracy greater than N_2 but less than $N_1 + N_2$. Obviously, if the regional estimate is the only estimate available, then the accuracy of the estimate in equivalent years of record is equal to N_2.

Illustrated Examples

In summary, the procedure for estimating flood discharges for a desired recurrence interval is outlined below.

Category	Method used	Explanation	Accuracy, in equivalent years, N
Gaged sites; greater than or equal to 10 years of record.	Q_W; equation 6	Gaged site station data weighted with regional estimate.	$N = N_1 + N_2$
Gaged sites; less than 10 years of record.	See ungaged sites.	--	--
Ungaged sites; located near gaged site.	Q_U; equation 7	Regional estimate at ungaged site adjusted against ratio of weighted station data to regional estimate at gaged site.	$N_2 < N < (N_1 + N_2)$
Ungaged sites; not located near gaged site.	Q_{RU}; equation 5	Regional estimate is the best estimate available.	$N = N_2$

In order to estimate flood discharges for any of the above categories in which the basin in question crosses a geographic zone boundary, a weighted zone coefficient, at the point where the discharge is desired, should be used. Overlap of zone boundaries has been accounted for in the development of the regression equations.

Two examples are shown to help clarify the use of the techniques described in this report.

Example 1: Assume a discharge is desired for a flood with a recurrence interval of 50 years for an ungaged site on the Peace River.

(1) First calculate Q_{RU} by equation 5.

$$Q_{RU} = C_R \quad C_G \quad DA^{B_1} \quad SL^{B_2} \quad LK^{B_3} \quad SO^{B_4}$$

$$= 140 \quad 1.28 \; (460)^{0.79} \; (1.30)^{0.46} \; (11.8)^{-0.10} \; (4.05)^{-0.70}$$

$$= 7{,}530 \text{ ft}^3/\text{s}.$$

B_1, B_2, B_3, B_4, C_R from table 4.

C_G from table 5 (site located in zone 3).

DA, SL, LK, SO measured for the ungaged site.

(2) A gaged site was located 13.3 mi upstream, station 02294650.

(a) Compute drainage area ratio (r) to determine if site is within the range of applicability.

$$r = A_G/A_U$$

$$= 390/460$$

$$= 0.85$$

Therefore, data can be used to adjust the estimate at the ungaged site.

(b) Adjust regression estimate using equation 7 for the gaged site upstream condition.

$$Q_U = Q_{RU} \; [(\frac{Q_W}{Q_{RG}} - 1)(\frac{2A_G - A_U}{A_U}) + 1]$$

$$Q_U = 7{,}530 \; [(\frac{4{,}830}{6{,}480} - 1)(\frac{2(390) - 460}{460}) + 1]$$

$$Q_U = 7{,}530 \; [(-0.255) \; (0.696) + 1]$$

$$Q_U = 7{,}530 \; (0.822)$$

$$Q_U = 6{,}190 \text{ ft}^3/\text{s}.$$

(3) Accuracy in equivalent years of record.

$$N_2 < N < (N_1 + N_2)$$

$$13 < N < (37 + 13)$$

$$13 < N < 50.$$

Example 2: Determine the 100-year flood for a gaged site on the upper Manatee River, station 02299950, having 10 years of record.

(1) Compute weighted estimate using equation 6.

$$\log Q_W = \frac{N_1 \ (\log Q_G) + N_2 \ (\log Q_{RG})}{N_1 + N_2}$$

$$= \frac{10 \ (\log 3{,}570) + 14 \ (\log 10{,}000)}{24}$$

$$\log Q_W = 3.8136$$

$$Q_W = 6{,}510 \ ft^3/s$$

Q_G, Q_{RG}, N_1 from table 7, N_2 from table 6.

(2) Determine accuracy in equivalent years.

$$N = N_1 + N_2$$

$$= 10 + 14$$

$$N = 24 \text{ years.}$$

Limitations of Relations

Regional flood-frequency relations provided in this report should be considered as defining relations within the range of data used. The maximum and minimum values of the basin characteristics used to calibrate the estimating equation are summarized in the following table:

Basin Characteristic	Range
Drainage area	10 to 2,500 mi^2
Soils index	1.9 to 12.2 in.
Slope	0.21 to 23.5 ft/mi
Lake area	0.01 to 27.5 percent

There were several stations used in the regional analysis with drainage areas larger than the range specified above. These stations were peripheral stations used to improve geographical zone delineations and were not used in determining the upper limit of drainage area to be used in the estimating equations. A planner should review each situation carefully before applying the methods in this report. For example, areas with a large number of sinkholes or karst topography may have significantly reduced flood peaks. In these areas, care should be taken in the use of the regression equations because the discharge calculated may not be representative of the actual discharge. In areas where peak flows were significantly affected by manmade works such as dams and reservoirs, or when changes in the watershed are occurring, such as urbanization, this method may not be applicable. In these situations, the planner should investigate the use of other techniques such as a hydrologic model to evaluate the specific problem.

ASSESSMENT OF RESULTS

Further research is needed to find additional or improved independent variables that would reduce the standard error of the regionalized regression equations or alternately, to find other estimating techniques. Further study can be made of the independent variables (basin characteristics) used in developing the regionalized regression equations. Drainage area, DA, had the greatest significance of all variables used and on the average, the geographic coefficient, C_G, was second in significance followed by soils index, SO, slope, SL, and lake area, LK, in that order.

None of the independent variables, either singularly or jointly, completely explain all of the variation in peak flows. Drainage area versus 50-year peak flows, shown in figure 7, illustrates this point. Although a general relationship is indicated, considerable scatter exists.

Intercorrelation among independent variables also exists. An almost perfect correlation was found between drainage area and length which resulted in the length parameter being dropped from the regression analysis.

The geographic zone coefficient, C_G, represents measurement error of the basin parameters and unknown hydrologic variables operating in each of the zones not explained by basin characteristics used in the analysis. Values of C_G used range from 0.59 to 1.29.

The final set of regional equations included four basin characteristics and C_G, where all parameters were significant at the 5 percent level or better. Inclusion of the geographic zone coefficient in the regression analysis was useful in reducing the standard errors of estimate of the regional equations. Values of C_G were determined from a partition analysis of the study area based on residual error of the regression for the 50-year recurrence interval. These values were then used to finalize the regression equations for all recurrence intervals. To what degree this approach contributed to the higher standard errors associated with the lower recurrence intervals is not known. However, residual error plots for all recurrence intervals were prepared and generally defined similar geographic zone boundaries. Further reduction in standard error may have been achieved if C_G had been optimized for one of the lower (2- through 10-year) recurrence intervals.

Effect of measurement errors in basin characteristics on flood estimates are not accurately determined. However, the regression equation was evaluated for incremental changes in the basin characteristics to determine the sensitivity of the regression equation. The results are shown

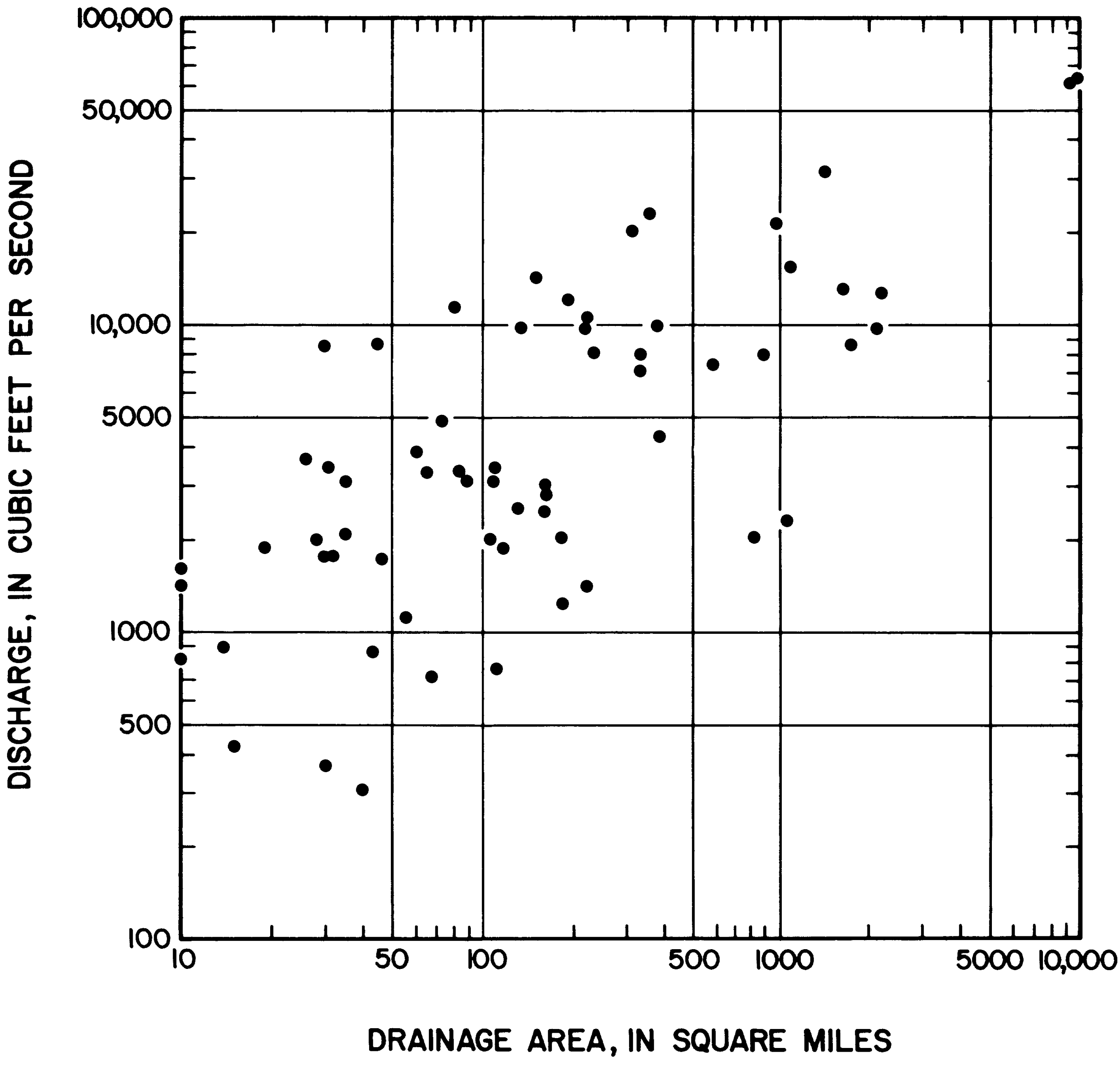

Figure 7.--Variation of 50-year flood with drainage area.

in the following table for 5 and 20 percent change in each value of the independent variable. The corresponding percent change of the estimate is also shown.

Basin characteristic[1/]	Percent change in 50-year regional estimate for 5 and 20 percent increase in basin characteristic value	
	5	20
Drainage area	4	15
Channel slope	2	9
Soils index	-3	-12
Lake area	-1	- 2

1/ Basin characteristic values used were for station number 02294650, Peace River at Bartow.

As expected, the greatest percent change in the estimate occurs in the order of variable significance. Combined error effects were not evaluated.

SUMMARY

Regional flood-frequency relations were developed for streams in west-central Florida. Flood data through September 1976 and basin characteristic data were used in a multiple linear-regression analysis to develop the regional relations.

Current guidelines and procedures recommended by the U.S. Water Resources Council (1976) were used in the station data analysis. The Pearson Type III distribution with log transformation of the annual peaks was used as the basic distribution for defining the flood-frequency distributions. From an analysis of area long-term station records, a generalized skew was determined and used to improve station flood-frequency distributions. Comparison of flood events between similar watersheds was used to reduce time sampling errors inherent in records of short-term stations.

Finally, in a multiple linear-regression analysis, flood magnitudes for recurrence intervals of 2, 5, 10, 25, 50, 100, 200, and 500 years were related to basin characteristics. Parameters found to be significant at the 5 percent level, or better, include drainage area, soils index, channel slope, and lake area. A geographic zone coefficient evaluated from a partitioning of the study area was used to determine the final regional flood relations. Average standard error of the estimate of the regional relations is 43.5 percent. Accuracy of the estimates in terms of equivalent years of record is provided. Methods are described to adjust flood estimates at gaged and ungaged sites based on the weighting of independent estimates.

The relations provided in this report are valid for determining flood potential at sites whose drainage area is greater than 10 mi^2 but less than 2,500 mi^2 and on streams where flood discharges are not significantly affected by regulation, tide, or ubanization.

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U. S. GOVERNMENT PRINTING OFFICE: 1980 - 646-613