AN EVALUATION OF THE CREST-STAGE GAGE PROGRAM IN LOUISIANA

By Richard A. Herbert, Darrell D. Carlson, and Gregg J. Wiche

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Multiply	By	To obtain
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
foot (ft)	0.3048	meter (m)
foot per mi (ft/mi)	0.1894	meter per kilometer (m/km)
inch (in.)	2.54	centimeter (cm)
square mile (mi^2)	2.590	square kilometer km^2)

"National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called mean sea level. NGVD of 1929 is referred to as sea level in this report."

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ABSTRACT

The crest-stage gage program in Louisiana was evaluated to determine if the data were adequate for use in developing regional flood-frequency equations and to determine if any crest-stage gage stations could be discontinued. An abundance of data at many crest-stage gage stations and a lack of data for urban areas and flat-slope areas indicated a need for a shift in the number, type, and locations of gages. Extensive correlations and comparisons of annual peak discharges and watershed characteristics of 96 existing stations resulted in a reduced network of 25 stations that could be used for future flood-frequency analyses.

The adequacy of the reduced network for development and verification of regional flood-frequency equations was tested by comparing a set of regional flood-frequency equations developed using data from the full network with a set developed using data from the reduced network. The results indicate that the crest-stage gage network can be reduced to 25 stations and still provide adequate information for future flood-frequency analyses.

INTRODUCTION

The crest-stage gage network in Louisiana was begun in 1948 by the U.S. Geological Survey as a cooperative program with the Louisiana Department of Highways (now Department of Transportation and Development, Office of Highways) to provide flood information for the efficient design of highway bridges and culverts. Currently, almost 85 percent of the State funding for the program is supported by the Office of Highways. The Louisiana Department of Transportation and Development, Office of Public Works, provides the remainder of the State funding.

Crest-stage gage stations were installed to expand the geographic coverage of flood data beyond that available at continuous-record gaging stations. Annual peak discharges can be defined at a crest-stage gage station at a fraction of the cost of operating a continuous-record gaging station.

Since the beginning of the crest-stage gage program, three editions of "Floods in Louisiana, Magnitude and Frequency" have been published (Cragwall, 1952; Sauer, 1964; and Neely, 1976). The flood-frequency information in these reports is used by the Office of Highways, the Office of Public Works, other agencies, and individuals for design and construction programs, flood mapping, and other projects. Flood-frequency characteristics at representative sites throughout the State are also needed as a basis for estimating the characteristics at ungaged sites. The flood-frequency information has been updated periodically to ensure that the most current data are available for the design of bridges, culverts, canals, and other structures that pass or convey streamflow.

This report describes a study of the crest-stage gage network that includes examining the quality of information collected at each existing site and the adequacy of the coverage geographically and with respect to various hydrologic conditions. Results of the study recommend modification of the network.

Purpose

This report presents an evaluation which supports the discontinuation of some crest-stage gage stations in Louisiana. Because there are as many as 35 years of peak-discharge data at many crest-stage gage stations and little or no data in urban and coastal areas, a shift in the emphasis of the program was being considered. The objective of the analysis was to determine if the existing network of crest-stage gages could be reduced to a smaller number of index stations and still maintain an adequate data base for the development and verification of regional flood-frequency equations.

Acknowledgments

The statistical analyses in this report were completed with the assistance of Brent Troutman of the U.S. Geological Survey.

INSTRUMENTATION

A crest-stage gage is a high-water indicator that records peak elevations. As shown in figure 1, the gage is made from a length of 2-inch galvanized pipe that is equipped with a bottom intake fitting and a vented top fitting. A 3/4- by 1 1/2-inch redwood measuring stick is placed inside the pipe. As the water level rises in the stream, regranulated cork placed in a perforated tin cup or wire basket at the bottom of the stick floats on the water surface in the pipe. When the water recedes, the cork adheres to the measuring stick leaving a high-water mark. The gage is installed vertically, generally on or near an existing highway bridge or culvert or at a proposed bridge site. Discharge measurements are made periodically to develop a stage-discharge relationship that can be used to compute the discharge for the annual peak discharges.

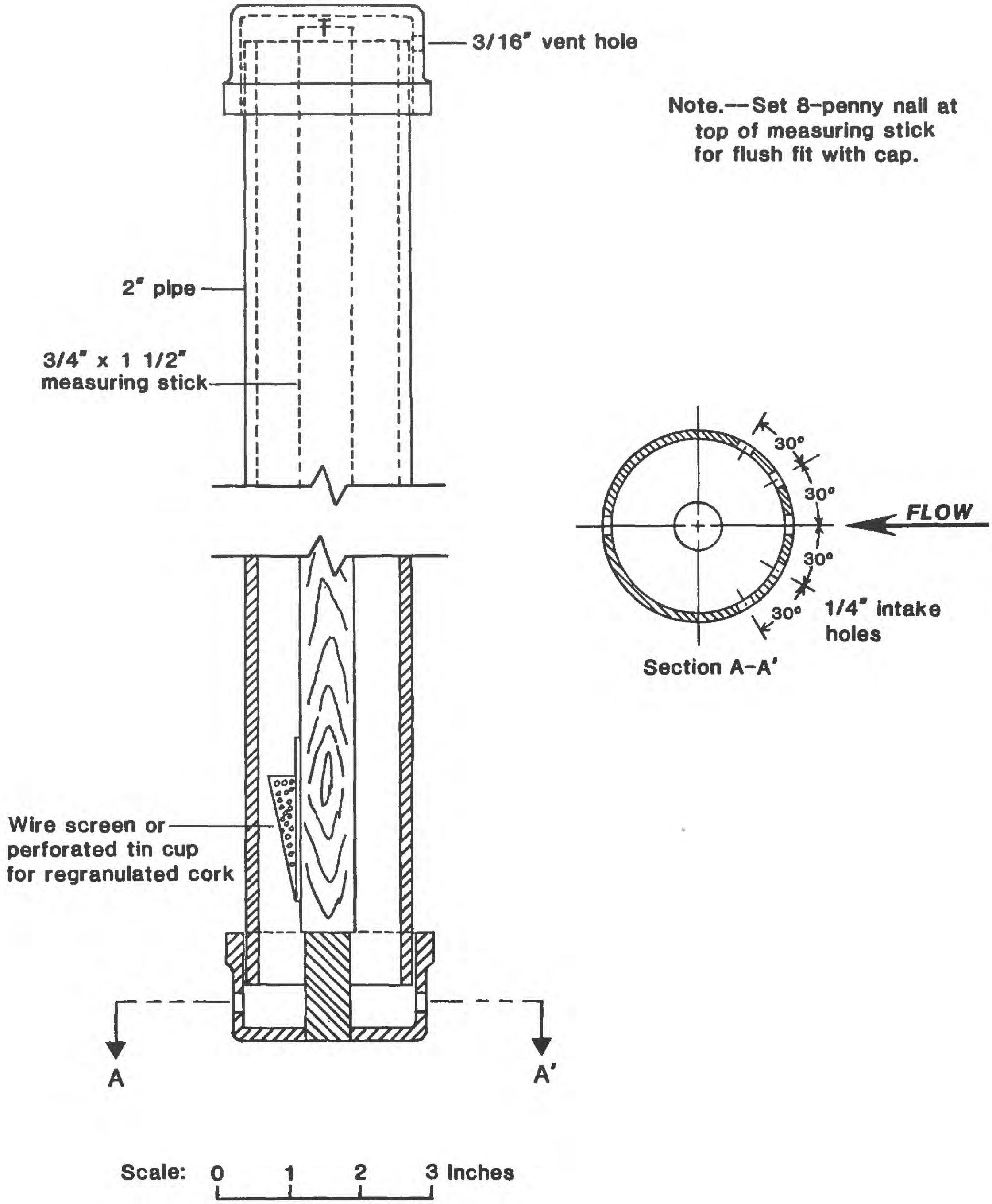

Figure 1.--Cross-section of a crest-stage gage.

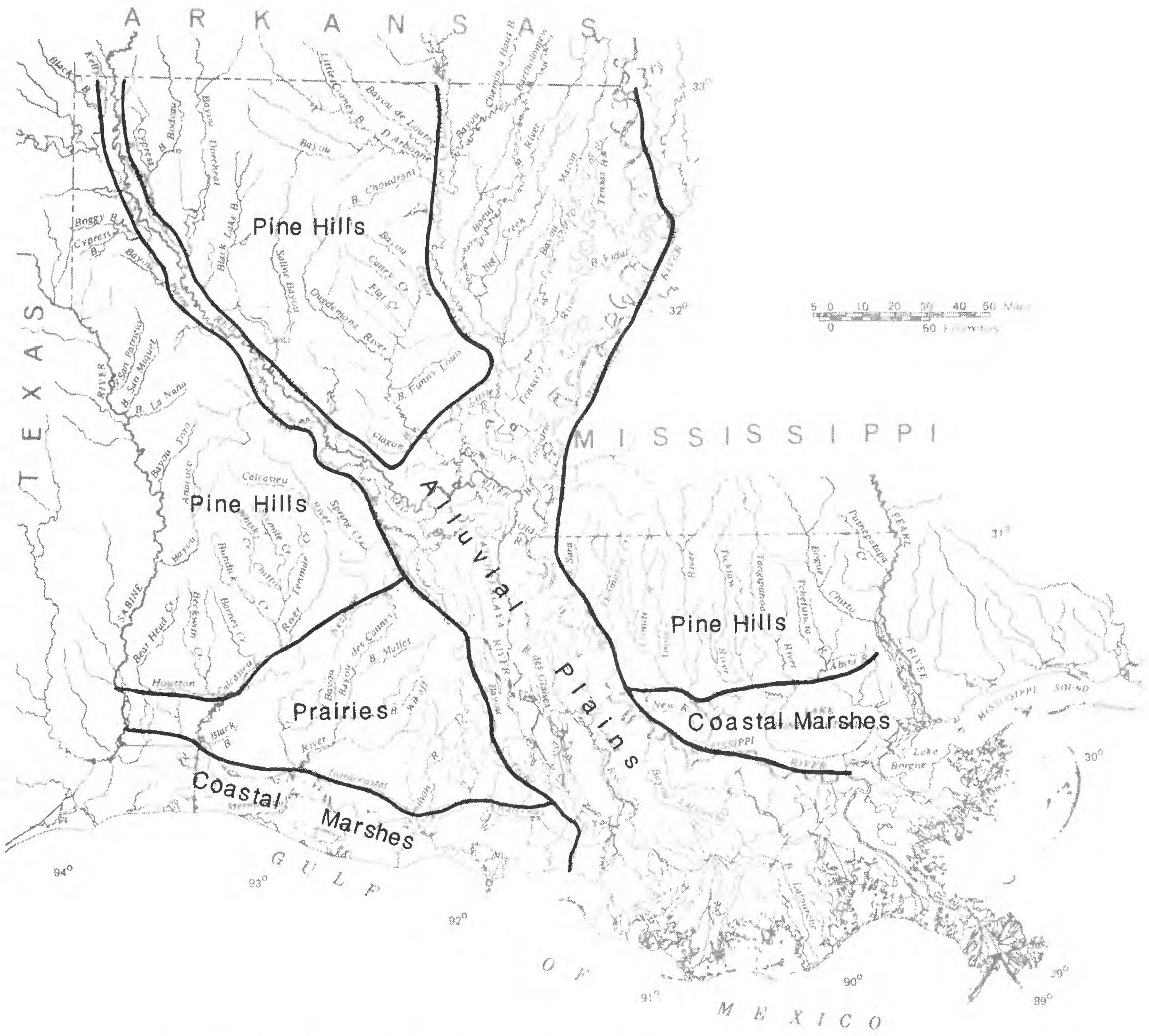

Figure 2.--Physiographic regions of Louisiana.

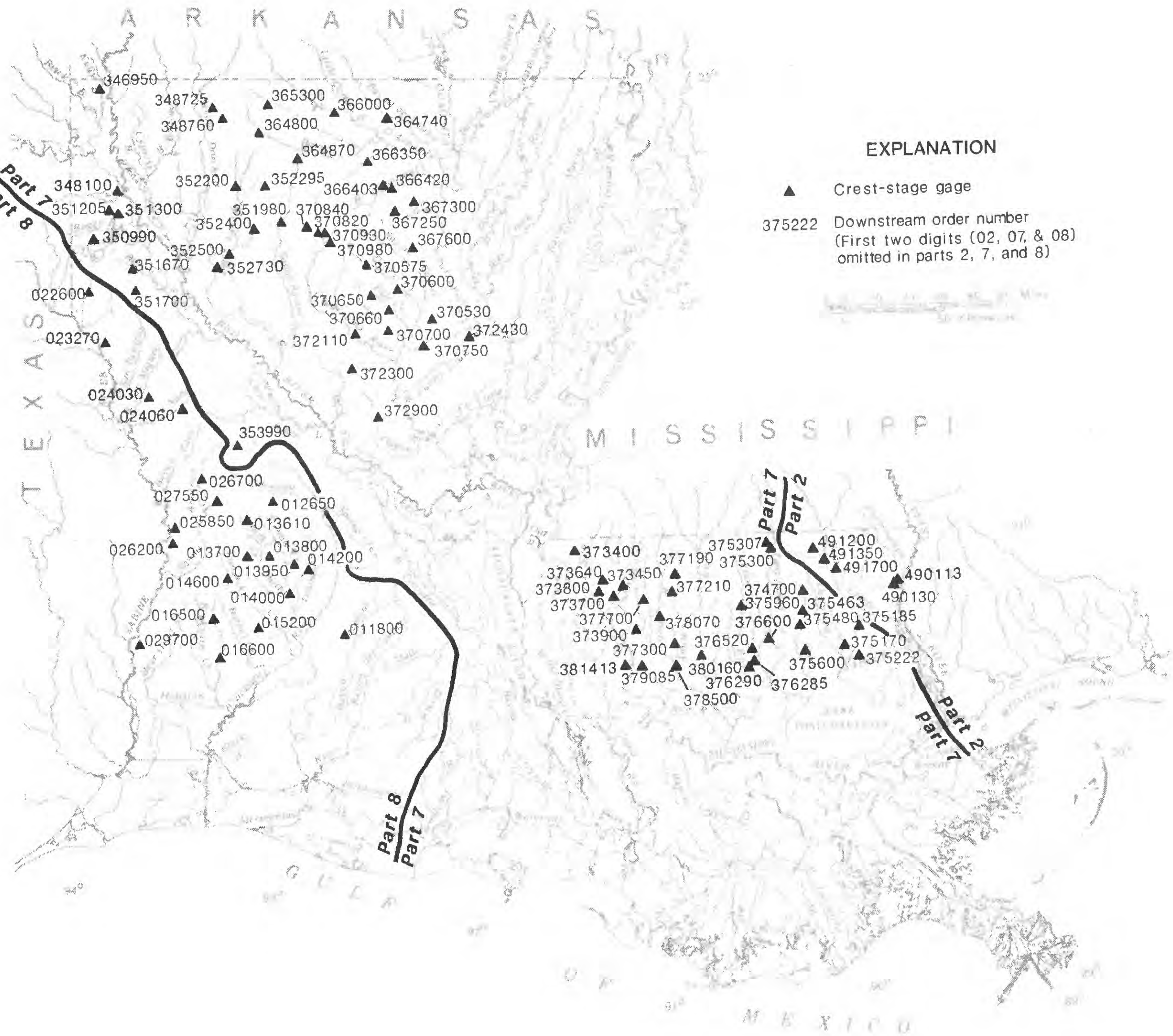

Figure 3.--Location of crest-stage gage stations in Louisiana, 1983.

PHYSIOGRAPHIC REGIONS IN LOUISIANA

In his flood-frequency report for Louisiana, Sauer (1964) divided the State into four major physiographic regions; (1) pine hills, (2) prairies, (3) coastal marshes, and (4) alluvial plains. He described these features, shown in figure 2, as being major factors influencing the magnitude and frequency of floods.

The pine hills region includes a large part of the State and can reach elevations up to almost 400 ft above sea level. It has the largest relief of the four physiographic regions.

According to Sauer (1964), the prairies are located in the southwestern part of the State. They range up to 50 ft above sea level and are generally treeless, except for some timber along the sluggish, meandering streams. The prairies blend into the coastal marshes, which fringe the Gulf Coast and are subject to inundation from tides. The alluvial plains are the river flood plains which extend up the Mississippi, Ouachita, and Red Rivers.

DESCRIPTION OF THE CREST-STAGE GAGE NETWORK

The crest-stage gage network in Louisiana in 1983 consisted of 96 crest-stage gage stations. A comparison of figures 2 and 3 shows that nearly all of the crest-stage gage stations are located in the pine hills region. Because stage-discharge relationships were difficult or impossible to develop in the flat slope regions due to factors such as extremely low velocities, backwater, and tidal effects, very few gages were located in the alluvial plains (3 stations), prairies (1 station), and coastal marshes (no stations). In addition, most of the gages are in rural areas, and very little information has been collected (1 station) in urban areas through this program.

Drainage areas range from 0.13 to 884 mi^2 (table 1). Approximately 12 percent of the stations have drainage areas less than 10 mi^2, 58 percent are 10 to 50 mi^2 and about 30 percent are greater than 50 mi^2. Channel slopes range from 1.86 to 114 ft/mi and the average annual rainfall ranges from 46 to 64 in.

EVALUATION OF THE CREST-STAGE GAGE NETWORK

Evaluation of the crest-stage gage network consisted of two major phases, the data review phase and the network evaluation phase. The data review was needed before new flood-frequency equations could be developed (F. Lee, U.S. Geological Survey, oral commun., 1983). The review of the data included extensive updating and some revision of the peak-discharge data. Because there was sufficient information at many sites to define the flood-frequency distribution, the network evaluation was begun to determine if the total number of crest-stage gage stations could be reduced without affecting the adequacy of data available for checking and verifying regional flood-frequency equations.

Table 1.--Crest-stage gage stations in Louisiana in operation as of 1983

[Area: A, approximation. Quality of rating: G, good; F, fair; P, poor; NR, no rating. Cooperator: H, Office of Highways; P, Office of Public Works]

Station number	Station name	Drainage area (square miles)	Channel slope (feet per mile)	Average annual rainfall (inches)	Period of record	Quality of rating	Cooperator
02490113	Bogue Lusa Creek at State Highway 21, at Bogalusa.	75.9	6.17	60	8/68-	G	P
02490130	Coburn Creek at Bogalusa------------------	7.96	13.5	60	8/68-	P	P
02491200	Silver Creek near Clifton----------------	50.1	8.20	62	9/55-10/63 10/65-	F	H
02491350	Hays Creek near Franklinton---------------	42.2	10.7	62	10/65-	G	P
02491700	Lawrence Creek near Franklinton-----------	44.2	11.4	46	10/63-	G	H
07346950	Kelly Bayou near Ida----------------------	A 73	11.4	46	11/68-	G	P
07348100	McCain Creek near Shreveport-------------	13.8	11.4	50	11/53-9/68 10/73-	P	H
07348725	Indian Creek at Shongaloo----------------	33.1	7.12	50	3/66-	F	H
07348760	Black Bayou at Leton---------------------	49.8	9.30	46	11/53-9/68 10/73-	P	H
07350990	Boggy Bayou at Woolworth Road, near Keithville.	41.3	12.4	46	10/65-	G	H
07351205	Brush Bayou tributary No. 2 at Shreveport-	3.68	15.9	47	10/66-8/71 11/72-	NR	H
07351300	Brush Bayou tributary near Shreveport-----	27.1	9.20	46	12/59-	F	P
07351670	Rambin Bayou near Frierson----------------	59.6	12.0	46	10/65-	P	H
07351700	Bayou Na Bonchasse near Mansfield---------	19.5	18.2	48	11/57-9/68 4/69-	G	H
07351980	Saline Bayou near Bienville---------------	54.9	5.84	52	2/66-	G	H
07352200	Black Lake Bayou near Minden--------------	38.6	10.2	51	12/50-9/68 10/73-	G	H
07352295	Black Lake Creek at Gibsland--------------	44.8	28.4	52	4/68-	G	P
07352400	Kepler Creek at Sparta--------------------	21.1	10.9	51	11/53-10/68 10/73-	G	H
07352500	Black Lake Bayou near Castor--------------	423	3.90	49	5/40-9/57 10/57-	G	P
07352730	Antoine Creek near Ashland----------------	17.7	21.1	50	5/64-	F	H
07353990	Kisatchie Bayou at Kisatchie--------------	37.3	9.55	54	11/65-	G	H
07364740	Bayou De Loutre near Farmerville----------	241	2.90	50	12/65-	G	H
07364800	Bayou D'Arbonne at Homer------------------	A 30	12.8	51	11/53-9/68 10/73-	F	H
07364870	Sugar Creek near Arcadia------------------	A 47	13.5	52	3/66-	G	H
07365300	Middle Fork Bayou D'Arbonne near Colquitt-	43.9	9.90	51	11/53-9/68 10/73-	P	H
07366000	Corney Bayou near Lillie------------------	462	3.50	50	6/40-9/57 10/57-	G	P
07366350	Stowe Creek near Farmerville--------------	A 29	11.9	51	11/53-9/68 10/73-	F	H
07366403	Bayou Choudrant tributary near Tremont----	.54	47.8	51	10/65-	G	H
07366420	Bayou Choudrant near Calhoun--------------	113	6.93	51	12/65-	F	H
07367250	Guyton Creek near Eros--------------------	8.76	18.7	51	10/67-	G	H
07367300	North Cheniere Creek at Cheniere----------	A 38	10.1	51	11/53-9/68 10/73-	G	H
07367600	Cypress Creek near Vixen------------------	A 16	12.7	51	11/53-9/68 10/73-	F	H
07370530	Black Bayou at Kelley---------------------	51.9	4.73	51	2/66-	G	H
07370575	Caney Creek near Chatham------------------	48.8	11.6	53	2/66-	F	H
07370600	Bayou Beaucoup near Cotton Plant----------	127	4.40	54	12/50-9/68 2/74-	G	H
07370650	Flat Creek near Sikes---------------------	41.5	7.20	55	12/50-9/68 2/74-	G	H
07370660	Flat Creek near Olla----------------------	103	1.86	56	12/65-	G	H
07370700	Beech Creek near Olla---------------------	A 58	7.10	56	11/53-9/68 2/74-	G	H
07370750	Big Chickasaw Creek near Olla-------------	47.6	8.10	56	11/53-	G	H
07370820	Dugdemona River near Quitman--------------	117	8.90	53	5/64-	G	H
07370840	Choctaw Creek near Quitman----------------	16.5	12.0	53	3/66-	G	H
07370930	Big Cypress Creek at Quitman--------------	91.8	7.80	53	12/65-	G	H
07370980	Little Dugdemona River near Hodge---------	A 20	12.7	53	5/64-	G	H
07372110	Brushy Creek near Joyce-------------------	A 24	10.8	56	6/64-	G	H

Table 1.--Crest-stage gage stations in Louisiana in operation as of 1983--Continued

Station number	Station name	Drainage area (square miles)	Channel slope (feet per mile)	Average annual rainfall (inches)	Period of record	Quality of rating	Cooperator
07372300	Bear Creek near Packton	A 11	13.3	55	11/53-9/68 2/74-	F	H
07372430	Bayou Funny Louis tributary No. 6 near Olla.	1.23	114	56	10/67-8/71 11/72-	P	H
07372900	Dyson Creek near Pollock	A 12	18.4	57	5/64-	F	H
07373400	Little Bayou Sara near Turnbull	22.3	18.6	56	3/49-6/61 10/62-9/68 2/74-	P	H
07373450	Thompson Creek at Jackson	99.3	9.20	56	3/49-9/59 10/71-9/73 8/74-	F	H
07373640	Hammer Creek tributary near Jackson	.20	64.8	55	10/67-	P	H
07373700	Thompson Creek near Starhill	249	8.40	56	3/49-9/68 2/74-	F	H
07373800	Alexander Creek near St. Francisville	23.9	14.3	55	4/53-9/68 2/74-	G	H
07373900	Bayou Baton Rouge above Baker	13.7	6.50	55	4/53-9/68 5/74-	G	H
07374700	Tchefuncta River near Franklinton	53.1	11.4	63	3/49-9/68 5/74-	G	H
07375170	Bogue Falaya at Covington	88.2	8.40	62	10/63-	G	H
07375185	Little Bogue Falaya near Blond	.91	28.6	62	10/76-	NR	H
07375222	Abita River north of Abita Springs	46.1	6.50	62	10/65-	G	H
07375300	Tangipahoa River near Kentwood	296	------	64	11/50-9/68 2/74-	F	H
07375307	Terrys Creek near Kentwood	52.0	8.20	64	10/65-	F	H
07375463	Chappepeela Creek near Husser	31.7	10.3	63	10/65-	G	H
07375480	Chappepeela Creek SE of Loranger	91.0	9.70	62	10/63-	G	H
07375600	Washley Creek near Robert	25.3	10.2	60	11/50-	P	H
07375960	Tickfaw River at Montpelier	220	7.20	60	12/50-9/68 2/74-	G	H
07376285	Hickory Branch near Albany	1.25	5.07	57	9/65-9/71 11/74-	NR	H
07376290	Blood River near Springfield	26.6	4.90	57	10/63-	F	H
07376520	Little Natalbany River at Albany	40.6	5.60	58	10/65-	G	H
07376600	Ponchatoula Creek at Natalbany	13.8	4.30	59	11/50-	P	H
07377190	Sandy Creek SE of Clinton	17.2	14.8	60	10/65-	G	H
07377210	Sandy Creek near Pride	69.9	7.30	58	5/74-10/74 11/76-	G	P
07377300	Amite River at Magnolia	884	5.50	55	3/49-	G	H
07377700	Redwood Creek near Slaughter	41.1	9.70	58	2/66-	G	P
07378070	Beaver Bayou near Fred	A .15	8.75	56	5/74-	NR	P
07379085	North Branch, Ward Creek tributary at Baton Rouge.	.13	12.2	55	9/68-4/75 10/76-	NR	H
07380160	Middle Colyell Creek near Walker	20.3	4.62	56	11/50-	P	H
07381413	Intracoastal Waterway tributary at Port Allen.	9.08	------	54	12/70-	NR	H
08011800	Castor Creek near Oberlin (at Hampton)	43.9	6.10	60	10/63-	F	H
08012650	Floctaw Creek near Lacamp	18.7	12.3	55	11/50-9/68 1/74-	F	H
08013610	Whisky Chitto Creek tributary near Leesville.	.32	37.4	55	9/65-	F	H
08013700	Drakes Creek near Pitkin	22.1	10.5	55	10/53-9/68 1/74-	G	H
08013800	Little Sixmile Creek near Pitkin	10.4	17.8	56	10/53-	F	H
08013950	Big Brushy Creek near Pitkin	34.4	10.9	56	5/64-	F	H
08014000	Sixmile Creek near Sugartown	171	6.70	58	2/56-	G	P
08014200	Tenmile Creek near Elizabeth	94.2	5.40	58	10/49-	G	P
08014600	Flat Creek near De Ridder	26.3	10.8	55	4/64-	G	H
08015200	Dry Creek at Dry Creek	42.7	6.20	58	10/53-9/68 1/74-	F	H
08016500	Hickory Branch near Longville	34.9	6.80	55	10/53-9/68 2/74-	G	H
08016600	Hickory Branch at Kernan	82.2	6.40	55	8/45-9/57 6/58-	G	P
08022600	Bayou Castor near Longstreet	27.7	8.80	47	10/53-9/68 12/73-	P	H

Table 1.--Crest-stage gage stations in Louisiana in operation as of 1983--Continued

Station number	Station name	Drainage area (square miles)	Channel slope (feet per mile)	Average annual rainfall (inches)	Period of record	Quality of rating	Cooperator
08023270	Bull Bayou near Hunter-------------------	8.54	13.7	50	4/64-	F	H
08024030	Bayou Scie at Zwolle---------------------	45.9	9.40	51	11/50-9/68 2/74-	G	H
08024060	Blackwell Creek at Many------------------	3.16	24.4	51	10/59-	F	P
08025850	Pearl Creek at State Highway 111, at Burr Ferry.	9.66	21.4	54	11/65-	P	H
08026200	Red Bank Creek at Evans------------------	17.2	13.4	55	11/65-	G	H
08026700	West Anacoco Creek near Hornbeck----------	22.2	11.0	54	11/50-9/68 12/73-	G	H
08027550	Prairie Creek near Leesville-------------	40.0	12.2	55	4/49-9/68 3/74-	G	H
08029700	Brushy Creek at Bancroft-----------------	25.9	6.60	54	10/53-9/68 1/74-	G	H

Data Review

Peak-discharge data for the stations in the crest-stage gage network were updated and verified during the first phase of the project. Discharge measurements for the entire period of record for each gaging station were reviewed and checked along with the rectilinear rating curves. Log ratings were developed for each station. In some cases, the rating curves lacked discharge measurements at higher stages. For those stations a concentrated effort was made to improve the ratings by making discharge measurements during the floods of December 1982 and March and April of 1983. At some stations where current-meter measurements were not obtained, indirect measurements of discharge were made. These measurements were incorporated into the development of the new ratings. On the basis of the log-rating curves, corrections and updates were made to the peak-discharge data where necessary.

After the data were updated and verified, a list of all stations that were active during 1983 was compiled (table 1). The drainage area, channel slope, average annual rainfall, period of record, and cooperator were determined for each station. In addition, the quality of each rating curve was assessed using the following subjective criteria:

1. A good rating (represented by a G in table 1) had five or more measurements without much scatter about the rating curve and a fairly complete range in stage.

2. A fair rating (represented by an F in table 1) had four to five measurements without much scatter or had more than five measurements that were fairly evenly scattered.

3. A poor rating (represented by a P in table 1) had less than four measurements, or the measurements were highly scattered. If one or more recent measurements seemed to indicate a shift in the curve, it also was considered to be poor.

4. In a few cases there was no rating (represented by an NR in table 1).

The information available at each station was then analyzed to determine if it could be eliminated. Stations that had no discharge measurements after a long period of record were usually designated to be eliminated. In general, the watersheds associated with these stations were fairly small, subject to very flashy runoff or in remote locations. Stations that had poor ratings were designated to be eliminated if the poor rating was due to backwater or an unstable channel.

Network Evaluation

The first step in the network evaluation phase of the project was to determine if any of the crest-stage gage stations correlated with other crest-stage gage stations. By eliminating highly correlated stations from regional-regression analyses, regression equations become more representative in space. If annual peak discharges at one or more stations could be predicted by annual peak discharges at another station, the stations that could be predicted were considered for elimination. A correlation matrix for all crest-stage gage stations having at least 10 years of data was developed using the PROC CORR procedure described in the "SAS User's Guide: Basics" (SAS Institute Inc., 1982a). The procedure uses a Pearson product-moment correlation to measure the closeness of a linear relationship between two variables, in this case annual peak discharges at two crest-stage gage stations. A correlation coefficient of 0.0 between two stations means each station has no linear predictive ability for the other. A correlation coefficient of 1.0 means that the stations are perfectly correlated. For purposes of this analysis, if two stations had a correlation coefficient of 0.8 or greater they were considered to be correlated and one could be used to estimate the flood characteristics of the other. The matrix of stations showing pairs of stations having a correlation coefficient of 0.8 or greater is presented in table 2.

After the correlation matrix was generated, the following steps were taken to determine which stations to retain and which to eliminate:

1. Each station that correlated with one or more stations was selected as a preliminary index station.

2. If stations that correlated with the preliminary index stations were located in the general vicinity of the appropriate preliminary index station, they were considered for elimination.

3. A list of index stations that best represented the greatest number of other stations was prepared after extensive cross checking among station correlations, locations, and the physical characteristics of each watershed. Some of the judgements made in selecting the index stations were subjective.

4. Stations that did not correlate well with any other crest-stage gage stations were added to the list of index stations. All other stations, those that were correlated with the index stations, were designated for potential elimination.

Table 2.--Correlation matrix of crest-stage gages

(Note: Correlation values are 1 x 10^{-2})

Station number

Station number	02490113	02491200	02481350	02491700	07346950	07348100	07348725	07348760	07350990	07351300	07351700	07351980	07352200	07352295	07352400	07352500	07353990	07364740	07364800	07364870	07365300	07366000	07366350	07366420	07367250	07367300	07367600	07370530	07370575	07370600	07370650	07370660	07370700	07370750	07370820	07370840	07370930	07370980	07372110	07372300	07372900	07373450	07373640	07373700	07373800	07373900	07374700	07375170	07375185	07375222	07375300	07375463	07375480	07375960	07376290	07376520	07376600	07377190	07377210	07377300	07377700	07379085	07380160	08011800	08012650	08013610	08013700	08013800	08013950	08014000	08014200	08014600	08015200	08016500	08016600	08023270	08024030	08024060	08025850	08026200	08026700	08027550	08029700
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5. The remaining crest-stage gage stations (the potential index stations and the uncorrelated stations) were then correlated with continuous-record gaging stations using the correlation procedure previously described.

6. Each crest-stage gage station that did not correlate well with another crest-stage gage station but correlated with a continuous-record gaging station was designated to be eliminated.

7. Crest-stage gage index stations that were correlated with continuous-record gaging stations were designated to be eliminated if all of the stations that they represented were determined to be correlated with the appropriate continuous-record gaging station.

8. Finally, the physical features of the remaining stations were compared. Where two or more stations in the same general location had roughly the same drainage area and were similar in slope, the stations having the longest period of record and the best defined rating curves were selected to be eliminated, provided they had not been designated as an index station. Information at these stations was adequate to develop flood-frequency curves and it was felt that they were no longer needed. Some stations that were initially designated to be eliminated were added back into the list of stations to be retained. These stations are in smaller watersheds and are needed to better define the flood-frequency curves for small drainage areas and may be used as a control in defining a set of flood-frequency curves for urban areas.

Results

After extensive correlation analyses, cross checks, and comparisons, the crest-stage gage network was narrowed to 24 existing stations and one newly proposed station. These 25 stations, listed in table 3 and shown in figure 4, could be used to represent the existing network. As shown in table 3, the drainage areas of the watersheds in the reduced network range from 0.13 to 127 mi^2. Approximately 21 percent of the stations have drainage areas less than 10 mi^2, 54 percent are 10 to 50 mi^2 and about 25 percent are greater than 50 mi^2. This distribution of drainage areas in the reduced network is somewhat similar to the distribution of the existing network (table 4), except that there is a larger percentage of small basins. This bias toward the smaller basins is a result of the need to better define the flood-frequency relationships for small drainage areas and urban areas. Also, the majority of the stations in the continuous-record gaging network have drainage areas greater than 100 mi^2. Channel slopes for the reduced network range from 4.40 to 64.8 ft/mi and the average annual rainfall ranges from 46 to 64 in. (table 3). The distribution of channel slope and rainfall by class are similar for the existing network and the reduced network (tables 5 and 6).

Table 3.--Crest-stage gage stations in Louisiana proposed for the reduced network

[Area: A, approximation. Quality of rating: G, good; F, fair; P, poor; NR, no rating. Cooperator: H, Office of Highways; P, Office of Public Works]

Station number	Station name	Drainage area (square miles)	Channel slope (feet per mile)	Average annual rainfall (inches)	Period of record	Quality of rating	Cooperator
	Existing stations						
02491350	Hays Creek near Franklinton------------	42.2	10.7	62	10/65-	G	P
07348725	Indian Creek at Shongaloo--------------	33.1	7.12	50	3/66-	F	H
07351670	Rambin Bayou near Frierson-------------	59.6	12.0	46	10/65-	P	H
07352400	Kepler Creek at Sparta-----------------	21.1	10.9	51	11/53-10/68 10/73-	G	H
07353990	Kisatchie Bayou at Kisatchie-----------	37.3	9.55	54	11/65-	G	H
07364870	Sugar Creek near Arcadia---------------	A 47	13.5	52	3/66-	G	H
07366403	Bayou Choudrant tributary near Tremont--	.54	47.8	51	10/65-	G	H
07366420	Bayou Choudrant near Calhoun-----------	113	6.93	51	12/65-	F	H
07367250	Guyton Creek near Eros-----------------	8.76	18.7	51	10/67-	G	H
07370600	Bayou Beaucoup near Cotton Plant--------	127	4.40	54	12/50-9/68 2/74-	G	H
07372110	Brushy Creek near Joyce----------------	A 24	10.8	56	6/64-	G	H
07373450	Thompson Creek at Jackson--------------	99.3	9.20	56	3/49-9/59 10/71-9/73 8/74-	F	H
07373640	Hammer Creek tributary near Jackson-----	.20	64.8	55	10/67-	P	H
07375222	Abita River north of Abita Springs------	46.1	6.50	62	10/65-	G	H
07375307	Terrys Creek near Kentwood-------------	52.0	8.20	64	10/65-	F	H
07377210	Sandy Creek near Pride-----------------	69.9	7.30	58	5/74-10/74 11/76-	G	P
07378070	Beaver Bayou near Fred-----------------	A .15	8.75	56	5/74-	NR	P
07379085	North Branch, Ward Creek tributary at Baton Rouge.	.13	12.2	55	9/68-4/75 10/76-	NR	H
08011800	Castor Creek near Oberlin (at Hampton)--	43.9	6.10	60	10/63-	F	H
08013610	Whisky Chitto Creek tributary near Leesville.	.32	37.4	55	9/65-	F	H
08014200	Tenmile Creek near Elizabeth-----------	94.2	5.40	58	10/49-	G	P
08015200	Dry Creek at Dry Creek-----------------	42.7	6.20	58	10/53-9/68 1/74-	F	H
08024030	Bayou Scie at Zwolle-------------------	45.9	9.40	51	11/50-9/68 2/74-	G	H
08025850	Pearl Creek at State Highway 111, at Burr Ferry.	9.66	21.4	54	11/65-	P	H
	Newly proposed station						
07369360	Bushley Creek at Manifest--------------	64.7	-----	--	---------	--	H

Most of the stations proposed to be discontinued correlate with a continuous-record gaging station or one or more of the 24 crest-stage gage stations proposed for the reduced network. By eliminating highly correlated stations from a flood-frequency analysis, regional-regression equations become more representative in space. The stations proposed to be discontinued that are correlated with another station are listed in table 7 along with the index stations with which they are best correlated.

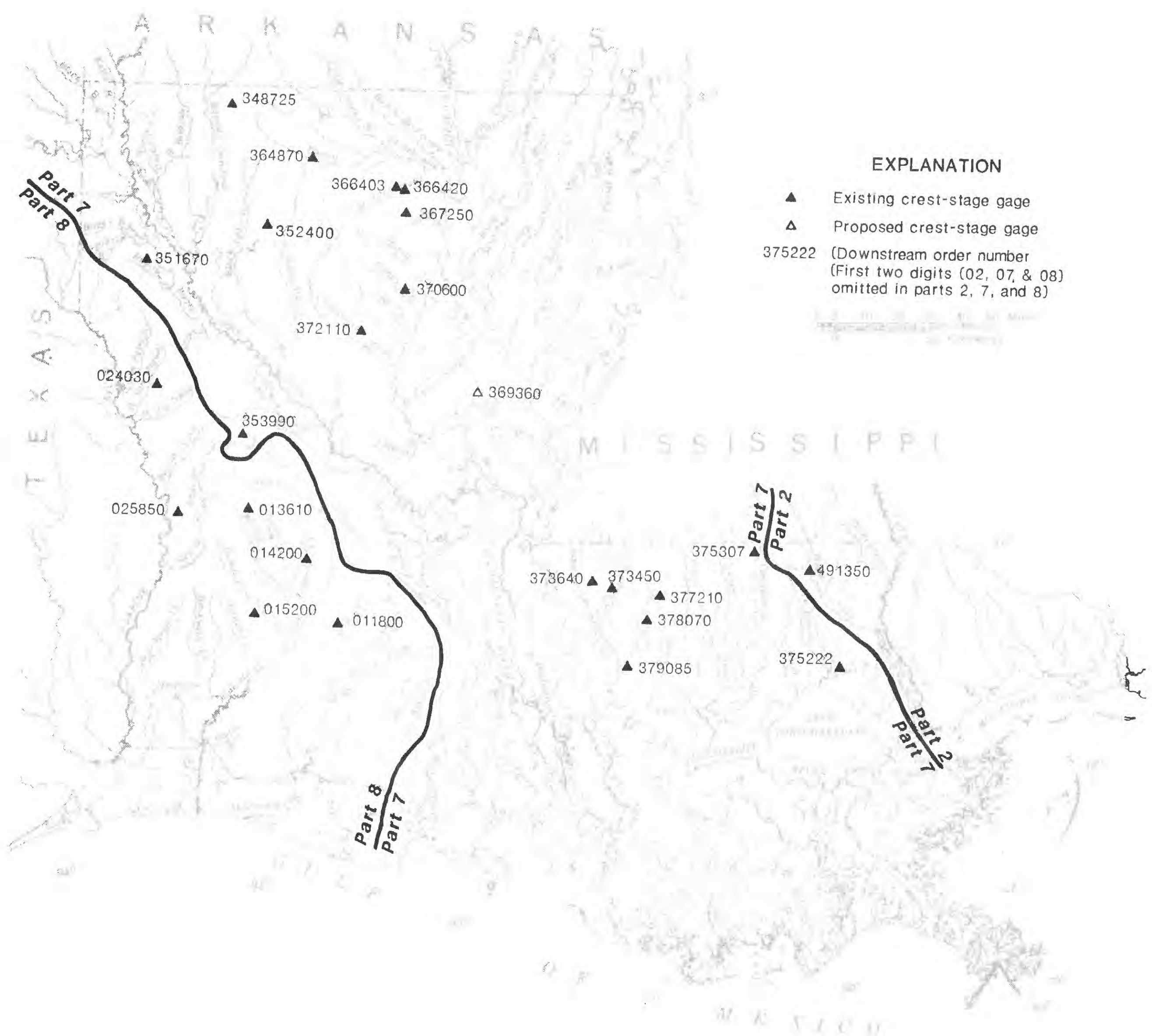

Figure 4.--Location of crest-stage gage stations proposed for the reduced network.

Table 4.--Distribution of drainage areas by class for the 1983 existing network and reduced network of crest-stage gages in Louisiana

Class (square miles)	Existing network (percent)	Reduced network (percent)
<10	12	21
10-50	58	54
>50	30	25

Table 5.--Distribution of channel slopes by class for the 1983 existing network and reduced network of crest-stage gages in Louisiana

Class (feet per mile)	Existing network (percent)	Reduced network (percent)
0.0- 4.99	10	4
5.0- 9.99	38	50
10.0-14.99	35	25
15.0-19.99	8	4
≥20.00	9	17

Table 6.--Distribution of average annual rainfall by class for the 1983 existing network and reduced network of crest-stage gages in Louisiana

Class (inches)	Existing network (percent)	Reduced network (percent)
45.0-49.99	9	4
50.0-54.99	35	41
55.0-59.99	38	38
≥60.00	18	17

Table 7.--Index stations correlated with crest-stage gage stations proposed to be discontinued in Louisiana

[D, continuous-discharge station]

Index stations and location		Crest-stage gage stations and location	
02490105	(D) Bogue Lusa Creek at State Highway 439, at Bogalusa	02490113	Bogue Lusa Creek at State Highway 21, at Bogalusa
		02491200	Silver Creek near Clifton
		02491700	Lawrence Creek near Franklinton
		07374700	Tchefuncta River near Franklinton
		07375300	Tangipahoa River near Kentwood
07348725	Indian Creek near Shongaloo	07364800	Bayou D'Arbonne at Homer
07349795	(D) Cypress Bayou near Benton	07352200	Black Lake Bayou near Minden
07352000	(D) Saline Bayou near Lucky	07351980	Saline Bayou near Bienville
07353990	Kisatchie Bayou at Kisatchie	07370650	Flat Creek near Sikes
07366200	(D) Little Corney Bayou near Lillie	07364740	Bayou De Loutre near Farmerville
07366420	Bayou Choudrant near Calhoun	07367300	North Cheniere Creek at Cheniere
		07370575	Caney Creek near Chatham
07367250	Guyton Creek near Eros	07352295	Black Lake Creek near Gibsland
07370600	Bayou Beaucoup near Cotton Plant	07367600	Cypress Creek near Vixen
07371500	(D) Dugdemona River near Jonesboro	07370820	Dugdemona River near Quitman
		07370840	Choctaw Creek near Quitman
		07370930	Big Cypress Creek at Quitman
		07370980	Little Dugdemona River near Hodge
07372110	Brushy Creek near Joyce	07370660	Flat Creek near Olla
		07370700	Beech Creek near Olla
07375000	(D) Tchefuncta River near Folsom	07375463	Chappepeela Creek near Husser
		07375480	Chappepeela Creek SE of Loranger

Table 7.--Index stations correlated with crest-stage gage stations proposed to be discontinued in Louisiana--Continued

Index stations and location		Crest-stage gage stations and location	
07376500	(D) Natalbany River at Baptist	07376520	Little Natalbany River at Albany
07377240	(D) Little Sandy Creek near Greenwell Springs	07376290	Blood River near Springfield
		07377190	Sandy Creek SE of Clinton
07377500	(D) Comite River near Olive Branch	07377700	Redwood Creek near Slaughter
07377782	(D) White Bayou SE of Zachary	07373700	Thompson Creek near Starhill
		07373900	Bayou Baton Rouge above Baker
07378500	(D) Amite River near Denham Springs	07377300	Amite River at Magnolia
08014200	Ten Mile Creek near Elizabeth	08012650	Floctaw Creek near Lacamp
		08013950	Big Brushy Creek near Pitkin
		08014000	Sixmile Creek near Sugartown
08015200	Dry Creek at Dry Creek	08016600	Hickory Branch at Kernan
08015500	(D) Calcasieu River near Kinder	08014600	Flat Creek near De Ridder
08016400	(D) Beckwith Creek near DeQuincy	08013700	Drakes Creek near Pitkin
		08016500	Hickory Branch near Longville
		08027550	Prairie Creek near Leesville
		08029700	Brushy Creek at Bancroft
08023400	(D) Bayou San Patricio near Benson	08023270	Bull Bayou near Hunter
08025500	(D) Bayou Toro near Toro	08026700	West Anacoco Creek near Hornbeck
08028000	(D) Bayou Anacoco near Rosepine	08026200	Red Bank Creek at Evans

If at some time in the future, flood statistics are needed at any of the individual stations to be discontinued, assuming basin characteristics do not change, regression equations can be developed using the appropriate index stations. For example, annual peak-discharge data of index station 07378500 (Amite River near Denham Springs) can be used to enhance flood statistics at station 07377300 (Amite River at Magnolia). The plot of the relationship is shown in figure 5. A procedure for adjusting the logarithmic mean and standard deviation of a short record on the basis of a regression analysis with a long-term station record is described in appendix 7 of Bulletin 17B (Hydrology Subcommittee, 1982).

The equation of the line in figure 5 is $Y = 2.62\ X^{0.89}$, where Y is the annual peak discharge at station 07377300, and X is the annual peak discharge at station 07378500.

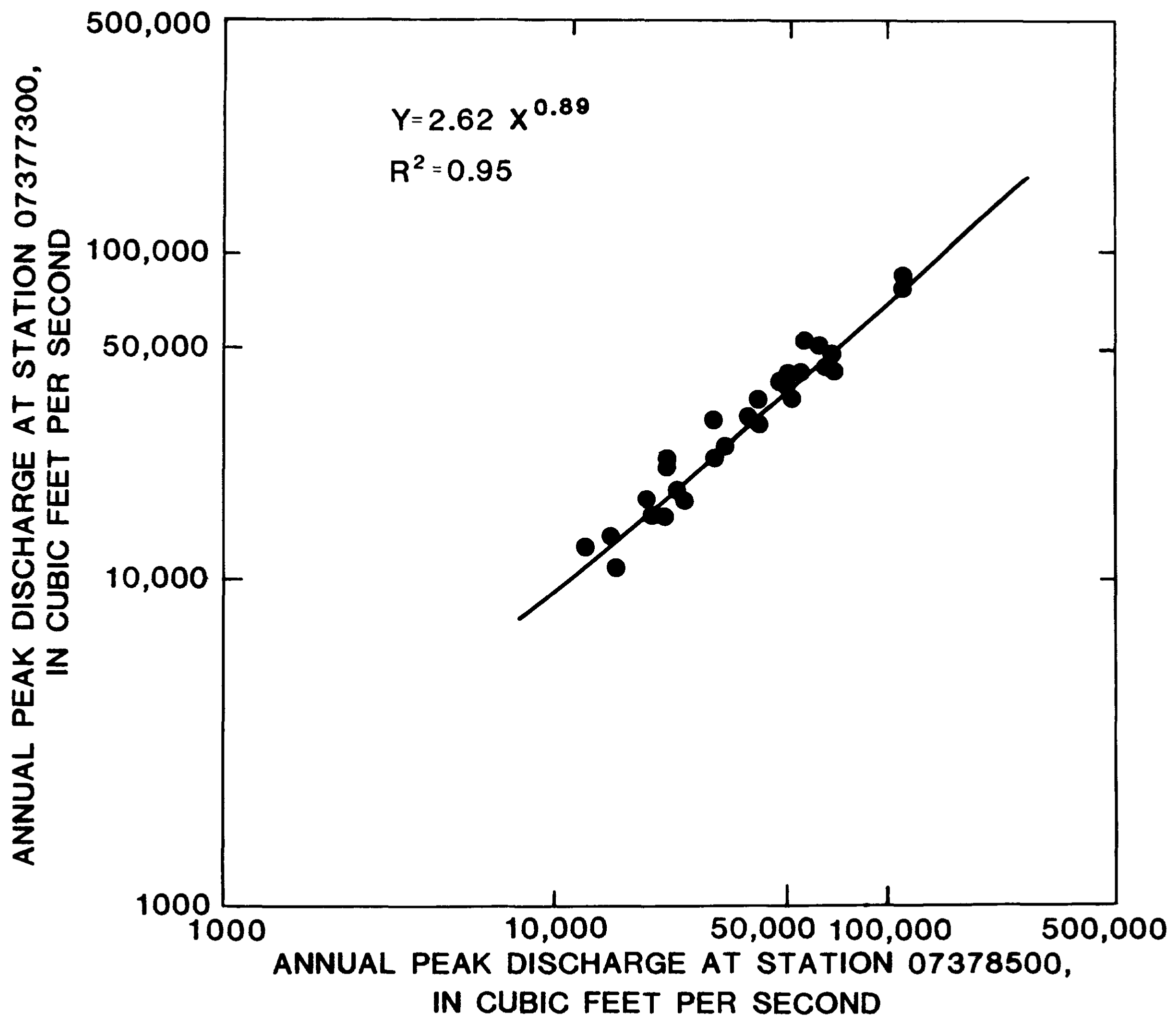

Figure 5.--Relation between annual peak discharge at station 07377300 and at station 07378500.

The relationship has an R^2 value [the ability of the regression line to explain variations in the dependent variable (Hann, 1977, p. 185)] of 0.95. The equation may be used to estimate discharge of the flood of a given recurrence interval for station 07377300 from the discharge for the same recurrence interval at the index station. However, discharges for individual storms estimated from this relation will be much less reliable. The two stations used in this example are on the same stream, where R^2 is typically high. Caution should be used when this method is applied to adjacent basins because it is less reliable in those applications.

Thirty-two of the stations that have been or are proposed to be discontinued are not highly correlated with any station in their general vicinity. (See table 8.) These stations either have a well defined stage-discharge relationship with a long period of record or have a poor stage-discharge relationship because of backwater, unstable channels, or flash flooding. Most of the stations with well defined stage-discharge relationships and long periods of record have drainage areas similar in size to stations proposed to remain in the network.

For three stations remaining in the reduced network, information was insufficient to develop a rating curve. They remain in the network so that the ratings can be completed and the peak-discharge data for the past several years can be compiled.

Bushley Creek at Manifest needs to be established as a new crest-stage gage station. Bushley Creek was operated as a low-flow station from 1954-63, when it was discontinued (Benton and Higgins, 1981). Upgrading this station to a crest-stage gage station will assure a fairly even geographic distribution (fig. 4) and provide discharge information in an area where only minimal flow data are available.

The adequacy of the reduced network for verifying or updating regional flood-frequency equations was tested by comparing a set of regional flood-frequency equations developed using data from the full network and all other stations with a set developed using data from the reduced network and all other stations. It was assumed that if equations developed using existing data from the reduced network produced results similar to equations developed using existing data from all stations, then the reduced network would be adequate for future flood-frequency analyses or verification of existing flood-frequency equations.

For this analysis, data from 19 crest-stage gage stations in the reduced network and 80 crest-stage gage stations in the full network were combined with data from 168 stations in the current continuous-record gaging network and other discontinued stations to develop regional flood-frequency equations. A total of 187 stations were used for the reduced network and 248 for the full network. Three stations in the reduced network and four stations in the full network of crest-stage gages did not have enough data for analysis. In addition, two stations in the reduced network and four in the full network, which are in the Thompson Creek basin, were not used in the analysis because Neely (1976) found their discharges to vary from the discharges at stations in the remainder of the State by a factor of 2.3.

Table 8.--Crest-stage gage stations in Louisiana to be discontinued that do not correlate with an index station

[Area: A, approximation. Quality of rating: G, good; F, fair; P, poor; NR, no rating. Cooperator: H, Office of Highways; P, Office of Public Works]

Station number	Station name	Drainage area (square miles)	Channel slope (feet per mile)	Average annual rainfall (inches)	Period of record	Quality of rating	Cooperator
02490130	Coburn Creek at Bogalusa	7.96	13.5	60	8/68-	P	P
07346950	Kelly Bayou near Ida	A 73	11.4	46	11/68-	G	P
07348100	McCain Creek near Shreveport	13.8	11.4	50	11/53-9/68 10/73-	P	H
07348760	Black Bayou at Leton	49.8	9.30	46	11/53-9/68 10/73-	P	H
07350990	Boggy Bayou at Woolworth Road, near Keithville.	41.3	12.4	46	10/65-	G	H
07351205	Brush Bayou tributary No. 2 at Shreveport	3.68	15.9	47	10/66-8/71 11/72-	NR	H
07351300	Brush Bayou tributary near Shreveport	27.1	9.20	46	12/59-	F	P
07351700	Bayou Na Bonchasse near Mansfield	19.5	18.2	48	11/57-9/68 4/69-	G	H
07351980	Saline Bayou near Bienville	54.9	5.84	52	2/66-	G	H
07352500	Black Lake Bayou near Castor	423	3.90	49	5/40-9/57 10/57-	G	P
07352730	Antoine Creek near Ashland	17.7	21.1	50	5/64-	F	H
07365300	Middle Fork Bayou D'Arbonne near Colquitt	43.9	9.90	51	11/53-9/68 10/73-	P	H
07366000	Corney Bayou near Lillie	462	3.50	50	6/40-9/57 10/57-	G	P
07366350	Stowe Creek near Farmerville	A 29	11.9	51	11/53-9/68 10/73-	F	H
07370530	Black Bayou at Kelly	51.9	4.73	51	2/66-	G	H
07370750	Big Chickasaw Creek near Olla	47.6	8.10	56	11/53-	G	H
07372300	Bear Creek near Packton	A 11	13.3	55	1/53-9/68 2/74-	F	H
07372430	Bayou Funny Louis tributary No. 6 near Olla.	1.23	114	56	10/67-8/71 11/72-	P	H
07372900	Dyson Creek near Pollock	A 12	18.4	57	5/64-	F	H
07373400	Little Bayou Sara near Turnbull	22.3	18.6	56	3/49-6/61 10/62-9/68 2/74-	P	H
07373800	Alexander Creek near St. Francisville	23.9	14.3	55	4/53-9/68 2/74-	G	H
07375170	Bogue Falaya at Covington	88.2	8.40	62	10/63-	G	H
07375185	Little Bogue Falaya near Blond	.91	28.6	62	10/76-	NR	H
07375600	Washley Creek near Robert	25.3	10.2	60	11/50-	P	H
07375960	Tickfaw River at Montpelier	220	7.20	60	12/50-9/68 2/74-	G	H
07376285	Hickory Branch near Albany	1.25	5.07	57	9/65-9/71 11/74-	NR	H
07376600	Ponchatoula Creek at Natalbany	13.8	4.30	59	11/50-	P	H
07380160	Middle Colyell Creek near Walker	20.3	4.62	56	11/50-	P	H
07381413	Intracoastal Waterway tributary at Port Allen.	9.08	------	54	12/70-	NR	H
08013800	Little Sixmile Creek near Pitkin	10.4	17.8	56	10/53-	F	H
08022600	Bayou Castor near Longstreet	27.7	8.80	47	10/53-9/68 12/73-	P	H
08024060	Blackwell Creek at Many	3.16	24.4	51	10/59-	F	P
08026200	Red Bank Creek at Evans	17.2	13.4	55	11/65-	G	H
08026700	West Anacoco Creek near Hornbeck	22.2	11.0	54	11/50-9/68 12/73-	G	H

Flood-frequency characteristics were developed for each station using a log-Pearson type III distribution as outlined in Bulletin 17B (Hydrology Subcommittee, 1982). Regional-regression equations were developed for the State (excluding the Thompson Creek basin) using the same general model form as Neely (1976) presented in the third edition of "Floods in Louisiana, Magnitude and Frequency": $Q_x = aA^bS^c(P-35)^d$, where Q_x is the peak discharge for the standard recurrence intervals; A, S, and P are drainage area, channel slope, and mean annual rainfall, respectively; a is the regression constant or intercept; and b, c, and d are regression coefficients. The equations were developed using the General Linear Models (GLM) procedure for multiple regression described in "SAS User's Guide: Statistics" (SAS Institute Inc., 1982b).

The parameter estimates for the flood-frequency equations developed using data from the reduced network and the full network are presented in table 9. Standard errors for the reduced network are consistently larger than for the full network. The mean-squared errors and R^2 are generally larger for the reduced network, which indicates that the overall variability of the regression equation for the reduced network is greater. However, the difference ranges from 0.01 to 0.04 natural log units and is not considered to be significant.

Discharge was calculated for each of the basins used in the analysis with both sets of equations. The discharges calculated for recurrence intervals of 2, 5, 10, 25, 50, and 100 years, using the equations developed from the full crest-stage gage network, were plotted against the discharges calculated using the equations developed from the reduced network. These plots are shown in figure 6. The straight line represents equal discharge and very closely represents the plotted points for all recurrence intervals. The slight under prediction of the reduced network equation for the five-year recurrence interval (fig. 6b) cannot be explained, but as most designs are based on 25-year or greater recurrence intervals, this bias is considered to be negligible. The comparison of the parameter estimates and standard errors of the estimates presented in table 9 and the plots in figure 6, indicate there are little or no differences between the results of the two sets of equations. Therefore, a network of 25 crest-stage gage stations is considered to be adequate to supplement the continuous-record gaging stations for future flood-frequency analyses.

CONCLUSIONS

An evaluation of the crest-stage gage program was completed to determine the minimum number of gages that would provide approximately the same degree of accuracy as the existing network. The quality of information collected at each site and the adequacy of the coverage geographically and with respect to various hydrologic conditions were examined. By eliminating gages that correlated well with other gages and by eliminating gages with inadequate data or well defined flood-frequency relationships, the crest-stage gage network can be reduced to 25 stations. The information provided by the reduced network will provide approximately the same degree of accuracy as the existing network when developing regional flood-frequency relationships.

Table 9.--Comparison of parameter estimates and associated errors for flood-frequency equations developed using data from the full network and the reduced network of crest-stage gages in Louisiana

[A, area exponent; S, channel slope exponent; P, exponent of average annual rainfall minus 35 inches; intercept, mean square error, and standard error of the estimate are in natural log units]

Recurrence interval	Parameter	Reduced network		Full network		Reduced network		Full network	
		Estimate	Standard error of the estimate	Estimate	Standard error of the estimate	Mean square error	R^2	Mean square error	R^2
Q_2	Intercept	1.81	0.48	1.89	0.41	0.24	0.93	0.21	0.92
	A	.67	.02	.66	.02				
	S	.23	.06	.21	.05				
	P	.93	.15	.93	.12				
Q_5	Intercept	1.99	0.46	2.11	0.40	0.22	0.94	0.21	0.93
	A	.72	.02	.72	.02				
	S	.34	.05	.32	.05				
	P	.93	.14	.92	.12				
Q_{10}	Intercept	2.03	0.48	2.17	0.42	0.23	0.94	0.22	0.93
	A	.75	.02	.74	.02				
	S	.39	.06	.38	.05				
	P	.95	.14	.93	.12				
Q_{25}	Intercept	2.14	0.51	2.28	0.46	0.26	0.93	0.27	0.91
	A	.78	.02	.77	.02				
	S	.44	.06	.43	.06				
	P	.95	.16	.93	.14				
Q_{50}	Intercept	2.01	0.53	2.17	0.42	0.28	0.93	0.22	0.92
	A	.80	.02	.74	.02				
	S	.49	.06	.38	.05				
	P	1.01	.16	.93	.12				
Q_{100}	Intercept	1.92	0.56	2.27	0.46	0.31	0.92	0.27	0.91
	A	.81	.02	.77	.02				
	S	.52	.06	.43	.06				
	P	1.06	.17	.93	.14				

Most of the existing 96 gages are located in the pine hills region of the State, and there is a need for continuous-record gaging stations in the coastal, flat-slope, and urban areas. A network of 10 to 12 basins in the Baton Rouge metropolitan area need to be instrumented with continuous-record gages and rain gages to define flood-frequency relationships for urban areas in southern Louisiana. In addition, a number of magnetic flowmeters need to be installed in the prairie and coastal marsh regions so that flood-frequency equations can be developed for those areas.

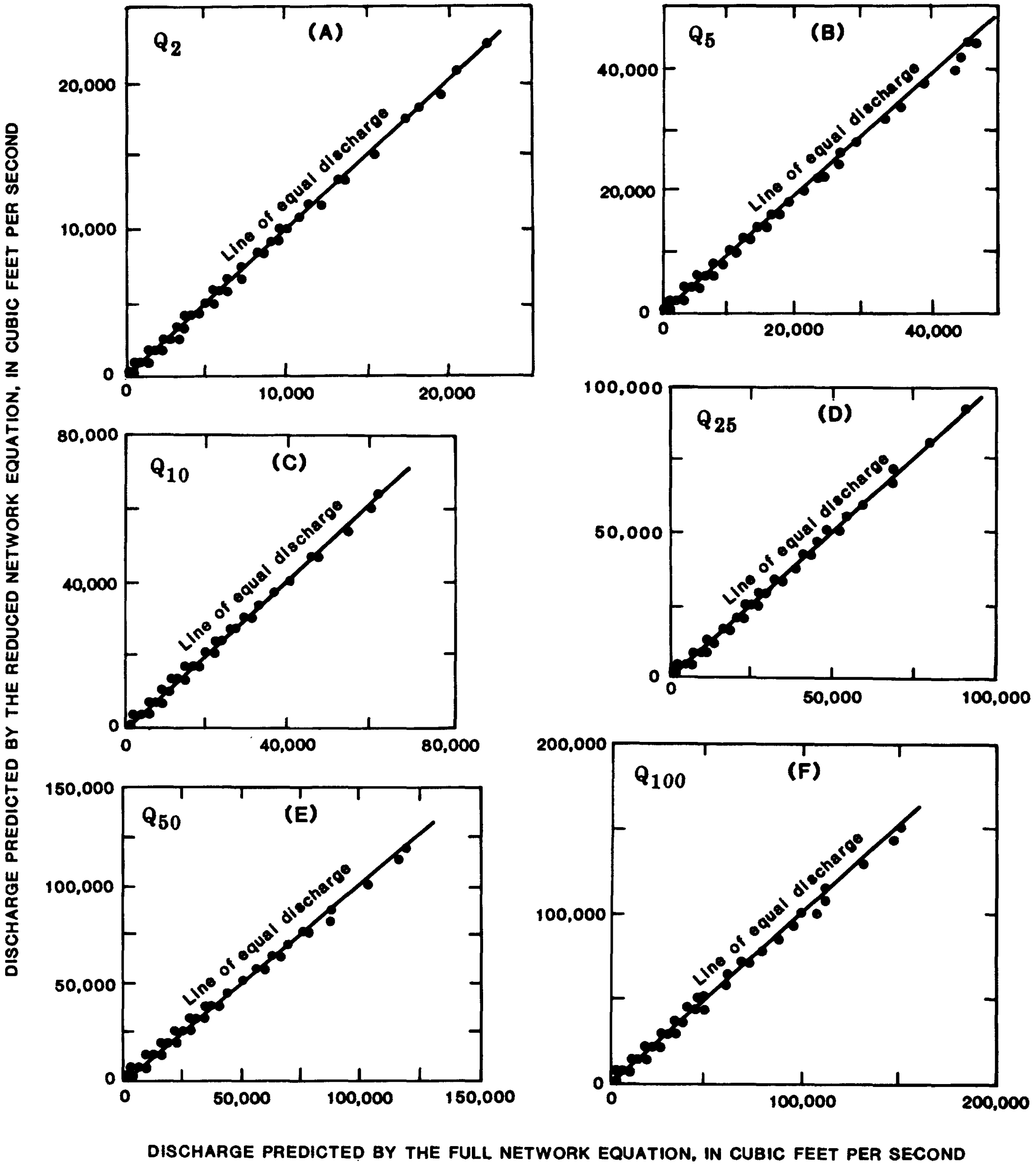

Figure 6.--Discharges predicted by the full network versus the reduced network for 248 watersheds.

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