BULLETIN 5807 E

TEXAS STREAM-GAGING PROGRAM: EVALUATION AND RECOMMENDATIONS

Prepared cooperatively by the Geological Survey
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PREFACE

This report was prepared by the United States Geological Survey whose staff cooperated extensively with members of the staff of the Board of Water Engineers. The evaluation of the stream gaging program in the State of Texas was deliberate and exhaustive. This report, therefore, represents the joint thinking of the Board of Water Engineers and the United States Geological Survey on this subject.

It is to be emphasized that this recommendation does not constitute one man's opinion, but rather represents the combined thoughts of a number of men who are experts in the field of basic data collection requirements for proper water resources development. There are an extensive number of tributary watersheds in Texas which have no stream gaging records at all. While these drainage areas vary in area some are rather sizeable. Data is badly needed on runoff from representative tributary areas for planning and administrative purposes.

Final locations of additional gaging stations recommended in this report will be coordinated with the need for streamflow data from watershed subdivisions established by the Board in carrying out the provisions of Arts. 7472d and 7472d-1, Vernon's Revised Civil Statutes of Texas.

It is essential that a planned expansion of the stream gaging program in the State of Texas be carried out, and this report is released in order that the results of the thorough study into the present stream gaging program in the State of Texas and the accompanying recommendations may be made available to all who may have an interest in them.

Gaging stations will need to be established and operated in addition to those outlined in this report. Responsibility for construction of these stations will be required of permittees to answer in part requirements placed in permits necessary to govern releases of water to satisfy downstream prior rights and give effect to provisions of permits under which water is taken. Because these locations will be determined by permit application, no forecast of their number or location is included in this report.

THE TEXAS BOARD OF WATER ENGINEERS

Durwood Manford

Durwood Manford, Chairman

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INTRODUCTION

Intelligent water resources development will be a key to future economic growth in the State of Texas. It is a very simple task to define the streamflow problem in general terms - at times there is too much and at other times too little water; however, such information is of little value in assuring adequate planning for proper water resources development.

The need is growing for an expanded stream-gaging program within the State to keep up with the increased demand for basic hydrologic data essential to the planning of new water-development projects, to improve and perfect many water-control and water-use projects now operating in the State, and to evaluate the effect of existing developments. Before any long-range consideration can be given to the development of surface-water supplies, streamflow data should be collected to define all phases of streamflow characteristics as they apply to given areas, and to evaluate the effects of one development upon another. It is the recommendation of the Board of Water Engineers and the U. S. Geological Survey that a balanced stream-gaging network be developed and maintained to supply the related hydrologic data required for water-resource developments in each watershed of the State, regardless of size.

As economic limitations prohibit the possibility of establishing stream-gaging stations at all possible water-development sites on every river, stream, or watercourse within the State, the problem becomes one of obtaining reliable hydrologic information at the greatest number of locations with a minimum expenditure.

Existing stream-gaging stations and their classification are shown in Table 1. Recommended locations for additional stream-gaging stations required to provide needed information are shown in Tables 2 and 3.

PURPOSE AND SCOPE

The present stream-gaging program in Texas has developed through the years principally because of the need for streamflow data by specific agencies at specific points. In the course of these developments, records of daily flow have been collected continuously at a number of stations; intermittently, with serious breaks in record, at some; and for brief intervals at others. In the past, records thus collected have met the needs for streamflow data, but as the population and economy of the State grow, demands for water become more competitive, and economic losses from deficiencies or excesses of streamflow become more critical. What was an adequate stream-gaging program in the past no longer suffices.

This report sets forth the procedures, problems, and findings in the analytical review and evaluation of the current stream-gaging program in Texas, with recommendations as to the number and location of new stations required to develop a balanced stream-gaging program. This study was made in accordance with the principles outlined by the U. S. Geological Survey in its analysis of the stream-gaging network.

PHYSIOGRAPHY AND CLIMATE

Many factors contribute to deficiencies in areal sampling of streams in Texas. The following general discussion of the physiography and climate of the State points out some of the basic problems involved in the attempt to correlate records of streamflow between various sections of the State.

Texas is known for its bigness. The surface of the State presents a gentle physiographic scene: plains, valleys, rolling plateaus, and ranges of hills and small mountains - these present a diversity of conditions extraordinary even for so large an area as Texas.

There are four physiographic, or natural regions in Texas. These are: (1) the Coastal Plain; (2) the Central Lowland; (3) the Great Plains province; and (4) the Basin and Range province. These regions are divided into smaller subregions which are not considered here.

The Coastal Plain is the segment of the State from the Gulf of Mexico northward to the Edwards Plateau in the Uvalde area and to the Red River, and to the eastern boundary of the State. The average annual rainfall in this area ranges from about 20 inches in the west to about 55 inches along the eastern boundary of the State.

The Central Lowland lies between the Blacklands of the Coastal Plain in the northeastern part of the State and the Great Plains province on the west, extending south nearly to the Colorado River. This region covers part of the north-central portion of the State and is largely subhumid, average annual rainfall ranging from 20 inches in the west to 30 inches in the east.

The Great Plains province is comprised of the High Plains, the Edwards Plateau, and the Central Texas section, and covers a large portion of west-central and west Texas. The average annual rainfall in this area ranges between 20 and 30 inches. Many streams, fed by springs issuing from the Edwards limestone, flow from the Edwards Plateau and from along the Balcones escarpment.

The fourth region, the Basin and Range province, lies generally west of the Pecos River. The average annual rainfall in this region ranges from less than 10 inches in some places to 20 inches in the mountains.

The geographical position of Texas is a contributing factor to the diversity of rainfall pattern. Lying as it does between the mountains and high plateaus of the west and the warm Gulf waters on the southeast, Texas experiences, in part, each of the general classifications of North American climatological conditions: maritime weather along the Gulf; mountain weather in the extreme western part of the State; and, through the central part of the State, continental weather characteristic of much of the interior of the United States.

Three types of storms produce heavy rainfall within the State: the tornado, with destruction usually limited to a small area; the tropical hurricane, which occasionally strikes the Gulf Coast, bringing torrential rains; and, most common of all, the storm resulting when the cooler air from the northwest collides with the warm, moisture-laden air from the Gulf, causing heavy downpour. Whatever the cause, the storm is usually confined to one or two river basins but may occasionally affect several river basins.

These varied meteorological and climatological conditions cause such differences in the general pattern of rainfall and run-off over the State that the streamflow records from one area cannot be used very reliably to indicate streamflow in other areas.

THE STREAM-GAGING PROGRAM IN TEXAS

Past and Current Program

The need for basic streamflow data was recognized as far back as 1889 when the first stream-gaging station in Texas was established on the Rio Grande at El Paso. Records collected at this station were the basis for the design and subsequent operation of the now famous Elephant Butte Reservoir and its associated irrigation projects. Since 1889, records of streamflow and reservoir content have been collected for various periods of time at 436 sites within the State. The location and number of these gaging stations have been governed principally by the immediate demand for flow data at specific sites rather than by the need for a comprehensive over-all program of investigation.

As of September 30, 1958, there were 296 streamflow and stage recording stations in operation in the State of Texas, not including those stations operated on the Rio Grande by the International Boundary and Water Commission. The records from these stations provide the basic hydrologic data for design and operation of water-resource development projects. The design and location of every dam, reservoir, municipal water-supply system, bridge, and hydroelectric plant in the State is controlled or influenced by the amount, variations in rates, and availability of streamflow.

A Basic Surface-Water Investigation Program

To provide a broad scope program of surface-water investigations in Texas, the following phases should be underway at all times:

1. Basic surface-water hydrologic investigations
2. Special surface-water hydrologic investigations
3. Project-design investigations
4. Operation of streamflow stations for water-management purposes
5. Research projects

1. Basic surface-water hydrologic investigations consist of the operation of a network of stream-gaging stations for the purpose of determining the quantity and the varying rates of streamflow in order to evaluate the surface-water resources of all sections of the State, and to supply basic data for the development and proper use of the resources throughout each river basin. Such a program also will be valuable in recording and evaluating long-term changes in the surface-water

hydrology of small or large watersheds and in determining the extent to which the water resources are being utilized under existing water developments. The value of this type of investigation is largely dependent upon the accuracy of the results and the length of reliable record obtained. A record for a very few years may reflect only drought or unusually wet conditions; a record of many years duration will provide a complete cycle of water yield from varying climatic conditions.

2. Special surface-water hydrologic investigations include the short-term operation of gaging stations; special measurements of streamflow to determine gains or losses from streams; these and similar studies being made to determine unusual hydrologic characteristics of a limited area. The length of time during which short-term gaging stations should be operated would depend entirely upon the purpose of the investigation and upon the results obtained. An investigation of this type is now being carried on to evaluate the ground- and surface-water resources of the upper portions of the Nueces, San Antonio, and Guadalupe River basins.

3. Project-design investigations provide the connecting link of hydrologic data which, when used in connection with records from permanent network stream-gaging stations, makes available a basis for planning and designing a specific water-development project. As any such project is converted from design to operation, the investigation should be modified to meet the new conditions. An investigation of this type is now underway on the Salt Fork Red River to determine the quantity and quality of water for a proposed irrigation and municipal water-supply reservoir.

4. Streamflow stations operated for water-management purposes are those stations for which records are required to fulfill the terms of a compact or legal agreement, for the day-to-day operation of a project or for programming future operations. For example, the network of stream-gaging stations operated on the Colorado River and its tributaries above Austin are necessary to the operation of the system of lakes on the Colorado River above Austin.

5. Research projects include the collection of streamflow and associated hydrologic data to determine and define the solution to special hydraulic problems; to develop criteria for the design of hydraulic features of structures to be placed in a river valley; and to determine the effects of man-made changes on the regimen of a stream. This classification also includes experiments necessary to develop scientific equipment, and studies to develop techniques necessary in solving a multitude of hydraulic and hydrologic problems. An example of a practical research project is the Waller Creek project at Austin, a study being made to determine the effect of urban development on surface-water supply, and to obtain hydrologic data that will be used in improving the design of storm sewers, drainage features, and other water-use structures. The type of operation and length of record required for any research project will be governed by the specific information needed.

The stream-gaging program of the State should be subject to frequent review; necessary adjustments should be made in the program to provide for changes in present and anticipated needs. Such a review is very important in watersheds where rapid development is underway.

REVIEW OF THE STREAM-GAGING PROGRAM

A broad philosophy and a definite policy have been recommended by the U. S. Geological Survey for operating a network of stream-gaging stations. A summary of this philosophy and this policy is as follows:

> All gaging stations should be classified according to the use to be made of the data obtained. Two general classifications are recognized, (1) hydrologic-network stations and (2) water-management stations. Hydrologic-network stations principally represent natural runoff and have the function of providing data to help solve general problems related to streamflow and hydrology. Water-management stations are operated to obtain streamflow at particular sites to answer specific need for data. Hydrologic-network stations look to the future because they provide data for planning and design. Water-management stations are related more to the present and the past.
>
> Within the hydrologic network of stations some long-term stations, called primary stations, are needed to define the variation of streamflow with time, and many short-term stations, called secondary stations, are needed to define the streamflow characteristics of particular sites or basins. Correlation of data from the short record at a secondary station with the long record at a primary station nearby produces a synthetic record, for the secondary site, that contains both the extended time element and the characteristics of the particular site.

The following procedures were used in analyzing the existing stream-gaging program:

1. All existing and most discontinued stations were classified according to their use.

2. A network of primary and secondary stations was identified.

3. The network of primary stations was analyzed and enough comparisons or correlations of streamflow data were made to verify the station classifications and the choice of primary stations.

4. Sites were indicated where additional primary and secondary stations are needed to provide data for hydrologic studies of the surface-water resources of the State of Texas.

Classification of Stream-Gaging Stations

All of the stream-gaging stations in Texas are classified according to the system shown in Figure 1. The major classifications indicated in this figure are defined below:

An areal primary station is one that is selected for representativeness and length of record to form an integral and important part of the areal hydrologic network. Insofar as is possible this station should be free from past and probable future regulation, diversion, or other developments; it should be operated for an indefinite period in order to obtain a long-range time sample of the runoff of the section in which it is located. Such a station may also serve as a water-management station without changing its primary classification.

Figure 1.--Classification of surface water records

	STREAMFLOW STATION		STAGE STATION		PARTIAL RECORD SITE
	<u>HYDROLOGIC NETWORK</u>		<u>HYDROLOGIC NETWORK</u>		<u>HYDROLOGIC NETWORK</u>
	Primary		Primary		Primary
					None
A-11	Areal (including necessary supporting records)	B-11	Areal (Ponds & lakes)		
A-12	Mainstream	B-12	Mainstream (Rivers & tidal estuaries)		
	Secondary		Secondary		Secondary
A-21	Areal	B-21	Areal (Ponds & lakes)	C-21	Flood crest
A-22	Mainstream	B-22	Mainstream (Rivers & tidal estuaries)	C-22	Low flow
A-23	Seasonal daily-hydrologic			C-23	Pond & lake inventory
				C-24	Periodic streamflow
	<u>WATER MANAGEMENT</u>		<u>WATER MANAGEMENT</u>		<u>WATER MANAGEMENT</u>
	Long term		Long term		Long term
A-31	Compact	B-31	Compact		
A-32	Legal	B-32	Legal		
A-33	Operational	B-33	Operational		
A-34	Administrative	B-34	Administrative		
A-35	Basin Accounting	B-35	Basin Accounting		
A-36	Federal Power Comm.	B-36	Federal Power Comm.		
	Short term		Short term		Short term
A-41	Research & experimentation	B-41	Research & experimentation	C-41	Flood hydrographs and timing
A-42	Detailed design	B-42	Detailed design		
A-43	Operational (including seasonal)	B-43	Operational	C-42	Seepage and low flow

Alternate classification is shown if more than one classification is applicable.
Hydrologic network takes precedence over water management; therefore, the former is shown as principal classification.

A mainstream primary station is one that is selected for representativeness and length of record to serve as a record of flow at a specific site on an economically important river; and to serve as an index of flow at other points upstream and downstream. The records of flow need not be free from past and future diversion or other development; the station should be operated for an indefinite period in order to record streamflow under varying conditions of upstream development. This type of station may also serve as a water-management station without changing its primary classification.

An areal secondary station is one located at a point where general streamflow information is needed or will likely be needed in the future. The length of record required will depend on the number of years necessary to define a correlation with a nearby primary station.

A mainstream secondary station is one on a main stream at a site other than a mainstream primary station where general information on streamflow characteristics under present conditions of development is desired. The length of record will depend on the number of years necessary to define a correlation with one or more upstream or downstream primary stations.

A water-management station is one on a stream, canal, or other watercourse where a record is required to fulfill the terms of a compact or treaty; for legal, operational, administrative, research, and experimental purposes; for detailed design; or for basin accounting. These stations answer specific needs for data and are related both to present and to past history of the stream.

Using the foregoing system of classification, all of the stream-gaging stations in Texas in operation September 30, 1958, were classified and are listed in Table 1. A summary of this table, indicating the number of stations under each classification, is given below:

Classification		Stream-gaging stations
Areal Primary		88
Mainstream Primary		31
Areal Secondary		32
Mainstream Secondary		12
Seasonal Daily Hydrologic		1
Water Management		
Compact	5	
Operational (long term)	41	
Basin Accounting	9	
Research and Experimentation	23	
Detail Design	9	
Operational (short term)	2	
		89
Areal Primary (ponds and lakes)		1
Water Management (operational-stage)		39
Periodic Streamflow		3
Total		296

Operation of Secondary Stations

The variations of natural streamflow follow variations in climate. Therefore, representative stream-gaging stations must be operated continuously to record variations in flow over a long period of time between and including extreme floods and extreme droughts. For example, a number of stream-gaging stations have been operated in Texas for 50 or more years, yet the most serious drought condition known was that which was observed during the last 10 years of record.

Economic limitations prohibit the operation of all stream-gaging stations indefinitely. Within the hydrologic network of stations a great many short-term stations, classified as secondary stations, are needed to define the streamflow characteristics at particular sites or within particular basins.

How long should a secondary station be operated? What accuracy is required in a secondary record? These are questions that have come up in connection with this concept of a network or secondary stations. Studies made by the Surface Water Branch indicate that 5 to 10 years of streamflow record collected at a secondary station will usually define an adequate correlation and also will define most of the fixed characteristics of a location. However, as is shown later in this report, correlation of streamflow records in much of Texas is very poor. In those parts of Texas, and elsewhere in the southwest, where satisfactory correlation of streamflow at secondary stations with streamflow at primary stations is not obtained, it may be necessary to operate secondary stations for periods longer than 5 to 10 years. Operation longer than 5 to 10 years will not materially improve correlation of the secondary record with that of a primary station nearby, but the longer operation does increase the accuracy of the mean and increase knowledge of extreme flows. Accuracy of the mean, however, increases only at a diminishing rate, approximately as the square root of the length of record; for a secondary station, therefore, a little less information is added each year than was added the previous year of operation. This law of diminishing returns for secondary stations indicates that money spent to operate 4 secondary stations each for 10 years furnishes more information than the same amount of money spent to operate one secondary station for 40 years. A secondary station that does not correlate need not be operated indefinitely but should only be operated until the accuracy of the mean discharge (as expressed by its standard error) and the definition of extremes and fixed characteristics are adequate to meet the purpose for which the data are being collected.

CORRELATION OF STREAMFLOW DATA

A streamflow record at a gaging station, in addition to providing information at that specific site, provides a sample of streamflow in that general area. In many cases streamflow data are needed for proposed projects at sites for which no streamflow data are available or at which streamflow records are much too short to provide a representative estimate of the magnitude and distribution of future flows.

For the latter case, correlation of the short-term record with a long record for another station nearby provides a means by which the short-term record can be extended to represent a long-term record. Correlation is the term applied to the technique of establishing a relationship between two or more sets of related data. For streamflow records, the data for a short-term station may be correlated with data for one or more long-term stations. The correlation is termed simple correlation if the relationship between only two sets of data is used, whereas it is termed multiple correlation if one set of data is correlated with two or more sets of related data.

For the purposes of this study, to evaluate the stream-gaging program in Texas, only simple correlations were used and were restricted to the degree of correlation shown by five concurrent years of streamflow records. The information derived using this length of record provides a means of determining which stations may be considered areal primary stations and should be operated indefinitely, and which stations may be considered areal secondary stations and need to be operated only long enough to obtain a representative record and then should be moved to another site. The correlations used in this study (that is, for program planning) provide only an index of the reliability of extending short streamflow records at one site on the basis of data obtained from a longer record at another site. However, all available concurrent data (not just 5 years) would be used in correlations made for the specific purpose of extending streamflow records.

The correlation curve is the line or equation that expresses the average relation between two variables. The variables used in this study were records of pairs of stream-gaging stations that had been given a classification of areal primary or areal secondary. Pairs of stations that had some similarity to each other with respect to drainage area, average rainfall, topography, and surface geology were selected for correlation. Each station classified as areal primary or areal secondary was used in at least one correlation study. In general the last five years of monthly discharges were used for the correlation study, except that if there had been a large change in regulation or storage upstream from a station, an earlier period was used. No seasonal adjustments were made.

The monthly discharge for an areal secondary station was plotted against the corresponding monthly discharge for an areal primary station on logarithmic paper, to develop the correlation curve. A total of 55 pairs of areal primary and areal secondary stations were used in making correlation studies. Of these, 28 plotted so erratically that a correlation curve could not be drawn. The other 27 correlations had standard errors of estimate ranging from 0.07 log units (-15% to +18%) to 0.71 log units (-80% to +413%). A standard error of estimate of 0.07 log units converted to percentages indicates that records for one such station could be estimated on the basis of records for another station and be within limits of -15% to +18% two-thirds of the time.

There were 28 correlation studies made of records for pairs of mainstream stations. The standard error of estimate of these ranged from 0.03 (-7% to +7%) to 0.68 (-79% to +380%) log units with one plotting so wildly that no correlation curve could be drawn.

An example of one of the better correlations of the monthly records of two stations is shown in Figure 2. The central line shows the average relation between monthly discharge at the two stations. The two parallel enveloping lines enclose two-thirds of the monthly discharges. Half of the vertical distance between the enveloping lines, when expressed as a part of one complete cycle of a logarithmic scale, or one log unit (0.11 log units here), is an approximation of one standard error of estimate, which is a measure of the variation of scatter of the points about the correlation curve. In this example, discharge for the secondary station, East Fork San Jacinto River near Cleveland, for any particular month could be estimated from records of the primary station, West Fork San Jacinto River near Conroe within an accuracy of -22% to +29% for two-thirds of the time. Such a degree of accuracy in determining monthly discharges would not be acceptable for water-management operations. However, for preliminary planning of future developments of the water resources of the State, the principal need is

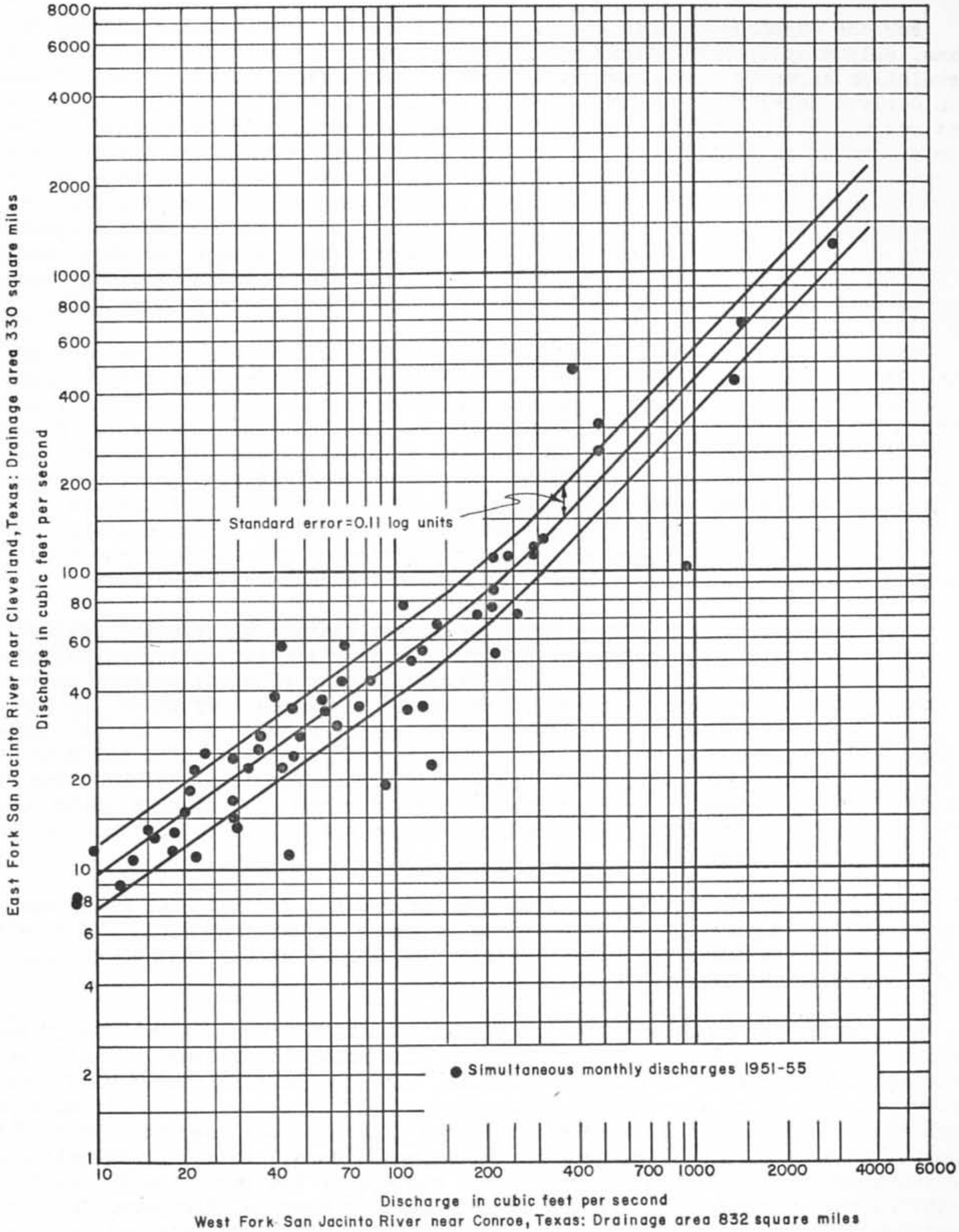


FIGURE 2.– Discharge relation between East Fork San Jacinto River near Cleveland, Texas and West Fork San Jacinto River near Conroe, Texas

for an estimate of amount and distribution of future yield and these limits of accuracy possibly would be acceptable. The predicted records as a whole could be expected to conform to the average as determined from the correlation curve, but the actual discharge for any month could be expected to vary greatly from any prediction that might be made.

Figure 3 is a plot of simultaneous monthly discharges for the stream-gaging stations on the Nueces River at Laguna, and on the Frio River at Concan. Both of these stations are free from regulation or any diversion of consequence and are located above any indicated fault zones. The wide scatter of the points indicates little correlation of monthly discharges between these two streams, even though the basins are only a short distance apart and the shape, topography, and geology of the two areas are similar.

Figure 4 is a plot of simultaneous monthly discharges for the stream-gaging stations on Richland Creek near Richland and on Chambers Creek near Corsicana. Sixty simultaneous monthly discharges greater than 1.0 cfs (cubic foot per second) for Chambers Creek and greater than 10 cfs for Richland Creek were used in this study. Many months of no flow were recorded at each station. Figure 4 indicates that monthly discharge for Chambers Creek, estimated on the basis of the monthly discharge for Richland Creek, would be within the limits of -62% and +163% two-thirds of the time that the discharge of Richland Creek was 10 cfs or more, too wide a limit of accuracy to be acceptable even for planning future development on these streams.

Figures 3 and 4 illustrate correlations of streamflow records from two entirely different parts of the State; each pair being of stations with drainage area of similar shape and size, topography and geology. Although the type of data obtained by these two correlations may, of necessity, owing to lack of better basic information, be used at times by engineers for project design, these two sample correlations are evidence that in parts of Texas streamflow records for one stream cannot be used for a reliable estimate of flow even for an adjacent basin.

SUMMARY AND PRESENTATION OF RESULTS

Adequate design or operation of any development or project using the surface-water resources of Texas requires that the characteristics of the stream be known, such as its pattern of rise and fall, the relative amounts of direct storm runoff and sustained base or ground-water flow, the time factor of long-term trends and of extremes of droughts and floods.

It is essential that a basic network of stream-gaging stations be maintained throughout the State to record the extreme variation of streamflow that occurs concurrently with certain extremes in climate: droughts and floods.

The analytical and evaluation study and review of the stream-gaging station network indicates that all of the existing primary stations in the State are essential at this time; and that the standard errors of estimate as determined from the correlation of records of pairs of stations are large. Of the 25 stations which originally were given a classification of areal secondary, only 6 correlated with a reasonable degree of accuracy with the primary station.

The study of the stream-gaging program in Texas indicates that 58 areal primary stations and 131 areal secondary stations are needed. These stations should be located on a sufficient number of streams to reflect runoff characteristics of relatively small areas in every section of the State.

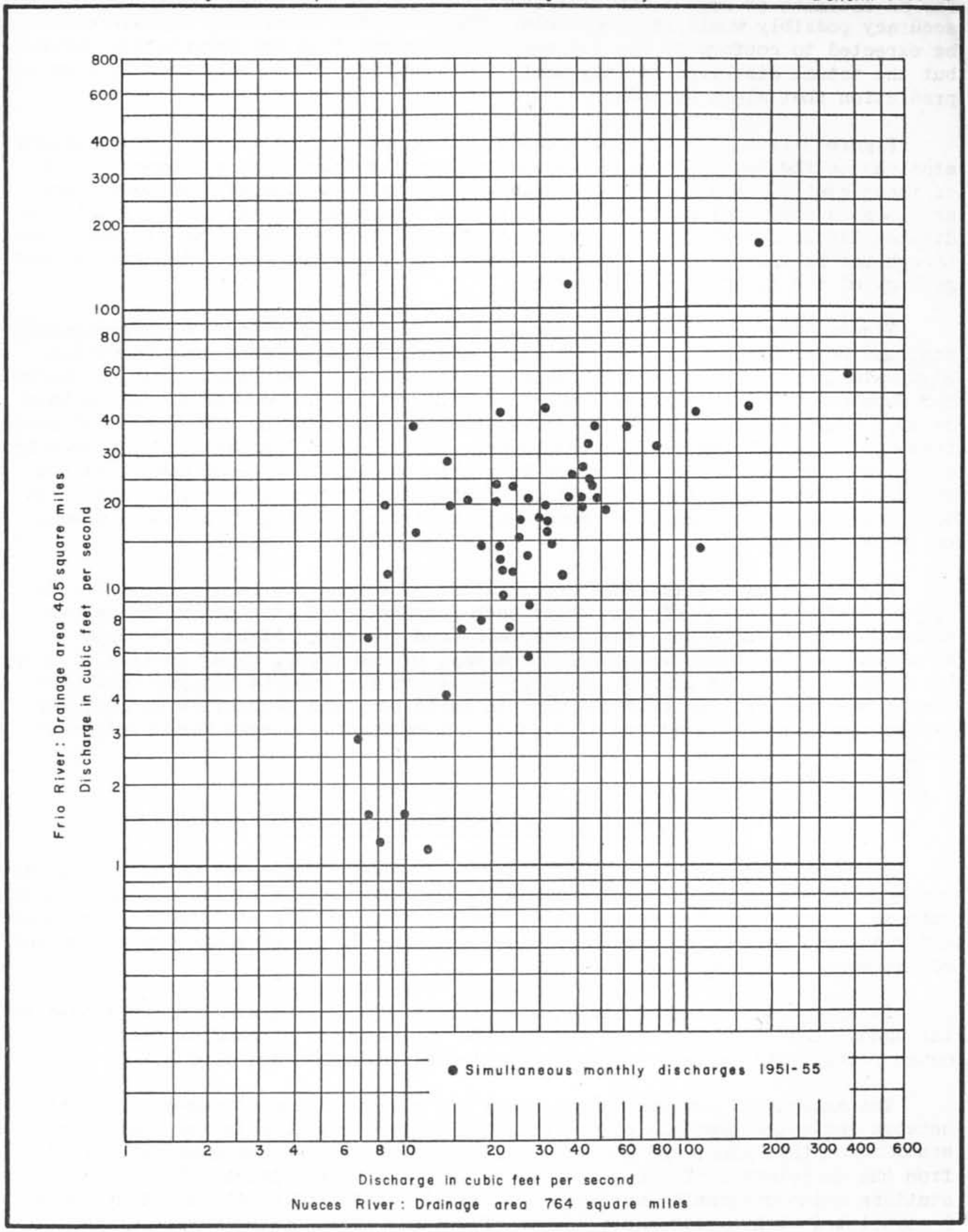


FIGURE 3. — Discharge relation between Frio River at Concan, Texas and Nueces River at Laguna, Texas

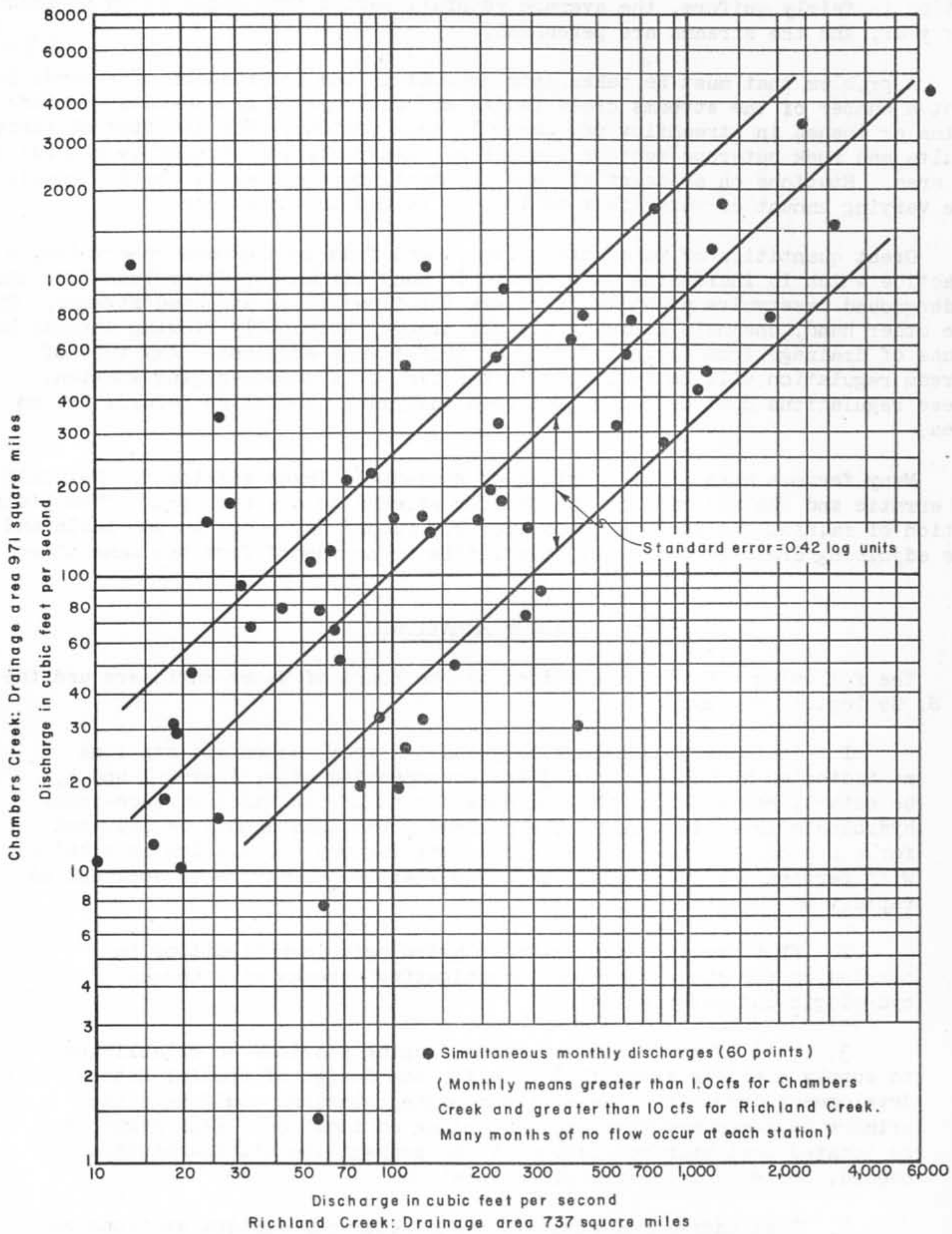


FIGURE 4.-Discharge relation between Chambers Creek near Corsicana, Texas and Richland Creek near Richland, Texas

The best correlations of records for streams in the State were obtained on small drainage basins in the eastern Gulf Coast area where the rainfall distribution is fairly uniform, the average rainfall varies from about 40 to 55 inches per year, and the streams are perennial.

A problem that must be taken into account in the correlation of records is that a number of the streams cross faults and outcrops of ground-water acquifers. Gains or losses in streamflow may occur in such regions. The location of these faults and rock outcrops must be considered when analyzing streamflow records for an area. Stations on adjacent streams in these areas correlate poorly because of the varying amount of water that is lost or gained in these zones.

Great quantities of water are being pumped from underground reservoirs, a practice which is increasing with time. In many instances, diversions from the underground reservoirs drastically reduce the flow of the affected streams. On the other hand, channels normally dry may become perennially flowing streams because of drainage from irrigated land or from sewage effluent. Any type of stream regulation will be reflected in the flow at a stream-gaging station. These regulations must be recognized when analyzing streamflow records for an area.

Many factors make areal sampling of streams in Texas difficult. Rainfall is erratic and the majority of the smaller streams go dry each year. The distribution of rainfall is such that considerable runoff may occur in one basin and the adjoining drainage basin may have little or no runoff from the same storm.

RECOMMENDATIONS

The following are recommendations by the Board of Water Engineers and the U. S. Geological Survey:

1. That the 58 areal primary and 131 areal secondary stations as indicated in Tables 2 and 3 and accompanying maps, Plates 1 and 2, be established and that they be made a part of the basic surface-water hydrologic investigations. The secondary stations should be operated for a period of 5 to 10 years where satisfactory correlation is obtained with permanent primary stations. New stations should be established as rapidly as possible.

2. That special surface-water hydrologic investigations be carried on for the purpose of investigating streams with unusual hydrologic characteristics.

3. That if time permits, stream-gaging stations be established to supply adequate streamflow data for the design of special water-development projects. These stream-gaging stations could be either primary or secondary stations, depending on location. Each might be so located that upon completion of the project the station could, if needed, become a water-management station.

4. That additional streamflow and reservoir-content stations be established for the successful operation and evaluation of water-use projects. There are at present comparatively few such stations - far too few to supply needed data for evaluating the effect of existing water-control projects on the over-all yield of the affected stream.

5. That research projects be established for determining the effect of urban development and of water-use projects on surface-water supplies.

Table 1.--Stream-gaging stations in Texas as of September 30, 1958, and their classification

Type of Gage	Station and Location	Classification
	ARKANSAS RIVER BASIN	
R	Canadian River near Amarillo, Texas	A-12
R	Canadian River near Canadian, Texas	A-31, A-22
	North Canadian River:	
R	Palo Duro Creek near Spearman, Texas	A-11
	RED RIVER BASIN	
	Red River:	
	Tule Creek:	
R	North Tule Draw at reservoir near Tulia, Texas	A-11
R	Salt Fork Red River near Wellington, Texas	A-11
	Pease River:	
	North Pease River:	
R	Quitaque Creek near Quitaque, Texas	A-11
	Wichita River:	
X	Lake Kemp near Mabelle, Texas a/	B-33
W	Wichita River at Wichita Falls, Texas	A-33, A-21
	North Fork Little Wichita River (head of Little Wichita River):	
S	Lake Kickapoo near Archer City, Texas a/	B-33
R	Little Wichita River near Henrietta, Texas	A-11
R	Red River near Terral, Oklahoma	A-12, A-33
R	South Sulphur River (head of Sulphur River) near Cooper, Texas	A-11
R	North Sulphur River near Cooper, Texas	A-11
R	Sulphur River near Talco, Texas	A-21
R	Whiteoak Creek near Talco, Texas	A-11
R	Texarkana Reservoir near Texarkana, Texas	B-33
R	Cypress Creek near Pittsburg, Texas	A-11
R	Boggy Creek near Daingerfield, Texas	A-11
R	Ellison Creek Reservoir near Daingerfield, Texas a/	B-33
R	Lake O' the Pines near Jefferson, Texas	B-33
R	Cypress Creek near Jefferson, Texas	A-21
	SABINE RIVER BASIN	
R	Sabine River near Emory, Texas	A-21, A-33
R	Sabine River near Mineola, Texas	A-21
W	Lake Fork Sabine River near Quitman, Texas	A-11
R	Big Sandy Creek near Big Sandy, Texas	A-11
R	Sabine River near Gladewater, Texas	A-12
	Cherokee Bayou:	
R	Lake Cherokee near Longview, Texas c/	B-33
R	Sabine River near Tatum, Texas	A-22
R	Murvaul Bayou Reservoir near Gary, Texas	B-33, B-21
R	Murvaul Bayou near Gary, Texas	A-31, A-35

(Continued on next page)

Table 1.--Stream-gaging stations in Texas as of September 30, 1958, and their classification--continued

Type of Gage	Station and Location	Classification
	SABINE RIVER BASIN (Continued)	
R	Sabine River at Logansport, Louisiana	A-31, A-12
W	Tenaha Creek near Shelbyville, Texas	A-11
R	Sabine River near Milam, Texas	A-21
W	Palo Gaucho Bayou near Hemphill, Texas	A-11
R	Sabine River below Toledo Bend near Burkeville, Texas	A-22, A-33
R	Sabine River near Bon Wier, Texas	A-22, A-31
R	Big Cow Creek near Newton, Texas	A-11
R	Cypress Creek near Buna, Texas	A-21
R	Sabine River near Ruliff, Texas	A-12, A-33, A-31
R	Cow Bayou near Mauriceville, Texas	A-11
	NECHES RIVER BASIN	
R	Neches River near Neches, Texas	A-11
R	Neches River near Alto, Texas	A-21
W	Neches River near Diboll, Texas	A-22
S	Neches River near Rockland, Texas	A-12
	Angelina River:	
	Mud Creek:	
	Prairie Creek:	
R	Lake Tyler near Whitehouse, Texas a/	B-33
R	Mud Creek near Jacksonville, Texas	A-11
R	Angelina River near Lufkin, Texas	A-11
R	Attoyac Bayou near Chireno, Texas	A-11
R	Angelina River near Zavalla, Texas	A-11, A-33
R	Angelina River at Horger, Texas	A-21
R	Dam B Reservoir at Town Bluff, Texas a/	B-33
R	Neches River at Town Bluff, Texas	A-33
R	Neches River at Evadale, Texas	A-12, A-33
R	Village Creek near Kountze, Texas	A-11
	TAYLOR BAYOU BASIN	
R	Taylor Bayou near LaBelle, Texas	A-11
	Hillebrandt Bayou at Lovell Lake, Texas	A-11
	TRINITY RIVER BASIN	
	West Fork Trinity River (head of Trinity River):	
R	North Creek near Jacksboro, Texas	A-11, A-41
R	West Fork Trinity River near Jacksboro, Texas	A-11, A-33
S	Bridgeport Reservoir above Bridgeport, Texas a/	B-33
R	Big Sandy Creek near Bridgeport, Texas	A-11
R	West Fork Trinity River near Boyd, Texas	A-11, A-33
S	Eagle Mountain Reservoir above Fort Worth, Texas a/	B-33
R	Clear Fork Trinity River near Aledo, Texas	A-11, A-33

(Continued on next page)

Table 1.--Stream-gaging stations in Texas as of September 30, 1958, and their classification--continued

Type of Gage	Station and Location	Classification
	TRINITY RIVER BASIN (Continued)	
R	Benbrook Reservoir near Benbrook, Texas a/	B-33
R	Clear Fork Trinity River near Benbrook, Texas	A-33
R	Clear Fork Trinity River at Fort Worth, Texas	A-33, A-21
R	West Fork Trinity River at Fort Worth, Texas	A-33, A-21
R	Lake Arlington near Arlington, Texas	B-11, B-33
R	West Fork Trinity River at Grand Prairie, Texas	A-12
R	Elm Fork Trinity River subwatershed 6-0 near Muenster, Texas	A-41
R	Elm Fork Trinity River near Muenster, Texas	A-41
R	Elm Fork Trinity River near Sanger, Texas	A-33
R	Isle du Bois Creek near Pilot Point, Texas	A-11, A-33
R	Clear Creek near Sanger, Texas	A-11, A-33
R	Little Elm Creek near Aubrey, Texas	A-11, A-41
R	Garza-Little Elm Reservoir near Lewisville, Texas a/	B-33
R	Elm Fork Trinity River near Lewisville, Texas	A-33, A-21
R	Denton Creek near Justin, Texas	A-33, A-21
R	Grapevine Reservoir near Grapevine, Texas a/	B-33
R	Denton Creek near Grapevine, Texas	A-33, A-21
R	Elm Fork Trinity River near Carrollton, Texas	A-33
	Trinity River:	
R	Turtle Creek at Dallas, Texas	A-42
R	Trinity River at Dallas, Texas	A-12, CA-33
	East Fork Trinity River:	
	Honey Creek:	
R	Honey Creek subwatershed #11 near McKinney, Texas	A-41
R	Honey Creek subwatershed #12 near McKinney, Texas	A-41
R	Honey Creek near McKinney, Texas	A-41
R	East Fork Trinity River near McKinney, Texas	A-11, A-33
R	Sister Grove Creek near Princeton, Texas	A-21
R	Lavon Reservoir near Lavon, Texas a/	A-33
R	East Fork Trinity River near Lavon, Texas	A-33
W	East Fork Trinity River near Rockwall, Texas b/	B-33, A-21
R	Duck Creek near Garland, Texas	A-11, A-35
R	East Fork Trinity River near Crandall, Texas	A-11
R	Trinity River near Rosser	A-22
R	Cedar Creek near Mabank, Texas	A-11
	Richland Creek:	
R	Pin Oak Creek near Hubbard, Texas	A-11, A-41
R	Richland Creek near Richland, Texas	A-11
R	Chambers Creek near Corsicana, Texas	A-11
R	Trinity River near Oakwood, Texas	A-12
W	Trinity River near Midway, Texas	A-22
W	Trinity River at Riverside, Texas	A-22
R	Trinity River at Romayor, Texas	A-12
W	Trinity River at Liberty, Texas	A-23

Table 1.--Stream-gaging stations in Texas as of September 30, 1958, and their classification--continued

Type of Gage	Station and Location	Classification
	SAN JACINTO RIVER BASIN	
R	West Fork San Jacinto River (head of San Jacinto River) near Conroe, Texas	A-11
R	Spring Creek near Spring, Texas	A-21
R	Cypress Creek near Westfield, Texas	A-42, A-21
R	West Fork San Jacinto River near Humble, Texas b/	B-33, A-21
R	East Fork San Jacinto River near Cleveland, Texas	A-11
R	Peach Creek at Splendora, Texas	A-21
R	Caney Creek near Splendora, Texas	A-21
R	Lake Houston near Sheldon, Texas a/	B-33
	Buffalo Bayou:	
R	Barker Reservoir near Addicks, Texas (at dam and upper gage) a/	B-33
R	Addicks Reservoir near Addicks, Texas (at dam, South Mayde, and Langham Creeks) a/	B-33
R	Buffalo Bayou near Addicks, Texas	A-11, A-33
R	Buffalo Bayou at Houston, Texas	A-21
R	Whiteoak Bayou at Houston, Texas	A-42, A-21
R	Brays Bayou at Houston, Texas	A-42, A-21
R	Simms Bayou at Houston, Texas	A-21, A-42
R	Green Bayou at Houston, Texas	A-21, A-42
R	Halls Bayou at Houston, Texas	A-21, A-42
	CLEAR CREEK BASIN	
R	Clear Creek near Pearland, Texas	A-35
	CHOCOLATE BAYOU BASIN	
R	Chocolate Bayou near Alvin, Texas	A-35
	OYSTER CREEK BASIN	
R	Oyster Creek near Angleton, Texas	A-33
	BRAZOS RIVER BASIN	
R	Double Mountain Fork Brazos River near Aspermont Texas	A-11
	Salt Fork Brazos River:	
R	Dove Creek near Aspermont, Texas	A-42
R	Salt Fork Brazos River near Aspermont, Texas	A-11
R	Brazos River at Seymour, Texas	A-12
	Clear Fork Brazos River:	
	Sweetwater Creek:	
S	Lake Sweetwater near Sweetwater, Texas	B-33
S	Fort Phantom Hill Reservoir near Nugent, Texas a/	B-33

(Continued on next page)

Table 1.--Stream-gaging stations in Texas as of September 30, 1958, and their classification--continued

Type of Gage	Station and Location	Classification
	BRAZOS RIVER BASIN (Continued)	
R	Clear Fork Brazos River at Nugent, Texas	A-11
	Paint Creek:	
W	Lake Stamford near Haskell, Texas a/	B-33
R	Clear Fork Brazos River at Fort Griffin, Texas	A-12
R	Hubbard Creek near Breckenridge, Texas	A-11
R	Brazos River near South Bend, Texas	A-12, A-33
R	Salt Creek at Olney, Texas	A-21, A-41
R	Salt Creek near Newcastle, Texas	A-11, A-41
R	Oak Creek near Graham, Texas	A-21, A-41
X	Possum Kingdom Reservoir near Graford, Texas a/	B-33
R	Brazos River near Palo Pinto, Texas	A-33
R	Palo Pinto Creek near Santo, Texas	A-11
R	Brazos River near Glen Rose, Texas	A-12, A-33
R	Paluxy Creek at Glen Rose, Texas	A-11, A-33
R	Nolands River at Blum, Texas	A-11, A-33
R	Whitney Reservoir near Whitney, Texas a/	B-33
R	Brazos River near Whitney, Texas	A-33, A-22
R	Aquilla Creek near Aquilla, Texas	A-11
R	North Bosque River at Stephenville, Texas	A-11 - A-35
R	Green Creek subwatershed #1 near Dublin, Texas	A-41
R	Green Creek near Alexander, Texas	A-41
R	North Bosque River near Clifton, Texas	A-11
R	Brazos River at Waco, Texas	A-12
	Cow Bayou:	
	South Cow Bayou:	
	Foster Branch:	
R	Cow Bayou subwatershed #4 near Bruceville, Texas	A-41
R	Cow Bayou near Mooreville, Texas	A-41
S	Leon Reservoir near Ranger, Texas a/	B-33
R	Leon River near Hasse, Texas	A-11
R	Leon River at Gatesville, Texas	A-21, A-33
R	Cowhouse Creek near Pidcoke, Texas	A-11
R	Belton Reservoir near Belton, Texas a/	B-33
R	Leon River near Belton, Texas	A-33, A-21
R	Lampasas River at Youngsport, Texas	A-11
	Little River:	
R	San Gabriel River at Georgetown, Texas	A-11
R	Little River at Cameron, Texas	A-12
R	Brazos River near Bryan, Texas	A-12
R	Yegua Creek near Somerville, Texas	A-11
R	Navasota River near Easterly, Texas	A-11
R	Navasota River near Bryan, Texas	A-21
W	Brazos River near Hempstead, Texas	A-12, A-33
R	American Canal Co.'s Canal near Fulshear, Texas	A-43
R	Richmond Irrigation Co.'s Canal near Richmond, Texas	A-43

(Continued on next page)

Table 1.--Stream-gaging stations in Texas as of September 30, 1958, and their classification--continued

Type of Gage	Station and Location	Classification
	BRAZOS RIVER BASIN (Continued)	
R	Brazos River at Richmond, Texas	A-33, A-22
R	Brazos River near Juliff, Texas	A-33, A-22
R	Big Creek near Needville, Texas	A-11
R	Dry Creek near Richmond, Texas	A-21
	SAN BERNARD RIVER BASIN	
R	San Bernard River near Boling, Texas	A-33
	COLORADO RIVER BASIN	
	Colorado River:	
R	Lake J. B. Thomas near Vincent, Texas a/	B-33
R	Bull Creek near Ira, Texas	A-42
R	Bluff Creek near Ira, Texas	A-11
R	Colorado River near Ira, Texas	A-42
R	Deep Creek near Dunn, Texas	A-11
R	Colorado River at Colorado City, Texas	A-11
R	Morgan Creek near Westbrook, Texas	A-21, A-33
R	Graze Creek near Westbrook, Texas	A-21, A-33
R	Lake Colorado City near Colorado City, Texas a/	B-33
R	Champlin Creek near Colorado City, Texas	A-11
R	Beals Creek at Big Spring, Texas	A-21
R	Beals Creek near Westbrook, Texas	A-21
R	Colorado River near Silver, Texas	A-22, A-42
S	Oak Creek Reservoir near Blackwell, Texas a/	B-33
R	Colorado River at Ballinger, Texas	A-12
R	Elm Creek at Ballinger, Texas	A-11
	South Concho River (head of Concho River):	
R	South Concho Irrigation Co.'s canal at Christoval, Texas	A-33
R	South Concho River at Christoval, Texas	A-11, A-33
R	Middle Concho River near Tankersly, Texas	A-11, A-33
	Spring Creek:	
M	Dove Creek Spring near Knickerbocker, Texas	C-24
R	Spring Creek near Tankersly, Texas	A-33, A-21
R	Lake Nasworthy near San Angelo, Texas a/	B-33
R	North Concho River at Sterling City, Texas	A-11
R	North Concho River near Carlsbad, Texas	A-33, A-21
R	San Angelo Reservoir at San Angelo, Texas a/	B-33
R	North Concho River at San Angelo, Texas	A-33, A-21
R	Concho River near San Angelo, Texas	A-12, A-33
R	Concho River near Paint Rock, Texas	A-33, A-22
R	Mukewater Creek at Trickham, Texas	A-11, A-41
R	Colorado River at Winchell, Texas	A-33, A-22

(Continued on next page)

Table 1.--Stream-gaging stations in Texas as of September 30, 1958, and their classification--continued

Type of Gage	Station and Location	Classification
	COLORADO RIVER BASIN (Continued)	
	Deep Creek:	
R	Deep Creek subwatershed #3 near Placid, Texas	A-41
R	Deep Creek near Mercury, Texas	A-41
R	Deep Creek subwatershed #8 (Dry Prong Deep Creek) near Mercury, Texas	A-41
R	Dry Prong Deep Creek near Mercury, Texas	A-41
	Pecan Bayou:	
	Jim Ned Creek:	
R	Hords Creek Reservoir near Valera, Texas a/	B-33
R	Hords Creek near Valera, Texas	A-33
R	Hords Creek at Coleman, Texas	A-11
S	Brownwood Reservoir near Brownwood, Texas a/	B-33
R	Brown County W.I.D. #1 canal near Brownwood, Texas	A-33
R	Pecan Bayou at Brownwood, Texas	A-33, A-21
	San Saba River:	
R	Noyes Canal at Menard, Texas	A-33
R	San Saba River at Menard, Texas	A-11
R	Brady Creek at Brady, Texas	A-41, A-33, A-21
R	San Saba River at San Saba, Texas	A-12, A-22
R	Colorado River near San Saba, Texas	A-33, A-22
X	Buchanan Reservoir near Burnet, Texas a/	B-33
R	North Llano River (head of Llano River) near Junction, Texas	A-11
R	Llano River near Junction, Texas	A-12, A-33
R	Llano River at Llano, Texas	A-33, A-22
R	Pedernales River near Johnson City, Texas	A-11
X	Lake Travis near Austin, Texas a/	B-33
M	Barton Springs at Austin, Texas	C-24
R	Waller Creek at 38th St. at Austin, Texas	A-41
R	Waller Creek at 23rd St. at Austin, Texas	A-41
R	Colorado River at Austin, Texas	A-12, A-33
R	Colorado River at Smithville, Texas	A-33, A-22
R	Dry Creek at Buescher Lake near Smithville, Texas	A-35
R	Colorado River at Columbus, Texas	A-12, A-33
W	Colorado River at Wharton, Texas	A-33, A-22
R	Colorado River near Bay City, Texas	A-33, A-22
	LAVACA RIVER BASIN	
R	Lavaca River at Hallettsville, Texas	A-11
W	Lavaca River near Edna, Texas	A-11
W	Navidad River near Ganado, Texas	A-33, A-21
	GUADALUPE RIVER BASIN	
	Guadalupe River:	
R	Johnson Creek near Ingram, Texas	A-11

(Continued on next page)

Table 1.--Stream-gaging stations in Texas as of September 30, 1958, and their classification--continued

Type of Gage	Station and Location	Classification
	GUADALUPE RIVER BASIN (Continued)	
R	Guadalupe River at Comfort, Texas	A-11
R	Guadalupe River near Spring Branch, Texas	A-21
R	Guadalupe River above Comal River at New Braunfels, Texas	A-11
R	Comal River at New Braunfels, Texas	A-35
R	San Marcos River spring flow at San Marcos, Texas	A-35
R	Blanco River at Wimberley, Texas	A-11
R	Blanco River near Kyle, Texas	A-35
R	San Marcos River at Luling, Texas	A-35
R	Plum Creek near Luling, Texas	A-11
R	Guadalupe River at Victoria, Texas	A-12, A-33
R	Coleto Creek near Schroeder, Texas	A-11
R	San Antonio River at San Antonio, Texas	A-42, A-21
R	Medina River near Pipe Creek, Texas	A-11, A-33
R	Red Bluff Creek near Pipe Creek, Texas	A-22
W	Medina Lake near San Antonio, Texas a/	B-33
R	Medina Canal near Riomedina, Texas	A-42
R	Medina River near Riomedina, Texas	A-33
R	Medina River near San Antonio, Texas	A-33, A-22
	Calaveras Creek:	
R	Calaveras Creek subwatershed #6 near Elmendorf, Texas	A-41
R	Calaveras Creek near Elmendorf, Texas	A-41
R	San Antonio River near Falls City, Texas	A-35
R	Cibolo Creek near Bulverde, Texas	A-41
R	Cibolo Creek at Selma, Texas	A-35
R	Cibolo Creek near Falls City, Texas	A-11
	Escondido Creek:	
R	Escondido Creek subwatershed #1 near Kenedy, Texas	A-41
R	Escondido Creek at Kenedy, Texas	A-41
R	Escondido Creek subwatershed #11 (Dry Escondido) near Kenedy, Texas	A-41
R	Dry Escondido Creek near Kenedy, Texas	A-41
R	San Antonio River at Goliad, Texas	A-12, A-33
	MISSION RIVER BASIN	
W	Mission River at Refugio, Texas	A-11
	NUECES RIVER BASIN	
R	Nueces River at Laguna, Texas	A-11
R	West Nueces River near Brackettville, Texas	A-11
R	Nueces River below Uvalde, Texas	A-12
R	Nueces River near Asherton, Texas	A-22

(Continued on next page)

Table 1.--Stream-gaging stations in Texas as of September 30, 1958, and their classification--continued

Type of Gage	Station and Location	Classification
	NUECES RIVER BASIN (Continued)	
W	Nueces River at Cotulla, Texas	A-12
R	Nueces River near Tilden, Texas	A-33, A-22
R	Frio River at Concan, Texas	A-11
R	Dry Frio River near Reagan Wells, Texas	A-21
R	Frio River below Dry Frio River near Uvalde, Texas	A-22
R	Sabinal River near Sabinal, Texas	A-11
R	Sabinal River at Sabinal, Texas	A-21
R	Hondo Creek near Tarpley, Texas	A-21
R	Hondo Creek near Hondo, Texas	A-21
R	Seco Creek near Utopia, Texas	A-21
R	Seco Creek near D'Hanis, Texas	A-21
R	Leona River spring flow near Uvalde, Texas	C-24
R	Frio River near Derby, Texas	A-12
R	Frio River at Calliham, Texas	A-22
R	Atascosa River at Whitsett, Texas	A-11
R	Nueces River near Three Rivers, Texas	A-12, A-33
W	Lake Corpus Christi near Mathis, Texas a/	B-33
R	Nueces River near Mathis, Texas	A-33
	PECOS RIVER BASIN	
R	Pecos River at Red Bluff, New Mexico	A-31, A-33
R	Delaware River near Red Bluff, New Mexico	A-11, A-31
S	Red Bluff Reservoir near Orla, Texas a/	B-33
R	Salt (Screwbean) Draw near Orla, Texas b/	A-11, A-31
R	Pecos River near Orla, Texas	A-31, A-33
	Toyah Creek:	
R	Phantom Lake Spring near Toyahvale, Texas	A-33
R	San Solomon Springs at Toyahvale, Texas	A-33
R	Comanche Springs at Fort Stockton, Texas	A-33, A-21
R	Pecos River near Girvin, Texas	A-12, A-31

Types of Gages

R - Recorder
S - Staff or inclined gage
W - Wire-weight or chain gage
X - Special type, Mercury U-tube, Selsyn indicator, etc.
M - Gage not maintained. Measurements of spring flow made several times yearly.

a/ Lake levels and contents.
b/ Gage heights only.
c/ Lake levels only.

Table 2.--Additional primary stations required to broaden the hydrologic network in Texas.

The indicated location is to show the local area in which a station is required. Exact location will depend on field inspection.

Map No.	Approximate Drainage Area Square Miles	Station
		ARKANSAS RIVER BASIN
1	1,300	Mustang Creek near Dalhart, Texas
2	200	Red Deer Creek near Canadian, Texas
3	384	Wolf Creek near Alfalfa, Texas
		RED RIVER BASIN
4	1,200	Tule Creek near Silverton, Texas
5	7,365 (4,769)	Prairie Dog Town Fork Red River north of Childress, Texas
6	320	Groesbeck Creek north of Quanah, Texas
7	700	North Fork Red River near Shamrock, Texas
8	1,100	North Pease River near Coleyville, Texas
9	470	South Pease River near Narcisso, Texas
10	3,400	Pease River at Vernon, Texas
11	920	North Fork Wichita River near Foard City, Texas
12	530	South Fork Wichita River near Benjamin, Texas
13	725	Beaver Creek near Wichita-Wilbarger County line, Texas
14	195	East Fork Little Wichita River near Walton, Texas
15	400	Bois d'Arc Creek near Monkstown, Texas
16	160	Pine Creek near Medill, Texas
17	228	Cuthand Creek near Cuthand, Texas
18	365	Black Cypress Creek near Jefferson, Texas
19	675	Little Cypress Creek near Jefferson, Texas
		SABINE RIVER BASIN
20	75	Sabine River above Iron Bridge Reservoir
		NECHES RIVER BASIN
21	200	Kickapoo Creek near Brownsboro, Texas
22	160	East Fork near Sacul, Texas
23	200	Ayish Bayou near Bronson, Texas
		TRINITY RIVER BASIN
24	564	Bedias Creek near Madisonville, Texas
25	374	White Rock Creek near Glendale, Texas
		SAN JACINTO RIVER BASIN
26	226	Lake Creek near Dobbin, Texas

Table 2.--Additional primary stations required to broaden the hydrologic network in Texas--continued

Map No.	Approximate Drainage Area Square Miles	Station
		BRAZOS RIVER BASIN
27	-	White River near Spur, Texas
28	197	Clear Fork Brazos River near Rotan, Texas
29	483	California Creek near Stamford, Texas
30	789	San Gabriel River near San Gabriel, Texas
31	381	Brushy Creek near San Gabriel, Texas
32	320	Elm Creek near Cameron, Texas
33	378	Mill Creek near Sealy, Texas
		COLORADO RIVER BASIN
34	797	Colorado River near Durham, Texas
35	244	Kickapoo Creek near Paint Rock, Texas
36	583	Pecan Bayou near Byrds, Texas
37	787	Jim Ned Creek near Thrifty, Texas
38	162	Cherokee Creek near Chappel, Texas
39	615	South Llano River at Telegraph, Texas
40	332	Sandy Creek near Marble Falls, Texas
41	337	Onion Creek near Delvalle, Texas (reestablish)
42	344	Cedar Creek near Hills Prairie, Texas
43	261	Cummins Creek below SCS projects near Columbus, Texas
		LAVACA RIVER BASIN
44	418	Navidad River near Subline, Texas
		GUADALUPE RIVER BASIN
45	3,453	Guadalupe River at Gonzales, Texas (reestablish)
46	493	Sandies Creek near Westhoff, Texas (reestablish)
47	197	Ecleto Creek near Helena, Texas
		COASTAL BASIN
48	86	Aransas River at Skidmore, Texas
		NUECES RIVER BASIN
49	1,492	Elm Creek near Crystal City, Texas
50	737	San Miguel Creek near Crowther, Texas
51	530	Atascosa River at McCoy, Texas (reestablish as full range)
		COASTAL BASIN
52	931	Agua Dulce Creek at Driscoll, Texas

Table 2.--Additional primary stations required to broaden the hydrologic network in Texas--continued

Map No.	Approximate Drainage Area Square Miles	Station
		RIO GRANDE BASIN
53	50	Madera Canyon near Toyahvale, Texas (reestablish)
54	190	Alpine Creek near Alpine, Texas
55	1,170	Coyanosa Draw near Fort Stockton, Texas
56	2,733	Devils River near Juno, Texas (reestablish)
57	630	Dry Devils River near Mouth, Texas
58	770	Wildhorse Creek near Van Horn, Texas

( ) Noncontributing drainage area.

Table 3.--Additional secondary stations recommended to be established in Texas

The indicated location is to show the local area in which a station is required. Exact location will depend on field inspection.

Map No.	Approximate Drainage Area Square Miles	Station
		CANADIAN RIVER BASIN
1	24	Alamoso Creek near Tascosa, Texas
2	230	Blue Creek near Fritch, Texas
3	500	Coldwater Creek at Stratford, Texas
		RED RIVER BASIN
4	2,075 (1,500)	Tierra Blanca Creek at reservoir near Umbarger, Texas (reestablish)
5	300	Buck Creek near Dodsonville, Texas
6	110	Wanders Creek near Chillicothe, Texas
7	168	Salt Ford Red River near Clarendon, Texas
8	88	Sweetwater Creek near Wheeler, Texas
9	96	Elm Creek near Shamrock, Texas
10	500	Quitaque Creek near Flomot, Texas
11	3,037 (559)	Pease River near Crowell, Texas (reestablish)
12	190	South Fork Wichita River near Guthrie, Texas
13	95	Buffalo Creek near Iowa Park, Texas
14	12	Fish Creek near Marysville, Texas
15	40	Washita River near Canadian, Texas
16	144	Choctaw Creek at U. S. Hwy. 69 near Denison, Texas
17	131	Bois d'Arc Creek near Bonham, Texas
18	134	Sanders Creek near Sumner, Texas
19	124	Pecan Bayou near Vesey, Texas
20	177	South Sulphur River near Commerce, Texas
21	74	Middle Sulphur River near Commerce, Texas
22	12	Doctors Creek near Cooper, Texas
23	151	Whiteoak Creek near Sulphur Springs, Texas
24	110	Lilly Creek near Bettie, Texas
25	385	Little Cypress Creek near James, Texas
26	260	Frazier Creek near Smithland, Texas
		SABINE RIVER BASIN
27	120	Cowleech Fork Sabine River near Dixon, Texas
28	30	Beech Creek at Canton, Texas
29	115	Martins Bayou near Tatum, Texas
30	129	Socagee Bayou near Deadwood, Texas
31	60	Little Cow Creek near Burkeville, Texas (convert to full record)
		NECHES RIVER BASIN
32	105	Hurricane Creek near Neches, Texas
33	80	Tails Creek near Maydelle, Texas

(Continued on next page)

Table 3.--Additional secondary stations recommended to be established in Texas--continued

Map No.	Approximate Drainage Area Square Miles	Station
		NECHES RIVER BASIN (Continued)
34	12	Lynn Creek near Keltys, Texas
35	210	Piney Creek near Benford, Texas
36	60	West Mud Creek near Bullard, Texas
37	170	Stricker Creek near New Salem, Texas
38	80	Lanana Bayou near Nacogdoches, Texas
39	50	Sandy Creek near Jasper, Texas
40	30	Walnut Creek at Beech Grove, Texas
41	140	Cypress Creek near Hillister, Texas
42	120	Cypress Creek at Daisetta, Texas
43	860	Pine Island Bayou near Beaumont, Texas
		TRINITY RIVER BASIN
44	44	Mary Creek near Benbrook, Texas
45	90	Village Creek below reservoirs near Handley, Texas
46	270	Mountain Creek near Grand Prairie, Texas (reestablish)
47	80	Hickory Creek near Krum, Texas
48	59	Brushy Bayou at Lawrence, Texas
49	270	Ferris Fork near Kemp, Texas
50	300	Chambers Creek near Italy, Texas
51	140	Tehuacana Creek near Streetman, Texas
52	260	Catfish Creek near Yard, Texas
53	120	Lower Keechi Creek near Centerville, Texas
54	80	White Rock Creek near Fodice, Texas
55	170	Long King Creek at Livingston, Texas
		SAN JACINTO RIVER BASIN
56	90	Mill Creek near Pinehurst, Texas
57	180	Luce Bayou near Huffman, Texas
		BRAZOS RIVER BASIN
58	230 (6,320)	Double Mountain Fork Brazos River near Post, Texas
59	*	Tank Creek near Old Glory, Texas
60	90	Sweetwater Creek near Sweetwater, Texas
61	1,380	Clear Fork Brazos River near Hawley, Texas
62	90	Big Caddo Creek near Brad, Texas
63	50	Nolands River near Cleburne, Texas
64	120	Neil Creek near Valley Mills, Texas
65	190	Middle Bosque River near McGregor, Texas
66	80	Deer Creek at Chilton, Texas (reestablish)
67	290	Big Creek near Marlin, Texas
68	70	South Fork Leon River near Cisco, Texas

(Continued on next page)

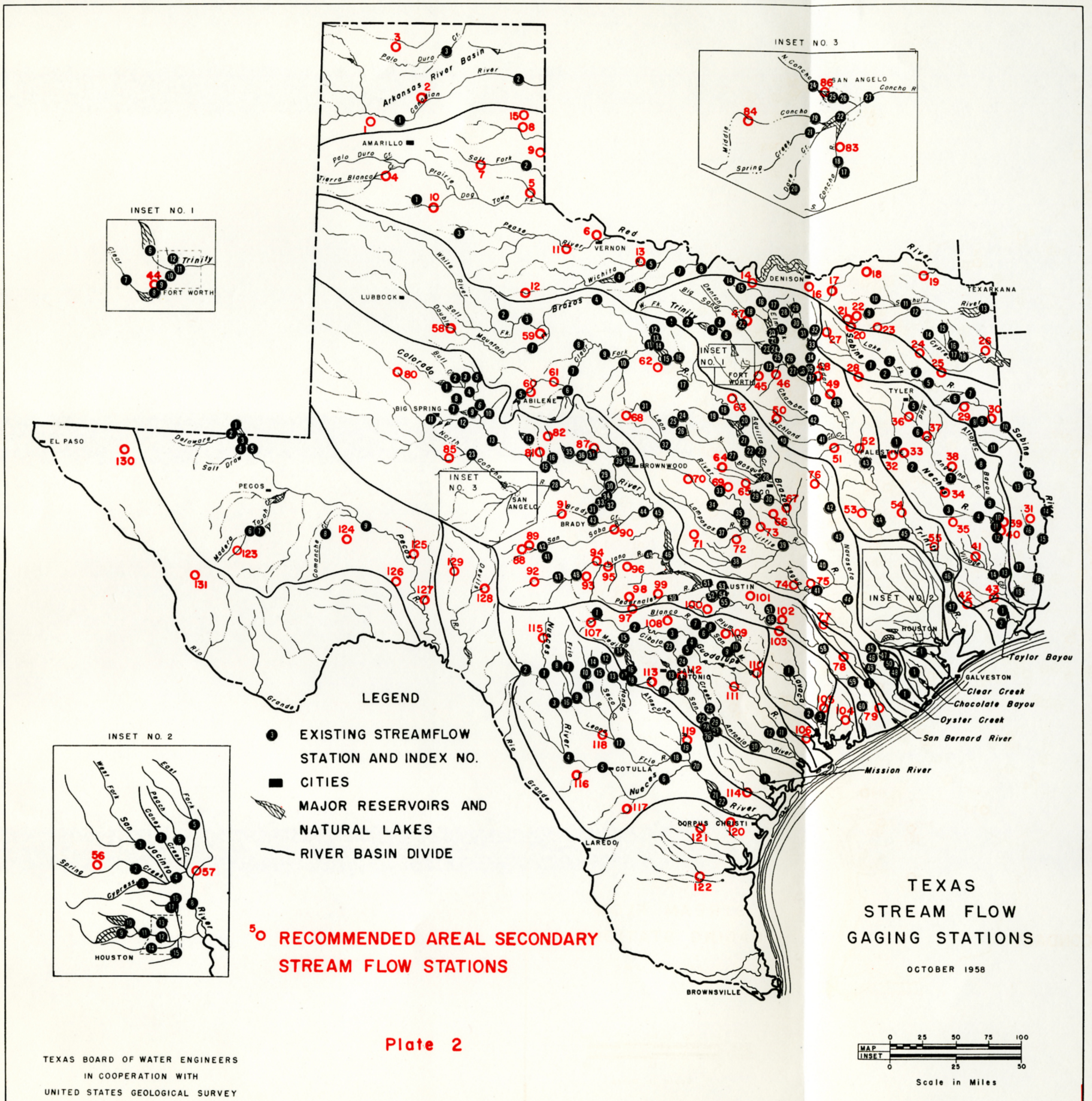
Table 3.--Additional secondary stations recommended to be established in Texas--continued

Map No.	Approximate Drainage Area Square Miles	Station
		BRAZOS RIVER BASIN (Continued)
69	33	Coryell Creek near Coryell, Texas
70	110	Cowhouse Creek near Shive, Texas
71	90	Sulphur Creek near Lampasas, Texas
72	150	Salado Creek near Salado, Texas
73	28	Elm Creek near Troy, Texas
74	130	Middle Yegua Creek near Lexington, Texas
75	130	Davidson Creek at Caldwell, Texas
76	240	Navasota River near Groesbeck, Texas
77	90	West Fork Mill Creek at Industry, Texas
		COASTAL
78	180	San Bernard River near Orange Hill, Texas
79	100	Caney Creek near Bay City, Texas
		COLORADO RIVER BASIN
80	70	Sulphur Springs Creek at Lamesa, Texas
81	170	Valley Creek near Ballinger, Texas
82	150	Bluff Creek near Winters, Texas
83	80	Pecan Creek near Christoval, Texas
84	330	Centralia Draw near Stiles, Texas
85	160	North Concho River near Cushing Ranch, Texas
86	84	Grape Creek near Carlsbad, Texas
87	380	Jim Ned Creek near Burkett, Texas
88	690	San Saba River near Fort McKavett, Texas
89	3	Clear Creek near Menard, Texas
90	1,670	San Saba River near Camp San Saba, Texas
91	140	Brady Creek at Eden, Texas
92	380	North Llano River at Roosevelt, Texas
93	120	Johnson Fork Llano River near Segovia, Texas
94	45	Comanche Creek near Mason, Texas
95	3,230	Llano River near Mason, Texas
96	157	Hickory Creek near Castell, Texas
97	380	Pedernales River near Fredericksburg, Texas
98	19	Barrons Creek near Fredericksburg, Texas
99	86	North Grape Creek near Sandy, Texas
100	20	Slaughter Creek near Austin, Texas
101	100	Big Sandy Creek near Sayersville, Texas
102	90	Rabbs Creek near Warda, Texas
103	190	Buckner Creek near La Grange, Texas
		COASTAL
104	150	Tres Palacios Creek near Buckeye, Texas
		LAVACA RIVER BASIN
105	140	West Mustang Creek near Ganado, Texas

Table 3.--Additional secondary stations recommended to be established in Texas--continued

Map No.	Approximate Drainage Area Square Miles	Station
		COASTAL
106	260	Arenoso Creek near Vanderbilt, Texas
		GUADALUPE RIVER BASIN
107	280	Guadalupe River at Hunt, Texas (reestablish)
108	20	Little Blanco River at Twin Sisters, Texas
109	160	Plum Creek near Lockhart, Texas
110	440	Peach Creek near Gonzales, Texas (reestablish)
111	100	Sandies Creek near Leesville, Texas
112	140	Salado Creek near San Antonio, Texas
113	40	Medio Creek near Macdona, Texas
		COASTAL
114	170	Chilipin Creek at Sinton, Texas
		NUECES RIVER BASIN
115	310	Nueces River near Vance, Texas
116	390	San Rogue Creek near Catarina, Texas
117	470	Salado Creek near Webb-LaSalle County, Line, Texas
118	560	Leona River near Divot, Texas (reestablish)
119	140	San Cristobal Creek near Fant City, Texas
		COASTAL
120	40	Oso Creek at Robstown, Texas
121	350	San Diego Creek near Alice, Texas
122	520	Los Olmos Creek near Falfurrias, Texas
		RIO GRANDE BASIN
123	300	Limpia Creek at Limpia, Texas (reestablish)
124	180	Tunis Creek near Fort Stockton, Texas
125	360	Liveoak Creek near Sheffield, Texas
126	580	Independence Creek near Sheffield, Texas
127	1,000	Howards Creek near Pandale, Texas
128	180	Angela Draw near Sonora, Texas
129	120	Johnson Creek near Ozona, Texas
		CLOSED BASINS IN TEXAS
130	900	Sacramento Creek near Dell City, Texas
131	410	Wildhorse Creek near Valentine, Texas

( ) Noncontributing drainage area.
* Less than 10.

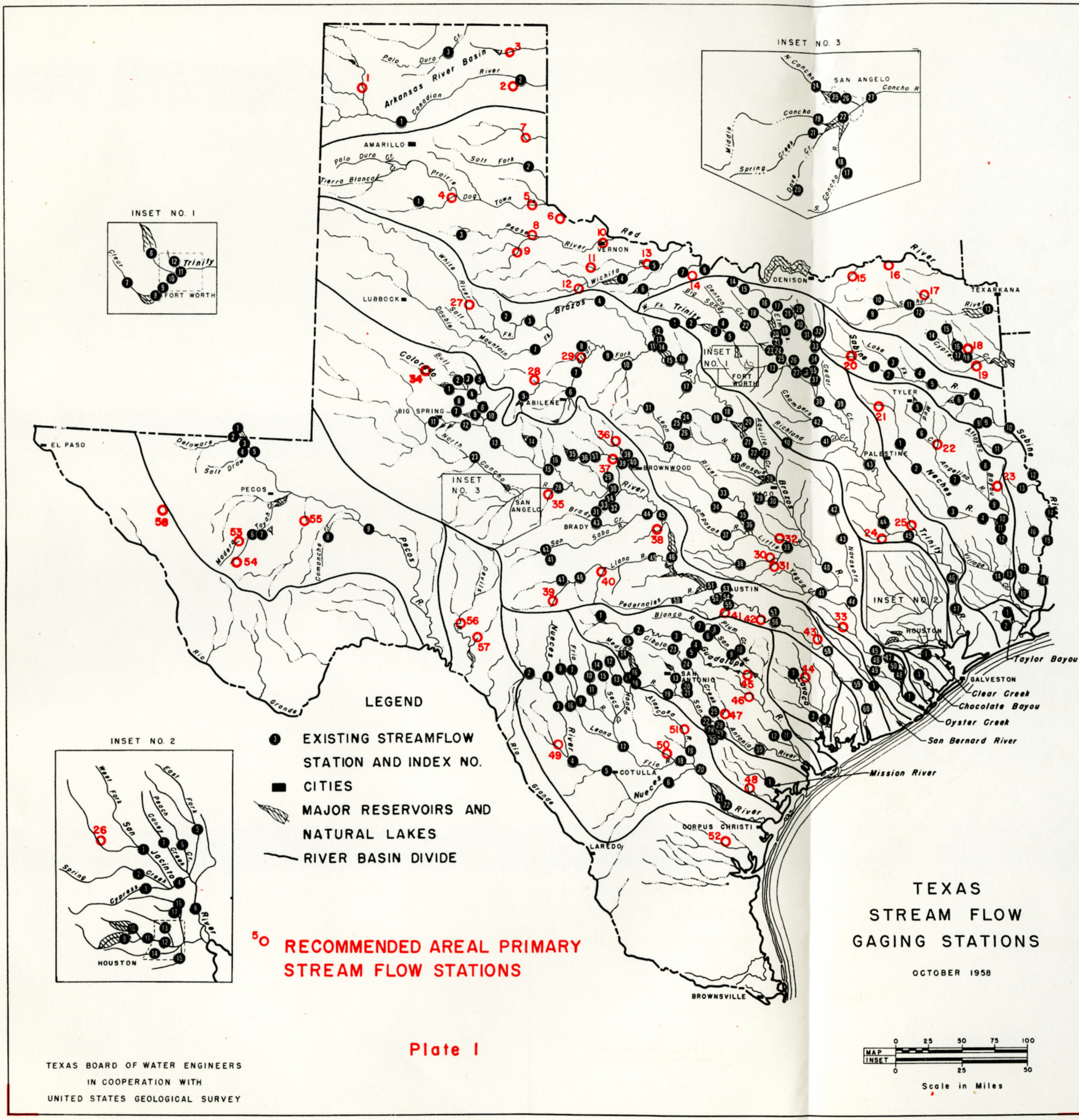


TEXAS STREAM FLOW GAGING STATIONS

OCTOBER 1958

Plate 2

TEXAS BOARD OF WATER ENGINEERS
IN COOPERATION WITH
UNITED STATES GEOLOGICAL SURVEY


TEXAS
STREAM FLOW
GAGING STATIONS
OCTOBER 1958
LEGEND
EXISTING STREAMFLOW STATION AND INDEX NO.
CITIES
MAJOR RESERVOIRS AND NATURAL LAKES
RIVER BASIN DIVIDE
RECOMMENDED AREAL PRIMARY STREAM FLOW STATIONS
Plate I
TEXAS BOARD OF WATER ENGINEERS
IN COOPERATION WITH
UNITED STATES GEOLOGICAL SURVEY
Scale in Miles
MAP
INSET
INSET NO. 1
INSET NO. 2
INSET NO. 3
AMARILLO
LUBBOCK
EL PASO
PECOS
VERNON
DENISON
TEXARKANA
ABILENE
BIG SPRING
SAN ANGELO
BROWNWOOD
BRADY
FORT WORTH
WACO
TYLER
PALESTINE
AUSTIN
SAN ANTONIO
HOUSTON
GALVESTON
COTULLA
LAREDO
CORPUS CHRISTI
BROWNSVILLE
Arkansas River Basin
Canadian River
Red River
Brazos
Colorado
Trinity
Sabine River
Neches
Pecos R.
Rio Grande
Nueces River
Guadalupe
San Antonio River
San Jacinto
Taylor Bayou
Clear Creek
Chocolate Bayou
Oyster Creek
San Bernard River
Mission River