# Sedimient Yields for Selected Streams in Texas

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# SEDIMENT YIELDS FOR SELECTED STREAMS IN TEXAS

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## ABSTRACT

The U.S. Geological Survey began a study to determine sediment yields for selected streams in Texas during the 1966 water year to provide information for areas in which sediment-yield data were meager or lacking. These data will aid in delineating problem areas and planning for water-resources development in the State. This report presents estimates of suspended-sediment loads and yields from 20 drainage basins ranging in area from 26 to 1,410 square miles. These estimates are based on samples collected periodically during water years 1966-74.

Sediment loads ranged from 1,500 tons per year at the station North Fork Hubbard Creek near Albany to 278,000 tons per year at the station Wichita River at Wichita Falls. Sediment yields ranged from 15 tons per square mile per year in the drainage area of East Yegua Creek near Dime Box to 500 tons per square mile per year in the drainage area of Denton Creek near Justin. Sediment yields from drainage areas generally decrease from northwest to southeast across the State.

## INTRODUCTION

The U.S. Geological Survey began a study to determine sediment yields for selected streams in Texas during the 1966 water year. The purpose of the study was to provide information for areas in which sediment-yield data were meager or lacking. These data will aid in planning for water-resources development and in delineating potential problem areas.

Clay, silt, sand, gravel, and other insoluble materials transported by streams, either as suspended matter or as the bedload, present problems of vital importance in many projects for flood control, soil conservation, irrigation, navigation, and water-power development. Costly maintenance, loss of efficiency, and in some places destruction of important engineering works have occurred as a result of reservoirs filling with sediment, filling or scouring of navigation and irrigation channels, or erosion and gullying of arable lands. Before any engineering projects dealing with streams or their watersheds are undertaken, the sediment yield of the watersheds should be known.

During the study, sediment samples were collected infrequently by using depth integrating samplers at one or more verticals in the cross section at 20 sites throughout the State. Where more than one vertical was necessary for sampling, the equal-discharge increment method (Guy and Norman, 1970, p. 31) was used. The sites were located at a stream-gaging station so that sediment loads and yields could be estimated from the relation between water and sediment discharges. Many of the sites were located in areas where reservoir construction is planned or has been completed. Other factors considered in site selection included geology, land use, and climate.

The terminology used in this report is as follows:

Bed material.--The shifting part of the granular material that forms the bed of most streams.

Bedload.--The sediment that moves in almost continuous contact with the streambed and material that bounces along the bed in short skips or leaps.

Flow-duration curve.--A cumulative-frequency curve that shows the percentage of time that specified discharges are equaled or exceeded.

Particle size.--This is the diameter, in millimeters (mm), of suspended sediment or bed material determined either by sieve or sedimentation methods. Sedimentation methods (pipet, bottom-withdrawal tube, visual-accumulation tube) determine the "fall-diameter" of particles in distilled water.

Particle-size classification.--This term, as used in this report, is consistent with recommendations made by the Subcommittee on Sediment Terminology of the American Geophysical Union (Lane and others, 1947). The classification is as follows:

| Classification | Size (millimeters) | Method of analysis |
|---|---|---|
| clay | 0.00024 - 0.004 | sedimentation |
| silt | .004 - .062 | do. |
| sand | .062 - 2.0 | sedimentation or sieve |
| gravel | 2.0 - 64.0 | sieve |

The particle-size distributions given in this report are not representative of all particles in transport in the stream during this study, but they may be used to describe qualitatively the general sediment-load characteristics of the stream. Most of the organic material is removed from the sample and the sample is subject to mechanical and chemical dispersion before analysis in distilled water.

Sediment-transport curve.--A curve showing the relation between water discharge and suspended-sediment discharge.

Suspended sediment.--The sediment that at any given time is in suspension as a colloid or is maintained in suspension by the upward components of turbulent currents.

Suspended-sediment concentration.--The velocity-weighted concentration of sediment in the sampled zone (from the water surface to a point approximately 0.3 foot above the bed), expressed as milligrams of dry sediment per liter of water-sediment mixture.

Suspended-sediment discharge.--The rate at which a dry weight of suspended sediment passes a section of a stream or the quantity of sediment, as measured by dry weight that is discharged in a given time.

Total sediment discharge.--The sum of the suspended-sediment discharge and the bedload discharge. It is the total quantity of sediment, as measured by dry weight or volume, that is discharged during a given time.

## COMPUTATION OF SUSPENDED-SEDIMENT DISCHARGE AND YIELD

Infrequent collection of sediment samples from each of the 20 stations (fig. 1) except Mineral Creek near Sadler was begun during the 1966 water year. Continuous streamflow records for these stations are available since the 1965 or earlier water years. Operation of the continuous streamflow and sediment station Mineral Creek near Sadler was begun during the 1968 water year. Therefore, the suspended-sediment discharge and yield for Mineral Creek near Sadler were computed for water years 1968-74.

Deliberate impoundment of water in Lake Conroe on the West Fork San Jacinto River was begun during the 1973 water year. Suspended-sediment discharge and yield for the West Fork San Jacinto River near Conroe were calculated for the water years 1965-72, before closure of the reservoir. Suspended-sediment discharges and yields for the other stations were computed for water years 1965-74.

The methods used for computation of sediment discharge were those described by Miller (1951). Sediment-transport curves showing the relation between instantaneous water and suspended-sediment discharges (fig. 2) at the time of sampling were prepared for each stream. On the basis of equations for these curves (table 1) and flow-duration curves for the base period (fig. 3), duration tables of suspended-sediment discharge were prepared (sample computation given in table 2), and the daily mean suspended-sediment discharges were computed. This value for each station, multiplied

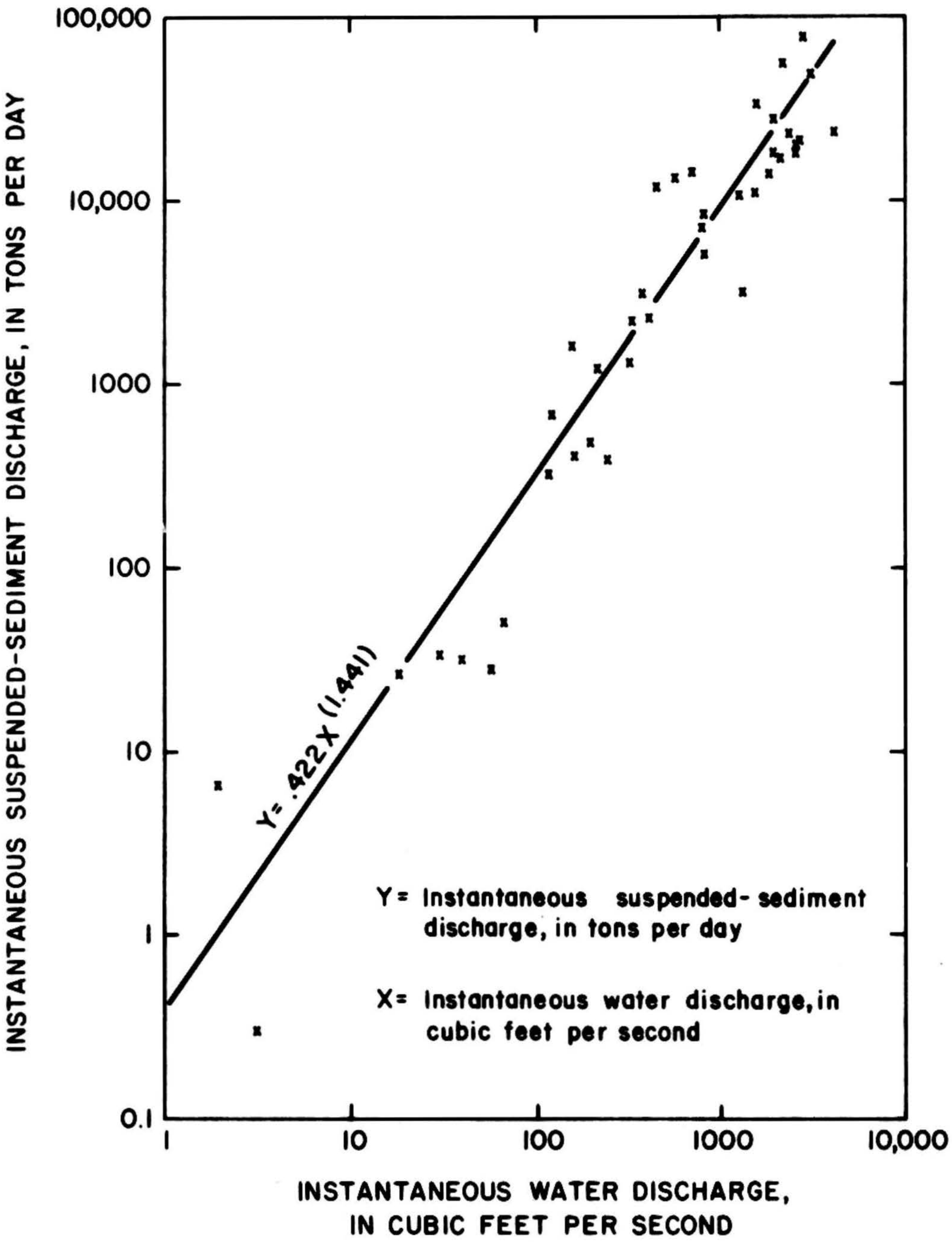


FIGURE 2.-Suspended-sediment transport curve, Beaver Creek near Electra, Texas

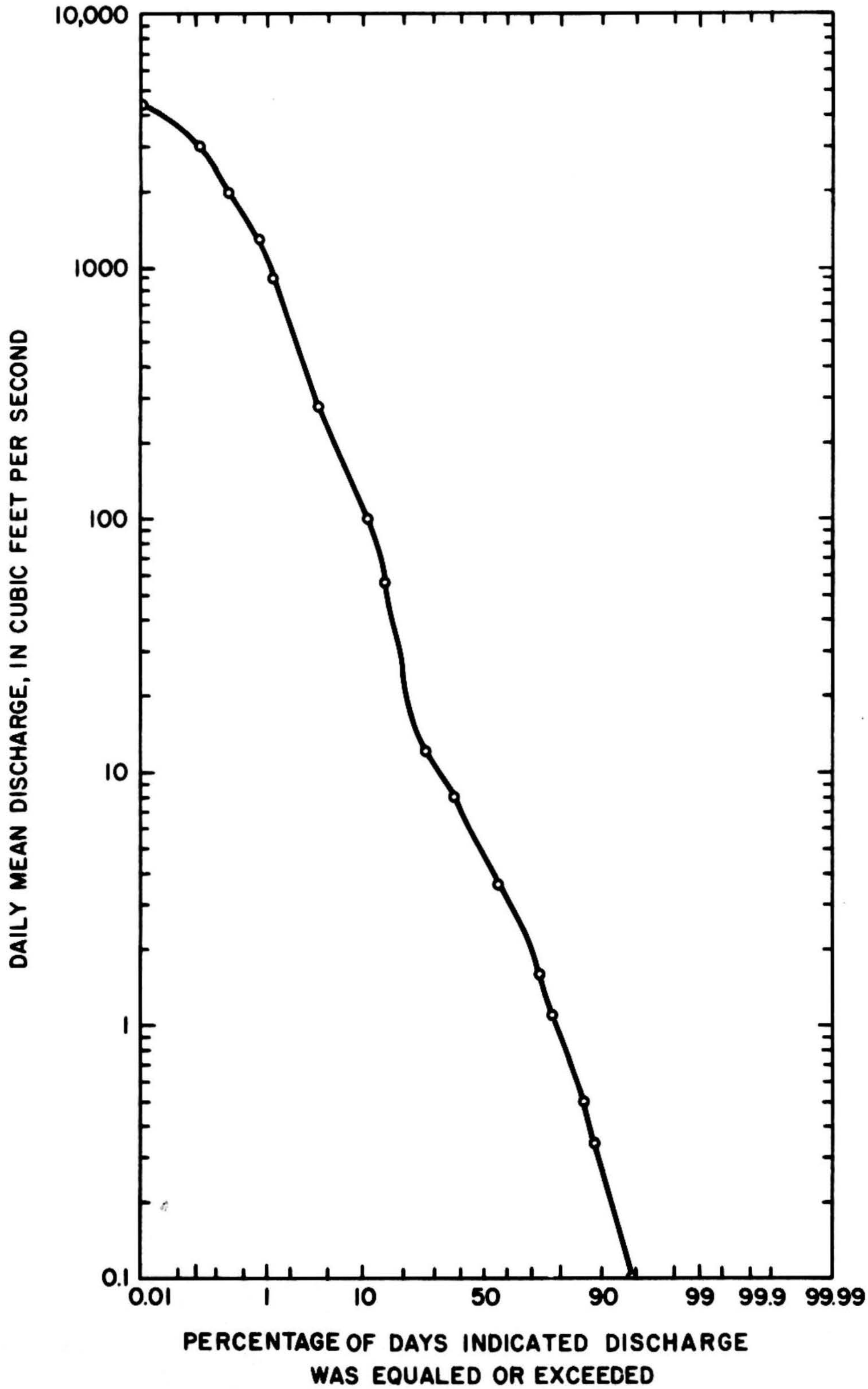


**FIGURE 3.-Flow-duration curve, Beaver Creek near Electra, October 1964-September 1974**

Table 1.--Summary of sediment data for selected streams in Texas

(Data for water years 1965-74, except as indicated)

| Station number | Station name | Drainage area (square miles) | Equations of suspended-sediment transport curves 1/ | Average annual load (tons per year) | Average annual yield (tons per square mile per year) | Bed-load 2/ | Particle size (percent) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Bed material | | | Suspended material | | |
| | | | | | | | Gravel | Sand | Silt and clay | Sand | Silt | Clay |
| 07312200 | Beaver Creek near Electra | a/316 | $y=0.422x^{(1.441)}$ | 143,000 | b/410 | M | -- | 45 | 55 | 3 | 30 | 67 |
| 07312500 | Wichita River near Wichita Falls | a/718 | $y= .118x^{(1.502)}$ | 278,000 | b/330 | S | -- | 80 | 20 | 4 | 24 | 72 |
| 07315200 | East Fork Little Wichita River near Henrietta | 178 | $y=1.815x^{(.896)}$ | 7,490 | 42 | S | -- | 81 | 19 | 1 | 23 | 76 |
| 07316200 | Mineral Creek near Sadler | 26.0 | $y= .069x^{(1.551)}$ | c/5,520 | 210 | S | 8 | 92 | -- | 26 | 30 | 44 |
| 08050500 | Elm Fork Trinity River near Sanger | a/286 | $y= .041x^{(1.473)}$ | 85,800 | b/300 | M | 89 | 10 | 1 | 2 | 25 | 73 |
| 08051000 | Isle du Bois Creek near Pilot Point | 266 | $y= .109x^{(1.359)}$ | 95,000 | 360 | M | 78 | 21 | 1 | 4 | 16 | 80 |
| 08053500 | Denton Creek near Justin | 400 | $y= .036x^{(1.663)}$ | 107,000 | b/500 | S | 6 | 51 | 43 | 18 | 15 | 67 |
| 08068000 | West Fork San Jacinto River near Conroe | 809 | $y= .049x^{(1.226)}$ | 36,500 | d/45 | S | 10 | 90 | -- | 48 | -- | e/52 |
| 08068500 | Spring Creek near Spring | 409 | $y= .028x^{(1.353)}$ | 23,400 | 57 | S | -- | 100 | -- | 37 | -- | e/63 |
| 08070500 | Caney Creek near Splendora | 105 | $y= .008x^{(1.594)}$ | 6,390 | 61 | S | -- | 100 | -- | 25 | -- | e/75 |
| 08086100 | Hubbard Creek near Albany | 461 | $y= .024x^{(1.730)}$ | 103,000 | 220 | S | 49 | 48 | 3 | 3 | 30 | 67 |
| 08086150 | North Fork Hubbard Creek near Albany | 38.4 | $y= .034x^{(1.661)}$ | 1,500 | 39 | M | -- | -- | -- | 5 | 35 | 60 |
| 08086300 | Big Sandy Creek near Breckenridge | a/275 | $y= .545x^{(1.378)}$ | 69,000 | b/250 | M | 79 | 20 | 1 | 4 | 28 | 68 |
| 08109800 | East Yegua Creek near Dime Box | 243 | $y= .124x^{(1.074)}$ | 3,650 | 15 | M | -- | 70 | 30 | -- | 10 | 90 |
| 08110100 | Davidson Creek near Lyons | 195 | $y= .071x^{(1.294)}$ | 11,000 | 56 | M | -- | 97 | 3 | -- | -- | -- |
| 08111700 | Mill Creek near Bellville | 377 | $y= .142x^{(1.209)}$ | 57,500 | 150 | S | 1 | 99 | -- | -- | -- | -- |
| 08183500 | San Antonio River near Falls City | a/1,410 | $y= .006x^{(1.667)}$ | 141,000 | b/100 | M | -- | 34 | 66 | 3 | 18 | 79 |
| 08186000 | Cibolo Creek near Falls City | 827 | $y= .327x^{(1.122)}$ | 82,300 | 100 | M | -- | 53 | 47 | <1 | 13 | 87 |
| 08186500 | Ecleto Creek near Runge | 239 | $y= .031x^{(1.482)}$ | 7,710 | 32 | S | 38 | 61 | 1 | 20 | 17 | 63 |
| 08189700 | Aransas River near Skidmore | 247 | $y= .069x^{(1.411)}$ | 24,500 | 100 | S | -- | 96 | 4 | 3 | 9 | 88 |

1/ Where y = instantaneous suspended-sediment discharge, in tons per day.
x = instantaneous water discharge, in cubic feet per second.

2/ M-minimal; S-possibly significant.

a/ Area below impoundments.

b/ Sediment yield of area below impoundments.

c/ For water years 1968-74.

d/ For water years 1965-72, before completion of Lake Conroe.

e/ Silt and clay.

Table 2.--Computation of estimated daily mean suspended-sediment discharge for Beaver Creek near Electra, Texas

| Duration table percentage | | | Water discharge for mean of interval 4/ (cubic feet per second) | Suspended-sediment discharge | |
|---|---|---|---|---|---|
| Time limits 1/ | Time interval 2/ | Mean of interval 3/ | | Discharge for mean of interval 5/ (tons per day) | Increment of discharge in time interval 6/ (tons per day) |
| 0.00 - 0.02 | 0.02 | 0.01 | 4,400 | 75,000 | 15.0 |
| .02 - .06 | .04 | .04 | 3,600 | 56,200 | 22.5 |
| .06 - .10 | .04 | .08 | 3,120 | 45,700 | 18.3 |
| .1 - .3 | .2 | .2 | 2,320 | 29,800 | 59.6 |
| .3 - .5 | .2 | .4 | 1,770 | 20,200 | 40.4 |
| .5 - 1.0 | .5 | .75 | 1,300 | 13,000 | 65.0 |
| 1 - 2 | 1 | 1.5 | 780 | 6,200 | 62.0 |
| 2 - 4 | 2 | 3.0 | 400 | 2,370 | 47.4 |
| 4 - 8 | 4 | 6.0 | 194 | 836 | 33.4 |
| 8 - 15 | 7 | 11.5 | 93 | 289 | 20.2 |
| 15 - 25 | 10 | 20 | 25.5 | 44.9 | 4.5 |
| 25 - 35 | 10 | 30 | 10.4 | 12.3 | 1.2 |
| 35 - 45 | 10 | 40 | 6.9 | 6.8 | .7 |
| 45 - 55 | 10 | 50 | 4.6 | 3.8 | .4 |
| 55 - 65 | 10 | 60 | 3.0 | 2.1 | .2 |
| 65 - 75 | 10 | 70 | 1.9 | 1.1 | .1 |
| 75 - 85 | 10 | 80 | .9 | .36 | 0 |
| | | | | Total - | 390.9 |

1/ Limits of spread of time interval used in integrating area under duration curves by partial areas. (See fig. 3.)
2/ Spread of time interval.
3/ Selected percentages on duration curves used in duration tables for this study.
4/ Flow-duration table of water discharge for water years 1965-74.
5/ Duration table of suspended-sediment discharge. (See fig. 2.)
6/ Time interval multiplied by discharge for mean of interval divided by 100.

by the average number of days per year during the study period (365.3), is the estimated average annual suspended-sediment load that passed the station. The sediment yield was computed by dividing the estimated average annual sediment load by the area of the drainage basin upstream from the station.

Part of the sediment transported from the drainage areas of some of the streams was trapped by upstream reservoirs. The sediment yields for the drainage areas of these streams were adjusted on the basis of published or estimated trap efficiencies of the reservoirs.

## ANALYSIS OF DATA

Sediment data for the 20 stations are summarized in table 1. The data presented include the estimated average annual suspended-sediment loads, yields, the results of a few analyses of size distributions of suspended sediment, and bed material. These estimates show that the average sediment discharge for the 20 sites studied ranged from 1,500 to 278,000 tons per year, and the sediment yield ranged from 15 to 500 tons per square mile per year. The data in table 1 show generally that sediment yields decrease while suspended-sand fractions increase from northwest to southeast. The highest yields are from subbasins of the Wichita and upper Trinity Rivers.

The total sediment discharge (sum of the suspended-sediment and bedload discharges) was not measured at any of the sites. However, the particle-size distribution of the suspended sediment (table 3) and bed material, supplemented by velocity measurements of the streams, provide a qualitative indication of whether or not the unmeasured bedload would be significant (greater than 10 percent, Lane and Borland, 1951). These data indicate that the bedload may be significant at about one-half of the 20 sites (table 1).

An analysis of the data for individual stations and a brief description of the drainage-basin characteristics that affect sediment yield are given in the following sections of this report. Information pertaining to soils, land usage, and climate was taken from station files and from individual county soil maps published by the U.S. Department of Agriculture. Generalized information on the geology of the drainage areas is from Renfro and Feray (1973).

### Beaver Creek near Electra, Texas (07312200)

Beaver Creek rises in Foard County, flows easterly through the lower third of Wilbarger County, and joins the Wichita River (a tributary to the Red River) in the southwestern part of Wichita County. The drainage basin is very sparsely populated ranchland, generally covered with grasses

Table 3.--Particle-size analyses of suspended-sediment samples for Texas streams

(Methods of analyses: B, bottom withdrawal tube; C, chemically dispersed; P, pipet; S, sieve; V, visual accumulation tube; W, in distilled water)

| Date of collection | Time | Discharge ($ft^3/s$-days) | Suspended sediment: Suspended sediment (milligrams per liter) | Suspended-sediment discharge (tons per day) | Percent finer than indicated size, in millimeters: 0.002 | 0.004 | 0.008 | 0.016 | 0.031 | 0.062 | 0.125 | 0.250 | 0.500 | Methods of analysis |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **07312200 BEAVER CREEK NEAR ELECTRA** | | | | | | | | | | | | | | |
| Apr. 12, 1967- | 1200 | 2,260 | 9,280 | 56,600 | 45 | 54 | 66 | 78 | 91 | 97 | 100 | -- | -- | VPCW |
| Apr. 13------- | 1245 | 706 | 7,650 | 14,600 | 49 | 60 | 70 | 80 | 90 | 98 | 100 | -- | -- | VPCW |
| Jan. 23, 1968- | 1025 | 215 | 2,120 | 1,230 | 65 | 72 | 76 | 79 | 88 | 96 | 99 | 100 | -- | SPWC |
| June 1-------- | 1140 | 2,880 | 10,200 | 79,300 | 51 | 62 | 75 | 86 | 95 | 98 | 99 | 100 | -- | SPWC |
| Sept. 24, 1969 | 1430 | 1.9 | 1,260 | 6.5 | 53 | 60 | 73 | 77 | 88 | 94 | 99 | 100 | -- | SBWC |
| Aug. 17, 1971- | 1605 | 18 | 563 | 27 | 77 | 82 | 86 | 91 | 94 | 99 | 100 | -- | -- | SPWC |
| Aug. 26------- | 1145 | 457 | 9,820 | 12,100 | 48 | 59 | 68 | 78 | 85 | 91 | 99 | 100 | -- | SPWC |
| May 10, 1972-- | 1730 | 571 | 8,890 | 13,700 | 47 | 56 | 65 | 74 | 86 | 93 | 99 | 100 | -- | SPWC |
| June 23------- | 0915 | 192 | 9,530 | 4,940 | 62 | 72 | 83 | 89 | 95 | 99 | 100 | -- | -- | SPWC |
| Nov. 1-------- | 1145 | 4,190 | 2,100 | 23,800 | 72 | 81 | 88 | 95 | 98 | 99 | 100 | -- | -- | SPWC |
| Feb. 13, 1973- | 1030 | 66 | 288 | 51 | 87 | 91 | 92 | 96 | 97 | 99 | 100 | -- | -- | SBWC |
| Mar. 31------- | 0945 | 2,690 | 2,540 | 18,400 | 65 | 67 | 71 | 80 | 88 | 94 | 97 | 99 | 100 | SPWC |
| Apr. 26------- | 0915 | 116 | 1,040 | 326 | 53 | 65 | 67 | 74 | 83 | 96 | 98 | 99 | 100 | SBWC |
| Sept. 25, 1974 | 1035 | 1,960 | 5,350 | 28,300 | 46 | 71 | 74 | 91 | 94 | 96 | 99 | 100 | -- | SBWC |
| **07312500 WICHITA RIVER AT WICHITA FALLS** | | | | | | | | | | | | | | |
| Apr. 12, 1967- | 1710 | 4,920 | 2,540 | 33,700 | 57 | 67 | 75 | 81 | 88 | 93 | 98 | 100 | -- | SPWC |
| Apr. 13------- | 1030 | 5,310 | 1,580 | 22,700 | 82 | 82 | 89 | 90 | 94 | 95 | 97 | 100 | -- | SPWC |
| Jan. 22, 1968- | 1625 | 1,720 | 2,610 | 12,100 | 56 | 63 | 67 | 79 | 93 | 98 | 99 | 100 | -- | SPWC |
| June 1-------- | 1100 | 778 | 10,400 | 21,800 | 47 | 62 | 76 | 89 | 97 | 98 | 99 | 99 | 100 | SPWC |
| June 1-------- | 1800 | 1,190 | 4,100 | 13,200 | 47 | 53 | 63 | 73 | 90 | 98 | 99 | 100 | -- | SPWC |
| Mar. 17, 1969- | 1330 | 1,120 | 1,700 | 5,140 | 60 | 67 | 75 | 87 | 93 | 96 | 99 | 100 | -- | SPWC |
| Sept. 23------ | 0915 | 2,800 | 2,990 | 22,600 | 65 | 75 | 85 | 92 | 96 | 99 | 100 | -- | -- | SPWC |
| Aug. 17, 1971- | 1715 | 736 | 5,060 | 10,100 | 57 | 69 | 82 | 90 | 97 | 98 | 99 | 99 | 100 | SPWC |
| Aug. 18------- | 1530 | 298 | 1,470 | 1,180 | 67 | 77 | 88 | 95 | 98 | 99 | 99 | 99 | 100 | SPWC |
| Aug. 26------- | 1035 | 2,640 | 6,840 | 48,800 | 62 | 73 | 85 | 94 | 98 | 99 | 99 | 100 | -- | SPWC |
| June 23, 1972- | 1450 | 1,420 | 6,220 | 23,800 | 38 | 54 | 73 | 90 | 99 | 100 | -- | -- | -- | SPWC |
| Nov. 1-------- | 1450 | 5,860 | 1,100 | 17,400 | 82 | 83 | 87 | 90 | 93 | 94 | 95 | 97 | 100 | SPWC |
| Mar. 31, 1973 | 1120 | 1,620 | 8,830 | 38,600 | 52 | 62 | 73 | 86 | 95 | 99 | 100 | -- | -- | SPWC |
| Apr. 27------- | 1155 | 319 | 942 | 811 | 61 | 73 | 82 | 92 | 98 | 99 | 100 | -- | -- | SBWC |
| May 1, 1974--- | 0835 | 2,220 | 4,170 | 25,000 | 54 | 67 | 82 | 93 | 99 | 99 | 100 | -- | -- | SPWC |
| Sept. 18------ | 1030 | 189 | 1,300 | 663 | 60 | 82 | 85 | 97 | 99 | 100 | -- | -- | -- | SPWC |

Table 3.--Particle-size analyses of suspended-sediment samples for Texas streams--Continued

| Date of collection | Time | Discharge ($ft^3$/s-days) | Suspended sediment: Suspended sediment (milligrams per liter) | Suspended sediment: Suspended-sediment discharge (tons per day) | Percent finer than indicated size, in millimeters: 0.002 | 0.004 | 0.008 | 0.016 | 0.031 | 0.062 | 0.125 | 0.250 | 0.500 | Methods of analysis |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 07315200 EAST FORK LITTLE WICHITA RIVER NEAR HENRIETTA | | | | | | | | | | | | | | |
| May 31, 1967-- | 1145 | 440 | 2,240 | 2,660 | 73 | 76 | 88 | 91 | 98 | 100 | -- | -- | -- | SPWC |
| Apr. 24, 1973- | 1510 | 249 | 1,910 | 1,280 | 70 | 76 | 81 | 91 | 98 | 99 | 100 | -- | -- | SPWC |
| 07316200 MINERAL CREEK NEAR SADLER | | | | | | | | | | | | | | |
| May 7, 1969--- | 0900 | 11,500 | 1,760 | 54,600 | 42 | 44 | 48 | 52 | 61 | 74 | -- | -- | -- | SBWC |
| 08050500 ELM FORK TRINITY RIVER NEAR SANGER | | | | | | | | | | | | | | |
| Apr. 23, 1964- | 1250 | 33 | 1,410 | 126 | 63 | 88 | 91 | 91 | 97 | 100 | -- | -- | -- | SPWC |
| Feb. 9, 1966-- | 1945 | 25,000 | 1,950 | 132,000 | 68 | 76 | 84 | 89 | 96 | 99 | 100 | -- | -- | SPWC |
| Feb. 10------- | 1135 | 4,300 | 784 | 9,100 | 80 | 80 | 86 | 87 | 94 | 99 | 100 | -- | -- | SPWC |
| Feb. 10------- | 1620 | 2,400 | 825 | 5,350 | 71 | 73 | 77 | 81 | 92 | 99 | 100 | -- | -- | SPWC |
| Mar. 20, 1968- | 1930 | 9,040 | 1,290 | 31,500 | 62 | 69 | 80 | 85 | 94 | 97 | 98 | 99 | 100 | SPWC |
| Apr. 19------- | 1635 | 5,920 | 2,600 | 41,600 | 52 | 63 | 73 | 81 | 92 | 97 | 99 | 100 | -- | SPWC |
| May 7, 1969--- | 0830 | 12,900 | 753 | 26,200 | 66 | 74 | 79 | 85 | 93 | 96 | 98 | 99 | 100 | SBWC |
| June 12, 1974- | 1335 | 42 | 270 | 31 | 76 | 86 | 88 | 90 | 91 | 98 | 99 | 100 | -- | SBWC |
| Sept. 25------ | 1600 | 4,450 | 536 | 6,440 | 58 | 64 | 71 | 81 | 90 | 96 | 99 | 100 | -- | SBWC |
| 08051000 ISLE DU BOIS CREEK NEAR PILOT POINT | | | | | | | | | | | | | | |
| Apr. 23, 1964- | 1230 | 540 | 2,430 | 35,400 | 81 | 86 | 89 | 94 | 97 | 98 | 99 | 100 | -- | SPWC |
| Sept. 25------ | 1115 | 74 | 336 | 67 | 79 | 88 | 95 | 98 | 98 | 100 | -- | -- | -- | SBWC |
| Feb. 10, 1966- | 0920 | 5,250 | 1,070 | 15,200 | 76 | 76 | 76 | 89 | 91 | 98 | 99 | 100 | -- | SPWC |
| Feb. 10------- | 1515 | 4,750 | 934 | 12,000 | 90 | 92 | 94 | 96 | 97 | 98 | 99 | 100 | -- | SPWC |
| Mar. 21, 1968- | 1425 | 5,580 | 634 | 9,550 | 85 | 89 | 91 | 93 | 93 | 96 | 99 | 100 | -- | SPWC |
| Apr. 19------- | 1710 | 3,070 | 1,500 | 12,400 | 52 | 60 | 67 | 76 | 89 | 98 | 99 | 100 | -- | SPWC |
| Oct. 3-------- | 1040 | .3 | 432 | .3 | 83 | 86 | 88 | 95 | 99 | 100 | -- | -- | -- | SBWC |
| Jan. 31, 1969- | 1540 | 1,260 | 645 | 2,190 | 79 | 83 | 85 | 86 | 88 | 94 | 96 | 99 | 100 | SBWC |
| Feb. 13, 1973- | 1715 | 33 | 136 | 12 | 82 | 88 | 91 | 94 | 95 | 100 | -- | -- | -- | SBWC |
| Apr. 17------- | 1420 | 1,180 | 645 | 2,050 | 60 | 61 | 62 | 64 | 64 | 94 | 96 | 97 | 98 | SPWC |
| Sept. 17, 1974 | 1200 | 1,070 | 891 | 2,570 | 58 | 67 | 68 | 74 | 76 | 80 | 86 | 96 | 99 | SBWC |

Table 3.--Particle-size analyses of suspended-sediment samples for Texas streams--Continued

| Date of collection | Time | Discharge (ft³/s-days) | Suspended sediment (milligrams per liter) | Suspended-sediment discharge (tons per day) | Suspended sediment: Percent finer than indicated size, in millimeters | | | | | | | | | Methods of analysis |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 0.002 | 0.004 | 0.008 | 0.016 | 0.031 | 0.062 | 0.125 | 0.250 | 0.500 | |
| **08053500 DENTON CREEK NEAR JUSTIN** | | | | | | | | | | | | | | |
| Feb. 10, 1966- | 1730 | 2,680 | 1,750 | 12,700 | 76 | 80 | 82 | 84 | 87 | 90 | 94 | 98 | 100 | SPWC |
| Apr. 24------- | 1300 | 460 | 2,620 | 3,250 | 54 | 70 | 76 | 88 | 94 | 98 | 99 | 100 | -- | SPWC |
| May 31, 1967-- | 1120 | 3,300 | 3,970 | 35,400 | 28 | 34 | 39 | 43 | 47 | 51 | 55 | 73 | 98 | VPWC |
| Mar. 21, 1968- | 1040 | 2,340 | 1,960 | 12,400 | 57 | 65 | 68 | 73 | 79 | 87 | 92 | 97 | 100 | VPWC |
| Feb. 23, 1969- | 1320 | 185 | 1,290 | 644 | 83 | 85 | 94 | 96 | 98 | 98 | 99 | 100 | -- | SBWC |
| May 7--------- | 1520 | 5,280 | 1,230 | 17,500 | 70 | 79 | 82 | 86 | 89 | 91 | 95 | 98 | 100 | SBWC |
| Oct. 26, 1972- | 1625 | 180 | 1,250 | 608 | 77 | 82 | 86 | 91 | 95 | 99 | 100 | -- | -- | SPWC |
| Oct. 26------- | 1715 | 276 | 882 | 657 | 78 | 84 | 88 | 91 | 97 | 100 | -- | -- | -- | SPWC |
| **08068000 WEST FORK SAN JACINTO RIVER NEAR CONROE*** | | | | | | | | | | | | | | |
| Sept. 14, 1961 | 1100 | 11,200 | 238 | 7,200 | -- | -- | -- | -- | -- | 43 | 60 | 89 | 98 | S |
| Sept. 21------ | 1430 | 340 | 36 | 33 | -- | -- | -- | -- | -- | 94 | 98 | 99 | 100 | S |
| Jan. 29, 1962- | 1650 | 3,100 | 491 | 4,110 | -- | -- | -- | -- | -- | 45 | 54 | 82 | 99 | S |
| Jan. 31------- | 0910 | 2,100 | 186 | 1,050 | -- | -- | -- | -- | -- | 68 | 73 | 92 | 99 | S |
| Feb. 1-------- | 1315 | 1,050 | 140 | 397 | -- | -- | -- | -- | -- | 75 | 80 | 95 | 100 | S |
| May 3--------- | 0945 | 810 | 108 | 236 | -- | -- | -- | -- | -- | 84 | 88 | 100 | -- | S |
| Oct. 29------- | 1530 | 800 | 233 | 503 | -- | -- | -- | -- | -- | 72 | 75 | 85 | 99 | S |
| Oct. 14, 1974- | 0815 | 2,200 | 29 | 172 | -- | -- | -- | -- | -- | 92 | -- | -- | -- | S |
| Dec. 5-------- | 1030 | 410 | 23 | 25 | -- | -- | -- | -- | -- | 90 | -- | -- | -- | S |
| Jan. 1, 1975-- | 1330 | 420 | 24 | 27 | -- | -- | -- | -- | -- | 95 | -- | -- | -- | S |
| Feb. 26------- | 1530 | 95 | 21 | 5 | -- | -- | -- | -- | -- | 82 | -- | -- | -- | S |
| **08068500 SPRING CREEK NEAR SPRING** | | | | | | | | | | | | | | |
| Feb. 2, 1966-- | 1715 | 109 | 29 | 9 | 94 | 98 | 99 | 100 | -- | -- | -- | -- | -- | S |
| Feb. 11------- | 1100 | 2,350 | 88 | 558 | 59 | 69 | 89 | 100 | -- | -- | -- | -- | -- | S |
| Mar. 8-------- | 1545 | 52 | 12 | 2 | 90 | 94 | 97 | 100 | -- | -- | -- | -- | -- | S |
| May 16-------- | 1720 | 250 | 11 | 7 | 80 | 84 | 87 | 96 | 100 | -- | -- | -- | -- | S |

* Includes data outside the study period.

Table 3.--Particle-size analyses of suspended-sediment samples for Texas streams--Continued

| Date of collection | Time | Discharge ($ft^3$/s-days) | Suspended sediment (milligrams per liter) | Suspended-sediment discharge (tons per day) | Suspended sediment: Percent finer than indicated size, in millimeters 0.002 | 0.004 | 0.008 | 0.016 | 0.031 | 0.062 | 0.125 | 0.250 | 0.500 | Methods of analysis |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **08070500 CANEY CREEK NEAR SPLENDORA** | | | | | | | | | | | | | | |
| Nov. 8, 1972-- | 1200 | 145 | 215 | 84 | 73 | 80 | 88 | 91 | 93 | 95 | 98 | 99 | 100 | SBWC |
| Apr. 18, 1973- | 1530 | 2,640 | 286 | 2,040 | 46 | 56 | 58 | 65 | 69 | 76 | 84 | 96 | 100 | SBWC |
| **08086100 HUBBARD CREEK NEAR ALBANY** | | | | | | | | | | | | | | |
| Apr. 29, 1966- | 2040 | 5,120 | 4,870 | 67,300 | 50 | 61 | 71 | 81 | 90 | 96 | 98 | 100 | -- | SPWC |
| Apr. 30------- | 1130 | 948 | 2,500 | 6,400 | 73 | 80 | 87 | 92 | 96 | 99 | 99 | 100 | -- | SPWC |
| Sept. 15------ | 1650 | 867 | 2,070 | 4,850 | 68 | 73 | 81 | 89 | 97 | 100 | -- | -- | -- | PWC |
| Jan. 22, 1968- | 1000 | 1,430 | 987 | 3,810 | 65 | 73 | 77 | 85 | 93 | 97 | 99 | 100 | -- | SPWC |
| Jan. 23------- | 1420 | 735 | 2,960 | 5,870 | 67 | 75 | 84 | 90 | 97 | 100 | -- | -- | -- | SPWC |
| Sept. 16, 1974 | 1610 | 176 | 2,220 | 1,050 | 43 | 60 | 62 | 78 | 85 | 91 | 99 | 100 | -- | SBWC |
| **08086150 NORTH FORK HUBBARD CREEK NEAR ALBANY** | | | | | | | | | | | | | | |
| Apr. 29, 1966- | 1815 | 1,250 | 2,200 | 7,430 | 60 | 67 | 77 | 85 | 94 | 98 | 99 | 100 | -- | SPWC |
| Sept. 15------ | 1545 | 750 | 1,210 | 2,450 | 68 | 70 | 77 | 86 | 93 | 98 | 99 | 100 | -- | SPWC |
| Jan. 21, 1968- | 1330 | 4,570 | 1,960 | 24,200 | 47 | 56 | 65 | 77 | 86 | 93 | 98 | 99 | 100 | SPWC |
| Jan. 16, 1974- | 1430 | 317 | 910 | 779 | 63 | 83 | 89 | 96 | 98 | 99 | 100 | -- | -- | SBWC |
| **08086300 BIG SANDY CREEK NEAR BRECKENRIDGE*** | | | | | | | | | | | | | | |
| May 13, 1965-- | 1715 | 1,810 | 2,130 | 10,400 | 60 | 62 | 68 | 75 | 97 | 98 | 99 | 100 | -- | SPWC |
| May 17-------- | 0945 | 709 | 1,380 | 2,640 | 66 | 69 | 76 | 78 | 89 | 98 | 99 | 100 | -- | SPWC |
| Apr. 29, 1966- | 2325 | 3,780 | 5,670 | 57,900 | 59 | 69 | 77 | 85 | 92 | 96 | 98 | 100 | -- | SPWC |
| Apr. 30------- | 1315 | 1,590 | 4,000 | 17,200 | 63 | 66 | 71 | 76 | 84 | 89 | 98 | 100 | -- | SPWC |
| May 1--------- | 1430 | 7,180 | 2,010 | 39,000 | 70 | 73 | 85 | 88 | 94 | 98 | 99 | 100 | -- | SPWC |
| Jan 22, 1968-- | 1415 | 1,190 | 2,960 | 9,510 | 44 | 51 | 56 | 65 | 79 | 92 | 99 | 100 | -- | SPWC |
| May 5, 1969--- | 1650 | 283 | 1,510 | 1,150 | 78 | 88 | 93 | 96 | 98 | 99 | 100 | -- | -- | SPWC |
| Aug. 7, 1974-- | 1430 | 10 | 1,050 | 28 | 78 | 85 | 87 | 94 | 95 | 100 | -- | -- | -- | SBWC |
| Sept. 17------ | 0847 | 162 | 2,440 | 1,070 | 54 | 78 | 80 | 94 | 95 | 99 | 100 | -- | -- | SBWC |

* Includes data outside the study period.

Table 3.--Particle-size analyses of suspended-sediment samples for Texas streams--Continued

| Date of collection | Time | Discharge ($ft^3/s$-days) | Suspended sediment: Suspended sediment (milligrams per liter) | Suspended sediment: Suspended-sediment discharge (tons per day) | Percent finer than indicated size, in millimeters: 0.002 | 0.004 | 0.008 | 0.016 | 0.031 | 0.062 | 0.125 | 0.250 | 0.500 | Methods of analysis |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 08109800 EAST YEGUA CREEK NEAR DIME BOX | | | | | | | | | | | | | | |
| Aug. 26, 1973- | 1130 | 0.2 | 91 | 0.05 | 75 | 90 | 93 | 98 | 99 | 100 | -- | -- | -- | BWC |
| 08183500 SAN ANTONIO RIVER NEAR FALLS CITY* | | | | | | | | | | | | | | |
| July 8, 1958-- | 1205 | 444 | 490 | 587 | 77 | 85 | 96 | 99 | 99 | 99 | 100 | -- | -- | BWC |
| July 8-------- | 1545 | 570 | 460 | 708 | 73 | 81 | 92 | 97 | 98 | 99 | 99 | 100 | -- | SBWC |
| July 8-------- | 1945 | 774 | 670 | 1,400 | 60 | 74 | 85 | 93 | 96 | 99 | 100 | -- | -- | SBWC |
| July 8-------- | 2315 | 975 | 636 | 1,670 | 55 | 68 | 77 | 91 | 96 | 99 | 99 | 100 | -- | SBWC |
| July 9-------- | 0705 | 1,400 | 1,300 | 4,910 | 57 | 76 | 88 | 94 | 95 | 99 | 100 | -- | -- | SBWC |
| July 9-------- | 1250 | 1,650 | 1,460 | 6,500 | 56 | 74 | 88 | 93 | 97 | 99 | 100 | -- | -- | SBWC |
| July 9-------- | 1750 | 1,820 | 2,160 | 10,600 | 61 | 77 | 91 | 95 | 96 | 98 | 100 | -- | -- | SBWC |
| July 10------- | 1115 | 1,905 | 853 | 4,390 | 69 | 79 | 88 | 93 | 96 | 98 | 99 | 100 | -- | SBWC |
| May 4, 1959--- | -- | 1,050 | 2,7[illegible]0 | 7,740 | 55 | 67 | 77 | 82 | 84 | 87 | 99 | 100 | -- | SBWC |
| May 18-------- | 1315 | 908 | 3,160 | 7,750 | 69 | 80 | 89 | 96 | 98 | 99 | 100 | -- | -- | SBWC |
| May 18-------- | 1530 | 938 | 1,840 | 4,660 | 63 | 79 | 89 | 95 | 98 | 100 | -- | -- | -- | BWC |
| Sept. 25, 1967 | 0923 | 7,250 | 868 | 17,000 | 78 | 84 | 90 | 93 | 94 | 97 | 99 | 100 | -- | SPWC |
| Sept. 26------ | 1125 | 2,980 | 1,140 | 9,170 | 64 | 71 | 81 | 88 | 93 | 96 | 99 | 100 | -- | SPWC |
| Oct. 5-------- | 1408 | 778 | 1,120 | 2,350 | 71 | 81 | 90 | 98 | 100 | -- | -- | -- | -- | PWC |
| Jan. 20, 1968- | 1618 | 13,800 | 1,780 | 66,300 | 74 | 83 | 90 | 96 | 97 | 98 | 99 | 99 | 100 | SPWC |
| May 7, 1969--- | 1545 | 1,680 | 578 | 2,620 | 78 | 79 | 86 | 89 | 93 | 94 | 95 | 100 | -- | SPWC |
| Aug. 27------- | 1250 | 736 | 1,070 | 2,130 | 56 | 72 | 82 | 96 | 99 | 100 | -- | -- | -- | BWC |
| Aug. 6, 1971-- | 1855 | 4,400 | 1,110 | 13,200 | 66 | 72 | 75 | 77 | 80 | 92 | 96 | 99 | 100 | SPWC |
| 08186000 CIBOLO CREEK NEAR FALLS CITY | | | | | | | | | | | | | | |
| Sept. 22, 1967 | 1500 | 18,100 | 1,300 | 63,500 | 79 | 87 | 92 | 97 | 99 | 100 | -- | -- | -- | PWC |
| Sept. 22------ | 1855 | 15,000 | 1,550 | 62,800 | 81 | 88 | 91 | 96 | 99 | 100 | -- | -- | -- | PWC |
| Jan. 20, 1968- | 1220 | 3,620 | 2,460 | 24,100 | 73 | 84 | 92 | 97 | 97 | 99 | 100 | -- | -- | SPWC |
| Jan. 21------- | 1505 | 18,400 | 1,260 | 62,600 | 83 | 87 | 89 | 94 | 97 | 99 | 100 | -- | -- | SPWC |
| May 7, 1969--- | 1245 | 165 | 203 | 90 | 92 | 94 | 95 | 96 | 97 | 98 | 99 | 100 | -- | SBWC |

* Includes data outside the study period.

Table 3.--Particle-size analyses of suspended-sediment samples for Texas streams--Continued

| Date of collection | Time | Discharge ($ft^3$/s-days) | Suspended sediment (milligrams per liter) | Suspended-sediment discharge (tons per day) | Suspended sediment: Percent finer than indicated size, in millimeters 0.002 | 0.004 | 0.008 | 0.016 | 0.031 | 0.062 | 0.125 | 0.250 | 0.500 | Methods of analysis |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **08186500 ECLETO CREEK NEAR RUNGE** | | | | | | | | | | | | | | |
| Sept. 23, 1967 | 1005 | 7,100 | 433 | 8,300 | 55 | 60 | 73 | 74 | 79 | 82 | 84 | 89 | 100 | SPWC |
| Sept. 23------ | 1415 | 6,040 | 812 | 13,200 | 34 | 44 | 48 | 51 | 55 | 60 | 69 | 78 | 96 | SPWC |
| Sept. 23------ | 1730 | 5,050 | 253 | 3,450 | 66 | 89 | 92 | 95 | 97 | 99 | 100 | -- | -- | SPWC |
| Sept. 24------ | 1640 | 347 | 225 | 211 | 47 | 78 | 80 | 90 | 98 | 100 | -- | -- | -- | PWC |
| May 6, 1969--- | 1625 | 157 | 593 | 251 | 90 | 94 | 96 | 97 | 97 | 99 | 100 | -- | -- | SPWC |
| Aug. 5, 1971-- | 1700 | 81 | 1,070 | 234 | 93 | 94 | 97 | 99 | 99 | 100 | -- | -- | -- | PWC |
| **08189700 ARANSAS RIVER NEAR SKIDMORE** | | | | | | | | | | | | | | |
| Sept. 23, 1967 | 1200 | 1,840 | 448 | 2,230 | 85 | 88 | 90 | 91 | 93 | 96 | 98 | 99 | 100 | SPWC |
| May 9, 1968--- | 1640 | 142 | 472 | 181 | 84 | 87 | 91 | 94 | 94 | 96 | 97 | 99 | 100 | SPWC |
| May 15, 1969-- | 1705 | 343 | 1,220 | 1,130 | 76 | 86 | 92 | 97 | 98 | 98 | 99 | 99 | 100 | SPWC |
| Aug. 6, 1971 | 1340 | 734 | 194 | 384 | 93 | 97 | 98 | 98 | 98 | 98 | 98 | 99 | 100 | SPWC |

and mesquite. Annual precipitation in the drainage basin is approximately 25 inches. The topography ranges from gently rolling in the upper reaches to moderately level in the lower reaches.

Beaver Creek drains Paleozoic sediments of the Permian System. The upper part of the basin is underlain by unconsolidated ferruginous shales, sands, and evaporites. These sediments in the lower reaches grade into consolidated limestones alternating with friable sandy shales. Soils in the upper part of the basin consist of clay, clay loam, or caliche. In the lower reaches of the basin in Wilbarger and Wichita Counties, the flood plain is composed of silt or clay loams.

The drainage area above the station is 652 square miles, of which 336 square miles are above Santa Rosa Lake in Wilbarger County. Santa Rosa Lake has a capacity of 11,570 acre-feet.

Thirty-nine sediment samples were collected during the study at water discharges ranging from 3.2 $ft^3/s$ (cubic feet per second) to 4,190 $ft^3/s$. The suspended-sediment concentrations of flood runoff varied from a few hundred mg/L (milligrams per liter) to more than 10,000 mg/L. The estimated annual sediment load was 143,000 tons for the total area, and the estimated sediment yield, assuming a 90-percent trap efficiency for Santa Rosa Lake, was 410 tons per square mile per year below the impoundment. The particle-size distribution of 14 suspended-sediment samples averaged 3 percent sand, 30 percent silt, and 67 percent clay.

The particle-size distribution of two bed-material samples averaged 45 percent sand and 55 percent silt and clay. The low percentage of sand in suspension and the high percentage of silt and clay in the bed material indicate that the bedload would be minimal.

## Wichita River at Wichita Falls, Texas (07312500)

The north and south forks of the Wichita River head in Dickens County and flow eastward through King, Cottle, Foard, and Knox Counties to their confluence in Baylor County 16 miles above Lake Kemp. Flow of the Wichita River in Baylor County is regulated by Lake Kemp and Diversion Lake (combined capacity, 643,000 acre-feet). From Baylor County, the Wichita River flows northeasterly and joins the Red River in the north-central part of Wichita County.

The Wichita River drains Paleozoic sediments of the Permian System. The upper reaches (in Dickens, King, Cottle, Foard, and Knox Counties) are underlain by unconsolidated ferruginous sands and shales, gypsum, salt, and anhydrite. These sediments grade into consolidated limestones interbedded with friable to unconsolidated shales in the lower reaches (Baylor and Wichita Counties). Soils in the upper reaches in Dickens and western King Counties are silty to fine sandy loams. From central King County to Knox County, soils are calcareous clay loams or caliche.

The terrain in the upper reaches is sloping to gently rolling and gullied in many areas, while calcareous clays and silts form a well developed flood plain in the lower reaches from Knox County to the confluence with the Red River. Soils on the gently sloping to level terrain beyond the flood plain are grayish-brown, noncalcareous silt loam to clay loam. The basin is sparsely populated ranchland generally covered with grasses and mesquite. Annual precipitation in the area is approximately 25 inches.

The drainage area above the station at Wichita Falls is 3,140 square miles, of which 2,086 square miles are above Lake Kemp and 336 square miles are above Santa Rosa Lake.

During the study period, 36 suspended-sediment samples were collected, and 16 samples were analyzed for particle-size distribution. Water discharge at the time of sampling ranged from 36 $ft^3/s$ to 5,860 $ft^3/s$. The estimated annual suspended-sediment load was 278,000 tons. Assuming a 95-percent trap efficiency for the combined storage of Lake Kemp and Diversion Lake on the Wichita River and Santa Rosa Lake on Beaver Creek, the sediment yield for the 718 square miles of drainage area between the reservoirs and the station at Wichita Falls was about 330 tons per square mile per year.

The particle-size distribution of the 16 suspended-sediment samples averaged 4 percent sand, 24 percent silt, and 72 percent clay. Analysis of one sample showed that the bed material averaged 80 percent sand and 20 percent silt and clay. The size distribution of the bed material indicated that the bedload would be significant at discharges exceeding about 1,500 $ft^3/s$.

## East Fork Little Wichita River near Henrietta, Texas (07315200)

The East Fork Little Wichita River in the Red River basin rises in the southern part of Clay County and flows northward to its confluence with the Little Wichita River, 5.8 miles downstream from the station near Henrietta.

The drainage area upstream from the station includes 178 square miles of gently sloping to undulating ranchland and farmland. Annual precipitation on the watershed averages about 29 inches. Paleozoic sands and calcareous clays of the Permian System that underlie the area weather to form sandy clay loam to silty clay loam soils.

Twenty suspended-sediment samples were collected during the study period at discharges ranging from 11 $ft^3/s$ to 3,730 $ft^3/s$. The suspended-sediment concentration of the flood runoff varied from a few hundred mg/L to about 2,000 mg/L. The estimated suspended-sediment load from the drainage basin averaged 7,490 tons per year, reflecting a yield of 42 tons per square mile per year. The suspended material in two samples was composed of 76 percent clay, 23 percent silt, and 1 percent sand, while the bed material in one sample was composed of 81 percent sand and 19 percent silt and clay. Although only 1 percent of the suspended sediment was sand, the size distribution of the bed material indicated that the bedload could be significant.

## Mineral Creek near Sadler, Texas (07316200)

Mineral Creek in the Red River basin flows northeastward from its headwaters in Cooke County and enters Big Mineral Arm of Lake Texoma in the northwest part of Grayson County. The drainage area upstream from the gaging station, which is located 1.4 miles north of Sadler, is 26 square miles. There are no known diversions above the station.

Mineral Creek drains Mesozoic sediments of the Cretaceous System, which are composed of unconsolidated argillaceous sands. Soils are clay and fine sandy loams. The basin is sparsely populated, gently rolling to rolling, grass-covered farmland with an annual precipitation of 33-46 inches.

Twenty-six suspended-sediment samples were collected at discharges ranging from 0.01 $ft^3/s$ to 11,500 $ft^3/s$. Most of the samples were collected at water discharges less than 100 $ft^3/s$. The estimated annual suspended load, based on these samples, was 5,520 tons, and the suspended-sediment yield was 210 tons per square mile per year.

The particle-size distribution of suspended sediment in one sample collected at a discharge of 11,500 $ft^3/s$ was 26 percent sand, 30 percent silt, and 44 percent clay. The size distribution of one sample of the bed material averaged 92 percent sand. These data indicate that the stream velocity at discharges of 50 $ft^3/s$ or greater would be high enough to move the bed material and that the bedload would be significant.

## Elm Fork Trinity River near Sanger, Texas (08050500)

The Elm Fork of the Trinity River originates in Montague County, flows east and then south through Cooke and Denton Counties, and enters Lewisville Lake downstream from the confluences of Isle du Bois and Clear Creeks. The drainage area above the station near Sanger is 381 square miles.

The watershed is underlain by Mesozoic sediments of the Cretaceous System. These deposits are composed of marls, shales, and shaly limestones that weather to form calcareous clay soils. The area is rolling to gently rolling farmland that is covered with grasses in the uncultivated areas. Annual precipitation averages 32-36 inches.

Forty-nine suspended-sediment samples were collected at discharges ranging from 1.6 $ft^3/s$ to 25,000 $ft^3/s$. The estimated annual suspended-sediment load at this station was 85,800 tons. Flow from 94.7 square miles upstream from the station is controlled by 41 floodwater-retarding structures. Assuming a trap efficiency of the floodwater-retarding structures of 95 percent (Gilbert and others, 1961), the yield of sediment below the floodwater-retarding structures would average about 300 tons per square mile per year.

The particle-size distribution of a suspended-sediment sample averaged 2 percent sand, 25 percent silt, and 73 percent clay. A particle-size analysis of the bed material showed that 89 percent of the material was coarser than sand. Velocities of the stream usually are too low to move significant quantities of the coarse material; therefore, the bedload should be minimal.

## Isle du Bois Creek near Pilot Point, Texas (08051000)

Isle du Bois Creek rises in the western part of Grayson County, flows south along the Cooke-Grayson County line, and joins the Elm Fork Trinity River in Denton County approximately 6.3 miles downstream from the gaging station. Isle du Bois Creek drains 266 square miles of gently rolling to rolling farmland that receives approximately 32-36 inches of precipitation a year.

The Isle du Bois Creek watershed is underlain by Mesozoic sediments of the Cretaceous System. These sediments consist of argillaceous sands that weather to form fine sandy loam soils. Vegetation in uncultivated areas consists predominantly of grasses.

Forty-nine suspended-sediment samples were collected at discharges ranging from 0.28 $ft^3/s$ to 8,540 $ft^3/s$. The estimated annual sediment load was estimated to be 95,000 tons; the sediment yield was 360 tons per square mile per year.

The particle-size distribution of 11 suspended-sediment samples averaged 80 percent clay, 16 percent silt, and 4 percent sand. A particle-size analysis of one sample of the bed material indicated that 21 percent was sand, 1 percent was silt and clay, and 78 percent was gravel.

These data indicate that the bedload would not be significant because velocities usually are too low to move appreciable quantities of the coarse material.

## Denton Creek near Justin, Texas (08053500)

The drainage area of Denton Creek above the station near Justin in the Trinity River basin includes 400 square miles that are gently rolling in the upper reaches and level to moderately level in the lower reaches. The area, which receives 30-34 inches of precipitation per year, is mostly farmland. Uncultivated areas are generally covered with grasses.

Denton Creek originates in central Montague County and flows southeastward across Wise and Denton Counties. Paleozoic sediments of the Permian System underlie the upper part of the drainage basin in Montague County. These sediments, which are composed of sandy limestones and shaly clays, weather to form sandy loam to clay loam soils. Mesozoic sediments of the Cretaceous System underlie the lower reaches in eastern Montague County and in Wise and Denton Counties. These sediments are composed of marls, friable clays, and partly broken limestone bedrock, which form the calcareous clay soils of the well-developed flood plain and surrounding area. Flow from 198 square miles above the station near Justin is controlled by 107 floodwater-retarding structures with a total combined capacity of 59,930 acre-feet.

Forty-five suspended-sediment samples were collected during the study period at discharges ranging from 0.25 $ft^3/s$ to 5,280 $ft^3/s$. Sediment concentration of samples collected during periods of runoff ranged from a few hundred mg/L to about 5,000 mg/L. The estimated annual sediment load at the station was 107,000 tons. If the floodwater-retarding structures in this area have a 95-percent trap efficiency (Gilbert and others, 1961), sediment yield from the 202 square miles below the controlled area would be 500 tons per square mile per year.

The particle-size distribution of eight suspended-sediment samples averaged 67 percent clay, 15 percent silt, and 18 percent sand. One particle-size analysis showed that the bed material was composed of 51 percent sand and 43 percent silt and clay, which indicates that the bedload would be significant.

## West Fork San Jacinto River near Conroe, Texas (08068000)

The West Fork San Jacinto River heads in northwest Walker County and flows southeastward through Montgomery and Harris Counties to Lake Houston. The drainage area above the station, 4.2 miles south of Conroe, is 809 square miles, of which 445 square miles are above Lake Conroe. Lake Conroe, which is located 14.5 miles upstream from the streamflow station, was completed in 1973. The maximum capacity of the lake is 532,000 acre-feet.

Annual precipitation in the drainage basin is 40-45 inches. The area is level to gently sloping, heavily wooded timberland with some farmland and pastures. Soils produced from the Cenozoic sands and shales of the Tertiary or Quaternary Systems in the basin are silty and sandy loams. On the well-developed flood plain, the soils are produced from recent overbank deposits of silt and mud and are dark acid clays or silty clay loams.

Fifty-one samples were collected and analyzed for suspended-sediment concentrations. The water discharge at the time of sampling ranged from 17 $ft^3/s$ to 18,600 $ft^3/s$. Suspended-sediment concentrations of most samples ranged from 100 to 300 mg/L. The estimated annual suspended-sediment load before the completion of Lake Conroe in 1973 was 36,500 tons, and the sediment yield was 45 tons per square mile per year. Particle-size analyses of 11 samples indicated that the suspended sediment averaged 48 percent sand, and the analyses of 2 bed-material samples averaged 90 percent sand. Although the velocities at this site are not usually high, significant quantities of sand particles probably are carried as bedload.

## Spring Creek near Spring, Texas (08068500)

Spring Creek, a tributary of the San Jacinto River, flows from its headwaters in north-central Waller County along the Harris-Montgomery County line to Lake Houston in Harris County. The watershed is level to gently sloping, heavily wooded timberland, with intermittent areas of pastures or farmland. Annual precipitation averages 40-45 inches.

The Spring Creek basin is underlain by friable to unconsolidated Cenozoic sands and shales of the Tertiary or Quaternary Systems. Deep, acidic, silty to sandy loams or clays are the dominant soil types in the area. The drainage area above the station, which is 2.4 miles northwest of Spring, is 409 square miles. There are no known diversions within the basin.

Suspended-sediment concentrations were determined for 51 samples collected at water discharges ranging from 4.3 $ft^3/s$ to 9,900 $ft^3/s$. Sediment concentrations in flood runoff ranged from 100 to 400 mg/L; and averaged less than 100 mg/L in the base flows.

The estimated annual suspended-sediment load was 23,400 tons, and sediment yield was 57 tons per square mile per year. The sand fraction of suspended material in four samples analyzed for particle-size distribution averaged 37 percent. The bed was 100 percent sand. At a discharge of about 100 $ft^3/s$, the velocity becomes high enough to move the sand particles on the streambed, and the bedload would be significant.

## Caney Creek near Splendora, Texas (08070500)

Caney Creek in the San Jacinto River basin rises in southeast Walker County and flows southeastward through the eastern part of Montgomery County to the confluence with Peach Creek near the Montgomery-Harris County line. Most of the level to gently sloping drainage area is heavily wooded timberland, but some of the area is pasture or farmland. The drainage area above the gaging station, located 8 miles west of Splendora in Montgomery County, is 105 square miles. Annual precipitation in the drainage area averages 40-45 inches. There are no known diversions or floodwater-retarding structures above the station.

Cenozoic sediments of friable to unconsolidated sands and shales of the Tertiary System underlie the upper reaches in Walker and Montgomery Counties. Quaternary sediments that underlie the lower reaches are essentially the same but contain some gravels. Soils are influenced heavily by the dense vegetation and are predominantly acidic sandy to silty loams, except in the headwater reaches in Walker County, where the soils are crumbly calcareous clays.

Thirty-six suspended-sediment samples were collected during the 10-year study period at discharges ranging from 7.2 $ft^3/s$ to 4,640 $ft^3/s$. Suspended-sediment concentrations for base flows were generally less than 50 mg/L. The sediment concentrations of flood runoff ranged from 100 mg/L to about 300 mg/L. The estimated suspended-sediment load was 6,390 tons per year or an average yield of 61 tons per square mile per year. The suspended-sediment size distribution was not well defined; however, two particle-size analyses of samples collected during flood runoff indicated that the sand fraction composed about 25 percent of the suspended material. The bed was composed of 100 percent sand. Available data indicate that the stream velocity at discharges greater than 150 $ft^3/s$ is great enough to move the sand particles along the bed and that the bedload would be significant.

## Hubbard Creek near Albany, Texas (08086100)

Hubbard Creek, a tributary to the Clear Fork Brazos River in the Brazos River basin, begins in north Callahan County and flows northeasterly through Shackleford County to Hubbard Creek Reservoir in west Stephens County. The gaging station is located 28.1 miles upstream from Hubbard Creek Dam and is 8.1 miles southeast of Albany.

The drainage area above the station includes 461 square miles of gently sloping to undulating farmland and ranchland. The area is underlain by Paleozoic rocks of the Permian System, consisting of mudstone, friable shale, sand, and sandy shale alternating with flaggy to blocky limestones. These rocks produce soils that range from a slightly acid sandy loam to a calcareous clay loam. Annual precipitation in the area averages about 24 to 26 inches.

Twelve suspended-sediment samples were collected during the study period at discharges ranging from 3.0 $ft^3/s$ to 5,120 $ft^3/s$. Samples collected during periods of flood runoff contained as much as 5,000 mg/L suspended sediment. On the basis of these samples, the estimated average annual suspended-sediment load was estimated to be 103,000 tons. Sediment yield was 220 tons per square mile per year. Particle-size analyses of six sediment samples indicated that the suspended load was composed of 3 percent sand, 30 percent silt, and 67 percent clay and that the analysis of one bed-material sample was composed of 49 percent gravel, 48 percent coarse to medium sand, and 3 percent silt and clay. The stream velocity during periods of flood runoff would move a significant amount of bed material.

North Fork Hubbard Creek near Albany, Texas (08086150)

North Fork Hubbard Creek heads in central Shackleford County and flows southeasterly to Salt Prong Hubbard Creek in east Shackleford County. The gaging station is located 1.7 miles southeast of Albany, and the drainage area above the station is 38.4 square miles.

The characteristics of the drainage area of North Fork Hubbard Creek are similar to those of the upper reaches of Hubbard Creek. The area is gently sloping to undulating farmland and ranchland covered with grasses and mesquite.

The area is underlain by Paleozoic rocks of the Permian System that consist of flaggy to blocky limestones alternating with friable sands, sandy shales, and evaporites. Soils of calcareous clay are indigenous to the area.

Fifteen suspended-sediment samples were collected during the study period at discharges ranging from 0.8 $ft^3/s$ to 4,570 $ft^3/s$. Sediment concentrations for periods of flood runoff varied from a few hundred mg/L to nearly 5,000 mg/L. The suspended-sediment load from this watershed was estimated to be 1,500 tons per year, and the sediment yield was 30 tons per square mile per year. The particle-size distribution of four sediment samples averaged 5 percent sand, 35 percent silt, and 60 percent clay. One bed-material sample was composed of rocks, pebbles, and sandy clay; therefore the bedload would be minimal.

Big Sandy Creek near Breckenridge, Texas (08086300)

Big Sandy Creek, a tributary to Hubbard Creek in the Brazos River basin, flows to the north from its headwaters in north Eastland County to the southern arm of Hubbard Creek Reservoir. The gaging station is located 8.2 miles southwest of Breckenridge in Stephens County.

The 298-square-mile drainage area above the station consists mostly of sloping to undulating farmland or ranchland. The region receives an annual precipitation of approximately 27 inches. Paleozoic rocks of the Pennsylvanian System consisting of flaggy to blocky beds of limestone alternating with friable sands and shales in the basin produce soils of fine sandy to clay loams or calcareous clays with limestone fragments.

Sixteen suspended-sediment samples were collected during the study period at discharges ranging from 4.0 $ft^3/s$ to 7,180 $ft^3/s$. Sediment concentrations for periods of flood runoff ranged from a few hundred mg/L to nearly 6,000 mg/L. Flow from 26 square miles upstream from the station is partly controlled by Lake Cisco.

The sediment load averaged 69,000 tons per year and the sediment yield below Lake Cisco was 250 tons per square mile per year. The particle-size distribution of 10 suspended-sediment samples averaged 4 percent sand, 28 percent silt, and 68 percent clay, while 1 bed-material sample was composed of 79 percent gravel and 21 percent sand, silt, and clay. The bedload would be minimal at this site because stream velocities are usually too low to move the coarse bed material.

## East Yegua Creek near Dime Box, Texas (08109800)

East Yegua Creek, a tributary to Yegua Creek in the Brazos River basin, begins in Milam County near Rockdale and flows southeasterly, forming the boundary between Lee and Burleson Counties. There are several diversions for irrigation upstream from the gaging station, which is located 3.5 miles north of Dime Box.

The drainage area upstream from the station includes 243 square miles of nearly level to gently sloping farmland. Cenozoic sediments of friable to unconsolidated sands and shales of the Tertiary System in the drainage area form soils of fine sandy loam to loamy fine sands. Annual precipitation averages 32-36 inches.

Thirty-three suspended-sediment samples were collected at discharges ranging from 0.16 $ft^3/s$ to 4,580 $ft^3/s$. Suspended-sediment concentrations at this site were low (usually less than 100 mg/L) even for periods of flood runoff. The sediment concentration of a sample collected at a discharge of 4,580 $ft^3/s$, for example, was only 64 mg/L. The maximum sediment concentration was 321 mg/L in a sample collected at a discharge of 120 $ft^3/s$.

The estimated suspended-sediment load averaged 3,650 tons per year, and the sediment yield averaged approximately 15 tons per square mile per year. The suspended sediment in the only sample analyzed for particle-size distribution consisted of 90 percent clay and 10 percent silt. A bed-material sample was composed of 70 percent sand and 30 percent silt and clay. The low velocity and lack of sand in suspension indicate that the bedload would be minimal at this site.

## Davidson Creek near Lyons, Texas (08110100)

Davidson Creek begins in south-central Milam County, flows in a southeasterly direction through the central part of Burleson County, and joins Yegua Creek below Somerville Reservoir. The drainage area upstream from the gaging station, which is 2.8 miles northeast of Lyons, includes 195 square miles of gently sloping to undulating farmland that receives 32-36 inches of annual precipitation. Sewage effluent from the city of Caldwell is discharged into the stream upstream from the gaging station.

The Cenozoic sediments in the drainage area are unconsolidated to friable sands, shales, and clays of the Tertiary System. Sandy or clay loam soils occur in the upper reaches, while clays dominate in the lower reaches near the gaging station. Uncultivated areas are covered mainly by grasses with some live oaks and mesquite.

Thirty suspended-sediment samples were collected at discharges ranging from 0.08 $ft^3/s$ to 16,700 $ft^3/s$. The suspended-sediment concentration was less than 100 mg/L during periods of base flow and between 100-300 mg/L during periods of flood runoff. The estimated sediment load was 11,000 tons per year and the sediment yield was 56 tons per square mile per year. No samples of suspended sediment were analyzed for particle-size distribution. One sample of the bed material showed the bed to be composed of 97 percent sand. The bedload would probably be minimal because the velocities are low even during periods of high runoff.

## Mill Creek near Bellville, Texas (08111700)

Mill Creek originates in the north-central part of Austin County and flows southeasterly, discharging into the Brazos River 6.0 miles downstream from the gaging station southeast of Bellville. The drainage area upstream from the station is 377 square miles and consists predominantly of farmland that receives an average annual precipitation of 38-40 inches.

The terrain in the upper reaches of the watershed is gently sloping to undulating, but is moderately level and well drained in the lower reaches. Areas not cultivated are usually covered with grasses. The drainage basin is underlain by Cenozoic clays, shales, and unconsolidated to friable sands of the Tertiary System. Soils in the upper reaches and outside the flood plain in the lower reaches are calcareous sand or clay loams. The well-developed flood plain in the lower reaches consists of noncalcareous dark gray to black clays.

Fifty-eight suspended-sediment samples were collected during the study period at discharges ranging from 0.20 $ft^3/s$ to 44,200 $ft^3/s$. Sediment concentrations of the base flow were usually less than 100 mg/L; the sediment concentration of flood runoff ranged from a few hundred mg/L to nearly 1,000 mg/L. The estimated suspended-sediment load was 57,500 tons per year, and the sediment yield was 150 tons per square mile per year.

The size distribution of the suspended sediment at this site was not defined; but the bed material of the main channel was composed almost entirely of sand. The stream velocity at water discharges between 50 $ft^3/s$ and 250 $ft^3/s$ probably is great enough to move the sand. At water discharges between 250 $ft^3/s$ and 20,000 $ft^3/s$, the stream widens greatly, and the velocity becomes too low to move significant quantities of bed material. However, at discharges greater than 20,000 $ft^3/s$, the velocity becomes high enough to move the bed material. Therefore, the bedload at intermediate flows and very high flows would be significant.

## San Antonio River near Falls City, Texas (08183500)

The drainage area of the San Antonio River upstream from the gaging station in Karnes County, 3.6 miles southwest of Falls City, is 2,113 square miles. Precipitation in the area, which includes parts of Bandera, Medina, Bexar, Wilson, and Karnes Counties, averages 28-32 inches annually. The principal tributaries that join the San Antonio River upstream from the gaging station include the Medina River and Salado Creek.

The undulating to rolling upper reaches of the area in Bandera County, Medina County, and the northwestern half of Bexar County are underlain by the Mesozoic limestones, marls, and shales of the Cretaceous System. Soils in the area consist of friable calcareous clays and sandy clay loams mixed with fragmented limestone or crusty thin caliche. Most of the area is ranchland covered by sparse grass with some live oaks and cedar. Flood plains in the lower reaches of the drainage basin in the southeastern half of Bexar County and in Wilson and Karnes Counties consists mostly of farmland with black, friable, and calcareous silty clay loam soils. The gently rolling areas surrounding the flood plain have fine sandy loam soils that are produced from the Cenozoic shales and sands of the Tertiary System. Vegetation in the uncultivated areas includes grasses with some mesquite and oaks.

Flow from about 740 square miles above the station is slightly regulated and retarded by Lake Medina, Olmos Reservoir, Victor Braunig Lake, Calaveras Lake, and by several floodwater-retarding structures and sediment-trap pools. Most of the low flow and part of the high flow is waste water discharged by the city of San Antonio and surrounding communities.

Thirty-five suspended-sediment samples were collected during the study period at discharges ranging from 102 $ft^3/s$ to 23,500 $ft^3/s$. Sediment concentrations of base flow were usually less than 100 mg/L, while the sediment concentrations of flood runoff ranged from a few hundred mg/L to about 2,000 mg/L. The estimated annual sediment load was 141,000 tons. The estimated annual sediment yield, based on a trap efficiency of 95 percent for the reservoirs, was about 100 tons per square mile of drainage area downstream from the reservoirs. The average-size distribution of 18 suspended-sediment samples was 3 percent sand, 18 percent silt, and 79 percent clay; and the analysis of 1 bed-material sample indicated a composition of 34 percent sand and 66 percent silt and clay. These data indicate that the bedload would not be significant.

## Cibolo Creek near Falls City, Texas (08186000)

Cibolo Creek originates in Kendall County; flows southeasterly along the boundaries of Comal and Bexar Counties and Bexar and Guadalupe Counties, through Wilson County, into Karnes County, and joins the San Antonio River 10.4 miles downstream from the gaging station near Falls City.

The drainage area upstream from the station near Falls City is 827 square miles. The upper reaches in Kendall and northwestern Bexar County are predominantly undulating to rolling ranchland. The bedrock consists of Mesozoic calcareous, sandy shales and limestones of the Cretaceous System. The calcareous clay loam or caliche soils are thin and poorly developed. Vegetation is predominantly sparse grasses with live oaks and cedar.

The lower reaches in Karnes, Wilson, and southwestern Bexar Counties are characterized by a well-developed flood plain of calcareous clays. The gently sloping to level areas adjacent to the flood plain are underlain by Cenozoic shales and sands of the Tertiary System. The lower drainage area is predominantly farmland with well developed sandy loam and calcareous clay soils. Uncultivated areas are covered with grasses, mesquite, and oaks.

The drainage basin receives an annual average precipitation of 28-32 inches. A considerable part of the flow upstream from the station near Falls City is infiltrated to the Edwards and associated limestones as it crosses the Balcones Fault Zone. Much of the base flow is derived from the Carrizo Sand in the vicinity of Sutherland Springs. Streamflow from 28.9 square miles above the station is controlled by floodwater-retarding structures with a combined capacity of 8,920 acre-feet.

During the study period, 24 suspended-sediment samples were collected at discharges ranging from 16 $ft^3/s$ to 33,000 $ft^3/s$. Suspended-sediment concentrations were usually less than 100 mg/L for base flow and ranged from a few hundred mg/L to nearly 2,500 mg/L for flood runoff. The estimated annual suspended-sediment load was 82,300 tons, and the estimated sediment yield, based on an assumed trap efficiency of 90 percent for the floodwater-retarding structures was 103 tons per square mile per year. The average-size distribution of five suspended-sediment samples was less than 1 percent sand, approximately 13 percent silt, and 87 percent clay; the size distribution of one bed-material sample was 53 percent sand and 47 percent silt and clay. The lack of sand in the suspension and the particle-size distribution of the bed material indicate that the bedload would be minimal.

## Ecleto Creek near Runge, Texas (08186500)

Ecleto Creek rises in south-central Guadalupe County, flows southerly through Wilson County, and joins the San Antonio River 5.2 miles downstream from the gaging station near Runge in Karnes County. The basin is nearly level to rolling farmland covered with grasses, oaks, and mesquite in uncultivated areas. The average annual precipitation in the drainage basin is approximately 28-32 inches.

Ecleto Creek drains Cenozoic sediments of the Tertiary System which consist of fine calcareous sands and shales and produce soils of calcareous sandy loams or sandy clay loams. The drainage area above the station is 239 square miles.

Twenty-three suspended-sediment samples were collected at discharges ranging from 0.04 $ft^3/s$ to 7,100 $ft^3/s$. Suspended-sediment concentrations ranged from 50 mg/L to 250 mg/L for base flow and from about 250 mg/L to less than 1,000 mg/L for flood runoff. The estimated suspended-sediment load was 7,710 tons per year and the suspended-sediment yield was 32 tons per square mile per year. The average-size distribution of six suspended-sediment samples was 20 percent sand, 17 percent silt, and 63 percent clay, and one bed-material sample was composed of 38 percent gravel, 61 percent sand, and 1 percent clay.

The large sand fractions of the suspended sediment and bed material indicate that the bedload would be significant.

## Aransas River near Skidmore, Texas (08189700)

The Aransas River, which rises in central Bee County, flows easterly through Bee County, along the San Patricio and Refugio County line, into Copano Bay on the Texas Coast.

The watershed is part of the gently sloping grass-covered Texas Coastal Plain and is primarily ranchland and farmland. Annual precipitation on the watershed averages 28-32 inches.

Cenozoic sediments of the Tertiary System in the upper half of the basin and of the Quaternary System in the lower half of the basin consist of friable to unconsolidated sands and shales. Soils are calcareous or alkaline sandy loams to clay loams. The drainage area above the gaging station, 4.4 miles northeast of Skidmore, is 247 square miles. No known diversions exist above the station, but Chase Field Naval Station and the city of Beeville release sewage effluent via Posta Creek.

Twenty-five sediment samples were collected during the study period at discharges ranging from 1.2 $ft^3/s$ to 1,840 $ft^3/s$. Suspended-sediment concentrations were less than 100 mg/L for base flow and ranged from a few hundred mg/L to about 2,000 mg/L for flood runoff. The estimated suspended-sediment load averaged 24,500 tons per year, and the sediment yield averaged 100 tons per square mile per year. The average-size distribution of four suspended-sediment samples was 88 percent clay, 9 percent silt, and 3 percent sand. One bed-material sample was composed of 96 percent sand and 4 percent silt and clay. Significant quantities of bed material could be moved by velocities at water discharges exceeding 1,500 $ft^3/s$.

## SUMMARY AND CONCLUSIONS

The estimated annual suspended-sediment discharge at the 20 sites studied ranged from 1,500 tons per year to 278,000 tons per year, and the average suspended-sediment yield ranged from 15 tons per square mile per year to 500 tons per square mile per year.

The highest sediment yields were from watersheds of the Wichita and the upper Trinity Rivers. The high-yield watersheds of the Wichita River are underlain by Paleozoic sediments of the Permian System. The high-yield watersheds of the upper Trinity River are underlain by Paleozoic sediments of the Permian System and by Mesozoic sediments of the Cretaceous System.

This study indicates that sediment yields generally decrease from northwest to southeast across the State, while the sand fraction of the suspended material generally increases from northwest to southeast.

Although no total-load measurements were made, data on the size distribution of the suspended sediments, composition of the bed material, and stream velocities indicate that the bedload (unmeasured load) would be significant at about half of the 20 sites studied.

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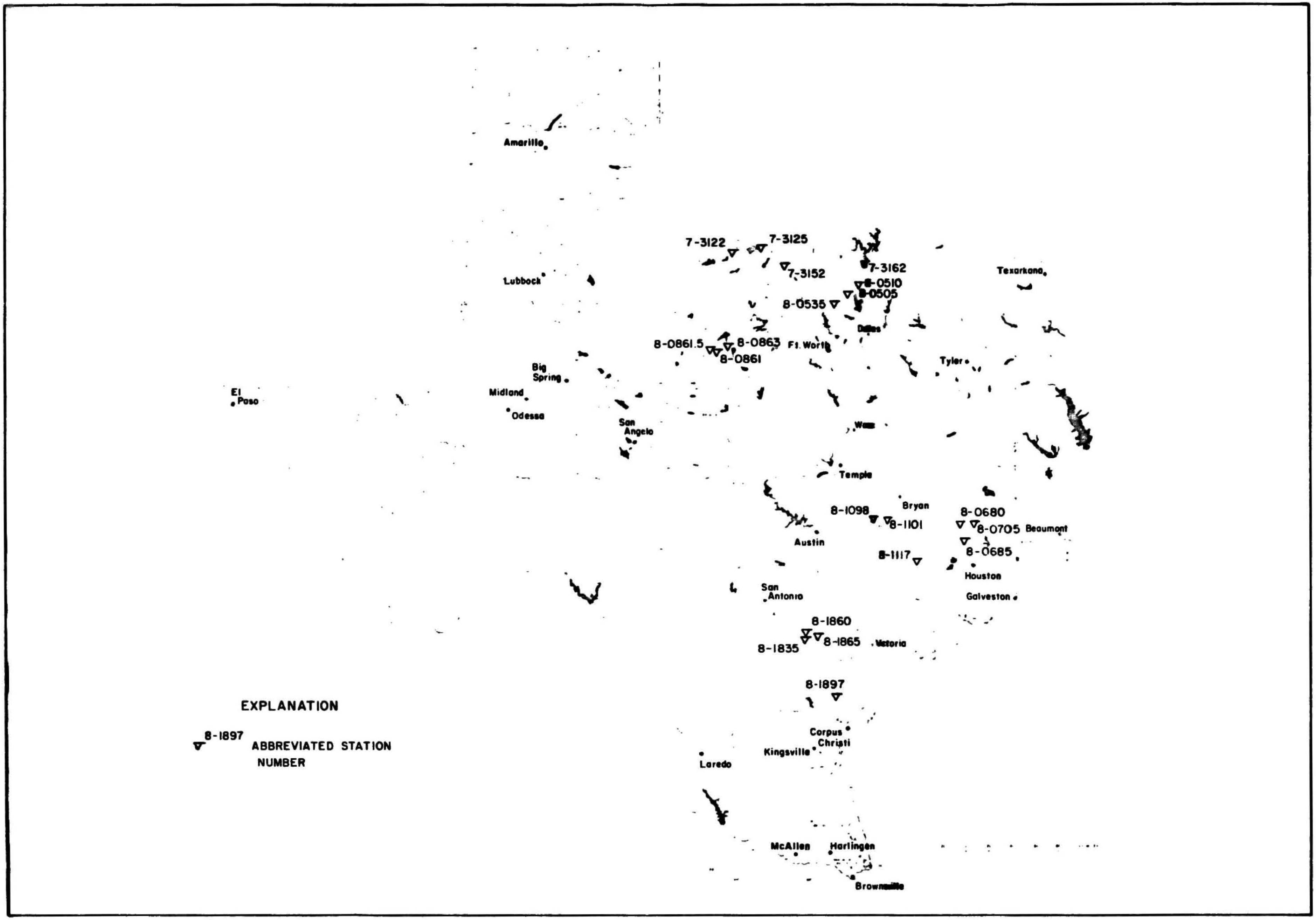


FIGURE 1.-Locations of sediment-collection stations