Preliminary Summaries and Trend Analyses of Stream Discharge and Sediment Data for the Yazoo River Basin Demonstration Erosion Control Project, North-Central Mississippi, July 1985 Through September 1991

By Richard A. Rebich

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CONVERSION FACTORS AND ABBREVIATED SEDIMENT UNITS

Multiply	By	To obtain
cubic feet per second (ft^3/s)	0.02832	cubic meter per second
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
tons per day (t/d)	0.9072	metric tons per day
mg/L		milligram per liter

PRELIMINARY SUMMARIES AND TREND ANALYSES OF STREAM DISCHARGE AND SEDIMENT DATA FOR THE YAZOO RIVER BASIN DEMONSTRATION EROSION CONTROL PROJECT, NORTH-CENTRAL MISSISSIPPI, JULY 1985 THROUGH SEPTEMBER 1991

by Richard A. Rebich

ABSTRACT

To assist an interagency task force in evaluating the effectiveness of the ongoing sediment data-collection program, this report presents preliminary data summaries and trend analyses results of daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge collected at eight sites in six watersheds of the Demonstration Erosion Control project in the Yazoo River Basin in north-central Mississippi for the period July 1985 through September 1991. The project is part of an ongoing joint-agency program of planning, design, construction, monitoring, and evaluation to alleviate flooding, erosion, sedimentation, and water-quality problems for watersheds located in the bluff hills above the Mississippi River alluvial plain. About 550 stream discharge measurements and about 20,000 suspended-sediment samples were analyzed, reviewed, and stored in USGS computer files. Stream discharge measurements and sediment samples were used to compute daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge.

The Seasonal Kendall trend test was used to detect trends in daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge for six of the eight sites. Two of the eight sites had an insufficient period of record on which to attempt trend analyses. Trends were detected in stream discharge at five of the six sites indicating an upward trend in stream discharge for the study period, which is consistent with rainfall conditions in the study area. Trends were detected in flow-adjusted suspended-sediment concentration at Hotopha Creek near Batesville and in flow-adjusted suspended-sediment concentration and flow-adjusted sediment discharge at Otoucalofa Creek Canal near Water Valley indicating a possible downward trend in the factors that contribute to sedimentation and erosion at these two sites. Trend analyses generally were inconsistent or no statistically significant trends were detected, however, for unadjusted and flow-adjusted suspended-sediment concentration and sediment discharge at most of the remaining sites analyzed, probably due to insufficient periods of record.

INTRODUCTION

In 1984, Congress directed the U.S. Army Corps of Engineers and the U.S. Department of Agriculture, Soil Conservation Service, to establish demonstration watersheds to address critical erosion and sedimentation problems. The Demonstration Erosion Control (DEC) Project is in the Yazoo River Basin in north-central Mississippi. It is part of an ongoing joint-agency program of planning, design, construction, monitoring, and evaluation to alleviate flooding, erosion, sedimentation, and water-quality problems by applying environmentally sound management practices in several watersheds located in the bluff hills above the Mississippi River alluvial plain.

In July 1985, at the request of the Interagency Task Force on Yazoo Basin Foothills Erosion and Flood Control, and in cooperation with the Corps of Engineers, the U.S. Geological Survey (USGS) began collecting sediment data for the Yazoo River Basin DEC project. These data will assist the task force in evaluating the effectiveness of the ongoing sediment data-collection program. Data were to be collected prior to, during, and after watershed-conservation and channel-stability measures were implemented in the study area.

Purpose and Scope

This report presents preliminary data summaries and results of trend analyses for daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge for eight USGS DEC project sites for 6 years of data collection, specifically, the period July 1985 through September 1991. These data are available in the USGS Water Data Storage and Retrieval system (WATSTORE) computer files and have been published annually in the data report series, "Water Resources Data-Mississippi," since 1989.

Description of Study Area, Sampling Sites, and Data-Collection Activities

The study area for the Yazoo River Basin DEC project consists of six watersheds in north-central Mississippi (fig. 1). In downstream order, they are the (1) Hotopha Creek, (2) Otoucalofa Creek, (3) Peters (Long) Creek, (4) Hickahala-Senatobia Creek, (5) Batupan Bogue and (6) Black Creek watersheds. The loess hills of the Yazoo River Basin were selected for the DEC project because the area is characterized by having large losses of soil and agrichemicals from agricultural lands and excessive upland and channel erosion by streams with unstable, deeply incised channels. The sparsely populated study area consists largely of forests, pastures, and small farms.

For the study period July 1985 through September 1991, sediment data-collection activities were conducted at eight sites in the six watersheds. USGS station (downstream order) numbers, names, drainage areas, latitude-longitude locations, and periods of record are listed in table 1. Specific start dates vary from site to site. Sediment data-collection activities have been extended for six of the eight sites into the current (1993) water year; however, activities were suspended at two sites, Senatobia Creek near Senatobia and Fannegusha Creek near Howard, in calendar year 1989 at the request of the

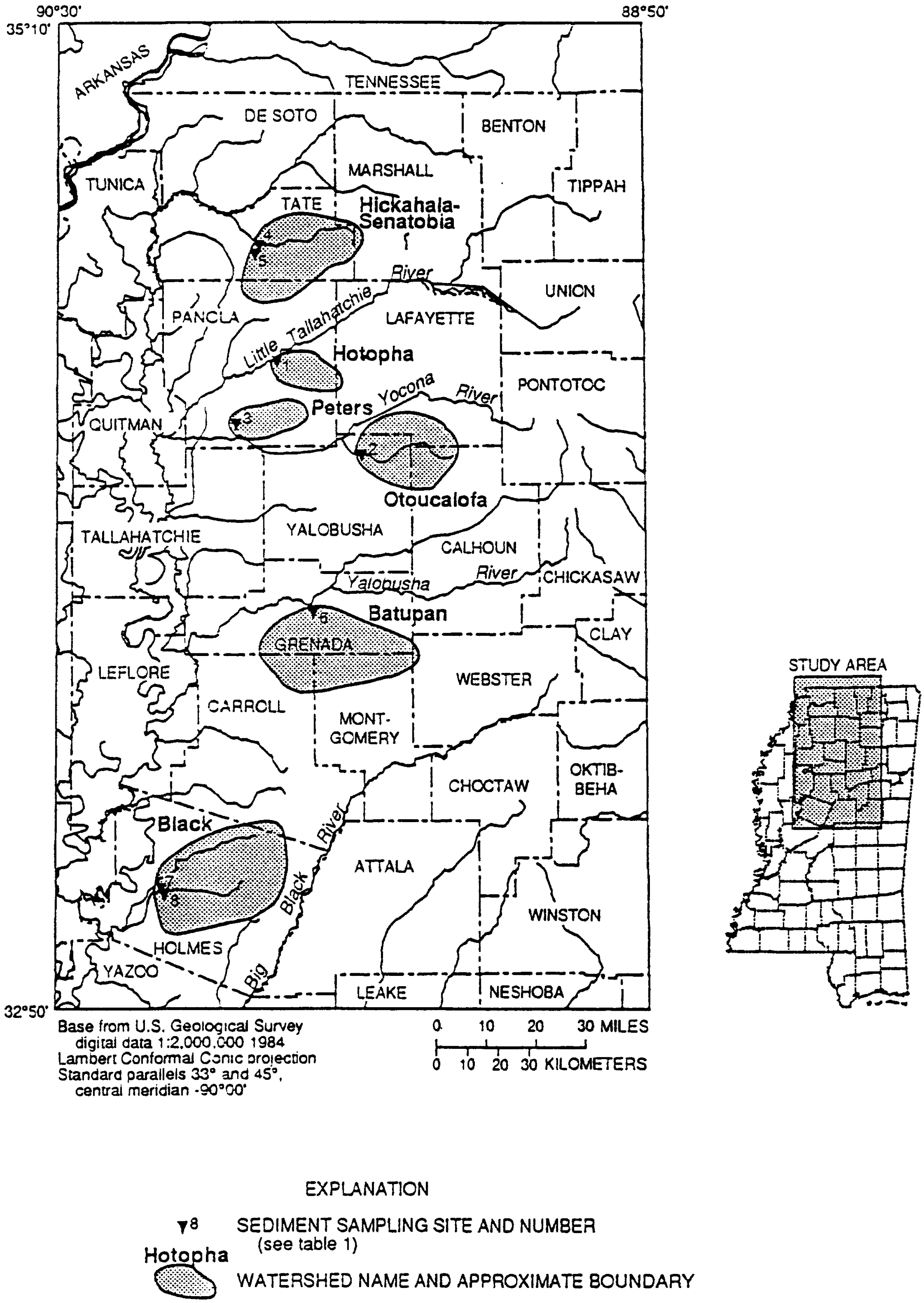

Figure 1.--Location of study area and sediment sampling sites.

cooperator. Drainage areas of the sites range from 35.1 mi^2 for Hotopha Creek near Batesville to 240 mi^2 for Batupan Bogue at Grenada. More complete site descriptions are available in "Water Resources Data-Mississippi" (Plunkett and others, 1992).

Stream discharge is routinely measured by personnel of the USGS once every 6 weeks and during selected storms. From July 1985 through September 1991, about 550 stream discharge measurements from the eight study sites were analyzed, reviewed, and stored in USGS computer files. The measurements are used to establish and verify stage-discharge relations at each site, which are used to compute instantaneous stream discharges from stage data recorded by automatic stage recorders. Instantaneous stream discharges are then used to compute daily mean values of stream discharge according to standard USGS procedures (Kennedy, 1983).

Suspended-sediment samples were collected in a consistent manner at each site by observers, automatic point samplers, and personnel of the USGS. Observers collect single, vertically integrated samples 3 days a week (Monday, Wednesday, and Friday) and supplemental samples during selected storms. Each site is equipped with a PS-69 automatic point sampler (pumping-sample device developed in 1969), which is stage-activated during storms. USGS personnel collect samples on a biweekly basis and during selected storms. Samples collected by USGS personnel may include single, vertically integrated samples but typically are multiple, vertically integrated samples taken at several sections across the stream. The sampling procedures used are described by Guy and Norman (1970).

From July 1985 through September 1991, about 20,000 suspended-sediment samples were analyzed and reviewed, and data were stored in USGS computer files. Measurable storm runoff was sampled at the eight sites for suspended-sediment concentration during 30 of 43 storms in 1986; 103 of 142 storms in 1987; 84 of 107 storms in 1988; 143 of 192 storms in 1989; 105 of 141 storms in 1990; and 177 of 212 storms in 1991. Sediment samples were used to compute daily mean values of suspended-sediment concentration and sediment discharge according to standard USGS procedures (Porterfield, 1972).

PRELIMINARY SUMMARIES OF STREAM DISCHARGE AND SEDIMENT DATA

The number of daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge stored in WATSTORE for the study period for each site of the DEC project is listed in table 2. Hydrographs of daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge for the study period for each site are presented in figure 2. Due to page restrictions, daily mean values of sediment discharge less than 0.1 t/d are plotted as 0.1 t/d in figure 2. Daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge are summarized in the following sections for the study period at each site. The summaries are divided into two sections: summaries of annual means per water year (October 1 through September 30) for each site; and statistical summaries, which present minimums, maximums, standard deviations, medians, 25th percentiles, and 75th percentiles per water year for each site.

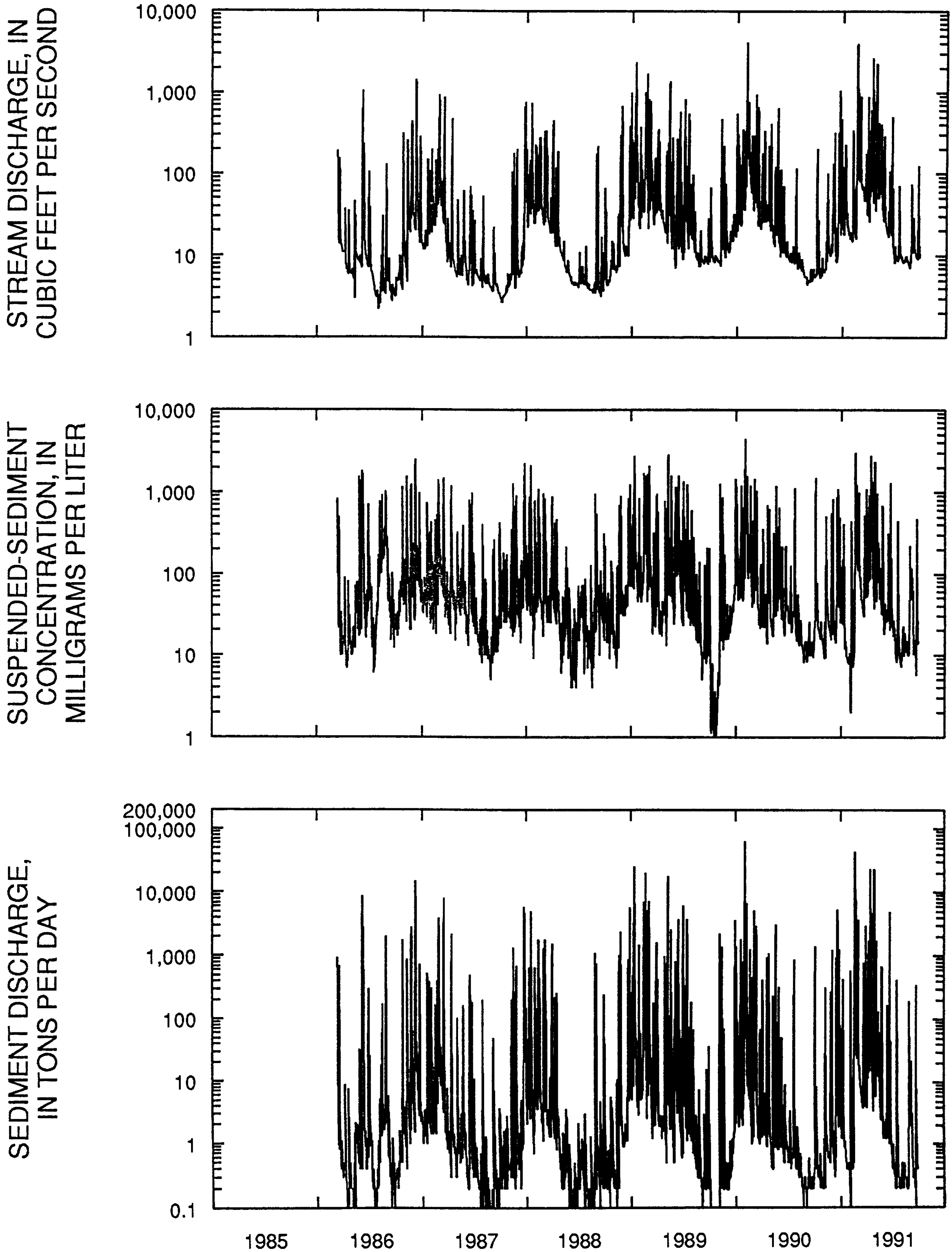

Figure 2a.--Hydrographs of stream discharge, suspended-sediment concentration, and sediment discharge at Hotopha Creek near Batesville.

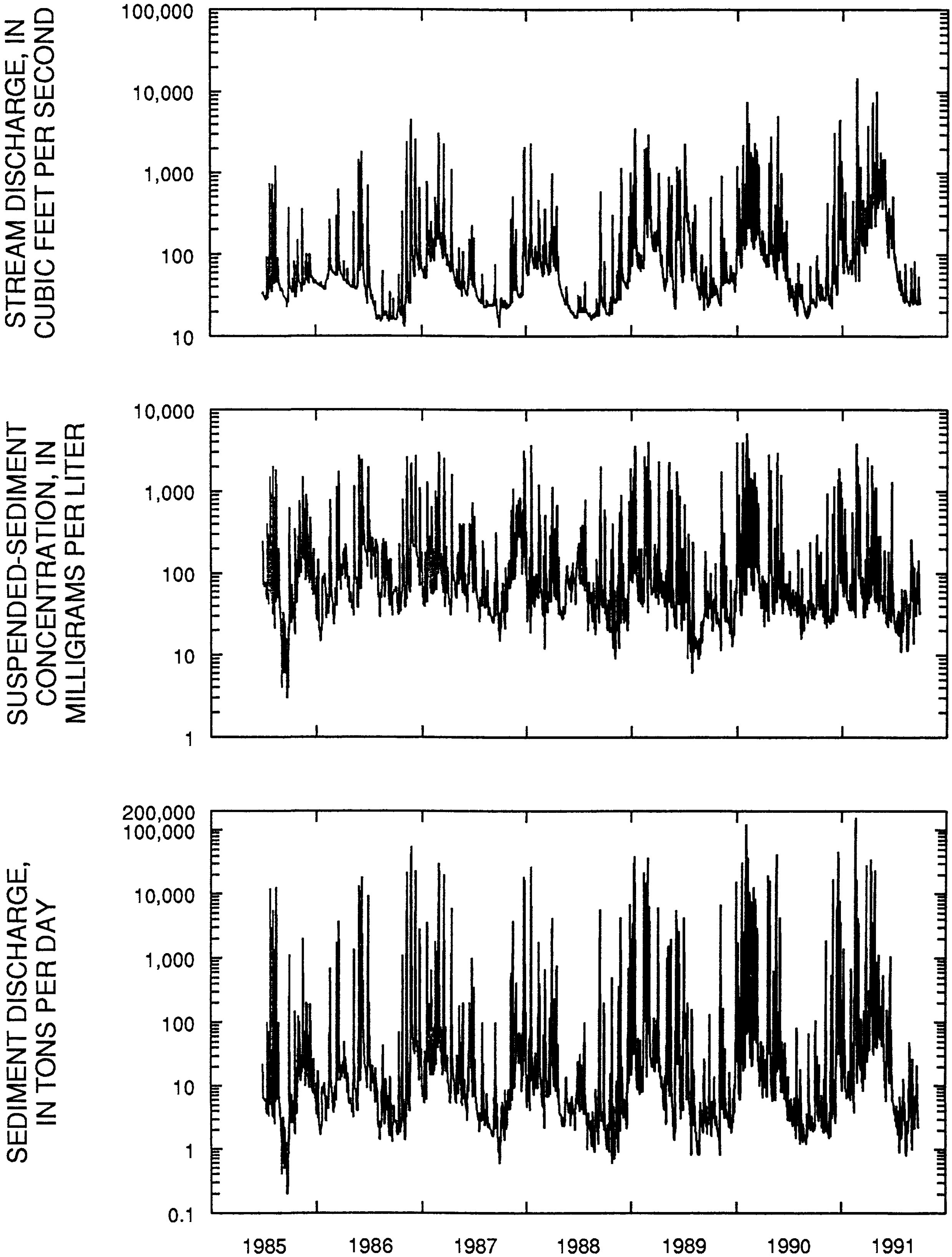

Figure 2b.--Hydrographs of stream discharge, suspended-sediment concentration, and sediment discharge at Otoucalofa Creek Canal near Water Valley.

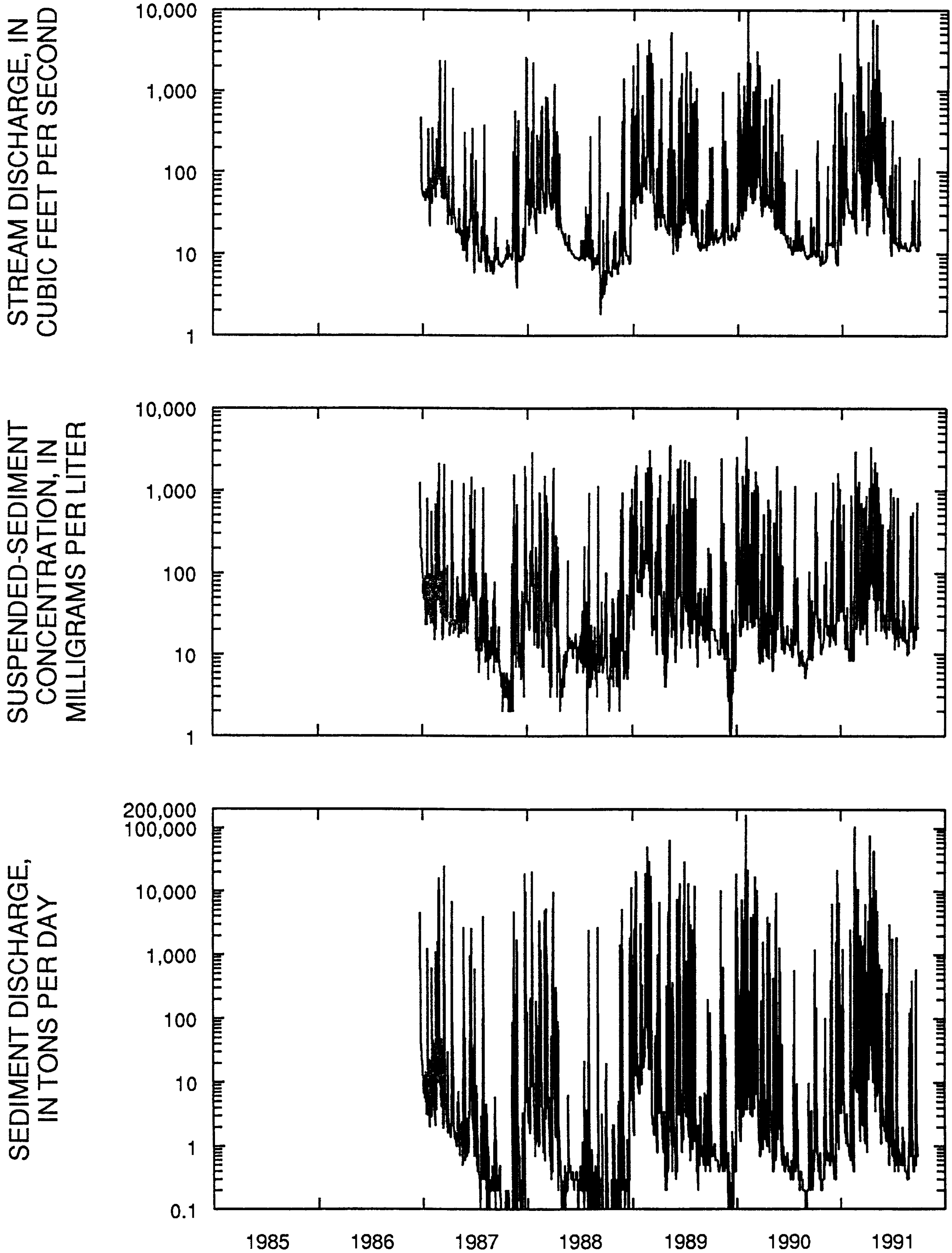

Figure 2c.--Hydrographs of stream discharge, suspended-sediment concentration, and sediment discharge at Peters (Long) Creek near Pope.

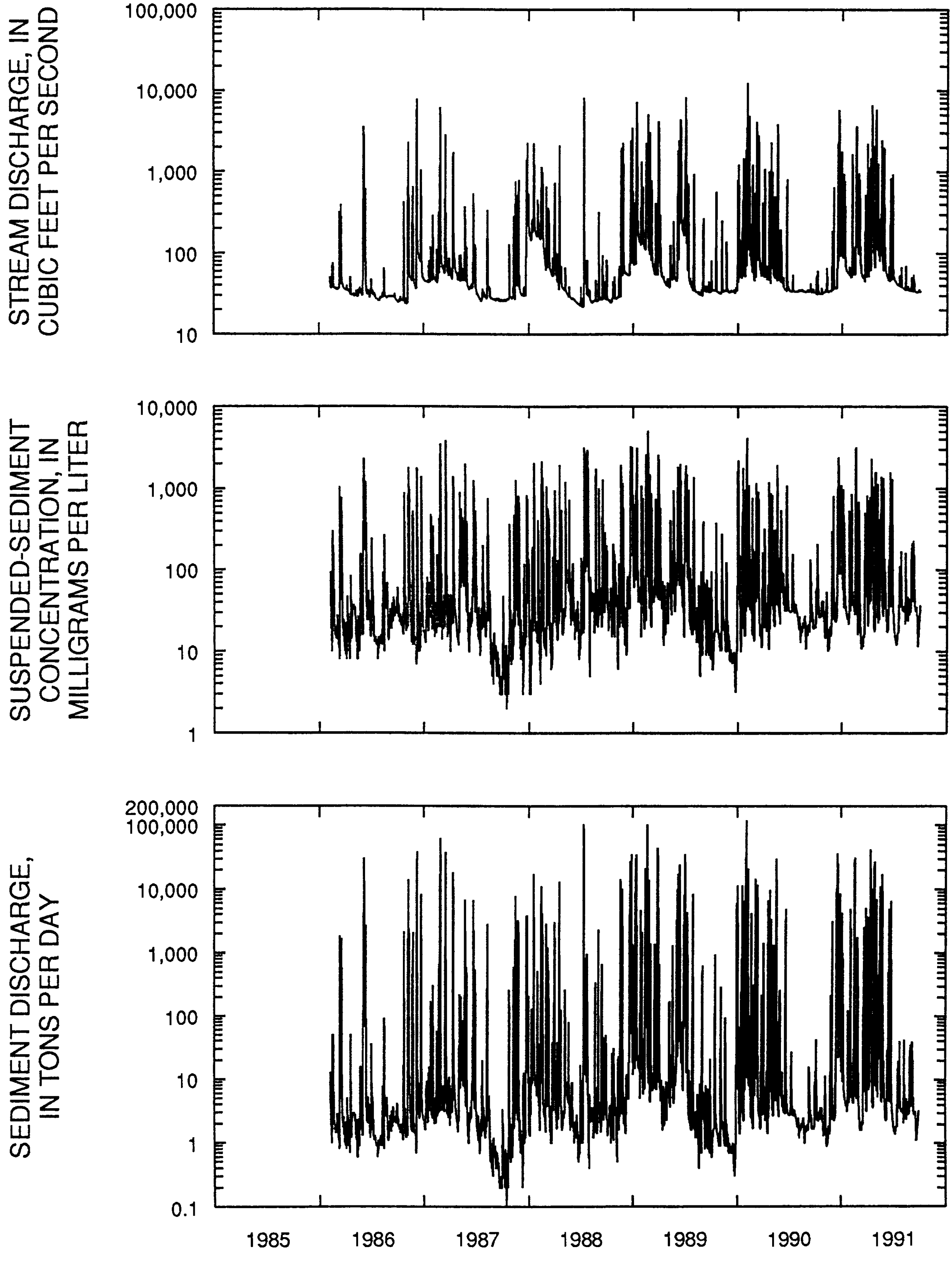

Figure 2d.--Hydrographs of stream discharge, suspended-sediment concentration, and sediment discharge at Hickahala Creek near Senatobia.

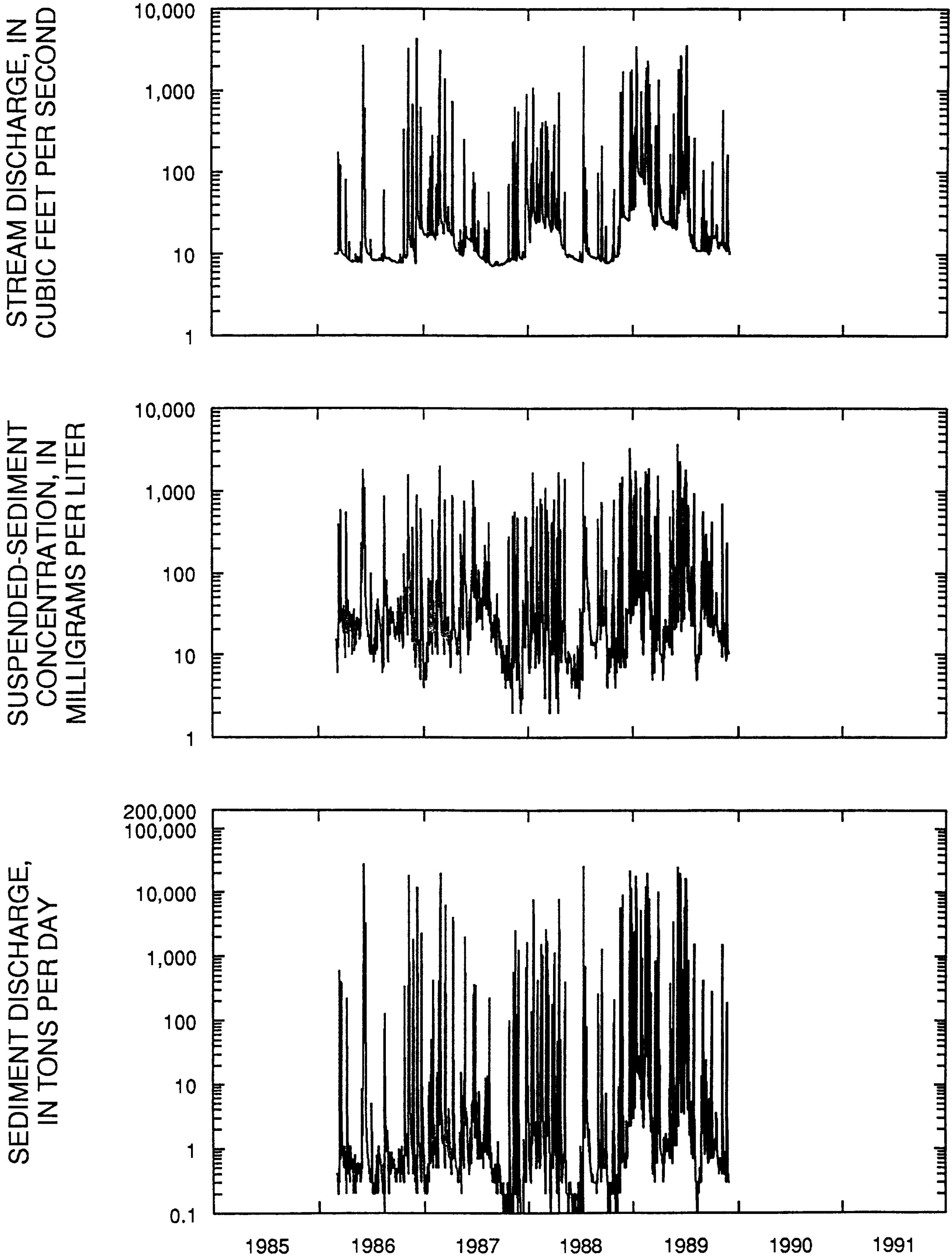

Figure 2e.--Hydrographs of stream discharge, suspended-sediment concentration, and sediment discharge at Senatobia Creek near Senatobia.

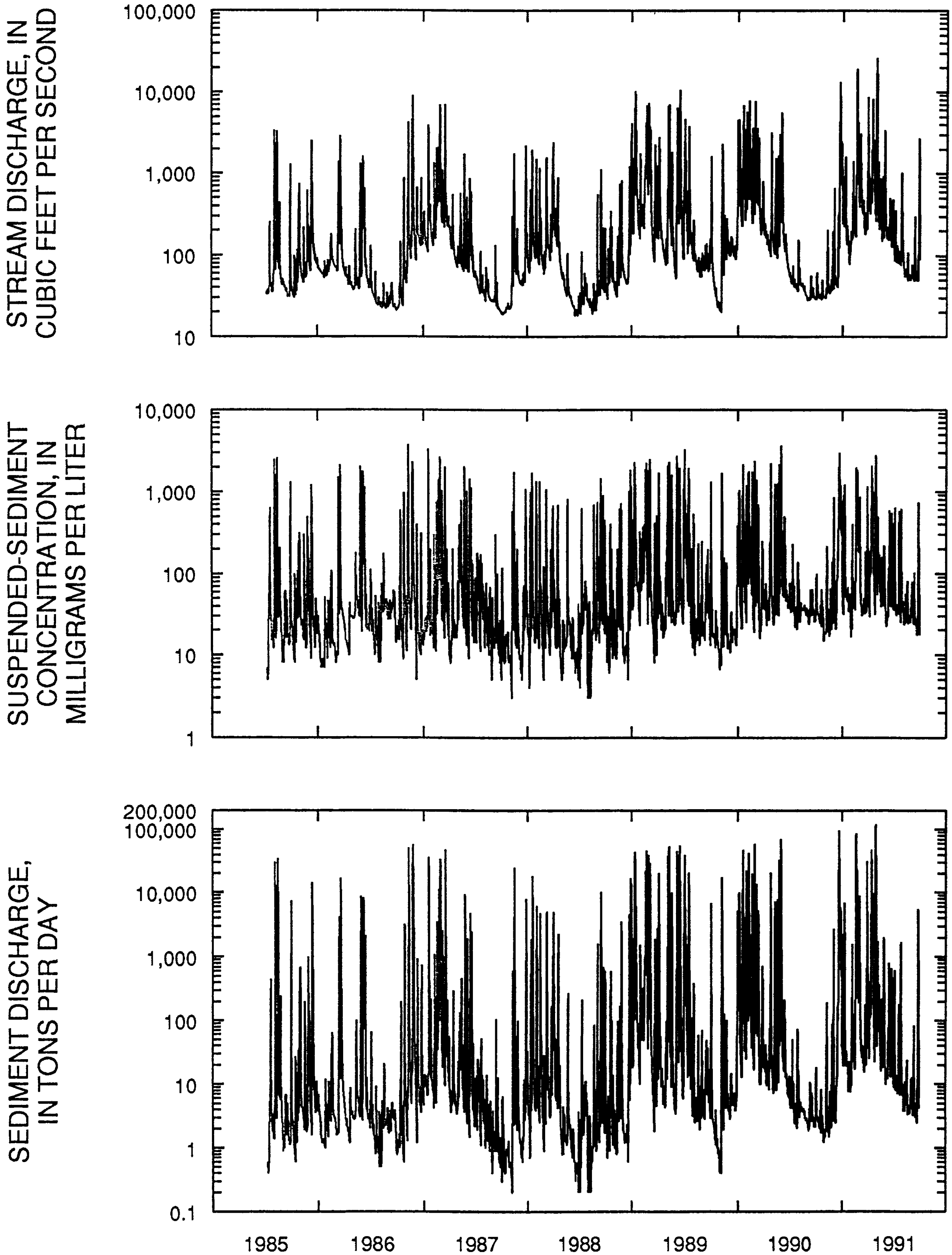

Figure 2f.--Hydrographs of stream discharge, suspended-sediment concentration, and sediment discharge at Batupan Bogue at Grenada.

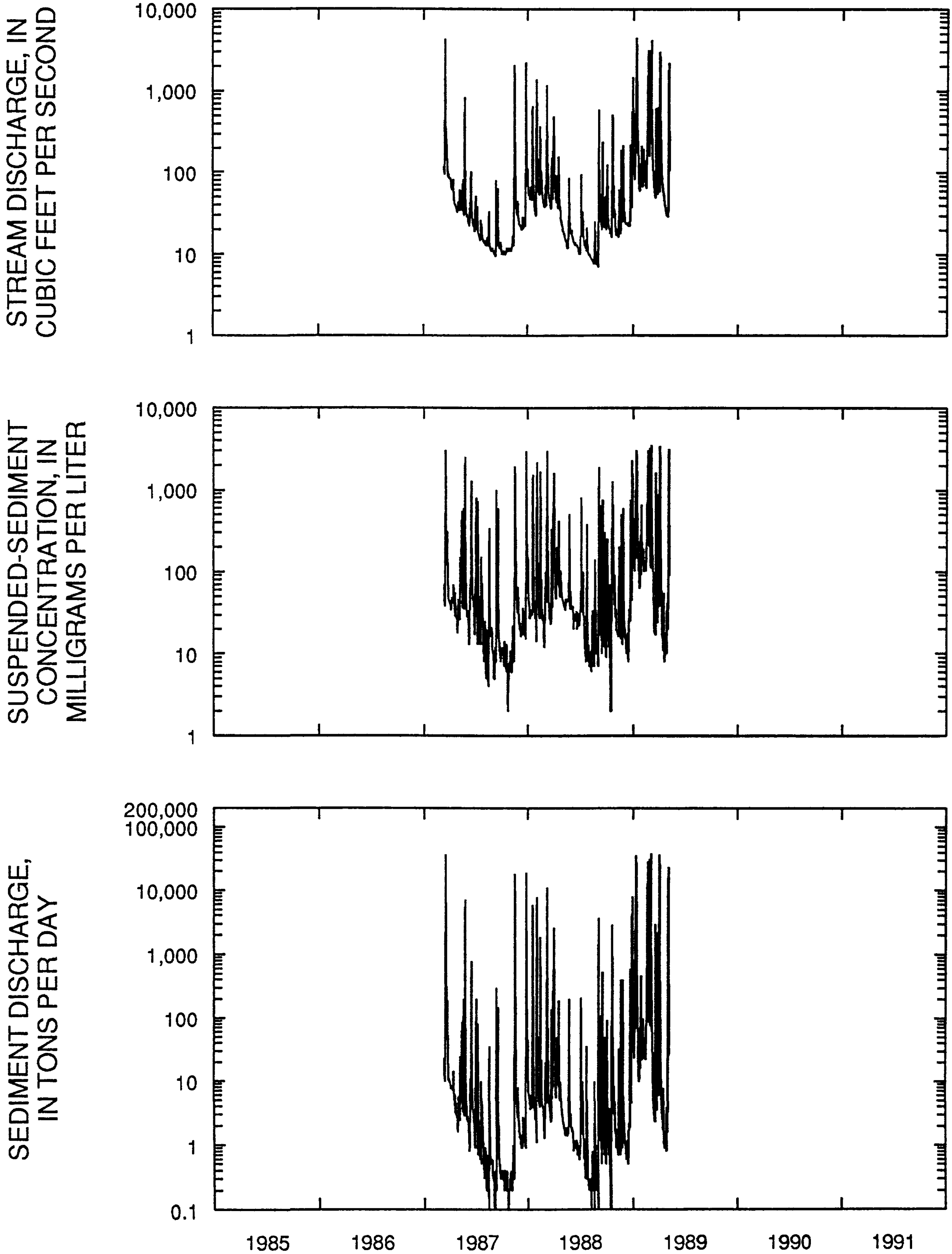

Figure 2g.--Hydrographs of stream discharge, suspended-sediment concentration, and sediment discharge at Fannegusha Creek near Howard.

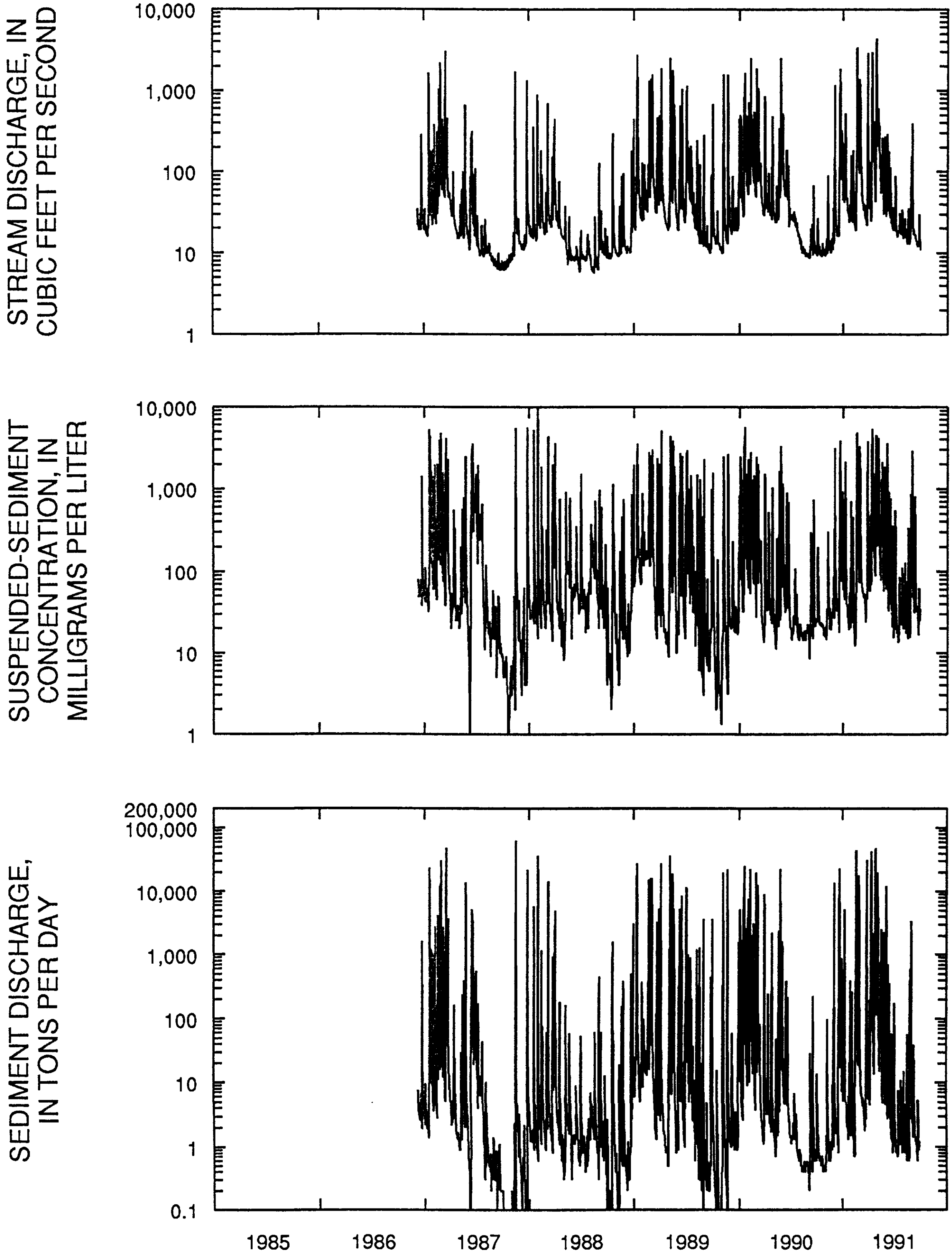

Figure 2h.--Hydrographs of stream discharge, suspended-sediment concentration, and sediment discharge at Harland Creek near Howard.

Summaries of Annual Means

Summaries of annual means of stream discharge, suspended-sediment concentration, and sediment discharge per water year for the DEC project sites are presented in table 3. The annual means summarized in the next paragraph are for complete water years of data.

For Hotopha Creek near Batesville, annual mean stream discharge ranged from 39 ft^3/s in 1988 to 105 ft^3/s in 1991; suspended-sediment concentration ranged from 112 mg/L in 1988 to 190 mg/L in 1989; and sediment discharge ranged from 99 t/d in 1988 to 533 t/d in 1991. For Otoucalofa Creek Canal near Water Valley, annual mean stream discharge ranged from 67 ft^3/s in 1986 to 393 ft^3/s in 1991; suspended-sediment concentration ranged from 177 mg/L in 1988 to 207 mg/L in 1987 and 1990; and sediment discharge ranged from 189 t/d in 1986 to 1,420 t/d in 1991. For Peters (Long) Creek near Pope, annual mean stream discharge ranged from 78 ft^3/s in 1988 to 228 ft^3/s in 1991; suspended-sediment concentration ranged from 87 mg/L in 1988 to 206 mg/L in 1989; and sediment discharge ranged from 268 t/d in 1988 to 1,340 t/d in 1991. For Hickahala Creek near Senatobia, annual mean stream discharge ranged from 146 ft^3/s in 1988 to 314 ft^3/s in 1989; suspended-sediment concentration ranged from 117 mg/L in 1990 to 265 mg/L in 1989; and sediment discharge ranged from 599 t/d in 1988 to 1,800 t/d in 1989. For Senatobia Creek near Senatobia, annual mean stream discharge ranged from 56 ft^3/s in 1988 to 175 ft^3/s in 1989; suspended-sediment concentration ranged from 86 mg/L in 1987 to 191 mg/L in 1989; and sediment discharge ranged from 183 t/d in 1988 to 842 t/d in 1989. For Batupan Bogue at Grenada, annual mean stream discharge ranged from 131 ft^3/s in 1986 to 757 ft^3/s in 1991; suspended-sediment concentration ranged from 90 mg/L in 1986 to 240 mg/L in 1989; and sediment discharge ranged from 260 t/d in 1986 to 2,440 t/d in 1989. Fannegusha Creek near Howard had only one complete water year of data, which was the 1988 water year. Annual mean stream discharge for the 1988 water year was 73 ft^3/s; suspended-sediment concentration was 126 mg/L; and sediment discharge was 288 t/d. For Harland Creek near Howard, annual mean stream discharge ranged from 39 ft^3/s in 1988 to 156 ft^3/s in 1991; suspended-sediment concentration ranged from 221 mg/L in 1988 to 378 mg/L in 1991; and sediment discharge ranged from 464 t/d in 1988 to 1,330 t/d in 1991.

For the DEC project sites, annual means of stream discharge generally were lowest in the 1988 water year corresponding to drought conditions in the study area; annual means of stream discharge generally were highest in the 1989 and 1991 water years corresponding to record rainfall in the study area (M.L. Plunkett, USGS, oral commun., 1992). Annual means of suspended-sediment concentration were lowest in the 1988 water year except for three sites and highest in the 1989 water year except for two sites. Annual means of sediment discharge were lowest in the 1988 water year except for two sites and highest in the 1989 and 1991 water years; these extremes coincide with stream discharge extremes, as expected.

Statistical Summaries

Statistical summaries of daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge for the DEC project sites are presented in table 4. Standard deviation and median value ranges summarized in the paragraphs to follow are for complete water years of data; extremes are summarized for partial or complete water years.

For Hotopha Creek near Batesville, daily mean values of stream discharge ranged from 2.2 ft^3/s in 1986 to 4,160 ft^3/s in 1990 (fig. 2a, table 4). Standard deviations for stream discharge ranged from 88 ft^3/s in 1988 to 344 ft^3/s in 1991, and median values ranged from 7.4 ft^3/s in 1988 to 26 ft^3/s in 1989. Daily mean values of suspended-sediment concentration ranged from 1 mg/L in 1990 to 4,460 mg/L in 1990. Standard deviations for suspended-sediment concentration ranged from 248 mg/L in 1988 to 372 mg/L in 1989, and median values ranged from 29 mg/L in 1991 to 58 mg/L in 1989. Daily mean values of sediment discharge ranged from less than 0.10 t/d in 1988 through 1991 to 63,800 t/d in 1990. Standard deviations for sediment discharge ranged from 519 t/d in 1988 to 3,390 t/d in 1990, and median values ranged from 0.90 t/d in 1988 to 3.0 t/d in 1989.

For Otoucalofa Creek near Water Valley, daily mean values of stream discharge ranged from 13 ft^3/s in 1987 and 1988 to 14,800 ft^3/s in 1991 (fig. 2b, table 4). Standard deviations for stream discharge ranged from 140 ft^3/s in 1986 to 1,200 ft^3/s in 1991, and median values ranged from 32 ft^3/s in 1988 to 81 ft^3/s in 1991. Daily mean values of suspended-sediment concentration ranged from 3 mg/L in 1985 to 5,060 mg/L in 1990. Standard deviations for suspended-sediment concentration ranged from 294 mg/L in 1986 to 573 mg/L in 1990, and median values ranged for 48 mg/L in 1990 to 90 mg/L in 1986. Daily mean values of sediment discharge ranged from less than 0.1 t/d in 1985 to 154,000 t/d in 1991. Standard deviations for sediment discharge ranged from 1,320 t/d in 1986 to 9,670 t/d in 1991, and median values ranged from 8.0 t/d in 1988 and 1990 to 11 t/d in 1987 and 1991.

For Peters (Long) Creek near Pope, daily mean values of stream discharge ranged from 1.8 ft^3/s in 1988 to 11,700 ft^3/s in 1990 (fig. 2c, table 4). Standard deviations for stream discharge ranged from 258 ft^3/s in 1988 to 901 ft^3/s in 1991, and median values ranged from 13 ft^3/s in 1988 to 29 ft^3/s in 1989. Daily mean values of suspended-sediment concentration ranged from 1 mg/L in 1988 and 1990 to 4,530 mg/L in 1990. Standard deviations for suspended-sediment concentration ranged from 280 mg/L in 1988 to 456 mg/L in 1989, and median values ranged from 12 mg/L in 1988 to 38 mg/L in 1989. Daily mean values of sediment discharge ranged from less than 0.10 t/d throughout the period of record to 167,000 t/d in 1990. Standard deviations for sediment discharge ranged from 1,710 t/d in 1988 to 8,970 t/d in 1990, and median values ranged from 0.40 t/d in 1988 to 3.0 t/d in 1989.

For Hickahala Creek near Senatobia, daily mean values of stream discharge ranged from 22 ft^3/s in 1988 to 12,300 ft^3/s in 1990 (fig. 2d, table 4). Standard deviations for stream discharge ranged from 502 ft^3/s in 1988 to 868 ft^3/s in 1989, and median values ranged from 35 ft^3/s in 1988 to 55 ft^3/s in 1989. Daily mean values of suspended-sediment concentration ranged from 2 mg/L in 1988 to 5,110 mg/L in 1989. Standard deviations for suspended-sediment concentration ranged from 356 mg/L in 1990 to 592 mg/L in 1989, and median values ranged from 25 mg/L in 1987 to 54 mg/L in 1989. Daily mean values of sediment discharge ranged from less than 0.10 t/d in 1987 through 1990 to 118,000 t/d in 1990. Standard deviations for sediment discharge ranged from 4,220 t/d in 1991 to 8,260 t/d in 1989, and median values ranged from 3.0 t/d in 1987, 1988, and 1990 to 8.0 t/d in 1989.

For Senatobia Creek near Senatobia, daily mean values of stream discharge ranged from 7.2 ft^3/s in 1987 to 4,370 ft^3/s in 1987 (fig. 2e, table 4). Standard deviations for stream discharge ranged from 218 ft^3/s in 1988 to 486 ft^3/s in 1989, and median values ranged from 10 ft^3/s in 1988 to 27 ft^3/s in 1989. Daily mean values of suspended-sediment concentration ranged from 2 mg/L in 1988 to 3,650 mg/L in 1989. Standard deviations for suspended-sediment concentration ranged from 206 mg/L in 1987 to 433 mg/L in 1989, and median values ranged from 14 mg/L in 1988 to 35 mg/L in 1989. Daily mean values of sediment discharge ranged from less than 0.10 t/d in 1986, 1988, and 1989 to 28,100 t/d in 1986. Standard deviations for sediment discharge ranged from 1,510 t/d in 1988 to 3,250 t/d in 1989, and median values ranged from 0.50 t/d in 1988 to 2.0 t/d in 1989.

For Batupan Bogue at Grenada, daily mean values of stream discharge ranged from 18 ft^3/s in 1988 to 26,600 ft^3/s in 1991 (fig. 2f, table 4). Standard deviations for stream discharge ranged from 306 ft^3/s in 1986 to 2,400 ft^3/s in 1991, and median values ranged from 57 ft^3/s in 1986 to 175 ft^3/s in 1987 and 1991. Daily mean values of suspended-sediment concentration ranged from 3 mg/L in 1988 to 3,790 mg/L in 1987. Standard deviations for suspended-sediment concentration ranged from 244 mg/L in 1988 to 494 mg/L in 1989, and median values ranged from 21 mg/L in 1988 to 49 mg/L in 1989. Daily mean values of sediment discharge ranged from less than 0.10 t/d in 1985, 1987, and 1990 to 118,000 t/d in 1991. Standard deviations for sediment discharge ranged from 1,470 t/d in 1986 to 11,800 t/d in 1991, and median values ranged from 3.0 t/d in 1988 to 20 t/d in 1991.

For Fannegusha Creek near Howard, daily mean values of stream discharge ranged from 6.9 ft^3/s in 1988 to 4,460 ft^3/s in 1989 (fig. 2g, table 4). The only complete water year of data at this site was the 1988 water year. The standard deviation of stream discharge for the 1988 water year is 213 ft^3/s, and the median value is 23 ft^3/s. Daily mean values of suspended-sediment concentration ranged from 2 mg/L in 1988 and 1989 to 3,500 mg/L in 1989. The standard deviation of suspended-sediment concentration for the 1988 water year is 359 mg/L and the median value is 32 mg/L. Daily mean values of sediment discharge ranged from less than 0.10 t/d in 1987 and 1989 to 38,000 t/d in 1989.

The standard deviation of sediment discharge for the 1988 water year is 1,800 t/d, and the median value is 1.9 t/d.

For Harland Creek near Howard, daily mean values of stream discharge ranged from 5.6 ft^3/s in 1988 to 4,360 ft^3/s in 1991 (fig. 2h, table 4). Standard deviations for stream discharge ranged from 141 ft^3/s in 1988 to 473 ft^3/s in 1991, and median values ranged from 13 ft^3/s in 1988 to 32 ft^3/s in 1989. Daily mean values of suspended-sediment concentration ranged from 1 mg/L in 1987, 1988, and 1990 to 11,100 mg/L in 1988. Standard deviations for suspended-sediment concentration ranged from 621 mg/L in 1990 to 848 mg/L in 1991, and median values ranged from 32 mg/L in 1990 to 57 mg/L in 1989. Daily mean values of sediment discharge ranged from less than 0.10 t/d throughout the period of record to 62,800 t/d in 1988. Standard deviations for sediment discharge ranged from 3,060 t/d in 1990 to 5,860 t/d in 1991, and median values ranged from 1.0 t/d in 1988 to 5.0 t/d in 1989.

Boxplots are graphical representations showing the distribution of a particular data set (fig. 3). The upper horizontal line of the box is the 75th percentile (the value that is greater than 75 percent of the data) and the lower horizontal line of the box is the 25th percentile. The box length between the 25th and 75th percentiles is called the interquartile range (IQR). The horizontal line that is drawn within the IQR is the median value. Vertical lines or "whiskers" are then drawn from the 25th and 75th percentiles to two adjacent values. The upper adjacent value is defined as the largest data value less than or equal to the 75th percentile plus 1.5 times the IQR. The lower adjacent value is the smallest data value greater than or equal to the 25th percentile minus 1.5 times the IQR. Values more extreme than the adjacent values are plotted individually. Those values from 1.5 to 3.0 times the IQR are called "outside values" and are plotted with an asterisk. Data more extreme than 3.0 times the IQR are called "far out values" and are plotted with a circle (Helsel and Hirsch, 1992). The statistical summaries of daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge per water year for each site are plotted in figure 4 in the form of boxplots. Adjacent, outside, and far out values less than 0.1 t/d were plotted as 0.1 t/d for the sediment discharge boxplots in figure 4 due to page restrictions.

Daily mean values of stream discharge for complete water years of data at the DEC sites had a wide range of minimums, maximums, standard deviations, and medians. The lowest minimum stream discharge was 1.8 ft^3/s at Peters (Long) Creek near Pope in 1988, and the highest minimum stream discharge was 32 ft^3/s at Hickahala Creek near Senatobia in 1990. The lowest maximum stream discharge was 768 ft^3/s at Hotopha Creek near Batesville in 1988, and the highest maximum stream discharge was 26,600 ft^3/s at Batupan Bogue at Grenada in 1991. The lowest standard deviation for stream discharge was 88 ft^3/s at Hotopha Creek near Batesville in 1988, and the highest standard deviation for stream discharge was 2,400 ft^3/s at Batupan Bogue at Grenada in 1991. The lowest median value for stream discharge was 7.4 ft^3/s at Hotopha Creek near Batesville in 1988, and the highest median value for stream discharge was 175 ft^3/s at Batupan Bogue at Grenada in 1987 and 1991.

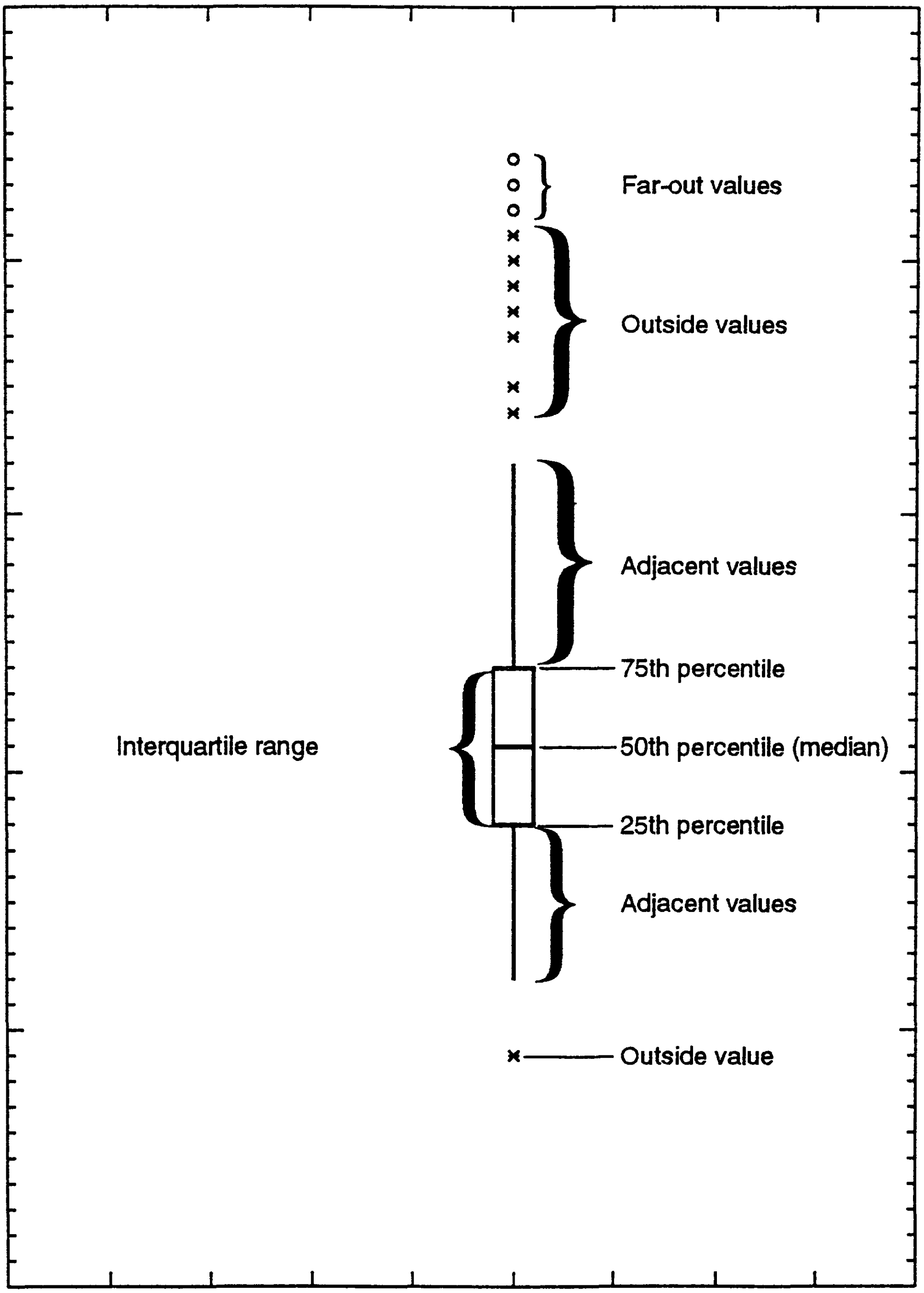

Figure 3.--Boxplot example.

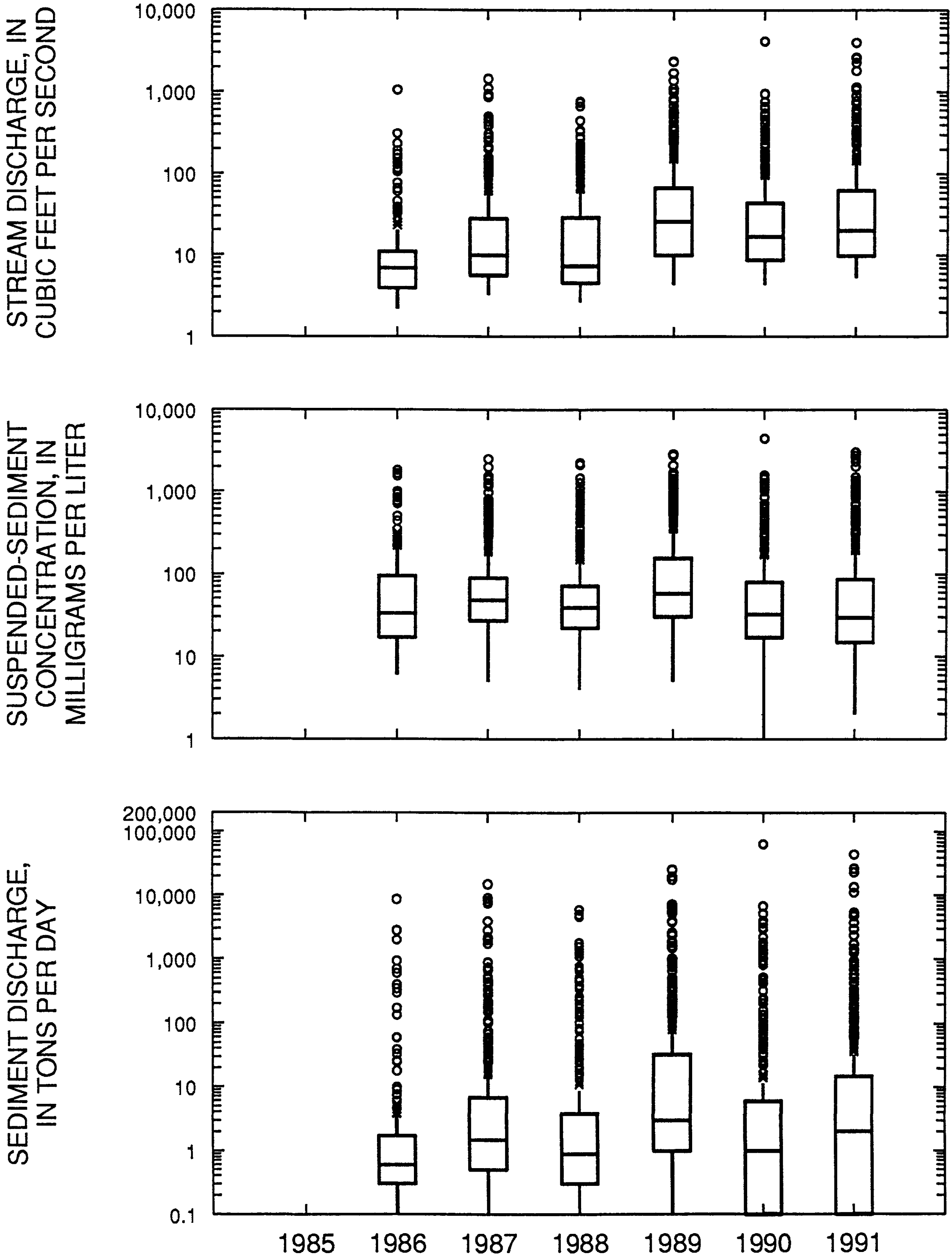

Figure 4a.--Distribution of daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge for Hotopha Creek near Batesville.

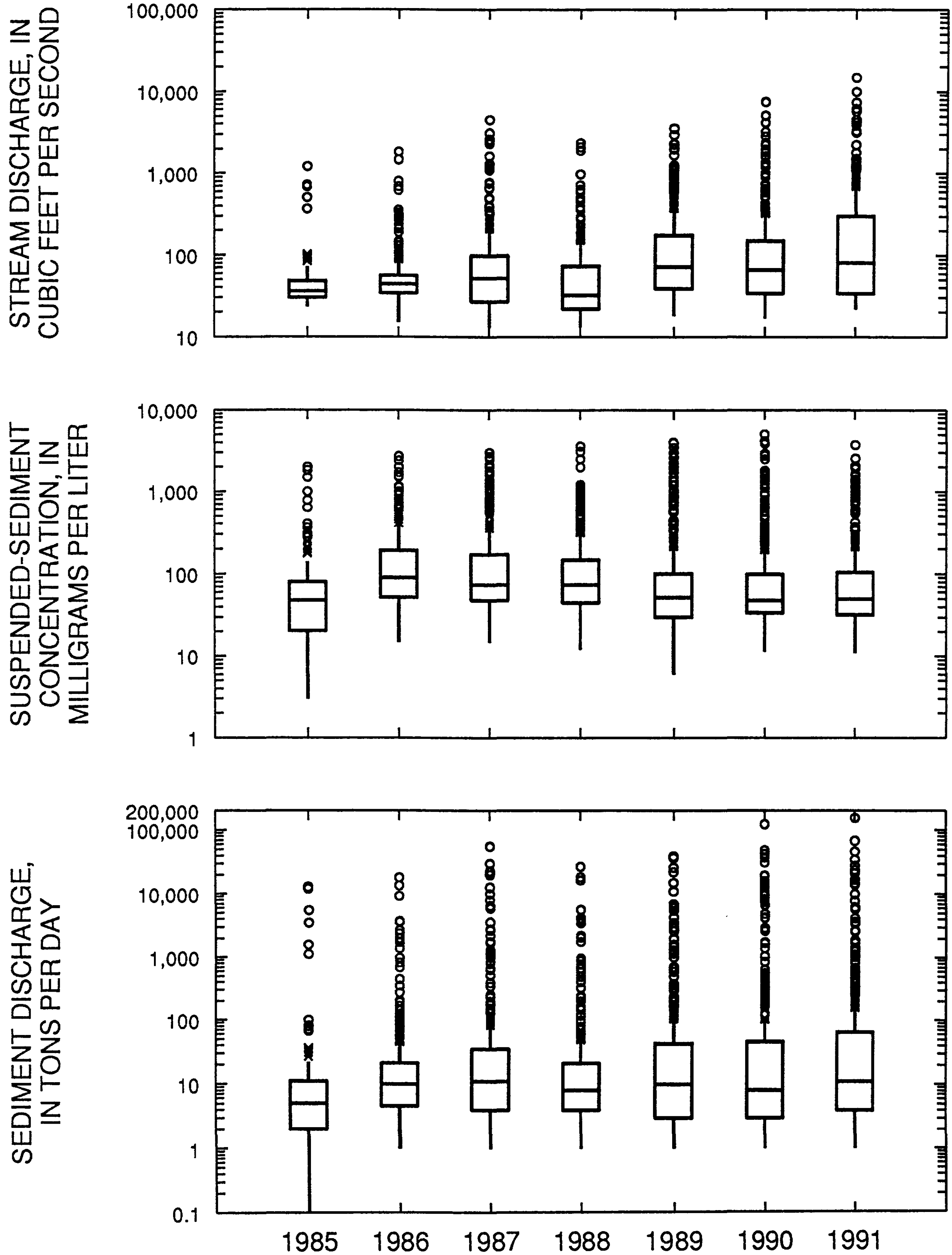

Figure 4b.--Distribution of daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge for Otoucalofa Creek Canal near Water Valley.

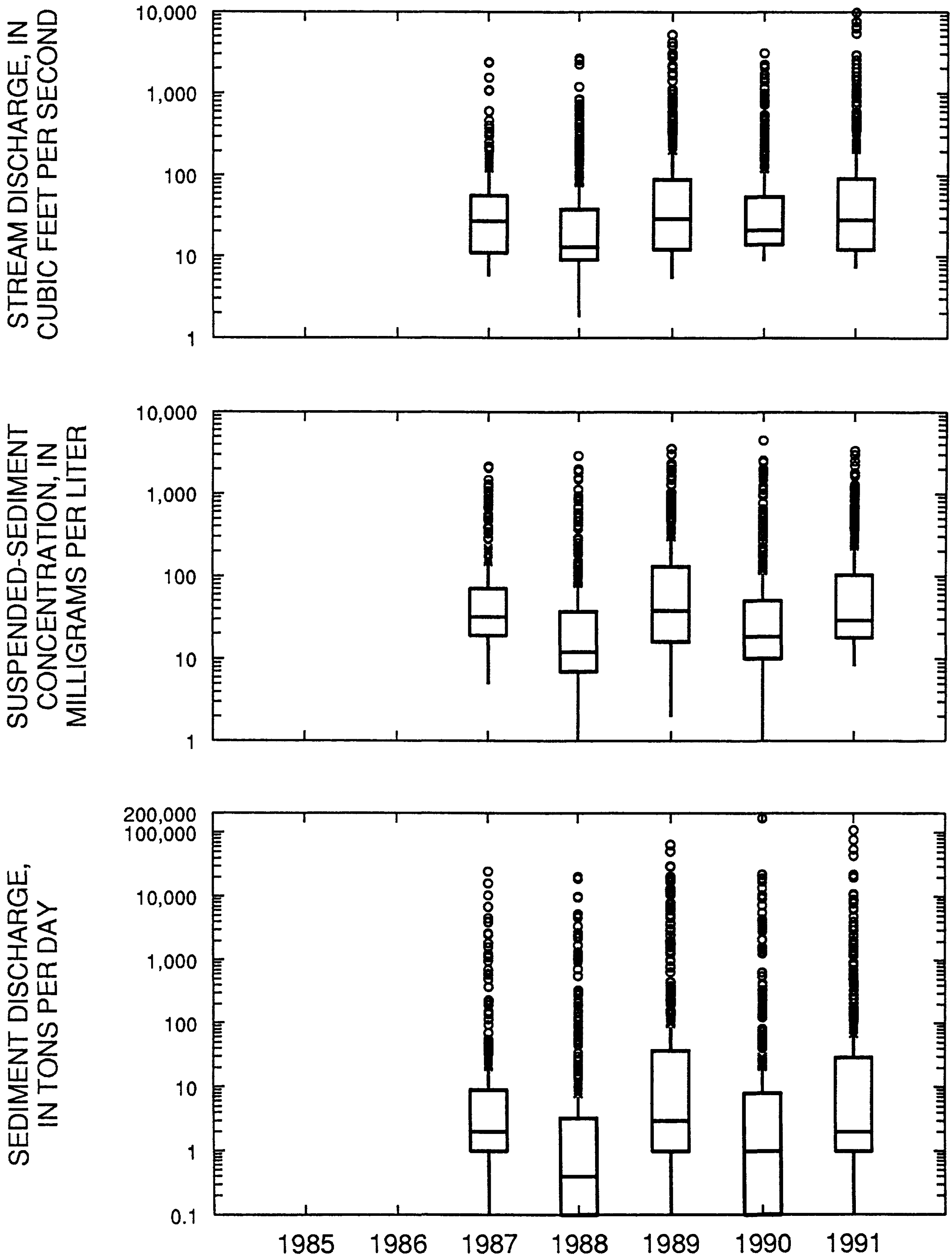

Figure 4c.--Distribution of daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge for Peters (Long) Creek near Pope.

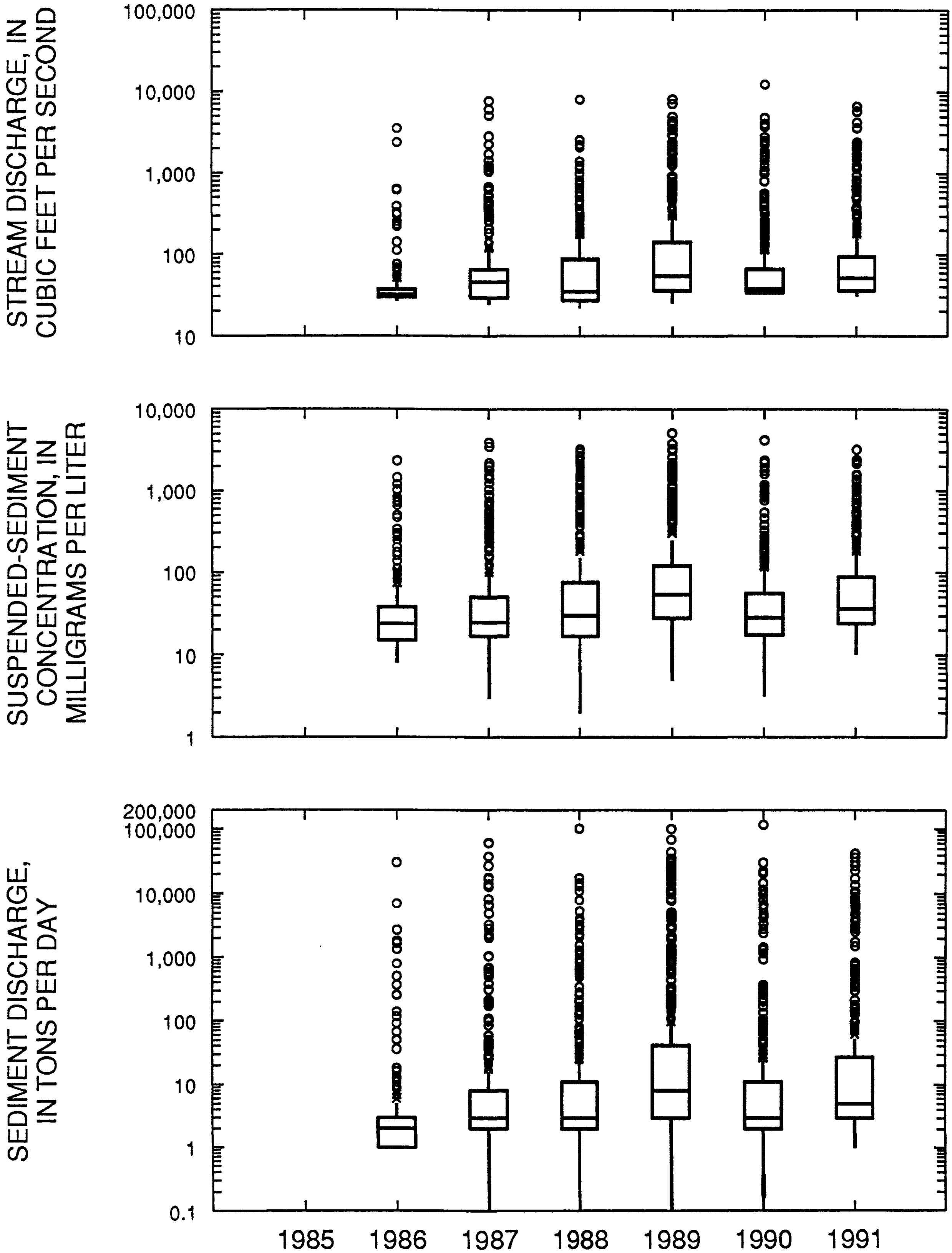

Figure 4d.--Distribution of daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge for Hickahala Creek near Senatobia.

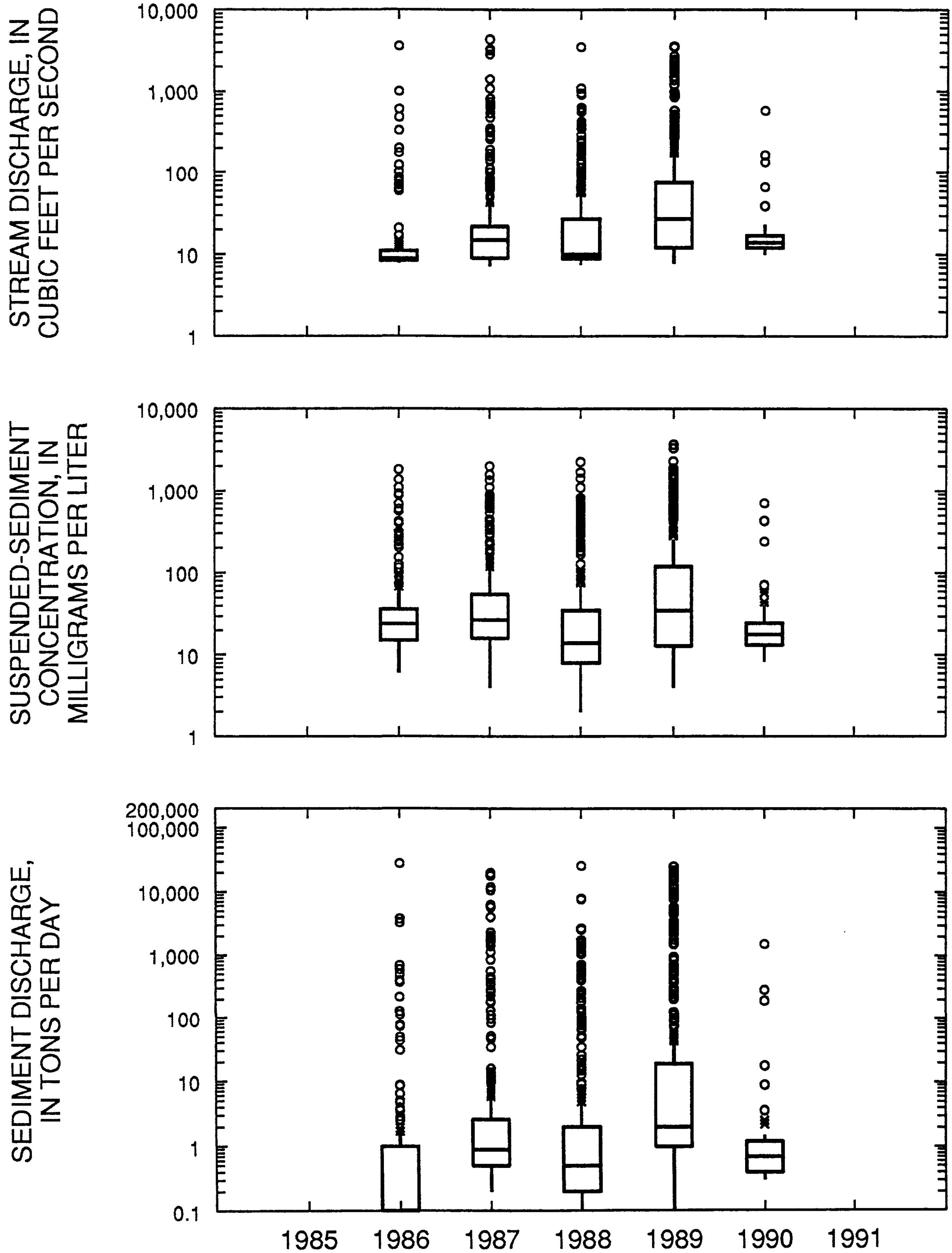

Figure 4e.--Distribution of daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge for Senatobia Creek near Senatobia.

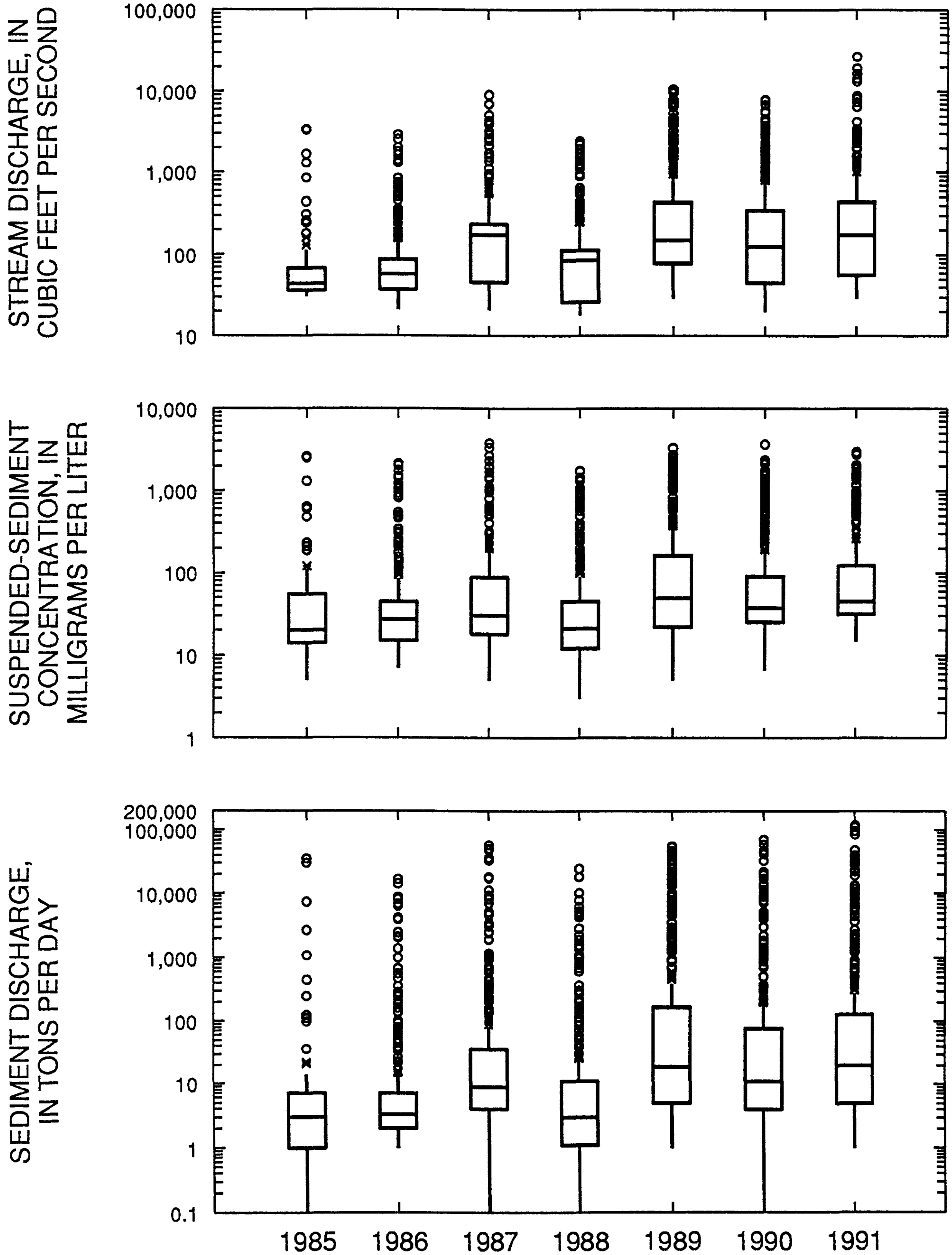

Figure 4f.--Distribution of daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge for Batupan Bogue at Grenada.

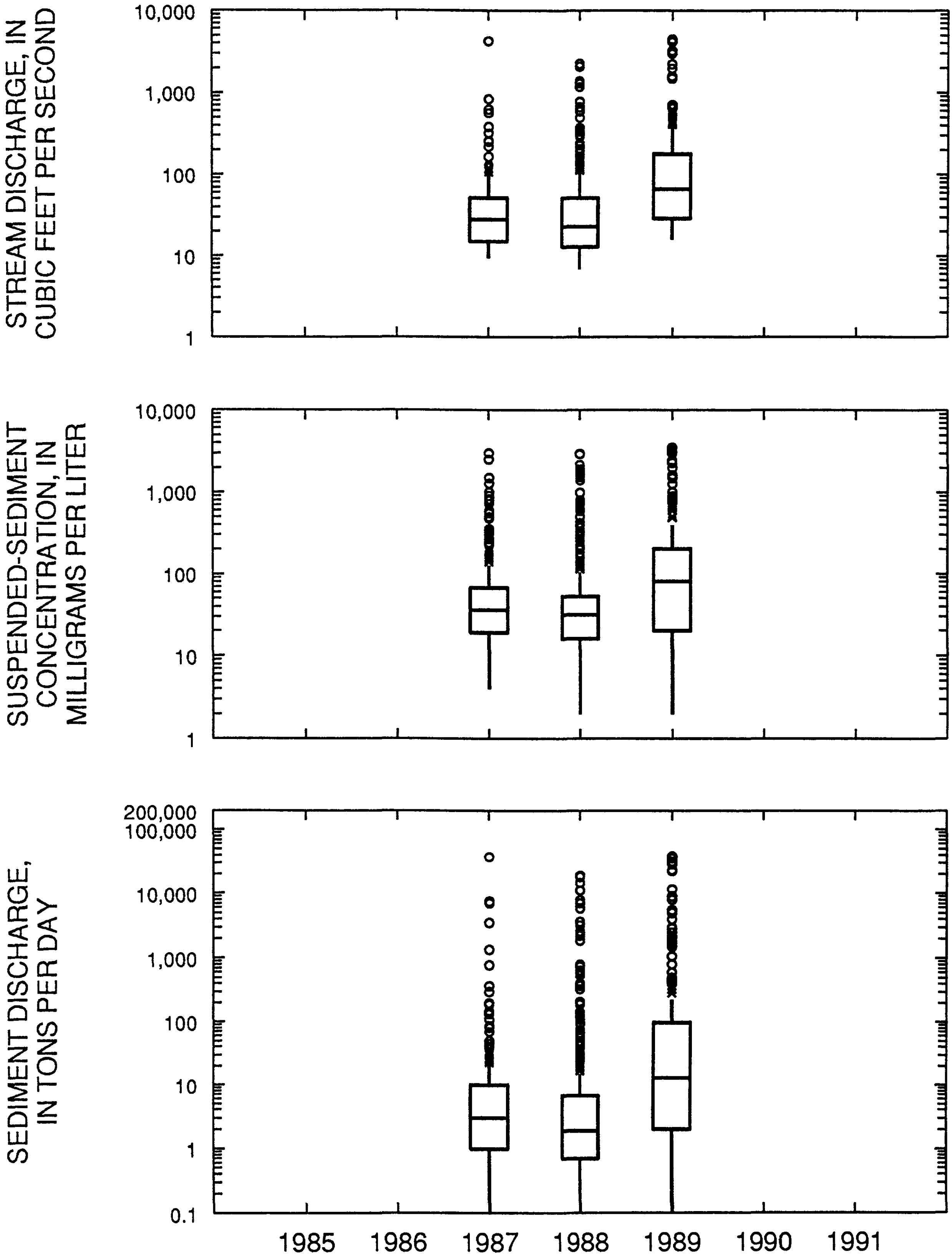

Figure 4g.--Distribution of daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge for Fannegusha Creek near Howard.

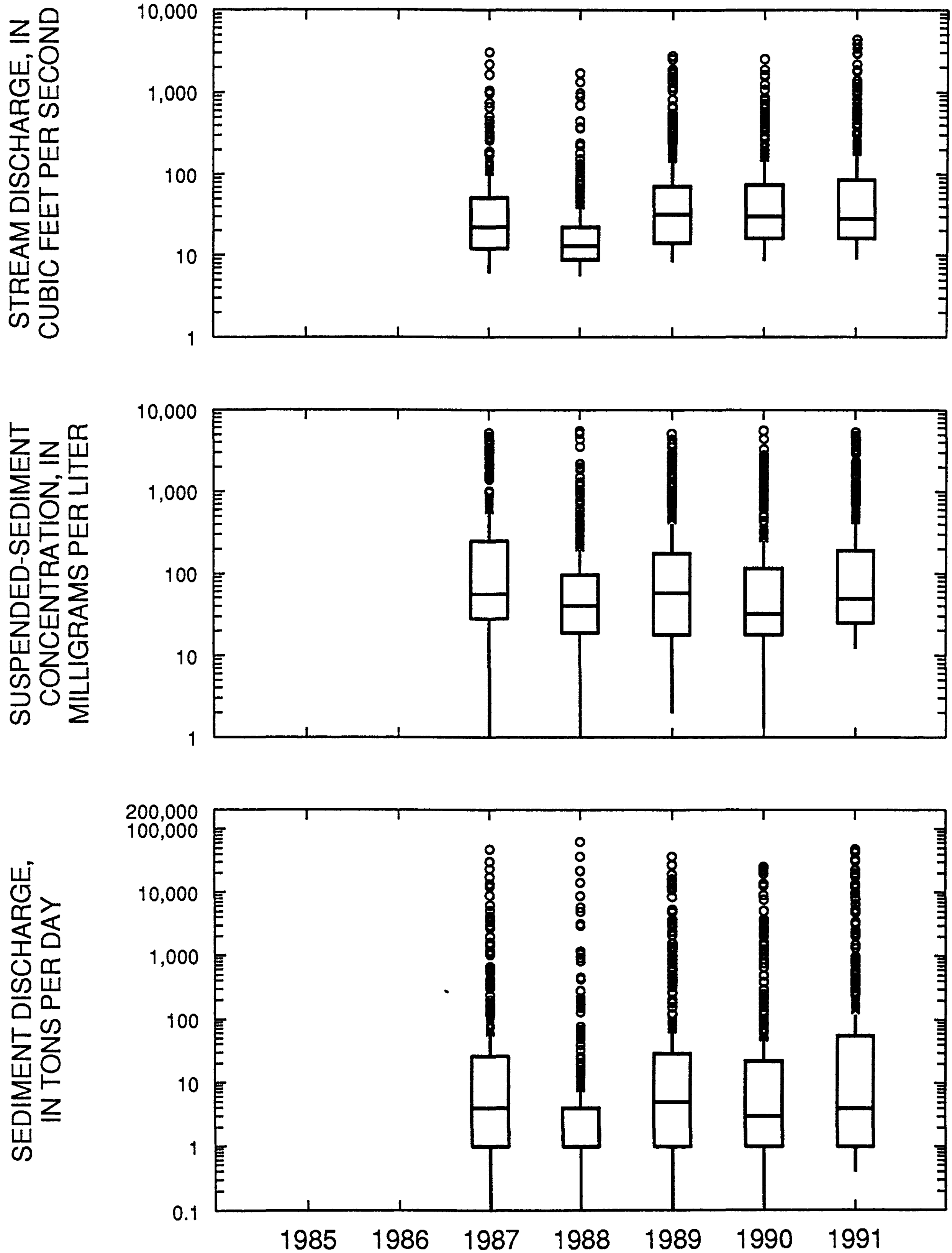

Figure 4h.--Distribution of daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge for Harland Creek near Howard.

Daily mean values of suspended-sediment concentration for complete water years of data at the DEC sites had a wide range of minimums, maximums, standard deviations, and medians. The lowest minimum suspended-sediment concentration value was 1 mg/L at Hotopha Creek near Batesville in 1990, Peters (Long) Creek near Pope in 1988 and 1990, and Harland Creek near Howard in 1988 and 1990, and the highest minimum suspended-sediment concentration value was 15 mg/L at Otoucalofa Creek Canal near Water Valley in 1986 and 1987 and at Batupan Bogue at Grenada in 1991. The lowest maximum suspended-sediment concentration value was 1,750 mg/L at Batupan Bogue at Grenada in 1988, and the highest maximum suspended-sediment concentration value was 11,100 mg/L at Harland Creek near Howard in 1988. The lowest standard deviation for suspended-sediment concentration was 206 mg/L at Senatobia Creek near Senatobia in 1987, and the highest standard deviation for suspended-sediment concentration was 848 mg/L at Harland Creek near Howard in 1991. The lowest median value for suspended-sediment concentration was 12 mg/L at Peters (Long) Creek near Pope in 1988 and the highest median value for suspended-sediment concentration was 90 mg/L at Otoucalofa Creek Canal near Water Valley in 1986.

Daily mean values of sediment discharge for complete water years of data at the DEC sites also had a wide range of minimums, maximums, standard deviations, and medians. Sediment discharge at all sites had values less than 0.10 t/d. The lowest maximum sediment discharge was 5,890 t/d at Hotopha Creek near Batesville in 1988, and the highest maximum sediment discharge was 167,000 t/d at Peters (Long) Creek near Pope in 1990. The lowest standard deviation for sediment discharge was 519 t/d at Hotopha Creek near Batesville in 1988, and the highest standard deviation for sediment discharge was 11,800 t/d at Batupan Bogue at Grenada in 1991. The lowest median value for sediment discharge was 0.40 t/d at Peters (Long) Creek near Pope in 1988, and the highest median value for sediment discharge was 20 t/d at Batupan Bogue at Grenada in 1991.

PRELIMINARY TREND ANALYSES OF STREAM DISCHARGE AND SEDIMENT DATA

Trend analyses of stream discharge and sediment data for the DEC project sites are needed to help evaluate the effectiveness of management practices used to alleviate flooding, erosion, sedimentation, and water-quality problems. Management practices include bank stabilization, energy-reduction structures in a study stream, and sediment-reduction structures in fields that drain into a study stream. Trends in sediment data over time may be used to indicate whether management practices have changed suspended-sediment concentration and sediment discharge. In addition, trends in sediment data may indicate if the factors that contribute to sedimentation and erosion have changed. The following paragraphs include a discussion of the trend analyses procedures used to detect trends in the data from the eight sites and a presentation of the results of the preliminary trend analyses of the data at these sites.

Trend Analyses Procedures

Two overall types of trend analyses used to identify trends in hydrologic time series data include step-trend and monotonic trend analyses. Step-trend analyses are used to detect changes in a constituent for a period of time prior to and after a specific event. For example, step-trend analyses would be performed to detect changes in suspended-sediment concentration prior to and after construction of a dam on a waterway. These analyses require knowledge of the event before examination of the data (Hirsch and others, 1991). Monotonic trend analyses are performed on data that consistently increase or decrease over time without regard to any specific pattern (Hirsch and others, 1991). The sediment data collected for the DEC project were collected prior to, during, and after flooding-erosion management practices were implemented. However, these practices were not implemented simultaneously in each watershed over a short time period; rather, they were implemented gradually from watershed to watershed. Therefore, monotonic trend analyses were used instead of step-trend analyses.

After a trend analysis method has been selected, parametric or non-parametric procedures are selected. Parametric procedures are used for data with specific distributions, typically normal distributions. Non-parametric procedures are used when the distribution of the data is unknown. Water quality (and sediment) data, in general, are seasonal, skewed, and serially correlated, and follow criteria for use of a non-parametric procedure (Smith and others, 1982). Therefore, the monotonic, non-parametric Seasonal Kendall test for trend was selected to detect trends in stream discharge, suspended-sediment concentration, and sediment discharge for the eight sites. In addition, the Seasonal Kendall Slope Estimator was used to indicate magnitude and direction of detected trends, and flow-adjustment procedures were used to attempt to remove stream discharge as a source of variance in suspended-sediment concentration and sediment discharge data. Brief explanations of the Seasonal Kendall test, the Seasonal Kendall Slope Estimator, and flow adjustment are presented in the following paragraphs.

Seasonal Kendall Test

The Seasonal Kendall test for trend is based on the Kendall's Tau test, which is a distribution-free test that uses the ranks of the data instead of the magnitudes (Smith and others, 1982). In this test, a positive value for the test statistic (Kendall's Tau) indicates an upward trend, a negative value indicates a downward trend, and a value close to zero indicates no trend (Hirsch and others, 1982). The Seasonal Kendall test is a modification of the Kendall's Tau test in which test statistics are computed for several "seasons" in a period of a year to compare years of record. The Seasonal Kendall test minimizes the effects of seasonal variability on the detection of trends by comparing only values from the same season of each year (Schertz, 1990). A season does not necessarily mean a climatic season, but is defined in this report as "a period of a year from which a single value will be selected to compare to values from the same season or period from other years" (Schertz, 1990). The test statistics for each season are then summed to determine an overall test statistic for the period of record.

The hypothesis of the Seasonal Kendall test is that no trend exists in the time series of data tested. A "p-value" associated with the results of the test is the probability that a trend resulted from a chance arrangement of the data rather than an actual change in the data (Schertz, 1990). The p-value associated with the trend result is then compared to a pre-selected level of significance. If the p-value is less than the pre-selected level of significance, then one would accept that a trend in the data does exist (or, that the hypothesis of no trend is rejected). A formal explanation and derivation of the Seasonal Kendall test is given by Hirsch and others (1982).

Requirements for the Seasonal Kendall test include an adequate period of record, number of seasons, and pre-selected level of significance. First, a minimum of 5 to 10 years of record is considered adequate to conduct trend analyses (Hirsch and others, 1982; Schertz, 1990). For the eight DEC project sites, four sites had more than 5 years of record: Hotopha Creek near Batesville, Otoucalofa Creek Canal near Water Valley, Hickahala Creek near Senatobia, and Batupan Bogue at Grenada. Of the remaining sites, two had nearly 5 years of record: Peters (Long) Creek near Pope and Harland Creek near Howard; and two sites had less than 4 years of record: Senatobia Creek near Senatobia and Fannegusha Creek near Howard. Trend analyses were conducted at the four sites with greater than 5 years of record and at the two sites with nearly 5 years of record. Trend analyses were not conducted at the two sites with less than 4 years of record. Also, trend analyses were conducted on an individual site basis only and were not used to compare sites or watersheds. To compare sites or watersheds, the period of record analyzed is required to be of comparable length for all of the sites (Schertz, 1990).

The number of seasons used to perform the Seasonal Kendall test was selected to represent the range of values in the sediment data for a year of record; however, a large number of seasons could cause potential problems with the trend test, such as eliminating independence in the test data (Hirsch and Slack, 1984). Because of the large number of daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge used for this study, trend analyses were performed on subsets of daily mean values based on 12 seasons per year or one set of values per month. For example, the first subset was formed by selecting daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge computed on the 15th day of each month for the period of record at all the sites at which trend analyses were performed. The day of the month used to form the subsets of data was selected at the discretion of the author. This procedure was then repeated by forming similar subsets of data for the 8th and 22nd days of each month. The replicate subsets were formed to support an overall trend result at a particular site.

A level of significance is pre-selected to indicate whether the results of the Seasonal Kendall test conducted on a particular subset is considered statistically significant. If the p-value of the trend test is less than the pre-selected level of significance, then the result can be considered statistically significant as stated earlier. The author chose a pre-selected level of significance of 0.1, the same as that used by Smith and others (1982).

Seasonal Kendall Slope Estimator

After using the Seasonal Kendall test to identify trends in the sediment data, the Seasonal Kendall Slope Estimator is used to estimate the magnitude and direction of the trend. The magnitude is expressed as a slope (value per unit time), although linearity is not implied in the trend. This slope estimate is the median of the differences (expressed as slopes) of the ordered pairs of data compared in the trend test. The median of differences is the change per year due to the trend (Smith and others, 1982). Because the median of the differences is used, this slope estimate is resistant to extreme values (or outliers) and to seasonal variation (Hirsch and others, 1982). A positive value of the slope estimate indicates an upward trend, and a negative value indicates a downward trend. The Seasonal Kendall Slope Estimator was computed for all trend analyses at the six sites analyzed.

Flow Adjustment

Suspended-sediment concentration and sediment discharge are strongly correlated with stream discharge. Suspended-sediment concentration and sediment discharge generally increase as stream discharge increases because of the transport of particulates within stormwater runoff (Schertz, 1990). The relations between suspended-sediment concentration and stream discharge and between sediment discharge and stream discharge are similar at all of the DEC project sites. An example of the relation between suspended-sediment concentration and stream discharge for Otoucalofa Creek Canal near Water Valley is shown in figure 5. An example of the relation between sediment discharge and stream discharge for the same site is shown in figure 6. If the variability due to stream discharge is removed, trend testing would have greater probability of detecting a trend when one exists, and the trend would not be an artifact of the history of stream discharge at that site (Schertz, 1990). Therefore, a statistically significant trend would indicate changes in the factors that contribute to sedimentation and erosion at a particular site.

The technique used to remove the effects of stream discharge on suspended-sediment concentration and sediment discharge is to compute a time series of flow-adjusted concentrations (FAC's) and test this time series for trend. The FAC is defined in this report as a residual computed by subtracting a predicted daily mean value from an actual daily mean value of suspended-sediment concentration or sediment discharge. Predicted daily mean values are computed from a mathematical expression that describes the relation between stream discharge and suspended-sediment concentration or between stream discharge and sediment discharge.

Many expressions that describe the relation between stream discharge and suspended-sediment concentration or between stream discharge and sediment discharge at a particular site were considered. Such expressions included linear regression, multiple regression (quadratic polynomial regression), and locally weighted scatterplot smooths (LOWESS; see Helsel and Hirsch, 1992) for a more detailed explanation of LOWESS). All of the expressions were evaluated to determine a "best" expression that described the relation between stream discharge and suspended-sediment concentration

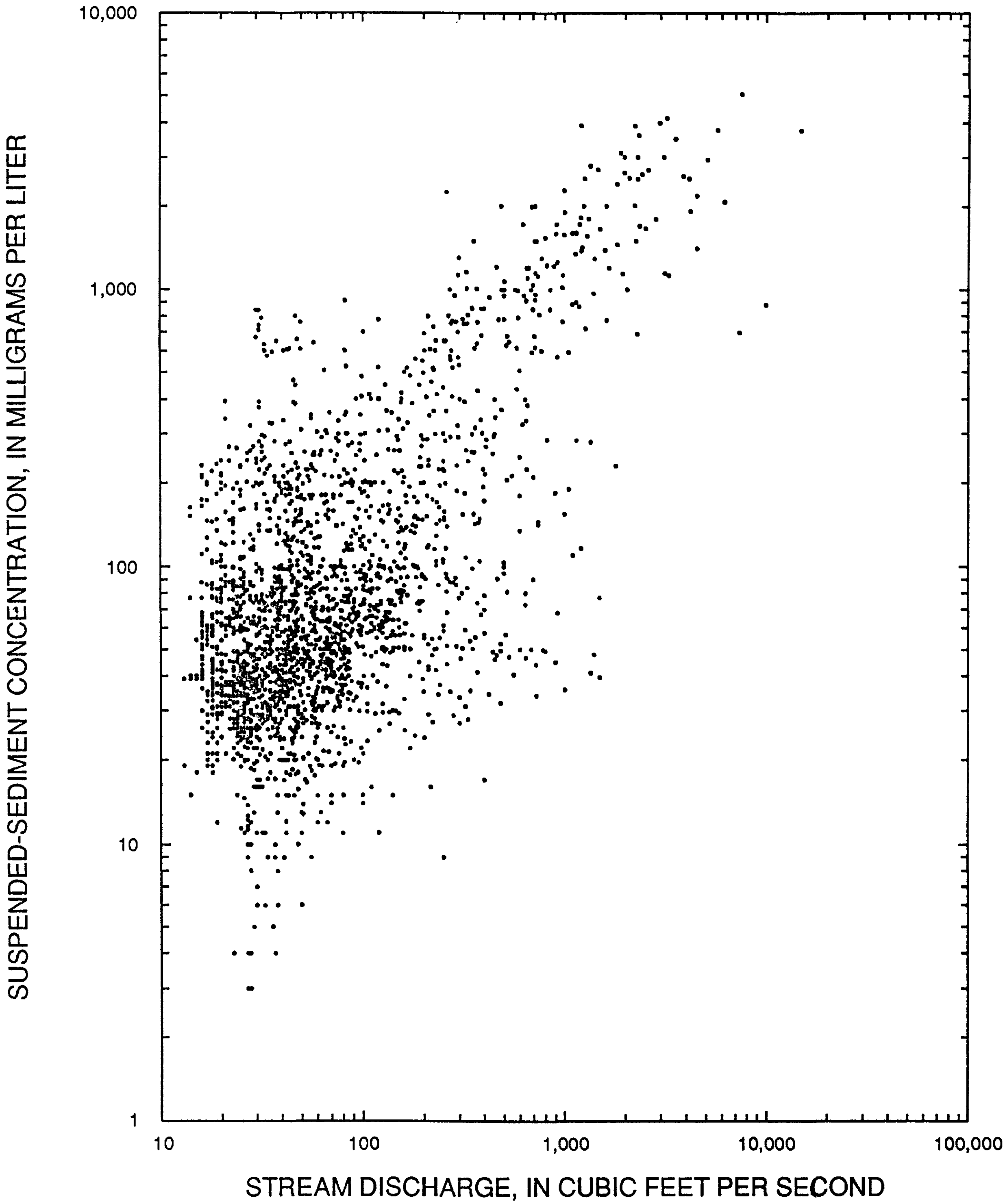

Figure 5.--Relation of daily mean values of stream discharge and suspended-sediment concentration at Otoucalofa Creek Canal near Water Valley, July 1, 1985 through September 30, 1991.

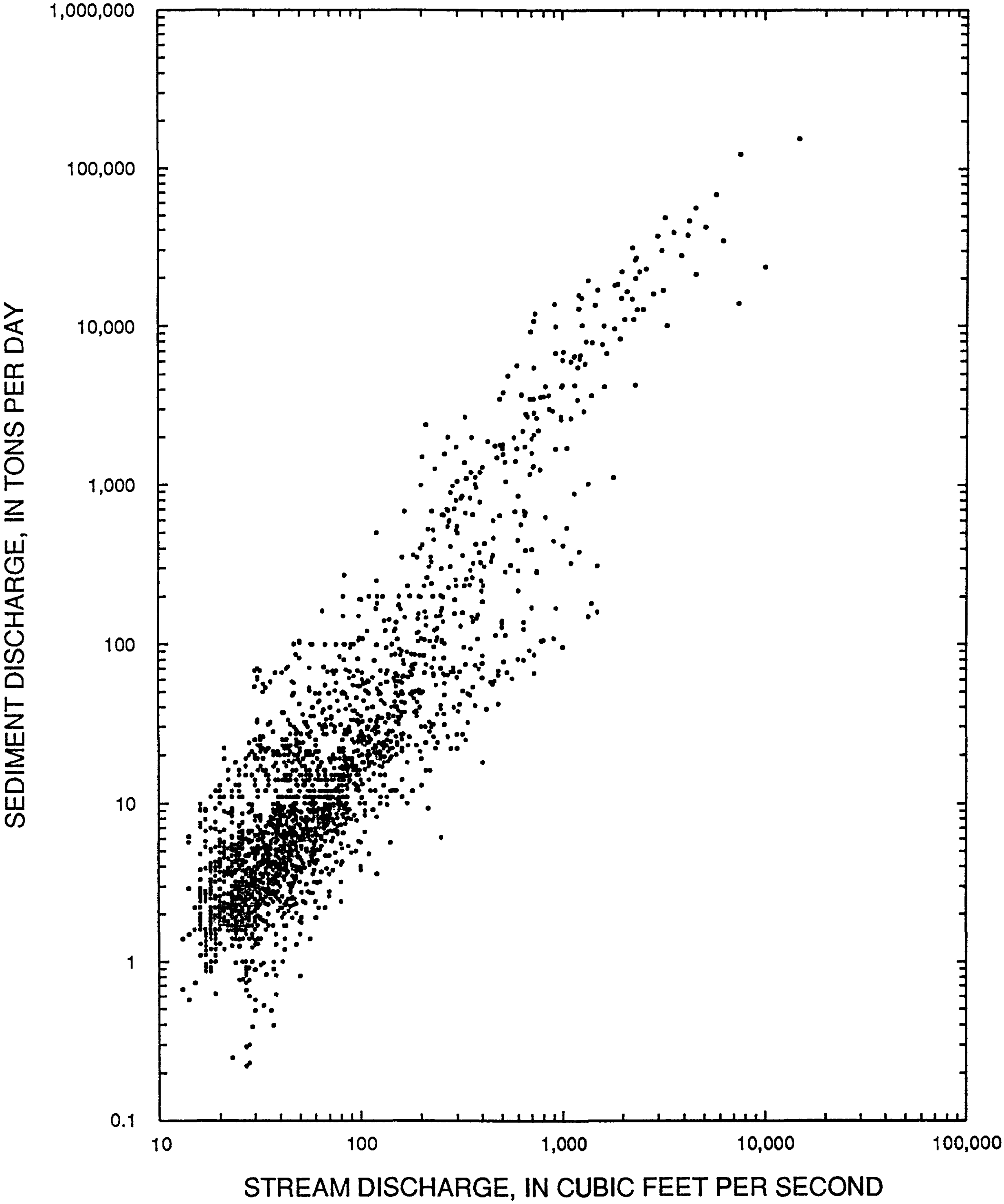

Figure 6.--Relation of daily mean values of stream discharge and sediment discharge at Otoucalofa Creek Canal near Water Valley, July 1, 1985 through September 30, 1991.

or sediment discharge at a particular site. The procedure to select the best expression is presented in a report by Schertz (1990) and was followed for each of the DEC project sites analyzed in this report.

Trend Analyses Results

The results of the trend analyses for the six DEC sites analyzed are presented in table 5. All of the data subsets are transformed using natural logs prior to trend testing. Log transformations are typically used for data that have ranges of more than one magnitude (Helsel and Hirsch, 1992). P-values are reported as decimal values rather than percentages in table 5 as a basis of comparison to the pre-selected level of significance of 0.1. Slope estimates are computed as change in log units per year, but are reported in table 5 as percentage change per year for easier interpretation and convention.

For the purposes of this report, consistent trend results refer to p-values associated with an individual trend test that are consistently below 0.1 for all three replicate subsets of data analyzed at a particular site. For example, p-values associated with trend tests conducted on the time series of stream discharge for subsets of data formed on the 15th, 8th, and 22nd days of the month were 0.0023, 0.0003, and 0.0001, respectively, for Hotopha Creek near Batesville (table 5). These three p-values were consistently less than 0.1, which indicates a statistically significant trend in the stream discharge data at this site. In addition, the respective slope estimates associated with the trend tests were consistently positive indicating an upward trend in discharge over time for this site.

Trend results are also considered consistent in this report when p-values associated with an individual trend test are consistently above 0.1 for all three replicate subsets of data analyzed at a particular site regardless of consistency in slope estimate direction. For example, p-values associated with trend tests conducted on time series of flow-adjusted suspended-sediment concentration for subsets of data formed on the 15th, 8th, and 22nd days of the month were 1.0000, 0.4478, and 0.8610, respectively, for Hickahala Creek near Senatobia (table 5), indicating that no statistically significant trend was detected. Slope estimates associated with these tests were all consistently negative for the replicate subsets of data. In another example, p-values associated with trend tests conducted on time series of sediment discharge for subsets of data formed on the 15th, 8th, and 22nd days of the month were 0.8790, 0.4752, and 0.2839, respectively, for Otoucalofa Creek Canal near Water Valley (table 5), also indicating that no statistically significant trend was detected. Slope estimates associated with these tests alternated from negative to positive to negative, respectively. Although no statistically significant trends were detected in either example, the trend results were considered consistent because the p-values associated with the respective trend results were all consistently above 0.1 for each replicate subset of data.

Inconsistent trend results refer to p-values associated with an individual trend test that are not consistently below or above 0.1 for the three subsets of data at a particular site. For example, p-values associated with trend tests conducted on the time series of suspended-sediment concentration for subsets of data formed on the 15th, 8th, and 22nd days of the month were 0.0739, 0.1782, and 0.2835, respectively, for Hotopha Creek near Batesville (table 5). These p-values were not all below or above 0.1; therefore, no assessment of trend in suspended-sediment concentration over time can be made at this particular site. A complete discussion of the trend results at each site is presented in the following paragraphs.

Hotopha Creek near Batesville.--Trend results for the different subsets of data were consistent for stream discharge and flow-adjusted suspended-sediment concentration and inconsistent for suspended-sediment concentration, sediment discharge, and flow-adjusted sediment discharge (table 5). Trends in stream discharge were detected (all p-values were less than 0.1) and the slope estimates were positive for all subsets of data indicating an upward trend in stream discharge for the period of record. Trends in flow-adjusted suspended-sediment concentration were detected, and the slope estimates were negative for all subsets of data, which may indicate a downward trend in the factors that contribute to sedimentation and erosion at this site.

Otoucalofa Creek Canal near Water Valley.--Trend results for the different subsets of data were consistent for all subsets of data at this site (table 5). Trends in stream discharge were detected, and the slope estimates were positive for all subsets of data indicating an upward trend in stream discharge for the period of record. Trends in suspended-sediment concentration and sediment discharge were not considered statistically significant (all p-values were greater than 0.1) in the different subsets of data. Trends in flow-adjusted suspended-sediment concentration and flow-adjusted sediment discharge were detected, and the respective slope estimates were negative for all subsets of data, which may indicate a downward trend in the factors that contribute to sedimentation and erosion at this site.

Peters (Long) Creek near Pope.--Trend results for the different subsets of data were consistent for stream discharge, flow-adjusted suspended-sediment concentration, and flow-adjusted sediment discharge and inconsistent for suspended-sediment concentration and sediment discharge (table 5). Trends in stream discharge were detected, and slope estimates were positive for all subsets of data indicating an upward trend in stream discharge for the period of record. Trends in flow-adjusted suspended-sediment concentration and flow-adjusted sediment discharge were not considered statistically significant for all subsets of data.

Hickahala Creek near Senatobia.--Trend results for the different subsets of data were consistent for stream discharge, flow-adjusted suspended-sediment concentration, and flow-adjusted sediment discharge and inconsistent for suspended-sediment concentration and sediment discharge (table 5). Trends in stream discharge were detected, and slope estimates were positive for all subsets of data indicating an upward trend in stream discharge for the period of record. Trends in flow-adjusted suspended-sediment concentration and flow-adjusted sediment discharge were not considered statistically significant for all subsets of data.

Batupan Bogue at Grenada.--Trend results for the different subsets of data were consistent only for sediment discharge (table 5). Trends in sediment discharge were detected, and slope estimates were positive for all subsets of data indicating an upward trend in sediment discharge for the period of record. Unlike the other five sites analyzed, trend results were inconsistent for stream discharge at this site. P-values associated with trend tests conducted on the series of stream discharge for subsets of data formed on the 15th, 8th, and 22nd days of the month were 0.2851, 0.0042, and 0.0016, respectively (table 5).

Harland Creek near Howard.--Trend results for the different subsets of data were consistent for stream discharge, suspended-sediment concentration, and sediment discharge and inconsistent for flow-adjusted suspended-sediment concentration and flow-adjusted sediment discharge (table 5). Trends in stream discharge were detected, and the slope estimates were positive for all subsets of data indicating an upward trend in stream discharge for the period of record. Trends in suspended-sediment concentration and sediment discharge were not considered statistically significant in the different subsets of data.

Trends were detected in stream discharge for all subsets of data for each site analyzed, except for the subset of stream discharges formed on the 15th day of the month at Batupan Bogue at Grenada. In addition, slope estimates indicated an upward trend in stream discharge for the study period where trends in stream discharge were detected. The increase in stream discharge at the six DEC sites was supported by the annual mean stream discharge extremes generally having lowest annual means in the 1988 water year and highest annual means in the 1989 and 1991 water years (which is consistent with rainfall conditions in the study area).

Trends were detected in flow-adjusted suspended-sediment concentration at Hotopha Creek near Batesville. For subsets of flow-adjusted suspended-sediment concentration data formed on the 15th, 8th, and 22d days of the month, p-values were 0.0019, 0.0089, and 0.0739, respectively, indicating a statistically significant trend at Hotopha Creek (table 5). Slope estimates associated with these tests were all negative, which may indicate a downward trend in the factors that contribute to sedimentation and erosion at this site.

Similar trends were detected at Otoucalofa Creek Canal near Batesville for flow-adjusted suspended-sediment concentration and flow-adjusted sediment discharge. For subsets of flow-adjusted suspended-sediment concentration data formed on the 15th, 8th, and 22d days of the month, p-values were 0.0002, 0.0374, and 0.0001, respectively, indicating a statistically significant trend (table 5). For subsets of flow-adjusted sediment discharge data formed on the 15th, 8th, and 22d days of the month, p-values were 0.0014, 0.0374, and 0.0001, respectively, also indicating a statistically significant trend (table 5). Slope estimates associated with both sets of trend results were all negative, which may indicate a downward trend in the factors that contribute to sedimentation and erosion at this site.

Trend analyses generally were inconsistent or no statistically significant trends were detected, however, for unadjusted and flow-adjusted suspended-sediment concentration and sediment discharge when comparing the three subsets of data at most of the remaining sites analyzed. The inconsistencies may be attributed to insufficient periods of record at each site. The study period may be too short to indicate consistent trend results in the suspended-sediment concentration and sediment discharge due to the high degree of variability in stream discharge from water year to water year. The largest amount of record collected at any site was 6.25 years, which is near the minimum amount considered adequate to attempt trend testing.

SUMMARY AND CONCLUSIONS

To assist an interagency task force in evaluating the effectiveness of the ongoing sediment data-collection program, this report presents preliminary data summaries and results of trend analyses for daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge for the Yazoo River Basin Demonstration Erosion Control (DEC) project sites for the study period July 1985 through September 1991. The eight sites are in the Hotopha Creek, Otoucalofa Creek, Peters (Long) Creek, Hickahala-Senatobia Creek, Batupan Bogue, and Black Creek watersheds in north-central Mississippi. About 550 stream discharge measurements and about 20,000 suspended-sediment samples were analyzed, reviewed, and stored in USGS computer files. Stream discharge measurements and sediment samples were used to compute daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge.

For the DEC project sites, annual means of stream discharge generally were lowest in the 1988 water year corresponding to drought conditions in the study area; annual means of stream discharge generally were highest in the 1989 and 1991 water years, corresponding to record rainfall in the study area. Annual means of suspended-sediment concentration were lowest in the 1988 water year except for three sites and highest in the 1989 water year except for two sites. Annual means of sediment discharge were lowest in the 1988 water year except for two sites and highest in the 1989 and 1991 water years; these extremes coincide with stream discharge extremes, as expected.

The Seasonal Kendall trend test was used to detect trends in daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge for the DEC project sites. Only six of the eight sites had sufficient data on which to perform the trend analyses. Trend analyses were conducted on an individual site basis only; trend analyses were not conducted to compare sites or watersheds. Because of the large number of daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge used for this study, trend analyses were performed on subsets of daily mean values based on 12 seasons per year or one set of values per month. Subsets of data were formed at each site for the 15th, 8th, and 22nd days of each month. Replicate subsets were formed to support an overall trend result at a particular site. In addition, slope estimates indicating magnitude and direction of the trend were computed.

Trend analyses were also conducted for flow-adjusted suspended-sediment concentration and flow-adjusted sediment discharge. These analyses were conducted on residuals computed from expressions describing relations between suspended-sediment concentration and stream discharge or sediment discharge and stream discharge.

Trends were detected in stream discharge at each site except Batupan Bogue at Grenada indicating an upward trend in stream discharge for the study period, which is consistent with rainfall conditions in the study area. Trends were detected in flow-adjusted suspended-sediment concentration at Hotopha Creek near Batesville and in flow-adjusted suspended-sediment concentration and flow-adjusted sediment discharge at Otoucalofa Creek Canal near Water Valley indicating a possible downward trend in the factors that contribute to sedimentation and erosion at these two sites. Trend analyses generally were inconsistent or no statistically significant trends were detected, however, for unadjusted and flow-adjusted suspended-sediment concentration and sediment discharge at most of the remaining sites analyzed, probably due to insufficient periods of record.

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Table 1. -- *Sediment sampling sites and period of record*

Map reference number	Down-stream order number	Station name	Drainage area (square miles)	Latitude	Longitude	Period of record Start	Period of record End
1	07273100	Hotopha Creek near Batesville	35.1	34°21'50"	89°52'42"	3-12-86	ongoing
2	07274252	Otoucalofa Creek Canal near Water Valley	97.1	34°08'36"	89°38'59"	7-01-85	ongoing
3	07275530	Peters (Long) Creek near Pope	79.2	34°12'50"	89°58'54"	12-23-86	ongoing
4	07277700	Hickahala Creek near Senatobia	121	34°37'54"	89°55'30"	2-07-86	ongoing
5	07277730	Senatobia Creek near Senatobia	82.0	34°37'02"	89°56'30"	3-01-86	11-30-89
6	07285400	Batupan Bogue at Grenada	240	33°46'26"	89°47'15"	7-10-85	ongoing
7	07287355	Fannegusha Creek near Howard	103	33°08'13"	90°11'40"	3-12-87	5-08-89
8	07287404	Harland Creek near Howard	62.1	33°06'05"	90°10'23"	12-09-86	ongoing

Table 2.--*Number of daily mean values available in the U.S. Geological Survey's Water Data Storage and Retrieval system files (WATSTORE) for the period July 1985 through September 1991 for the Demonstration Erosion Control project sites*

Downstream order number	Station name	Number of daily mean values: Stream discharge	Suspended-sediment concentration	Sediment discharge
07273100	Hotopha Creek near Batesville	2,035	2,029	2,029
07274252	Otoucalofa Creek Canal near Water Valley	2,295	2,283	2,283
07275530	Peters (Long) Creek near Pope	1,748	1,742	1,742
07277700	Hickahala Creek near Senatobia	2,062	2,062	2,062
07277730	Senatobia Creek near Senatobia	1,392	1,371[a]	1,371[a]
07285400	Batupan Bogue at Grenada	2,294	2,274	2,274
07287355	Fannegusha Creek near Howard	934	789[a]	789[a]
07287404	Harland Creek near Howard	1,774	1,757	1,757

[a] Suspended-sediment concentration and sediment discharge data-collection ended in calendar year 1989.

Table 3.--*Summaries of annual means of stream discharge, suspended-sediment concentration, and sediment discharge for the Demonstration Erosion Control project sites*
[ft^3/s, cubic feet per second; mg/L, milligrams per liter; t/d, tons per day]

Water year	Annual mean stream discharge (ft^3/s)	Annual mean suspended-sediment concentration (mg/L)	Annual mean sediment discharge (t/d)
	HOTOPHA CREEK NEAR BATESVILLE		
1986[a]	23	127	97
1987	44	143	187
1988	39	112	99
1989	89	190	401
1990	66	126	308
1991	105	150	533
	OTOUCALOFA CREEK CANAL NEAR WATER VALLEY		
1985[a]	80	147	407
1986	67	178	189
1987	148	207	658
1988	83	177	266
1989	209	198	710
1990	224	207	1,280
1991	393	178	1,420
	PETERS (LONG) CREEK NEAR POPE		
1987[a]	79	128	323
1988	78	87	268
1989	197	206	1,120
1990	142	131	897
1991	228	171	1,340
	HICKAHALA CREEK NEAR SENATOBIA		
1986[a]	72	84	236
1987	153	142	773
1988	146	163	599
1989	314	265	1,800
1990	207	117	911
1991	255	155	919

Table 3.--*Summaries of annual means of stream discharge, suspended-sediment concentration, and sediment discharge for the Demonstration Erosion Control project sites*--Continued

Water year	Annual mean stream discharge (ft^3/s)	Annual mean suspended-sediment concentration (mg/L)	Annual mean sediment discharge (t/d)
	SENATOBIA CREEK NEAR SENATOBIA		
1986[a]	39	77	196
1987	82	86	258
1988	56	88	183
1989	175	191	842
1990[a]	103	42	34
	BATUPAN BOGUE AT GRENADA		
1985[a]	164	133	935
1986	131	90	260
1987	336	166	1,120
1988	146	95	322
1989	706	240	2,440
1990	522	169	1,520
1991	757	181	2,260
	FANNEGUSHA CREEK NEAR HOWARD		
1987[a]	72	124	296
1988	73	126	288
1989[a]	242	291	1,330
	HARLAND CREEK NEAR HOWARD		
1987[a]	90	375	736
1988	39	221	464
1989	110	297	772
1990	114	250	682
1991	156	378	1,330

[a] partial year of record

Table 4. -- *Statistical summaries of daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge for the Demonstration Erosion Control project sites*

[Q1, 25th percentile; Q3, 75th percentile]

Water year	Minimum	Maximum	Standard deviation	Q1	Median	Q3
HOTOPHA CREEK NEAR BATESVILLE						
Stream discharge, cubic feet per second						
1986[a]	2.2	1,050	81	4.0	7.1	11
1987	3.3	1,440	131	5.6	10	28
1988	2.7	768	88	4.6	7.4	29
1989	4.4	2,350	218	10	26	68
1990	4.4	4,160	240	8.6	17	44
1991	5.3	3,990	344	9.8	20	63
Suspended-sediment concentration, milligrams per liter						
1986[a]	6	1,820	266	17	33	95
1987	5	2,500	290	27	48	90
1988	4	2,240	248	22	39	71
1989	5	2,880	372	30	58	160
1990	1	4,460	341	17	32	80
1991	2	3,030	371	15	29	87
Sediment discharge, tons per day						
1986[a]	0.10	8,650	671	0.30	0.60	1.7
1987	.10	15,000	1,130	.50	1.5	6.8
1988	<.10	5,890	519	.30	.90	3.8
1989	<.10	25,500	2,120	1.0	3.0	33
1990	<.10	63,800	3,390	<.10	1.0	6.0
1991	<.10	44,000	3,340	<.10	2.0	15

Table 4. -- *Statistical summaries of daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge for the Demonstration Erosion Control project sites* -- Continued

Water year	Minimum	Maximum	Standard deviation	Q1	Median	Q3
OTOUCALOFA CREEK CANAL NEAR WATER VALLEY						
Stream discharge, cubic feet per second						
1985[a]	23	1,210	168	30	36	48
1986	15	1,830	140	34	44	56
1987	13	4,530	412	27	52	98
1988	13	2,330	210	22	32	73
1989	18	3,540	412	39	72	177
1990	17	7,500	626	34	66	152
1991	22	14,800	1,200	34	81	300
Suspended-sediment concentration, milligrams per liter						
1985[a]	3	2,000	340	20	48	81
1986	15	2,710	294	52	90	190
1987	15	3,000	398	48	74	172
1988	12	3,620	348	45	74	146
1989	6	4,000	484	30	52	100
1990	12	5,060	573	34	48	98
1991	11	3,770	424	32	50	104
Sediment discharge, tons per day						
1985[a]	<0.10	12,800	1,930	2.0	5.0	11
1986	1.3	18,100	1,320	4.6	9.9	21
1987	1.0	56,000	3,990	4.0	11	35
1988	1.0	26,800	1,950	4.0	8.0	21
1989	1.0	39,000	3,660	3.0	10	43
1990	1.0	123,000	7,940	3.0	8.0	46
1991	1.0	154,000	9,670	4.0	11	65

Table 4. -- *Statistical summaries of daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge for the Demonstration Erosion Control project sites*-- Continued

Water year	Minimum	Maximum	Standard deviation	Q1	Median	Q3
			PETERS (LONG) CREEK NEAR POPE			
			Stream discharge, cubic feet per second			
1987[a]	5.7	2,380	239	11	28	56
1988	1.8	2,650	258	9.0	13	38
1989	5.3	5,230	573	12	29	90
1990	8.8	11,700	680	14	21	56
1991	7.2	9,800	901	12	28	92
			Suspended-sediment concentration, milligrams per liter			
1987[a]	5	2,150	292	19	32	70
1988	1	2,920	280	7	12	37
1989	2	3,570	456	16	38	130
1990	1	4,530	415	10	18	50
1991	8	3,370	394	18	29	103
			Sediment discharge, tons per day			
1987[a]	<0.10	24,900	1,980	1.0	2.0	9.0
1988	<.10	20,400	1,710	.10	.40	3.3
1989	<.10	65,200	5,430	1.0	3.0	37
1990	<.10	167,000	8,970	<.10	1.0	8.0
1991	<.10	109,000	8,410	1.0	2.0	29

Table 4. -- *Statistical summaries of daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge for the Demonstration Erosion Control project sites* -- Continued

Water year	Minimum	Maximum	Standard deviation	Q1	Median	Q3
			HICKAHALA CREEK NEAR SENATOBIA			
			Stream discharge, cubic feet per second			
1986[a]	26	3,530	282	29	32	37
1987	24	7,700	625	29	46	65
1988	22	8,020	502	27	35	87
1989	25	8,150	868	36	55	142
1990	32	12,300	830	34	38	66
1991	31	6,600	738	36	52	95
			Suspended-sediment concentration, milligrams per liter			
1986[a]	8	2,340	240	15	24	38
1987	3	3,900	432	17	25	50
1988	2	3,220	421	17	30	75
1989	5	5,110	592	28	54	120
1990	3	4,150	356	18	29	56
1991	10	3,200	363	24	36	87
			Sediment discharge, tons per day			
1986[a]	1.0	30,500	2,100	1.0	2.0	3.0
1987	<.10	62,000	4,840	2.0	3.0	8.0
1988	<.10	103,000	5,610	2.0	3.0	11
1989	<.10	102,000	8,260	3.0	8.0	41
1990	<.10	118,000	6,800	2.0	3.0	11
1991	1.0	42,100	4,220	3.0	5.0	27

Table 4. -- *Statistical summaries of daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge for the Demonstration Erosion Control project sites* -- Continued

Water year	Minimum	Maximum	Standard deviation	Q1	Median	Q3
			SENATOBIA CREEK NEAR SENATOBIA			
			Stream discharge, cubic feet per second			
1986[a]	7.8	3,630	250	8.4	8.9	11
1987	7.2	4,370	382	9.0	15	22
1988	7.5	3,570	218	8.9	10	27
1989	7.8	3,600	486	12	27	76
1990[a]	10	577	76	12	15	17
			Suspended-sediment concentration, milligrams per liter			
1986[a]	6	1,810	206	15	24	36
1987	4	2,000	206	16	27	56
1988	2	2,250	236	8	14	35
1989	4	3,650	433	13	35	119
1990[a]	8	706	105	13	18	25
			Sediment discharge, tons per day			
1986[a]	<0.10	28,100	1,960	<0.10	1.0	1.0
1987	.20	20,000	1,730	.50	.90	2.6
1988	<.10	26,300	1,510	.20	.50	2.0
1989	<.10	25,300	3,250	1.0	2.0	19
1990[a]	.30	1,540	201	.40	.70	1.2

Table 4. -- *Statistical summaries of daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge for the Demonstration Erosion Control project sites* -- Continued

Water year	Minimum	Maximum	Standard deviation	Q1	Median	Q3
			BATUPAN BOGUE AT GRENADA			
			Stream discharge, cubic feet per second			
1985[a]	31	3,400	501	36	44	68
1986	21	2,900	306	37	57	86
1987	21	9,010	901	46	175	234
1988	18	2,390	318	26	85	113
1989	29	10,600	1,520	78	151	430
1990	20	7,890	1,110	45	126	345
1991	29	26,600	2,400	56	175	437
			Suspended-sediment concentration, milligrams per liter			
1985[a]	5	2,600	421	14	20	55
1986	7	2,120	258	15	27	44
1987	5	3,790	439	18	30	88
1988	3	1,750	244	12	21	45
1989	5	3,310	494	22	49	162
1990	7	3,660	404	25	38	91
1991	15	2,980	377	31	44	123
			Sediment discharge, tons per day			
1985[a]	<0.10	35,000	5,080	1.0	3.0	7.0
1986	.50	16,600	1,470	2.0	3.3	6.8
1987	<.10	57,600	5,940	4.0	9.0	36
1988	.20	24,300	1,860	1.1	3.0	11
1989	1.0	55,400	8,360	5.0	19	166
1990	<.10	70,100	6,670	4.0	11	78
1991	1.0	118,000	11,800	5.0	20	130

Table 4. -- *Statistical summaries of daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge for the Demonstration Erosion Control project sites* -- Continued

Water year	Minimum	Maximum	Standard deviation	Q1	Median	Q3
			FANNEGUSHA CREEK NEAR HOWARD			
			Stream discharge, cubic feet per second			
1987[a]	9.5	4,250	308	15	28	51
1988	6.9	2,250	213	13	23	51
1989[a]	16	4,460	568	30	68	186
			Suspended-sediment concentration, milligrams per liter			
1987[a]	4	3,010	335	19	36	67
1988	2	2,970	359	16	32	53
1989[a]	2	3,500	624	20	80	200
			Sediment discharge, tons per day			
1987[a]	<0.10	36,900	2,690	1.0	3.0	10
1988	.10	18,800	1,800	.70	1.9	6.7
1989[a]	<.10	38,000	5,610	2.0	13	98

Table 4. -- *Statistical summaries of daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge for the Demonstration Erosion Control project sites* -- Continued

Water year	Minimum	Maximum	Standard deviation	Q1	Median	Q3
			HARLAND CREEK NEAR HOWARD			
			Stream discharge, cubic feet per second			
1987[a]	6.1	3,060	270	12	22	51
1988	5.6	1,700	141	8.8	13	22
1989	8.4	2,750	301	14	32	72
1990	8.6	2,520	287	16	30	74
1991	8.9	4,360	473	16	28	86
			Suspended-sediment concentration, milligrams per liter			
1987[a]	1	5,210	824	28	56	250
1988	1	11,100	841	19	40	96
1989	2	5,100	673	18	57	176
1990	1	5,570	621	18	32	115
1991	12	5,320	848	25	49	191
			Sediment discharge, tons per day			
1987[a]	<0.10	47,500	3,950	1.0	4.0	26
1988	<.10	62,800	4,080	1.0	1.0	4.0
1989	<.10	36,600	3,540	1.0	5.0	29
1990	<.10	25,100	3,060	1.0	3.0	22
1991	<.10	47,800	5,860	1.0	4.0	56

[a] partial year of record

Table 5. -- *Results of the Seasonal Kendall trend tests on subsets of unadjusted and flow-adjusted daily mean values for the Demonstration Erosion Control project sites*

[subset date, date of every month selected to create subsets of data for the period of record on which to perform trend analyses; p-value, dimensionless level of significance; slope estimate, magnitude and direction of trend in percentage change per year; LOWESS, locally weighted scatterplot smooth. All data natural log-transformed.]

Data	Subset date	Flow adjustment technique	p-value	Slope estimate (% / year)
HOTOPHA CREEK NEAR BATESVILLE (5.58 YEARS OF DATA)				
stream discharge	15th	not applicable	0.0023	18.98
stream discharge	8th	not applicable	0.0003	26.04
stream discharge	22d	not applicable	0.0001	36.11
suspended sediment	15th	unadjusted	0.0739	-18.00
suspended sediment	8th	unadjusted	0.1782	-8.53
suspended sediment	22d	unadjusted	0.2835	16.19
suspended sediment	15th	multiple regression	0.0019	-25.96
suspended sediment	8th	multiple regression	0.0089	-17.62
suspended sediment	22d	LOWESS	0.0739	-15.68
sediment discharge	15th	unadjusted	1.0000	0.00
sediment discharge	8th	unadjusted	0.9515	1.97
sediment discharge	22d	unadjusted	0.0061	39.14
sediment discharge	15th	multiple regression	0.0008	-21.47
sediment discharge	8th	LOWESS	0.0019	-17.99
sediment discharge	22d	LOWESS	0.1899	-11.64
OTOUCALOFA CREEK CANAL NEAR WATER VALLEY (6.25 YEARS OF DATA)				
stream discharge	15th	not applicable	0.0167	11.55
stream discharge	8th	not applicable	0.0050	14.19
stream discharge	22d	not applicable	0.0013	11.45
suspended sediment	15th	unadjusted	0.1893	-6.27
suspended sediment	8th	unadjusted	0.6477	-3.17
suspended sediment	22d	unadjusted	0.2430	-7.52
sediment discharge	15th	unadjusted	0.8790	-1.56
sediment discharge	8th	unadjusted	0.4752	7.21
sediment discharge	22d	unadjusted	0.2839	-6.01
suspended sediment	15th	LOWESS	0.0002	-19.44
suspended sediment	8th	LOWESS	0.0374	-11.09
suspended sediment	22d	LOWESS	0.0001	-14.62
sediment discharge	15th	LOWESS	0.0014	-18.66
sediment discharge	8th	LOWESS	0.0374	-10.96
sediment discharge	22d	LOWESS	0.0001	-15.36
PETERS (LONG) CREEK NEAR POPE (4.75 YEARS OF DATA)				
stream discharge	15th	not applicable	0.0963	9.09
stream discharge	8th	not applicable	0.0233	18.19
stream discharge	22d	not applicable	0.0008	26.49
suspended sediment	15th	unadjusted	0.5454	8.21
suspended sediment	8th	unadjusted	0.0418	21.23
suspended sediment	22d	unadjusted	0.0418	19.39
sediment discharge	15th	unadjusted	0.2000	20.66
sediment discharge	8th	unadjusted	0.0343	44.31
sediment discharge	22d	unadjusted	0.0083	55.55
suspended sediment	15th	LOWESS	0.4975	-4.69
suspended sediment	8th	LOWESS	0.5977	8.41
suspended sediment	22d	LOWESS	0.8211	-2.83
sediment discharge	15th	LOWESS	0.3271	-6.28
sediment discharge	8th	LOWESS	0.4070	8.92
sediment discharge	22d	LOWESS	1.0000	0.77

Table 5. -- *Results of the Seasonal Kendall trend tests on subsets of unadjusted and flow-adjusted daily mean values for the Demonstration Erosion Control project sites* -- Continued

Data	Subset date	Flow adjustment technique	p-value	Slope estimate (% / year)
HICKAHALA CREEK NEAR SENATOBIA (5.67 YEARS OF DATA)				
stream discharge	15th	not applicable	0.0387	5.23
stream discharge	8th	not applicable	0.0002	8.85
stream discharge	22d	not applicable	0.0001	11.58
suspended sediment	15th	unadjusted	0.2673	7.48
suspended sediment	8th	unadjusted	0.4129	4.78
suspended sediment	22d	unadjusted	0.0410	20.56
sediment discharge	15th	unadjusted	0.1444	12.95
sediment discharge	8th	unadjusted	0.0121	19.75
sediment discharge	22d	unadjusted	0.0061	36.70
suspended sediment	15th	LOWESS	1.0000	-0.10
suspended sediment	8th	multiple regression	0.4478	-5.69
suspended sediment	22d	LOWESS	0.8610	-1.87
sediment discharge	15th	LOWESS	0.9534	0.50
sediment discharge	8th	multiple regression	0.5992	-5.78
sediment discharge	22d	LOWESS	0.9534	-1.68
BATUPAN BOGUE AT GRENADA (6.25 YEARS OF DATA)				
stream discharge	15th	not applicable	0.2851	5.59
stream discharge	8th	not applicable	0.0042	17.55
stream discharge	22d	not applicable	0.0016	17.25
suspended sediment	15th	unadjusted	0.4464	10.46
suspended sediment	8th	unadjusted	0.0038	19.95
suspended sediment	22d	unadjusted	0.2318	9.89
sediment discharge	15th	unadjusted	0.0223	18.39
sediment discharge	8th	unadjusted	0.0020	34.91
sediment discharge	22d	unadjusted	0.0127	22.46
suspended sediment	15th	LOWESS	0.6477	-1.82
suspended sediment	8th	LOWESS	0.0477	11.29
suspended sediment	22d	LOWESS	1.0000	-0.07
sediment discharge	15th	LOWESS	0.7223	1.75
sediment discharge	8th	LOWESS	0.0756	10.00
sediment discharge	22d	LOWESS	0.9587	0.25
HARLAND CREEK NEAR HOWARD (4.83 YEARS OF DATA)				
stream discharge	15th	not applicable	0.0374	14.73
stream discharge	8th	not applicable	0.0181	26.71
stream discharge	22d	not applicable	0.0624	16.00
suspended sediment	15th	unadjusted	0.4598	-7.55
suspended sediment	8th	unadjusted	0.7624	6.35
suspended sediment	22d	unadjusted	0.6058	8.12
sediment discharge	15th	unadjusted	0.6058	11.58
sediment discharge	8th	unadjusted	0.1134	33.02
sediment discharge	22d	unadjusted	0.6574	14.81
suspended sediment	15th	LOWESS	0.2688	-14.94
suspended sediment	8th	LOWESS	0.3271	-10.80
suspended sediment	22d	multiple regression	0.0653	-11.34
sediment discharge	15th	LOWESS	0.0900	-20.59
sediment discharge	8th	LOWESS	0.8211	-6.95
sediment discharge	22d	LOWESS	0.0465	-10.13