Sediment Transported by Georgia Streams

By VANCE C. KENNEDY

GEOLOGICAL SURVEY WATER-SUPPLY PAFER 1668

Prepared in cooperation with the Georgia Department of Mines, Mining, and Geology

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1964

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

The U.S. Geological Survey Library has cataloged this publication as follows:

Kennedy, Vance Clifford, 1923–
Sediment transported by Georgia streams. Washington, U.S. Govt. Print. Off., 1963.

v, 101 p. maps, diagrs., tables. 24 cm. (U.S. Geological Survey. Water-supply paper 1668)
Prepared in cooperation with the Georgia Dept. of Mines, Mining, and Geology.
Bibliography: p. 97–98.
1. Sedimentation and deposition. 2. Sediments (Geology)—Georgia. 3. Stream measurements—Georgia. I. Georgia. Dept. of Mines, Mining and Geology. II. Title. (Series)

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

CONTENTS

ILLUSTRATIONS

TABLES

SEDIMENT TRANSPORTED BY GEORGIA STREAMS

By Vance C. Kennedy

ABSTRACT

A reconnaissance investigation of the sediment transported by selected Georgia streams during the period December 1957 to June 1959 was made to provide a general understanding of the physical quality of stream water in Georgia and to supply facts needed in planning more detailed work.

The investigation was made by studying the variation of sediment concentration and sediment load with stream discharge at 33 sites and by relating the available data to topographic, geologic, climatic, and soil conditions in the State.

In the Blue Ridge Mountains area of northern Georgia the great relief, moderately heavy precipitation, fast runoff, and loamy soils cause sediment concentrations and sediment loads which are above average for the State. During periods of moderate to low streamflow, the concentration of suspended sediment ranges from 1 to 25 ppm (parts per million). After heavy rainfall, sediment concentration increases rapidly as water discharge rises, and occasionally exceeds 1,000 ppm before decreasing again. The concentration may reach a maximum and decrease before the discharge peak is reached. A major part of the annual sediment load can be carried during a short period of time because of the great increase in both water discharge and sediment concentration during floods.

The lower Coastal Plain differs from the mountainous areas in several respects. The topography is gently rolling to almost level, precipitation and runoff are less than average for the State, and topsoils generally consist of sand and loamy sand. Concentration of suspended sediment in streamflow commonly ranges from 1 to 20 ppm during periods of low to moderate discharge and increases to 15 to 60 ppm at high discharge. Because of the small increase in concentration with increasing stream discharge, the sediment load varies approximately in proportion to the discharge.

The sediment characteristics of streams in the Piedmont, the Valley and Ridge area, and the upper Coastal Plain are intermediate between those of the Blue Ridge area and the lower Coastal Plain.

Comparison of suspended load with estimated bed load in a few Georgia streams suggests that bed load is less than 20 percent of the suspended load for most streams.

Factors which appear to be most important in causing variation in sediment yield in Georgia are topographic relief, soil texture, and location of dams. Variations in other factors such as precipitation, runoff, covering vegetation, drainage area, and channel types serve to modify the effects of the major factors.

In general, Georgia stream water is of good quality. Water of some streams is of exceptionally fine quality and contains less than 30 ppm combined dissolved and suspended solids during at least 90 percent of the time. Knowledge of the nature and cause of variation in water quality will permit the most effective use of Georgia streams.

INTRODUCTION

A reconnaissance investigation of the sediment transported by selected Georgia streams was made during the period December 1957 to June 1959 to provide some understanding of the physical quality of stream water in Georgia and to supply facts needed in planning more detailed work.

The investigation was made by studying the variation of sediment concentration and sediment load with stream discharge at 38 sites and by relating the available data to the topographic, geologic, climatic, and surface soil conditions in the State.

Because of the reconnaissance nature of the study, considerable extrapolation from meager data was necessary, and conclusions, especially regarding sediment load and concentration-frequency relations, must necessarily be tentative.

Little information concerning sediment transported by the larger Georgia streams is available from previous work. About the only detailed earlier work is the sampling done by the U.S. Army Corps of Engineers and the Tennessee Valley Authority in connection with dam construction. The U.S. Geological Survey, as early as 1906, analyzed water samples for suspended matter, but the samples were collected primarily for chemical analysis and the suspended matter reported probably represented only the finer particles in suspension. A summary of the data available in June 1959, exclusive of the data in this report, concerning suspended sediment in Georgia streams and in streams deriving most of their flow from Georgia is presented in table 1.

In addition to the suspended-sediment sampling listed in table 1, a few sedimentation surveys have been made either of reservoirs in Georgia or of reservoirs getting much of their sediment from Georgia. The data obtained by such surveys are valuable in estimating both the sediment yield from the drainage basin above the reservoir and the length of time required to fill the reservoir with sediment. A summary of available information on sedimentation in Georgia reservoirs is presented in table 2.

Some information from the studies listed in tables 1 and 2 is incorporated in this report.

TABLE 1.—*Sites within or on the boundary of Georgia at which sediment data had been collected prior to June 1959 (exclusive of data in this report)*

[Dates of sampling indicate only the years in which some sampling was done; sampling may not have been done throughout the year. Agency collecting data: CE, U.S. Army Corps of Engineers; USGS, U.S. Geol. Survey; SCS, Soil Conservation Service of U.S. Department of Agriculture; TVA, Tennessee Valley Authority]

Site			Dates of sampling	Agency collecting data	Reference
Downstream order	Stream	Location			
1	Tugaloo River	2 miles below Yonah Lake.	1956–59	CE	Unpublished data.
2	do	Near Fair Play, S.C	1956–59	CE	Do.
3	Savannah River	Junction with US 29	1956–59	CE	Do.
4	do	Junction with Georgia Route 181.	1956–59	CE	Do.
5	do	Junction with Georgia Route 82.	1956–59	CE	Do.
6	do	Near Calhoun Falls, S.C	1950–51	CE	Do.
7	Tributary to North Fork of Broad River.	Near Avalon, Ga	1956–59	USGS for SCS.	Do.
8	Broad River	Near Bell, Ga	1950–51	CE	Do.
9	Little River	Near Roytown, Ga	1950–51	CE	Do.
10	Savannah River	At Clark Hill dam	1949–59	CE	Do.
11	do	Near Augusta, Ga	1906–07	USGS	Dole (1909).
12	do	At New Savannah Bluff, Ga.	1949–50	CE	Unpublished data.
13	do	At Burtons Ferry bridge, near Millhaven, Ga.	1949–50	CE	Do.
14	do	Near Clyo, Ga	1938–39 1949–59	USGS CE	Lamar (1944). Unpublished data.
15	do	Near Savannah, Ga	1931–33	CE	Do.
16	Ogeechee River	Near Eden, Ga	1937–38	USGS	Lamar (1944).
17	Ocmulgee River	At Macon, Ga	1906–07 1937–38	USGS USGS	Dole (1909). Lamar (1944).
18	do	At Lumber City, Ga	1945–46	USGS	Unpublished data.
19	Oconee River	At Milledgeville, Ga	1937–38	USGS	Lamar (1944).
20	do	Near Dublin, Ga	1906–07	USGS	Dole (1909).
21	Altamaha River	At Doctortown, Ga	1937–38	USGS	Lamar (1944).
22	Satilla River	Near Waycross, Ga	1937–38	USGS	Do.
23	Chattahoochee River	At Atlanta, Ga	1937–38	USGS	Do.
24	do	At West Point, Ga	1906–07 1956–59	USGS CE	Dole (1909). Unpublished data.
25	do	At Columbus, Ga	1940–41	USGS	Lamar (1944).
26	do	At Fort Gaines, Ga	1956–59	CE	Unpublished data.
27	do	At Columbia, Ala	1951–59	CE	Do.
28	Flint River	At Montezuma, Ga	1943–44	USGS	USGS (1947).
29	do	Near Albany, Ga	1906–07	USGS	Dole (1909).
30	Ichawaynochaway Creek.	Near Newton, Ga	1944–45	USGS	USGS (1949).
31	Flint River	At Bainbridge, Ga	1941–42 1952–59	USGS CE	Lamar (1944). Unpublished data.
32	Conasauga River	At Tilton, Ga	1942–43	USGS	Howard and Love (1945).
33	Oostanaula River	Near Rome, Ga	1906–07 1941–42	USGS USGS	Dole (1909). Lamar (1944).
34	Etowah River	Near Cartersville, Ga	1938–39	USGS	Do.
35	Chattooga River	At Trion, Ga	1946–47	USGS	Unpublished data.
36	Nottely River	Ranger, N.C	1934–42	TVA	Do.
37	South Chickamauga Creek.	McCarty, Tenn	1937–38	TVA	Do.

TABLE 2.—*Georgia reservoirs for which sediment data are available*

[TVA, Tennessee Valley Authority; SCS, Soil Conservation Service, U.S. Department of Agricutlure]

Reservoir	Stream	Accumulation time of sediment measured	Agency collecting data	Reference
Lloyd Shoals	Ocmulgee River	1910–35		Federal Inter-Agency Committee on Water Resources (1957).
Newnan	Bolton Mill Creek	1924–45		Do.
Sequoyah	Small Branches	1929–39		Do.
White Manganese No. 6	Pettit Creek	1929–38		Do.
Chatuge	Hiwassee River	1942–54	TVA	Do.
Nottely	Nottely River	1942–55	TVA	Do.
Blue Ridge	Toccoa River	1944–54	TVA	Do.
Sky Lake	Tributary to Chattahoochee River in White County.	1925–56	SCS	Unpublished data.
Carrol Lake	Tributary to Tallapoosa River.	1949–57	SCS	Do.
Temple	do	1954–57	SCS	Do.

Most of the determinations of sediment concentration and size distribution for this report were made in the Ocala, Fla., laboratory of the U.S. Geological Survey by B. J. Sanders, L. M. Teboe, C. L. Cole, H. L. Weisner, and D. E. Shattles. Some size determinations were made in the U.S. Geological Survey Quality of Water laboratory at Raleigh, N.C., by H. E. Reeder and M. D. Edwards. Many of the sediment samples were collected by personnel of the Geological Survey Surface Water Branch during routine visits to sampling sites.

ECONOMIC ASPECTS OF SEDIMENT STUDY

When soil is eroded, land values are reduced and there is an increase in the amount of sediment transported and deposited by streams. High concentrations of suspended sediment interfere with the use of stream water by industries and municipalities. Excessive concentrations also harm fish and wildlife. Stream sediment is deposited in reservoirs and reduces their capacities. Irrigation canals, highway structures, and navigable streams often are adversely affected by sediment deposits.

Ordinarily, two separate but related types of sediment data are needed. Many users of stream water are concerned almost exclusively with variation in concentration of suspended sediment; others are concerned only with the magnitude of the sediment load. For example, most industries and municipalities are interested in the concentration of suspended sediment in the water which they withdraw from a stream. They are not concerned about the total sediment load carried by the stream. Groups engaged in dam construction, however, are not as much interested in concentration data as they are in the potential loss of reservoir capacity due to the sediment load transported by the stream.

Information regarding the relation of concentration and particle size of suspended sediment to stream discharge is helpful in selecting the best time and place to withdraw water from a stream. The knowledge also enables a factory to discharge industrial wastes into a stream at times when it will be least damaging to water quality. In the Piedmont and Blue Ridge sections of Georgia, sediment concentration commonly increases rapidly as stream discharge increases, and then decreases again while the discharge is still high. When sediment concentration is high, the release of industrial wastes is least harmful, for fine-grained mineral and organic matter remove some dissolved material from solution. After the concentration of suspended sediment has decreased, but while the discharge is still high, large quantities of good-quality water are available.

The concentration of suspended sediment usually is lowest near the water surface in a slow-moving part of the stream cross section, but is highest near the bottom in a swiftly flowing part of the section. Water can be withdrawn from the stream where sediment concentration is relatively low, and waste disposal can be made where sediment concentration is highest.

A detailed study of the time variation in concentration of suspended sediment permits the construction of curves showing the probable frequency of occurrence of various concentrations. Water users can combine this information with particle-size data and estimate the cost of water treatment required to remove the sediment. Such a study of sediment concentration also provides information necessary in predicting when high or low concentrations can be expected.

The total sediment load carried by a stream can be calculated from discharge data, suspended sediment concentration, and estimates of the amount of material moving along or near the bottom of a stream. Sediment-load data is helpful in identifying areas in which the rate of erosion is great and in determining which streams are supplying most of the sediment that fills reservoirs and clogs stream channels and estuaries.

A partial list of activities in which sediment data are useful is given below:

Concentration data needed for:

1. Treatment of domestic water supplies
2. Treatment of industrial water supplies
3. Fish and wildlife studies
4. Recreational uses of water
5. Pollution studies
6. Hydrologic studies
7. Hydroelectric power generation
8. Industrial and radioactive waste disposal
9. Control of infiltration losses during irrigation

10. Maintenance of stream and canal channels
11. Canal design

Sediment-load data needed for:

1. Reservoir design
2. Maintenance of stream and canal channels
3. Erosion control
4. Industrial and radioactive waste disposal
5. Flood control
6. Canal design
7. Dredging in navigable streams

The value of streams containing water of excellent quality has not always been emphasized in sediment studies. Although it is known that Georgia generally has a plentiful supply of good water, that information alone is not as effective in attracting potential users as is a description of the quality of the water in quantitative terms. Whitewater Creek in Taylor County can be used as an example of a stream whose waters are of exceptionally good quality. The total content of dissolved plus suspended solids probably does not exceed 30 ppm (parts per million) more than 5 to 10 percent of the time. The water discharge varies little throughout the year and exceeded 100 cfs (cubic feet per second) even during the drought period in 1954. Industries in need of a dependable supply of exceptionally good water might become interested in using water from a stream like Whitewater Creek if quantitative data concerning its quality and quantity were brought to their attention. Thus it seems probable that information about the physical as well as the chemical quality of Georgia streams can be very helpful in the industrial development of the State.

In summary, facts concerning the amount and source of stream sediment are helpful in planning programs which will reduce the quantity of soil that is eroded and transported by stream waters. Knowledge of variations in quantity and characteristics of stream sediment permits the most efficient use of streams as sources of water and as transporting agents for waste products. Streams of unusually good quality can be identified, their characteristics determined, and their advantages publicized.

GENERAL FACTORS AFFECTING SEDIMENT YIELD

The amount and type of sediment transported by a stream at any point is the net result of the interaction of all the many factors capable of affecting sediment movement. Glymph (1954, p. 180) has listed eight factors which are important in estimating sediment yield. (Sediment yield is defined as the total sediment outflow from a watershed or drainage basin.) The factors listed are: soils, covering vegetation, precipitation, drainage-area and topographic features, channel types, runoff, soil and cover management practices, and conservation practices and watershed treatment measures. These causal factors can be considered the result of the interaction of geology, climate, and man's activities. Glymph's study was concerned mainly with sediment yields in small watersheds, whereas the present study is concerned almost completely with large watersheds; there is, therefore, some variation in the importance attributed to particular causal factors in the two studies. Some factors influencing sediment yield in the State of Georgia are discussed below.

PRECIPITATION

The distribution of precipitation in Georgia in 1958 and 1959 is shown in figures 1 and 2. The precipitation during 1958 was below

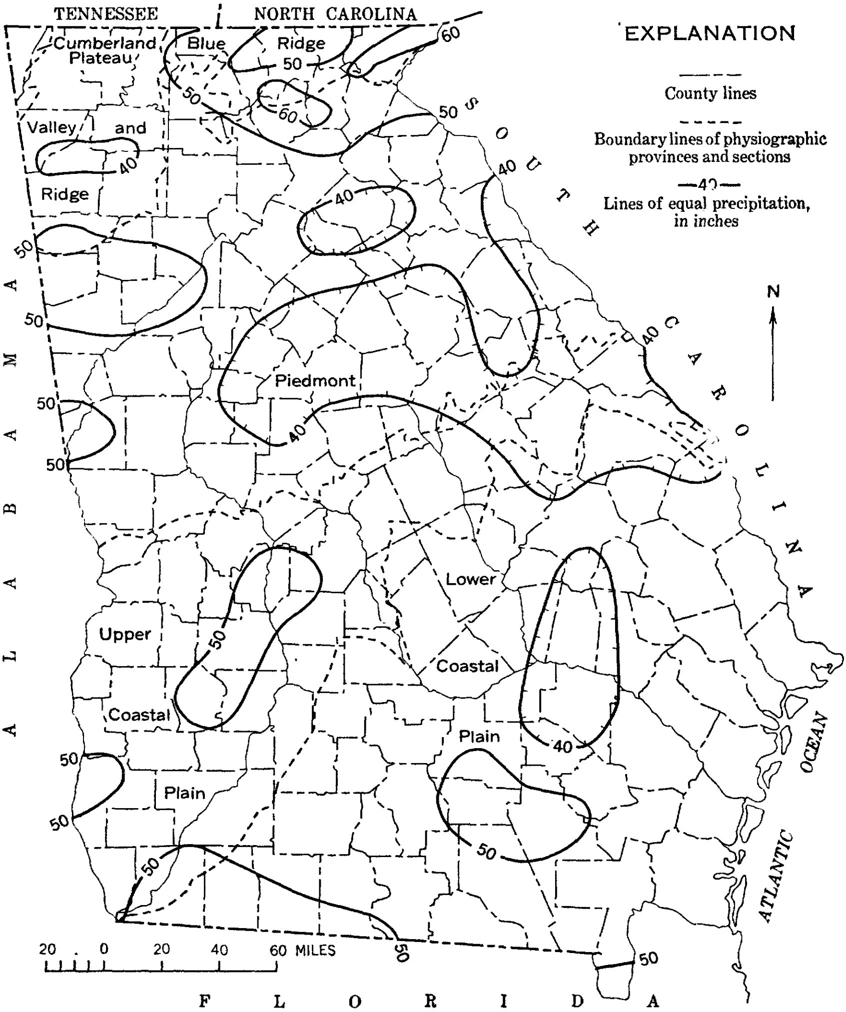

FIGURE 1.—Total precipitation in Georgia during 1958. (From U.S. Weather Bureau, 1959.)

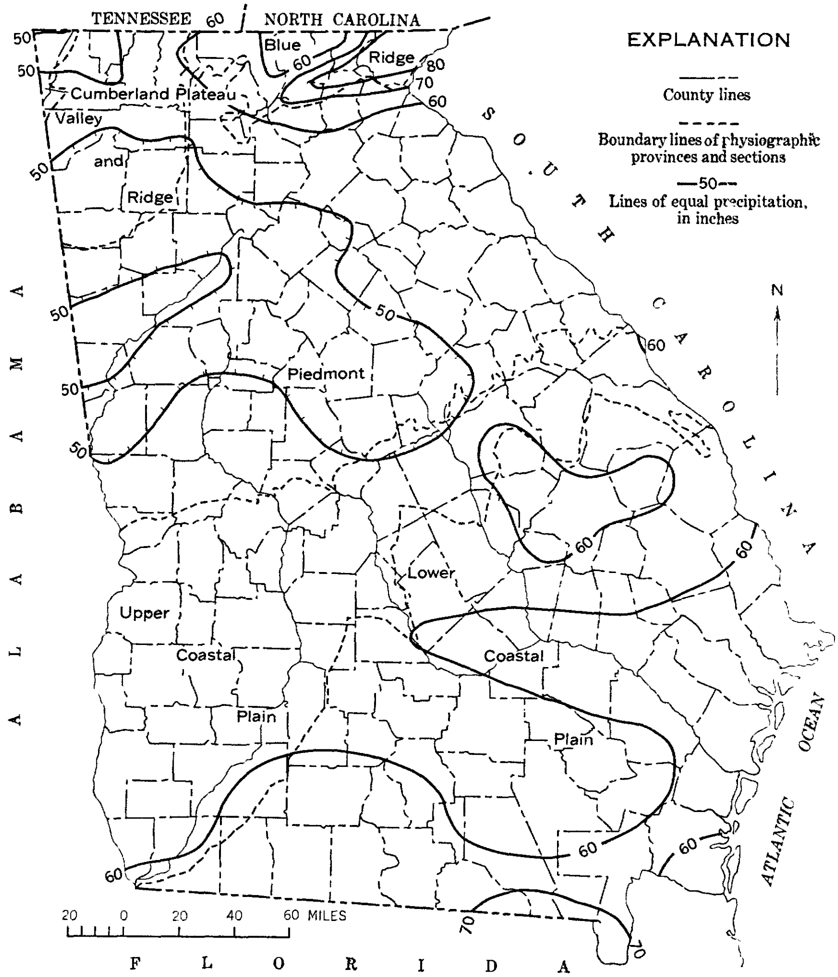

FIGURE 2.—Total precipitation in Georgia during 1959. (From U.S. Weather Bureau, 1960.)

normal and that in 1959 was above normal. Although figures 1 and 2 show the amount of precipitation received, they do not show the form, seasonal occurrence, or relative intensity. A snowfall which melts slowly, for example, will cause much less sediment yield than a hard spring rain after the fields have been plowed. The long-term monthly mean precipitation for various parts of the State is shown in table 3; most precipitation is received in the winter and early spring in northwest Georgia, and during the summer in southeast Georgia. Snow is rather common in the mountainous area of northern Georgia during the winter but is rare in southern Georgia.

TABLE 3.—*Long-term monthly mean precipitation, in inches, for various parts of Georgia*

[From U.S. Weather Bureau (1959). Based in part on the period 1921–50 and in part on the period 1931–55]

Part of State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Northwest	5.49	5.29	5.96	4.51	3.74	3.88	4.75	4.39	2.90	2.66	3.39	5.30
North central	5.13	4.98	5.63	4.57	3.61	3.93	4.98	4.13	2.90	2.78	3.26	5.23
Northeast	5.20	4.87	5.81	4.52	3.57	3.07	5.20	4.85	3.29	3 06	3.53	5.33
West central	4.33	4.53	5.71	4.64	3.36	3.95	5.77	4.61	3.14	2.09	3.86	4.63
Central	3.96	4.07	5.03	4.23	3.44	3.68	5.29	4.36	3.08	2.27	2.61	4.34
East central	3.09	3.67	4.20	3.63	3.24	3.77	4.74	4.71	3.59	2.26	2.24	3.62
Southwest	3.82	4.14	5.24	4.66	3.69	4.33	6.30	5.59	3.81	1.82	2.63	4.25
South central	3.26	3.51	4.56	4.03	3.24	4.27	6.18	5.56	3.96	2.10	1.98	3.40
Southeast	2.50	2.93	3.64	3.01	3.13	5.0	6.78	6.46	6.61	3 16	1.78	2.87

RUNOFF

Average runoff reported for Georgia streams (Thomson and others, 1956) ranges from a low of 0.39 mgdsm (million gallons per day per square mile; 1.0 mgd=1.547 cfs) in the Coastal Plain to a high of 1.86 mgdsm in the Blue Ridge area. This difference is due in part to the greater precipitation in the mountains; however, variation in runoff depends also upon soil type, covering vegetation, topography, and other factors.

The amount of sediment carried is dependent upon the rate of flow as well as upon the volume of the water which runs off the land. A short period of heavy rainfall causes a greater sediment yield than a longer period of gentle rainfall even though the runoff or total rainfall may be the same for the two periods.

Runoff data quoted at various places in this report were taken from Thomson and others (1956).

TEMPERATURE

The viscosity of water increases with decreasing temperature. The increased viscosity of the water during cold weather enables it to move more sediment and thus to increase sediment yield. Temperature, as a factor in sediment transport, is critical only when the particles are of sand size or coarser. The natural turbulence of streamflow is more than sufficient to transport silt and clay sizes, especially in the normal range of water temperatures. In the major rivers of Georgia the temperature range during the year is usually between 40 °F and 85 °F (Thomson and others, 1956, p. 228). Rivers in the mountainous regions show a larger range and rivers in the Coastal Plain a smaller range. This temperature variation causes a change in the water viscosity by a factor of about two. In the smaller streams the water temperature probably ranges from freezing to about 100 °F.

TOPOGRAPHIC FEATURES

The amount of relief (difference in elevation between the high and low points on a land surface) and the nature of the topography are of considerable importance in determining how much of the material dislodged from the land surface by rainfall will be carried away by water. The topography results mostly from the effect of climate on the rocks of the region. The relief in a particular area is a measure of the potential energy available for moving sediment. The way in which that relief is expressed in the topography also influences sediment movement. The relief may be the same in two different areas, but the potential energy may not be utilized as efficiently in moving sediment in one area as in another.

Figure 3 is a map of Georgia showing the average relief per square mile in each county. The data were obtained by determining the highest and lowest elevations for each county, as shown on maps prepared by the Army Map Service, Corps of Engineers, U.S. Army, and dividing the difference in elevation, expressed in feet, by the square miles of area in the county. In a few counties the relief per square mile does not accurately indicate the average energy available for erosion. For example, in the Valley and Ridge province in northwest Georgia, the relief shown is that from the ridge crests to the river bottoms. However, very little of the land area is at or near the elevation of the ridge crests; furthermore, the cultivated land is mostly in the valleys, and there is very little elevation difference between this highly erodible land and the streams. Hence, relatively little sediment is removed from the valley areas. In some areas of the Piedmont province, a few isolated mountains standing high above the surrounding region give a distorted picture of the normal relief. In general, however, figure 3 does indicate the amounts of potential energy available for moving sediment in various parts of Georgia.

SOILS

The characteristics of the soil in an area are always significant in determining the amount of erosion from the land. Sandy soils absorb precipitation rapidly and reduce the water available for transportation of soil particles. Clayey soils, on the other hand, tend to shed water, and thereby cause a large part of the rainfall to run off the land surface. Figure 4 shows the types of surface soils in Georgia. Most of the information in this report regarding soils in Georgia was obtained from Carter and Giddens (1953).

The grain-size distribution of soil particles is important in determining how effective surface runoff will be in transporting material from the land and out of a drainage basin. Coarse-grained sand, granules, pebbles, and large rock fragments commonly move by rolling or slumping downslope under the influence of surface runoff. Because these materials move at velocities which are much less than that of the water, they travel downslope only short distances during each period of rainfall. The fine-grained fraction of the soil, however, can be held in suspension in water draining off the land surface and hence will move at or near the velocity of the water. Grains which are intermediate in size will move partly in suspension and partly by rolling and bouncing.

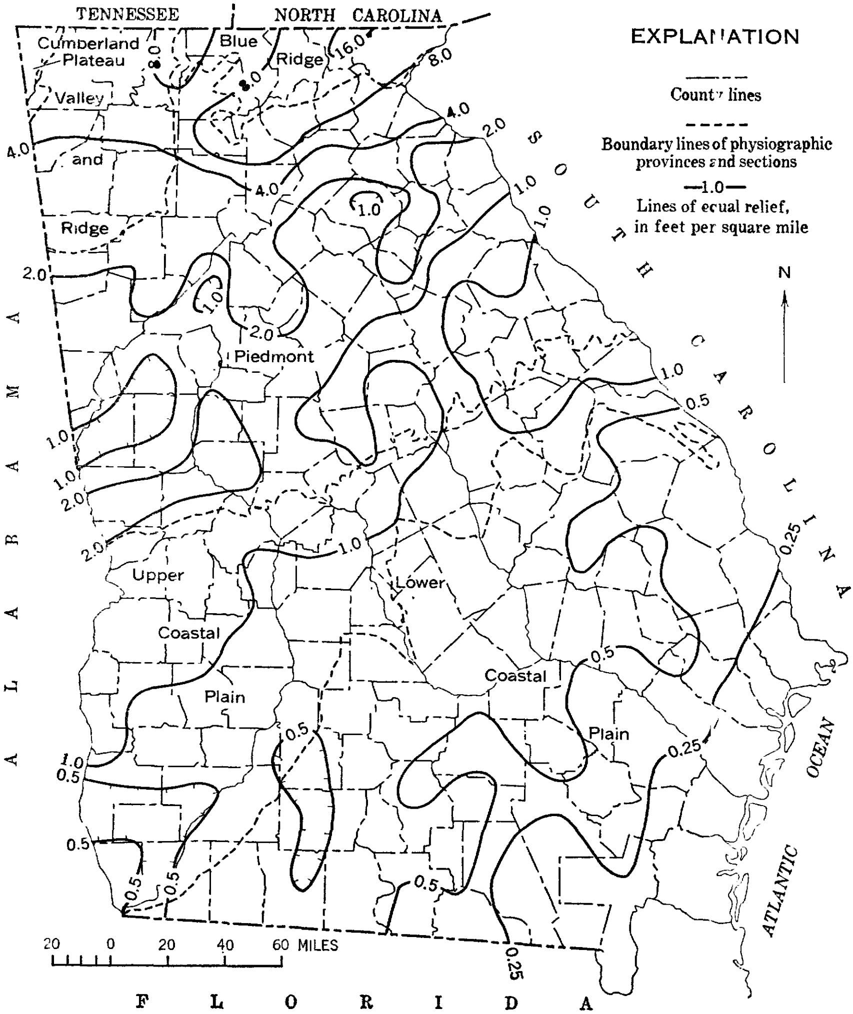

FIGURE 3.—Average relief per square mile in Georgia.

Clay and silt-sized particles can be carried into the streams and out of a local drainage basin during one storm period, and it is this type of material which constitutes much of the suspended load in Georgia streams. Thus, large concentrations of suspended sediment are found only in stream waters that run off soils containing a significant proportion of fines.

It should be emphasized that the grain size of particles that can be carried in suspension will vary with the velocity and turbulence of a stream. In mountain areas coarse sands may be carried in suspension, but on the Coastal Plain even coarse silt may move mainly as bed load.

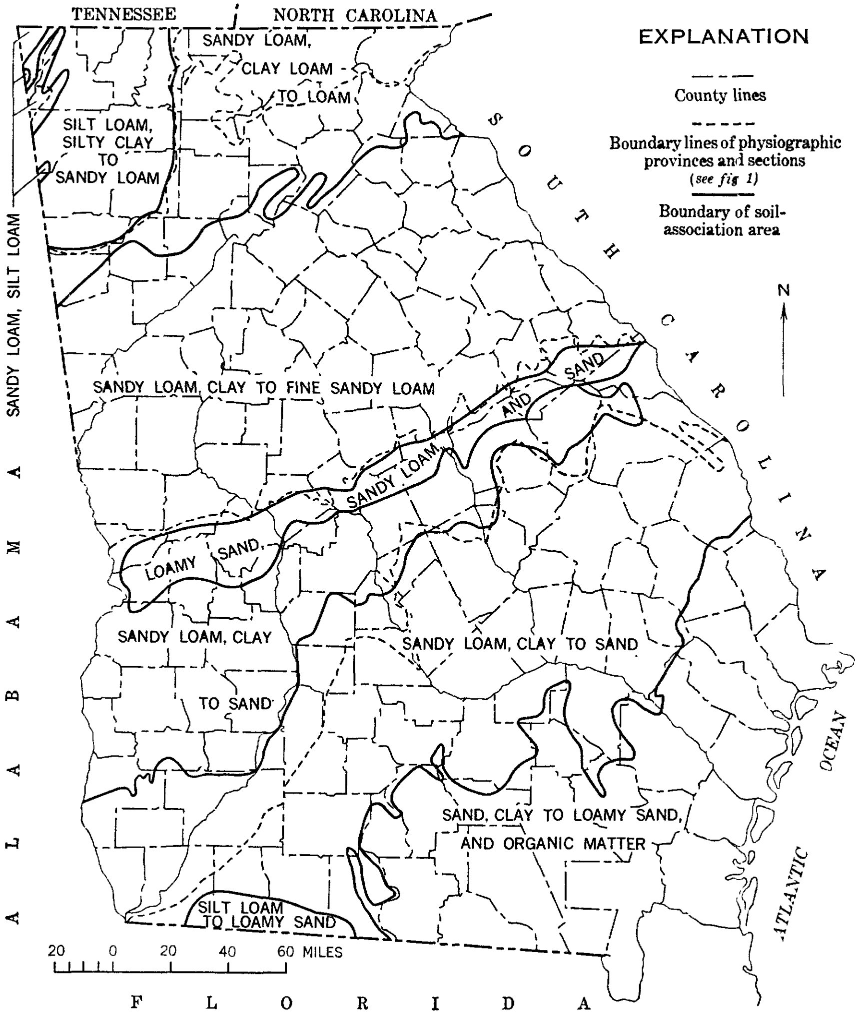

FIGURE 4.—Surface soils in Georgia. The first name given is that of the most common soil type; other names show range of types present. Adapted from Carter and Giddens (1953).

COVER

The type of vegetation covering the land influences greatly the force with which rainfall strikes the ground. The presence of rootlets which cling to soil particles is also a factor in holding the soil in place. Although no detailed information is available concerning the type of cover in various parts of Georgia, areas in which bare soil is exposed at least part of the year and areas which are covered throughout the year have been distinguished on maps (figs. 5, 6) showing distribution of "croplands" and "harvested croplands" in Georgia. The maps are based on data published by the U.S. Bureau of the Census (1956). Figure 5 shows the distribution of total cropland as a percent of the land area; this figure was prepared by calculating the percent of cropland in each county and plotting these percentages at the center of each county. The resulting map was contoured to emphasize the continuity and trends of the croplands in Georgia. (Croplands are those farmlands from which crops are harvested, those used only for pasture, and those not harvested and not pastured. Excluded are woodlands and rough or brush lands.) Figure 6 shows the percentage of harvested cropland during 1954. Much of the harvested cropland is cultivated and exposed to erosion during at least part of the year; hence, the harvested cropland can be considered as a measure of the "erodible farmland." The term "harvested cropland," as used here, includes land from which crops were harvested, land from which hay was cut, and land in small fruits, orchards, vineyards, nurseries, and greenhouses.

DETENTION RESERVOIRS

The presence of dams and reservoirs in a drainage basin can be a major factor in the control of sediment yield from the basin. One or more dams have been built on most major Georgia rivers, and there are more than 27,000 farm ponds on the small streams (Thomson and others, 1956, p. 197). The efficiency with which the various reservoirs trap sediment is related to the ratio of the reservoir capacity to the rate of inflow. Brune (1953) has shown that the trap efficiency for large reservoirs is in the ranges 30 to 57, 78 to 94, and 94 to 100 percent for capacity to annual-inflow ratios of 0.01, 0.1, and 1.0, respectively. Preliminary studies by H. P. Guy and others (written communication, 1958) suggest that trap efficiency for reservoirs on small watersheds generally is in the range 50 to 98 percent.

Thomson and others (1956, p. 192) have indicated that the average farm pond in the Piedmont region contains 2.7 million gallons. If the average runoff in the Piedmont region is 0.8 mgdsm and the average drainage area of the farm ponds is in the range 50 to 200 acres (estimated), then the capacity to annual-inflow ratio for the average farm pond ranges from 0.03 to 0.12. Brune's (1953) data indicate that, under these conditions, trap efficiency would range from 57 to 94 percent. Therefore, based upon the studies by Brune and Guy, a reasonable estimate for the trap efficiency of Georgia farm ponds is probably about 80 percent.

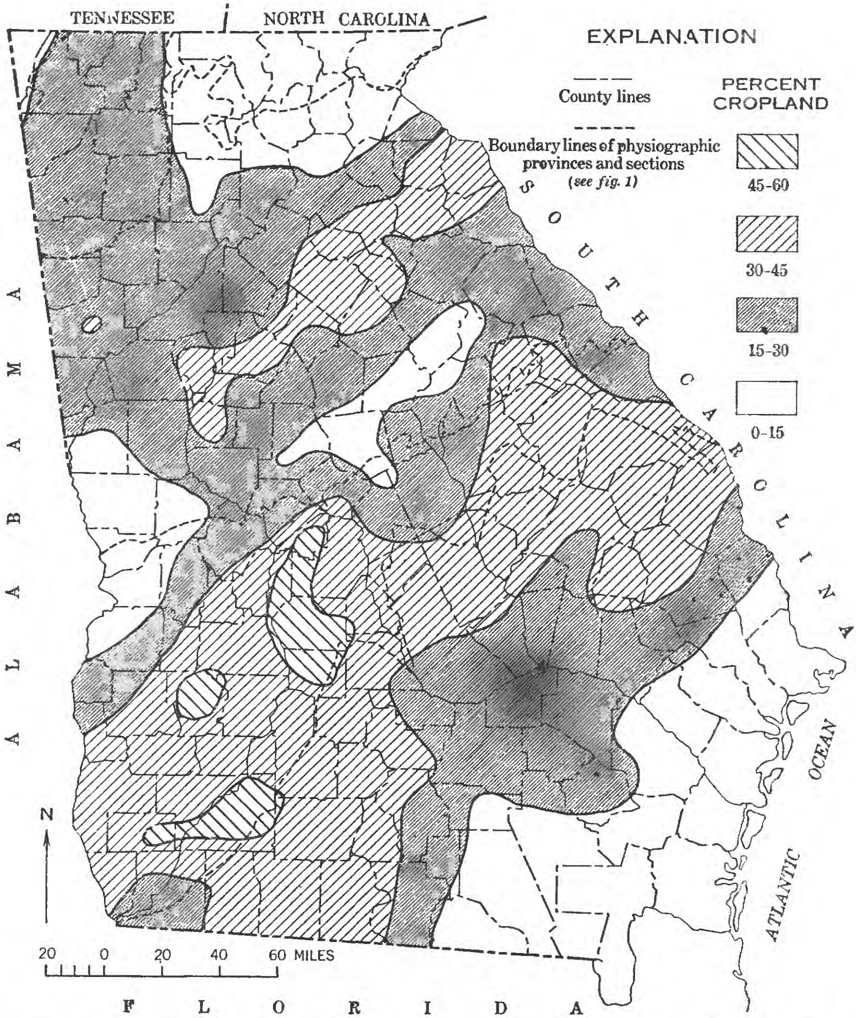

Figure 5.—Percent of land in Georgia classified as cropland. From U.S. Bureau of Census (1956).

According to Brune (1953), the trap efficiency of Lloyd Shoals Reservoir on the Ocmulgee River is about 81 percent and that of Hiwassee Reservoir on the Hiwassee River is about 98 percent. It seems probable that the trap efficiency of most other large reservoirs in Georgia is in the same range.

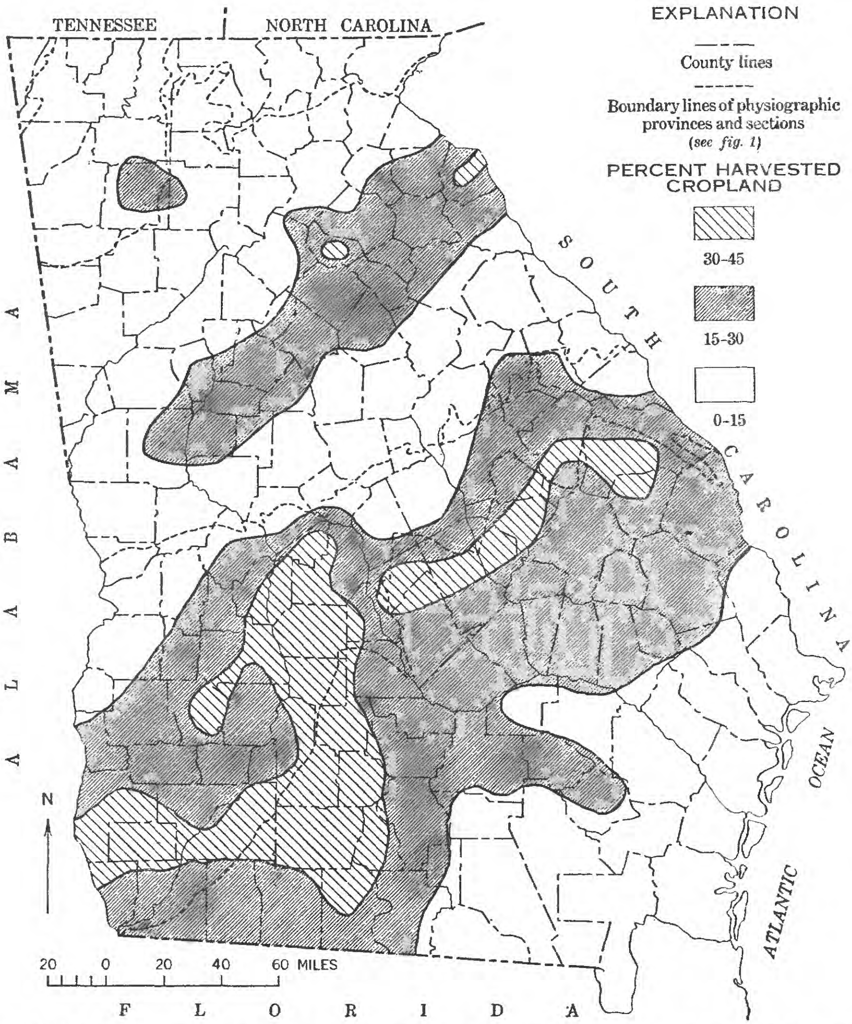

FIGURE 6.—Percent of land in Georgia classified as harvested cropland. From U.S. Bureau of Census (1956).

An estimate of the proportion of runoff which passes through farm ponds can be made by using data supplied by Thomson, and others (1956, p. 198–203) concerning the number of farm ponds in each county and by assuming an average drainage area per farm pond. To prepare figure 7, the drainage area of each farm pond was assumed to be 100 acres and the percentage of land in each county upstream from a pond was calculated. If the estimate of 100 acres for the average drainage area is nearly correct, in most parts of Georgia only a minor proportion of the runoff passes through farm ponds.

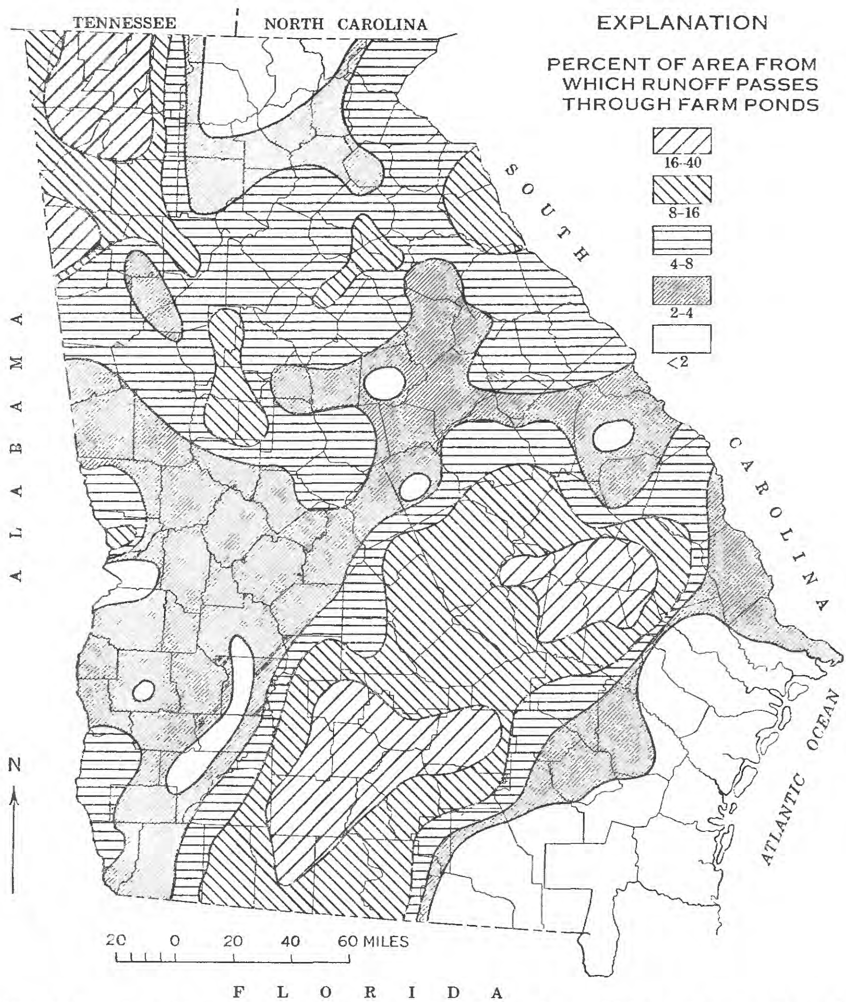

FIGURE 7.—Map of Georgia showing percent of land area from which runoff passes through farm ponds. An average of 100 acres upstream assumed for each pond.

The locations of dams on streams with drainage areas of 100 square miles or more are given on figure 8. There are also many dams on streams having drainage areas of less than 100 square miles but greater than that of a single farm pond. Little up-to-date information is available concerning the location and number of these intermediate-size dams.

In summary, it seems probable that the sediment deposited in Georgia farm ponds does not greatly exceed 10 percent of the total carried by Georgia streams. Because one or more large dams are located on many of the major rivers, perhaps as much as 50 percent of the stream sediment is trapped in reservoirs and is not carried out of the State.

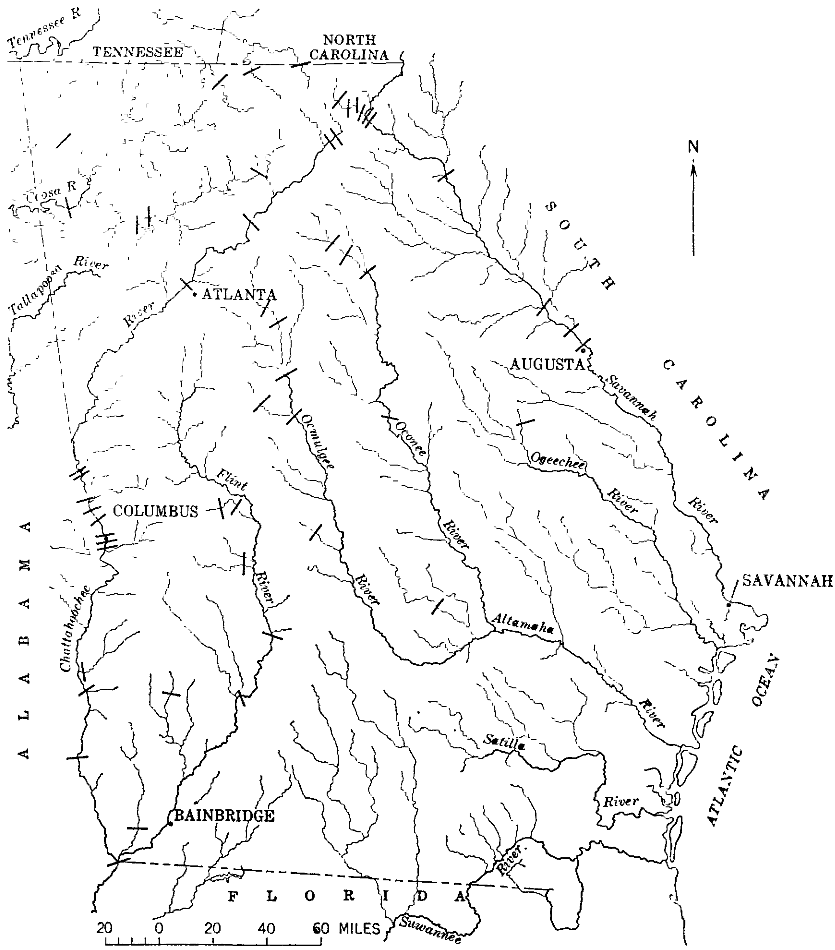

Figure 8.—Reservoirs on streams in Georgia having a drainage area greater than 100 square miles.

CHANNEL CHARACTERISTICS

The sediment yield from a drainage basin represents the material eroded from the land surface as modified by the effects of gains or losses in the stream channel. If a stream is near equilibrium, about as much sediment will leave a drainage basin annually as is washed into the stream channels. However, many streams are not in equilibrium, either because changing conditions alter the volume of sediment supplied to the stream or because the sediment-carrying capacity of the stream is varied.

Soil conservation practices have reduced land erosion in Georgia, in recent years and the supply of stream sediment has decreased. Streams which previously had been in equilibrium or were depositing sediment along their channels now may tend to erode their beds. Such a condition can result in a measured-sediment yield greater than the amount of sediment presently being washed into the channel system. Similarly, dam construction can temporarily overload the sediment-carrying capacity of a stream, but, after a dam is completed, most sediment will be deposited in the reservoir and the stream will be capable of eroding its bed downstream from the dam.

Even very large floods which tend to deepen stream channels may cause streams to be out of equilibrium for several years while bed material is being deposited again. Thus, over a period of years the sediment yield from a drainage basin may equal the sediment carried into the stream channel system, but on a short-term basis equilibrium conditions probably are uncommon.

PHYSIOGRAPHIC PROVINCES AND THEIR CHARACTERISTICS

Topography, climate, soils, and other factors affecting sediment yield vary considerably throughout Georgia. However, the State can be divided into areas within whch these factors are fairly uniform. For the purpose of this study the physiographic provinces and sections defined by Fenneman (1938) and Thomson and others (1956, p. 68–70) have been considered to be such areas. The boundaries of these areas are shown on figure 1 and each is described below.

BLUE RIDGE

The Blue Ridge province is mountainous and has deep narrow valleys. The topography is mature. Rocks underlying the area include slate, quartzite, conglomerate, biotite gneiss, phyllite, schist, granite gneiss, and smaller amounts of granite, marble, and hornblende gneiss. On weathering, these rocks form soils ranging from sandy loam to clay loam. Where covering vegetation is removed, the soil erodes easily and supplies considerable quantities of fine particles which are carried away in suspension. The great relief and abundant rainfall result in high water velocities and great sediment-transporting capacity in the streams. The low percentage of land which is under cultivation, however, means that relatively little of the soil is exposed to direct rainfall. There are several large reservoirs in the Blue Ridge province but comparatively few farm ponds.

VALLEY AND RIDGE

The folded beds of shale, sandstone, and carbonate which characterize the Valley and Ridge province resulted from the thrust of forces from the east against the more stable area of the Cumberland Plateau (Butts and Gildersleeve, 1948, p. 56). Solution and erosion of carbonate and shale beds have produced gently rolling to almost level valleys between ridges of resistant sandstone and quartzite. Some streams flow across the area from the Blue Ridge and the Cumberland Plateau; others originate within the province. Many of the streams are only a few feet below the level of the valley floor, and there is relatively little potential energy available for transporting sediment off the valley lands. Ridges rise as much as several hundred feet above the valley bottoms, but most are covered with vegetation so that comparatively little land is exposed to rapid erosion. The sharp change in slope from ridge flank to valley floor probably causes deposition of much of the sediment that is removed from the ridge slopes. Soils in the Valley and Ridge province range from very fine sandy loam to silt-clay loam, and can be easily transported by flowing water. Average annual rainfall is 54 to 56 inches and runoff is approximately 1.0 mgdsm. The number of farm ponds is about average for the State, but large dams are few. About 25 percent of the area is cropland.

CUMBERLAND PLATEAU SECTION OF APPALACHIAN PLATEAU

Only the extreme northwestern corner of Georgia lies within the Cumberland Plateau. The area is underlain by beds of sandstone, shale, coal, and limestone which show very little folding, in contrast to the rocks of the Valley and Ridge province. Average annual rainfall is about 54 inches and runoff is a little more than 1 mgdsm. As indicated by the name, the region is a plateau which is cut by narrow valleys. Soils consist of sandy loam and silt loam. Only about 11 percent of the area is in cropland and 7 percent is harvested cropland. Drainage in the province is mainly to the north and west. No sediment samples from this area were collected by the writer.

PIEDMONT

The Piedmont province includes about one-third of Georgia. Average annual rainfall ranges from 46 to 60 inches and runoff from much of the area is in the range 0.70 to 0.90 mgdsm. The topography is gently rolling to very hilly, and relief is great enough to provide the energy needed for transportation of sand, silt, and clay. The soil ranges from sandy loam to clay loam and is easily eroded when the covering vegetation is removed. The proportion of land under cultivation varies considerably throughout the province, depending upon topography and soil type (see fig. 6). A zone trending southwestward from Hart County contains more cultivated land than other areas in the Piedmont. The number of farm ponds is about average for the State; however, most of the major dams in Georgia are on rivers in the Piedmont, and therefore much of the Piedmont sediment yield is trapped in reservoirs and not carried out of the province.

COASTAL PLAIN

The Coastal Plain can be conveniently divided into upper and lower sections as shown on figure 1. In the northern part of the upper Coastal Plain, the "sandhills" region, the topography is rolling to hilly, the soils are very sandy, and little farming is done. South of the sandhills region, the topography is rolling to nearly level, and the soils range from sandy loam to clay loam, the sandy soils being most common in the southern part of the upper Coastal Plain. Large areas of the upper Coastal Plain are suitable for mechanized large-scale farming operations. Much of the lower Coastal Plain is nearly level, and some of the land is poorly drained. A part of the area is covered by forests, and little of the sandy soil in the southeastern part of the lower Coastal Plain is farmed. Average annual rainfall ranges from 46 to 54 inches in the upper Coastal Plain and from 48 to 50 inches in the lower Coastal Plain. Runoff is generally 0.5 to 0.8 mgdsm in the upper Coastal Plain and 0.4 to 0.6 mgdsm in the lower Coastal Plain. A few dams have been built on the Flint and Chattahoochee Rivers where they lie on the upper Coastal Plain, but no major reservoirs are present in the lower Coastal Plain of Georgia.

METHODS AND ACCURACY OF SAMPLING

SUSPENDED LOAD

Most of the samples of suspended sediment were taken with a U.S. DH-48 or D-43 sampler. In a few instances a U.S. D-49 sampler was used. All these samplers, when lowered to the streambed and raised again at a constant speed, collect a quantity of water-sediment mixture which is a depth-integrated representation of the streamflow at the time and place sampled.

The concentration of suspended sediment varies from point to point across a stream, but the magnitude of the variation is dependent both upon the size distribution of suspended sediment (coarser sediment causes greater variation) and upon the nature of the individual stream. Ideally, a large number of samples should be collected at different points across a stream to determine its average sediment concentration but, practically, only three to five samples could be collected. Thus the concentration determined is an approximation of the true average suspended-sediment concentration. The range in concentration among the samples collected was considered an indication of the magnitude of the variation present across the stream and, hence, an indication of the probable accuracy of the measurements.

At most sites selected for sampling, the actual sampling points were determined by estimating, either visually or from stream-discharge measurement notes, the position of imaginary lines which would divide the stream into six parallel substreams of equal discharge.

Samples were collected at points dividing the first and second substreams, the third and fourth substreams, and the fifth and sixth substreams. If five samples were desired, the stream was divided into 10 imaginary substreams of equal discharge and samples taken between the first and second, third and fourth, fifth and sixth, seventh and eighth, and ninth and tenth substreams. Samples taken as described above are said to have been taken at three or five centroids of discharge.

Suspended-sediment data from five Georgia rivers obtained at single verticals showed that during at least 80 percent of the time any one sample could be expected to have a concentration within 40 percent of the average of samples collected at three centroids. These data indicate that at a given time there is considerable variation in concentration of suspended sediment within the cross section in Georgia streams. Thus, a measurement of suspended-sediment concentration made at only one vertical can deviate appreciably from an average of three or more measurements.

TOTAL SEDIMENT LOAD

Though the sediment transported along or within 0.3 foot above the streambed is not sampled when suspended sediment is collected, the suspended-sediment load is calculated by multiplying the suspended-sediment concentration by the total water discharge; this computation accounts for a part of the sediment transported in the lower 0.3 foot of the stream. The difference between the total sediment load and the calculated suspended load consists of particles moving in substantially continuous contact with the streambed and of particles which progress by a bouncing action just above the streambed. The sediment which moves by bouncing is probably an insignificant fraction of the total load (Benedict, 1957, p. 897; Kalinske, 1942, p. 641–643). For the purposes of this study the total sediment load will be considered to be composed of just two parts, bed load and suspended load.

No method of direct measurement of bed load is available which is practical for general use in a study of this type. However, estimates of instantaneous bed load can be made using the modified Einstein method as described by Colby and Hembree (1955), if the following data are available for a particular time:

1. Stream width, average depth, and mean velocity.
2. Average concentration of suspended sediment.
3. Size analyses of the suspended sediment.
4. Average depth at the verticals where suspended sediment samples were collected.
5. Size analyses of the bed material.
6. Water temperature.

The modified Einstein method has been checked for accuracy on sand-bed streams in the western United States where the stream characteristics may be different from those of Georgia streams. Therefore, the probable accuracy of this method when applied in Georgia cannot be stated. However, the modified Einstein method has been used in this report because it is probably the best method now available for an estimate of either the total load or bed load.

DATA FROM SAMPLING SITES

Sediment data from Georgia streams were collected with a view to obtaining detailed information concerning a few streams and some general information about many streams. By applying knowledge gained about the relation of sediment concentration to water discharge in the detailed studies to streams for which only sparse data were available, it was possible to draw conclusions about sediment conditions throughout the State.

The locations of all the sampling sites are shown on figure 9; other information regarding the streams studied is given in table 4.

Sites designated on table 4 as frequently sampled are those where local observers were asked to collect suspended-sediment samples at least once every 5 days during periods of little change in discharge. When the discharge was changing rapidly, samples were to be collected with every foot of rise or fall in gage height. Although all the desired information was not obtained, it was still possible to gain some understanding of the relation of suspended-sediment concentration to water discharge at these sites.

At other sites listed in table 4, water samples were obtained at less frequent intervals, commonly when a Survey representative visited the station in connection with other dutes.

SITES OF FREQUENT SAMPLING

BROAD RIVER NEAR BELL, GA.

The Broad River (see fig. 9) lies entirely within the Piedmont province and drains an area of rolling to hilly topography. About 30 percent of the area is cropland and 20 to 25 percent is harvested cropland. Topsoils range from sandy loam to clay loam of the Cecil, Lloyd, Appling, and Madison series which have developed on granite, gneiss, and schist of varied composition. Farm-pond capacity averages 0.6 to 0.7 mgsm, and average daily runoff is 0.74 mgdsm.

Suspended-sediment concentration.—Water samples were obtained from the Broad River during the period December 1957 to May 1959. The variation in sediment concentration across the Broad River was studied by averaging the concentrations of the samples collected at three centroids of discharge and determining for each sample set the maximum percentage deviation of any one sample from the average. This study showed that, of the 60 sample sets suitable for the study, 67 percent of the sets contained no samples differing from the average concentration by more than 23 percent, and 95 percent differed by no more than 40 percent. The study showed, furthermore, that samples taken at the south centroid contained the lowest suspended-sediment concentration 65 percent of the time and those taken at the middle centroid had the highest concentration 52 percent of the time. These figures indicate that the measured variation in suspended sediment is not entirely due to random sampling errors but, rather, that the concentration normally is lower than average at the south centroid and higher than average at the middle centroid.

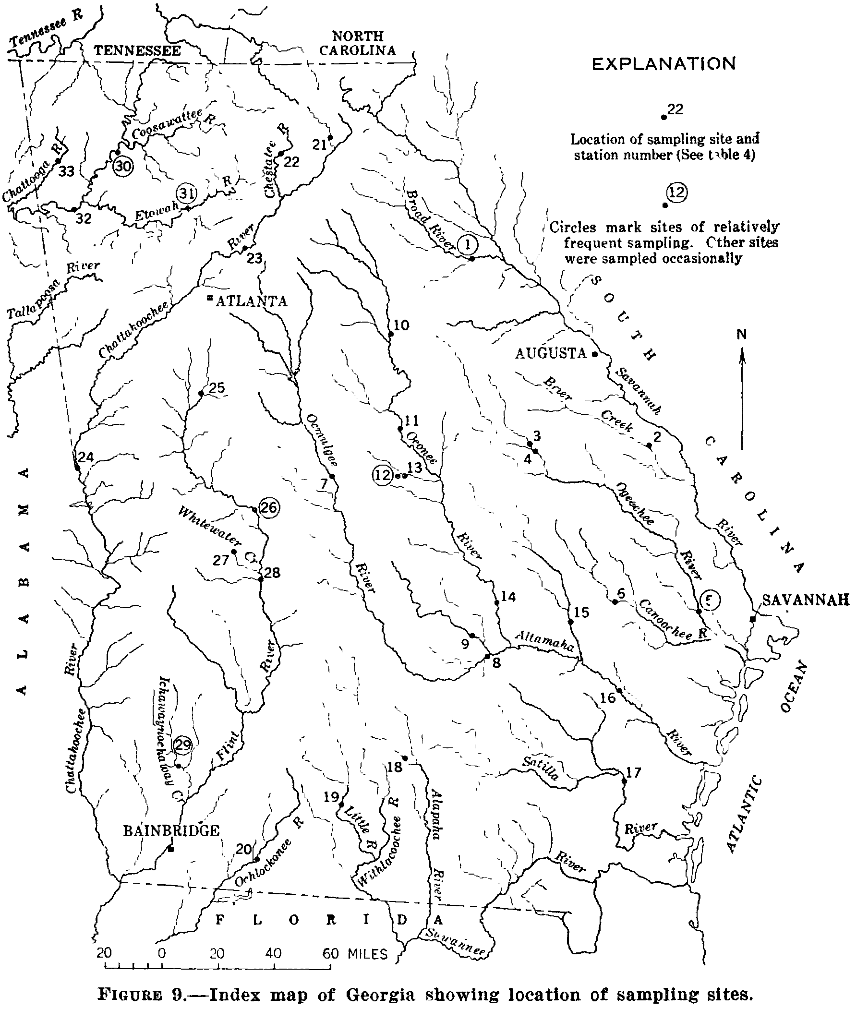

FIGURE 9.—Index map of Georgia showing location of sampling sites.

TABLE 4.—*Drainage area and physiographic province(s) above each sampling site*

No. (fig. 9)	Sampling site: Name	Drainage area above sampling site (sq mi)	Physiographic province(s) containing major part of drainage area above sampling site
1	Broad River near Bell [1]	1,430	Piedmont.
2	Brier Creek at Millhaven	646	Coastal Plain.
3	Rocky Comfort Creek near Louisville.	286	Do.
4	Ogeechee River near Louisville.	800	Do.
5	Ogeechee River near Eden [1]	2,650	Do.
6	Canoochee River near Claxton.	555	Do.
7	Ocmulgee River at Macon	2,240	Piedmont.
8	Ocmulgee River at Lumber City.	5,180	Coastal Plain, Piedmont.
9	Little Ocmulgee River at Towns.	329	Coastal Plain.
10	Oconee River near Greensboro.	1,090	Piedmont.
11	Oconee River at Milledgeville.	2,950	Do.
12	Slash Creek near McIntyre [1]	Not determined	Coastal Plain.
13	Commissioner Creek at Toomsboro.	191	Do.
14	Oconee River near Mount Vernon.	5,110	Coastal Plain, Piedmont.
15	Ohoopee River near Reidsville.	1,110	Coastal Plain.
16	Altamaha River at Doctortown.	13,600	Coastal Plain, Piedmont.
17	Satilla River at Atkinson	2,790	Coastal Plain.
18	Alapaha River near Alapaha	663	Do.
19	Little River near Adel	547	Do.
20	Ochlockonee River near Thomasville.	550	Do.
21	Chattahoochee River near Leaf.	150	Blue Ridge, Piedmont.
22	Chestatee River near Dahlonega.	153	Do.
23	Chattahoochee River at Atlanta.	1,450	Piedmont, Blue Ridge.
24	Chattahoochee River at West Point.	3,550	Piedmont.
25	Flint River near Griffin	272	Do.
26	Flint River near Culloden [1]	1,850	Do.
27	Whitewater Creek below Rambulette Creek near Butler.	93.4	Coastal Plain.
28	Flint River at Montezuma	2,900	Piedmont.
29	Ichawaynochaway Creek at Milford.[1]	620	Coastal Plain.
30	Oostanaula River at Calhoun [1]	1,625 [2]	Valley and Ridge, Piedmont.
31	Etowah River at Canton [1]	605	Piedmont.
32	Coosa River near Rome	4,040	Valley and Ridge, Piedmont.
33	Chattooga River at Summerville.	193	Valley and Ridge.

[1] Station sampled frequently.
[2] Approximate.

Average concentrations of suspended sediment at sampling dates during 1957–59 are given in table 5. Average discharge for the periods 1928–31 and 1937–57 was 1629 cfs (U.S. Geological Survey, 1959a).

TABLE 5.—*Concentration of suspended sediment in samples from the Broad River near Bell, Ga.*

Date	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)
1957		
Dec. 11	2,450	116
1958		
Jan. 14	1,750	43
Jan. 21	1,200	19
Jan. 29	2,000	72
Feb. 11	1,950	82
Feb. 27	8,400	510
Mar. 6	1,700	36
Mar. 12	2,650	56
Mar. 25	5,500	122
Apr. 15	2,800	96
Apr. 23	3,000	89
Aug. 27	940	29
Sept. 21	440	26
Oct. 31	460	9
Nov. 17	565	14
Dec. 13	605	10
Dec. 16	680	15
Dec. 19	640	11
Dec. 21	620	10
Dec. 26	670	13
Dec. 29	1,990	227
Dec. 29	1,980	158
Dec. 30	1,240	111
Dec. 31	955	57
1959		
Jan. 1	925	45
Jan. 6	795	23
Jan. 11	780	25
Jan. 18	930	34
Jan. 21	760	20
Jan. 22	1,300	165
Jan. 22	1,660	185
Jan. 23	2,520	335
Jan. 23	2,150	405
Jan. 24	1,300	160
Jan. 26	1,000	60
Feb. 1	910	40
Feb. 4	1,820	154
Feb. 4	2,600	234
Feb. 5	3,250	199
Feb. 6	2,750	137
Feb. 7	1,630	76
Feb. 8	1,250	51
Feb. 9	1,300	37
Feb. 11	1,300	46
Feb. 13	4,200	226
Feb. 13	5,500	277
Feb. 13	6,450	389
1959 (continued)		
Feb. 13	7,600	450
Feb. 14	8,450	466
Feb. 14	8,200	300
Feb. 15	6,300	231
Feb. 16	3,100	187
Feb. 21	1,230	42
Feb. 26	1,020	33
Mar. 2	950	35
Mar. 6	3,180	153
Mar. 6	3,760	158
Mar. 6	4,250	174
Mar. 7	4,150	211
Mar. 8	2,550	105
Mar. 9	1,580	64
Mar. 12	1,610	56
Mar. 15	2,400	118
Mar. 16	4,430	236
Mar. 16	5,000	360
Mar. 17	4,200	285
Mar. 18	2,400	116
Mar. 19	1,750	57
Mar. 21	1,470	45
Mar. 26	1,100	34
Mar. 27	1,830	113
Mar. 27	1,970	103
Mar. 30	2,850	84
Mar. 30	3,100	108
Mar. 31	3,000	95
Apr. 1	2,100	75
Apr. 2	2,750	102
Apr. 3	2,520	96
Apr. 4	1,850	73
Apr. 6	1,400	51
Apr. 11	1,100	31
Apr. 13	4,120	487
Apr. 13	4,800	565
Apr. 14	5,350	354
Apr. 14	4,550	226
Apr. 15	2,250	111
Apr. 16	1,700	88
Apr. 21	1,690	72
Apr. 23	1,300	59
Apr. 27	1,010	33
May 1	950	51
May 7	730	27
May 12	630	42
May 13	1,430	248
May 13	2,200	187
May 14	1,440	107
May 14	1,390	108

The relation of stream discharge to concentration of suspended sediment is shown in figure 10. The position of the solid line was obtained by inspection. The line represents the median of concentration for a given water discharge, and points falling on this line are presumed to represent the most probable concentration for a given water discharge rather than the average concentration. Combination of the data in figure 10 with flow-duration curves (cumulative frequency curves that show the percent of time during which specified discharges were exceeded or equaled in a given period, Searcy, 1959) for the Broad River during the periods 1950–55 and 1958–59 permits the preparation of two concentration-frequency curves. Although these curves differ somewhat, they are of value in determining the percent of time that the concentration of suspended sediment is equal to or less than any certain value. For example, figure 11 shows that, for the 1959 water year, the concentration of suspended sediment was

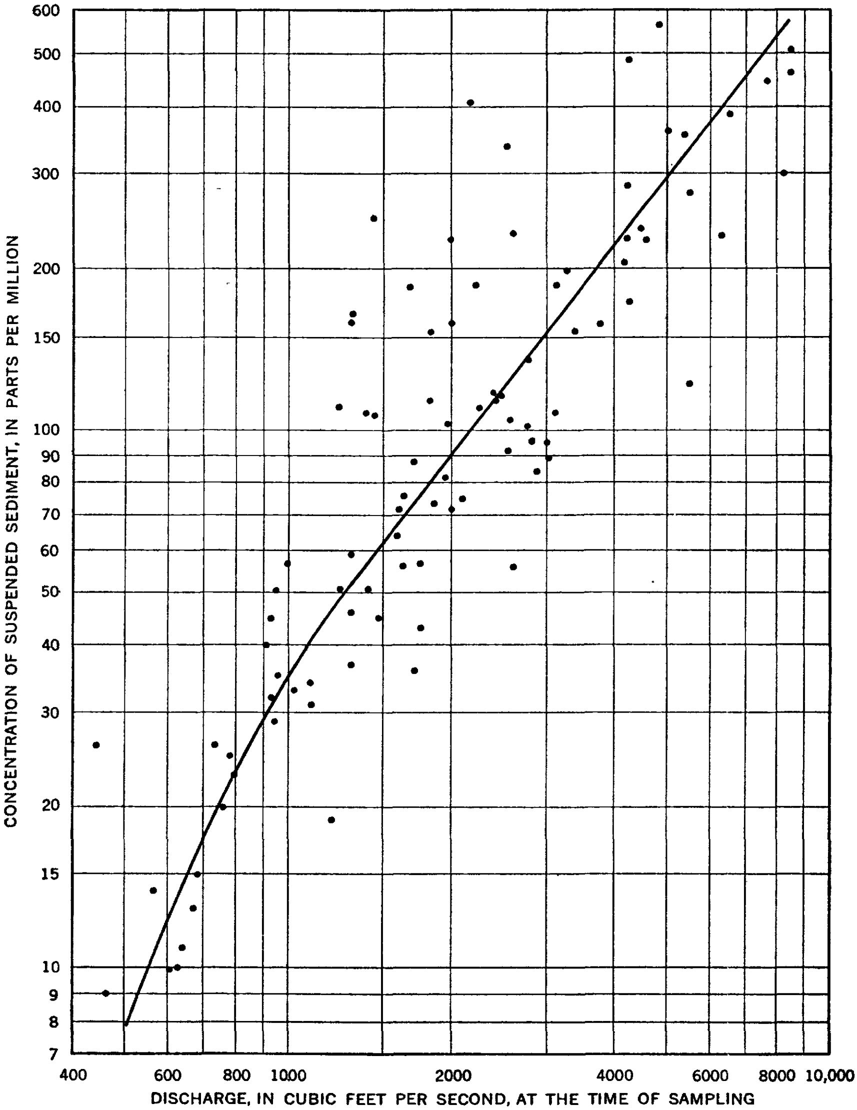

FIGURE 10.—Relation of stream discharge to concentration of suspended sediment in samples from the Broad River near Bell, Ga.

less than 16 ppm during 40 percent of the time and less than 84 ppm during 90 percent of the time. Because the character of the flow-duration curve changes from year to year and the relation of water discharge to concentration of suspended sediment shows considerable variation, a concentration-frequency curve for any one year is only an approximation of a long-term curve.

Size distribution of suspended sediment.—Particle-size analyses were made for 18 samples of suspended sediment taken during 16 river observations (table 6). Three of the samples were analyzed in native water and the others were dispersed and analyzed in distilled water. The analyses in native water were made to indicate the degree of flocculation which might be expected during deposition under natural conditions. Analyses in distilled water containing a dispersing agent were made to show the ultimate particle-size distribution in the samples under conditions of no flocculation. Samples 3 to 11 were taken at various times during and after the storm of Feb. 13, 1959, to determine whether there was a systematic change in particle size with stream discharge.

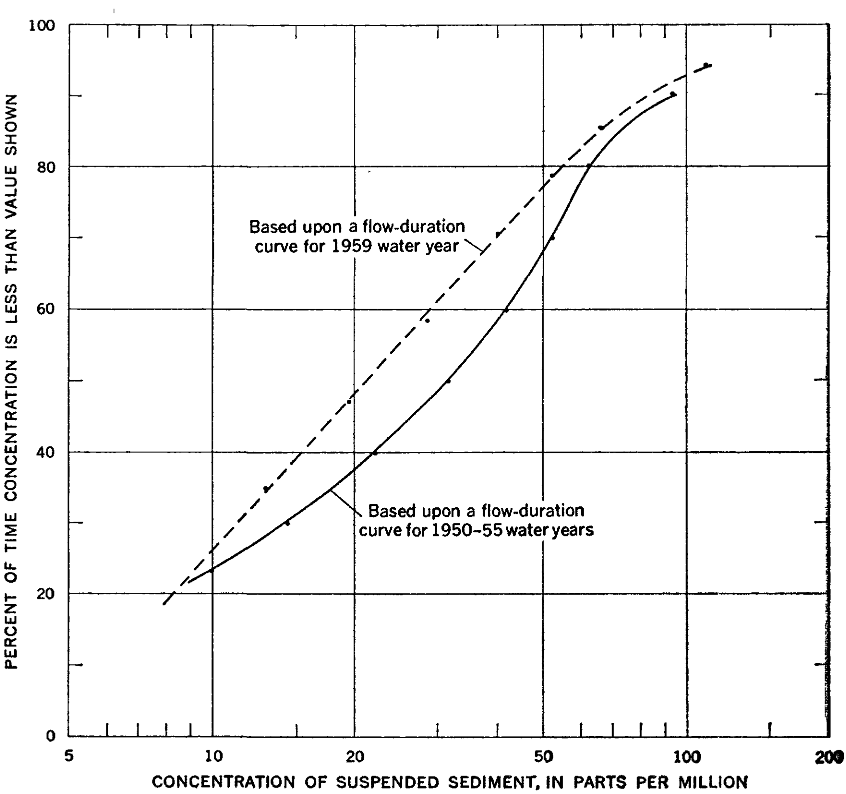

FIGURE 11.—Suspended-sediment concentration-frequency curve for the Broad River near Bell, Ga.

TABLE 6.—*Particle-size analyses of suspended sediment, Broad River near Bell, Ga.*

[Method of analysis: B, bottom withdrawal tube; N, in native water; W, in distilled water; C, chemically dispersed; M, mechanically dispersed]

Sample	Date of collection	Time	Discharge (cfs)	Water temperature (°F)	Suspended sediment										Method of analysis
					Concentration of sample (ppm)	Concentration of suspension analyzed (ppm)	Percent finer than indicated size (mm)								
							0.004	0.008	0.016	0.031	0.062	0.125	0.250	0.500	
	1958														
1	Feb. 27	12:50 p.m.	8,400	53	422	443	70	76	88	92	94	96	98	99	BWMC
2	Feb. 27	12:50	8,400	53	502	453	49	67	81	89	90	93	97	99	BN
	1959														
3	Feb. 13	8:00 a.m.	4,200	47	245	208	46	54	68	72	74	79	92	99	BWMC
4	Feb. 13	1:00 p.m.	5,500	48	320	297	48	56	60	67	68	73	86	98	BWMC
5	Feb. 13	1:00	5,500	48	258	271	36	52	67	75	77	83	92	99	BN
6	Feb. 13	4:30	6,450	49	454	361	40	48	55	63	65	75	89	99	BWMC
7	Feb. 13	9:30	7,600	49	388	327	36	50	67	76	78	84	92	99	BN
8	Feb. 14	8:30 a.m.	8,450	49	538	463	32	44	56	65	67	72	85	99	BWMC
9	Feb. 14	7:00 p.m.	8,200	53	363	342	38	47	56	62	64	69	81	99	BWMC
10	Feb. 15	7:00	6,300	51	209	154	35	43	50	56	60	66	74	96	BWMC
11	Feb. 16	7:00	3,100	54	156	162	38	49	58	68	73	80	86	98	BWMC
12	Mar. 7	10:15 a.m.	4,150	48	261	245	51	62	72	76	79	83	91	98	BWMC
13	Mar. 15	3:30 p.m.	2,400	54	112	129	42	60	73	81	85	91	95	100	BWMC
14	Mar. 16	3:30	4,480	51	461	538	56	64	74	82	84	89	96	99	BWMC
15	Mar. 18	7:50 a.m.	2,400	48	140	169	52	60	69	75	81	86	92	99	BWMC
16	Mar. 19	7:15	1,750	48	67	86	33	47	60	67	77	86	94	100	BWMC
17	Apr. 13	10:00	4,120	59	535	686	44	57	73	82	86	92	96	99	BWMC
18	Apr. 14	7:00	5,350	52	391	455	50	54	61	68	71	80	84	91	BWMC

The variation in concentration of suspended sand, silt, and clay with water discharge from February 13 to 16, 1959, is shown in figure 12. All samples, with the exception of the one collected at 9 : 30 p.m. on February 13, were taken at the middle centroid of discharge (samples analyzed in native water for particle-size distribution are not shown in fig. 12). The concentration of suspended clay was considerably higher than that of sand or silt during the early part of the rise in discharge. As the discharge continued to rise, however, the proportion of suspended sand increased rapidly and was probably about equal to that of the clay just prior to the discharge peak. The silt concentration lagged behind that of both the sand and clay during the early part of the discharge rise, but probably equaled or exceeded the sand and silt near the discharge peak.

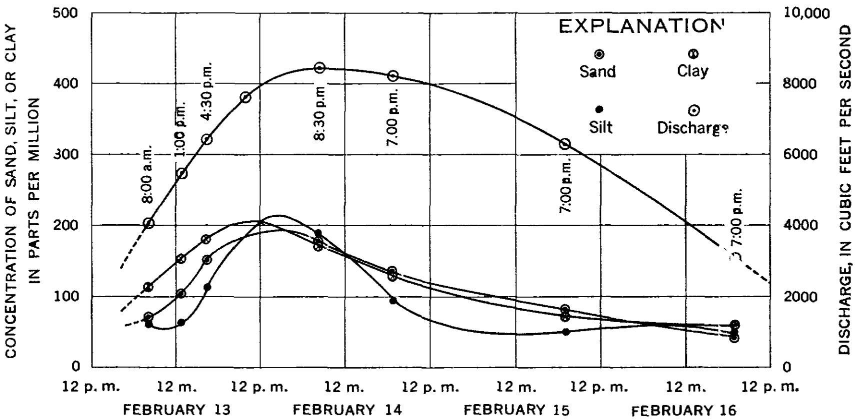

FIGURE 12.—Variation of water discharge and concentration of suspended sand, silt, and clay in Broad River near Bell, Ga., Feb. 13–16, 1959.

The concentration of suspended sediment in a sample collected at 9 : 30 p.m., February 13 at the south centroid of discharge apparently would not plot on a curve of sediment concentration for the middle centroid of discharge. The difference in concentration of suspended sediment at the two sampling points is believed to result from differences in flow characteristics and from the fact that an important tributary enters the river from the south approximately 1 mile upstream from the sampling site.

Suspended-sediment load.—Water samples were collected from the Broad River during the period Dec. 16, 1958, to May 15, 1959, in sufficient number to permit an estimate of the suspended-sediment load. The daily sediment loads are shown in table 7, and a sediment transport curve showing the relation of daily mean discharge to daily suspended load is given in figure 13. The calculated total suspended-sediment load of the Broad River during this period was about 75,000 tons. Size analyses of suspended sediment indicated that the sediment

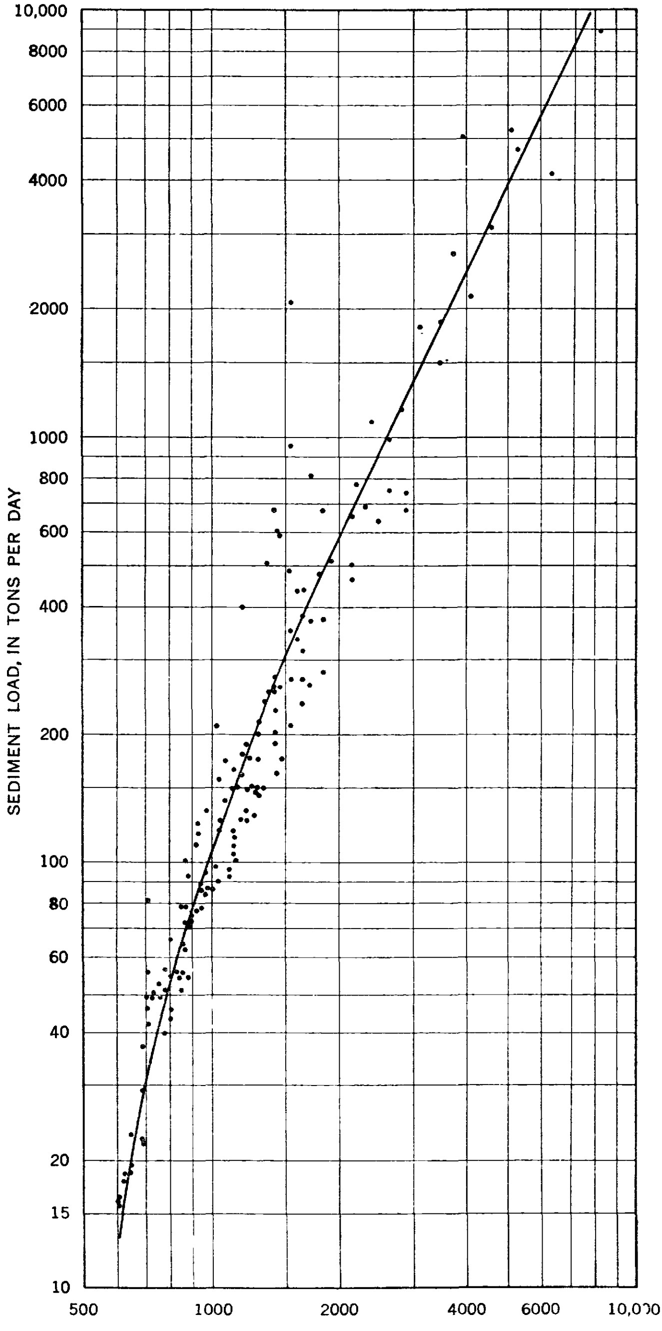

FIGURE 13.—Suspended-sediment transport curve for the Broad River near Bell, Ga.

TABLE 7.—*Daily suspended-sediment concentration and load, Broad River near Bell, Ga., Dec. 16, 1958, to May 15, 1959*

[Suspended-sediment concentration estimated from curve shown on fig. 10 except where otherwise indicated]

Day	Mean discharge (cfs)	Suspended sediment: Mean concentration (ppm)	Suspended sediment: Load (tons)	Mean discharge (cfs)	Suspended sediment: Mean concentration (ppm)	Suspended sediment: Load (tons)	Mean discharge (cfs)	Suspended sediment: Mean concentration (ppm)	Suspended sediment: Load (tons)
	December			January			February		
1	---	---	---	920	•47	117	945	•35	89
2	---	---	---	1,200	59	•191	870	31	73
3	---	---	---	1,340	66	239	870	23	54
4	---	---	---	1,070	48	139	1,340	•97	•502
5	---	---	---	945	33	84	3,100	•216	•1,810
6	---	---	---	845	•22	50	2,620	•133	•990
7	---	---	---	795	20	43	1,640	•86	381
8	---	---	---	770	19	40	1,220	•53	174
9	---	---	---	845	24	55	1,280	•42	145
10	---	---	---	895	31	•74	1,310	42	149
11	---	---	---	820	•25	55	1,280	•43	149
12	---	---	---	770	24	50	1,400	63	•257
13	---	---	---	745	24	48	5,270	•285	•4,700
14	---	---	---	720	25	49	8,200	•394	•8,950
15	---	---	---	700	25	48	6,350	•239	•4,120
16	680	•16	29	895	32	77	3,480	•195	•1,870
17	640	13	23	1,170	50	•160	2,380	168	1,080
18	640	11	19	970	•36	94	1,820	138	678
19	640	•11	19	845	28	64	1,580	101	431
20	620	11	18	795	25	54	1,430	67	259
21	600	•10	16	795	•21	45	1,250	•45	152
22	600	10	16	1,430	•142	•600	1,200	39	126
23	600	10	16	1,520	•335	•2,070	1,120	38	115
24	620	11	18	1,520	•227	•956	1,120	34	103
25	680	12	22	1,170	126	398	1,100	32	95
26	680	•12	22	1,040	•56	157	1,040	•32	90
27	640	11	19	970	50	132	995	32	86
28	820	24	•54	920	44	109	970	32	84
29	1,700	•163	•810	870	39	92	---	---	---
30	1,430	•148	•602	845	28	64	---	---	---
31	1,020	•76	209	870	33	78	---	---	---
Total	12,610	---	1,913	30,005	---	6,436	57,180	---	27,712
	March			April			May		
1	945	31	78	2,140	•77	•464	920	•49	122
2	920	•31	77	2,780	•103	•777	870	43	101
3	895	30	73	2,460	•94	•634	845	34	78
4	870	30	71	1,820	•76	373	795	31	66
5	1,370	51	•252	1,520	66	271	770	27	56
6	3,480	•159	•1,500	1,400	•53	201	745	26	52
7	4,060	•197	•2,140	1,280	50	173	720	•25	49
8	2,620	•105	•750	1,220	45	148	700	24	45
9	1,820	•57	280	1,170	40	126	700	22	42
10	1,400	50	189	1,120	36	109	680	20	37
11	1,250	38	128	1,100	•31	93	700	29	55
12	1,640	•61	270	1,280	54	•199	700	•43	81
13	2,140	87	503	3,810	•467	•5,040	1,400	•128	•675
14	1,640	53	234	5,080	•383	5,280	1,520	•108	•483
15	1,900	•87	•515	2,780	•140	•1,160	1,020	60	165
16	4,510	•284	•3,100	1,760	•101	480	---	---	---
17	3,720	•259	•2,700	1,520	85	349	---	---	---
18	2,300	•104	•686	1,400	72	272	---	---	---
19	1,700	•57	262	1,400	60	227	---	---	---
20	1,520	51	209	1,700	80	•368	---	---	---
21	1,460	•45	177	1,580	•79	337	---	---	---
22	1,430	42	162	1,400	67	253	---	---	---
23	1,280	42	145	1,280	•62	214	---	---	---
24	1,200	41	133	1,170	57	180	---	---	---
25	1,120	38	115	1,120	49	148	---	---	---
26	1,120	•34	103	1,040	42	118	---	---	---
27	1,640	•86	•438	1,020	•35	97	---	---	---
28	2,140	112	•652	970	32	84	---	---	---
29	1,640	69	•314	1,040	41	•127	---	---	---
30	2,860	•89	•673	1,070	60	173	---	---	---
31	2,860	•93	•740	---	---	---	---	---	---
Total	59,450	---	17,669	---	50,430	18,475	13,085	---	2,107

• At least one water-sediment sample was collected on this date and used in estimating the suspended-sediment load.

• Computed by subdividing day.

was composed of about 24 percent sand, 32 percent silt, and 44 percent clay (all percentages by weight). Such material, when deposited in a reservoir and kept under water, would weigh approximately 45 lb per cu ft at the end of 1 year and 60 lb per cu ft at the end of 10 years (calculated by the method of Lane and Koelzer, 1943). If a weight of 50 lb per cu ft is assumed, the suspended sediment transported would occupy a volume of 3 million cubic feet or about 69 acre-feet when deposited.

It is unfortunate that sediment sampling on the Broad River was discontinued on May 15, 1959, for the largest flows by far of the 1959 water year (October 1958 through September 1959) occurred in the period May 26 to June 5, 1959. Extrapolation of data obtained from Dec. 16, 1958, to May 15, 1959, indicated that the amount of suspended sediment transported during the period May 26 through June 5 was from 100,000 to 150,000 tons. Thus, probably more sediment was carried in these 11 days than during the previous 5 months. This fact emphasizes the importance of floods in transporting suspended sediment in the Broad River. About two-thirds of the total water discharge for the 1959 water year flowed past the sampling station between Dec. 16, 1958, and June 5, 1959. Because much of the remaining one-third of the total flow passed when stream level and sediment concentration were low, it seems probable that more than 90 percent of the sediment load for the water year was carried during the period Dec. 16, 1958, through June 5, 1959.

If approximately 200,000 tons of suspended sediment was transported by the Broad River during the 1959 water year, the average amount of sediment removed from the Broad River drainage basin was about 140 tons per square mile. Of this tonnage, 52 tons was measured and 88 tons was estimated.

The fact that much of the annual sediment load is transported in a relatively short period of time is shown by suspended-sediment load-distribution curves (fig. 14). Although the load-distribution curve based upon the 1959 water year differs from that based upon the 1950–55 water years, it is evident that about 90 percent of the annual suspended-sediment load is carried during only 20 percent of the time, and 50 percent or more is carried during 2 percent of the time.

OGEECHEE RIVER NEAR EDEN, GA.

The Ogeechee River heads in the rolling hills of Greene and Taliaferro Counties above the Fall Line and flows southeastward across the Coastal Plain. Only about 10 percent of the Ogeechee River drainage area is in the Piedmont; the remainder is in the very gently rolling to almost level Coastal Plain. Although many names are given to soils of the basin, practically all the soils are of sand, loamy sand, or sandy loam. Average runoff is 0.60 mgdsm. Harvested cropland

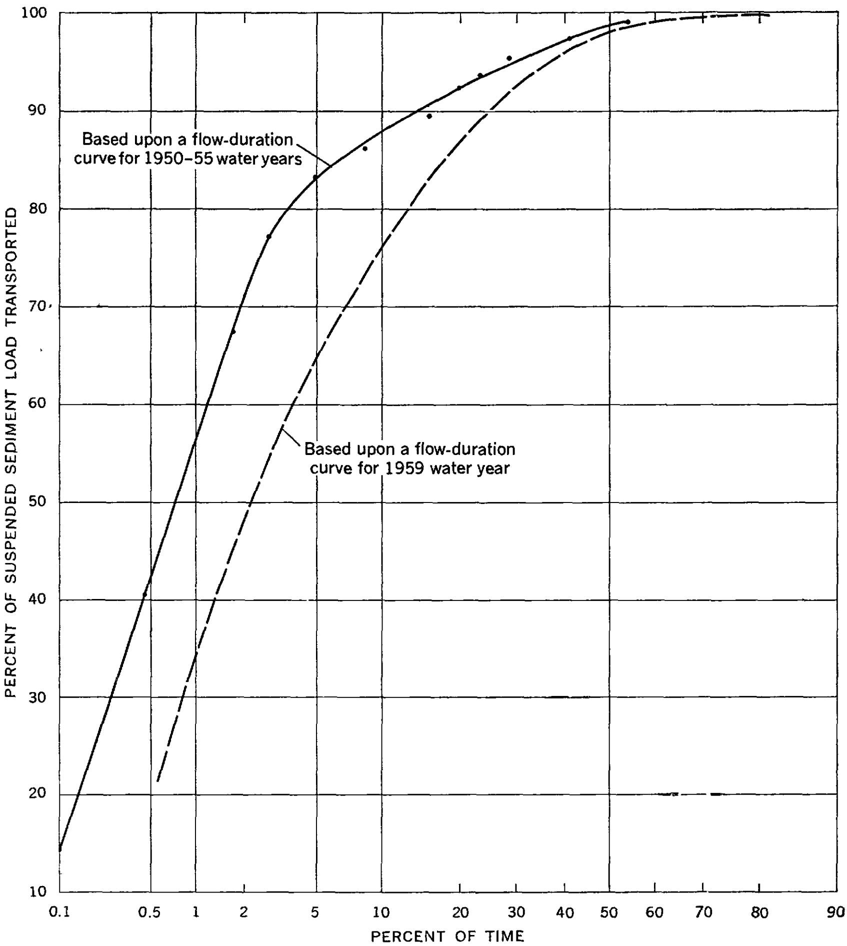

FIGURE 14.—Suspended-sediment load-distribution curves for the Broad River near Bell, Ga.

is nearly 20 percent of the total land area, and total cropland is 25 percent. Most of the cropland is in the almost level, well-drained middle part of the drainage basin. Less land is farmed in the hilly areas above the Fall Line and in the low, poorly drained areas along the coast.

Suspended-sediment concentration.—The concentration of suspended sediment was 13 ppm or less (and averaged 7.5 ppm) in 26 samples collected during the period July 7, 1958, to Apr. 24, 1959. Average discharge for the period 1937–57 was 2,037 cfs (U.S. Geol. Survey, 1959b). The suspended-sediment concentration and instantaneous stream discharge are shown in table 8 and are plotted graphically in figure 15. Correlation between the suspended-sediment concentration and water discharge is poor. The suspended-sediment concentration also shows no consistent variation in the stream cross section. Because of the very low concentration of suspended sediment, insufficient material was available for a particle-size analysis. The fact that the suspended-sediment concentration does not vary appreciably across the stream, despite considerable variation of stream velocity, suggests that the suspended sediment is mostly silt or clay and that the streambed is composed of coarse-grained material.

Suspended-sediment load.—Daily suspended-sediment loads for the period Dec. 16, 1958, to May 15, 1959, were calculated and are shown

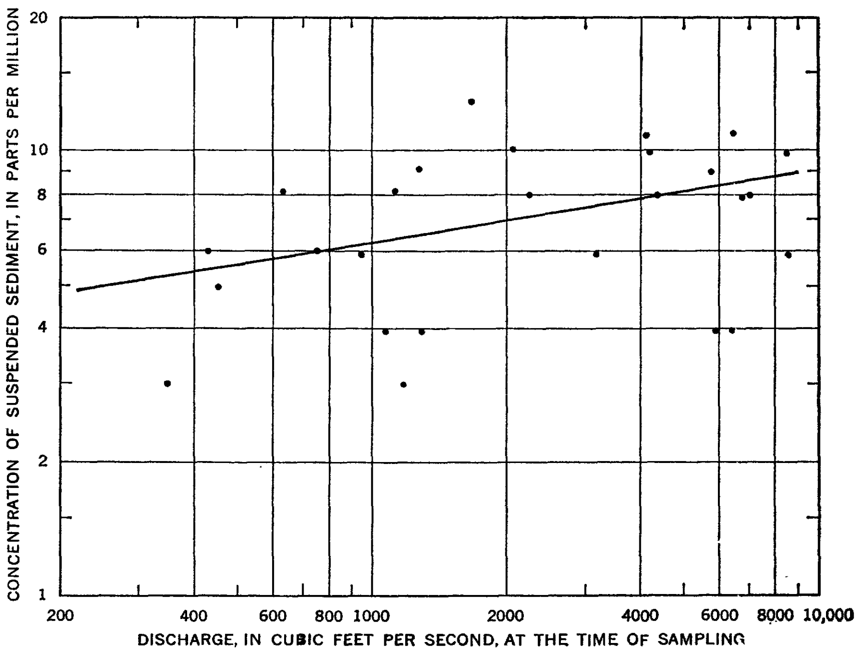

FIGURE 15.—Relation of stream discharge to concentration of suspended sediment in samples from the Ogeechee River near Eden, Ga.

TABLE 8.—*Concentration of suspended sediment in samples from the Ogeechee River near Eden, Ga.*

Date	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)	Date	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)
1958			*1959*—Continued		
July 14	2,030	10	Feb. 4	1,670	13
Aug. 4	950	6	Feb. 5	2,280	8
Sept. 24	345	3	Feb. 7	4,030	11
Dec. 5	430	6	Feb. 9	4,310	8
Dec. 11	460	5	Feb. 9	4,180	10
Dec. 22	630	8	Feb. 16	5,860	4
Dec. 27	770	6	Feb. 23	6,710	8
			Mar. 1	6,980	8
1959			Mar. 6	6,400	11
Jan. 4	1,050	4	Mar. 10	8,450	10
Jan. 11	1,150	3	Mar. 19	8,450	6
Jan. 17	1,260	4	Mar. 29	6,330	4
Jan. 23	1,120	8	Apr. 13	5,910	9
Jan. 30	1,270	9	Apr. 24	3,110	6

in table 9. The total suspended-sediment load is about 10,000 tons for the sampled period but, because the stream discharge during the period was approximately 75 percent of the discharge for the water year, the total suspended-sediment load for the period October 1958 to September 1959 is estimated at 12,000 to 15,000 tons. This suspended-sediment load corresponds to an annual sediment yield for the Ogeechee River basin of about 5 tons per square mile.

Size distribution of bed material.—Samples of bed material were collected from the Ogeechee River on Feb. 9, 1959, when the discharge was 4,000 cfs, or almost twice the average discharge of the river. Suitable samples were obtained at only 4 of the 10 stations in the cross section selected for sampling. Fortunately, however, these four stations were near the middle of the stream where current velocity was greatest. The size distribution of particles in the four samples is shown in table 10. The sample collected at station 499 may be slightly affected by currents swirling about the base of a pier 11 feet away, for the particle-size distribution is different from that in the other three samples. The average depth of water between stations 455 and 488 was 12.2 feet, the average velocity 2.87 ft per second, and the discharge approximately 30 percent of the total stream discharge. Suspended-sediment concentration was 8 ppm.

An estimate of the approximate magnitude of bed load between stations 455 and 488 was made by the modified Einstein method (Colby and Hubbell, 1957). In the part of the stream studied, the bed load was about 13 tons per day and the suspended sediment about 25 tons per day. It should be emphasized that this estimate of bed load may be in error by a factor of two or more because, as previously pointed out, the modified Einstein method has not been tested in deep streams in the eastern United States.

SLASH CREEK NEAR McINTYRE, GA.

Although the major purpose of this study was to determine sediment concentration and load in streams which were not markedly polluted, one greatly polluted stream, Slash Creek, was investigated at the request of the Georgia Department of Mines, Mining and Geology.

Slash Creek (Little Commissioner Creek), a tributary to Commissioner Creek in Wilkinson County, drains an area of rolling to hilly topography. Clay mines and clay-processing plants are located in the basin and contribute varying quantities of clay to Slash Creek. Samples were collected from Slash Creek at a point about 2 miles west of McIntyre, Ga., where a wooden bridge crosses the stream. Two samples were collected on alternate days from December 16, 1958, to Apr. 1, 1959. A discharge measurement was made at less than average flow on Dec. 16, 1958, and the sample collector was instructed to measure the water level each time a sample was collected thereafter.

TABLE 9.—*Daily suspended-sediment concentration and load, Ogeechee River near Eden, Ga., Dec. 16, 1958, to May 15, 1959*

[Suspended-sediment concentration estimated from curve shown on fig. 15 except where otherwise indicated]

Day	Mean discharge (cfs)	Suspended sediment		Mean discharge (cfs)	Suspended sediment		Mean discharge (cfs)	Suspended sediment	
		Mean concentration (ppm)	Load (tons)		Mean concentration (ppm)	Load (tons)		Mean concentration (ppm)	Load (tons)
	December			January			February		
1				820	5	11	1,400	10	38
2				820	4	9	1,500	11	45
3				880	4	10	1,600	12	52
4				910	•4	10	1,900	•13	67
5				970	4	11	2,200	•8	46
6				1,000	4	11	2,600	9	63
7				1,030	4	11	3,100	•11	92
8				1,030	3	8	3,700	10	100
9				1,000	3	8	4,000	•8	86
10				1,030	3	8	3,900	8	84
11				1,030	•3	8	4,200	7	79
12				1,060	3	9	4,300	6	70
13				1,090	3	9	4,480	6	73
14				1,120	4	12	4,820	5	65
15				1,120	4	12	5,180	4	56
16	540	7	10	1,120	4	12	5,540	•4	60
17	540	7	10	1,200	•4	13	6,100	4	66
18	540	7	10	1,200	4	13	6,700	5	91
19	555	8	12	1,100	5	15	7,100	5	96
20	555	8	12	1,100	6	18	7,350	6	119
21	570	8	12	1,000	7	19	7,100	6	1,150
22	585	•8	13	1,000	8	22	6,700	7	127
23	600	8	13	1,000	•8	22	6,500	•8	140
24	630	7	12	1,100	8	24	6,300	8	136
25	630	7	12	1,100	8	24	5,900	8	127
26	655	6	11	1,200	8	26	5,720	8	124
27	655	•6	11	1,200	8	26	5,540	8	120
28	680	6	11	1,300	9	32	5,180	8	112
29	705	6	11	1,300	9	32			
30	760	5	11	1,300	•9	32			
31	790	5	11	1,400	9	34			
Total	9,990		182	33,530		511	130,610		2,449

Day	Mean discharge (cfs)	Mean concentration (ppm)	Load (tons)	Mean discharge (cfs)	Mean concentration (ppm)	Load (tons)	Mean discharge (cfs)	Mean concentration (ppm)	Load (tons)
	March			April			May		
1	5,180	•8	112	5,200	4	56	2,080	6	34
2	5,000	8	108	6,000	5	81	1,980	6	32
3	4,820	9	117	6,600	5	89	1,880	6	30
4	4,480	10	121	7,000	6	113	1,740	6	28
5	4,480	11	133	7,000	6	113	1,620	5	22
6	5,900	•11	175	7,100	7	134	1,500	5	20
7	6,200	11	187	7,100	7	134	1,390	5	19
8	7,350	11	218	7,200	7	136	1,250	5	17
9	7,850	10	212	7,000	8	151	1,150	5	16
10	7,850	•10	212	6,700	8	145	1,030	5	14
11	7,600	10	206	6,400	9	156	940	5	13
12	7,100	9	172	6,200	9	151	850	5	12
13	6,900	9	168	6,100	•9	148	790	5	11
14	7,350	8	159	5,720	9	139	760	5	10
15	7,850	8	170	5,540	9	135	760	5	10
16	7,650	7	145	5,000	9	108			
17	7,350	7	139	4,480	8	97			
18	7,350	6	119	4,180	8	90			
19	7,000	•6	113	3,920	7	74			
20	6,800	6	110	3,700	7	70			
21	6,600	6	107	3,510	7	66			
22	6,300	6	102	3,330	6	54			
23	6,200	5	84	3,150	6	51			
24	6,500	5	88	2,990	•6	48			
25	6,800	5	92	2,830	6	46			
26	6,800	5	92	2,690	6	44			
27	6,600	4	71	2,620	6	42			
28	6,300	4	68	2,480	6	40			
29	6,100	•4	66	2,360	6	38			
30	5,800	4	63	2,300	6	37			
31	5,300	4	57						
Total	197,360		4,186	146,400		2,786	19,720		287

• At least one water-sediment sample was collected on this date and used in estimating the suspended-sediment load.

TABLE 10.—*Particle-size distribution of bed material from the Ogeechee River near Eden, Ga., Feb. 9, 1959*

[Station number indicates distance, in feet, from a reference point on the bridge which crosses the river at the sampling site]

Size range (mm)	Weight percent			
	Station 455	Station 471	Station 488	Station 499
>4	<0.1	0.04	0.1	7.6
2-4	.21	.9	1.32	24.6
1-2	4.9	13.2	11.02	36.1
0.5 -1	35.9	47.4	51.5	23.7
0.25 -0.5	54.4	37.0	35.2	7.5
0.125-0.25	4.6	1.5	.9	.6
0.062-0.125	<.1	<.1	<.1	<.1
<.062	<.1	<.1	<.1	<.1

These data made possible an estimate of the minimum average daily sediment load in Slash Creek and permitted determination of the relation of suspended concentration to water stage.

Suspended-sediment concentration.—The suspended-sediment concentration of samples taken from Slash Creek Apr. 9, 1958, to Apr. 1, 1959, are given in table 11. The average concentration during the last half of December 1958 was 1,650 ppm; in January 1959, 1,620 ppm; in February, 495 ppm; and in March, 365 ppm. Although the sharp drop in concentration in February may be due only to a change in the amount of clay put into the stream, it is possible that other factors are important. Much of the clay carried by Slash Creek appears to be contributed by factories in the town of Gordon, about 7 miles upstream from the sampling point; the clay tends to be deposited in the streambed during periods of low flow. As the stream rises, this deposited clay is flushed out. In the case of Slash Creek, sampling was begun after about 3 months of low rainfall and corresponding low streamflow. Moderate amounts of rain fell in the latter part of December 1958 and January 1959, and the resultant runoff probably caused erosion of some clay from the stream channel. On Feb. 3–5, 1959, about 2.5 inches of rain fell, and Slash Creek rose to 2.5 feet from a normal gage height of about 1.1 feet. This rise probably was accompanied by the flushing out of much of the accumulated clay. Following this heavy rain, sediment concentration was low, possibly because most of the accumulated clay had been removed. As the streamflow decreased, the concentration of suspended sediment slowly increased. This relation suggests that there was less dilution of the clay by clear water derived from the drainage basin upstream from Gordon. During the last part of February and all of March, the suspended-sediment concentration varied in a rather erratic fashion, but the average concentration was well below, and the average discharge was higher than, that observed prior to the flood of early February.

TABLE 11.—*Concentration of suspended sediment in samples from Slash Creek near McIntyre, Ga.*

[Gage height, based on arbitrarily assumed reference, obtained by measuring between the water surface and a particular point on the bridge crossing Slash Creek]

Date	Gage height (feet)	Suspended-sediment concentration (ppm)	Date	Gage height (feet)	Suspended-sediment concentration (ppm)
1958			*1959* (continued)		
Apr. 9.		276	Feb. 4	2.1	520
Apr. 30		474	Feb. 5	2.5	400
Dec. 16	1.1	843	Feb. 6	2.5	565
Dec. 17		1,583	Feb. 8	2.1	284
Dec. 18	1.0	1,493	Feb. 10	2.3	264
Dec. 20	.9	4,310	Feb. 12	2.1	238
Dec. 22	.7	1,516	Feb. 14	2.1	246
Dec. 24	1.0	1,972	Feb. 16	2.1	253
Dec. 26	1.1	496	Feb. 18	2.1	340
Dec. 28	1.5	936	Feb. 20	1.6	496
Dec. 30	1.3	1,712	Feb. 22	1.2	510
			Feb. 24	1.0	801
1959			Feb. 26	2.0	779
Jan. 1	1.2	744	Feb. 28	1.3	1,294
Jan. 3	1.5	1,526	Mar. 2	1.3	519
Jan. 5	1.2	596	Mar. 4	1.2	422
Jan. 7	1.2	4,762	Mar. 6	3.0	404
Jan. 9	1.2	5,300	Mar. 8	2.3	200
Jan. 11	1.1	380	Mar. 10	1.8	410
Jan. 13	1.0	524	Mar. 12	1.7	299
Jan. 15	1.0	1,998	Mar. 14	1.9	251
Jan. 17	1.6	563	Mar. 16	1.8	371
Jan. 19	1.4	2,171	Mar. 18	1.7	352
Jan. 21	1.4	1,535	Mar. 18	1.8	796
Jan. 23	1.5	1,002	Mar. 20	1.3	428
Jan. 25	1.4	875	Mar. 22	1.9	326
Jan. 27	1.1	1,764	Mar. 24	1.8	165
Jan. 29	1.1	1,114	Mar. 26	1.5	335
Jan. 31	1.2	877	Mar. 28	1.9	197
Feb. 2	1.5	449	Apr. 1	2.0	218

Suspended-sediment load.—Estimates of the suspended sediment in Slash Creek are based on measurements of concentration and on a discharge measurement of 33 cfs made at a gage height of 1.1 feet. The average suspended-sediment concentration for the sampling period was approximately 950 ppm. The daily suspended-sediment load was calculated as 85 tons for a discharge of 33 cfs and a concentration of 950 ppm. However, the average discharge during the sampling period was greater than 33 cfs by an unknown amount. Although an accurate determination of the average load cannot be made, the data available suggest than an estimate of 125 tons per day is reasonable.

The great changes in concentration from one day to the next or even during one day show that the suspended load is highly variable. (See table 11, Jan. 5–11 and Mar. 18, 1959.) The instantaneous load at the time of sampling on Jan. 9, 1959, was approximately 530 tons per day. By comparison, the instantaneous load on Mar. 24, 1959, was perhaps 30 tons per day.

Source of clay particles.—A thorough study of the sources of the clay carried by Slash Creek was beyond the scope of this study, but the major source of the clay was determined. Samples were collected three times from Slash Creek above and below the town of Gordon; the suspended-sediment concentration was found to increase greatly because of clay derived from mills in the town of Gordon. The data obtained are shown in table 12.

TABLE 12.—*Concentration of suspended sediment in samples from Slash Creek near Gordon, Ga.*

Date	Suspended-sediment concentration (ppm)	
	At bridge south of Gordon on Georgia Route 18	At bridge southeast of Gordon
1958		
Dec. 17	4	2,340
1959		
Jan. 20	8	1,160
Apr. 1	9	270

FLINT RIVER NEAR CULLODEN, GA.

The headwaters of the Flint River are located near Hapeville just south of Atlanta. From there the river flows southward across the Piedmont and Coastal Plain until it leaves Georgia at the southwest corner of the State. The Flint River was sampled just a few miles above the Fall Line. The drainage area above this site is about 1,890 square miles.

Upstream from the sampling site the terrane is characteristic of much of the Georgia Piedmont. The land is hilly, and the soils are of gray-brown to reddish-brown sandy to clay loam. The more common soils include the Cecil, Lloyd, Appling, and Madison series. Average runoff is 0.73 mgdsm. Cropland constitutes about 25 percent of the drainage basin and, of this, about one-half is harvested cropland. No large reservoirs are located upstream from the sampling point, and it can be assumed that the sediment yield is not greatly affected by dams.

Suspended-sediment concentration.—Water-sediment samples were collected from the Flint River near Culloden, Ga., during the period Dec. 18, 1958, to May 15, 1959. Only 25 samples were collected during the sampling period. The suspended-sediment concentration is shown in table 13 and plotted against instantaneous discharge in figure 16. The graph demonstrates the increase of sediment concentration with increasing discharge. Average discharge during the periods 1911–22, 1928–31, and 1937–57 was 2,341 cfs (U.S. Geol. Survey, 1959b).

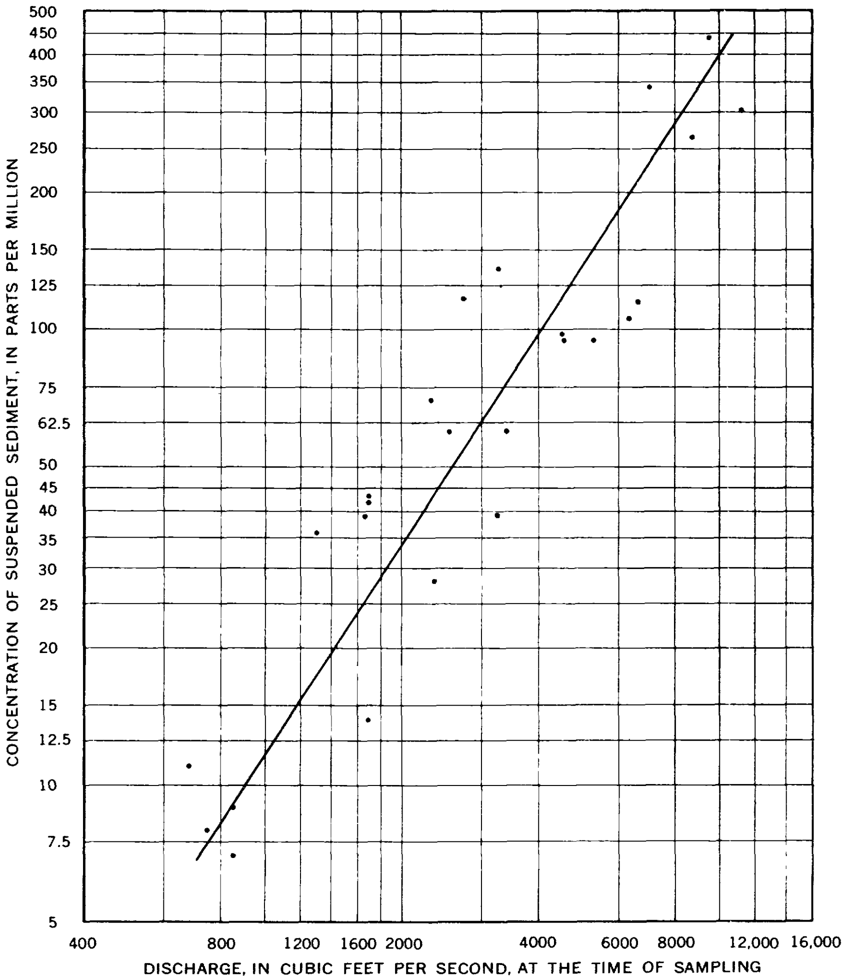

FIGURE 16.—Relation of stream discharge to concentration of suspended sediment in samples from the Flint River near Culloden, Ga.

Samples were taken at three centroids of discharge, and, in 14 of the 17 groups of three samples that were suitable for study, the sample collected at the middle centroid had the highest concentration. The sample from the south centroid contained the lowest concentration of sediment 65 percent of the time. Thus, it is apparent that suspended sediment is unevenly distributed in the river cross section.

Size distribution of suspended sediment.—Size analyses were made on 11 samples from the Flint River; the data are presented in table 14. Six of these samples were collected at the middle centroid of discharge during periods of above-normal flow and were dispersed

TABLE 13.—*Concentration of suspended sediment in samples from the Flint River near Culloden, Ga.*

Date	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)
1958		
Dec. 18	850	7
Dec. 21	680	11
Dec. 26	750	8
1959		
Jan. 14	850	9
Jan. 17	2,740	118
Jan. 18	2,300	70
Jan. 22	3,260	141
Jan. 25	2,520	60
Feb. 1	1,690	43
Feb. 5	8,720	267
Feb. 8	4 530	95
Feb. 11	4 480	98
Feb. 14	6 580	115
Feb. 16	6 140	106
Feb. 21	2,340	28
Mar. 4	1,690	14
Mar. 5	7,000	339
Mar. 6	9 390	436
Mar. 6	11,100	302
Mar. 8	5 230	99
Mar. 16	3 220	39
Mar. 30	3 380	61
May 13	1,300	36
May 13	1,690	42
May 16	1,630	39

before analysis. The six samples were similar in their particle-size distribution and averaged 35 percent sand, 35 percent silt, and 30 percent clay. In one instance, size analyses of dispersed sediment were made on samples collected at both the south and the middle centroids of discharge (samples 2 and 3, table 14). The sample at the middle centroid had a higher suspended-sediment concentration and a higher percentage of sand. In two instances, a sample collected at the middle centroid was analyzed in a dispersed condition and a sample collected at the same time from the north centroid was analyzed in native water (samples 6–9, table 14). In both instances the sample collected at the middle centroid had a higher suspended-sediment concentration and a somewhat higher percentage of sand. The samples analyzed in native water showed very little tendency to flocculate. This fact agrees with previous findings by R. N. Cherry (oral communication) that turbidity is persistent in the water of some Piedmont streams. The failure to flocculate is probably related to the low concentration of dissolved solids in the water.

A sample collected at relatively low flow (sample 11, table 14) had a particle-size distribution quite different from that of the samples collected at higher flows. The suspended sediment contained very little sand and a high percentage of clay.

Suspended-sediment load.—The estimate of the suspended-sediment load transported by the Flint River must necessarily be only an approximation because of the small number of samples collected. If the discharge-sediment concentration curve shown in figure 16 is used in estimating sediment concentration at times of no sampling, the suspended-sediment load during the period Dec. 15, 1958, to May 15, 1959, is calculated to be about 80,000 tons.

TABLE 14.—*Particle-size analyses of suspended sediment, Flint River near Culloden, Ga.*

[Method of analysis: B, bottom withdrawal tube; N, in native water; W, in distilled water; C, chemically dispersed; M, mechanically dispersed]

Sample	Date of collection	Time	Discharge (cfs)	Water temperature (°F)	Suspended sediment										Method of analysis
					Concentration of sample (ppm)	Concentration of suspension analyzed (ppm)	Percent finer than indicated size (mm)								
							0.004	0.008	0.016	0.031	0.062	0.125	0.250	0.500	
	1959														
1	Jan. 22	5:30 p.m.	3,270	38	155	127	30	46	54	60	66	72	89	98	BWMC
2	Feb. 5	6:15	8,720	42	335	250	25	39	49	56	63	71	85	99	BWMC
3	Feb. 5	6:15	8,720	42	223	263	54	60	74	82	87	93	98	99	BWMC
4	Feb. 11	7:00	4,010	43	88	74	28	40	51	57	61	69	81	97	BWMC
5	Mar. 5	11:30	7,000	40	433	371	28	36	44	52	61	72	86	99	BWMC
6	Mar. 6	2:00 a.m.	9,430	46	535	497	30	37	45	53	60	70	83	99	BWMC
7	Mar. 6	2:00	9,430	46	395	389	32	40	51	64	72	87	96	99	BN
8	Mar. 6	10:40	11,100	----------	331	260	34	41	49	58	66	76	88	99	BWMC
9	Mar. 6	10:40	11,100	----------	285	294	32	41	51	61	68	80	91	99	BN
10	Mar. 9	8:00 p.m.	4,400	44	175	145	30	40	44	50	66	80	92	100	BWMC
11	May 13	9:45 a.m.	1,300	73	40	137	73	83	86	90	94	96	98	99	BWMC

On June 2, 1959, after sampling was discontinued, the Flint River reached a discharge slightly greater than 30,000 cfs. This discharge is much greater than the 11,000 cfs maximum reached during the sampling period. Sediment concentration rises with increasing discharge as shown in figure 16, so the sediment concentration probably exceeded 2,000 ppm on June 2 and the daily sediment load may have exceeded 150,000 tons. Because the sediment load carried on June 2 was probably not more than one-half of the load carried during the period June 1–4, a reasonable estimate of suspended sediment transported during the whole flood would be at least 300,000 tons. Thus the suspended-sediment load estimated for the period Dec. 15, 1958, to May 15, 1959, is small compared to the load transported June 1–4, 1959. If the total suspended-sediment load for the 1959 water year is assumed to have been 400,000 tons, the sediment yield was approximately 200 tons per square mile.

Size distribution of bed material.—Bed material was collected on Mar. 4, 1959, near each of three centroids of discharge. Size distribution of samples is shown in table 15. The discharge at the time of sampling was only 1,680 cfs and the size distribution determined may not represent equilibrium conditions at this discharge. Nevertheless, the size analyses are of value in indicating the approximate size distribution of bed material in the Flint River near Culloden, Ga.

TABLE 15.—*Particle-size distribution of bed material from the Flint River near Culloden, Ga., Mar. 4, 1959*

Size range (mm)	Weight percent		
	North centroid	Middle centroid	South centroid
>4	0.1	0.2	9.7
2–4	.7	.7	13.7
1–2	3.6	7.4	29.2
0.5–1	26.8	50.0	43.0
0.25–0.5	59.9	40.3	4.0
0.125–0.25	8.8	1.4	.4
0.062–0.125	.2	<.1	.1
<0.062	<.1	<.1	<.1

ICHAWAYNOCHAWAY CREEK AT MILFORD, GA.

Ichawaynochaway Creek is a tributary to the Flint River in the Coastal Plain of southwestern Georgia. The topography is gently rolling to almost level but, in general, the land is well drained. Soil is sandy loam of the Greenville, Magnolia, Faceville, and Carnegie series. Average runoff is 0.83 mgsm. Cropland constitutes about 40 percent of the land area and harvested cropland about 28 percent. Cordrays Pond in northeastern Calhoun County causes the deposition of much of the sediment from approximately 40 percent of the drainage area above Milford.

Suspended-sediment concentration.—Instantaneous values of suspended-sediment concentration for Ichawaynochaway Creek during the period Nov. 3, 1958, to May 15, 1959, are given in table 16. Average discharge for the period 1939–57 was 762 cfs (U.S. Geol. Survey, 1959b). Data given in table 16 are plotted against stream discharge in figure 17. At least a part of the scatter of points in figure 17 is due to the fact that, during floods, the peak in sediment concentration precedes the discharge peak.

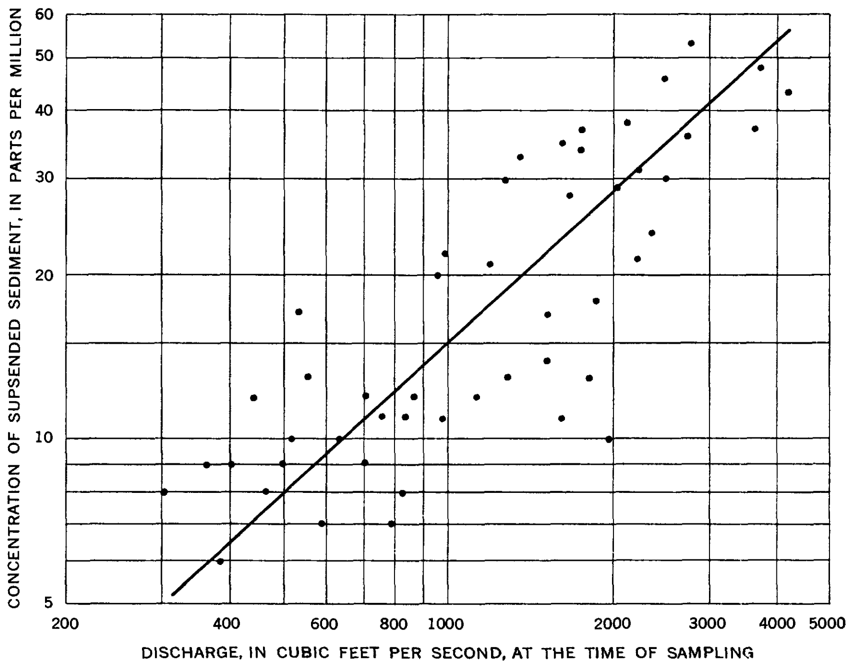

FIGURE 17.—Relation of stream discharge to concentration of suspended sediment in samples from Ichawaynochaway Creek at Milford, Ga.

Suspended-sediment concentration data, collected at three centroids of discharge, showed no consistent tendency to be higher at any particular centroid. Of the 35 sample sets suitable for study, 67 percent contained no samples differing from the average by more than 33 percent, and 95 percent contained no samples differing by more than 61 percent. The correlation between suspended-sediment concentration and discharge permits an estimate of the percent of the time that sediment concentration is equal to or less than certain values (fig. 18). If the years 1950–55 inclusive are considered as normal and the discharge-sediment concentration relation for the sampling period is typical, the suspended-sediment concentration is less than 7 ppm about 50 percent of the time and less than 15 ppm during 90 percent of the time.

TABLE 16.—*Concentration of suspended sediment in samples from Ichawaynochaway Creek at Milford, Ga.*

Date	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)	Date	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)
1958			*1959*—Continued		
Nov. 3	300	8			
Dec. 19	400	9	Mar. 8	3,730	48
Dec. 21	380	6	Mar. 8	4,160	43
Dec. 31	585	7	Mar. 9	3,610	37
			Mar. 10	2,740	36
1959			Mar. 11	2,200	23
Jan. 9	515	10	Mar. 12	1,650	28
Jan. 14	460	8	Mar. 15	1,515	14
Jan. 18	700	12	Mar. 16	1,960	10
Jan. 24	700	9	Mar. 18	2,360	24
Jan. 28	630	10	Mar. 20	1,860	18
Feb. 3	980	22	Mar. 21	1,520	17
Feb. 5	1,600	35	Mar. 25	1,280	13
Feb. 7	2,480	46	Mar. 28	1,120	12
Feb. 8	2,490	30	Mar. 30	1,700	37
Feb. 9	2,220	31	Mar. 30	2,050	29
Feb. 14	1,270	30	Apr. 2	1,800	13
Feb. 18	1,200	21	Apr. 6	1,600	11
Feb. 23	745	11	Apr. 9	980	11
Feb. 27	955	20	Apr. 13	860	12
Mar. 3	825	8	Apr. 24	830	11
Mar. 4	785	7	Apr. 28	550	13
Mar. 6	1,350	33	May 2	530	17
Mar. 6	1,745	34	May 6	440	12
Mar. 7	2,125	38	May 10	360	9
Mar. 7	2,780	53	May 15	500	9

Suspended-sediment load.—Daily suspended-sediment loads were computed from discharge and sediment-concentration data for the 5-month period Dec. 15, 1958, to May 15, 1959, and are shown in table 17. Daily suspended-sediment load is plotted against average daily discharge in figure 19. The part of the annual suspended-sediment load carried during a particular part of the time can be estimated from figure 20. Because data are available for just a short period, the relation shown in figure 20 can only be a first approximation. Apparently, about 50 percent of the annual load is carried during only 10 percent of the time and 90 percent of the load is carried during 50 percent of the time.

The suspended-sediment yield from the drainage basin above Milford during the 1959 water year is estimated to be approximately 11,000 tons. The water from about 40 percent of the drainage basin above Milford passes through a reservoir, and much sediment is removed from it. If the reservoir is considered, the average yield for the 620 square miles in the drainage basin was about 30 tons per square mile during the 1959 water year.

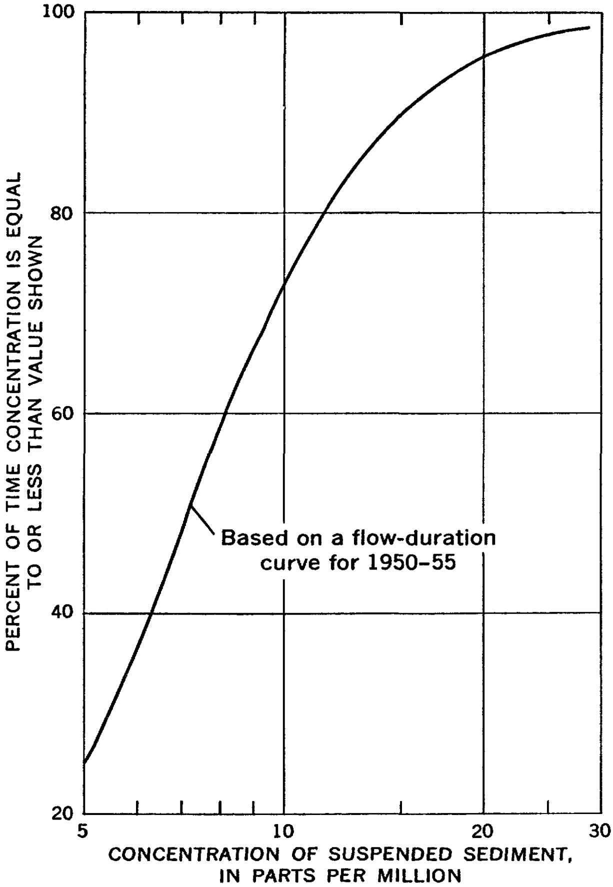

FIGURE 18.—Suspended-sediment concentration-frequency curve for Ichawaynochaway Creek at Milford, Ga.

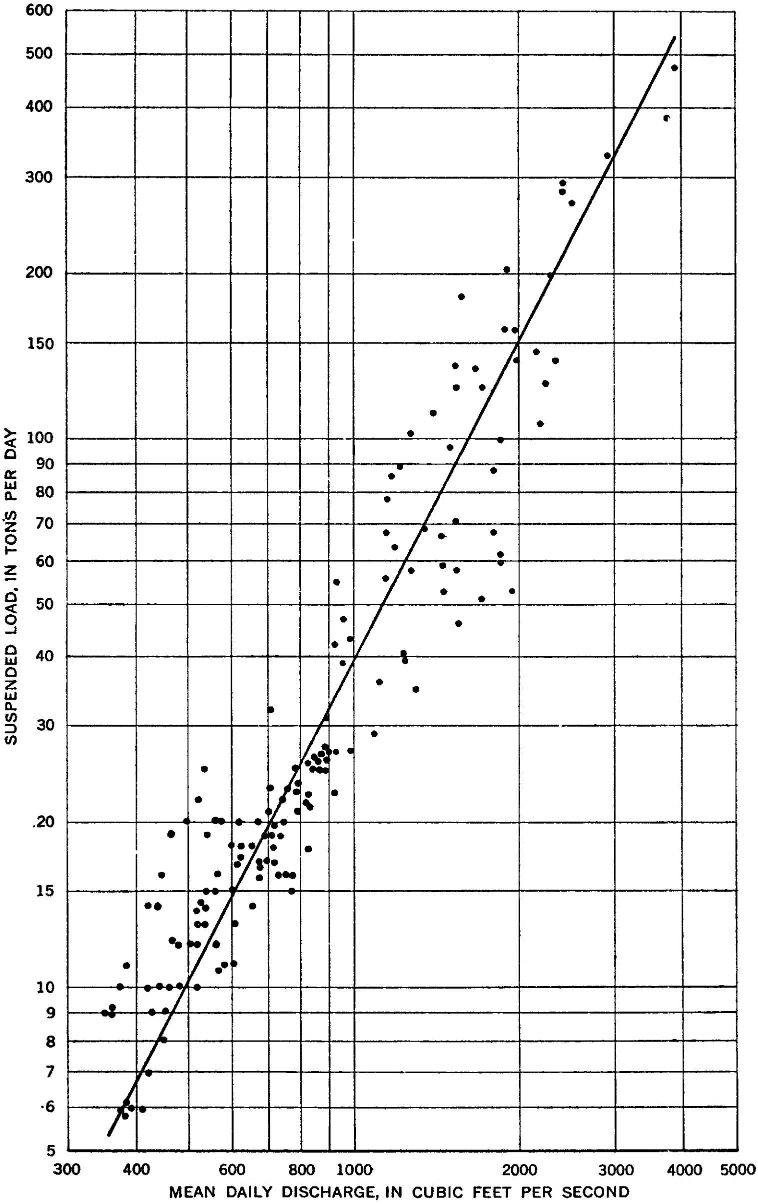

FIGURE 19.—Suspended-sediment transport curve for Ichawaynochaway Creek at Milford, Ga.

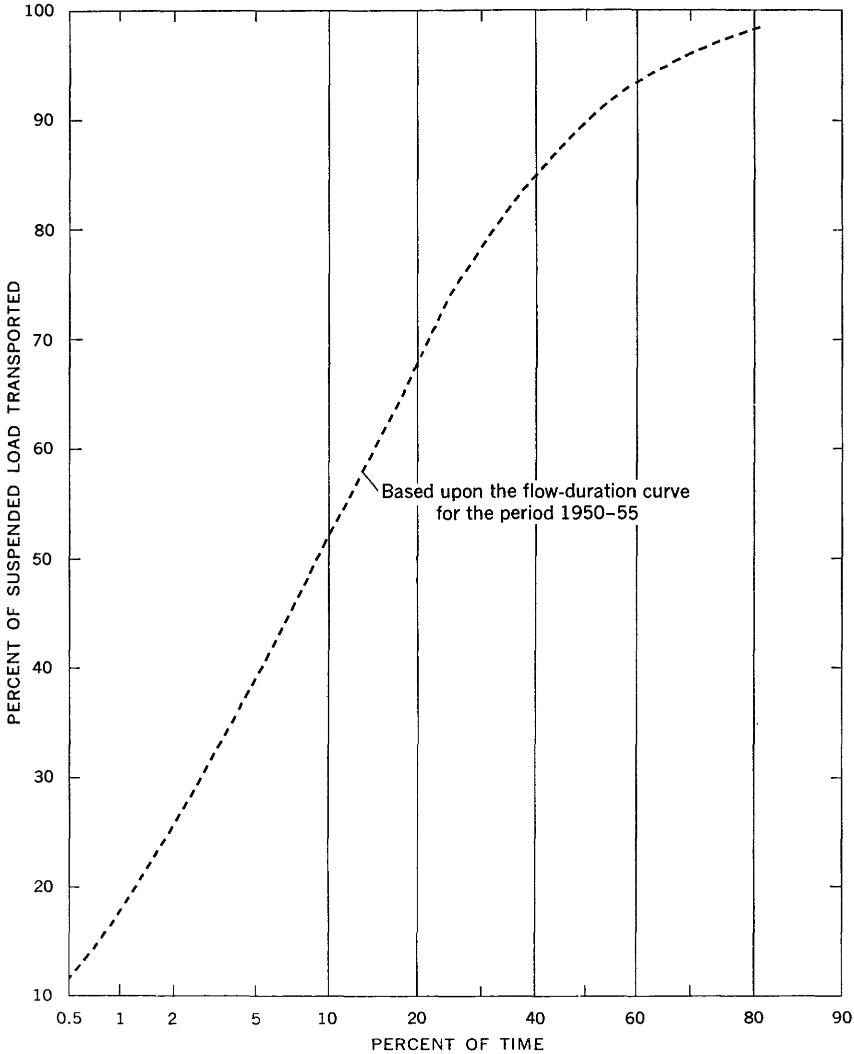

FIGURE 20.—Suspended-sediment load-distribution curve for Ichawaynochaway Creek at Milford, Ga.

TABLE 17.—*Daily suspended-sediment concentration and load, Ichawaynochaway Creek at Milford, Ga., Dec. 16, 1958, to May 15, 1959*

[Suspended-sediment concentration estimated from curve shown on fig. 17 except where otherwise indicated]

Day	Mean discharge (cfs)	Suspended sediment		Mean discharge (cfs)	Suspended sediment		Mean discharge (cfs)	Suspended sediment	
		Mean concentration (ppm)	Load (tons)		Mean concentration (ppm)	Load (tons)		Mean concentration (ppm)	Load (tons)
	December			January			February		
1	---	---	---	573	7	11	618	11	18
2	---	---	---	561	8	12	706	17	32
3	---	---	---	604	8	13	925	[a]22	55
4	---	---	---	650	8	14	1,220	27	89
5	---	---	---	678	9	16	1,540	[a]33	137
6	---	---	---	678	9	16	1,900	40	205
7	---	---	---	604	9	15	2,400	[a]45	292
8	---	---	---	555	10	15	2,500	[a]40	270
9	---	---	---	525	[a]10	14	2,300	[a]32	199
10	---	---	---	531	10	14	1,950	30	158
11	---	---	---	525	9	13	1,670	30	135
12	---	---	---	507	9	12	1,540	30	125
13	---	---	---	471	8	10	1,400	30	113
14	---	---	---	443	[a]8	10	1,270	[a]30	103
15	---	---	---	426	8	9	1,180	27	86
16	741	11	22	477	9	12	1,150	25	78
17	706	11	21	604	11	18	1,150	22	68
18	618	10	17	706	[a]12	23	1,180	[a]20	64
19	537	[a]9	13	783	12	25	1,150	18	56
20	465	8	10	790	11	23	990	16	43
21	410	[a]6	6	706	10	19	892	13	31
22	390	6	6	692	10	19	825	11	25
23	385	6	6	685	9	17	762	[a]8	16
24	385	6	6	699	[a]9	17	734	8	16
25	385	6	6	720	9	18	741	8	16
26	421	6	7	706	9	17	825	10	22
27	448	7	8	650	10	18	925	[a]17	42
28	454	7	9	618	[a]10	17	958	18	47
29	513	7	10	567	10	16	---	---	---
30	579	7	11	531	10	14	---	---	---
31	604	[a]7	11	543	10	15	---	---	---
Total	8,041	---	169	18,808	---	482	35,401	---	2,541

Day	Mean discharge (cfs)	Mean concentration (ppm)	Load (tons)	Mean discharge (cfs)	Mean concentration (ppm)	Load (tons)	Mean discharge (cfs)	Mean concentration (ppm)	Load (tons)
	March			April			May		
1	958	15	39	1,850	20	100	519	16	22
2	892	11	27	1,800	[a]14	68	537	[a]17	25
3	825	[a]8	18	1,850	12	60	495	15	20
4	769	[a]7	15	1,850	12	60	465	15	19
5	825	10	22	1,710	11	51	448	13	16
6	1,580	[a]32	183	1,540	[a]11	46	438	[a]12	14
7	2,400	[a]44	285	1,300	10	35	421	12	14
8	3,870	[a]45	471	1,090	10	29	385	11	11
9	3,730	[a]38	383	990	[a]10	27	375	10	10
10	2,900	[a]35	331	892	11	27	360	[a]9	9
11	2,150	[a]25	145	860	11	25	356	9	9
12	1,710	[a]27	125	825	12	25	360	9	9
13	1,500	24	97	860	[a]12	26	421	9	10
14	1,350	19	69	860	12	26	477	9	12
15	1,540	[a]14	58	825	11	25	513	[a]9	12
16	1,950	[a]10	53	790	11	23	---	---	---
17	2,200	18	107	762	11	23	---	---	---
18	2,350	[a]22	140	720	10	19	---	---	---
19	2,250	21	127	706	10	19	---	---	---
20	1,800	[a]18	88	790	10	21	---	---	---
21	1,540	[a]17	71	892	11	27	---	---	---
22	1,450	17	67	925	11	27	---	---	---
23	1,450	15	59	892	11	27	---	---	---
24	1,400	14	53	825	[a]10	22	---	---	---
25	1,300	[a]13	46	741	10	20	---	---	---
26	1,240	12	40	664	11	20	---	---	---
27	1,240	12	40	611	12	20	---	---	---
28	1,120	[a]12	36	573	[a]13	20	---	---	---
29	1,270	17	58	561	13	20	---	---	---
30	1,900	[a]31	159	543	15	19	---	---	---
31	2,000	26	140	---	---	---	---	---	---
Total	53,459	---	3,552	30,097	---	957	6,570	---	212

[a] At least one water-sediment sample was collected on this date and used in estimating the suspended-sediment load.

ETOWAH RIVER AT CANTON, GA.

The Etowah River drains an area of hilly to mountainous topography. Approximately 15 percent of the drainage basin is cropland and, of this, about one-half is harvested cropland. Topsoils are of loam and sandy loam of the Ashe, Habersham, and Porters series which have formed on gneiss, schist, quartzite, slate, and marble. The relief is great and the streams have much transporting power, but the high proportion of the land covered by permanent vegetation limits the amount of material available for transport. A dam on the Etowah River east of Dawsonville regulates the streamflow from about 15 percent of the drainage area upstream from Canton. No other dams are known which would significantly affect the sediment transported by the Etowah River at Canton.

Suspended-sediment concentration.—The concentration of suspended sediment in samples collected from the Etowah River ranged from about 10 ppm to more than 1,900 ppm, as shown in table 18. Average discharge for the period 1937–57 was 1,059 cfs (U.S. Geol.

TABLE 18.—*Concentration of suspended sediment in samples from the Etowah River at Canton, Ga.*

Date	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)	Date	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)
1957			*1959* (continued)		
Dec. 4	860	11			
			Mar. 6	2,440	318
1958			Mar. 6	2,770	370
Jan. 4	900	10	Mar. 7	2,000	230
Jan. 14	1,290	53	Mar. 7	1,530	132
Jan. 16	1,010	70	Mar. 8	1,310	68
Feb. 18	800	13	Mar. 9	1,200	68
Feb. 24	950	40	Mar. 11	1,030	47
Mar. 5	1,220	64	Mar. 12	1,410	111
Mar. 17	1,290	65	Mar. 12	1,850	167
Mar. 27	3,500	350	Mar. 13	1,600	132
Apr. 8	1,650	93	Mar. 14	1,230	52
Apr. 18	2,060	120	Mar. 15	1,850	252
May 10	1,250	58	Mar. 15	2,380	551
Sept. 11	405	13	Mar. 15	3,750	830
Sept. 29	480	27	Mar. 15	4,000	683
Nov. 15	470	9	Mar. 16	3,650	525
Dec. 14	490	21	Mar. 16	2,300	211
			Mar. 17	1,700	128
1959			Mar. 18	1,420	81
Jan. 15	590	24	Mar. 21	1,230	53
Jan. 16	740	39	Mar. 26	1,020	48
Jan. 16	870	41	Mar. 31	1,280	79
Jan. 18	610	16	Apr. 2	1,980	386
Jan. 21	640	14	Apr. 2	2,150	302
Jan. 21	1,240	92	Apr. 3	1,690	178
Jan. 22	3,050	1,920	Apr. 4	1,400	98
Jan. 22	3,300	1,406	Apr. 5	1,250	71
Jan. 22	4,200	997	Apr. 11	1,380	127
Jan. 23	2,070	376	Apr. 12	2,200	183
Jan. 26	1,000	55	Apr. 13	2,900	327
Feb. 5	1,290	90	Apr. 14	2,040	171
Feb. 13	4,600	810	Apr. 21	1,830	139
Feb. 13	5,900	807	Apr. 26	1,290	82
Feb. 14	7,000	363	May 1	1,100	73
Mar. 5	830	48	May 6	930	47
Mar. 5	940	60	May 11	895	49
Mar. 6	1,520	141	May 15	900	40

Survey, 1959b). In general, the concentration increased with increasing discharge, as indicated by figure 21. Concentration shown represents, in most instances, an average of three samples collected near centroids of water discharge. Although suspended-sediment con-

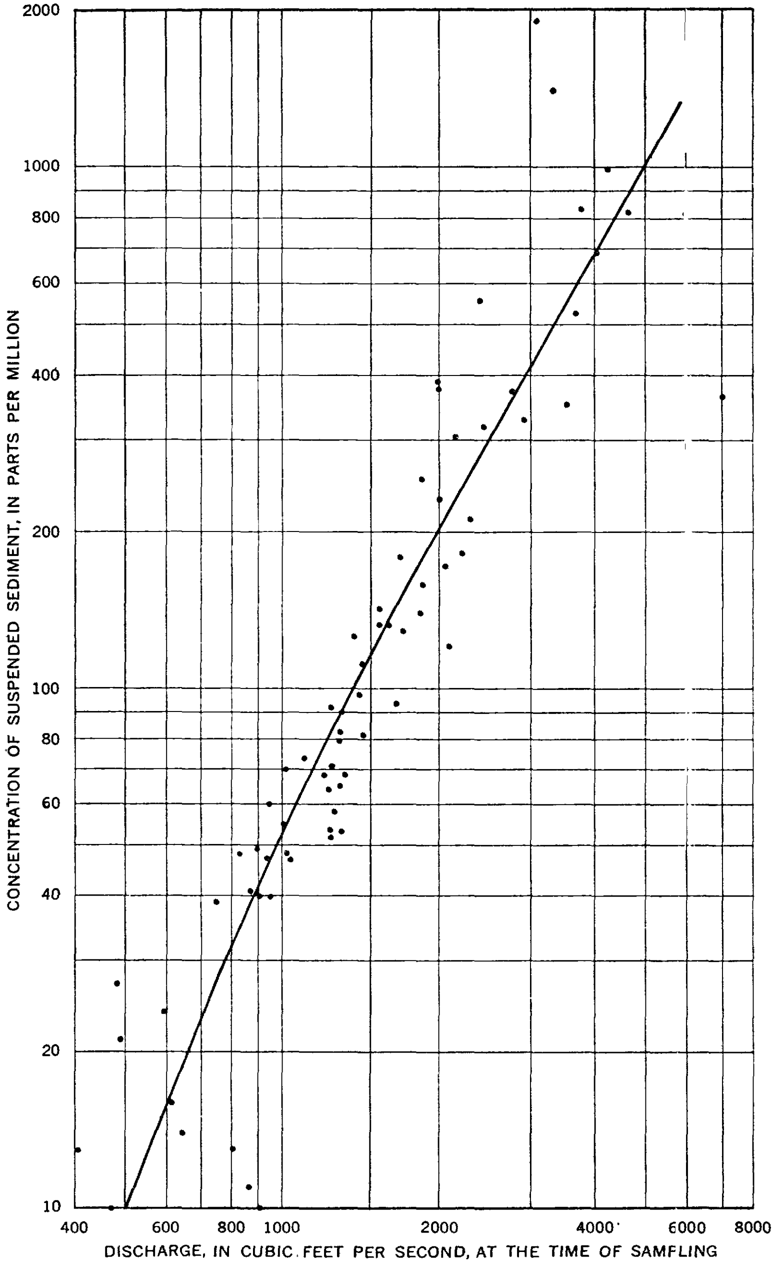

FIGURE 21.—Relation of stream discharge to concentration of suspended sediment in samples from the Etowah River at Canton, Ga.

centration generally increases with increasing water discharge, the correlation is affected—particularly during floods—by the tendency of sediment concentration to reach a maximum before the discharge peak and then to decrease rapidly. This tendency is demonstrated by samples collected during the period Jan. 21–23, 1959, and Mar. 15–17, 1959. (See figs. 22, 23.)

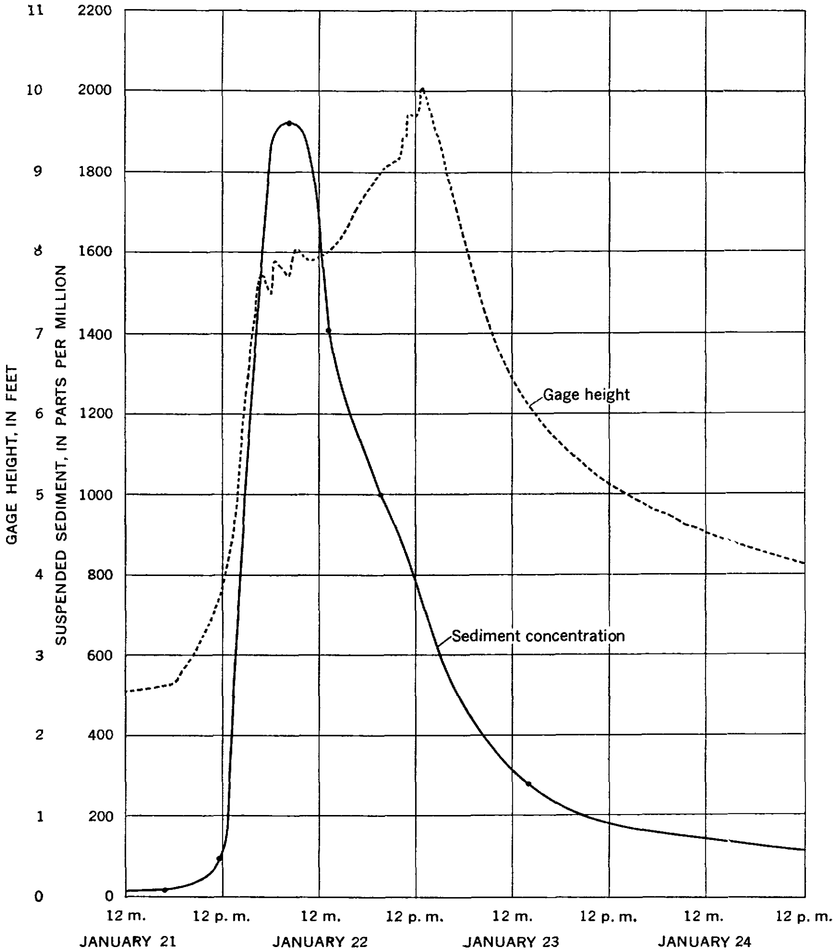

FIGURE 22.—Variation in gage height and concentration of suspended sediment in the Etowah River at Canton, Ga., during the period Jan. 21–24, 1959.

Sediment concentration also shows a variation which is related to the position in the cross section at which the sample was collected. At the south centroid, the sediment concentration was equal to or less than that in samples collected at the other two centroids 36 times out of 52, or in 69 percent of the observations. At the middle centroid, the sediment concentration equaled or exceeded that at the other centroids 39 times out of 52, or in 75 percent of the observations. Thus, there is apparent a well-defined tendency for sediment concentration to be highest near the middle of the stream and lowest on the south side.

Of the 52 sets of samples from the three centroids, 67 percent contained no samples which deviated from the average concentration by more than 28 percent. In 95 percent of these sample sets, no sample differed from the average by more than 52 percent. This variation is an indication of what to be expected in samples collected at the same time but at different places in the cross section of the Etowah River at Canton.

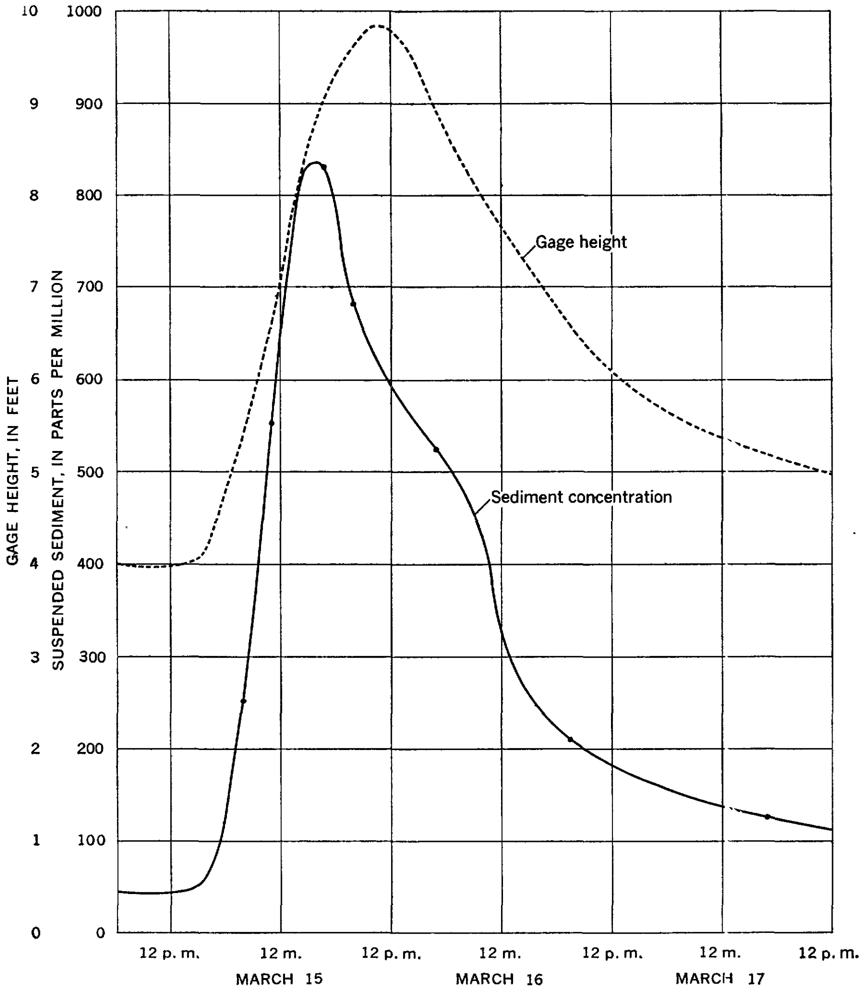

FIGURE 23.—Variation in gage height and concentration of suspended sediment in the Etowah River at Canton, Ga., during the period Mar. 15–17, 1959.

Although relatively high concentration of suspended sediment is characteristic of the Etowah River during floods, the concentration is moderate to low most of the time (fig. 24). During the 1959 water year the concentration was less than 36 ppm during about 50 percent of the time and less than 100 ppm during about 90 percent of the time. If the flow-duration curve for 1950–55 and the concentration-

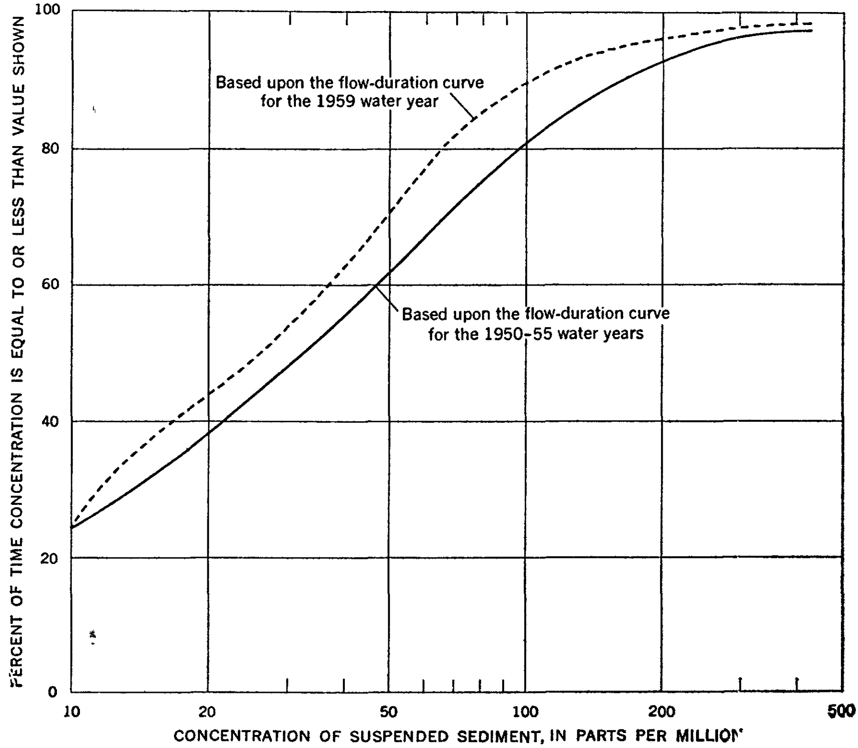

FIGURE 24.—Suspended-sediment concentration-frequency curve for the Etowah River at Canton, Ga.

discharge curve for the 1959 water year be combined, as shown in figure 24, the resulting concentration-frequency curve is displaced in the direction of higher concentrations.

Size distribution of suspended sediment.—Size analyses were made on 15 samples from the Etowah River at Canton (table 19). Samples collected on Jan. 22, 1959, and Feb. 13, 1959, were high in suspended sediment and the percent of sand was low. Samples taken on Mar. 5–8, 1959, had only moderate sediment concentration and the percent of sand was high. No well-defined trends in size distribution were noted during this rise and fall of the river. Size determinations in native water were not markedly different from those made using a dispersing agent.

TABLE 19.—*Particle-size analyses of suspended sediment, Etowah River at Canton, Ga.*

[Method of analysis: B, bottom withdrawal tube; N, in native water; W, in distilled water; C, chemically dispersed; M, mechanically dispersed]

Sample	Date of collection	Time	Discharge (cfs)	Water temperature (°F)	Suspended sediment: Concentration of sample (ppm)	Concentration of suspension analyzed (ppm)	Percent finer than indicated size (mm): 0.004	0.008	0.016	0.031	0.062	0.125	0.250	0.500	Method of analysis
	1959														
1	Jan. 22	12:10 p.m.	3,350	47	1,385	1,610	36	49	63	77	85	91	95	100	BWMC
2	Jan. 22	9:45	4,200	47	1,045	1,090	34	47	60	74	82	88	92	98	BWMC
3	Feb. 13	8:00	3,980	48	831	685	31	39	50	63	69	73	79	97	BWMC
4	Mar. 5	2:00	800	44	148	148	11	20	31	45	50	68	90	98	BWMC
5	Mar. 5	9:00	942	45	66	253	25	33	40	48	57	70	82	94	BWMC
6	Mar. 6	4:45 a.m.	1,550	44	154	294	18	27	35	43	51	67	89	98	BWMC
7	Mar. 6	4:45	1,550	44	161	190	20	35	43	51	67	85	-------	-------	BN
8	Mar. 6	11:45	2,420	44	351	315	18	23	30	37	45	62	80	95	BWMC
9	Mar. 6	5:20 p.m.	2,770	46	310	330	26	38	50	66	76	88	95	99	BWMC
10	Mar. 6	5:50	2,770	46	422	312	24	33	41	51	60	73	85	98	BWMC
11	Mar. 6	6:10	2,770	46	375	318	20	27	37	47	59	74	84	94	BWMC
12	Mar. 7	9:00 a.m.	2,000	45	192	287	20	26	36	48	65	79	90	98	BN
13	Mar. 7	9:00	2,000	45	285	177	20	26	34	46	51	65	81	98	BWMC
14	Mar. 7	11:20 p.m.	1,530	45	127	101	32	39	50	58	62	75	89	97	BWMC
15	Mar. 8	2:15	1,310	47	59	175	22	32	40	50	64	72	81	90	BWMC

Intense rainfall, which may wash much fine-grained material into a river, can cause an increase in the proportion of clay in the suspended sediment, and apparently does so on the Etowah River; a rapid rise on Jan. 22 and Feb. 13, 1959, indicated heavy rainfall, and the suspended sediment consisted of 30 to 35 percent clay. Rainfall of moderate to low intensity on Mar. 5 and 6 caused a slower rise in the river and the suspended sediment contained 20 to 25 percent clay.

The increased proportion of suspended clay in stream water after intense rainfall reflects the fact that fine-grained material is derived mainly from the land surface during storms and that coarse-grained material already in the streambed is the source of much of the sand. Thus the concentration of sand in suspension is related much more to water velocity, which increases with increasing discharge, than to the intensity of rainfall.

A tendency for the proportion of suspended sand to vary with position in the stream cross section is shown by size analyses of samples collected on Mar. 6 and 7, 1959. Samples 9 and 12 (table 19) were obtained at the south centroid of discharge, whereas samples 10 and 13 were collected at the middle centroid. In both instances the concentration of suspended sediment and the proportion of suspended sand were less at the south centroid than at the middle centroid.

Suspended-sediment load.—Daily sediment loads for the period Dec. 16, 1958, to May 15, 1959, are presented in table 20. The relation of the daily load to the daily mean discharge is shown in figure 25. By use of this suspended-sediment transport curve and a flow-duration curve for the 1959 water year, an estimate of approximately 120,000 tons can be made for the suspended-sediment load during the entire year. This load corresponds to a sediment yield for the Etowah drainage basin of about 200 tons per square mile. A suspended-sediment load-duration curve (fig. 26) indicates that more than 75 percent of the annual suspended load is carried during 10 percent of the time.

Total-load estimation computed by the modified Einstein method.—Suspended sediment and bed material were collected at peak discharge on March 6 following rainfall on March 5 and 6. Suspended-sediment concentration in samples taken at nine points in the stream cross section were determined. Size analyses were made for three suspended-sediment and eight bed-material samples. The particle-size distribution of the suspended sediment is given in table 19 for a gage height of 7.40 feet (discharge, 2,770 cfs). The concentration of suspended sediment and the particle-size distribution of the bed material are shown in table 21.

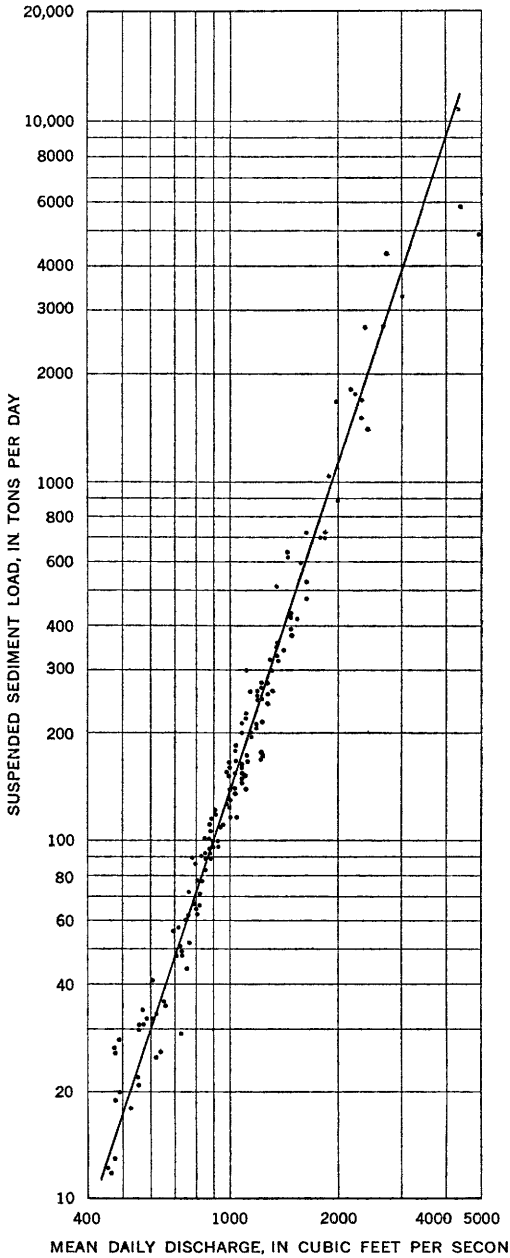

FIGURE 25.—Suspended-sediment transport curve for the Etowah River at Canton, Ga.

The concentration of suspended sediment demonstrates the variation found in the cross section. The size analyses of bed material show most of the material to be in the 0.5 to 1.0 mm size range and therefore of relatively uniform size.

Inasmuch as the average depth of the stream at the time of sampling was 8.05 feet and the average sampled depth was about 7.75 feet, 96 percent of the depth, corresponding to about 98 percent of the flow, was sampled. The instantaneous load in the sampled zone was 2,800 tons per day and the total load estimated by the modified Einstein method (Colby and Hembree, 1955) was 3,200 tons per day. Thus the estimated load in the unsampled zone was equal to 15 percent of the load in the sampled zone.

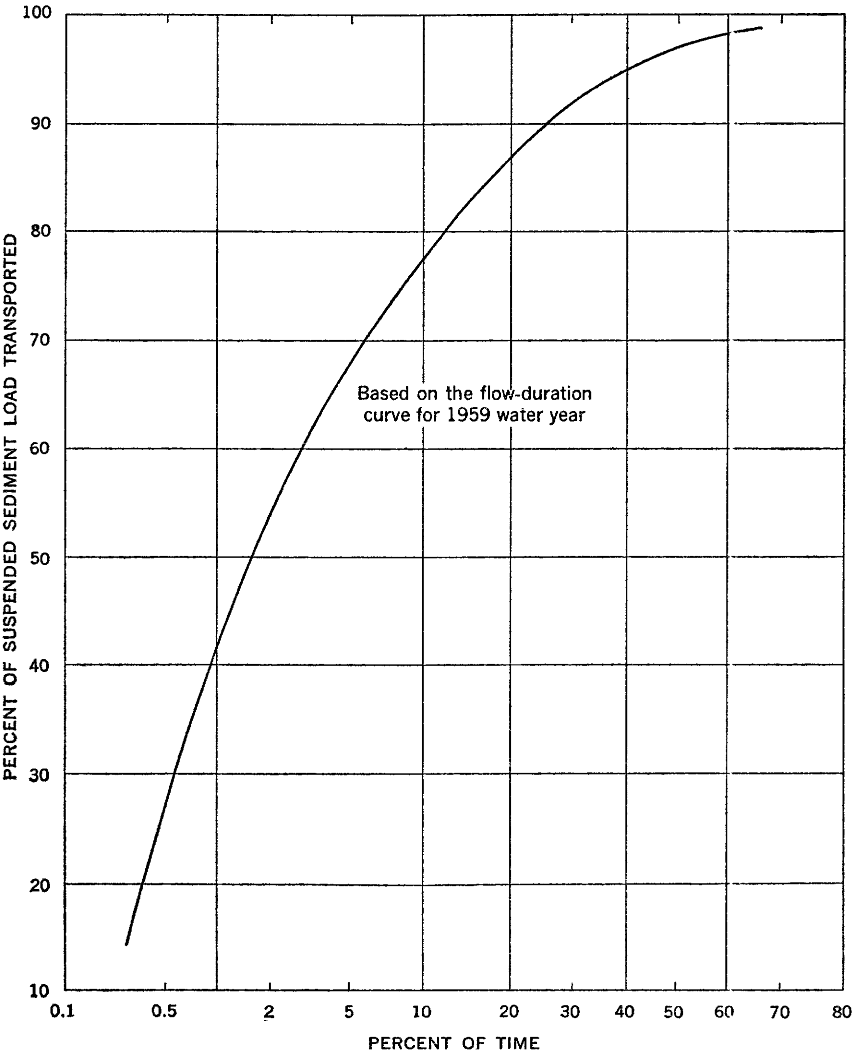

FIGURE 26.—Suspended-sediment load-distribution curve for the Etowah River at Canton, Ga., for the 1959 water year.

TABLE 20.—*Daily suspended-sediment concentration and load, Etowah River at Canton, Ga., Dec. 16, 1958, to May 15, 1959*

[Suspended-sediment concentration estimated from curve shown on fig. 21 except where otherwise indicated]

Day	Mean discharge (cfs)	Suspended sediment: Mean concentration (ppm)	Suspended sediment: Load (tons)	Mean discharge (cfs)	Suspended sediment: Mean concentration (ppm)	Suspended sediment: Load (tons)	Mean discharge (cfs)	Suspended sediment: Mean concentration (ppm)	Suspended sediment: Load (tons)
	December			January			February		
1				710	25	48	746	30	60
2				952	43	111	728	25	49
3				914	40	99	728	25	49
4				764	35	72	838	40	91
5				692	30	56	1,180	[a] 78	248
6				603	25	41	1,030	60	167
7				603	20	32	857	40	92
8				620	20	33	800	30	65
9				710	30	57	800	30	65
10				656	25	44	819	30	66
11				586	20	32	1,070	55	159
12				570	20	31	1,070	40	116
13				554	20	30	4,400	[a] 464	[b] 5,800
14				554	20	30	4,940	[a] 320	4,880
15				570	[a] 22	34	2,420	215	1,400
16	490	21	28	782	[a] 42	89	1,840	145	720
17	474	20	26	800	40	86	1,530	100	413
18	474	20	26	656	[a] 20	35	1,400	90	340
19	490	15	20	620	15	25	1,260	80	272
20	474	15	19	638	15	26	1,100	73	217
21	474	10	13	728	[a] 52	[b] 29	1,030	66	184
22	458	10	12	4,300	[a] 1,220	[b] 10,750	990	57	152
23	458	10	12	2,370	[a] 357	[b] 2,670	990	48	128
24	554	15	22	1,350	140	510	1,100	47	140
25	656	20	35	1,100	100	297	990	46	123
26	554	14	21	990	[a] 60	160	933	43	109
27	522	13	18	876	40	95	914	40	99
28	990	57	152	819	35	77	876	39	93
29	1,300	90	316	764	30	62			
30	895	41	99	764	25	52			
31	728	26	51	800	30	65			
Total	9,991		870	28,415		15,778	37,379		16,297

Day	Mean discharge (cfs)	Suspended sediment: Mean concentration (ppm)	Suspended sediment: Load (tons)	Mean discharge (cfs)	Suspended sediment: Mean concentration (ppm)	Suspended sediment: Load (tons)	Mean discharge (cfs)	Suspended sediment: Mean concentration (ppm)	Suspended sediment: Load (tons)
	March			April			May		
1	876	38	90	1,220	81	266	1,070	[a] 73	211
2	857	36	83	1,980	[a] 309	[b] 1,670	1,070	69	199
3	838	34	77	1,620	[a] 165	722	1,030	64	178
4	819	32	71	1,350	[a] 95	346	990	60	160
5	857	[a] 40	92	1,220	[a] 70	267	952	54	139
6	2,220	[a][b] 276	[b] 1,740	1,180	65	207	914	[a] 49	121
7	1,890	[a][b] 212	[b] 1,030	1,140	61	195	914	48	118
8	1,350	[a] 87	317	1,100	56	166	876	47	111
9	1,180	[a] 66	210	1,070	53	153	857	44	102
10	1,100	58	172	990	47	126	876	43	102
11	1,030	[a] 55	153	1,440	[a] 162	630	895	[a] 48	116
12	1,580	[a][b] 130	[b] 594	2,320	[a] 233	[b] 1,510	876	45	107
13	1,480	[a] 105	421	2,680	[a] 370	[b] 2,690	990	43	115
14	1,220	[a] 51	168	1,940	[a] 165	[b] 884	1,070	50	145
15	2,740	[a] 488	[b] 4,300	1,620	120	526	895	[a] 40	97
16	3,010	[a] 362	[b] 3,240	1,440	109	630			
17	1,800	[a] 143	695	1,350	96	350			
18	1,480	[a] 94	386	1,350	90	328			
19	1,300	74	260	2,170	295	[b] 1,800			
20	1,220	65	214	2,320	270	1,690			
21	1,220	[a] 53	175	1,840	[a] 140	696			
22	1,220	51	168	1,620	107	469			
23	1,100	51	152	1,480	93	372			
24	1,070	51	148	1,350	89	324			
25	1,030	50	139	1,300	85	298			
26	1,030	[a] 48	134	1,220	[a] 83	273			
27	1,140	62	198	1,180	81	258			
28	1,220	75	247	1,140	81	259			
29	1,070	56	162	1,180	79	252			
30	1,260	71	241	1,100	76	226			
31	1,260	[a] 75	255						
Total	41,467		16,332	44,910		18,583	14,275		2,021

[a] At least one water-sediment sample was collected on this date and used in estimating the suspended-sediment load.
[b] Computed by subdividing day.

TABLE 21.—*Concentration of suspended sediment and particle-size distribution of bed material from the Etowah River at Canton, Ga., Mar. 6, 1959*

Station	Percent of bed material in each size fraction (size range in mm)							Suspended-sediment concentration (ppm)
	0.0625–0.125	0.125–0.25	0.25–0.5	0.5–1.0	1.0–2.0	2.0–4.0	>4.0	
154	2.6	6.5	14.1	60.6	15.2	0.9	0.1	318
173	.1	.5	5.0	59.8	31.8	2.2	.6	310
183	.1	1.1	16.5	50.0	27.3	3.8	1.2	417
192	.1	1.7	24.8	47.5	19.5	4.5	1.9	373
202	.1	3.1	36.6	42.8	14.0	2.6	.8	422
209	.1	1.4	22.4	57.9	16.5	1.4	.3	451
216	.1	1.3	18.4	48.5	20.9	7.1	3.7	375
223	---	---	---	---	---	---	---	343
240	.1	.8	15.0	7.0	10.9	1.1	.1	317

OOSTANAULA RIVER AT CALHOUN, GA.

The drainage basin of the Oostanaula River lies partly in the mountainous Blue Ridge province and partly in the Valley and Ridge province. Near the head of the Oostanaula drainage basin, valleys are narrow and stream gradients are high. After the streams leave the mountains, valleys are wide, the streams meander, and gradients are relatively low. The soils in the Blue Ridge province are commonly of loam on the slopes and of silt loam in the valley bottoms. In the Valley and Ridge province most soils are of silt loam, but the soils on the ridges tend to be more rocky than those of the valleys.

Runoff from the drainage basin above Resaca, Ga., 6.5 miles upstream from Calhoun, averages 1.06 mgdsm.

Cropland constitutes only 4 to 7 percent of the area in the upper drainage basin and harvested cropland 2.5 to 5 percent. In the lower drainage basin, where river valleys are broad and the relief is less, 15 to 25 percent of the area is cropland and 10 to 15 percent is harvested cropland.

Although there are a few small dams on tributaries to the Oostanaula, no large reservoirs are located upstream from Calhoun. Thus, very little sediment is removed from the water by deposition in reservoirs. Average discharge for the period 1937–57 is estimated as 1,149 cfs (U.S. Geol. Survey, 1959b).

Suspended-sediment concentration.—Water-sediment samples were collected from the bridge over the Oostanaula River on Georgia Route 143 at Calhoun during the period Nov. 16, 1958, to May 15, 1959. Samples were collected at three stations in the cross section near the centroids of discharge corresponding to a gage height of 3 feet. At gage heights above 4 feet, the distribution of water discharge in the channel changed considerably, and sampling was also done at a fourth station in the cross section.

The suspended-sediment concentration determined in 43 samples is shown in table 22; the concentrations are plotted against discharge in figure 27. No samples were obtained during the rising stage of the

Apr. 19–23, 1959, flood, so a comparison between rising and falling stages cannot be made. However, during the flood of Feb. 13–15, 1959, the suspended-sediment concentration reached a maximum before the discharge peak and then decreased. Probably the sediment concentration also peaked before the discharge maximum during the flood of April 19–23; if so, samples collected on the rising stage would have plotted on figure 27 more nearly in line with the other data. The

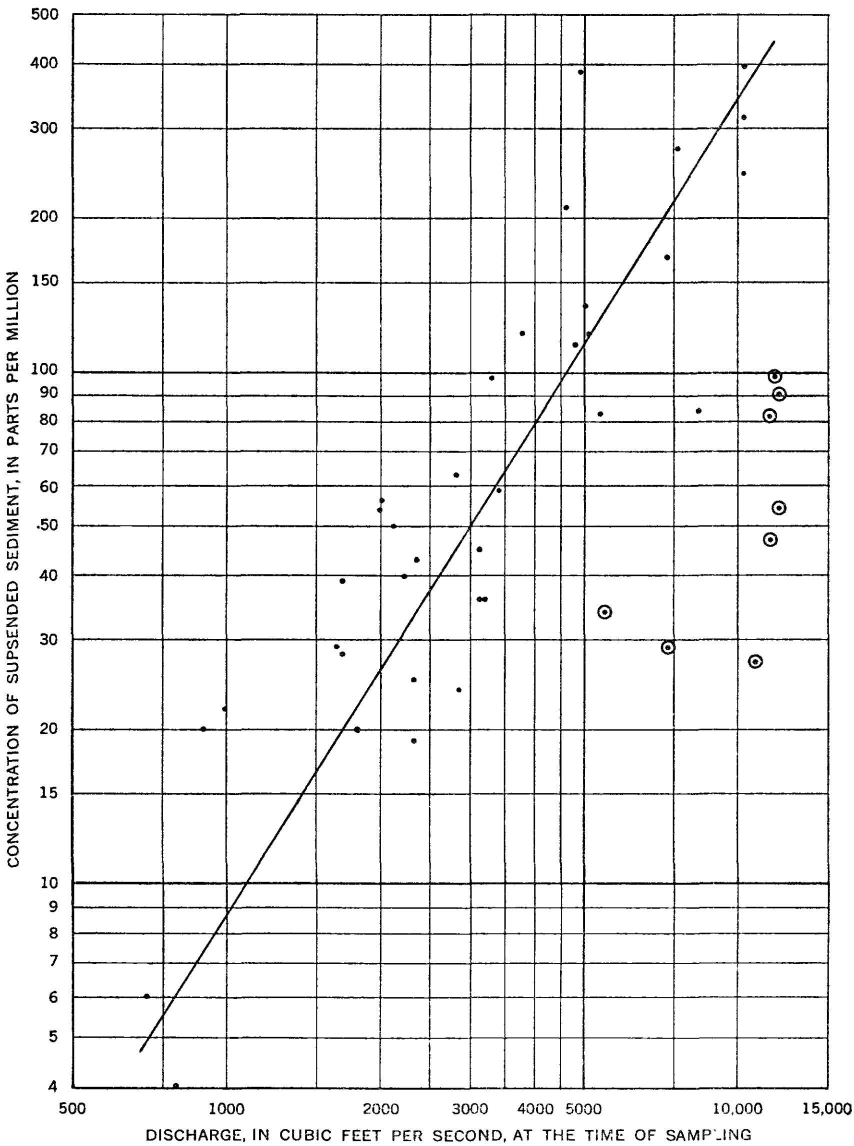

FIGURE 27.—Relation of stream discharge to concentration of suspended sediment in samples from the Oostanaula River at Calhoun, Ga. Points enclosed in circles designate samples collected after the crest of the flood of Apr. 19–23, 1959.

concentration in samples collected during smaller floods does not show this great deviation from the median line. It seems possible that the larger the flood and the longer the water is high, the farther the points will plot from the line extrapolated from smaller floods.

TABLE 22.—*Concentration of suspended sediment in samples from the Oostanaula River at Calhoun, Ga.*

Date	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)	Date	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)
1958			*1959*—Continued		
Nov. 16	700	6			
Dec. 15	790	4	Mar. 6	5,050	135
Dec. 26	920	20	Mar. 7	5,100	124
			Mar. 8	3,200	36
1959			Mar. 9	2,820	24
Jan. 6	995	22	Mar. 10	2,330	25
Jan. 17	4,600	221	Mar. 12	3,400	59
Jan. 18	3,300	98	Mar. 13	3,100	45
Jan. 19	2,120	50	Mar. 16	7,220	168
Jan. 21	1,680	28	Mar. 17	5,350	83
Jan. 21	4,900	387	Mar. 18	3,180	36
Jan. 22	10,500	394	Mar. 20	2,320	19
Jan. 23	10,250	314	Mar. 23	2,220	40
Jan. 27	2,350	43	Apr. 14	8,350	84
Feb. 10	1,680	39	Apr. 20	12,200	90
Feb. 11	2,000	56	Apr. 21	11,700	98
Feb. 13	7,600	272	Apr. 21	11,500	82
Feb. 14	10,200	243	Apr. 22	11,500	54
Feb. 26	1,800	20	Apr. 22	11,600	47
Mar. 5	1,640	29	Apr. 23	10,800	27
Mar. 5	1,980	54	Apr. 24	7,400	29
Mar. 6	2,800	63	Apr. 24	5,450	34
Mar. 6	3,800	121	May 15	1,620	30

The distribution of suspended sediment across the width of the Oostanaula at Calhoun is fairly uniform. Of the 29 sets composed of at least three valid samples, 67 percent contained no samples which deviated from the average concentration by more than 22 percent, and 95 percent of the sets contained no samples deviating by more than 50 percent.

If the median line of figure 27 is assumed to represent the normal relation of concentration to discharge, curves can be drawn to estimate the percent of time that the concentration is equal to or less than a given value. In figure 28 the concentration-discharge relation has been combined with flow-duration data for the 1959 water year to give a concentration-frequency curve. If the average flow-duration curve for the 1950–55 water years is used, a different concentration-frequency curve results. Because data from a few months' sampling cannot be expected to be exactly typical of much longer periods, these curves permit only a rough estimate of the frequency of occurrence of certain suspended-sediment concentrations. In general, the estimated frequency of occurrence of a given concentration will be most accurate if it is near the middle part of the curve. Accurate data for the upper and lower ranges of the concentration-frequency curves can be obtained only by sampling over a long period of time.

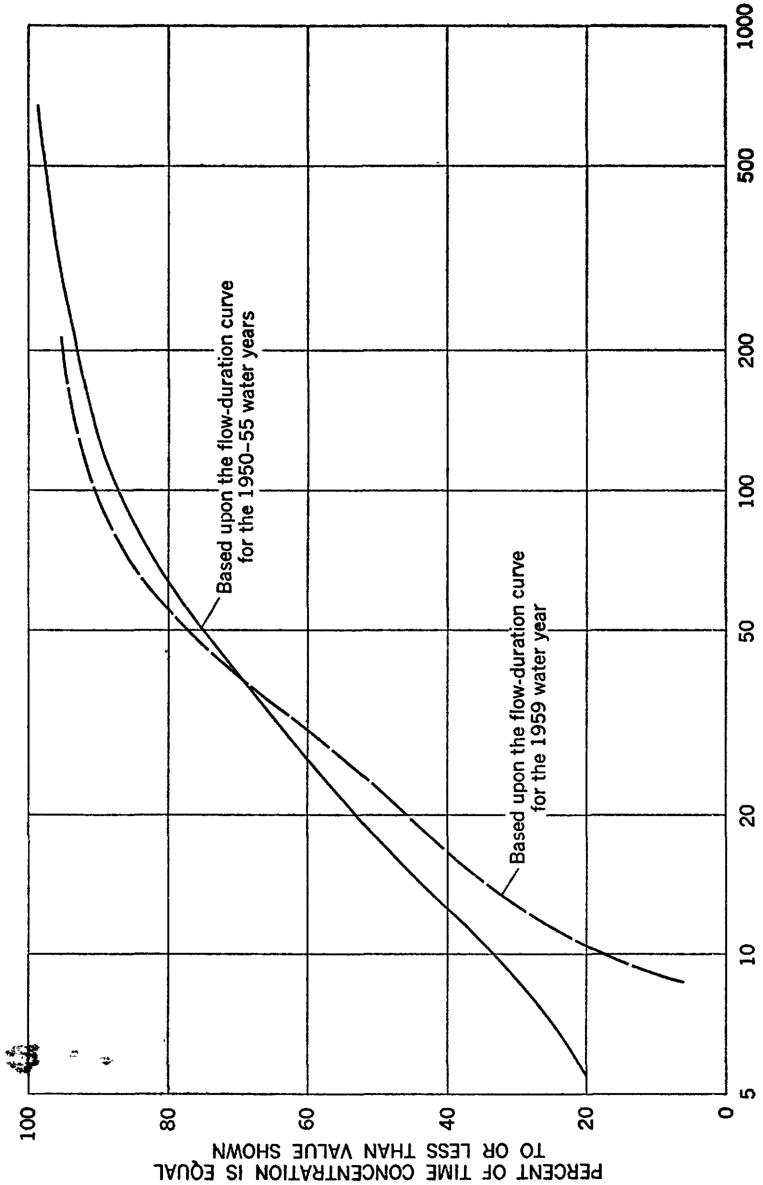

FIGURE 28.—Suspended-sediment concentration-frequency curve for the Oostanaula River at Calhoun, Ga.

Size distribution of suspended sediment.—Suspended-sediment samples collected during five different floods were subjected to size analysis. The particle-size distribution is shown in table 23. Little sand is carried by the Oostanaula at Calhoun compared to the Etowah River at Canton. The upper part of the Oostanaula drainage basin resembles the Etowah basin, so the character of the stream sediments in the two basins might logically be expected to be similar. However, the Oostanaula flows through the Valley and Ridge province after leaving the mountains, and changed stream gradients and addition of fine-grained sediments may cause a decrease in the proportion of sand in the stream sediments.

Samples 8 through 16 (table 23) were collected at various times during the rise and fall of the river in the period March 6–8. It is probable that the river crested between 7 and 8 a.m., March 7, at a discharge of about 5,300 cfs. No consistent changes in grain-size distribution were noted as the stream rose and fell. Considerable variation in size distribution was found in samples 8 through 11, which were collected between 2 and 3 p.m., March 7, at various points in the cross section. This variation suggests that, on river rises of only a few feet, the range in grain-size distribution may be as great in the cross section at any one time as it is throughout the period of the rise and fall of the river.

The average size distribution of the suspended sediment in samples analyzed was as follows: 6 percent sand, 36 percent silt, and 58 percent clay.

Suspended-sediment load.—The suspended-sediment load for the 5-month sampling period was calculated by using a discharge versus load (sediment-transport) curve. Approximately 150,000 tons of sediment was carried from Dec. 15, 1958, to May 15, 1959. During this period about 63 percent of the annual discharge occurred and an estimated 75 percent of the annual suspended-sediment load was carried. It seems probable, therefore, that the suspended-sediment load for the 1959 water year was about 200,000 tons. This load corresponds to an average sediment yield of 125 tons per square mile of drainage area. The estimate is only an approximation because no samples were collected during several floods.

Size distribution of bed material.—Bed-material samples were collected on Mar. 7, 1959, when the discharge was 5,100 cfs. An attempt was made to get samples at 12 points in the cross section, but sand was found at only three points. The particle-size distribution in the three samples of bed material is given in table 24. The lack of sufficient bed-material samples makes it impossible to calculate a bed load for the Oostanaula River; however, the fact that sandy material was present on the bed at only 25 percent of the points tested suggests either that not much sand was available for transport or that the stream

TABLE 23.—*Particle-size analyses of suspended sediment, Oostanaula River at Calhoun, Ga.*

[Method of analysis: B, bottom withdrawal tube; N, in native water; W, in distilled water; C, chemically dispersed; M, mechanically dispersed]

Date of collection	Time	Discharge (cfs)	Water temperature (° F)	Suspended sediment										Method of analysis
				Concentration of sample (ppm)	Concentration of suspension analyzed (ppm)	Percent finer than indicated size (mm.)								
						0.004	0.008	0.016	0.031	0.062	0.125	0.250	0.500	
1959														
Jan. 21	8:45 p.m.	4,900	49	459	654	56	72	84	94	97	98	99	99	BWMC
Jan. 22	5:30	10,600	47	407	546	60	74	84	92	96	98	99	99	BWMC
Jan. 22	5:30	10,600	47	358	521	62	74	86	94	96	98	99	99	BWMC
Jan. 22	5:30	10,600	47	416	473	60	68	83	91	93	96	98	99	BWMC
Jan. 23	4:45	10,300	45	310	447	66	75	81	89	91	93	94	97	BWMC
Feb. 13	6:00	7,400	50	222	302	44	56	74	91	94	99	99	100	BWMC
Feb. 14	3:30	10,300	57	187	212	46	60	73	80	90	97	99	100	BWMC
Mar. 6	7:00 a.m.	2,800	46	51	90	56	69	83	87	88	90	92	94	BWMC
Mar. 6	2:30 p.m.	3,850	47	148	520	38	46	62	91	98	99	99	100	BWMC
Mar. 6	11:45	5,000	44	116	307	47	61	75	83	92	96	98	100	BWMC
Mar. 7	2:10	5,100	47	130	141	59	73	87	93	95	96	97	98	BWMC
Mar. 7	2:35	5,100	53	150	245	54	77	89	95	98	99	99	100	BWMC
Mar. 7	2:55	5,050	47	126	147	62	72	74	84	88	90	92	94	BWMC
Mar. 7	3:00	5,050	47	152	156	68	79	85	87	88	89	90	92	BWMC
Mar. 7	7:00	4,800	44	119	119	68	88	94	96	100	100	100	100	BWMC
Mar. 8	10:00 a.m.	3,900	46	90	211	48	64	89	95	96	98	99	99	BWMC
Mar. 16	4:30 p.m.	7,100	53	139	132	68	78	86	91	95	99	99	100	BWMC
Apr. 20	10:45	12,200	63	92	319	68	75	82	88	91	94	96	98	BWMC
Apr. 21	9:10 a.m.	10,800	61	81	201	59	71	83	90	92	95	97	99	BWMC
Apr. 22	9:30	10,700	60	51	150	64	79	87	91	94	96	98	99	BWMC

velocity was high enough to sweep the bed clear of sand. If not much sand was available, the bed load was probably a small fraction of the total load. If the velocity of the water was sweeping the bed clean, then the sand should have been in suspension or bouncing along the bottom. Most of that in suspension would be sampled by the suspended-sediment sampler and measured. Therefore, it seems probable that bed load did not constitute an appreciable fraction of the total load at the time of sampling.

TABLE 24.—*Particle-size distribution of bed material from the Oostanaula River at Calhoun, Ga., Mar. 7, 1959*

Size range (mm)	Weight percent		
	Station 107	Station 127	Station 206
>4	0.1	<0.1	2.3
2–4	.1	.4	14.7
1–2	4.9	20.6	54.2
0.5–1	53.4	55.9	18.7
0.25–0.5	39.4	21.4	9.2
0.125–0.25	1.5	1.4	.9
0.062–0.125	.5	.3	<.1
<0.062	.1	<.1	<.1

SITES OF OCCASIONAL SAMPLING

BRIER CREEK AT MILLHAVEN, GA.

Brier Creek originates just above the Fall Line in Warren and McDuffie Counties. It flows southeastward through the upper Coastal Plain and into the lower Coastal Plain before joining the Savannah River. Relief is low, and soils are sandy in the drainage basin.

Suspended-sediment concentration.—Suspended-sediment data collected from Brier Creek during the period Dec. 21, 1957, to Sept. 30, 1959, are shown in table 25. It is apparent that there is little correlation between sediment concentration and stream discharge. With three exceptions, all samples contained less than 9 ppm. It seems reasonable to conclude, therefore, that the suspended-sediment concentration is less than 10 ppm most of the time.

Particle size of suspended sediment.—One sample of suspended sediment (Sept. 30, 1959) was subjected to size analysis. The amount of sediment available was very low (16 ppm in the stream), and the analysis is accordingly only semiquantitative. Of the sediment present, approximately 85 percent was finer than 0.0039 mm. The remaining sediment was in the size range 0.0039 to 0.0156 mm.

Suspended-sediment load.—The sediment load can be only approximated with the limited available data. The average concentration of suspended sediment in Brier Creek is probably about 15 ppm. Such an estimate is based on the assumption of a slight increase in sediment concentration with increasing stream discharge. The annual suspended-sediment load is approximately 9,000 tons, based on the above estimates of discharge and load. This load corresponds to an annual suspended-sediment yield of 14 tons per square mile.

TABLE 25.—*Concentration of suspended sediment in samples from Brier Creek at Millhaven, Ga.*

[Average discharge: 1937–56, 613 cfs (U.S. Geol. Survey, 1958, p. 294)]

Date	Time	Gage height (feet)	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)	Ratio of instantaneous discharge to average discharge
1957					
Dec. 21	6:05 p.m.	6.05	903	4	1.47
1958					
Jan. 14	10:45 a.m.	5.45	831	3	1.35
Feb. 4	1:30 p.m.	6.13	1,042	4	1.71
Feb. 25	1:15	5.00	710	3	1.16
Feb. 27	3:30	6.30	1,101	6	1.80
Mar. 10	11:30 a.m.	7.30	1,511	3	2.46
Mar. 12	1:30 p.m.	7.36	1,535	4	2.50
Mar. 21	11:05 a.m.	6.55	1,192	5	1.94
Apr. 1	11:55	6.72	1,263	7	2.06
Apr. 14	11:50	7.00	1,377	7	2.25
Apr. 25	10:55	6.81	1,295	7	2.11
July 14	1:00 p.m.	5.20	762	8	1.24
Aug. 6	12:30	1.90	218	17	.36
Sept. 23	11:30 a.m.	1.99	228	7	.37
Dec. 5	1:00 p.m.	2.70	306	6	.50
1959					
Jan. 13	5:20	4.00	491	6	.80
Feb. 9	10:45 a.m.	6.65	1,233	6	2.01
Feb. 9	2:15 p.m.	6.58	1,205	4	1.97
Feb. 13	10:50 a.m.	7.31	1,516	4	2.47
Mar. 12	8:00 p.m.	8.62	2,232	12	3.64
May 13	10:45 a.m.	2.20	250	5	2.04
Sept. 30	10:30	4.88	680	16	1.11

No samples of bed material were collected during high water on Brier Creek. However, Brier Creek is believed to be a sand-bed stream, and the sandy soils of the drainage basin, when eroded, would be expected to contribute mostly sand to the stream sediment load. Thus it is possible that bed load constitutes the major part of the total sediment load carried by Brier Creek.

ROCKY COMFORT CREEK NEAR LOUISVILLE, GA.

The headwaters of Rocky Comfort Creek lie in Warren County just above the Fall Line. The stream flows through the rolling hills of the upper Coastal Plain in an area of predominantly sandy soils before flowing into the Ogeechee River near Louisville. A small dam, about 6 miles upstream from the sampling site, probably causes deposition of some of the sediment load.

Suspended-sediment concentration.—Information obtained during the period December 1957 to December 1958 is tabulated in table 26. The data are very similar to those obtained for Brier Creek, and therefore it can reasonably be expected that the sediment-transport characteristics are similar to Brier Creek. No gaging station is maintained on Rocky Comfort Creek and discharge data are not available.

TABLE 26.—*Concentration of suspended sediment in samples from Rocky Comfort Creek near Louisville, Ga.*

[Rainfall data from U.S. Weather Bureau (1958)]

Date	Time	Suspended-sediment concentration (ppm)	Date	Time	Suspended-sediment concentration (ppm)
1957			*1958*—Continued		
Dec. 10	11:30 a.m.	5	Mar. 21	1:05	4
1958			Apr. 1	1:50	5
Jan. 13	4:55 p.m.	5	Apr. 14	1:30	6
Jan. 22	1:35	3	Apr. 15	12:00 m.	[1] 11
Feb. 4	4:15	4	Apr. 25	12:20 p.m.	7
Feb. 25	11:30 a.m.	8	May 27	2:40	[2] 12
Mar. 6	1:15 p.m.	6	July 9		[3] 52
Mar. 10	1:05	9	Dec. 8	2:05	10
Mar. 12	4:00	6			

[1] 2.75 inches of rain fell in Louisville this date.
[2] Less than 0.01 inch of rain fell in Louisville, May 25–28, 1958.
[3] About 2 inches of rain fell in the drainage basin on this date.

OGEECHEE RIVER NEAR LOUISVILLE, GA.

The Ogeechee River originates in Green and Taliaferro Counties above the Fall Line and flows southeastward across the Coastal Plain. The topography is gently rolling, and soils are generally sandy.

Suspended-sediment concentration.—Suspended-sediment data collected for the Ogeechee River near Louisville during the period December 1957 to December 1958 are shown in table 27. No stage recorder is operated at this station, and gage heights are available for only a few samples; discharge data are not available. Examination of the data indicates that suspended-sediment concentration is less than 10 ppm most of the time and that there is no well-defined correlation between gage height and suspended-sediment concentration.

TABLE 27.—*Concentration of suspended sediment in samples from the Ogeechee River near Louisville, Ga.*

[Rainfall data from U.S. Weather Bureau (1958)]

Date	Time	Suspended-sediment concentration (ppm)	Gage height (feet)
1957			
Dec. 10	1:30 p.m.	6	10.1
Dec. 21	3:30	3	9.08
1958			
Jan. 13	4:10	14	
Jan. 22		5	8.18
Feb. 25	11:15	4	
Mar. 6	12:00 m.	14	10.8
Mar. 10	1:30 p.m.	3	
Mar. 12	4:15	9	
Mar. 21	1:50	7	
Apr. 1	2:20	9	
Apr. 14	2:00	5	
Apr. 15	10:45 a.m.	[1] 4	12.00
Apr. 25	12:45 p.m.	6	
May 27	12:40	18	5.35
July 9		[2] 49	
Aug. 12	11:50 a.m.	20	3.95
Sept. 16	12:40 p.m.	23	
Sept. 22	12:30	6	
Dec. 8	12:15	3	

[1] 2.75 inches of rain fell in Louisville on this date.
[2] About 2 inches of rain fell in the drainage basin on this date.

CANOOCHEE RIVER NEAR CLAXTON, GA.

The Canoochee River drainage lies entirely within the lower Coastal Plain in an area of low relief and generally well-drained sandy soils.

Suspended-sediment concentration.—Information obtained during the period December 1957 to May 1959 is presented in table 28. The relation of stream discharge to suspended-sediment concentration is not consistent, but the sediment concentration is probably less than 10 ppm at least 50 percent of the time.

Suspended-sediment load.—If the average suspended-sediment concentration is estimated to be 20 ppm, the average annual load would be about 8,000 tons, which corresponds to a suspended-sediment yield of 14 tons per square mile.

TABLE 28.—*Concentration of suspended sediment in samples from the Canoochee River near Claxton, Ga.*

[Average discharge: 1937-57, 397 cfs]

Date	Time	Gage height (feet)	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)	Ratio of instantaneous discharge to average discharge
1957					
Dec. 22	10:25 a.m.	5.08	690	4	1.74
1958					
Mar. 12	8:00	11.90	3,400	6	8.56
Mar. 13	12:00 m.	11.50	3,010	29	7.58
Apr. 25	10:15 a.m.	7.39	1,060	10	2.67
July 14	4:10 p.m.	5.62	735	34	1.85
Aug. 4	4:30	2.18	111	10	.28
Dec. 6	9:45 a.m.	1.69	27	4	.07
1959					
Feb. 5	10:10	8.24	1,265	27	3.20
Feb. 9	11:35	10.00	1,930	5	4.86
Feb. 10	10:15	10.40	2,140	5	5.39
Feb. 13	12:20 p.m.	9.80	1,840	5	4.63
Mar. 13	8:50 a.m.	9.80	1,840	6	4.63
May 12	5:00 p.m.	1.70	27	10	.07

OCMULGEE RIVER AT MACON, GA.

The Ocmulgee River heads in DeKalb and Gwinnett Counties and flows southeastward across the Piedmont and part of the Coastal Plain before joining the Oconee River to form the Altamaha River. The topography in the drainage basin above Macon is rolling to hilly, and soils range from sandy loam to clay loam. Lloyd Shoals dam lies about 42 miles upstream from Macon and probably traps much of the sediment from the upper part of the drainage basin. The drainage area above Macon is approximately 2,240 square miles (U.S. Geol. Survey, 1959b, p. 21), and the drainage area above the Lloyd Shoals dam is about 1,400 square miles.

Suspended-sediment concentration.—Data collected during the period December 1957 to January 1959 are shown in table 29. These data indicate that there is a poorly defined positive correlation between stream discharge and suspended-sediment concentration. Samples were not obtained at high stages, so prediction of suspended-sediment concentration under such conditions is not possible. Sediment concentration was less than 30 ppm in samples collected when the discharge was less than average.

TABLE 29.—*Concentration of suspended sediment in samples from the Ocmulgee River at Macon, Ga.*

[Average discharge: 1893–1911 and 1931–57, 2,591 cfs (U.S. Geol. Survey, 1959b, p. 2?)]

Date	Time	Gage height (feet)	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)	Ratio of instantaneous discharge to average discharge
1957					
Dec. 16	5:10 p.m.	5.27	1,430	28	0.55
1958					
Jan. 28	1:10	9.21	3,600	37	1.39
Feb. 24	4:00	9.44	3,780	40	1.46
Mar. 7	10:30 a.m.	10.56	4,550	111	1.75
Mar. 20	1:25 p.m.	10.60	4,600	26	1.77
Mar. 31	2:45	11.34	5,100	24	1.97
Apr. 7	3:40	12.54	6,200	84	2.39
Apr. 10	10:00 a.m.	13.40	6,900	107	2.66
Apr. 24	12:45 p.m.	10.92	4,800	44	1.85
Aug. 11	4:30	4.41	1,040	16	.40
Sept. 18	12:30	4.1	890	10	.34
Oct. 30	3:00	3.80	760	3	.29
Dec. 18	10:10 a.m.	4.26	960	7	.37
1959					
Jan. 26	3:00 p.m.	6.74	2,170	26	.84

Suspended-sediment load.—The information available does not permit an accurate estimate of the annual load at Macon. However, the sediment accumulation in Lloyd Shoals reservoir for the period December 1910 to March 1935 is known (Federal Inter-Agency Committee on Water Resources, 1957, p. 6), and the sediment yield for the drainage basin upstream from the dam has been calculated. The sediment deposited in the reservoir during that period was equal to an average annual sediment accumulation of 533 tons per square mile of drainage area. Soil conservation measures and changes in land use in the period after 1935 have probably resulted in considerable reduction of the sediment yield, and the present average annual sediment yield may be considerably less than 500 tons per square mile.

OCMULGEE RIVER AT LUMBER CITY, GA.

From Macon to Lumber City the Ocmulgee River flows through the upper Coastal Plain and part of the lower Coastal Plain. The topography near Macon is characterized by low hills, but the relief gradually decreases southeastward. In the Lumber City region the topography is gently rolling. Sandy soils are characteristic of the Ocmulgee River basin below Macon.

Suspended-sediment concentration.—Data collected during the period January 1958 to March 1959 are shown in table 30. The concentration of suspended sediment tends to increase with increasing discharge, but the range of concentration is less than at Macon. The surface water of the Coastal Plain generally has a low concentration of suspended sediment, even during floods. It seems probable, therefore, that the clear streams of the Coastal Plain serve mainly to dilute the muddy streams from the Piedmont. The average discharge at Macon is almost exactly half that at Lumber City. Thus it may not be fortuitous that the maximum suspended-sediment concentration observed at Macon is about twice that observed at Lumber City.

TABLE 30.—*Concentration of suspended sediment in samples from the Ocmulgee River at Lumber City, Ga.*

[Average discharge: 1937–57, 5,251 cfs (U.S. Geol. Survey, 1959b, p. 28)]

Date	Time	Gage height (feet)	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)	Ratio of instantaneous discharge to average discharge
1958					
Feb. 3	10:45 a.m.	8.68	8,420	29	1.60
Feb. 25	12:45 p.m.	9.21	9,150	16	1.74
Mar. 13	11:15 a.m.	13.85	19,400	61	3.69
May 1	9:30	11.92	13,750	13	2.61
July 14	8:55	4.45	4,180	27	.80
Aug. 1	3:30 p.m.	5.20	4,800	21	.91
Dec. 8	12:05	1.10	1,980	12	.38
1959					
Jan. 9	11:10 a.m.	2.30	2,700	15	.51
Feb. 10	2:20 p.m.	10.88	11,700	21	2.23
Feb. 11	2:40	11.45	12,800	24	2.44
Feb. 12	1:55	11.18	12,260	26	2.34
Mar. 12	3:45	12.39	14,950	20	2.85
Mar. 31	5:10	12.35	14,820	11	2.82

LITTLE OCMULGEE RIVER AT TOWNS, GA.

The drainage basin of the Little Ocmulgee River lies entirely in the lower Coastal Plain. The topography is gently rolling and the soils are sandy. Seven samples were collected during the period February 1958 to January 1959. The concentration of suspended sediment in these samples is shown in table 31. No stage recorder is maintained at this site, so the average stream discharge is not available. However, the character of the drainage basin and the concentration of suspended sediment determined indicate that the annual sediment yield may be similar to that of Brier Creek near Millhaven, that is, about 14 tons per square mile.

OCONEE RIVER NEAR GREENSBORO, GA.

The Oconee River originates in the hilly country of the upper Piedmont and flows southeastward across the Piedmont and Coastal Plain until it joins the Ocmulgee River. Soils in the Oconee River drainage above Greensboro are mainly of sandy to clayey loam, and, where exposed to erosion, contribute considerable amounts of fine-grained sediment to the stream. Several dams (including the Barnett Shoals dam only 12 miles upstream) trap sediment above the sampling site.

TABLE 31.—*Concentration of suspended sediment in samples from the Little Ocmulgee River at Towns, Ga.*

Date	Time	Gage height (feet)	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)
1958				
Feb. 3	11:30 a.m.			13
Mar. 13	10:15			8
May 19	3:45 p.m.	9.59		9
July 14	9:45 a.m.	4.17	150	13
Aug. 1	4:15 p.m.	4.12	145	9
Dec. 8	1:00	1.80		2
1959				
Jan. 7	4:40	2.38		4

Suspended-sediment concentration. Information obtained during the period December 1957 to December 1958 is presented in table 32. It is apparent that suspended-sediment concentration tends to increase with increasing stream discharge. Concentration at moderately low flows ranges from 15 to 30 ppm and at medium flows from 60 to 120 ppm. Samples were not obtained at high flows, but it seems probable that under such conditions much fine sediment would be carried through the upstream reservoirs, and would cause relatively high concentration of suspended sediment in the Oconee River near Greensboro.

TABLE 32.—*Concentration of suspended sediment in samples from the Oconee River near Greensboro, Ga.*

[Average discharge: 1903–13, 1914–31, and 1937–57, 1,425 cfs (U.S. Geological Survey, 1959b, p. 31)]

Date	Time	Gage height (feet)	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)	Ratio of instantaneous discharge to average discharge
1957					
Dec. 2	2:20 p.m.	6.15	2,070	100	1.45
1958					
Jan. 6	11:20 a.m.	3.34	900	39	.63
Feb. 3	11:30	4.41	1,310	42	.92
Feb. 8	10:20	13.27	5,720	99	4.00
Feb. 24	11:40	4.04	1,170	25	.82
Mar. 3	11:00	6.88	2,400	94	1.68
Mar 11	11:10	8.09	2,950	115	2.07
Mar. 19	11:00	6.90	2,405	88	1.69
Mar. 31	9:50	6.32	2,145	72	1.50
Apr. 1	11:55	6.45	2,200	54	1.54
Apr. 22	12:50 p.m.	5.88	1,945	65	1.37
May 1	2:35	4.96	1,530	60	1.07
June 2	1:50	3.40	920	14	.65
July 1	3:00	2.10	480	31	.34
Aug. 1	12:00 m.	2.34	555	44	.40
Sept. 2	11:30 a.m.	1.45	310	20	.22
Sept. 20	12:30 p.m.	1.30	275	16	.19
Dec. 31	1:20	3.34	815	70	.57

OCONEE RIVER AT MILLEDGEVILLE, GA.

The sampling site at Milledgeville is near the Fall Line and is 4 miles downstream from Sinclair Dam. Much of the fine-grained, and nearly all the coarse-grained, sediment carried by the Oconee probably is deposited in the reservoir. Regulation of the streamflow results in very rapid changes in stage at Milledgeville, and high gage heights cannot be used as an indication of intense rainfall.

Suspended-sediment concentration.—Data collected during the period December 1957 to September 1958 are shown in table 33. No consistent relation between discharge and concentration is evident from the data obtained.

TABLE 33.—*Concentration of suspended sediment in samples from the Oconee River at Milledgeville, Ga.*

[Average discharge: 1906–08, 1909–16, 1918–31, and 1937–57, 3,355 cfs (U.S. Geol. Survey, 1959b, p. 36)]

Date	Time	Gage height (feet)	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)	Ratio of instantaneous discharge of average discharge
1957					
Dec. 11	10:30 a.m.	13.5	7,150	39	2.13
1958					
Jan. 22	3:10 p.m.	8.20	1,760	78	.52
Feb. 24	2:15	10.89	4,300	42	1.28
Mar. 6	8:50 a.m.	13.3	6,930	102	2.07
Mar. 6	10:25	13.20	6,820	27	2.03
Mar. 20	10:45	13.22	6,840	22	2.04
Mar. 31	11:55	13.52	7,170	17	2.14
Apr. 14	2:35 p.m.	9.7	3,100	21	.92
Apr. 28	10:30 a.m.	12.07	5,580	66	1.66
May 27	8:00	6.00	325	31	.10
Aug. 12	7:20	5.80	265	32	.08
Sept. 19	11:35	7.0	910	53	.27

COMMISSIONER CREEK AT TOOMSBORO, GA.

The headwaters of Commissioner Creek lie above the Fall Line in Jones County, but most of the drainage basin above Toomsboro is in the sandhills region just below the Fall Line. Here the soils are generally very sandy because of the Cretaceous and Eocene sandstones underlying the area. Lenses of kaolin are interbedded with the sandstone, however, and some of this kaolin is being mined by open-cut methods. Wash water from some clay-processing plants is dumped into the streams and greatly increases the suspended-sediment concentration. Slash Creek, which was discussed above, is a tributary to Commissioner Creek above Toomsboro. Most of the clay in Commissioner Creek appears to be due to inflow from Slash Creek. Three samples were collected in 1958 from Commissioner Creek prior to the sampling of Slash Creek. The data are tabulated below.

Date of sampling	*Suspended-sediment concentration (ppm)*
Apr	58
Apr	32
Dec	62

OCONEE RIVER NEAR MOUNT VERNON, GA.

Below Milledgeville the Oconee River flows southeastward through the low hills of the upper Coastal Plain and then through the gently rolling to almost-level land of the lower Coastal Plain. Most of the soils downstream from Milledgeville are sandy and provide little fine-grained sediment. The average flow of the Oconee River prior to 1955 was 3,385 cfs at Milledgeville and 4,977 cfs (U.S. Geological Survey, 1959b, p. 36) near Mount Vernon, so approximately 32 percent of the flow at Mount Vernon is derived from the Coastal Plain.

Suspended-sediment concentration.—The concentrations of suspended sediment in samples collected during the period March 1958 to March 1959 are shown in table 34. Samples were taken during 1959 at three to six places in the cross section. The suspended concentration was highest in samples taken on the east side of the river four out of five times. The fifth time the concentration was highest near the middle of the river.

TABLE 34.—*Concentration of suspended sediment in samples from the Oconee River near Mount Vernon, Ga.*

[Average discharge: 1937–55, 4.977 cfs (U.S. Geol. Survey, 1957, p 36)]

Date	Time	Gage height (feet)	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)	Ratio of instantaneous discharge to average discharge
1958					
Mar. 13	9:10 a.m.	16.84	24,200	62	4.86
May 1	8:45	11.21	8,230	48	1.65
1959					
Feb. 10	11:55	13.14	11,650	42	2.34
Feb. 11	12:55	13.79	13,250	41	2.66
Feb. 12	3:00 p.m.	14.30	14,640	37	2.94
Mar. 12	4:40	14.84	16,200	34	3.26
Mar. 31	7:00	11.24	8,280	28	1.66

Suspended-sediment load.—The suspended-sediment concentration in the samples collected during high discharge did not exceed 62 ppm. An estimate of 40 ppm for the average concentration of suspended sediment is probably reasonable. In sampling a river which is 15 or more feet deep at high discharges, about 99 percent of the flow will be sampled by the method employed in this study. It is probable, therefore, that the unsampled suspended load constitutes an insignificant part of the total load. If the average discharge is taken as 4,980 cfs and the average concentration as 40 ppm, then the average annual suspended-sediment load may be estimated at about 200,000 tons.

OHOOPEE RIVER NEAR REIDSVILLE, GA.

The drainage basin of the Ohoopee River lies in the lower Coastal Plain. The topography near the headwaters is rolling but where the Ohoopee River empties into the Altamaha River it is almost level. The surface soils are of sand and loamy sand.

Suspended-sediment concentration.—Data collected during the period March 1958 to February 1959 are reported in table 35. Except in the samples collected on Mar. 11 and 12, 1958, the suspended-sediment concentration is similar to that of other Coastal Plain streams. It is uncertain whether the unusually high sediment concentration observed on March 11 and 12 is the result of scooping bed material with the suspended-sediment sampler or is the true concentration resulting from the movement of large amounts of sand at very high floodflows.

TABLE 35.—*Concentration of suspended sediment in samples from the Ohoopee River near Reidsville, Ga.*

[Average discharge: 1903–07 and 1937–57, 888 cfs (U.S. Geol. Survey, 1959b, p. 42)]

Date	Time	Gage height (feet)	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)	Ratio of instantaneous discharge to average discharge
1958					
Mar. 1	11:45 a.m.	9.82	2,500	10	2.82
Mar. 11	4:30 p.m.	16.00	8,000	[1] 352	9.01
Mar. 12	4:00	16.00	8,000	[1] 724	9.01
Mar. 14	12:00 m.	15.00	6,900	66	7.77
July 14	5:20 p.m.	4.44	660	12	.74
Aug. 5	12:45	2.25	195	5	.22
Dec. 6	12:00 m.	1.04	44	7	.05
1959					
Jan. 13	10:00 a.m.	1.86	135	5	.15
Feb. 5	2:00 p.m.	8.82	2,050	33	2.31

[1] Only one sample was analyzed for this date. The accuracy of the data, therefore, is uncertain.

ALTAMAHA RIVER AT DOCTORTOWN, GA.

The Altamaha River is formed by the confluence of the Ocmulgee and Oconee Rivers south of Charlotte, Ga., in the lower Coastal Plain. Approximately 60 percent of the drainage basin above Doctortown is in the Coastal Plain, and 50 percent of the discharge is derived from Coastal Plain streams.

Suspended-sediment concentration.—Two samples were collected in March 1958 and one in January 1959. The concentration of suspended sediment in these samples is shown in table 36. Although the concentration is about the same, the small number of samples involved does not permit generalizations. Variations in the proportion of

TABLE 36.—*Concentration of suspended sediment in samples from the Altamaha River at Doctortown, Ga.*

[Average discharge: 1931–57, 12,420 cfs (U.S. Geol. Survey, 1959b, p. 43)]

Date	Time	Gage height (feet)	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)	Ratio of instantaneous discharge to average discharge
1958					
Mar. 11	2:45 p.m.	7.9	44,300	16	3.57
Mar. 14	10:00 a.m.	8.32	51,700	17	4.16
1959					
Jan. 12	2:20 p.m.	.20	4,520	16	.36

floodwaters derived from the Piedmont should have a major effect on suspended-sediment concentration, and conclusions regarding probable concentration must take into account the source of the stream water.

SATILLA RIVER AT ATKINSON, GA.

The Satilla River drainage is entirely within the lower Coastal Plain. Topography is almost level and much of the area is poorly drained. Soils are of sand and loamy sand.

Suspended-sediment concentration.—Information obtained during the period February–May 1959 is presented in table 37. Only a few samples were collected, but the range of discharge at the time of sampling was great.

TABLE 37.—*Concentration of suspended sediment in samples from the Satilla River at Atkinson, Ga.*

[Average discharge: 1931–57, 1,915 cfs (U.S. Geol. Survey, 1959b, p. 50)]

Date	Time	Gage height (feet)	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)	Ratio of instantaneous discharge to average discharge
1959					
Feb. 8	10:30 p.m.	9.71	2,280	17	1.18
Feb. 13	3:40	12.82	4,900	12	2.56
Mar. 12	6:00	19.00	29,000	24	15.1
Mar. 13	11:15 a.m.	19.09	30,000	17	15.7
May 5	12:30 p.m.	6.61	990	19	.52

Suspended-sediment load.—The suspended-sediment concentration appears to show little variation with discharge, so an estimate of the average annual suspended-sediment load can be computed from discharge data. If the average suspended-sediment concentration is estimated as about 20 ppm, the calculated average annual suspended-sediment load is approximately 38,000 tons. This figure corresponds to an average suspended-sediment yield for the Satilla River drainage of 13 tons per square mile.

Size distribution of suspended sediment.—A particle-size analysis was made of one sample collected at station 223 (see table 38) on Mar. 12, 1959, when the gage height was 19.00 feet. The low sediment concentration in this sample permitted only a semiquantitative analysis of particle-size distribution. However, the analysis indicated that about 98 percent of the suspended sediment was finer than 0.0312 mm and 80 percent was finer than 0.0039 mm.

Size distribution of bed material.—Bed material was collected from the Satilla River on Mar. 12, 1959. The suspended-sediment concentration and particle-size distribution of bed material in samples collected at five points in the cross section are shown in table 38.

TABLE 38.—*Data from sampling verticals, Satilla River at Atkinson, Ga., and Alapaha River near Alapaha, Ga.*

[Station number indicates distance, in feet, from a reference point on the bridge which crosses the river at the sampling site]

Station	Depth (feet)	Average velocity (fps)	Velocity 1 foot above stream bed (fps)	Suspended-sediment concentration (ppm)	Particle-size distribution, in mm, of bed material (percent by weight)							
					less than 0.062	0.062–0.125	0.125–0.25	0.25–0.50	0.50–1.0	1.0–2.0	2.0–4.0	>4
Satilla River at Atkinson, Ga. Mar. 12, 1959												
197	20.2	2.26	0.80	19	0.4	4.4	27.9	28.0	12.2	6.1	4.8	16.2
223	22.9	3.48	2.35	47	<.1	.2	9.8	51.0	34.2	4.6	2	<.1
251	20.7	3.54	2.06	36	<.1	.3	18.7	55.7	23.7	1.6	<.1	<.1
278	16.5	3.83	2.21	14	<.1	.1	18.3	63.0	16.9	1.4	.1	.2
306	15.1	3.29	2.45	51	<.1	<.1	9.5	50.2	32.1	7.0	1.	.1
Alapaha River near Alapaha, Ga. Feb. 12, 1959												
465	12.5	1.31	7	1.4	4.3	16.2	46.4	28.1	2.6	0.3	0.7	------
485	13.5	2.08	7	<.1	.2	14.8	60.1	18.6	3.3	1.9	1.1	------
505	13.7	2.43	7	<.1	.4	5.9	41.2	35.7	6.5	5.8	4.5	------
535	11.4	1.55	7	.2	1.6	30.0	54.9	10.5	1.6	.6	.6	------

Bed load.—If the bed load be computed for the section of the stream between stations 223 and 251, some indication of the relation of the bed load to the suspended-sediment load can be obtained. The bed load was calculated as approximately 30 tons per day, by use of the method described by Colby and Hubbell (1957). The suspended-sediment load in the same section was about 240 tons per day. If these conditions are representative of the Satilla River at high discharges, the major part of the sediment load is carried as suspended sediment.

ALAPAHA RIVER NEAR ALAPAHA, GA.

The Alapaha River drains an area of low relief in the south-central part of the Georgia Coastal Plain. Soils are of sand and sandy loam and, in the low areas, are poorly drained.

Suspended-sediment concentration.—The concentration of suspended sediment in seven samples collected during the period March 1958 to April 1959 is shown in table 39. The observed concentrations did not exceed 17 ppm despite the fact that all samples except one were collected when streamflow was at least 4.7 times greater than average. These data are insufficient to define the relation of suspended-sediment concentration to stream discharge, if any exists.

TABLE 39.—*Concentration of suspended sediment in samples from the Alapaha River near Alapaha, Ga.*

[Average discharge: 1937-57, 446 cfs (U.S. Geol. Survey, 1959b, p. 165)]

Date	Time	Gage height (feet)	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)	Ratio of instantaneous dscharge of average discharge
1958					
Mar. 6	3:20 p.m.	10.67	2,100	7	4.71
Mar. 13	2:15	11.42	2,820	6	6.32
July 15	8:00 a.m.	5.48	382	17	.85
1959					
Feb. 11	4:50 p.m.	11.77	3,200	11	7.18
Feb. 12	10:05 a.m.	12.14	3,720	7	8.34
Mar. 12	2:00 p.m.	13.22	5,330	17	11.95
Apr. 1	6:35	12.39	4,070	16	9.12

Suspended-sediment load.—An estimate of the average annual suspended-sediment load carried by the Alapaha River was made from stream-discharge records because there appears to be little variation in the concentration of suspended sediment. The average discharge from 1937 to 1957 was 446 cfs. The average suspended-sediment concentration is estimated as 12 ppm. From these data the average annual suspended load is calculated to be approximately 5,000 tons. This load corresponds to an annual suspended-sediment yield for the drainage basin of 8 tons per square mile.

Size distribution of bed material.—Bed material was collected from the main channel of the Alapaha River on Feb. 12, 1959, when the river was at a high stage. The suspended-sediment concentration and particle-size distribution of the bed-material samples are shown in table 38. The bed material is well sorted, for 65 to 78 percent of it falls in the 0.25 to 1.00 mm size range.

Bed load.—The very low concentration of suspended sediment in the Alapaha River and the fact that the river has a sandy bed suggest that a significant part of the sediment load may be transported as bed load. Therefore, an estimate of the bed load for February 12, 1959, was made from the data available. (See table 38.)

The section between stations 485 and 505 was in the deepest part of the main stream channel, and water velocity was highest there. The bed load in this section was calculated by the method of Colby and Hubbell (1957) and was approximately 4 tons per day. The suspended-sediment load was about 12 tons per day for the same section. The main stream channel of the Alapaha River is the most favorable section for bed-material movement, for vegetation prevents much bed-material movement on the flood plain. Because the bed load is calculated to be only about one-third as great as the suspended load in the main stream channel, it is probable that, at the time of sampling, the bed load constituted only a minor proportion of the total sediment load.

LITTLE RIVER NEAR ADEL, GA.

The drainage basin of the Little River lies in the lower Coastal Plain in an area of gently rolling topography. Soils are of sand or loamy sand and have numerous iron-and-clay-cemented concretions.

Suspended-sediment concentration.—Data collected during the period March–May 1959 are shown in table 40. The concentration of suspended sediment tends to increase with increasing discharge, but the highest suspended-sediment concentration determined was only 59 ppm, despite the fact that the river was sampled during periods of very high discharge.

TABLE 40.—*Concentration of suspended sediment in samples from the Little River near Adel, Ga.*

[Average discharge: 1940–57, 448 cfs (U.S. Geol. Survey, 1959b, p. 167)]

Date	Time	Gage height (feet)	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)	Ratio of instantaneous discharge to average discharge
1959					
Mar. 6	11:00 a.m.	16.5	5,070	59	11.31
Mar. 8	6:50 p.m.	17.6	8,300	32	18.52
Mar. 11	2:25	15.9	4,070	26	9.09
Mar. 12	2:20	14.6	2,920	48	6.51
Mar. 13	10:20 a.m.	13.3	2,100	14	4.69
Mar. 13	2:20 p.m.	13.1	2,020	13	4.51
Mar. 20	10:20 a.m.	15.7	3,800	24	8.48
Apr. 2	6:15 p.m.	14.4	2,820	14	6.30
Apr. 30	6:45	4.83	240	14	.54
May 26	2:00	13.1	2,020	25	4.51

Suspended-sediment load.—The annual suspended-sediment load can be estimated if an average concentration is assumed. The available data indicate that an estimate of 30 ppm would be reasonable for the average suspended-sediment concentration. The average discharge for the period 1940–57 was 448 cfs. The average annual load, therefore, is probably about 13,000 tons. This average corresponds to an annual suspended-sediment yield in the drainage basin of 24 tons per square mile.

Size distribution of bed material.—A series of bed-material samples were collected from the Little River on Mar. 13, 1959, when the gage height was 13.3 feet. The concentration of suspended sediment and the particle-size distribution of bed-material samples are given in table 41.

Bed load.—The data presented in table 41 can be used to estimate the bed load of the Little River for Mar. 13, 1959. In the section between stations 108 and 141, the velocity and depth of water show little variation. The bed load computed for this section was about 1 ton per day. The suspended load for the same section at the same time was 38 tons per day. The bed-load to total-load ratio is greater for this stream section than for the stream as a whole, because vegetation on the flood plain prevents the movement of much bed material outside the main stream channel. These results indicate, therefore, that the bed load was a minor part of the total load carried by the Little River at the time of sampling.

The sampling was done during the falling stage of the river after a flood, and some of the finer grained sediment may have been removed from the bed material by the more rapidly moving water at the peak of the flood. This condition could be partially responsible for the low proportion of bed load, because the median diameter of bed material is 0.78 mm (table 41). Observation of four other streams in the lower Coastal Plain shows a range in median diameter of bed material from 0.38 to 0.64 mm.

OCHLOCKONEE RIVER NEAR THOMASVILLE, GA.

The Ochlockonee drains an area in the southwestern part of the Georgia Coastal Plain. The topography is gently rolling to almost level. Soils are of sand and loamy sand.

Suspended-sediment concentration.—Sample data from the Ochlockonee River during the period February to April 1959 are given in table 42.

Suspended-sediment load.—Although insufficient data are available from the Ochlockonee River alone to permit generalizations concerning average suspended-sediment concentration, the data in table 42, when combined with information about concentrations in other Coastal Plain streams, indicate that 20 ppm would be a reasonable approxima-

TABLE 41.—*Data from sampling verticals, Little River near Adel, Ga., and Ochlockonee River near Thomasville, Ga.*

[Station number indicates distance, in feet, from a reference point on the bridge which crosses the river at the sampling site]

Station	Depth (feet)	Average velocity (fps)	Velocity 1 foot above stream bed (fps)	Suspended-sediment concentration (ppm)	Particle-size distribution, in mm, of bed material (percent by weight)							
					<0.062	0.062–0.125	0.125–0.25	0.25–0.50	0.50–1.0	1.0–2.0	2.0–4.0	>4
Little River near Adel, Ga., Mar. 13, 1959												
97	13.7	1.52	1.26	14	<0.1	0.1	1.0	15.3	56.2	20.3	5.2	1.9
108	13.2	2.28	2.10	14	<.1	<.1	.4	7.3	42.8	33.8	12.0	3.7
119	12.6	2.54	1.93	14	<.1	<.1	.1	19.8	69.0	10.5	.4	.2
130	13.0	2.37	1.48	16	<.1	<.1	.1	9.9	57.5	29.2	3.2	.1
141	13.7	2.15	1.36	14	<.1	.2	.3	13.2	59.9	24.0	2.2	.2
Ochlockonee River near Thomasville, Ga., Feb. 13, 1959												
900	17.6	2.91		15	0.0	0.4	4.6	24.9	50.2	19.3	0.6	0.0
100	16.9	2.68		15	.0	.0	4.7	42.0	41.9	10.7	.7	.0
110	16.6	2.28		41	.0	.2	2.6	30.6	35.7	24.7	5.8	.4
120	15.4	1.76		14	.0	3.0	31.2	52.3	10.2	.8	.3	2.2

tion for average suspended-sediment concentration. The average discharge for the period 1937–57 was 426 cfs. On the basis of these data the average annual load of suspended sediment is estimated to be approximately 8,500 tons per year. This figure corresponds to an annual suspended-sediment yield of 15 tons per square mile.

Size distribution of bed material.—Samples of bed material were collected from the Ochlockonee River on Feb. 13, 1959, when the gage height was 14.39 feet. The concentration of suspended sediment and the particle-size distribution of bed-material samples are shown in table 41. Other data pertaining to the sampling stations also are in table 41.

TABLE 42.—*Concentration of suspended sediment in samples from the Ochlockonee River near Thomasville, Ga.*

[Average discharge: 1937–57, 426 cfs (U.S. Geol. Survey, 1959b, p. 182)]

Date	Time	Gage height (feet)	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)	Ratio of instantaneous discharge to average discharge
1959					
Feb. 13	10:40 a.m.	14.39	3,610	15	8.34
Mar. 2	6:00 p.m.	9.62	1,310	12	3.08
Mar. 12	11:00 a.m.	12.78	2,430	28	5.75
Apr. 3	8:15	12.61	2,340	30	5.52

Bed load.—An estimate of the bed load for Feb. 13, 1959, was made from the data in table 41. Approximately 4 tons of sediment per day moved through the section between stations 90 and 110 as bed load and about 35 tons passed the section as suspended load. Bed load probably represents a higher percentage of the total load in the section studied than in the stream as a whole because vegetation obstructs movement of sediment on the flood plain. These data, therefore, suggest that the bed load constituted a minor fraction of the total load at the time of sampling. The flood reached its peak 2½ days before the sampling was done, and it is possible that considerably larger amounts of sediment were transported as bed load during the period of higher stream discharge.

CHATTAHOOCHEE RIVER NEAR LEAF, GA.

The headwaters of the Chattahoochee River lie in White County in the Blue Ridge province. The topography is mountainous and runoff is rapid. Soils range from fine sandy loam to clay loam.

Suspended-sediment concentration.—The concentration of suspended sediment in samples collected during the period November 1957 to April 1959 is shown in table 43. Samples were not obtained during periods of high discharge because the flow increases and decreases so rapidly that it is difficult for distant observers to reach the stream in time to collect samples before and during peak discharge. The data indicate that the concentration of suspended sediment tends to increase with increasing discharge but that the relation is not a linear one.

TABLE 43.—*Concentration of suspended sediment in samples from the Chattahoochee River near Leaf, Ga.*

[Average discharge: 1940–57, 380 cfs (U.S. Geol. Survey, 1959b, p. 191)]

Date	Time	Gage height (feet)	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)	Ratio of instantaneous discharge to average discharge
1957					
Nov. 1	3:30 p.m.	1.87	197	5	0.52
Dec. 2	3:50	2.31	384	7	1.01
Dec. 9	3:20	2.68	580	34	1.53
1958					
Jan. 2	3:50	2.34	400	35	1.05
Jan. 15	11:20 a.m.	2.42	450	18	1.18
Jan. 24	2:20 p.m.	3.26	950	114	2.50
Feb. 18	4:00	2.47	465	9	1.22
Mar. 3	4:45	2.51	485	7	1.28
Mar. 4	10:00 a.m.	2.48	470	5	1.24
Mar. 18	12:45 p.m.	2.83	665	25	1.75
Mar. 28	10:45 a.m.	2.79	635	34	1.67
Apr. 1	11:00	2.62	545	10	1.43
Apr. 16	11:50	3.00	775	30	2.08
May 1	4:00 p.m.	------	------	22	------
June 2	------	2.32	390	14	1.03
July 1	------	1.98	235	10	.62
Aug. 2	3:45	1.88	200	11	.53
Aug. 9	6:30	1.81	180	10	.47
Oct. 1	3:07	2.64	560	166	1.47
Nov. 3	2:35	1.79	170	9	.45
Dec. 1	------	1.75	160	5	.42
1959					
Jan. 2	4:00 p.m.	2.25	355	37	1.47
Mar. 11	12:00 m.	2.17	320	5	.84
Apr. 18	1:00 p.m.	3.30	379	68	1.00
Apr. 20	10:45 a.m.	2.91	718	30	1.89

It was not possible to estimate suspended loads or bed loads from available data.

One analysis for particle-size gradation of suspended sediment was made; the results are shown below. The sample was collected April 18, 1959, at 1:00 p.m.; discharge was 379 cfs.

Size fraction	*Percent in size fraction*
>0.0625 mm (sand)	17
0.0039–0.0625 mm (silt)	51
<0.0039 mm (clay)	32

CHESTATEE RIVER NEAR DAHLONEGA, GA.

The Chestatee River originates in White and Lumpkin Counties in the Blue Ridge province. The topography is mountainous and the soils are of sandy loam to clay loam. The character of streamflow is much like that of the Chattahoochee River near Leaf.

Suspended-sediment concentration.—Data collected from the Chestatee River near Dahlonega during the period December 1957 to April 1959 are given in table 44. There is a well-defined tendency for the concentration of suspended sediment to increase with increasing discharge, but data were not obtained at high discharges to confirm the validity of such a correlation for the complete range of flow.

TABLE 44.—*Concentration of suspended sediment in samples from the Chestatee River near Dahlonega, Ga.*

[Average discharge: 1929–31 and 1940–57, 331 cfs (U.S. Geol. Survey, 1959b, p. 102)]

Date	Time	Gage height (feet)	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)	Ratio of instantaneous discharge to average discharge
1957					
Dec. 23	3:30 p.m.	2.25	471	16	1.42
1958					
Jan. 15	12:15	1.75	315	12	.95
Jan. 31	10:15 a.m.	1.73	310	4	.94
Feb. 13	2:30 p.m.	1.92	366	5	1.10
Mar. 4	11:05 a.m.	1.92	366	10	1.10
Mar. 11	4:25 p.m.	1.95	375	12	1.13
Mar. 18	11:15 a.m.	2.74	642	64	1.94
Mar. 28	9:10	2.41	525	25	1.59
Apr. 16	1:00 p.m.	3.02	748	75	2.26
Apr. 21	5:40	2.17	444	21	1.34
June 5	9:05 a.m.	1.58	267	15	.81
July 15	6:45 p.m.	2.28	481	50	1.45
Aug. 28	8:30 a.m.	1.31	197	14	.60
Sept. 10	12:30 p.m.	1.06	136	8	.41
Oct. 6	2:50	1.19	168	16	.51
Dec. 18	10:35 a.m.	1.01	126	2	.38
1959					
Apr. 19	2:20 p.m.	3.65	1,020	158	3.08
Apr. 20	2:20	2.88	694	49	2.10

The available data are also not sufficient for the calculation of sediment loads. One particle-size analysis of suspended sediment was made, however, and the results are given below. The sample was collected at 2:20 p.m., Apr. 19, 1959; discharge was 1,020 cfs.

Size fraction	*Percent in size fraction*
>0.062 mm (sand)	34
0.0039–0.062 mm (silt)	42
<0.0039 mm (clay)	24

CHATTAHOOCHEE RIVER AT ATLANTA, GA.

The Chattahoochee River at Atlanta is formed by streams from the Blue Ridge and upper Piedmont provinces. The topography in the drainage basin is hilly to mountainous and soils are of sandy loam to clay loam.

Suspended-sediment concentration.—Data concerning the Chattahoochee River at Atlanta during the period November 1957 to December 1958 is presented in table 45. Flow at this site is controlled by release of water from Lake Sidney Lanier, by action of Morgan Falls hydroelectric plant, and by rainfall. The suspended-sediment concentration may increase greatly or only moderately with increasing flow, depending upon the cause of rise in discharge. Approximately 3 inches of rain fell during the period Nov. 23–25, 1957. The sediment in the sample taken November 25, therefore, probably resulted from erosion during the rainy period. Similarly, heavy rains fell on Feb. 6, 1958, and caused high sediment concentrations. However, release of water from storage upstream was responsible for the above-normal flow on Sept. 13, 1958, and the resulting suspended-sediment concentration was relatively low. Determination of the sediment load and estimation of suspended-sediment concentration at this site cannot be made without sampling several times a day during periods of rapid change in concentration. Data would also be needed for several storm events occurring throughout the year.

TABLE 45.—*Concentration of suspended sediment in samples from the Chattahoochee River at Atlanta, Ga.*

[Average discharge: 1928–31 and 1937–57, 2,413 cfs (U.S. Geol. Survey, 1959b, p. 197)]

Date	Time	Gage height (feet)	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)	Ratio of instantaneous discharge to average discharge
1957					
Nov. 25	2:05 p.m.	5.00	3,600	137	1.49
1958					
Jan. 3	1:40	2.55	715	18	.30
Jan. 7	1:30	2.57	730	5	.30
Jan. 16	1:05	2.87	970	14	.40
Feb. 6	10:20 a.m.	3.61	1,690	530	.70
Feb. 6	3:00 p.m.	4.20	2,370	1,030	.98
Feb. 18	10:40 a.m.	2.38	610	12	.25
Mar. 5	10:10	2.56	720	12	.30
Mar. 17	9:10	2.77	885	10	.37
Mar. 27	10:10	4.06	2,190	58	.91
Mar. 28	12:15 p.m.	3.33	1,400	39	.58
Apr. 18	12:20	3.62	1,700	60	.70
May 1	3:20	4.00	2,120	60	.89
June 3	----------	1.25	<200	14	<.08
Sept. 13	2:00 p.m.	4.90	3,440	23	1.43
Dec. 30	10:20 a.m.	4.65	3,040	38	1.26

CHATTAHOOCHEE RIVER AT WEST POINT, GA.

The Chattahoochee River at West Point drains an area of about 3,550 square miles, most of which is in the Piedmont physiographic province. Topography is mountainous at the headwaters, but the relief decreases downstream. Buford Reservoir causes deposition of much of the sediment derived from the area above it. However, more than 1,000 square miles of the Piedmont drains into the channel system between Buford Reservoir and West Point. The soils in the Piedmont upstream from West Point are of sandy to clay loam.

Suspended-sediment concentration.—Data collected during the period December 1957 to May 1959 are given in table 46. Concentration of suspended sediment definitely tends to increase with increasing discharge, but data are insufficient to permit an estimate of the normal limits of variation in sediment concentration.

Size distribution of suspended sediment.—Analyses of five samples of suspended sediment for particle-size distribution (table 47) indicate that silt and clay are about equal in amount and together represent almost 90 percent of the suspended sediment.

TABLE 46.—*Concentration of suspended sediment in samples from the Chattahoochee River at West Point, Ga.*

[Average discharge: 1896–1910 and 1912–57, 5,539 cfs (U.S. Geol. Survey, 1959b, p. 201)]

Date	Time	Gage height (feet)	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)	Ratio of instantaneous discharge to average discharge
1957					
Dec. 16	3:40 p.m.	3.85	3,280	81	0.59
1958					
Jan. 8	2:10	2.62	1,380	16	.25
Jan. 27	11:00 a.m.	3.78	1,585	142	.29
Feb. 7	12:05 p.m.	16.30	33,200	690	6.00
Feb. 17	11:30 a.m.	4.70	4,720	50	.85
Feb. 28	12:05 p.m.	10.56	16,500	557	3.00
Mar. 13	2:00	5.55	6,190	61	1.12
Mar. 24	12:20	4.66	4,640	32	.84
Apr. 2	12:30	4.95	5,150	34	.93
Apr. 17	11:40 a.m.	13.15	22,950	345	4.15
Apr. 28	3:25 p.m.	4.64	4,620	41	.83
June 11	7:30	2.87	1,710	12	.31
July 21	6:30	5.86	6,750	202	1.22
Sept. 15	11:55 a.m.	3.65	2,950	25	.53
Oct. 13	5:50 p.m.	2.87	1,720	15	.31
Nov. 24	3:00	3.20	2,230	13	.40
Dec. 26	2:15	4.37	3,990	111	.72
1959					
Mar. 6	1:55	7.92	10,550	228	1.90
Mar. 7	10:20 a.m.	9.35	13,500	278	2.44
Mar. 23	4:00 p.m.	4.57	4,500	67	.81
May 13	4:45	4.22	3,900	67	.70

TABLE 47.—*Particle-size analyses of suspended sediment, Chattahoochee River at West Point, Ga.*

[All samples mechanically and chemically dispersed before analysis. Station number indicates distance, in feet, from a reference point on the bridge across the Chattahoochee River]

Date	Time	Gage height (feet)	Instantaneous discharge (cfs)	Station	Suspended-sediment concentration (ppm)	Percent in size range (mm)		
						>0.062	0.0039–0.062	<0.0039
1958								
Feb. 28	11:55 a.m.	10.56	16,500	190	572	12	34	54
1959								
Mar. 6	2:15 p.m.	7.92	10,550	210	244	14	44	42
Mar. 6	2:15	7.92	10,550	270	243	11	40	48
Mar. 7	9:50 a.m.	9.35	13,500	210	310	16	43	41
Mar. 7	9:50	9.35	13,500	270	303	14	48	38
Average						13	42	45

FLINT RIVER NEAR GRIFFIN, GA.

The Flint River above Griffin is in the Piedmont in an area of hilly topography and sandy-loam to clay-loam soils. The headwaters are in Fulton County in a well-populated area on the outskirts of Atlanta, Ga.

Suspended-sediment concentration.—The concentration of suspended sediment in samples collected during the period December 1957 to November 1958 is shown in table 48. There is some tendency for the concentration to increase with increasing discharge; however, no samples were collected during very high flows, so the normal range of concentrations to be expected was not determined. The highest concentration found was 88 ppm. This concentration is considerably less than the highest measured in samples from the Flint River near Culloden, and indicates either that the drainage basin above Griffin is yielding little sediment or that no samples were obtained during periods of high sediment load.

TABLE 48.—*Concentration of suspended sediment in samples from the Flint River near Griffin, Ga.*

[Average discharge for the period 1937-57 was 315 cfs (U.S. Geol. Survey, 1959b, p. 203)]

Date	Time	Gage height (feet)	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)	Ratio of instantaneous discharge to average discharge
1957					
Dec. 2	2:25 p.m.	6.52	404	68	1.28
Dec. 27	1:45	6.18	350	13	1.11
1958					
Jan. 11	12:45	4.63	168	5	.55
Jan. 27	3:00	8.18	743	22	2.36
Feb. 11	11:00 a.m.	8.84	932	25	2.96
Feb. 28	3:35 p.m.	9.49	1,215	34	3.86
Mar. 13	11:30 a.m.	8.15	732	11	2.32
Mar. 18	4:15 p.m.	7.50	585	15	1.86
Mar. 24	2:30	6.19	350	9	1.11
Apr. 2	2:45	6.39	382	9	1.21
Apr. 17	4:00	9.06	1,015	21	3.22
Apr. 29	3:50	5.61	268	12	.85
June 13	2:00	3.13	69	15	2.19
July 23	5:45	7.47	580	88	1.84
Sept. 14	11:30 a.m.	2.96	70	13	.22
Oct. 15	1:30 p.m.	2.91	58	18	.18
Nov. 25	3:00	----------	----------	10	----------

WHITEWATER CREEK BELOW RAMBULETTE CREEK NEAR BUTLER, GA.

Whitewater Creek drains an area in the upper Georgia Coastal Plain. The topography is hilly, but the topsoils are of clean sand and absorb water rapidly. This water percolates down to the water table and helps supply the surface streams which show fairly constant discharge even during dry periods.

Suspended-sediment concentration.—Data collected during the period March 1958 to March 1959 are reported in table 49. The concentration of suspended sediment is uniformly low and shows little tendency to change with discharge.

The water from Whitewater Creek is exceptionally low in dissolved and suspended mineral matter. R. N. Cherry (oral communication, 1960) states that four samples which he collected contained dissolved solids in the range 15 to 18 ppm. The available data suggest that combined dissolved and suspended solids rarely exceed 30 ppm.

Surface-water records indicate that Whitewater Creek shows little variation in discharge. Even during the low-flow period of 1954 (U.S. Geol. Survey, 1956, p. 168), the discharge was not less than 100 cfs.

TABLE 49.—*Concentration of suspended sediment in samples from Whitewater Creek below Rambulette Creek near Butler, Ga.*

[Average discharge: 1951–57, 160 cfs (U.S. Geol. Survey, 1959b, p. 212)]

Date	Time	Gage height (feet)	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)	Ratio of instantaneous discharge to average discharge
1958					
Mar. 28	2:00 p.m.	2.13	189	4	1.18
May 5	11:05 a.m.	1.71	152	8	.95
June 30	12:00 m.	1.69	150	13	.94
Aug. 13	8:00 a.m.	1.87	165	14	1.03
Sept. 16	11:00	1.54	138	6	.86
Nov. 4	1:00 p.m.	1.49	134	4	.84
Dec. 22	2:30	1.49	134	2	.84
1959					
Jan. 27	3:30	1.59	142	5	.89
Mar. 3	6:30	1.80	159	5	1.00
Mar. 6	8:30 a.m.	3.48	370	12	2.31
Mar. 7	1:00 p.m.	3.14	316	4	1.98

Suspended-sediment load.—If the average concentration of suspended sediment be estimated as 10 ppm, the annual suspended-sediment load is approximately 1,600 tons. This annual load corresponds to an average annual sediment yield per square mile of 17 tons.

FLINT RIVER AT MONTEZUMA, GA.

The station at Montezuma is located about 58 miles downstream from the station near Culloden. The intervening drainage area is almost entirely in the upper Coastal Plain where topography is gently rolling to hilly and soils are generally sandy.

Suspended-sediment concentration.—Information obtained during the period November 1957 to January 1959 is reported in table 50.

TABLE 50.—*Concentration of suspended sediment in samples from the Flint River at Montezuma, Ga.*

[Average discharge: 1930–32, 1934–57, 3,500 cfs (U.S. Geol. Survey, 1959b, p. 213)]

Date	Time	Gage height (feet)	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)	Ratio of instantaneous discharge to average discharge
1957					
Nov. 22	9:05 a.m.	11.64	8,800	154	2.52
1958					
May 1	5:20 p.m.	6.22	3,650	45	1.04
July 1	9:30 a.m.	3.77	2,100	32	.60
July 22	9:00	9.77	6,700	188	1.92
Aug. 13	12:00 m.	3.70	2,050	32	.59
Sept. 17	12:00	1.9	1,140	21	.33
Nov. 3	4:00 p.m.	2.00	1,180	14	.34
Dec. 22	1:30	2.89	2,600	11	.74
1959					
Jan. 28	11:00 a.m.	5.38	3,100	54	.89

The concentration of suspended sediment shows a positive correlation with discharge, probably because of suspended sediment from the Piedmont rather than sediment from the Coastal Plain. The data suggest that the normal concentration of suspended sediment is 10 to 20 ppm during periods of low flow and more than 150 ppm during high flows.

COOSA RIVER NEAR ROME, GA.

The Coosa River is formed by the confluence of the Etowah and Oostanaula rivers. The Etowah River originates in the Blue Ridge and flows across the upper Piedmont to the Allatoona reservoir where much of the sediment load is deposited. Below the Allatoona dam, mining activity contributes an undetermined amount of sediment to the Etowah River. The Oostanaula River also originates in the Blue Ridge but flows through the Valley and Ridge province before joining the Etowah River near Rome. No major dams cause deposition of the sediment load from the Oostanaula.

Suspended-sediment concentration.—The concentration of suspended sediment in samples collected during the period December 1957 to January 1959 are reported in table 51. There is a positive but poorly defined correlation between stream discharge and suspended-sediment concentration. Concentration during periods of low flow probably ranges from 10 to 40 ppm and at high flows exceeds 100 ppm.

TABLE 51.—*Concentration of suspended sediment in samples from the Coosa River near Rome, Ga.*

[Average discharge, 1928–31 and 1937–57, 6,104 cfs (U.S. Geol. Survey, 1959b, p. 268)]

Date	Time	Gage height (feet)	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)	Ratio of instantaneous discharge to average discharge
1957					
Dec. 5	3:00 p.m.	5.82	6,130	79	1.00
1958					
Jan. 8	6:30	3.66	4,100	49	.67
Jan. 17	1:15	6.60	6,910	39	1.13
Feb. 5	12:20	4.61	4,960	28	.81
Feb. 26	12:20	4.15	4,550	25	.75
Mar. 14	2:20	8.45	8,940	86	1.46
Apr. 3	11:55 a.m.	9.48	10,220	109	1.67
Apr. 21	1:15 p.m.	5.80	6,110	25	1.00
June 18	2:15	2.90	3,150	36	.52
July 29	------------	4.50	4,860	70	.80
1959					
Jan. 13	------------	2.40	2,970	11	.49

CHATTOOGA RIVER AT SUMMERVILLE, GA.

The Chattooga River drains a part of the Valley and Ridge province in northwest Georgia. Soils are of silt loam to sandy loam on the ridges and of silt loam to silty clay loam in the valleys. More than 80 percent of the flow of the Chattooga River at the sampling site is controlled by a dam at Trion, and an undetermined part of the sediment load is deposited in the reservoir.

Suspended-sediment concentration.—Data collected during the period December 1957 to January 1959 are shown in table 52. In general, the concentration of suspended sediment is low and shows little increase with increasing discharge.

TABLE 52.—*Concentration of suspended sediment in samples from the Chattooga River at Summerville, Ga.*

[Average discharge, 1937-57, 341 cfs (U.S. Geol. Survey, 1959b, p. 270)]

Date	Time	Gage height (feet)	Instantaneous discharge (cfs)	Suspended-sediment concentration (ppm)	Ratio of instantaneous discharge to average discharge
1957					
Dec. 11	1:55 p.m.	4.66	540	8	1.58
1958					
Jan. 8	10:58 a.m.	3.21	259	3	.76
Jan. 18	12:10 p.m.	3.92	392	5	1.15
Jan. 28	11:30 a.m.	4.42	494	11	1.45
Feb. 14	1:50 p.m.	3.70	353	13	1.03
Mar. 3	11:00 a.m.	4.01	410	12	1.20
Mar. 14	12:35 p.m.	5.57	740	36	2.17
Mar. 26	11:30 a.m.	6.01	845	20	2.49
Apr. 1		4.16	442	6	1.30
Apr. 21	12:50 p.m.	3.91	392	11	1.15
May 13		4.35	480	32	1.41
June 18	5:00 p.m.	2.47	130	5	.38
July 29		2.60	150	12	.44
Sept. 9	10:15 a.m.	2.18	88	4	.26
Sept. 12	10:45	2.22	93	3	.27
Dec. 2	4:45 p.m.	2.13	80	16	.24
1959					
Jan. 13	5:00	2.24	95	11	.28

DATA FROM OTHER SOURCES

Several agencies other than the U.S. Geological Survey have collected information concerning the sediment transported by Georgia streams. Some of the data are tabulated below.

The Hydraulic Data Branch of the Tennessee Valley Authority made a comprehensive investigation of the suspended-sediment load in a number of Tennessee Valley streams during the period 1934–42 (Albert S. Fry, written communication 1959). Later, after reservoirs had been built on some of these streams, surveys were made to determine how much sediment had accumulated during known time intervals. Some of the data obtained by the Tennessee Valley Authority pertained to Georgia streams. These data are presented in tables 53 and 54.

Information concerning sediment deposited in other Georgia reservoirs has been collected by the Federal Inter-Agency Committee on Water Resources (1957). A summary of available data on sedimentation in reservoirs (other than that reported in tables 53 and 54) is given in table 55.

Comparison of the average annual suspended-sediment load in the Nottely and Hiwassee Rivers (measured prior to construction of Nottely and Chatuge dams) with the sediment deposited in reservoirs formed after dams were built indicates that most of the sediment load is transported in suspension. The contrast between the minimum and maximum suspended-sediment concentrations is extreme and shows the great increase in sediment concentration caused by erosion during storms.

TABLE 53.—*Suspended-sediment data from streams originating in northern Georgia*

[From records of the Tennessee Valley Authority]

Description	Sampling site		
	South Chickamauga Creek, McCarty, Tenn.	Nottely River, Ranger, N.C.	Hiwassee River, Murphy, N.C.
Drainage area (sq mi):			
Above sampling site	458	272	421
In Georgia	400	200	150
Period of record	Jan. 1937–June 1938	Aug. 1934–May 1942	Aug. 1934–May 1942
Daily mean concentration (ppm):			
Maximum	1,550	6,950	8,740
Minimum	2	1	1
Monthly mean concentration (ppm):			
Maximum	745	2,010	1,235
Minimum	35	6	4
Monthly mean load (tons):			
Maximum	116,400	196,120	231,100
Minimum	527	68	82
Annual load (tons):			
Total	[1] 251,000	[2] 189,000	[2] 219,000
Per square mile	550	700	520

[1] Calendar year 1937.
[2] Average for calendar years 1935–41.

TABLE 54.—*Sediment deposited in reservoirs in northern Georgia and western North Carolina*

[From data collected by the Tennessee Valley Authority]

Description	Location of reservoir		
	Blue Ridge dam on Toccoa River	Nottely dam on Nottely River	Chatuge dam on Hiwassee River
Drainage area:			
Net sediment-contributing area sq mi	227	207	178
Approximate sediment-contributing area in Georgia sq mi	227	207	130
Ratio of original capacity to watershed ac ft per sq mi	851	825	1,282
Date of sediment investigations:			
Original soundings	April 1944	January 1942	February 1942
Latest soundings	August 1954	April 1955	August 1954
Average annual sediment yield tons per sq mi	[1] 839	[2] 677	[3] 444

[1] Average for 10.3 years.
[2] Average for 13.3 years.
[3] Average for 12.5 years.

The annual sediment yield from the drainage basins above the reservoirs ranges from 444 to 2,638 tons per square mile. In general, the higher sediment yields were found in the small drainage basins. All the reservoirs for which sediment data are available receive their water from hilly or mountainous parts of Georgia, hence the sediment yields to be expected from areas of low relief can be estimated only from sediment-concentration measurements.

TABLE 55.—*Sediment deposited in Georgia reservoirs*

[Data from Federal Inter-Agency Committee on Water Resources (1957) and from records of the U.S Department of Agriculture Soil Conservation Service]

Reservoir	County	Sediment-contributing area (sq mi)	Time of sediment accumulation	Number of years sediment accumulated	Original reservoir capacity (acre-feet per sq mi of drainage area)	Total sediment volume (acre-feet)	Average annual sediment accumulation per sq mi of sediment-contributing area		Density of deposit (lb per cu ft)
							Acre-feet	Tons	
Carroll Lake	Carroll	6.91	1949–57	8.6	202	122.6	2.07	1,916	42.5
Lloyd Shoals	Butts, Jasper, and Newton.	1,407	1910–35	24.3	79.6	13,960	.408	533	[1]60
Newnan	Coweta	1.34	1924–37	13.4	276	26	1.45	1,580	[1]50
			1937–45	7.3		4	.41	446	[1]50
Seguoyah	Pickens	1.51	1929–39	10	556	25	1.66		
Sky Lake	White	2.31	1925–56	31	93.3	41.9	.58	846	67
Temple	Carroll	.61	1954–57	3	104	5.0	2.74	2,638	44.2
White Manganese No. 6.	Bartow	11.0	1929–38	9.2	72.2	121	1.20	1,660	63.7

[1] Density is assumed.

SIGNIFICANCE OF DATA

Information obtained during this study is summarized in table 56. In general, streams draining from mountainous areas show great changes in sediment concentration and sediment load with changes in discharge and especially with periods of intense rainfall. In areas of very low relief, suspended-sediment concentration changes little with discharge, and sediment load is believed to increase approximately in proportion to the increase in discharge. Annual sediment yields range from about 10 tons per square mile on the Coastal Plain to more than 1,000 tons per square mile in the Blue Ridge province.

Consideration of the information gained in this study emphasizes the fact that the sediment yield from a drainage basin is appreciable only if the following conditions exist:

1. Rainfall is great enough, and of sufficient intensity, that a significant amount of surface runoff occurs.
2. Covering vegetation is sparse enough that the runoff has opportunity to erode the land surface.
3. The surface soil contains an appreciable proportion of fine-grained particles.
4. The topographic relief is such that water velocity and turbulence are great enough to transport at least silt and clay particles.
5. The streams are free of major obstructions to streamflow which reduce water velocity and cause deposition of sediment.

The influence of these various factors can be illustrated with information available from this study. On the Coastal Plain the topographic relief is low, and many of the surface soils are very sandy. Thus, even though some areas have much open cultivated land, comparatively little sediment is transported by the streams. In the Piedmont region, loamy soils, intensive cultivation of land in some areas, and moderate relief tend to increase sediment yields, whereas the presence of many dams on the larger rivers causes deposition of sediment in reservoirs. The net sediment yield from the Piedmont, nevertheless, is perhaps 5 to 20 times that of the Coastal Plain.

The great relief, loamy soils, and few dams in the mountainous Blue Ridge area encourage sediment transportation. The fact that there is little open cultivated land apparently does not prevent considerable erosion. It is possible, however, that the amount of cultivated land is not a good measure of open areas in the mountains. Many of the smaller watercourses have cut through the veneer of surface vegetation and laid bare the underlying soil. The soil so exposed can be rapidly eroded. The sediment yield from the mountain areas is large because of the many factors which combine in favoring erosion and transportation of sediment.

VARIATION IN CONCENTRATION AND PARTICLE-SIZE DISTRIBUTION OF SUSPENDED SEDIMENT

The concentration of suspended sediment shows large variations in the Blue Ridge mountain areas. During periods of low to average discharge, the concentration usually ranges from 5 to 25 ppm. After heavy rains the suspended-sediment concentration increases very rapidly with increasing discharge and may reach 10,000 ppm in areas of greatest relief. Available evidence indicates that the concentration reaches a maximum before the stream discharge does and that the concentration then decreases rapidly while the discharge reaches a peak and decreases slowly. As the suspended-sediment concentration increases, there is a tendency for the proportion of clay-size material to increase also. This rapid rise in concentration, followed by an almost equally rapid fall, may take place in 12 hours or less even though the water discharge may be great for 2 to 3 days. Sediment concentration is lowest near the surface of the stream in slow-moving parts of the cross section and is highest near the bottom in the fastest moving part of the cross section.

In the Piedmont province, the characteristics of the stream sediments are much like those of the Blue Ridge province, but suspended-sediment concentration and water discharge do not change so rapidly and probably only rarely does the concentration in the larger streams exceed 1,000 ppm. Concentration at low to average flows is 5 to 25 ppm, about the same as in the Blue Ridge area. Many dams have been

Table 56.—*Sediment characteristics of Georgia streams as related to the physiographic province in which the drainage basin is located*

[Sediment concentrations and high ratio of instantaneous to average discharge values are only for the samples collected in this study or for samples collected by U.S. Army Corp of Engineers or Soil Conservation Service. The bed loads of the streams sampled are assumed to be negligible]

Physiographic province or section	Location of sampling site	Sediment concentration (ppm)		Ratio of instantaneous to average discharge		Approximate annual sediment yield per square mile (tons)	Average percent of suspended sediment in each grain size			Average percentage of bed material in various sizes			Remarks
		Low	High	Low	High		Sand >0.062 mm	Silt 0.0039–0.062 mm	Clay <0.0039 mm	>1.0 mm	0.25–1.0 mm	<0.25 mm	
Cumberland Plateau, Valley and Ridge.	South Chickamauga Creek at McCarty, Tenn.	2	1,550			550							(a)
Valley and Ridge	Chatooga River at Summerville, Ga	3	36	0.24	2.49								(b)
Blue Ridge, Valley and Ridge.	Oostanaula River at Calhoun, Ga	4	394	.25	4.38	125	6.5	36.0	57.5	32.5	66.0	1.5	
Blue Ridge	Hiwassee River, Murphy, N.C	1	8,740			520							(a)
	Nottely River, Ranger, N.C	1	6,950			700							(a)
Blue Ridge, Piedmont	Chattahoochee River near Leaf, Ga	5	166	.42	2.50		17	51	32				(c)
	Chestatee River near Dahlonega, Ga	2	138	.38	3.08		34	42	24				(c)
	Etowah River at Canton, Ga	9	1,920	.38	6.61	200	40.5	36.5	23.0	23.5	74.0	2.5	
Blue Ridge, Piedmont, Valley and Ridge.	Coosa River near Rome, Ga	11	109	.49	1.67								
Piedmont	Broad River near Bell, Ga	9	565	.27	5.11	140	24	32	44				
	Ocmulgee River at Macon, Ga	3	111	.29	2.66								(d)
	Oconee River near Greensboro, Ga	14	115	.19	4.00								(e)
	Oconee River near Milledgeville, Ga	17	102	.08	2.14								(f)
	Chattahoochee River at Atlanta, Ga	5	1,028	<.08	1.49								(g)
	Chattahoochee River at West Point, Ga	12	690	.25	6.00		13.5	42.0	44.5				
	Flint River near Griffin, Ga	5	88	.18	3.86								
	Flint River near Culloden, Ga	7	436	.29	4.74	200	35	35	30	21.5	74.5	4.0	
Piedmont, Coastal Plain.	Rocky Comfort Creek near Louisville, Ga	3	52										(h)
	Ogeechee River near Louisville, Ga	3	49										(h)
	Ocmulgee River at Lumber City, Ga	11	61	.38	3.69								
	Commissioner Creek near Toomsboro, Ga	32	62										(h)
	Oconee River near Mount Vernon, Ga	28	62	1.65	4.86								
	Altamaha River at Doctortown, Ga	16	17	.40	3.57								
	Flint River at Montezuma, Ga	11	188	.33	2.52								

Coastal Plain	Brier Creek near Millhaven, Ga	3	17	.36	3.64	14	0	15	85				([c])
	Ogeechee River near Eden, Ga	3	13	.17	4.15	5				25.0	73.0	2.0	
	Canoochee River near Claxton, Ga	4	34	.07	8.56	14							
	Little Ocmulgee River at Towns, Ga	2	13										([h])
	Slash Creek near McIntyre, Ga	165	5,300										([h, i])
	Ohoopee River near Reidsville, Ga	5	724	.05	9.01								([j])
	Satilla River at Atkinson, Ga	17	24	.52	15.7	13	0	20	80	8.5	73.0	18.5	([k])
	Alapaha River near Alapaha, Ga	6	17	.85	11.95	8				7.5	73.5	19.0	
	Little River near Adel, Ga	13	59	.54	18.52	24				29.5	70.0	0.5	
	Ochlockonee River near Thomasville, Ga	12	30	3.08	8.34	15				16.5	70.0	13.5	
	Whitewater Creek near Butler, Ga	2	14	.84	2.31	17							
	Ichawaynochaway Creek at Milford, Ga	6	53	.39	5.46	30							

[a] Sediment-concentration range and approximate annual sediment yield are from table 53.
[b] Dam 6 miles upstream stops some sediment.
[c] One particle-size analysis made.
[d] Lloyd Shoals reservoir 48 miles upstream stops much sediment.
[e] Barnett Shoals dam 12 miles upstream stops some sediment.
[f] Sinclair dam 4 miles upstream stops some sediment.
[g] Much sediment is probably deposited in Lake Sidney Lanier 46 miles upstream.
[h] No stage recorder here.
[i] Stream is polluted by clay-processing plants.
[j] The high concentration of suspended sediment reported may represent some contamination of the sample by bed material.
[k] Only one sample analyzed for particle-size distribution of suspended sediment.

constructed on rivers in the Piedmont, and presumably these serve to trap all the coarse-grained and some of the fine-grained sediment. Stream water just below these dams can be expected to contain less sediment than normal for Piedmont streams.

Streams which derive all their flow from the Coastal Plain show little change in suspended-sediment concentration with increasing discharge. The normal concentration is 10 to 20 ppm and only rarely does the concentration exceed 100 ppm.

The sediment characteristics of streams which derive their water from more than one physiographic province are intermediate between those of the provinces concerned.

Particle-size analysis of suspended sediment indicates that sand constitutes 6 to 38 percent, silt 30 to 42 percent, and clay 25 to 58 percent of most samples. The average particle-size distribution of suspended sediment in five Georgia rivers is shown on a trilinear diagram in figure 29.

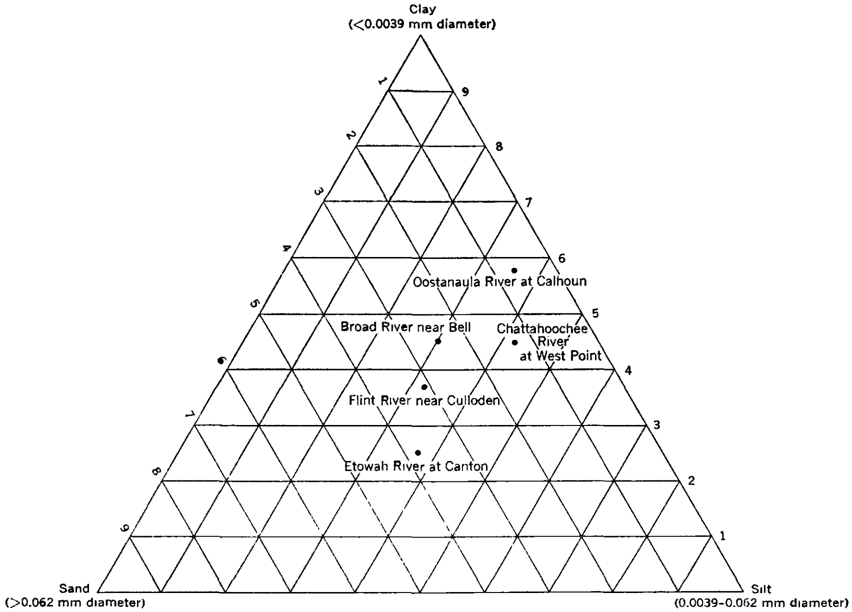

FIGURE 29.—Average particle-size distribution of suspended sediment in samples from selected Georgia rivers.

Curves showing discharge-concentration and concentration-frequency relations are very helpful in summarizing the data and can profitably be used if sufficient information is available.

VARIATION IN SEDIMENT LOAD

The rate of transportation of sediment varies greatly between physiographic provinces. In the Blue Ridge area the great increase in suspended-sediment concentration, combined with increasing water discharge, results in an extremely rapid increase in sediment load during storms. More than 75 percent of the annual sediment load may be transported during only 10 percent of the time, hence a good estimate of the annual sediment load can be made from water samples collected during only the larger floods. Data obtained by the Tennessee Valley Authority suggest that the average annual sediment yield per square mile in the Blue Ridge area ranges from 200 to 1,000 tons per square mile.

The rate of sediment transport in the Piedmont also increases rapidly with increasing discharge. For example, it is probable that more than half of the sediment load for the 1959 water year was carried by the Broad River between May 26 and June 5, 1959. Sampling to estimate sediment load in the Piedmont also need be done only during the larger floods. Available data indicate that sediment yields in the Georgia Piedmont ranges from 100 to 500 tons per square mile per year.

The sediment load carried by streams in the Georgia Coastal Plain is relatively small and probably ranges from 5 to 30 tons per square mile per year. The suspended-sediment load can be estimated by detailed sampling during the larger floods and by occasional sampling at other times.

Sediment-transport curves and load-distribution curves are helpful in summarizing sediment-load information and may be used where sufficient data make them feasible.

Data obtained during the present study suggest that the bed load is not a major part of the total sediment load. However, this hypothesis is not proven and more data are needed, especially for streams on the Coastal Plain.

REFERENCES CITED

Benedict, P. C., 1957, Fluvial sediment transportation: Trans. Amer. Geophys. Union, v. 38, p. 897–902.

Brune, G. M., 1953, Trap efficiency of reservoirs: Trans. Amer. Geophys. Union, v. 34, p. 407–418.

Butts, Charles, and Gildersleeve, Benjamin, 1948, Geology and mineral resources of the Paleozoic area in northwest Georgia: Georgia Dept. Mines, Mining, and Geology Bull. 54, 176 p.

Carter, R. L., and Giddens, Joel, 1953, Soils of Georgia: Agricultural Experiment Station Bull. 2, 68 p., Athens, Ga.

Colby, B. R., and Hembree, C. H., 1955, Computation of total sediment discharge, Niobrara River near Cody, Nebr.: U.S. Geol. Survey Water-Supply Paper 1357, 187 p.

Colby, B. R. and Hubbell, D. W., 1957, Simplified methods for computing total sediment discharge with the modified Einstein procedure: U.S. Geol. Survey open-file report, 35 p.

Dole, R. B., 1909, Quality of surface waters in the United States, pt. 1, Analyses of waters east of the one hundredth meridian: U.S. Geol. Survey Water-Supply Paper 236, p. 54–99.

Federal Inter-Agency Committee on Water Resources, 1957, Summary of reservoir sedimentation surveys made in the United States through 1953: Sedimentation Bull. 6, U.S. Government Printing Office, Washington 25, D.C.

Feneman, N. M., 1938, Physiography of Eastern United States: New York, N.Y., McGraw-Hill Book Co.

Glymph, L. M., Jr., 1954, Studies of sediment yields from watersheds: Internat. Assn. Sci. Hydrology, Rome assembly, Pub. 1, p. 178–191.

Howard, C. S., and Love, S. K., 1945, Quality of surface waters of the United States, 1943: US. Geol. Survey Water-Supply Paper 970, 180 p.

Kalinske, A. A., 1942, Criteria for determining sand-transport by surface-creep and saltation: Trans. Amer. Geophys. Union, v. 23, p. 641–643.

Lamar, W. L., 1944, Chemical character of surface waters of Georgia: U.S. Geol. Survey Water-Supply Paper 889–E, p. 350–377.

Lane, E. W., and Koelzer, V. A., 1943, Density of sediments deposited in reservoirs, *in* A study of methods used in measurement and analysis of sediment loads in streams: Federal Inter-Agency River Basin Comm. Rpt. 9, p. 60.

Searcy, J. K., 1959, Flow duration curves: U.S. Geol. Survey Water-Supply Paper 1542–A, p. 1–33.

Thomson, M. T., Herrick, S. M., Brown, Eugene, and others, 1956, The availability and use of water in Georgia: Georgia Dept. Mines, Mining, and Geology Bull. 65, 329 p.

U.S. Bureau of the Census, 1956, United States census of agriculture, 1954, Georgia: v. 1, pt. 17, 380 p.

U.S. Geological Survey, 1945, Quality of surface waters of the United States, 1940: U.S. Geol. Survey Water-Supply Paper 1030, 355 p.

——— 1947, Quality of surface waters of the United States, 1944: U.S. Geol. Survey Water-Supply Paper 1022, 311 p.

——— 1956, Surface water supply of the United States, 1954: U.S. Geol. Survey Water-Supply Paper 1334.

——— 1957, Surface water supply of the United States, 1955: U.S. Geol. Survey Water-Supply Paper 1384.

——— 1958, Surface water supply of the United States, 1956: U.S. Geol. Survey Water-Supply Paper 1433.

——— 1959a, Surface water supply of the United States, 1957: U.S. Geol. Survey Water-Supply Paper 1503.

——— 1959b, Surface Water supply of the United States, 1957: U.S. Geol. Survey Water-Supply Paper 1504.

U.S. Weather Bureau, 1958, Climatological data, Georgia: v. 62, nos. 1–12.

——— 1959, Annual Summary 1958, Climatological data, Georgia: v. 62, no. 13, p. 191.

——— 1960, Annual Summary 1959, Climatological data, Georgia: v. 63, no. 13. p. 187.

INDEX

[Where several page numbers appear, major references are in italic]