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A PRELIMINARY ANALYSIS OF SEDIMENTATION LOADING RATES IN THE UPPER BUTTAHATCHEE RIVER, ALABAMA, 2004-2005

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by

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ABSTRACT

This study summarizes a preliminary effort to document the rates of sediment loading in the upper Buttahatchee River system and to determine primary sources of sedimentation in a reach of river devoid of mussels, based on limited synoptic data from selected sites. Data collected from nine sites on the Buttahatchee River and selected tributaries indicated that sedimentation rates in the watershed are elevated and that much of the sediment originates in the upstream portion of the watershed. Mean suspended sediment rates varied from less than 1 ton per day to more than 2,000 tons per day and composed from 18 to 94 percent of the total sediment loads of the monitored watersheds. Bedload transport rates varied from less than 0.5 ton per day to 137 tons per day.

ACKNOWLEDGMENTS

Individuals who aided in the completion of this project are acknowledged herein. Phillip Henderson and Neil Moss of GSA assisted in field data collection, and Mirza Beg, Lifo Chen, and Bob Meintzer analyzed samples in the GSA Geochemistry Lab.

INTRODUCTION

The Mobile River basin, the largest Gulf of Mexico river basin east of the Mississippi River, is second only to the Tennessee River drainage basin in diversity of freshwater mussels, historically supporting at least 72 species (Williams and others, 1993). The Tombigbee River system alone supported over 50 species (Williams and others, 1992). The Mobile River basin mussel fauna is also noteworthy for its high number of endemic species. Significant human-induced impacts to the basin over the past 100 years, including impoundment, eutrophication, sedimentation, pollution, and channel modifications, have caused a drastic decline in this fauna (Hartfield, 1994; Mott and Hartfield, 1994; Williams and others, 1992). Currently, 17 species of freshwater mussels in the Mobile River basin are federally listed endangered or threatened species, and 14 species in the genus *Pleurobema* endemic to the basin are considered extinct (Hartfield, 1994).

Recent sampling for freshwater mussels at 163 stations in the western Mobile River basin in Alabama and Mississippi documented a severely altered mussel fauna comprised of 45 species (McGregor and Haag, 2004). Habitat condition and quality varied greatly among stations sampled during that study, with most of the variation attributed to the geology of the basin and to anthropogenic factors. Stations with the most diverse mussel faunas were in streams characterized by stable gravel or gravel/sand substrates with stable riparian buffer zones and were relatively unaffected by municipal or industrial effluents.

The Sipsey and Buttahatchee Rivers and Bull Mountain, Coal Fire, Lubbub, and Yellow Creeks consistently yielded the most diverse mussel faunas during recent sampling (McGregor and Haag, 2004). In the Buttahatchee River system 30 species were reported, including the only known extant population of one federally listed endangered species, *Epioblasma penita* (table 1). Among those species, eight are considered to be of high or highest conservation concern in Alabama and four are federally listed endangered or threatened species (Mirarchi, 2004). Of the 30 species found in the Buttahatchee system, 28 were found in the main channel Buttahatchee River from the mouth upstream to the vicinity of the Alabama Highway 17 bridge (lower Buttahatchee), 7 were found in the main channel upstream of the Alabama Highway 17 bridge to the headwaters (upper Buttahatchee), and 5 were found in tributaries (table 1).

It is not unusual for downstream reaches of streams to yield higher abundance and diversity values for mussels than headwaters or tributaries because of increased potential for occupation. This increased potential is due to several factors, including larger areal extent, more habitat diversity, possibly better sustained stream flows, and a larger pool of potential host fishes. However, the extreme disparity in mussel abundance and diversity between the lower Buttahatchee and the headwaters and the complete absence of mussels in a long stretch mid-river indicates there are likely serious problems limiting faunal diversity in that reach. A further concern is that the mechanism negatively affecting the

Table 1.-Freshwater mussel species recently collected from the Buttahatchee River system, Alabama and Mississippi, and conservation status of each (from McGregor and Haag, 2004; Mirarchi, 2004)

Species	Status[1]	Stream Reaches[2]		
		Lower Buttahatchee	Upper Buttahatchee	Tributaries
Amblema plicata	P4	X		
Anodonta suborbiculata	P4	X		
Anodontoides radiatus	P2		X	X
Ellipsaria lineolata	P4	X		
Elliptio arca	P1	X		
Elliptio arctata	P1	X		
Elliptio crassidens	P5	X		
Epioblasma penita	P1, E	X		
Fusconaia cerina	P5	X	X	
Lampsilis ornata	P4	X	X	
Lampsilis straminea	P4	X	X	X
Lampsilis teres	P5	X		
Lasmigona c. alabamensis	P3	X		
Leptodea fragilis	P5	X		X
Medionidus acutissimus	P2, T	X	X	
Megalonaias nervosa	P5	X		
Obliquaria reflexa	P5	X		
Obovaria jacksoniana	P3	X		
Obovaria unicolor	P2	X		
Pleurobema decisum	P2, E	X		
Pleurobema perovatum	P1, E	X		
Pyganodon grandis	P5	X		
Quadrula apiculata	P5	X		
Quadrula asperata	P5	X		
Quadrula rumphiana	P4	X		
Strophitus subvexus	P3	X		X
Tritogonia verrucosa	P4	X		
Truncilla donaciformis	P3	X		
Uniomerus declivis	P4		X	
Villosa lienosa	P5	X	X	X
Totals		28	7	5

[1]Conservation priority-P1 Highest, P2 High, P3 Moderate, P4 Low, P5 Lowest; E=federally listed endangered, T=federally listed threatened.

[2]Lower Buttahatchee is from mouth of Buttahatchee River upstream to Alabama Hwy. 17; Upper Buttahatchee is upstream of Alabama Hwy. 17 to headwaters.

mid-reach fauna may eventually extend upstream or downstream and negatively affect the remaining mussel populations, if left unchecked.

Erosion, sedimentation, unstable substrates, and flow regimes altered by anthropogenic activities are known to be major factors limiting successful occupation of streams by mussels, though little is known of the actual limits of each that can be tolerated. Ellis (1931, 1936) reported that silt causes mortality in mussels by clogging gills and interfering with respiration and feeding and that one-fourth to one inch of deposited silt caused high mortality rates in mussels in the Tennessee, Ohio, and Mississippi Rivers. Vannote and Minshall (1982) determined that large block boulders in the Salmon River, Idaho, stabilize substrates, prevent significant bed scour during floods, and act as refugia for mussels, which repopulate the river after periodic floods scour its less well-protected reaches. Dennis (1984) found that heavily silted reaches of the Powell River in Tennessee and Virginia were unsuitable for transplant of mussels and that suspended silt interfered with feeding, reducing food uptake by 50 percent at silt levels of 211 to 820 milligrams per liter (mg/L), and up to 80 percent at levels over 1,000 mg/L in laboratory tests. Layzer and Madison (1995) reported that high shear stress in a fourth-order stream in the Upper Cumberland River drainage in Kentucky limited mussel recruitment by unseating juveniles deposited after encystment on a host fish. Similarly, Hardison and Layzer (2001) found consistently negative correlations between mussel density and complex hydraulic variables such as shear stress in three regulated rivers in Kentucky, and also related their results to removal of juveniles during spring and summer floods. Ziuganov and others (1998) found that highly organic water was unsuitable for mussels and that translocated mussels moved against rapid flows to avoid those conditions in the Varzuga River of northwestern Russia. Stone and others (2004) reported that habitat stability was the limiting factor influencing mussel occurrence, abundance, and population structure in western Washington streams. They further reported that complex hydraulic characteristics, such as shear stress and turbulence, need to be considered in addition to traditional values such as water velocity and depth when associating mussels with their environment. Archaeological investigations have also implicated changes in land use (specifically the advent of maize production, presumably leading to increased sedimentation) in the precipitous decline of one genus of freshwater mussel in eastern North America (Peacock and others, 2005).

Hartfield and Jones (1989) reported that as much as 28,000 tons of sediment were introduced annually into upper Buttahatchee River via Camp Creek from abandoned kaolin strip mines. Observations made during a recent study documented denuded stream banks and loose, unstable substrates in Buttahatchee River upstream of Alabama Highway 17 (McGregor and Haag, 2004). Because of concern for the critically imperiled but still relatively diverse mussel fauna in lower Buttahatchee River by possible sediment loading, the Geological Survey of Alabama (GSA) entered into a contract with the World Wildlife Fund to make preliminary investigations of sediment loading rates in that system. This study is two-fold: First, sedimentation rates at selected stations in the upper Buttahatchee River system are documented; second, primary sediment sources in the reach of river devoid of mussels are identified. This report summarizes results of the investigation.

STUDY AREA

The study area includes the Buttahatchee River and selected tributaries in Lamar and Marion Counties, Alabama, from the vicinity of the Alabama Highway 17 bridge upstream to the headwaters (fig. 1, 2). Most of the study area lies within the Fall Line Hills district of the East Gulf Coastal Plain physiographic section. The Fall Line Hills physiographic district represents the transition from the indurated rocks of the interior districts to the less consolidated sediments of the East Gulf Coastal Plain. Streams draining the Fall Lines Hills district are well sustained due to extensive sand and gravel aquifers. A small portion of the study area, representing the headwaters of the Buttahatchee River, lies within the Warrior Basin district of the Cumberland Plateau physiographic section (Sapp and Emplaincourt, 1975). Streams in this dissected plateau of sandstone and shale frequently go dry due to low recharge from aquifers (Mettee and others, 1996).

MONITORING PLAN

The initial monitoring plan included two data sets collected at four sites on the main stem of the Buttahatchee River and two sites on tributary watersheds. However, the scope of the project was expanded to include six data sets at nine sites: four on the

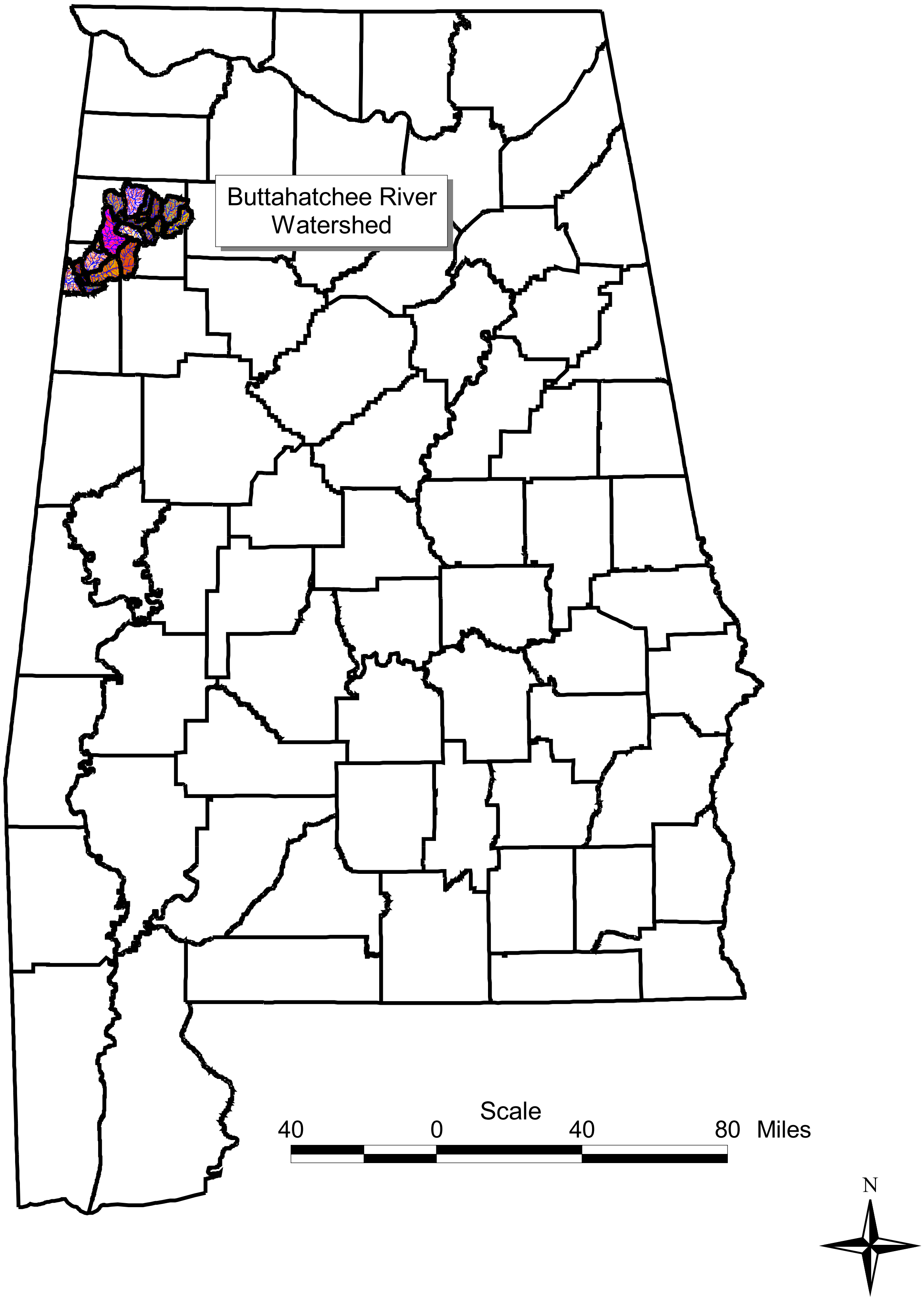


Figure 1.—Map of the study area.

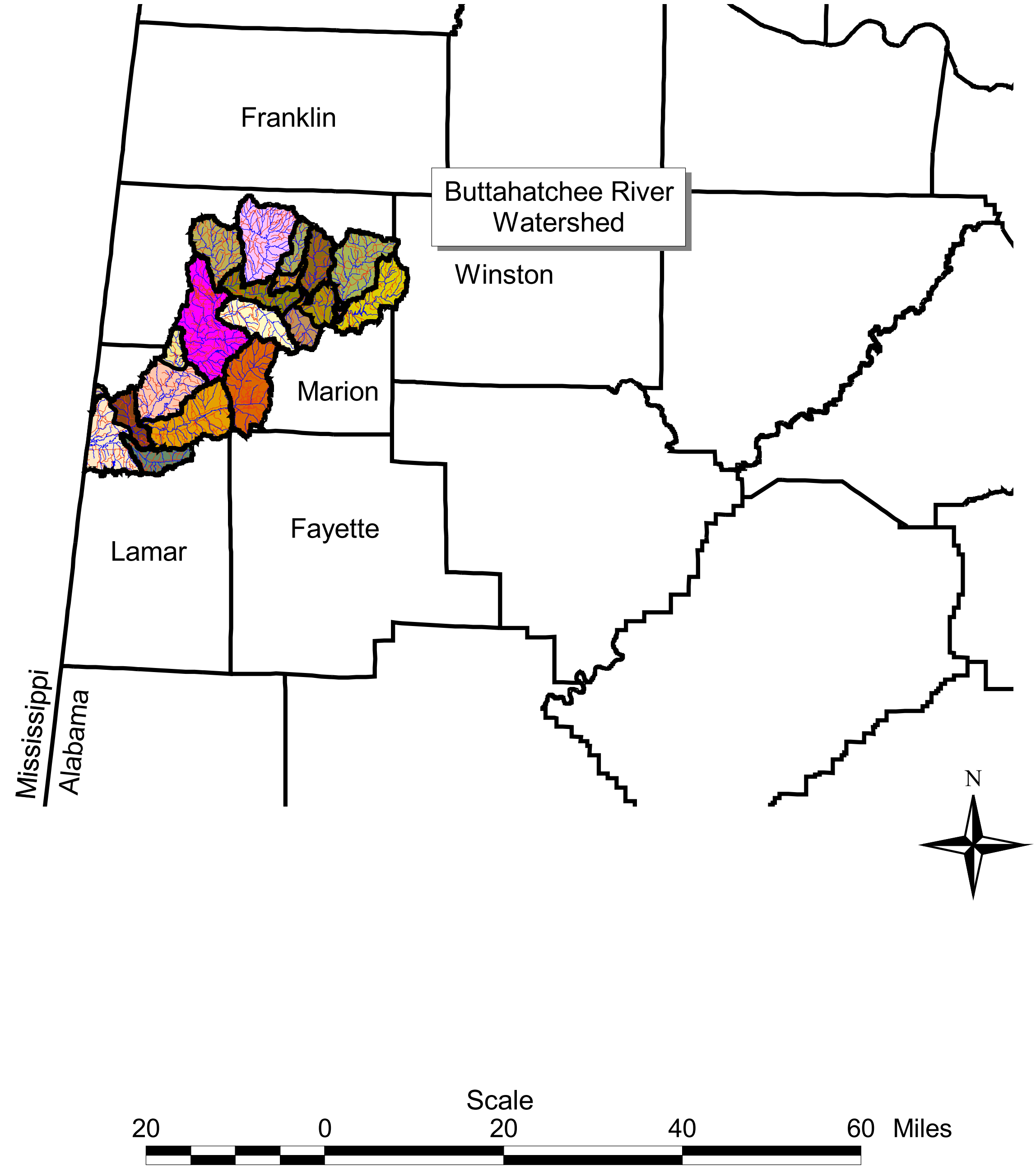


Figure 2.—Regional view of the study area.

Buttahatchee River and one in each of five tributary watersheds (fig. 3). The sites were chosen to evaluate critical portions of selected watersheds. The monitored areas of the selected watersheds vary from 12 to 469 square miles (mi^2) (table 2) (fig. 3).

Parameters measured on site and delivered with samples to the geochemistry laboratory included water temperature, pH, specific conductance, dissolved oxygen (DO), turbidity, stream water level, discharge, and mean stream flow velocity. Grab samples of water from each station were analyzed in the laboratory to determine total suspended solids (TSS). TSS is the concentration of suspended solids in the stream at the time of sampling and is used in calculations of suspended sediment loads. Bedload sediment was determined in situ using a direct measurement method developed by the GSA.

Table 2.—Monitored areas of project watersheds.

Stream and monitoring site designation	Monitored watershed area (upstream from site) (mi^2)
Buttahatchee River at Alabama Hwy. 17 (BR1)	469
Buttahatchee River and county road 16 (BR2)	330
Buttahatchee River at Alabama Hwy. 253 (BR3)	106
Buttahatchee River at Alabama Hwy. 129 (BR4)	31
Barn Creek at U.S. Hwy. 278 (BC1)	20
Camp Creek at Alabama Hwy. 253 (CC1)	12
Pearces Mill Creek at Alabama Hwy. 253 (PM1)	13
West Br. Buttahatchee River at Alabama Hwy. 129 (WB1)	38
Williams Creek at Old Hwy. 43 (WC1)	30

STREAM DISCHARGE

Discharge is a primary physical parameter that influences and/or controls surface-water quality in the project area. Ionic concentrations, specific conductance, DO, biochemical oxygen demand, suspended and bedload sediment transport, and bacterial concentrations are all influenced by the volume and velocity of stream discharge (Cook and Puckett, 1998). The original monitoring plan for Buttahatchee River was designed to collect data during one low flow and one high flow discharge event. Due to the expansion of the project scope, additional discharge events were monitored at eight of nine sites. Discharge was measured using a Price AA flow meter mounted on a standard wading rod or bridge board. U.S. Geological Survey (USGS) methodology was used for the measurement of stream discharge.

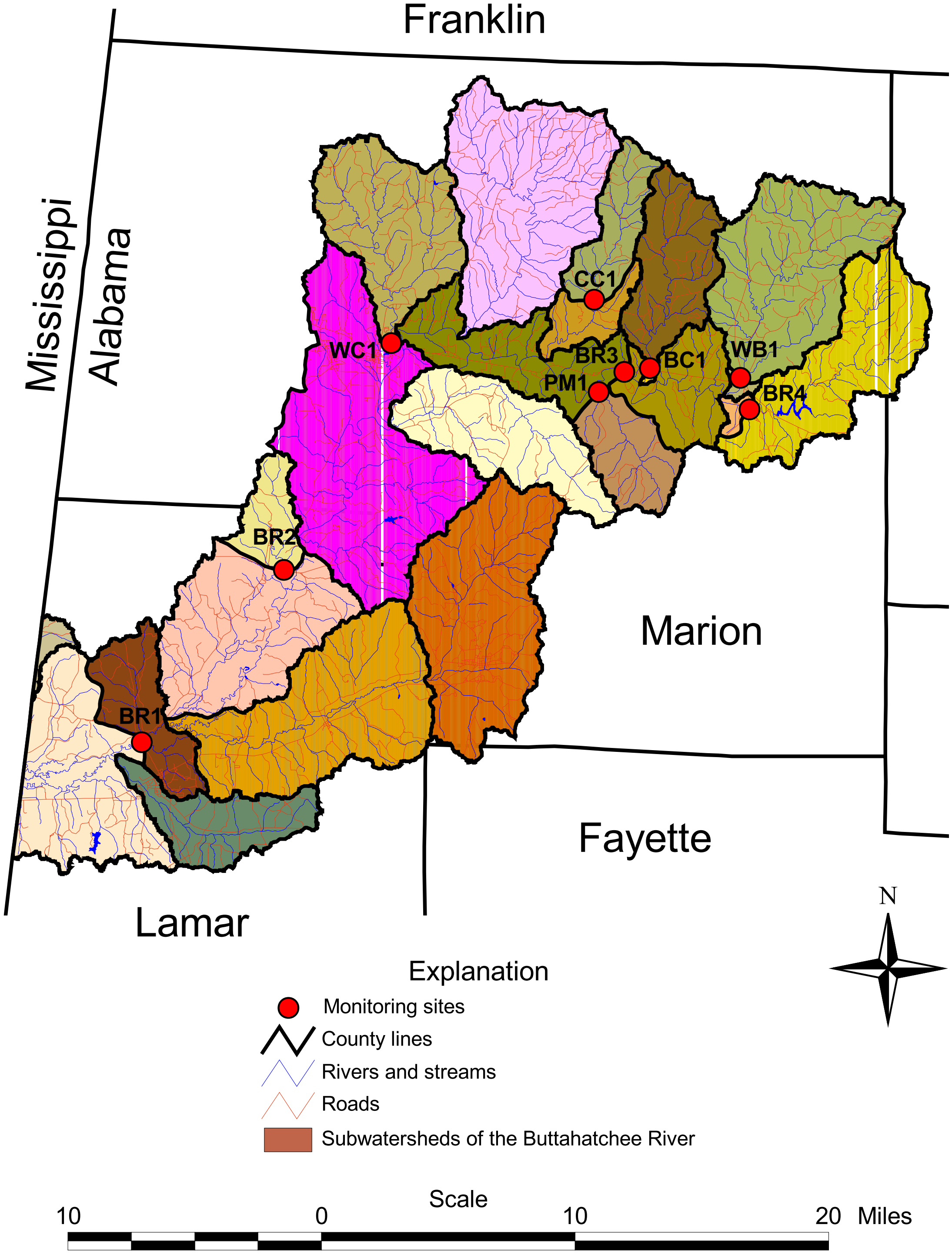


Figure 3.—Watershed view of the study area.

The largest discharge (10,293 cubic feet per second (cfs)) was measured at site BR2 on April 7, 2005. The smallest discharge was measured at site CC1 on January 6, 2005 (354 cfs). Maximum and minimum measured discharge values for each site are given in table 3.

Table 3.—Measured discharge values for monitoring sites.

Monitoring Site	Maximum discharge (cfs)	Minimum discharge (cfs)
Buttahatchee River (BR1)	6,873	487
Buttahatchee River (BR2)	10,293	354
Buttahatchee River (BR3)	3,088	108
Buttahatchee River (BR4)	2,059	71
Barn Creek (BC1)	228	9
Camp Creek (CC1)	150	13
Pearces Mill Creek (PM1)	21	18
West Branch Buttahatchee River (WB1)	1,132	47
Williams Creek (WC1)	926	39

SEDIMENTATION

Sedimentation is a process by which eroded particles of rock are primarily transported by moving water from areas of relatively high elevation to areas of relatively low elevation, where the particles are deposited. Upland sediment transport is primarily accomplished by overland flow and rill and gully development. Lowland or floodplain transport occurs in varying order streams where upland sediment joins sediment eroded from floodplains, stream banks and streambeds. Erosion rates are accelerated by human activity related to agriculture, construction, timber harvesting, unimproved roadways or any activity where soils or geologic units are exposed or disturbed. Sedimentation is detrimental to water quality, destroys biologic habitat, reduces storage volume of water impoundments, impedes the usability of aquatic recreational areas, and causes damage to structures. Sediment loads in streams are primarily composed of relatively small particles suspended in the water column (suspended solids) and larger particles that move on or periodically near the streambed (bedload).

SEDIMENT LOAD MODELING METHODOLOGY

SUSPENDED SEDIMENT LOADING

Total Suspended Solids is defined as that portion of a water sample that is separated from the water by filtering. This solid material may be composed of organic and inorganic constituents that include algae, industrial and municipal wastes, urban and agricultural runoff, and erosional material from geologic formations. These materials are transported to stream channels by overland flow related to storm-water runoff.

The GSA uses either of two methods to estimate suspended sediment loads based on the number of measured suspended sediment values. If a relatively large number of monitored values collected over a relatively large range of discharge events are available, the computer model Regr_Cntr.xls (Regression with Centering) is used to calculate suspended sediment loads from the analytical and stream discharge data. The program is an Excel adaptation of the USGS seven-parameter regression model for load estimation (Cohn and others, 1992). The Regr_Cntr.xls program was adapted by R. Peter Richards at the Water Quality Laboratory at Heidelberg College (Richards, 1999). The program establishes a regression model using a calibration set of data composed of concentrations of the constituent of interest and discharge values measured at the time of water sampling. The resulting load estimates are given in annual metric tons and are converted to a number of mass and volume per unit time values.

If few values are available (1-10), suspended loads may only be estimated for an individual instantaneous value over a relatively short time interval (mass per day). This method was used for the sediment assessment for the Buttahatchee River. Concentrations of suspended sediment in mg/L were determined by laboratory analysis of water grab samples collected periodically at variable stream discharge rates. The analytical results were used to determine suspended sediment loads for each sampled discharge event (instantaneous load). Instantaneous suspended sediment loads can be quantified by the formula:

$$Q_s = Q_w \; C_s \; k,$$

where

- Q_s is the sediment discharge, in tons per day (tons/day)
- Q_w is the water discharge, in cubic feet per second (cfs)
- C_s is the concentration of suspended sediment in mg/L

and

- k is a coefficient based on the unit of measurement of water discharge and assumes a specific weight of 2.65 for sediment (Porterfield, 1972).

BEDLOAD

Transport of streambed material is controlled by a number of factors primarily related to stream discharge and flow velocity, erosion and sediment supply, stream base level, and physical properties of the streambed material. Most streambeds are in a state of constant flux in order to maintain a stable base level elevation. The energy of flowing water in a stream is constantly changing to supply the required power for erosion or deposition of bedload to maintain equilibrium with the local water table and regional or global sea level. Stream base level may be affected by regional or global events including fluctuations of sea level or tectonic movement. Local factors affecting base level include fluctuations in the water table elevation, changes in the supply of sediment to the stream caused by changing precipitation rates, and/or land use practices that promote excessive erosion in the floodplain or upland areas of the watershed.

Bedload sediment is composed of particles that are too large or too dense to be carried in suspension by stream flow. These particles roll, tumble, or are periodically suspended as they move downstream. Traditionally, bedload sediment has been difficult to quantify due to deficiencies in monitoring methodology or inaccuracies of estimating volumes of sediment being transported along the streambed. This is particularly true with streams that flow at high velocity or in streams with excessive sediment loads.

The GSA has developed a portable sedimentation rate-monitoring device designed to accurately measure bedload sediment values in shallow sand or gravel bed streams. The volume of bedload sediment at each station was measured directly in the stream channel of each sand or sand and gravel bed stream along with stream discharge and velocity. These data were used to determine bedload volumes for each monitored discharge event (instantaneous bedload).

TOTAL SEDIMENT LOADS

The total sediment load transported by a stream is composed of the suspended and bed loads. For streams with sand or gravel beds the suspended and bed loads were measured separately and combined. For streams with beds composed of rock or, in urban settings, stream beds may be composed of concrete or limestone rip-rap, sediment loads are almost totally suspended. In these cases, water samples collected near the stream bed will contain representative volumes of the total sediment load.

Stream beds at three of nine project sites (BC1, BR3, and BR4) were composed of Pottsville Sandstone. The suspended sediment loads for these sites are assumed to be representative of the total sediment loads.

MEASURED SEDIMENT LOADS FOR THE BUTTAHATCHEE RIVER WATERSHED

Suspended sediment loads calculated from instantaneous measurements for the monitored sites were highly variable. The variability of suspended loads for individual samples collected at a particular site is primarily the result of discharge at the time of sample collection and if the sample was collected during rising or falling water levels. Figures 4 through 12 portray individual instantaneous suspended sediment loads determined at each monitored site.

Figure 4.--Instantaneous suspended sediment loads calculated for site BR1, Buttahatchee River at Alabama Highway 17, Lamar County, AL.

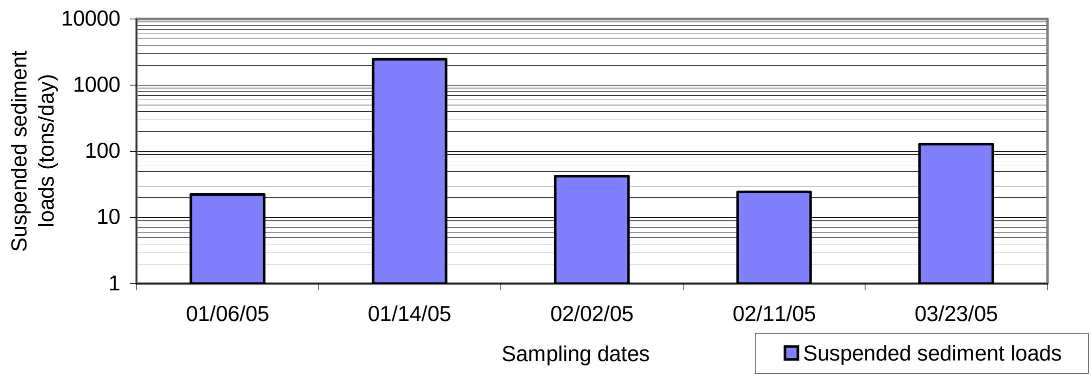


Figure 5.--Instantaneous suspended sediment loads calculated for site BR2, Buttahatchee River at county road 16, Lamar County, Alabama.

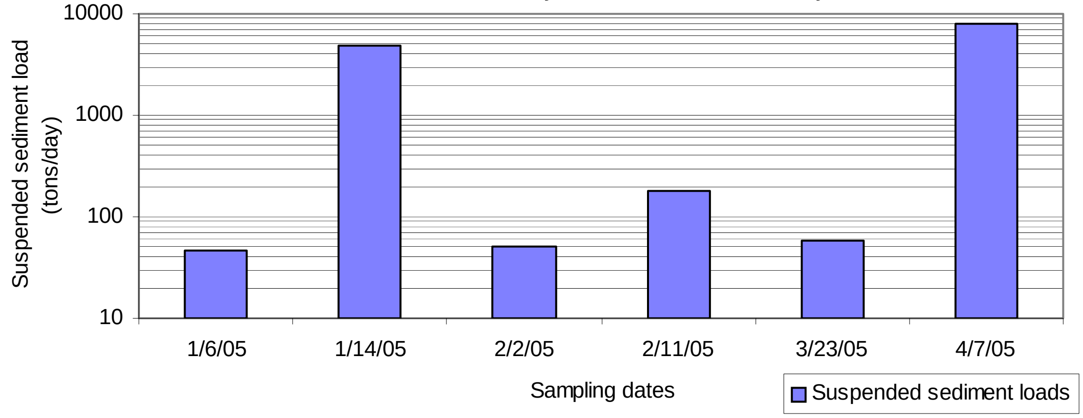


Figure 6.--Instantaneous suspended sediment loads calculated for site BR3, Buttahatchee River at Alabama Highway 253, Marion County, Alabama.

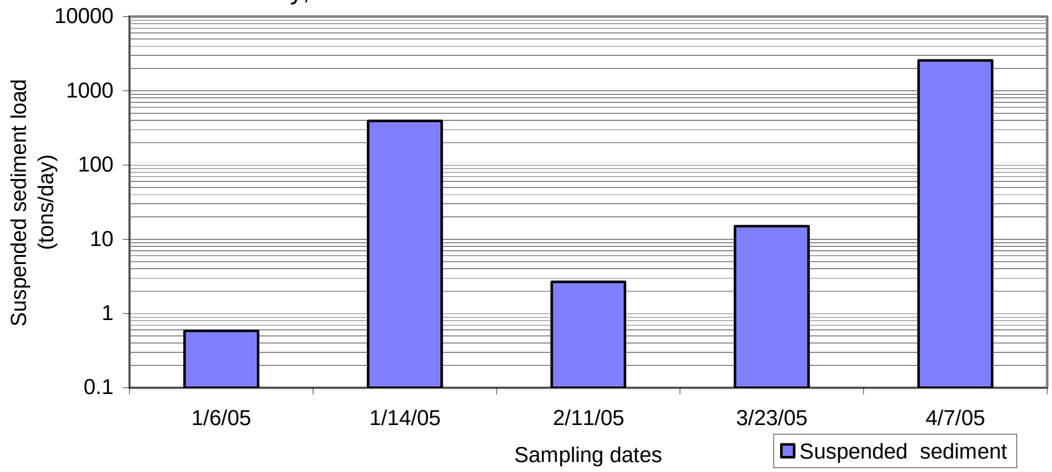


Figure 7.--Instantaneous suspended sediment loads calculated for site BR4, Buttahatchee River at Alabama Highway 129, Lamar County, Alabama.

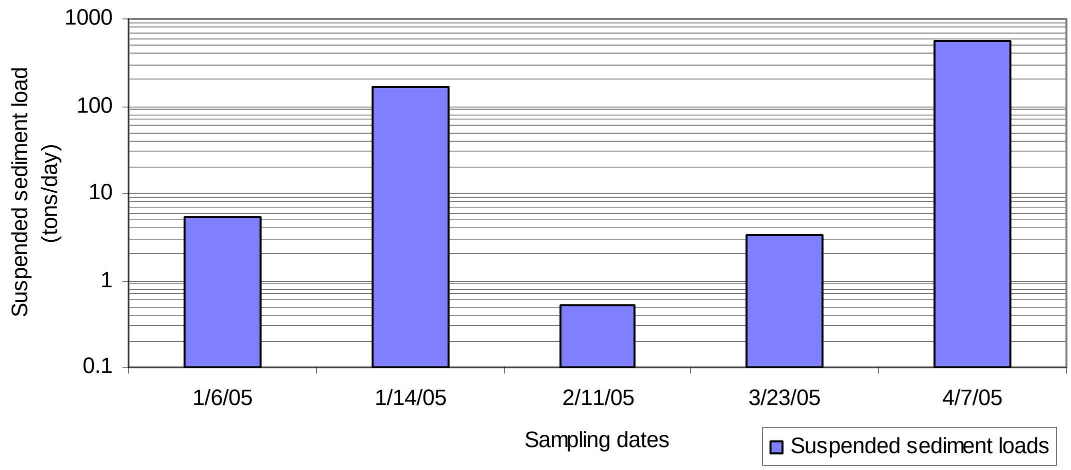


Figure 8.--Instantaneous suspended sediment loads calculated for site BC1, Barn Creek at U.S. Highway 278, Marion County, Alabama.

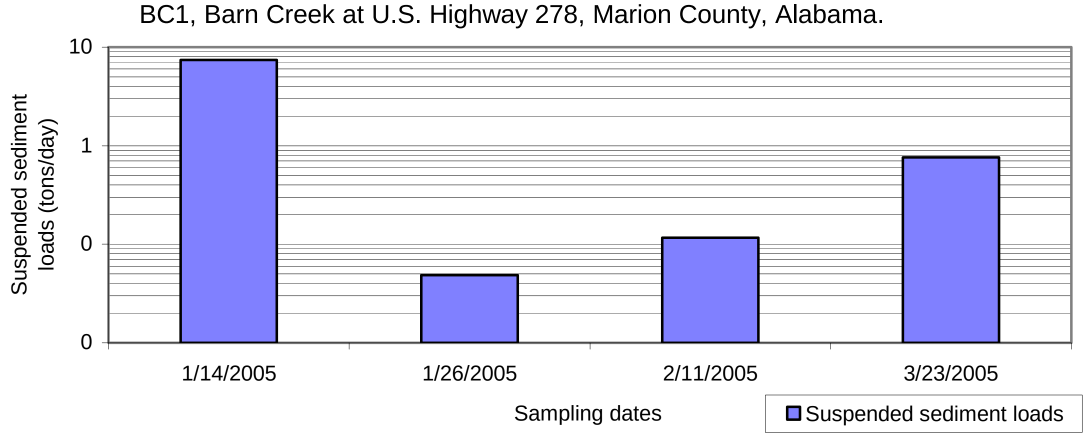


Figure 9.--Instantaneous suspended sediment loads calculated for site CC1, Camp Creek at Alabama Highway 253, Marion County, Alabama.

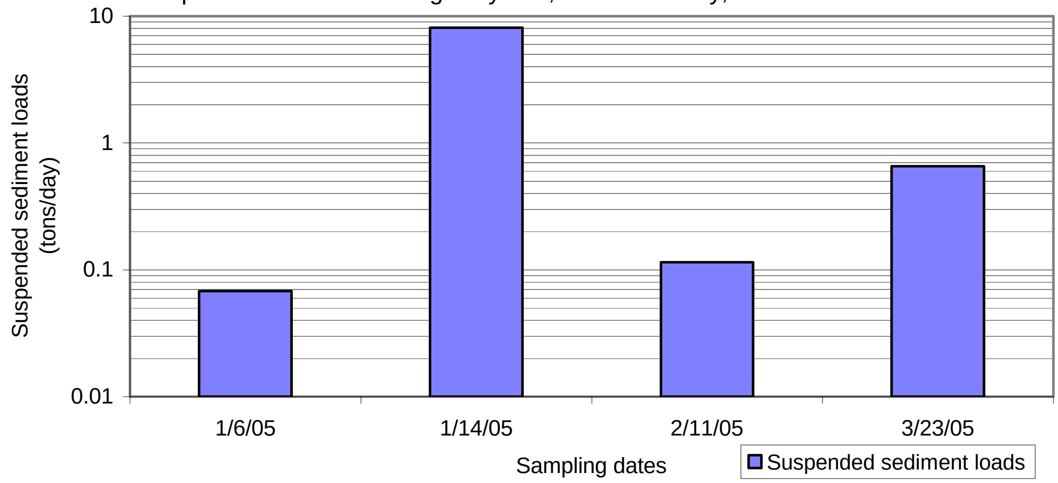


Figure 10.--Instantaneous suspended sediment loads calculated for site PM1, Pearces Mill Creek at Alabama Highway 253, Marion County, AL.

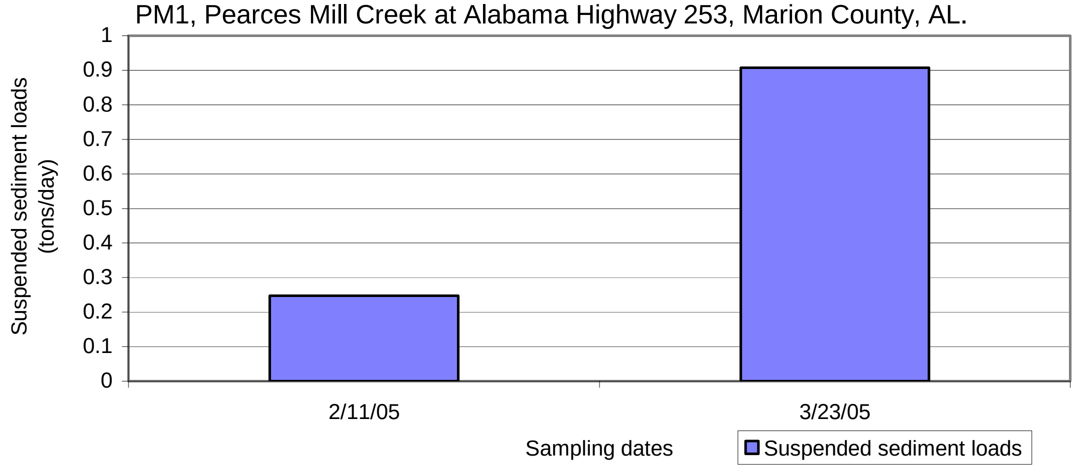


Figure 11.--Instantaneous suspended sediment loads calculated for site WB1, West Branch of the Buttahatchee River at Alabama Highway 129, Marion County, Alabama.

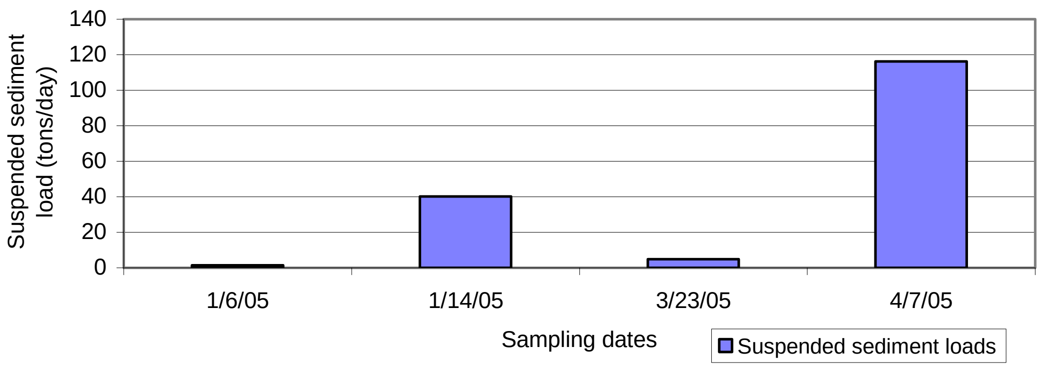
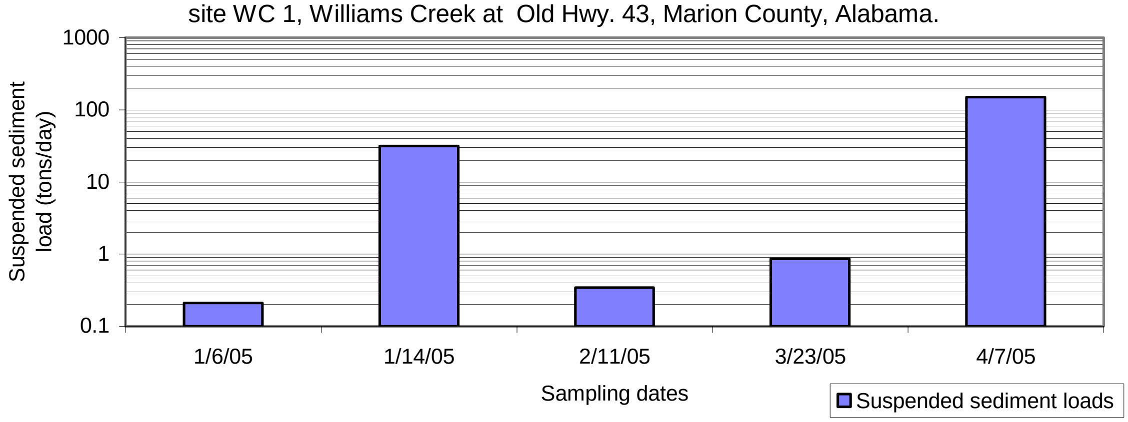


Figure 12.--Instantaneous suspended sediment loads calculated for site WC 1, Williams Creek at Old Hwy. 43, Marion County, Alabama.



Variability of loads between sites is attributed to the size differences of the watersheds, stream flow conditions at the time of sampling, and erosional conditions and volume of sediment contributed to the stream in each watershed. Relative watershed size and discharge may be accounted for by normalizing sedimentation data. The largest suspended sediment loads (maximum load 7,921 tons per day (t/d)) were measured at site BR2. However, normalization of the data clearly shows that the West Branch of the Buttahatchee River (site WB1) transports the largest suspended load relative to size of watershed and discharge. Figures 13 through 17 portray the normalized data for each monitored event in tons per square mile per cubic feet per second per day.

Figure 13.--Instantaneous suspended sediment loads, normalized with respect to watershed size and discharge, determined for selected Buttahatchee River and tributary sites, from samples collected on January 6, 2005.

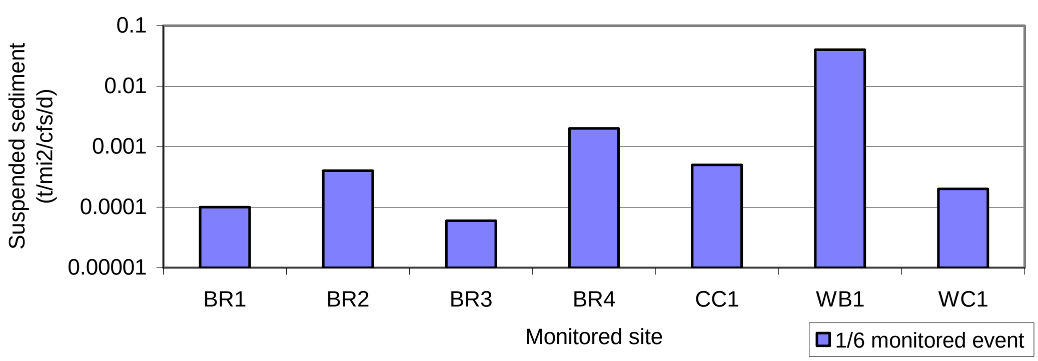


Figure 14.--Instantaneous suspended sediment loads, normalized with respect to watershed size and discharge, determined for selected Buttahatchee River and tributary sites, from samples collected on January 14, 2005.

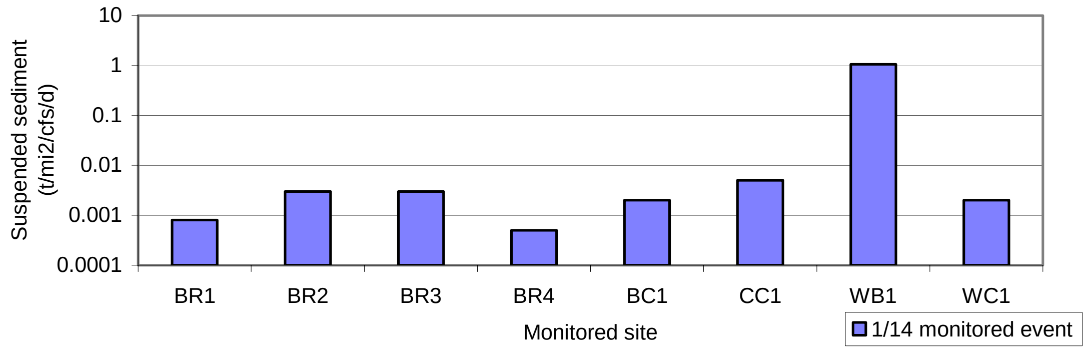


Figure 15.--Instantaneous suspended sediment loads, normalized with respect to watershed size and discharge, determined for selected Buttahatchee River and tributary sites, from samples collected on February 11, 2005.

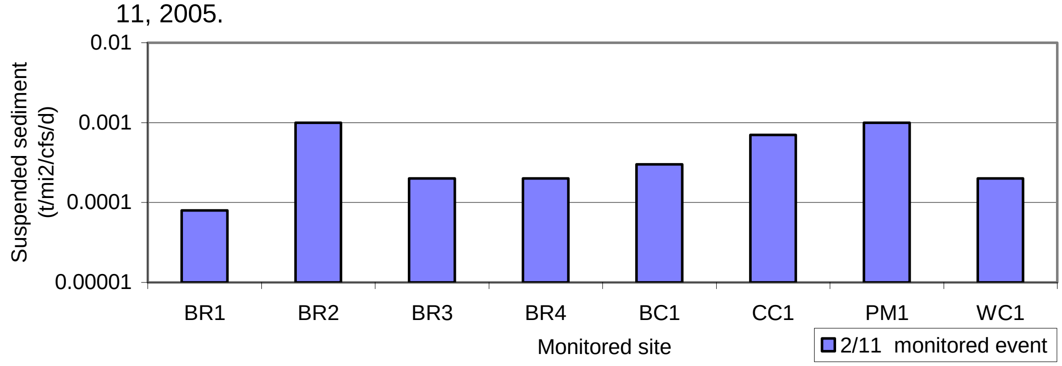


Figure 16.--Instantaneous suspended sediment loads, normalized with respect to watershed size and discharge, determined for selected Buttahatchee River and tributary sites, from samples collected on March 23, 2005.

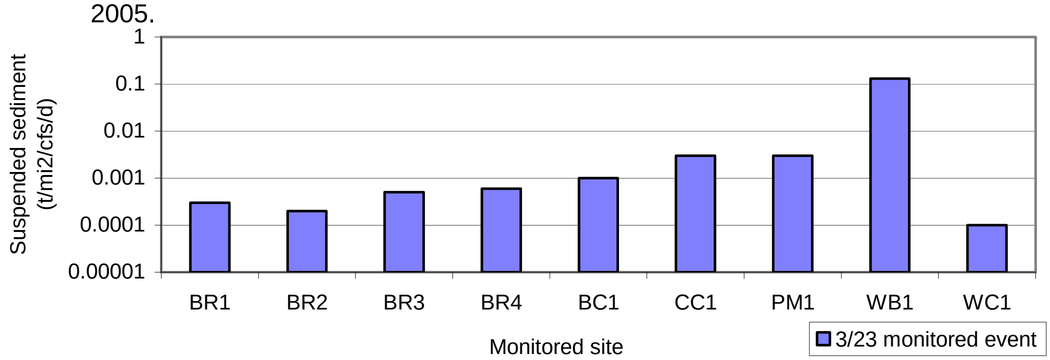
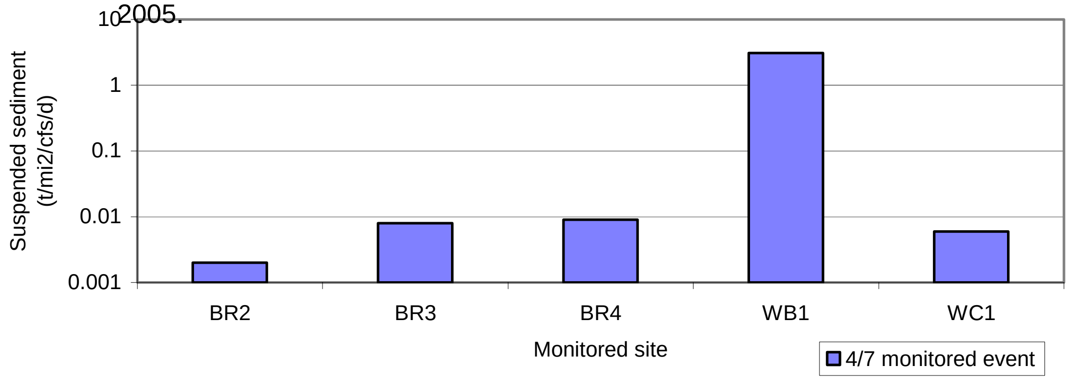
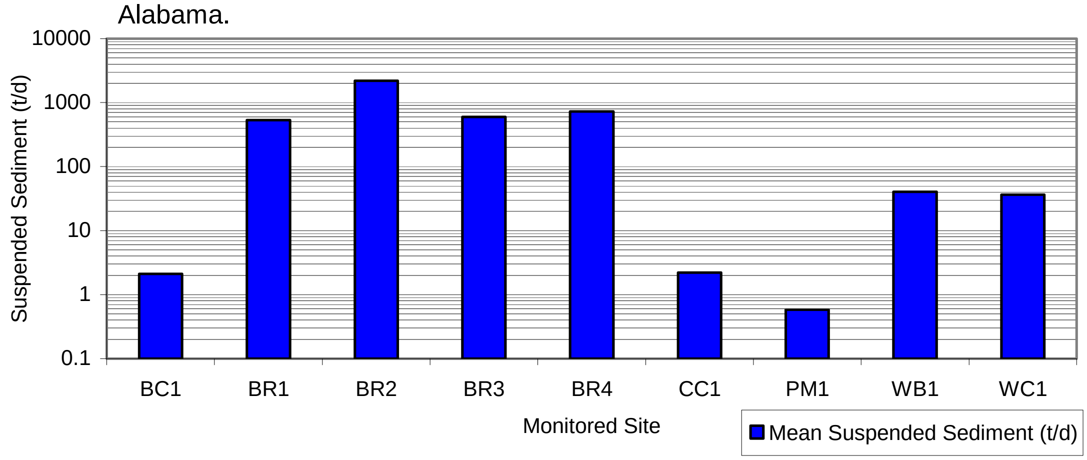


Figure 17.--Instantaneous suspended sediment loads, normalized with respect to watershed size and discharge, determined for selected Buttahatchee River and tributary sites from samples collected on April 7, 2005.



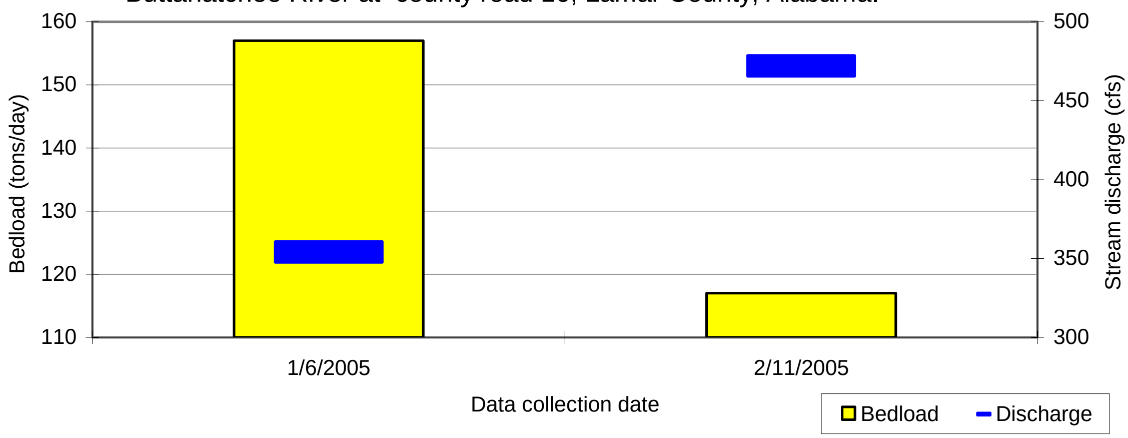
The investigation of sediment loading in the Buttahatchee River watershed indicates that suspended sediment comprises a major portion of the total sediment load transported by the river. Figures 13 through 17 show that the tributary streams consistently transport as much or more suspended sediment as do the main stem river segments relative to watershed size and discharge. The sediment transport system consists of tributaries that supply much of the sediment load to the main stem of the river which serves as a conduit to move the sediment downstream. Figure 18 portrays the mean suspended loads determined from individual instantaneous samples collected at each monitored site. The monitored Buttahatchee River segments transport from 500 to 2,200 tons of suspended sediment per day (based on limited synoptic data).

Figure 18.--Mean instantaneous suspended sediment loads calculated for Buttahatchee River and tributary sites in Lamar and Marion Counties, Alabama.



Bedload sediment generally comprises less than 50% of the total sediment load transported by streams. However, it is usually a significant part of the total load and must be considered in sedimentation studies. In large streams such as the Buttahatchee River, bedload tends to move in pulses related to trends in discharge and mean stream flow velocity resulting from seasonal precipitation patterns rather than single precipitation events. This is illustrated in figure 19, where a short term increase in discharge on February 11, 2005, correlated with a lower bedload transport rate when compared to data collected on January 6, 2005, in the Buttahatchee River at county road 16 in Lamar County.

Figure 19.--Measured stream discharge and bedload sediment for site BR2, Buttahatchee River at county road 16, Lamar County, Alabama.



In smaller streams and in headwaters, the influences of precipitation, discharge, and mean velocity on bedload movement are more immediate. This is portrayed in figures 20 through 25 for the West Branch of the Buttahatchee River, Camp Creek, and Pearces Mill Creek, where precipitation (not shown), discharge, mean velocity, and bedload are closely related.

Figure 20.--Stream discharge and bedload sediment measured at site WB1, West Branch of the Buttahatchee River at Alabma Highway 129 , Marion County, Alabama.

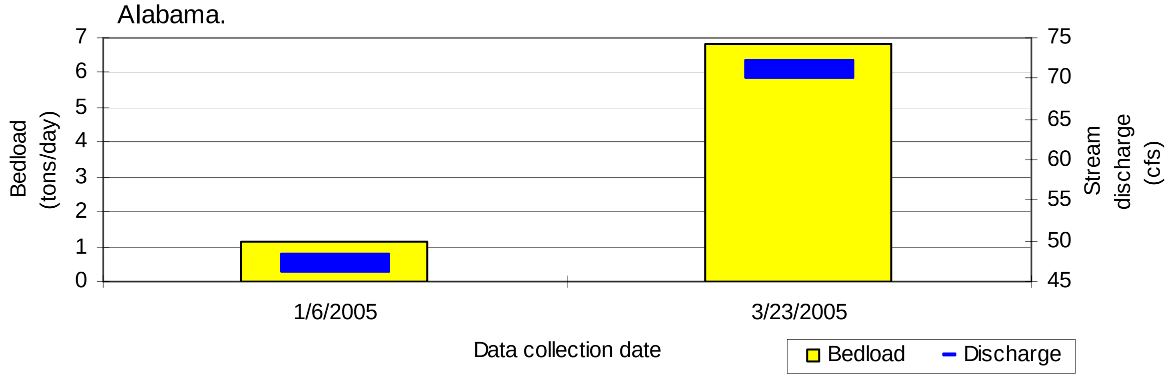


Figure 21.--Mean stream flow velocity and bedload sediment measured at site WB1, West Branch of the Buttahatchee River at highway 129 , Marion County, Alabama.

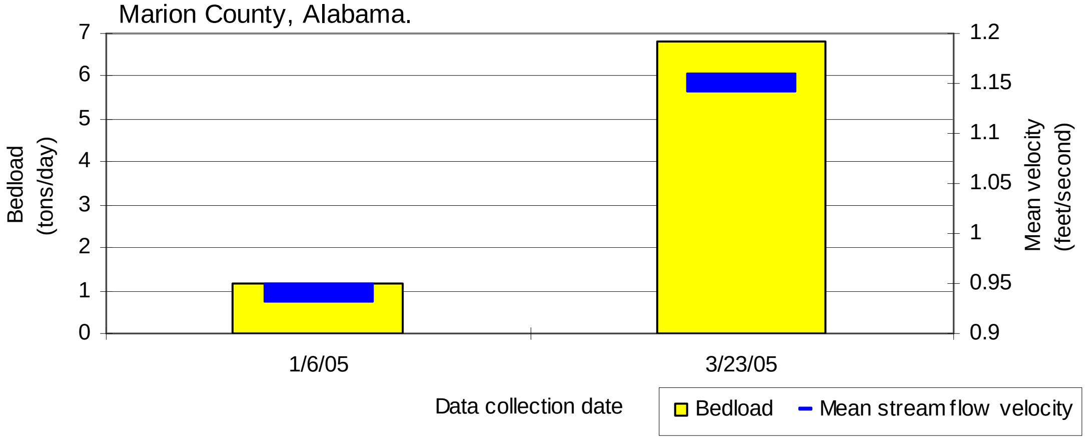


Figure 22.--Stream discharge and bedload sediment measured at site CC1, Camp Creek at Alabama Highway 253, Marion County, Alabama.

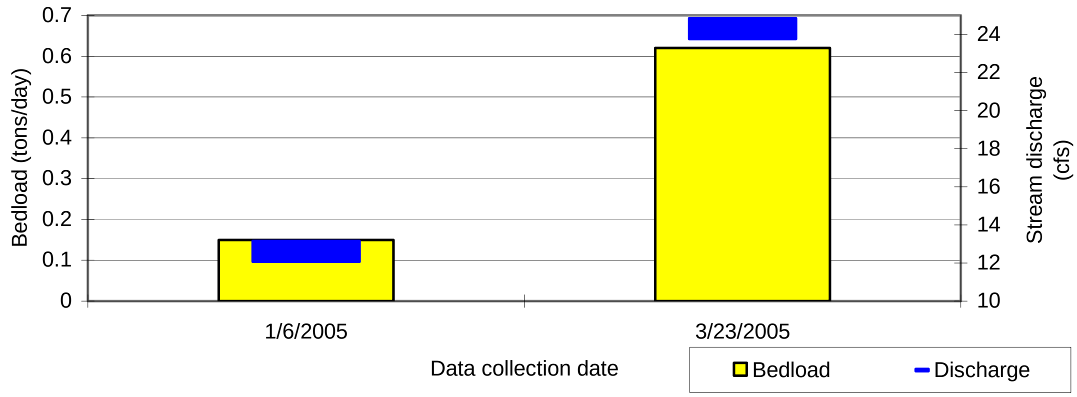


Figure 23.--Mean stream flow velocity and bedload sediment measured at site CC1, Camp Creek at Alabama Highway 253 , Marion County, AL.

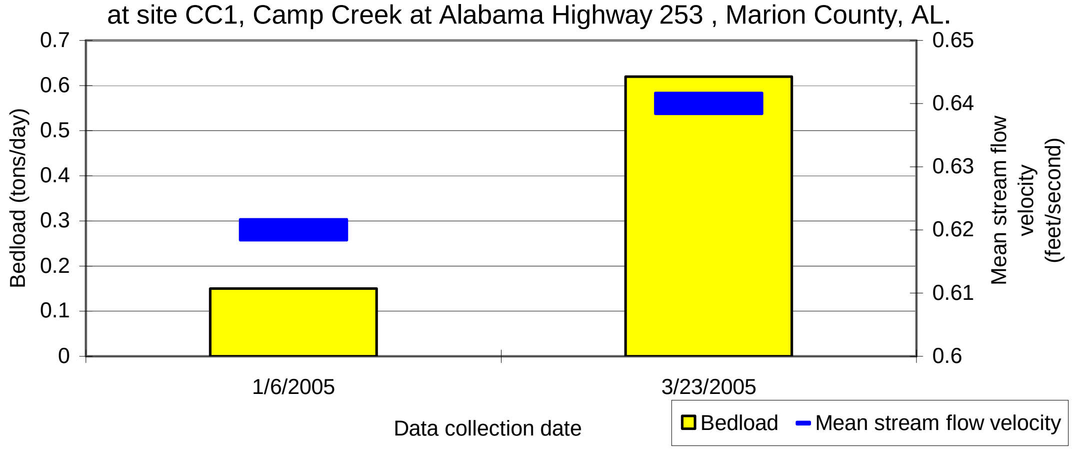


Figure 24.--Stream discharge and bedload sediment measured at site PM1, Pearces Mill Creek at highway 253 , Marion County, Alabama.

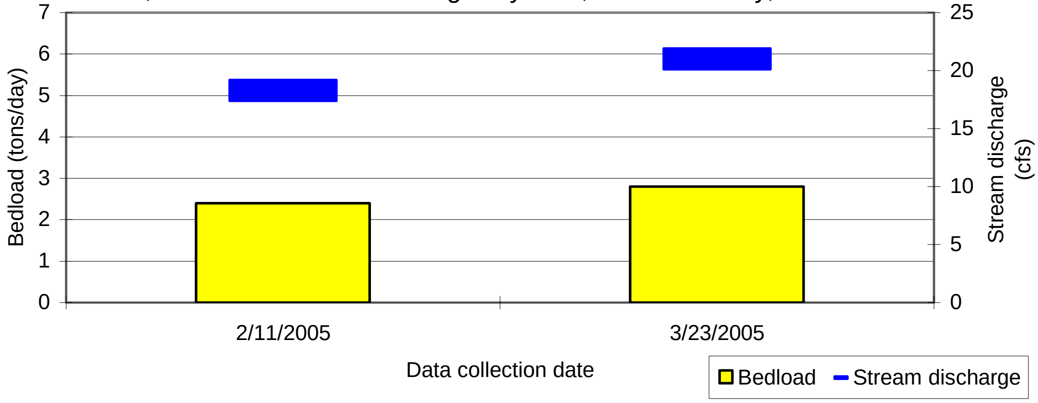
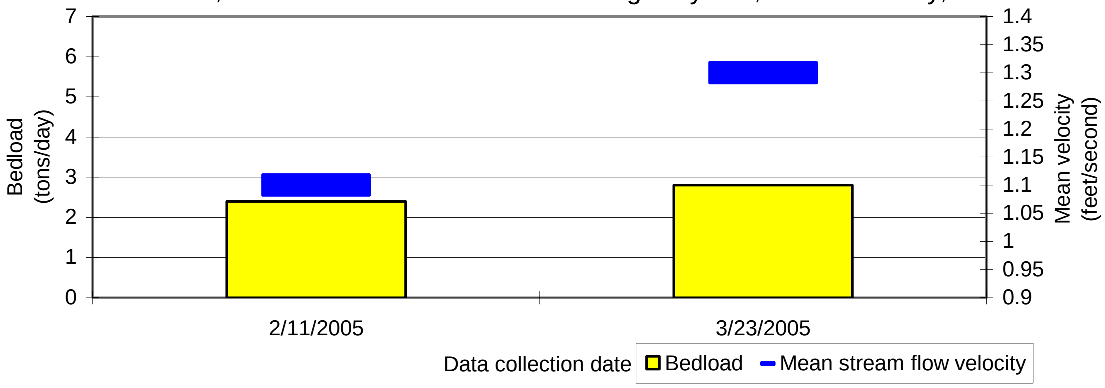
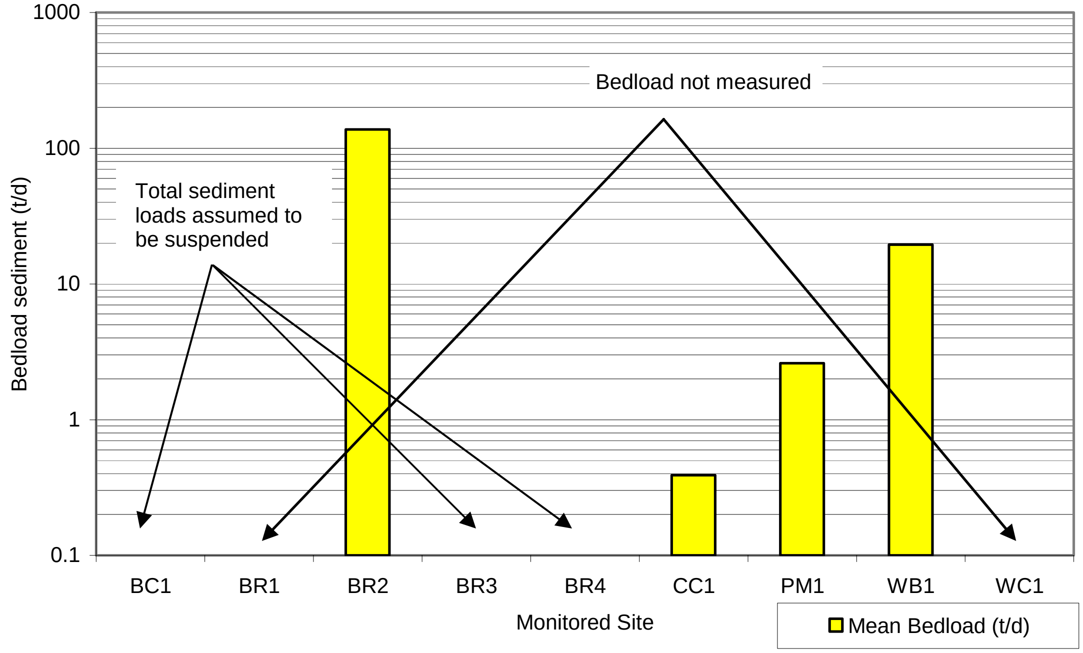


Figure 25.--Mean stream flow velocity and bedload sediment measured at site PM1, Pearces Mill Creek at Alabama Highway 253, Marion County, AL.



Bedload was not measured at the most downstream site BR1 (stream depth precluded measurement) or site WC1 (stream flow velocity during monitored events was insufficient to mobilize the gravel bed). The largest bedload transport rate measured during the project period was 157 tons per day at site BR2 which is the most downstream bedload monitoring site. Other sites-specific maximum bedload rates included 6.8 tons per day at site WB1, 2.8 tons per day at site PM1, and 0.39 tons per day at site CC1. The stream beds of all other sites were composed of rock and were assumed to have total sediment loads composed primarily of suspended sediment. Mean instantaneous bedload rates are given in figure 26.

Figure 26.--Mean instantaneous bedload calculated for Buttahatchee River and tributary sites in Lamar and Marion Counties, Alabama.

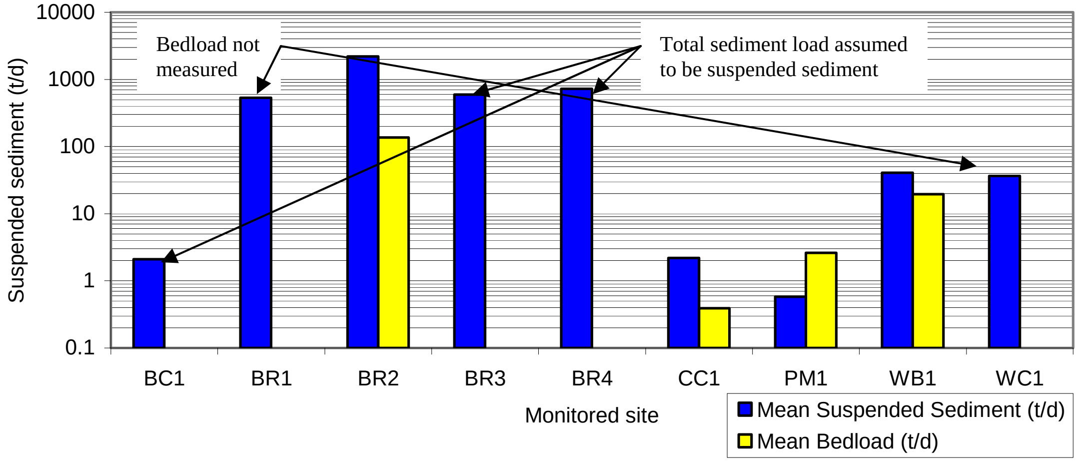


Total sediment loads are composed of suspended load and bedload. Total mean sediment loads based on the limited data collected for this project are shown in table 4. As discussed earlier, 100 percent of the sediment loads at sites BR3, BR4, and BC1 is assumed to be suspended material. Ninety-four percent of the total sediment load at site BR2 is composed of suspended material. The portion total sediment loads composed of suspended sediment at sites CC1, PM1, and WB1 is 85, 18, and 68 percent, respectively (fig. 27). Percentages are derived from data shown on figure 27.

Table 4.—Mean total sediment loads for the Buttahatchee River and selected tributaries.

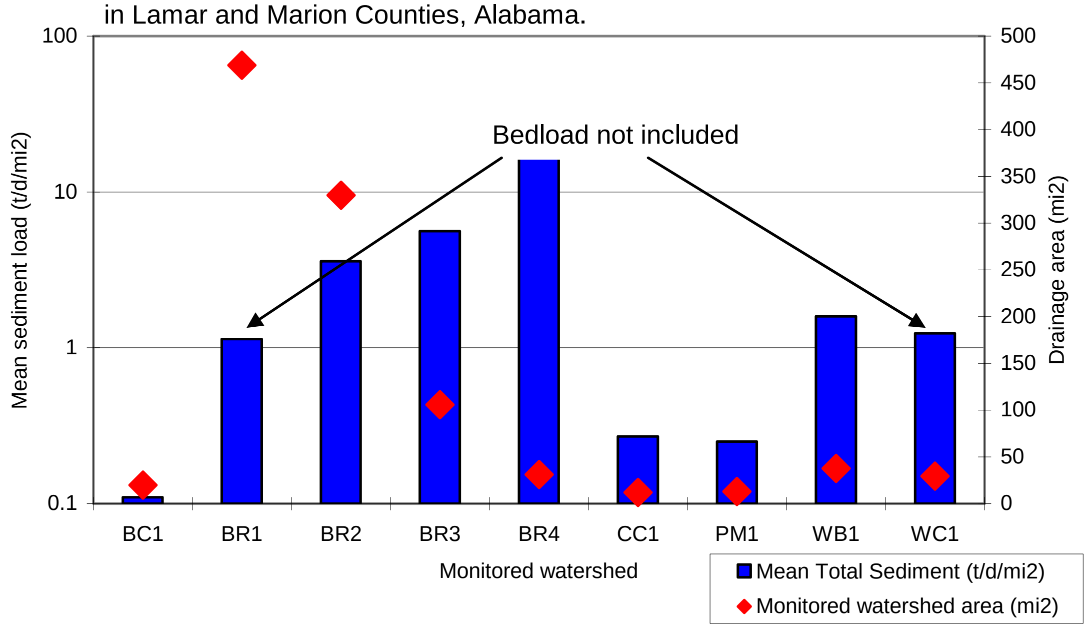
Stream and monitoring site designation	Mean total sediment loads (t/d)
Buttahatchee River (BR1)	Total load not determined
Buttahatchee River (BR2)	2,330
Buttahatchee River (BR3)	596
Buttahatchee River (BR4)	727
Barn Creek (BC1)	2.1
Camp Creek (CC1)	2.6
Pearces Mill Creek (PM1)	3.2
West Branch Buttahatchee River (WB1)	60
Williams Creek (WC1)	Total load not determined

Figure 27.--Mean instantaneous suspended and bed sediment loads calculated for Buttahatchee River and tributary sites in Lamar and Marion Counties, Alabama.



When the total sediment loads are normalized with respect to monitored watershed area, two significant findings emerge. First, the contributions of sediment from the West Branch of the Buttahatchee River (site WB1) and Williams Creek (site WC1) are significant (fig. 28). Second, most of the sediment load transported by the Buttahatchee River originates in the upstream portion of the watershed. Figure 28 shows that as the watershed area decreases upstream, the unit sedimentation rate increases. The watershed area upstream from site BR1 (most downstream Buttahatchee River site) contributes approximately 1.5 t/d/mi^2, the area upstream from site BR2 contributes approximately 3.6 t/d/mi^2, the area upstream from site BR3 contributes approximately 5.6 t/d/mi^2, and the area upstream from site BR4 (most upstream Buttahatchee River site) contributes approximately 23.4 t/d/mi^2.

Figure 28.--Normalized mean instantaneous total sediment loads and monitored watershed areas for the Buttahatchee River and tributary sites in Lamar and Marion Counties, Alabama.



CONCLUSIONS AND RECOMMENDATIONS

The scope of this project included the collection of only a limited amount of synoptic sedimentation data. However, these data indicate that sedimentation rates in the Buttahatchee River watershed are significant and that much of the sediment originates in the upstream portion of the watershed. Mean suspended sedimentation rates varied from less than 1 t/d to more than 2,000 t/d, comprising from 18 to 94 percent of the total sediment loads of the monitored watersheds. Bedload transport rates varied from less than 0.5 t/d to 137 t/d.

These findings demonstrate the need for additional data collection sufficient to perform the modeling necessary to determine accurate annual sedimentation loads for Buttahatchee River and all major tributaries. This more comprehensive, accurate data may be used to identify specific watersheds for land use investigations that may lead to implementation of best management practices to reduce sedimentation.

Data in this report are an initial step toward attaining ultimate goals for the Buttahatchee River watershed: improving water quality, protecting biologic habitat, and conserving the species that rely on these conditions for their continued existence.

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