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Abstract: The Amite River is a Gulf Coastal Plain stream in southwestern Mississippi and eastern Louisiana. Since the early 1970s, riparian sand and gravel mining has been conducted on a 48-km reach of the river centered on Grangeville, LA. Riparian mining has been considered responsible for instability and changes in the hydraulic and geomorphic regime of the river and local extirpation of the inflated heelsplitter mussel.

Field and rotary-wing aerial studies were conducted along the main stem of the river and along the principal tributaries including Beaver Creek, Darling Creek, and the Comite River. These studies indicated that the greatest erosion was occurring along the mined reach; however, erosion was also occurring upstream of the mined reach and along tributaries along and upstream of the mined reach. Erosion was less prevalent downstream of the mined reach; however, erosion was present on the Comite River which enters the Amite River downstream of the mined reach. Bridge survey data for the Amite River showed that the channel width upstream, along and downstream of the mined reach had, respectively, increased by as much as 25, 50 and 60 percent. Historical, rectified panchromatic aerial photography revealed that stream length upstream and downstream of the mined reach, between 1953 and 1998, had decreased, respectively, by as much as 5 and 29 percent. During the same period, the reach downstream of the mined reach had increased by as much as 7 percent.

Historical, stream gauge data were examined for six stations along the main stem of the Amite River and four stations on the Comite River. These data for Amite River stations above the mined reach did not reveal a significant trend; however, the data for the one station along the mined reach showed a significant decrease in both peak annual stream flow and peak annual gauge height. Two stations downstream but near the mined reach revealed increases in peak annual streamflow, annual mean streamflow, and peak annual gauge height. The most distal station from the mined reach indicated decreased peak annual streamflow and peak annual gauge height. The Comite River stream gauge data indicated that there have been historic increases in annual mean streamflow and peak annual streamflow; however, peak annual gauge height significantly decreased or remained relatively constant. These data support the notion that the processes acting on the Comite River are distinct and unrelated to riparian mining.

The Comite River erosion is considered to be caused by increased runoff and gully development due to land use/land cover changes related to increased urbanization in the Baton Rouge area. The Amite River erosion is attributed entirely to riparian mining. The shortening and straightening of the river is considered to be due to the movement of water into the riparian mines during high-water events. Thus, these high-water discharges tend to cut off or straighten the bends in the river similar to, but on a larger scale than that of natural meander cutoffs.

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Preface

This research describes fluvial instability and channel degradation of the Amite River in Mississippi and Louisiana. The system application of this study includes the effects of gravel mining in a fluvial environment. This research was conducted by the U.S. Army Engineer Research and Development Center (ERDC), Geotechnical and Structures Laboratory (GSL), for the System-Wide Water Resources Program (SWWRP). Dr. Steven L. Ashby was Program Manager of SWWRP. Paul Hartfield of the U.S. Fish and Wildlife Service, Jackson, MS, provided support and funding for earlier and related studies of this river. The work was performed under the sediment process focus area. The report was written by D. Ryan Hood and Dr. David M. Patrick of the University of Southern Mississippi, Hattiesburg, MS, and Dr. Maureen K. Corcoran, Engineering Geology and Geophysics Branch (EGGB), Geosciences and Structures Division (GSD) of ERDC.

The study was performed under the direct supervision of Dr. Lillian Wakeley, Chief, EGGB, and Dr. Robert Hall, Chief, GSD. Dr. David W. Pittman was Acting Director, GSL, during the period of this investigation and Director of GSL at time of publication. Dr. William P. Grogan was Deputy Director.

COL Richard B. Jenkins was Commander and Executive Director of ERDC. Dr. James R. Houston was Director.

1 Introduction

Objectives

The objectives of this project were to: (1) determine causes and effects of fluvial instability on the Amite River in Louisiana and Mississippi (Figure 1) in terms of past and ongoing in-channel mining (Mossa 1995); (2) collect, compare, and evaluate additional data relative to that collected during studies completed in 1996 (Meadows and Patrick 1999); (3) investigate extent to which erosion had proceeded in Amite River tributaries in Louisiana and headwaters in Mississippi; and (4) evaluate the influence of erosion processes on quality of riverine habitat.

Background

Both in-stream and floodplain gravel mining operations have been conducted along the Amite River since the early 1970s (Mossa and Autin 1998). The Amite River Sand and Gravel Committee (1992) estimated that approximately 0.5 sq km of sand and gravel are mined annually along a 48-km reach of the river centered near Grangeville, LA. No mining operations have occurred along the headwater reaches of the Amite River in southwest Mississippi and northern Louisiana. Mossa and Autin (1998) and Meadows and Patrick (1999) considered that the sand and gravel extraction was the main cause of accelerated erosion and channel instability along the mined reach. Meadows and Patrick (1999) found evidence that erosion had proceeded upstream beyond the mined reach.

Methodology

In order to conduct a thorough survey of the study area, a multifaceted methodology was employed. The investigation consisted of the following components:

a. *Literature review*. Various publications pertaining to fluvial geomorphology and instability, especially those addressing accelerated erosion and effects of in-stream gravel mining on stream channel stability, were collected and reviewed. Individual parish/county geological reports, soil surveys, and hydrographic surveys, relative to the study area, were also obtained and studied.

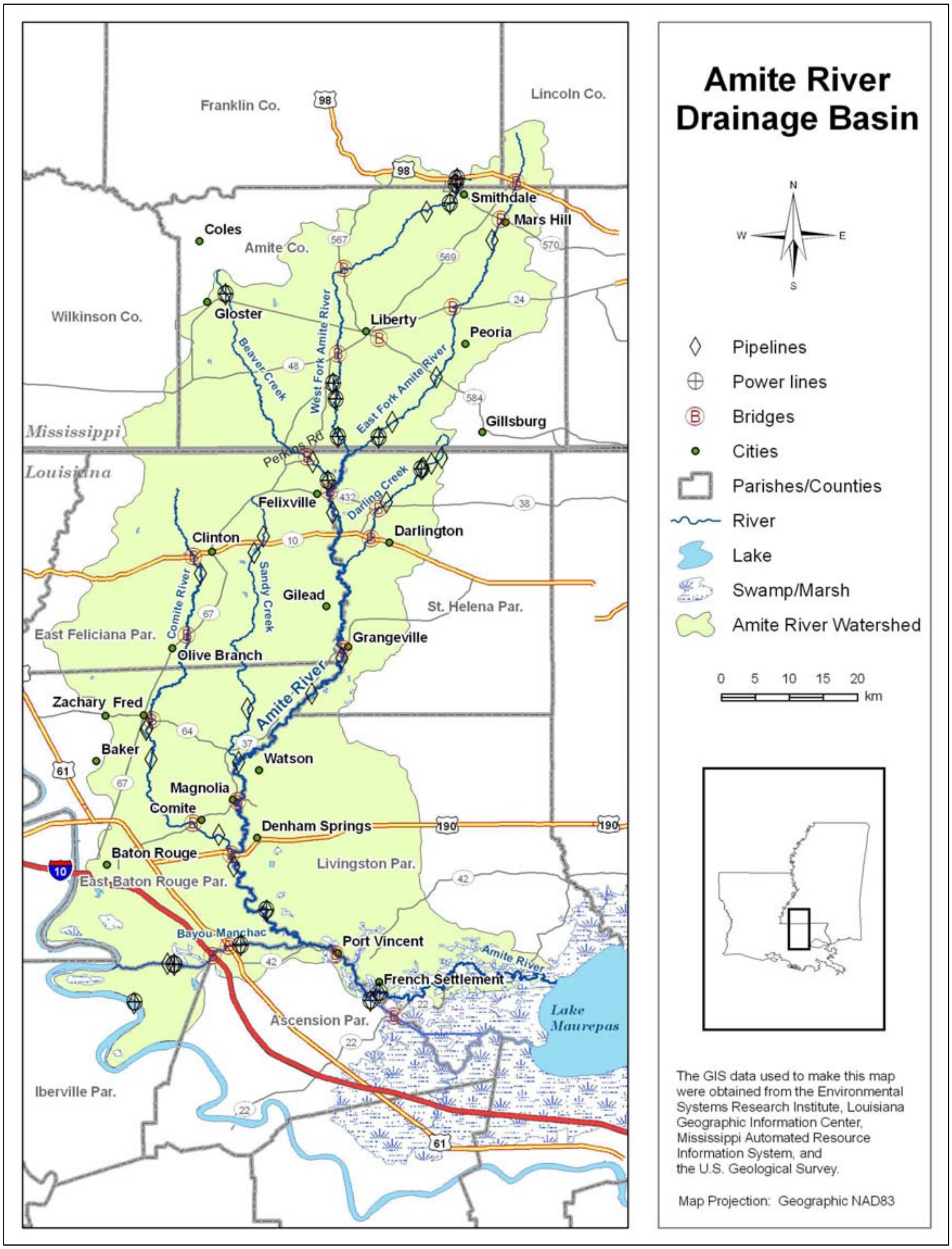


Figure 1. Location map showing the Amite River Basin in Louisiana and Mississippi.

b. *Field investigations*. Field work was conducted along the Amite River drainage in order to document and describe bed and bank erosion, channel characteristics, bankline conditions, bed and bank materials, and mining operations. Field investigations were carried out in July, August, and September of 2003 and 2004. The sites visited and studied in this project were located at bridge crossings due to safety concerns pertaining to bed/channel stability and inaccessibility of the channel along most reaches. As a result of safety/accessibility issues as well as for better observation, a helicopter was chartered in July 2004 to perform a low-altitude flyover of the river. During the flyover, visual observations were made and digital images were taken of channel conditions.

c. *Analysis of bridge survey data*. Fathometer surveys of the Amite River were conducted by the Louisiana Department of Transportation and Development (LDTD) in 1977, 1980, 1985, 1988 and 1990. These surveys were conducted at bridge crossings near Felixville, Darlington, Grangeville, Magnolia, and Denham Springs (Figure 1). Water elevation and channel width and depth were collected during the surveys and were evaluated during this current study.

d. *Analysis of aerial imagery and topographic maps*. The purpose of this phase of the study was to identify trends and changes in planform geometry of the channels. The imagery consisted of panchromatic photography covering five decades (1953, 1967, 1978, 1989, and 1998) and was acquired from the U.S. Department of Agriculture (USDA) Aerial Photography Field Office in Salt Lake City, UT. Topographic and geomorphic data from recent U.S. Geological Survey (USGS) topographic quadrangle maps were used throughout the investigation.

e. *Hydrology*. USGS stream gauge data were available at Amite River crossings near Peoria, MS, and at Darlington, Grangeville, Magnolia, Denham Springs, and Port Vincent, LA (Figure 1). USGS stream gauge data were also available at Comite River crossings near Clinton, Olive Branch, Zachary, and Comite, LA (Figure 1). Stream gauge data were used to evaluate possible, historic changes in water discharge and stage.

f. *Data synthesis*. Field examination, bridge survey data, historic aerial imagery and hydrologic data were evaluated and synthesized in order to understand erosional processes and cause(s) of erosion.

2 Geographic, Geologic, and Geomorphic Setting

Location

The Amite River system drains portions of southwest Mississippi (Lincoln, Franklin, and Amite Counties) and southeast Louisiana (East Feliciana, St. Helena, East Baton Rouge, Livingston, and Ascension Parishes) (Figure 1). The basin is contained within the East Gulf Coastal Plain, a geographic region of typically low relief and overall low elevation.

Fluvial setting

The Amite River (Figure 1) drains an area of approximately 5,180 sq km. At its northernmost extent in southwest Mississippi, the Amite River comprises two forks: the East Fork River and the West Fork River. These two forks converge in southeast Louisiana approximately 0.5 km south of the Mississippi/Louisiana state line. From this convergence, the main trunk of the Amite River flows to the south for approximately 121 km in a course lying approximately 24 km east of Baton Rouge, LA. South of Baton Rouge, the river flows to the southeast for approximately 77 km before finally discharging into Lake Maurepas, which lies within the Pontchartrain Basin, northwest of New Orleans. In Louisiana, the Amite River forms the boundary between five southeastern parishes (East Feliciana, St. Helena, East Baton Rouge, Livingston, and Ascension) known as the Florida Parishes.

The primary tributary to the Amite River is the Comite River. Other significant tributaries to this study include Beaver Creek, Darling Creek, and Bayou Manchac. The channels of the Amite River as well as its main tributaries are briefly described in the following section.

East Fork Amite River

The East Fork Amite River heads in Lincoln County, MS. It rises approximately 6 km northwest of Smithdale, MS, and flows in a southwest direction through Peoria, MS, in Amite County before converging with the West Fork, in southeast Louisiana, approximately 0.5 km south of the Mississippi/Louisiana state line.

West Fork Amite River

The West Fork Amite River begins in the southeastern corner of Franklin County, MS, and flows south through Liberty, MS, in Amite County. It converges with the East Fork River approximately 0.5 km south of the Mississippi/Louisiana state line.

Amite River (main trunk)

The main trunk of the Amite River flows in a southerly direction for approximately 121 km from the convergence of the East Fork and West Fork rivers. This course of the main trunk initiates approximately 6 km north of Felixville, LA, in St. Helena Parish. It continues south through Felixville, Darlington, Grangeville, Watson, and Denham Springs, LA, forming the boundaries between St. Helena, East Feliciana, East Baton Rouge, and Livingston Parishes. Grangeville and Watson are major sand and gravel mining cities in southeast Louisiana. South of Denham Springs, LA, the Amite River flows southeast for approximately 48 km before discharging into Lake Maurepas. Along this stretch, the river forms the boundary between Livingston and Ascension Parishes.

Comite River

The Comite River flows from northwest Louisiana in a southeasterly direction before converging with the Amite River just upstream of the Louisiana Highway 190 bridge near Denham Springs, LA. The Comite River and the Amite River confluence lies downstream of the main mined reaches. Because of increased flooding of the Comite River from the Amite River overflow, a flood-control structure is under construction on this stream.

Beaver Creek

Beaver Creek heads in Amite County, MS, approximately halfway between Gloster and Coles, MS. From this location it flows southeast, across the Mississippi/Louisiana state line, before converging with the Amite River approximately 2.4 km northeast of Felixville, LA. Beaver Creek is a significant tributary to the Amite River, especially in this study, because of its position in the drainage basin relative to the main mined reaches. Beaver Creek's confluence with the Amite River is approximately 19.3 km north or upstream from the beginning of the main mined reach and serves as a major supply tributary to the upper portion of the Amite River.

Darling Creek

Darling Creek begins near Gillsburg, MS, in Amite County, approximately 2.4 km north of the Mississippi/Louisiana state line. It flows southwest across St. Helena Parish and ultimately converges with the Amite River approximately 4.8 km downstream of the Louisiana Highway 10 crossing near Darlington, LA. Darling Creek's importance in this study is similar to that of Beaver Creek. It is an upper reach tributary, which enters the Amite River approximately 4.8 km upstream of the main mined reach.

Bayou Manchac

Bayou Manchac is a lower reach tributary that enters the Amite River just south of Baton Rouge, LA. It flows in a west to east direction from the Mississippi River to its confluence with the Amite River. Bayou Manchac forms the parish boundary between East Baton Rouge Parish, Iberville Parish, and Ascension Parish in southern Louisiana.

Geology

Pleistocene terraces dominate the geology of the Amite River drainage basin. These terraces are generally divided into three units (Autin 1989): the Upland Complex, Intermediate Complex, and Prairie Complex as shown in Figure 2 (Saucier and Snead 1989).

The Upland Complex (Citronelle Formation)

The Upland Complex, or Citronelle Formation, is the oldest geologic unit within the basin and consists of a gradational sequence of upland fluvial gravels and sands inter-bedded with silts and clays (Mossa and Autin 1998). The complex is late Pliocene to early Pleistocene, making it the oldest geologic unit within the basin. Coarse clastics occurring in the Upland Complex are the most likely source of sands and gravels found in the Amite River channel.

The Intermediate and Prairie Complexes

The Intermediate and Prairie complexes are remnants of preexisting Pleistocene floodplains (Autin 1989) and, as such, are referred to as terraces, e.g., Prairie Terrace. They are composed of silts and sandy clays grading downward into coarse-grained sand with gravel (U.S. Army Corps of Engineers (USACE) 1975 and Mossa and Autin 1998). The Intermediate

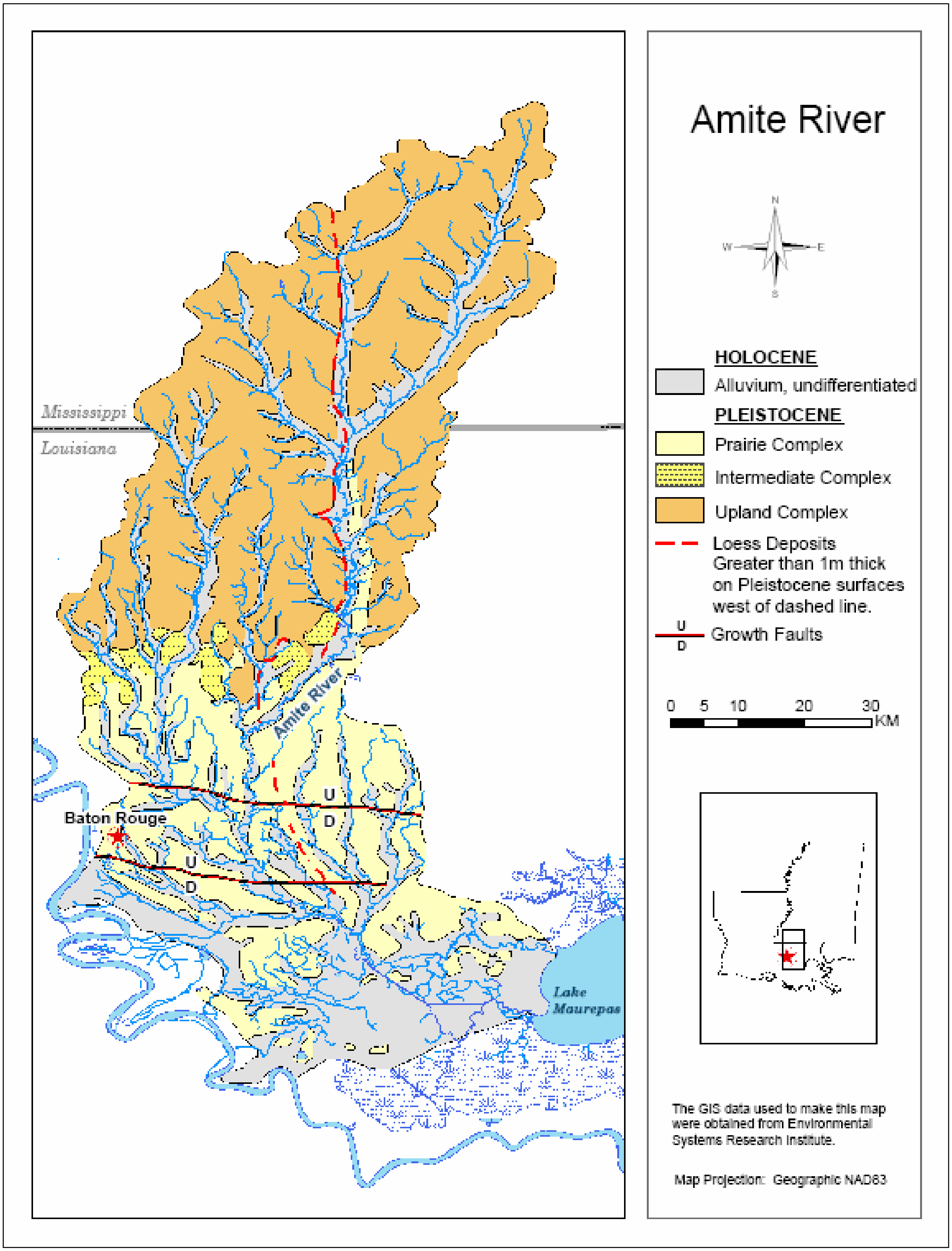


Figure 2. Pleistocene geology of the Amite River region. Explanation: Upland Complex (Pu), Intermediate Complex (Pi), and Prairie Complex (Pp) (after Saucier and Snead 1989).

Complex covers a relatively small area, with elevations that range from 30.48 m to 50.29 m.

Holocene alluvium

Holocene alluvium indicated by rather wide, flat areas adjacent to the stream channel are common in the lower reaches of the Amite River near its mouth (Mossa and McLean 1997). These sediments are regularly saturated and constitute a large wetland area that covers much of the eastern portion of Ascension Parish, LA, and the southern portion of Livingston Parish, LA. Because of poor drainage of these sediments and very low elevations, these reaches of the Amite River are subject to regular flooding.

Regional and fluvial geomorphology

The Amite River Basin is composed of three physiographic regions within the East Gulf Coastal Plain—the Loess Hills, the Southern Pine Hills, and the Pine Meadows (Autin 1989). The occurrence of these three physiographic regions is controlled by local geology (Figure 2). The most northwestern portion of the basin consists of the Loess Hills, which lies on and to the west of the Upland Complex in Louisiana and Mississippi. This area is typified by a highly dissected upland area that also forms bluffs adjacent to the Mississippi River alluvial valley. The southern Pine Hills makes up the northern part of the basin and is described as a maturely dissected cuesta with a moderate Gulfward slope (Autin 1989). Most of the Pine Hills region is underlain by the Upland Complex. The Pine Meadows, which comprises the southern portion of the basin, is a nearly level, low-relief plain with a gentle Gulfward slope. The Pine Meadows region is underlain by the Intermediate and Prairie complexes.

Regionally, elevations within the Amite River Basin are relatively low. The maximum elevation of the basin is 152.4 m above Mean Sea Level (MSL) in the northern uplands of Mississippi and the lowest elevations (0 to 1.5 m) are found at the basin mouth near Lake Maurepas.

The fluvial geomorphology along the mined reach of the Amite River is shown in the topographic map in Figure 3. The map shows the Prairie Complex (Terrace) surface to be relatively flat with the Amite River floodplain incised into this surface. Thus, the floodplain of the river lies several meters below the Pine Meadows surface. Point bars and midchannel bars described by Autin (1989) are apparent. The geology and geomorphology

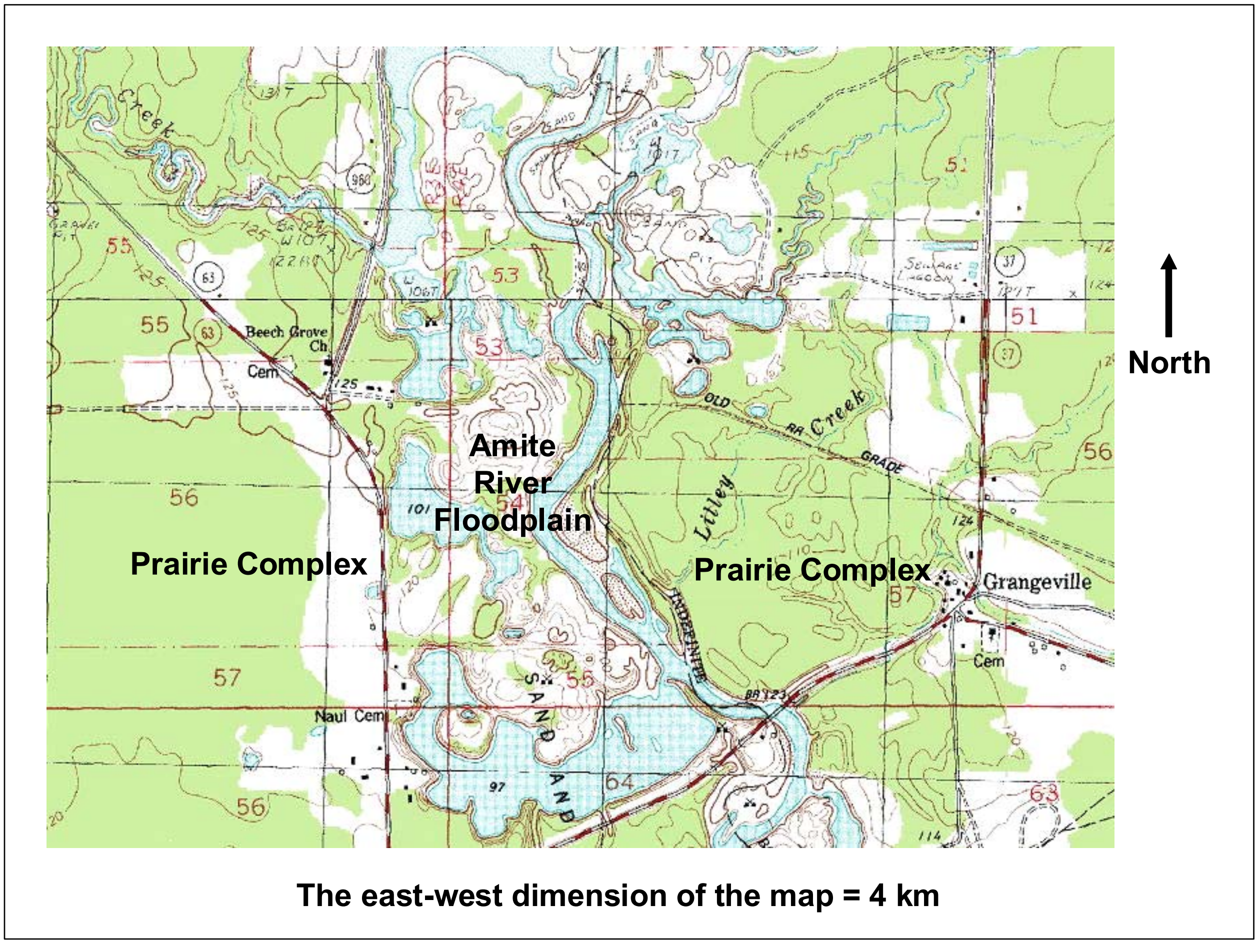


Figure 3. Topographic map view of the Amite floodplain incised below the Prairie Complex surface west of Grangeville, LA.

in the region upstream of the mined reach at the confluence of the East Fork and West Fork rivers near the Mississippi/Louisiana state line are shown in Figure 4. The upstream reaches in Mississippi and Louisiana beyond the outcrop area of the Prairie or Intermediate complexes, broad floodplains bordered by the Upland Complex/Pine Hills physiographic region dominate the landscape.

Autin (1989) divided the Amite River Drainage Basin into three physiographic zones: (1) zone of sediment production, (2) zone of sediment transport, and (3) zone of sediment accumulation. These zones can also be referred to, geographically, as the Upper Amite River (southwest Mississippi to Watson), the Middle Amite River (Watson to Denham Springs), and the Lower Amite River (Denham Springs to Lake Maurepas), respectively. The southern portion of the Middle Amite River is the most heavily mined and exhibits relatively large point bar development and mid-channel bars producing divided flow (Autin 1989). These physiographic

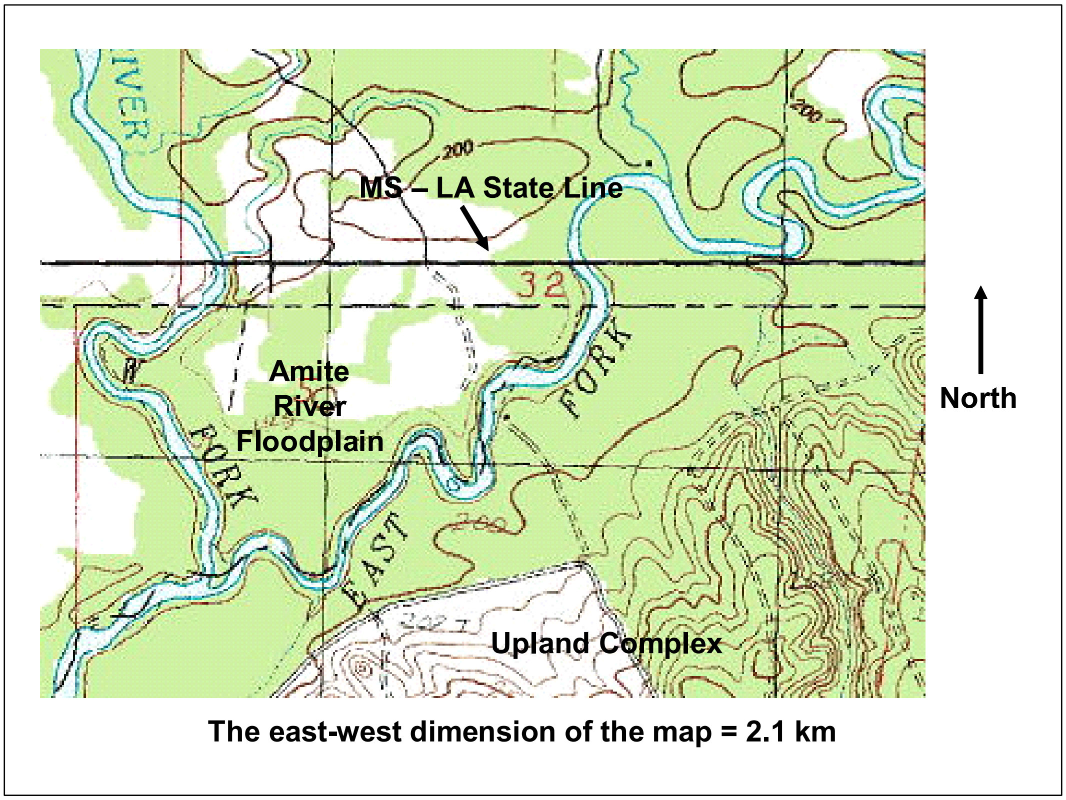


Figure 4. Topographic map of confluence of the East Fork and West Fork south of the Mississippi/Louisiana state line. The highland area in the southeast part of the map represents the Pine Hill physiographic region and is underlain by the Upland Complex.

divisions are somewhat arbitrary, with boundaries that would fluctuate as the stream degrades, headcutting occurs, and the overall channel morphology is changed (Meadows and Patrick 1999).

Fluvial instability and possible causes and effects

The previous description of the Amite River indicates that the river is, from a geomorphic perspective, unstable. The indicators, accelerated bank erosion, divided flow, and progressive upstream erosion, are widespread. Possible causes of instability include activities or actions that have resulted in changing the hydrologic regime of the river. These hydrologic changes may have, in turn, modified the fluvial geomorphology of the stream in terms of its planform and gradient.

Causative actions or activities may be local or basin-wide and include land-use/land-cover changes and local engineered changes. Changes in land-use or land-cover include urbanization, deforestation and riparian mining. Engineered changes include navigational or flood-control improvements to the channel. Such changes, either engineered ones or natural changes, may result in flooding, riparian land loss, bridge scour, excessive sedimentation, aesthetic degradation, and habitat loss. Urbanization-related flooding issues are not of specific interest in this present study; however, the USACE has conducted a number of flood-control studies and riparian mining was considered to be a possible cause (USACE 1975, 1984, 1990a, and 1990b).

Riparian mining

The principal mining operations occur downstream of the Clinton, LA, crossing and upstream of the Magnolia, LA, crossing and are approximately centered at Grangeville, LA. The reaches upstream of Clinton and downstream are mainly not mined. The operation of these uncontrolled in-stream sand and gravel mining appears the dominant land-use/land-cover changes within the basin. An estimated 53 to 57 ha are mined annually in the channel and floodplain of the Amite River, providing in excess of 2,721,000 metric tons of sand and gravel to the market each year (Amite River Sand and Gravel Committee 1992).

Several mining practices affect the channel and floodplain morphology and processes. Before excavating a pit, riparian vegetation is removed from the streambank and floodplain. Fine-grained surface sediment or overburden is then scraped with a bulldozer and sold as topsoil. Hydraulic dredges are placed in the ponds to extract a sediment-water mixture, which is sorted into various size fractions. Gravel is typically sold and transported away, whereas sand is usually kept onsite and forms tailings piles and fans. These piles of sand remain unvegetated for years and are left standing on the floodplain because gravel is the more valuable commodity (Mossa, Autin, and Vernon 1992). In pits on the floodplain, suspended sediment may be released in the channel if the levee or buffer between the turbid ponds and the channel is breached.

Mossa and Autin (1998) reported that over 809 sq km of previously forested or farmed land along the Amite River had degraded in such a way that it was either covered by sand or water. Besides contributing to riparian land loss, mining activities also augment the potential for indirect planform modifications during floods. Part or all of the flow could be diverted during high flows because the ponds and pits on the floodplain become inundated during high discharge (Patrick and Hartfield 1996; Mossa and Autin 1998).

Engineered structures

The principal engineered structures in the basin are bridges, power transmission lines, pipelines crossing the river, and the Amite River Diversion Canal, a flood-control measure constructed in the Lower Amite River to divert floodwaters away from the main channel and to improve navigation. There are no known adverse impacts from this diversion canal. Accelerated erosion of bridge piers and abutments, however, may result in weakening or failure of the bridge (Patrick, Mao, and Ross 1991) and exposure of the once-buried pipeline. Besides mitigation costs of replacing or repairing the bridge or pipeline, safety and environmental issues become paramount.

Recreational and aesthetic values

The Louisiana Scenic Rivers Act, as updated in 1988, designated the Amite River from the Mississippi/Louisiana state line to the Louisiana Highway 37 crossing near Grangeville as a part of the Louisiana Natural and Scenic River System (Figure 1). The general purposes of the Act were to protect these rivers from channel modifications, protect water quality and habitats, and preserve recreational and scenic aspects of these streams. Many of the Amite River reaches upstream and downstream of Grangeville have experienced significant mining activity and are neither natural nor scenic.

Biological habitat and diversity

The nature and quality of fluvial habitats are a function of water quality (including suspended sediment), water depth and velocity, and conditions of the channel bed and banks. Accelerated channel erosion may endanger bank, bed, and lotic habits by removal of bankline vegetation, bed scour, and turbidity. Bank erosion and loss of bankline vegetation may result in increased water temperature, bed scour may destroy the habitat of sessile faunas, such as mussels, and increased turbidity may affect bank, bed, and lotic faunas. These processes may result in decreased diversity, reduced productivity, and extirpation or complete extinction of certain faunal groups (Hartfield 1988; Patrick, Ross, and Hartfield 1994).

Many fish species are negatively affected by the Amite River erosion. Changes in species dominance, decreases in biomass and growth, and suffocation due to excessive sedimentation and overall decline in water clarity are some of the adverse effects that fish communities suffer from in the Amite River drainage. Although the degradation of fish species along the Amite River from accelerated erosion is a potentially serious problem, the main biological concern is the decline in certain mussel species (Hartfield 1988).

Prior to 1988, the Amite River channel, upstream of the main mined reach, was relatively stable with a well-vegetated canopy and a high mussel diversity (Hartfield 1988). Subsequently, mining of sand and gravel bars resulted in a 10 percent reduction in channel length through the main mined reach (Hartfield 1993). Headcutting, triggered by over-steepening the channel gradient by mining, removed stable substrate in which mussels lie, and produced excessive sedimentation. Thus, mussels have been virtually extirpated from the main mined reach, as well as from significant portions of upstream reaches, and their range has been reduced by 30 percent since 1976 (Hartfield 1988).

In 1990, the U.S. Fish and Wildlife Service (USFWS) listed the inflated heelsplitter (*Potamilus inflatus*) as a threatened species (USFWS 1990). The state of Louisiana listed this mussel species as threatened in 1992.

3 Results of Investigations

Ground and low-level aerial field studies

The ground field study began at the northernmost crossings of the two forks of the Amite River in the headwaters of southwest Mississippi and proceeded in a downstream progression to the southernmost crossing of the Amite River in southeast Louisiana. Lower reaches of the Amite River drainage were only briefly covered because they exhibited little, if any, significant changes over time according to topographic maps and aerial photography of the area. Data collected at each crossing included conditions of bridge piers and abutments, bank-line vegetation, evidence of bank erosion, divided flow, and knickpoints because these features are indicators of accelerated erosion. Knickpoints are identified in the field by the presence of waterfalls or rapids and are caused by downstream channel incision. The face of the waterfall is a headcut and, over time, the headcut will move upstream (headward erosion or headcutting) (Ritter, Kochel, and Miller 2002).

In the summer of 2004, a low-level, reconnaissance rotary-wing over-flight of the river was conducted to observe and photograph general and regional conditions of the stream and compare these observations to those made during a fixed-wing over-flight in 1995 (Meadows and Patrick 1999).

East Fork Amite River

The East Fork Amite River was studied from four major bridge crossings in southwest Mississippi. The northernmost major crossing observed was the US Highway 98 crossing approximately 7.2 km northeast of Smithdale, MS (Figures 5, 6, and 7). In the upper reaches of the East Fork, channel conditions appeared to be relatively stable with only local areas of erosion. The channel was narrow and straight with minor bar development. Streambanks displayed rather moderate slopes and were well vegetated on both sides of the channel. The only evidence of bank instability was tree trunks inclined toward the channel and erosion of the left (east) bank directly beneath the bridge (Figure 7). This erosion exposed bridge piers in the channel.

Figure 5. Downstream view of the East Fork Amite River at the Hwy 98 crossing near Smithdale, MS (July 2003) (arrow notes flow direction).

Figure 6. Upstream view of the East Fork Amite River at the Hwy 98 crossing near Smithdale, MS (July 2003) (arrow notes flow direction).

Figure 7. Scour of bridge piers at the Hwy 98 crossing of the East Fork near Smithdale, MS (July 2003).

The East Fork Amite River exhibited additional channel instability at the Mississippi Highway 570 crossing near Mars Hill, MS (Figures 8 through 11). At this site, which is approximately 6.4 km downstream of the Mississippi Highway 98 crossing, the channel is still narrow and well vegetated, but there is more leaning vegetation present as well as some dead vegetation in the channel. Both sides of the channel have been over-steepened and excessive, local erosion has occurred.

The Mississippi Highway 24 Bridge Crossing near Peoria, MS, is a good example of the East Fork's middle reaches (Figures 12 through 15). The channel has widened, as opposed to the upper reaches, but the banks are still well vegetated. The left (east) and right (west) banks are steep and eroded with the right bank erosion threatening the piers of the Mississippi Highway 24 bridge (Figure 15). Leaning vegetation and vegetation in the channel are present here as well. The channel and bed materials for each of the sites were predominately sand with some silt.

At the Mississippi Highway 584 crossing, in the lower reaches of the East Fork, the channel is composed predominately of brown gravel and sand, some with slight manganese staining. While this is indicative of a certain degree of stability and lack of churning of gravel, this site also shows

Figure 8. Downstream view of the East Fork at the Hwy 570 crossing near Mars Hill, MS (July 2003) (arrow notes flow direction).

Figure 9. Upstream view of the East Fork at the Hwy 570 crossing near Mars Hill, MS (July 2003) (arrow notes flow direction).

Figure 10. Steep, eroded bank of the East Fork at the Hwy 570 crossing near Mars Hill, MS (July 2003).

Figure 11. Steep, eroded right bank of the East Fork at the Hwy 570 crossing near Mars Hill, MS (July 2003).

Figure 12. Upstream view of the East Fork at the Hwy 24 crossing near Peoria, MS (July 2003) (arrow notes flow direction).

Figure 13. Downstream view of the East Fork at the Hwy 24 crossing near Peoria, MS (July 2003) (arrow notes flow direction).

Figure 14. Steep, eroded left bank of the East Fork at the Hwy 24 crossing near Peoria, MS (July 2003).

Figure 15. Scour of bridge piers at the Hwy 24 crossing of the East Fork near Peoria, MS (July 2003).

instability by leaning dead and living vegetation (Figure 16). The overall condition of the channel and banks of the East Fork Amite River appeared to reflect a state of semi-stability although some localized areas of channel bed incision and bank erosion were observed.

Figure 16. Upstream view of the East Fork Amite River at the MS Hwy 584 crossing near Liberty, MS (October 2003) (arrow notes flow direction).

West Fork Amite River

Field observations in the middle and upper reaches of the West Fork Amite, Mississippi Highway 567 (Figures 17 and 18) and Mississippi Highway 24 (Figures 19 and 20) crossings, revealed relatively stable bank and channel conditions. Bank-line vegetation was well established and erosion was minor along these reaches. There was, however, leaning vegetation and a minor amount of vegetative debris in the channel.

At the uppermost portion of the lower reach of the West Fork (Mississippi Highway 48 crossing), slightly more unstable conditions were observed (Figures 21 through 24). At this crossing near Liberty, MS, the banks are well vegetated but they have become much steeper, especially on both sides of the channel, than the banks of the upper reaches. It is obvious that bed incision occurred along the West Fork although none of the bridges

Figure 17. Upstream view of the West Fork at the Hwy 567 crossing near Liberty, MS (July 2003) (arrow notes flow direction).

Figure 18. Downstream view of the West Fork at the Hwy 567 crossing near Liberty, MS (July 2003) (arrow notes flow direction).

Figure 19. Downstream view of the West Fork at the Hwy 24 crossing near Liberty, MS (July 2003) (arrow notes flow direction).

Figure 20. Upstream view of the West Fork at the Hwy 24 crossing near Liberty, MS (July 2003) (arrow notes flow direction).

Figure 21. Downstream view of the West Fork at the Hwy 48 crossing near Liberty, MS (July 2003) (arrow notes flow direction).

Figure 22. Upstream view of the West Fork at the Hwy 48 crossing near Liberty, MS (July 2003) (arrow notes flow direction).

Figure 23. Steep, eroded right bank of the West Fork at the Hwy 48 crossing near Liberty, MS (July 2003).

Figure 24. Steep, eroded left bank of the West Fork at the Hwy 48 crossing near Liberty, MS (July 2003).

studied seemed to be threatened. The channel and banks of the West Fork seem to be in slightly better condition than those of the East Fork Amite River but instability still appears to be an issue along this stream.

Main trunk of the Amite River – Upper Reach

The main trunk of the Amite River begins at the confluence of the East and West Forks, south of the Mississippi/Louisiana state line (Figure 25). Louisiana Highway 432 is the northernmost main trunk crossing (Figures 26 through 30). This crossing is approximately 8 km south of the convergence of the East and West Forks and is located near Felixville, LA. Figure 26 is an aerial view of the bridge, Figures 27 and 28 are aerial views of the channel upstream of the bridge, and Figures 29 and 30 are ground views at the bridge. A much wider channel is found in the upper reach than in the headwaters, and the banks have undergone significant erosion and loss of vegetation. A small, midchannel sandbar developed just downstream of the Louisiana Highway 432 bridge and is probably the result of decreased stream energy in a wider, shallower channel. A large amount of debris was observed in the channel and bridge remains were present at this site. The remains of a bridge are probably an indication that the bridge failed and had to be replaced. It is likely that the bridge failed as a result of accelerated erosion moving through the system.

Approximately 100 m downstream of the Highway 43 bridge, a power transmission pylon in the channel has been placed on pilings to help protect it from undermining effects of erosion (Meadows and Patrick 1999) (Figure 31). Erosion has worked its way around the structure and appears to be downcutting the pilings. The right (west) bank of the channel, directly across from the power company structure, has undergone severe erosion that has left it steep and bare (Figure 32). Erosion still seems to be relatively active on this bank and the channel appears to be, at least locally, migrating from east to west.

The Louisiana Highway 10 crossing near Darlington, LA, is approximately 9.6 km upstream of the main mined reach. Figure 33 is an aerial view of the bridge. Figure 34 is a ground view upstream and Figures 35 and 36 are downstream ground views. Steep, eroding banks; leaning vegetation; loss of bank-line vegetation; a wide, shallow channel; and divided flow conditions were prominent at this site.

Figure 25. Confluence of the East and West Forks of the Amite River south of the Mississippi/Louisiana state line (view upstream—July 2004) (arrow notes flow direction).

Figure 26. Downstream view of the Amite River at the Louisiana Hwy 432 crossing near Felixville, LA (July 2004) (arrow notes flow direction).

Figure 27. Steep eroding left bank of the Amite River in southeast Louisiana just north of the Louisiana Hwy 432 crossing near Felixville, LA (arrow notes flow direction—July 2004).

Figure 28. Divided flow conditions of the Amite River in southeast Louisiana just north of the Louisiana Hwy 432 crossing near Felixville, LA (arrow notes flow direction—July 2004).

Figure 29. Downstream view of the Amite River at the Louisiana Hwy 432 crossing near Felixville, LA (September 2003) (arrow notes flow direction).

Figure 30. Upstream view of the Amite River at the Louisiana Hwy 432 crossing near Felixville, LA (September 2003) (arrow notes flow direction).

Figure 31. Power transmission pylon at the Louisiana Hwy 432 crossing of the Amite River near Felixville, LA (view downstream—September 2003) (arrow notes flow direction). Note the terrace effect on the point bar.

Figure 32. Steep, eroding right bank of the Amite River downstream from the Louisiana Hwy 432 crossing near Felixville, LA (view downstream—September 2003) (arrow notes flow direction).

Figure 33. Downstream view of the Amite River at the Louisiana Hwy 10 crossing near Darlington, LA (July 2004) (arrow notes flow direction).

Figure 34. Upstream view of the Amite River at the Louisiana Hwy 10 crossing near Darlington, LA (September 2003) (arrow notes flow direction).

Figure 35. Downstream view of the Amite River at the Louisiana Hwy 10 crossing near Darlington, LA (September 2003) (arrow notes flow direction).

Figure 36. Downstream view of the Amite River at the Louisiana Hwy 10 crossing near Darlington, LA (notice steep, eroding bank behind bar—September 2003) (arrow notes flow direction).

The reach of the Amite River most seriously affected by accelerated erosion is centered at Grangeville, LA. Figures 37 and 38 illustrate the extent of mining upstream of Grangeville and Figures 39 and 40 are 2004 and 1995, respectively, downstream aerial views of the Louisiana Highway 37 crossing southwest of Grangeville. Since 1995, there has been significant mining on the left bank upstream of the bridge. Both views show two bridge sections, a dry span on the left bank and a water crossing on the right bank. Prior to active mining the currently dry, left bank section was the only crossing of the river (see Analysis of Aerial Photography). The main channel contains virtually all of the streamflow during most of the year with the secondary channels holding standing water during normal rainfall conditions as well as excess flow during times of significant flooding (Mossa 1995). The presence of this abandoned channel is evidence that along this reach, the river has become less sinuous and the channel has migrated to the west. This change in course required the Louisiana Highway 37 bridge to be extended.

Both active and abandoned gravel pits are numerous along both sides of the river throughout this reach. Nearly every field indicator of channel instability was observed at this crossing including sandbars on sides of the

Figure 37. Divided flow conditions of the Amite River just upstream of the Louisiana Hwy 37 crossing near Grangeville, LA (view is downstream—July 2004) (arrow notes flow direction).

Figure 38. Large abandoned gravel mine on the left bank of the Amite River just upstream of the Louisiana Hwy 37 crossing near Grangeville, LA (arrow notes flow direction—July 2004)

Figure 39. Downstream view of the Amite River at the Louisiana Hwy 37 crossing near Grangeville, LA (note large, dry abandoned channel at left bank—July 2004) (arrow notes flow direction).

Figure 40. 1995 downstream view of the Amite River at the Louisiana Hwy 37 crossing near Grangeville, LA, showing abandoned riverbed (Meadows and Patrick 1999) (arrow notes flow direction).

channel, bank erosion, absence of vegetation and debris in the water. The condition of banks and channel are shown in Figures 41 and 42 and presence of riprap for erosion protection upstream of the bridge is shown in Figure 43.

Beaver Creek (Upper Reach Tributary)

Beaver Creek enters the Amite River from the west in the vicinity of Felixville. At the Perkins Road crossing (Figures 44 through 47), there were signs of channel degradation manifested by steep, eroding banks, leaning vegetation, and dead vegetation in the channel (Figures 44 and 45). A large debris jam formed beneath the Perkins Road bridge (Figure 46) and extends the width of the channel. Erosion protection at the left abutment is apparent in Figure 47.

Darling Creek (Upper Reach Tributary)

Darling Creek enters the Amite River from the east near Darlington, LA. The Louisiana Highway 10 crossing showed signs of channel instability evident from leaning vegetation, bridge pier damage, debris in the channel, and steep, eroded banks (Figures 48 through 51). Remains of a wooden bridge and undermined banks were also observed. Undermining can cause the bank to become unstable by removing the toe of the bank. At the Louisiana Highway 38 crossing (Figures 52 through 57), bridge piers were scoured and threatened by bed erosion. Undercutting of the right bank was observed and a debris jam was present underneath the bridge.

Main trunk of the Amite River – Middle Reach

This reach near Magnolia, LA, is actively mined as shown in the 2004 aerial over-flight views (Figures 58 through 61). Figure 58 shows a right-bank mine, which is buffered from the river whereas the right-bank mine shown in Figure 59 does not appear to be buffered, and the buffer of the right-bank mine shown in Figure 60 has been breached. A power transmission pylon surrounded by water is shown in Figure 61. This structure was most likely not constructed in the channel but on the floodplain and the subsequent erosional widening of the channel resulted in the pylon's current location.

Figures 62 through 65 are ground views of an active mine on the left bank floodplain of the Amite River near Magnolia, LA. Instead of being

Figure 41. Upstream view of the Amite River at the Louisiana Hwy 37 crossing near Grangeville, LA (September 2003) (arrow notes flow direction).

Figure 42. Downstream (left bank) view of the Amite River at the Louisiana Hwy 37 crossing near Grangeville, LA (September 2003) (arrow notes flow direction).

Figure 43. Riprap on the left bank of the Amite River at the Louisiana Hwy 37 crossing near Grangeville, LA (September 2003).

Figure 44. Upstream view of Beaver Creek at the Perkins Road crossing near the Mississippi/Louisiana state line (September 2003) (arrow notes flow direction).

Figure 45. Downstream view of Beaver Creek at the Perkins Road crossing near the Mississippi/Louisiana state line (September 2003) (arrow notes flow direction).

Figure 46. Debris jam on Beaver Creek at the Perkins Road crossing near the Mississippi/Louisiana state line (view upstream—September 2003) (arrow notes flow direction).

Figure 47. Left bank bridge abutment of Beaver Creek at the Perkins Road crossing near the Mississippi/Louisiana state line (note erosion control feature—September 2003).

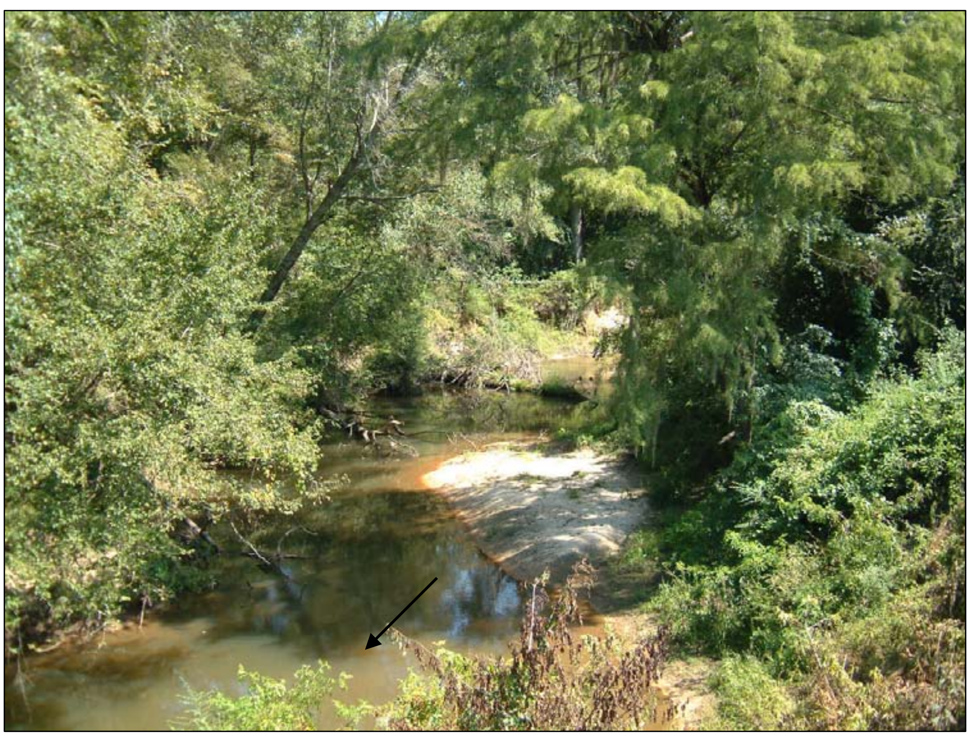


Figure 48. Upstream view of Darling Creek at the Louisiana Hwy 10 crossing near Darlington, LA (September 2003) (arrow notes flow direction).

Figure 49. Downstream view of Darling Creek at the Louisiana Hwy 10 crossing near Darlington, LA (September 2003) (arrow notes flow direction).

Figure 50. Steep, eroded right bank of Darling Creek at the Louisiana Hwy 10 crossing near Darlington, LA (view upstream—September 2003) (arrow notes flow direction).

Figure 51. Steep, eroded left bank of Darling Creek at the Louisiana Hwy 10 crossing near Darlington, LA (arrow notes flow direction—September 2003).

Figure 52. Downstream view of Darling Creek at the Louisiana Hwy 38 crossing near Darlington, LA (September 2003) (arrow notes flow direction).

Figure 53. Upstream view of Darling Creek at the Louisiana Hwy 38 crossing near Darlington, LA (September 2003) (arrow notes flow direction).

Figure 54. Undercutting of the right bank of Darling Creek at the Louisiana Hwy 38 crossing near Darlington, LA (view is upstream—September 2003) (arrow notes flow direction).

Figure 55. Bridge pier scour at the Louisiana Hwy 38 crossing of Darling Creek near Darlington, LA (arrow notes flow direction—September 2003).

Figure 56. Right bank of Darling Creek at the Louisiana Hwy 38 crossing near Darlington, LA (arrow notes flow direction—September 2003)

Figure 57. Debris jam at the Louisiana Hwy 38 crossing of Darling Creek near Darlington, LA (arrow notes flow direction—September 2003).

Figure 58. Large gravel mine on right bank of the Amite River near Magnolia, LA (arrow notes flow direction—July 2004).

Figure 59. Downstream view of the Amite River near Magnolia, LA (note power company pylon in the channel—July 2004) (arrow notes flow direction).

Figure 60. Downstream view of breached right bank of the Amite River near Magnolia, LA (July 2004) (arrow notes flow direction).

Figure 61. Exposed pipeline and steep, eroding right bank of the Amite River near Magnolia, LA (arrow notes flow direction—July 2004).

Figure 62. Gravel mine and large lake adjacent to the Amite River near Magnolia, LA (note channel in background—June 2003).

Figure 63. Dredge machine at adjacent gravel mine of the Amite River near Magnolia, LA (June 2003).

Figure 64. Clearcutting (deforestation) of the riparian buffer between the Amite River and adjacent gravel mine near Magnolia, LA (note the channel runs beneath the power line in background—June 2003).

Figure 65. Front-end loader and large sand piles at gravel mine near Magnolia, LA (note the Amite River channel is just beyond the sand pile—June 2003).

separated from the channel by a riparian buffer, the mine was separated by a terraced sand and gravel bar. The riparian buffer was being cleared for access to the channel so the bar could be mined. A large lake with several sand piles lining its shoreline formed as a result of the mine pit filling with water.

The Amite River channel along this short mined stretch exhibited sand and gravel bars, divided flow, steep eroded banks and loss of bank-line vegetation (Figures 66 through 71). Streambank material consisted of predominately fine-grained sediments, suggesting that the Amite River incised its channel into the Prairie Formation (Figure 69). This fine-grained bank section also exhibited a reddish-brown, approximately 10-cm-thick zone near the waterline (Figure 69). This zone may represent a paleosol within the Prairie Complex. The channel bed material was predominantly sand and gravel.

Louisiana Highway 64 crosses the Amite River approximately 4.8 km south of Magnolia, LA, and is within the lowermost part of the main mined reach with gravel mining both upstream and downstream of the site. Locally, the channel was wide and shallow (Figure 72) and exhibited bank erosion, leaning, fallen and uprooted vegetation (Figures 73 through 76), sand and gravel bars, and divided flow (Figures 77 and 78).

Figure 66. Large midchannel sand and gravel bar of the Amite River adjacent to gravel mine near Magnolia, LA (arrow notes flow direction—June 2003).

Figure 67. Upstream view of the Amite River adjacent to active gravel mine near Magnolia, LA (note steep, eroding banks and divided flow conditions—June 2003) (arrow notes flow direction).

Figure 68. Downstream view of the Amite River adjacent to active gravel mine near Magnolia, LA (note divided flow conditions and debris in the channel—June 2003) (arrow notes flow direction).

Figure 69. Steep, eroding right bank exhibiting a reddish-brown lens or zone near the waterline adjacent to active gravel mine near Magnolia, LA (arrow notes flow direction—June 2003).

Figure 70. Steep, eroding right bank of the Amite River adjacent to gravel mine near Magnolia, LA (arrow notes flow direction—June 2003).

Figure 71. Terraced point bar of the Amite River adjacent to active gravel mine near Magnolia, LA (arrow notes flow direction—June 2003).

Figure 72. Upstream view of the Amite River at the Louisiana Hwy 64 crossing near Magnolia, LA (June 2003) (arrow notes flow direction).

Figure 73. Downstream view of the Amite River at the Louisiana Hwy 64 crossing near Magnolia, LA (June 2003) (arrow notes flow direction).

Figure 74. Steep, eroding left bank of the Amite River approximately 100 m downstream of the Louisiana Hwy 64 crossing near Magnolia, LA (note flow is from left to right—June 2003).

Figure 75. Fallen vegetation and bank erosion on left bank of the Amite River at the Louisiana Hwy 64 crossing near Magnolia, LA (arrow notes flow direction—June 2003).

Figure 76. Uprooted tree in the channel of the Amite River just downstream of the Louisiana Hwy 64 crossing near Magnolia, LA (arrow notes flow direction—June 2003).

Figure 77. Eroding sand and gravel bar at the Louisiana Hwy 64 crossing of the Amite River near Magnolia, LA (arrow notes flow direction—June 2003).

Figure 78. Sand and gravel bar in the Amite River channel at the Louisiana Hwy 64 crossing near Magnolia, LA (arrow notes flow direction—June 2003).

Aerially, channel conditions south of Magnolia and upstream of the Louisiana Highway 190 crossing near Denham Springs (Figure 79) exhibited fewer and more localized indications of instability than in the close vicinity of Magnolia. Bank erosion (Figure 80), divided flow (Figure 81), and point bar development (Figure 82) are apparent in the 2004 aerial views. This decreased level of instability is most likely due to fewer mining operations along this reach. Figure 83 is a 2004 downstream aerial view of the Louisiana Highway 190 crossing showing the confluence of the Amite River and the Comite River.

Similarly, channel conditions seen on the ground at the Louisiana Highway 190 crossing near Denham Springs, LA, exhibited fewer indications of instability than in upstream reaches. However, leaning vegetation and bank erosion were evident (Figures 84 and 85).

Comite River (Middle Reach Tributary)

The Comite River, the largest tributary to the Amite River, enters the Amite River from the west, approximately 50 m upstream of the Louisiana Highway 190 crossing near Denham Springs, LA. The 2004 aerial view of the confluence is shown in Figure 83 and a 2003 ground view is shown in Figure 86. At its confluence with the Amite River, the level of instability of

Figure 79. Downstream view of the Amite River just north of Denham Springs, LA (July 2004) (arrow notes flow direction).

Figure 80. Steep, eroding left bank of the Amite River just north of Denham Springs, LA (arrow notes flow direction—July 2004).

Figure 81. Upstream view of the Amite River north of Denham Springs, LA (note large midchannel sand and gravel bar—July 2004) (arrow notes flow direction).

Figure 82. Downstream view of the Amite River upstream of the Louisiana Hwy 190 crossing near Denham Springs, LA (July 2004) (arrow notes flow direction).

Figure 83. Downstream view of the Amite River at the Louisiana Hwy 190 crossing near Denham Springs, LA (note convergence with the Comite River enters on the right bank—July 2004) (arrow notes flow direction).

Figure 84. Steep, eroding left bank of the Amite River at the Louisiana Hwy 190 crossing near Denham Springs, LA (view upstream—June 2003) (arrow notes flow direction).

Figure 85. Downstream view of the Amite River at the Louisiana Hwy 190 crossing near Denham Springs, LA (note debris in the channel—June 2003) (arrow notes flow direction).

Figure 86. Upstream view of the Amite River and the Comite River confluence at the Louisiana Hwy 190 crossing near Denham Springs, LA (note the Comite River enters at the right bank—June 2003) (arrow notes flow direction).

the Comite River appeared similar to that of the Amite River. Ground studies of the Comite River were conducted at three crossings proceeding upstream of the Amite-Comite River confluence.

The Louisiana Highway 37 crossing near Comite, LA, is approximately 8 km upstream of the Amite-Comite River confluence. At this lower-reach crossing, banks appeared relatively stable. However, vegetation was leaning and there was vegetation in the water as shown in Figures 87 and 88.

The middle reach of the Comite River is represented in Figures 89 and 90. These photos were taken at the Louisiana Highway 64 crossing near Zachary, LA. The banks at this location were still relatively stable with well developed, mature vegetation. There were a few small midchannel sand and gravel bars as well as a terraced sand and gravel point bar.

At the Louisiana Highway 67 crossing near Olive Branch, LA, the left bank upstream of the bridge was steep and eroding (Figure 91), and there were several moderately sized midchannel sand and gravel bars (Figure 92). Riprap had recently been placed on the left bank upstream of the bridge

Figure 87. Upstream view of the Comite River at the Louisiana Hwy 37 crossing near Comite, LA (July 2004) (arrow notes flow direction).

Figure 88. Downstream view of the Comite River at the Louisiana Hwy 37 crossing near Comite, LA (July 2004) (arrow notes flow direction).

Figure 89. Downstream view of the Comite River at the Louisiana Hwy 64 crossing near Zachary, LA (July 2004) (arrow notes flow direction).

Figure 90. Upstream view of the Comite River at the Louisiana Hwy 64 crossing near Zachary, LA (July 2004) (arrow notes flow direction).

Figure 91. Upstream view of the Comite River at the Louisiana Hwy 67 crossing near Olive Branch, LA (note steep, eroding left bank—July 2004) (arrow notes flow direction).

Figure 92. Downstream view of the Comite River at the Louisiana Hwy 67 crossing near Olive Branch, LA (note divided flow conditions—July 2004) (arrow notes flow direction).

(Figure 93) and bridge pier replacement was underway (Figure 94). A construction supervisor at the site mentioned that the Comite River had completely shifted its course along this stretch within the last two to three years (prior to 2004). Overall, the instability along this reach appeared to be localized.

Construction is underway by the USACE for a $163 million diversion canal, which is an effort to divert floodwaters from the unpredictable Comite River to the Mississippi River. The diversion canal project is located near the cities of Baker and Zachary, LA, in the north portion of East Baton Rouge Parish. The project will entail a 19.3-km diversion channel from the Comite River to the Mississippi River and diversion structures at both the Comite River and Lilly Bayou.

Main trunk of the Amite River – Lower Reach

In the vicinity of the Interstate 12 crossing, the general nature and condition in the lower reach of the channel are shown in the 1995 and 2004 aerial views in Figure 95. It is apparent that the channel appearance is significantly different from upstream reaches, such as those at Grangeville or

Figure 93. Newly installed riprap on the left bank of the Comite River at the Louisiana Hwy 67 crossing near Olive Branch, LA (downstream view—July 2004) (arrow notes flow direction).

Figure 94. Bridge pier repair at the Louisiana Hwy 67 crossing of the Comite River near Olive Branch, LA (downstream view—July 2004) (arrow notes flow direction).

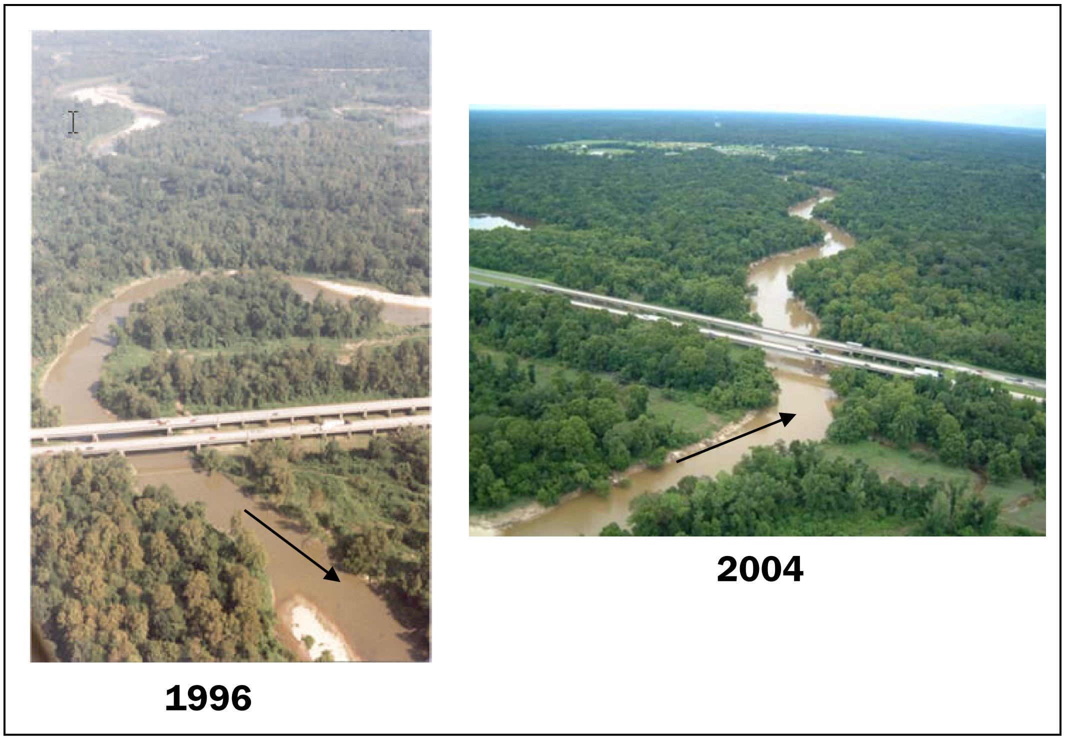


Figure 95. 1995 upstream and 2004 downstream aerial views of the Interstate 12 crossing of the Amite River between Baton Rouge and Denham Springs. (arrow notes flow direction).

Magnolia, and there are no indications of significant bar construction in this downstream area.

The lower reach of the Amite River was observed from the Louisiana Highway 42 crossing near Port Vincent, LA (Figures 96 and 97). Channel conditions indicated a strong state of stability and reflect the beauty that the Amite River once possessed in its upper and middle reaches prior to gravel mining. Banks are sloping and support thick, mature, healthy stands of mixed deciduous and conifer forests. The basin in this area is virtually flat and composed of poorly drained soils and sediments. As a result, increased flooding is a major problem. This increased flooding may also result from increased water and sediment discharge in the upstream reaches of the river due to urbanization and gravel mining.

Bayou Manchac (Lower Reach Tributary)

Bayou Manchac is a lower reach tributary of the Amite River. It flows from the west and converges with the Amite near Port Vincent, LA. No gravel mining operations exist in this portion of the basin although the Amite River Diversion Canal and five major cutoffs are present downstream of

Figure 96. Downstream view of the Amite River at the Louisiana Hwy 42 crossing near Port Vincent, LA (July 2004) (arrow notes flow direction).

Figure 97. Upstream view of the Amite River at the Louisiana Hwy 42 crossing near Port Vincent, LA (July 2004) (arrow notes flow direction).

the confluence of Bayou Manchac and the Amite River. Two major crossings were visited on this stream and both revealed relatively stable channel conditions. The I-10 crossing (Figures 98 and 99) and the Louisiana Highway 61 crossing (Figures 100 and 101) cross Bayou Manchac just south of Baton Rouge, LA. Moderately sloping, well vegetated banks were observed at both locations although there were some minor signs of leaning vegetation present. The channel appeared to be rather straight with no bar development at either site. If instability is occurring or has occurred along this stream, then it is minor.

Figure 98. Downstream view of Bayou Manchac at the I-10 crossing near Baton Rouge, LA (July 2004) (arrow notes flow direction).

Bridge survey data

Data from bridge surveys conducted by the LDTD were examined for the purpose of understanding channel characteristics and changes in river morphology. These surveys were performed periodically at five Louisiana highway bridge crossings on the upper and middle reaches of the Amite River. The crossings, proceeding downstream, are Louisiana Highway 432 at Felixville, Louisiana Highway 10 at Darlington, Louisiana Highway 37 at Grangeville, Louisiana Highway 64 near Magnolia, and Louisiana Highway 190 at Denham Springs.

Figure 99. Upstream view of Bayou Manchac at the I-10 crossing near Baton Rouge, LA (July 2004) (arrow notes flow direction).

Figure 100. Upstream view of Bayou Manchac at the Louisiana Hwy 61 crossing near Baton Rouge, LA (July 2004) (arrow notes flow direction).

Figure 101. Downstream view of Bayou Manchac at the Louisiana Hwy 61 crossing near Baton Rouge, LA (July 2004) (arrow notes flow direction).

Typically, surveys were made at three locations upstream and three crossings downstream of the bridge. Data collected were channel width, maximum and minimum elevation of the channel bed, and water elevation.

Figures 102 through 106 are plots of channel width and deepest channel elevation (thalweg) versus time at the five surveyed bridge crossing sites. In each plot, values of width and channel elevation are averaged for the three survey points upstream of the bridge. In general, each plot illustrates an increase in channel width. The increased channel width is more pronounced with distance downstream. Channel elevation, on the other hand, has remained mainly unchanged over time. Channel width change data are summarized in Table 1.

Analysis of aerial photography

Aerial photography, particularly historical photography, is useful because images provide data regarding: (1) nature and condition of bank-line vegetation; (2) location and change in planform along the stream channel and the location and extent of point bar development; and (3) regional changes in land-use/land-cover. Therefore, USDA vertical, panchromatic aerial photography was acquired for the years: 1953, 1967, 1978, 1989, 1990, and 1998.

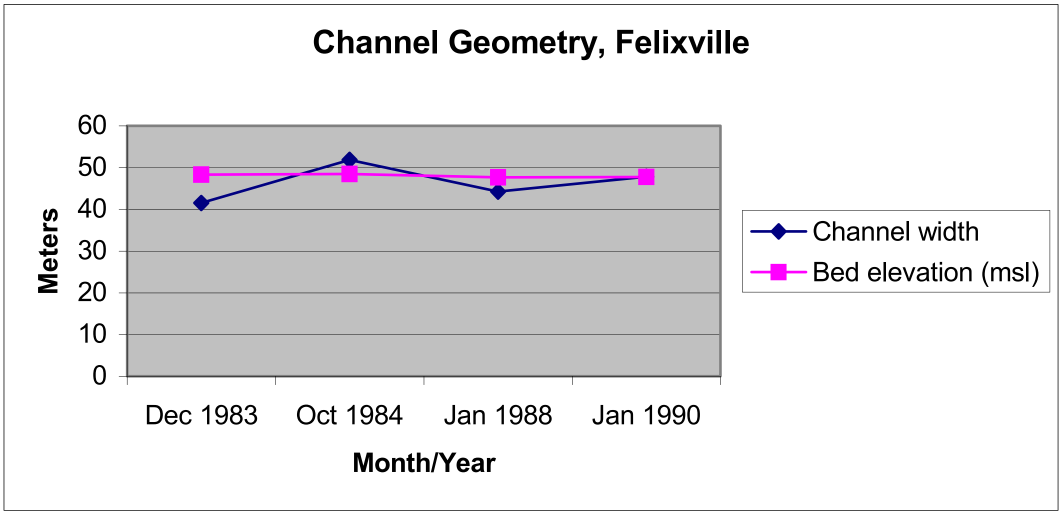


Figure 102. Channel width and bed elevation versus date at the Felixville crossing.

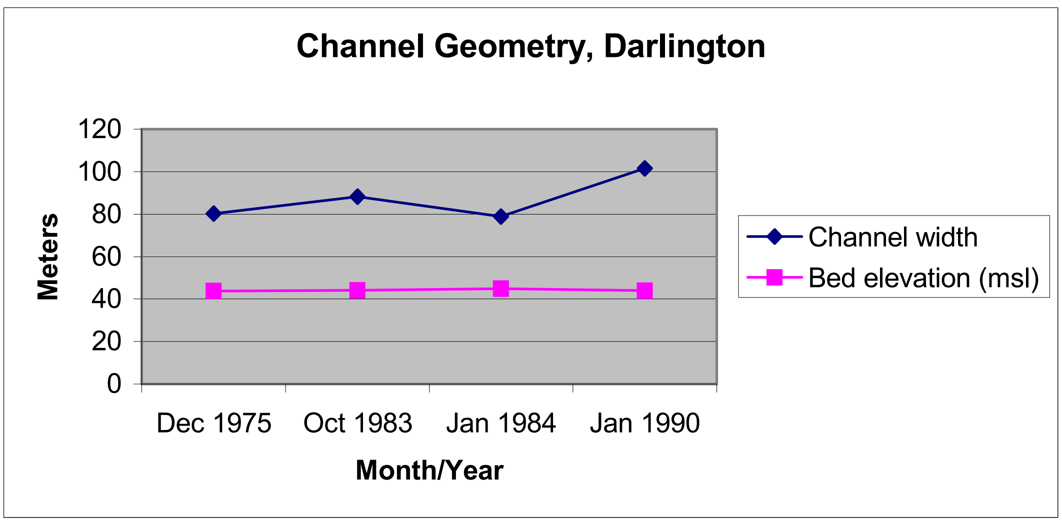


Figure 103. Channel width and bed elevation versus date at the Darlington crossing.

Because the scales of these photographs were not the same, each photograph, from the headwaters down to and including Port Vincent, was scanned and rectified and the stream channel outline was digitized and plotted on 2004 ATLAS imagery. The digitized image of the channel was used to more accurately represent changes in planform over time. For each reach of the stream, beginning in the headwaters, the 1953 (pre-mining and/or earliest view available) and the 1998 photographs are presented as well as the planform images for all four periods of time. The upstream terminus of severe erosion may usually be identified by a rapid decrease in stream width. To facilitate comparisons between imagery, two points, “a”

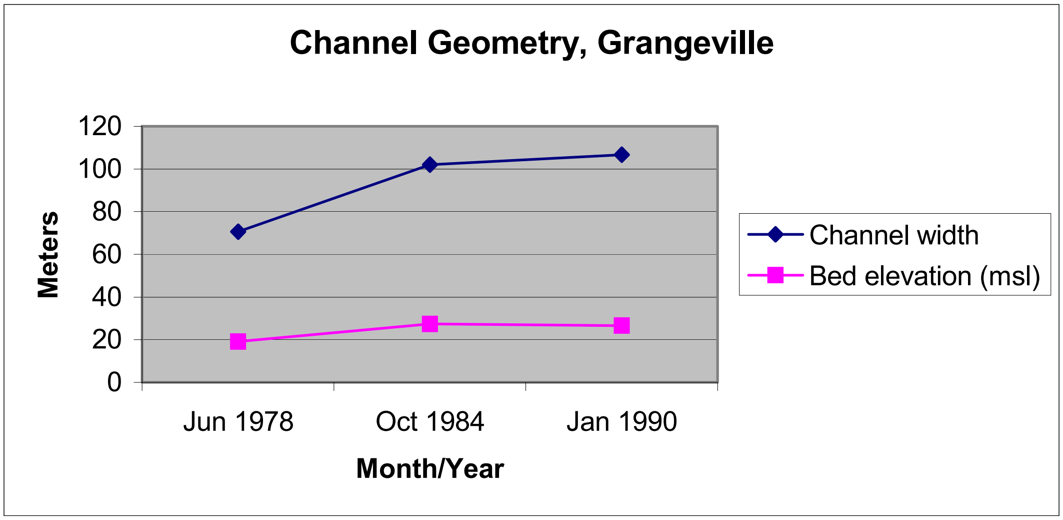


Figure 104. Channel width and bed elevation at the Grangeville crossing.

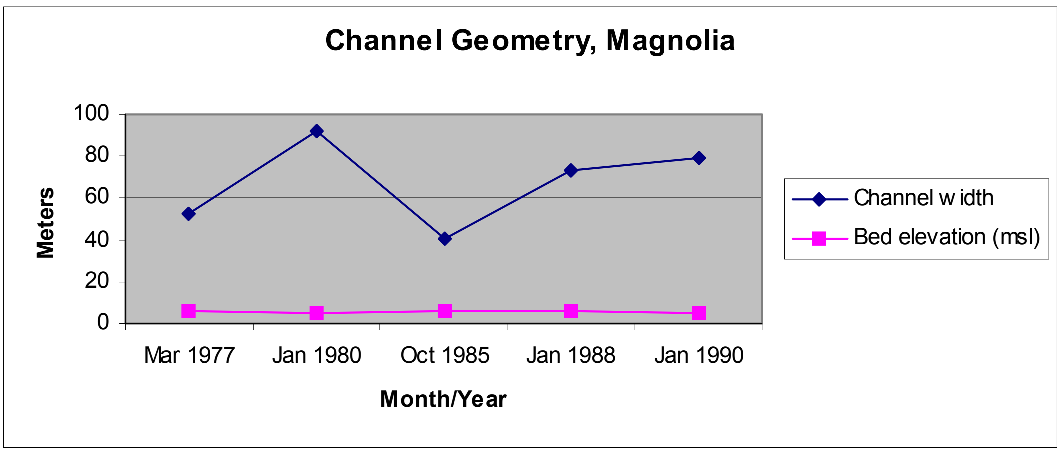


Figure 105. Channel width and bed elevation at the crossing near Magnolia.

and "b," are shown on each image and represent common locations on each view. In some cases "c" was used to depict three common points on the photograph.

Confluence of East Fork Amite River and West Fork Amite River

Figure 107 shows the 1953 (a) and 1998 (b) photos of the headwater reach upstream of the mined reach and Figure 108 is the digitized planform for all four periods of time. In 1953, the channels of the West and East Forks appear narrow and sinuous with well-vegetated banks, an indication of stability. The reach downstream of the West Fork and East Fork confluence appears stable. By 1998, a significant amount of channel straightening had occurred on the West Fork Amite and the main stem of the

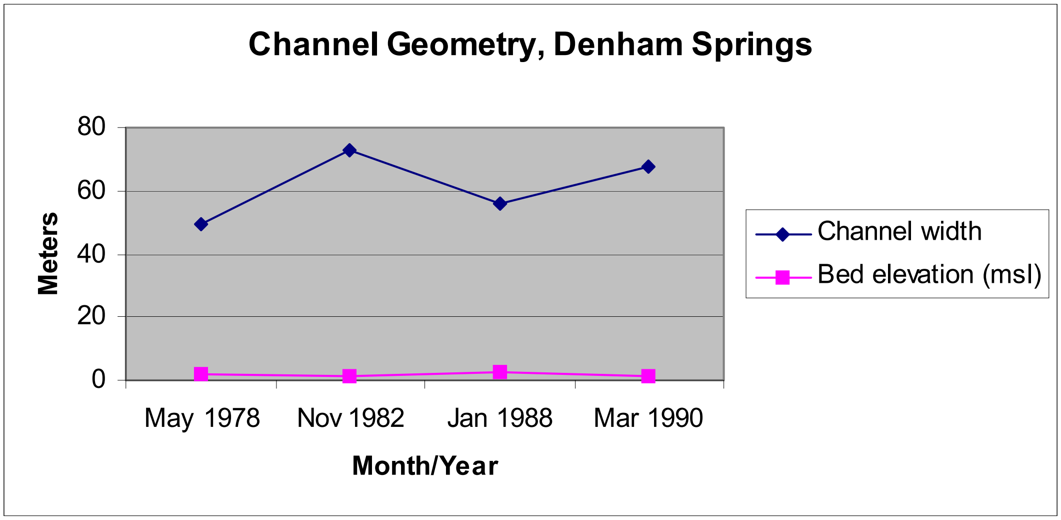


Figure 106. Channel width and bed elevation at the Denham Springs crossing.

Table 1. Summary of approximate changes in Amite River Channel width (m).

Location	Earliest (m) / year	Latest (m) / year	Percent Change
No Mining (Upstream of Mined Reach)			
Felixville	40 / 1983	50 / 1989	+ 25
Darlington	80 / 1975	100 / 1989	+ 25
Mined Reach			
Grangeville	70 / 1978	105 / 1990	+ 50
No Mining (Downstream of Mined Reach)			
Magnolia	50 / 1977	80 / 1990	+ 60
Denham Springs	50 / 1978	70 / 1990	+ 40

channel. Although the stream channel was locally straightened, the bankline still appears to be well-vegetated in the 1998 photo. By 1998, there is less forest cover as indicated by the areas of lighter phototone. The changes in stream plan form along this reach is shown in Figure 108.

Confluence of Darling Creek and the Amite River

Darling Creek is a main upper reach tributary to the Amite River. It converges with the Amite River near Darlington, LA, approximately 4.8 km downstream of the Louisiana Highway 10 crossing of the Amite River. This confluence lies well upstream of the main mined reach of the Amite River. Figure 109 depicts 1953 (a) and 1998 (b) photography of the reach upstream of this confluence shown in the lower center of each photograph. The 1953 image showed that the Amite River channel, approximately 4.5 km upstream of the confluence, was bifurcated. The bifurcation

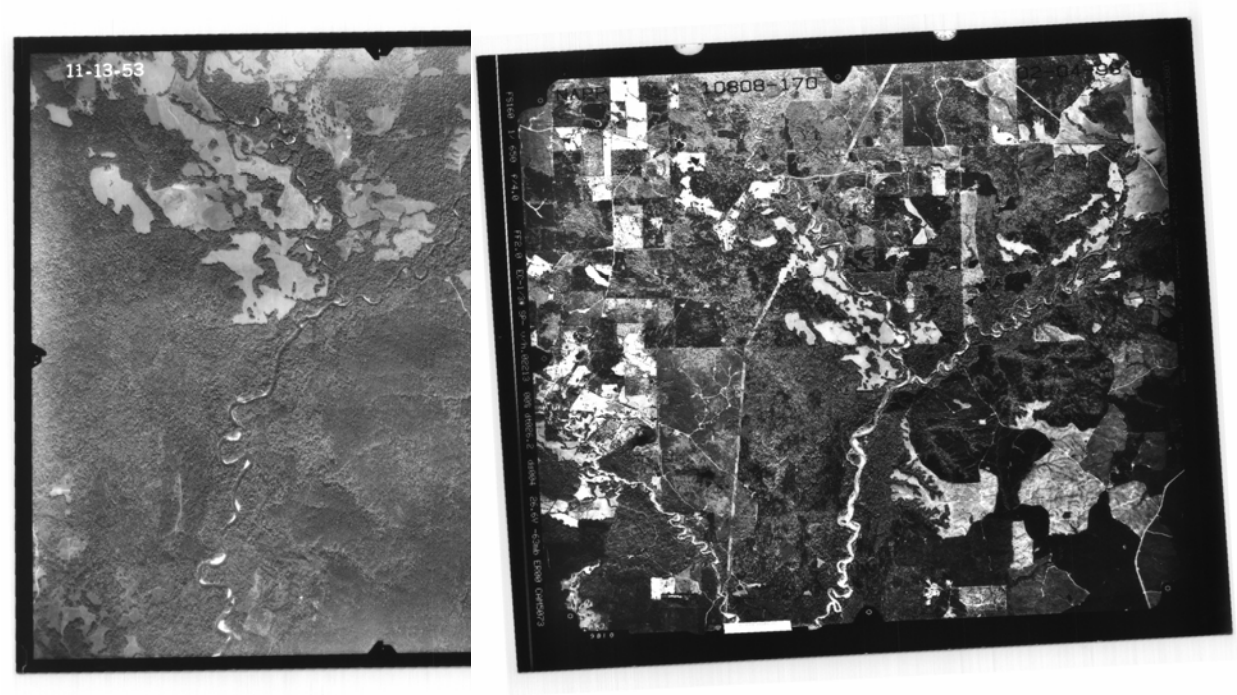


Figure 107. 1953 and 1998 aerial photographs of the Amite River headwaters in Mississippi and Louisiana.

extended downstream approximately 0.8 km upstream of the confluence. The two channels are the West Prong and East Prong of the Amite River. The 1998 photograph showed that bifurcation was present; however, most of the East Prong had been abandoned. The 1998 photograph also indicated larger and more extensive point bar development and less forest/more cleared areas. Planform changes are shown in Figure 110.

The Louisiana Highway 37 Crossing of the Amite River near Grangeville, LA

The 1953 and 1998 aerial photographs of the Louisiana Highway 37 crossing of the Amite River near Grangeville, LA, are shown in Figure 111. The Louisiana Highway 37 crossing is represented by “a” in the photos. In the 1953 photograph, the stream appears to be sinuous with good bar development and well vegetated banks. On the right bank, a large floodplain gravel mine is apparent in the 1953 photo, upstream of the Louisiana Highway 37 crossing. There appears to be a riparian buffer zone between this mine and the Amite River channel. No mines are present in this view downstream of the crossing. The 1953 photograph shows bank-line vegetation, absence of divided flow, and point bar development. The 1953 photography shows a pipeline crossing the river approximately 1.7 km downstream of the crossing. The 1953 photograph shows bank-line

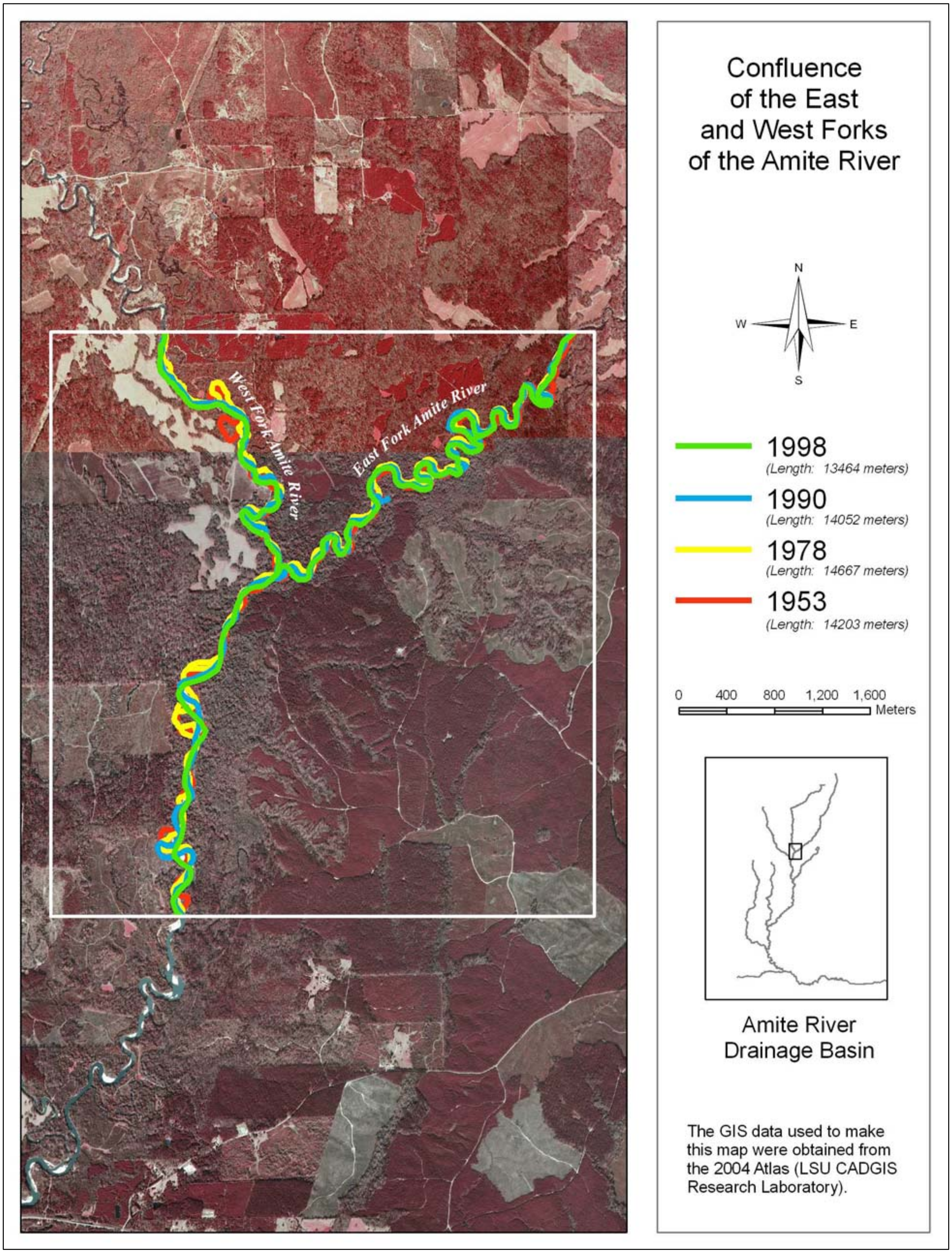


Figure 108. Changes in stream planform between 1953 and 1998.

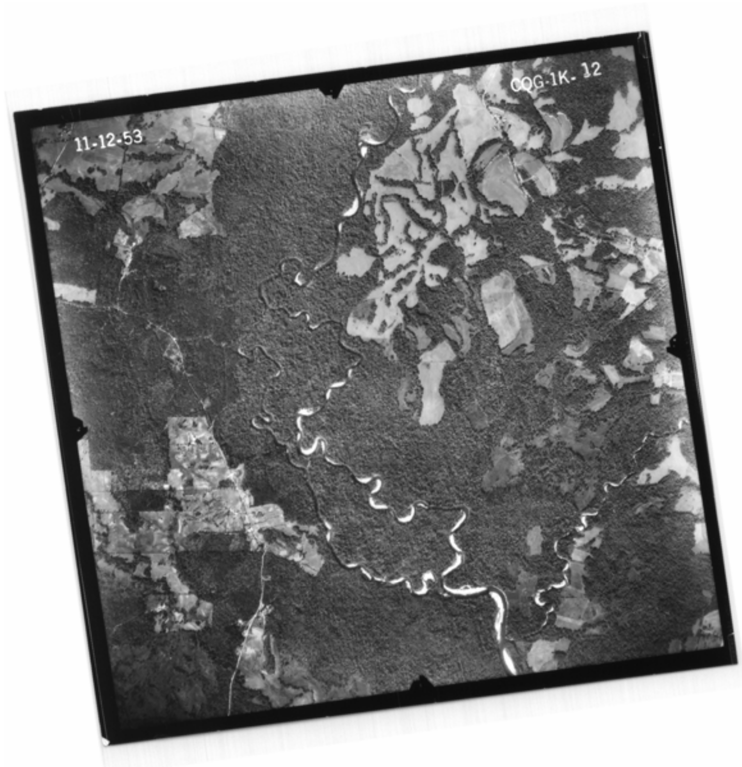


Figure 109. 1953 (upper) and 1998 (lower) views of the Amite River near the confluence with Darling Creek downstream of the Louisiana Highway 10 crossing. Darling Creek enters the Amite River from the east and the confluence is shown at the bottom center of the photographs.

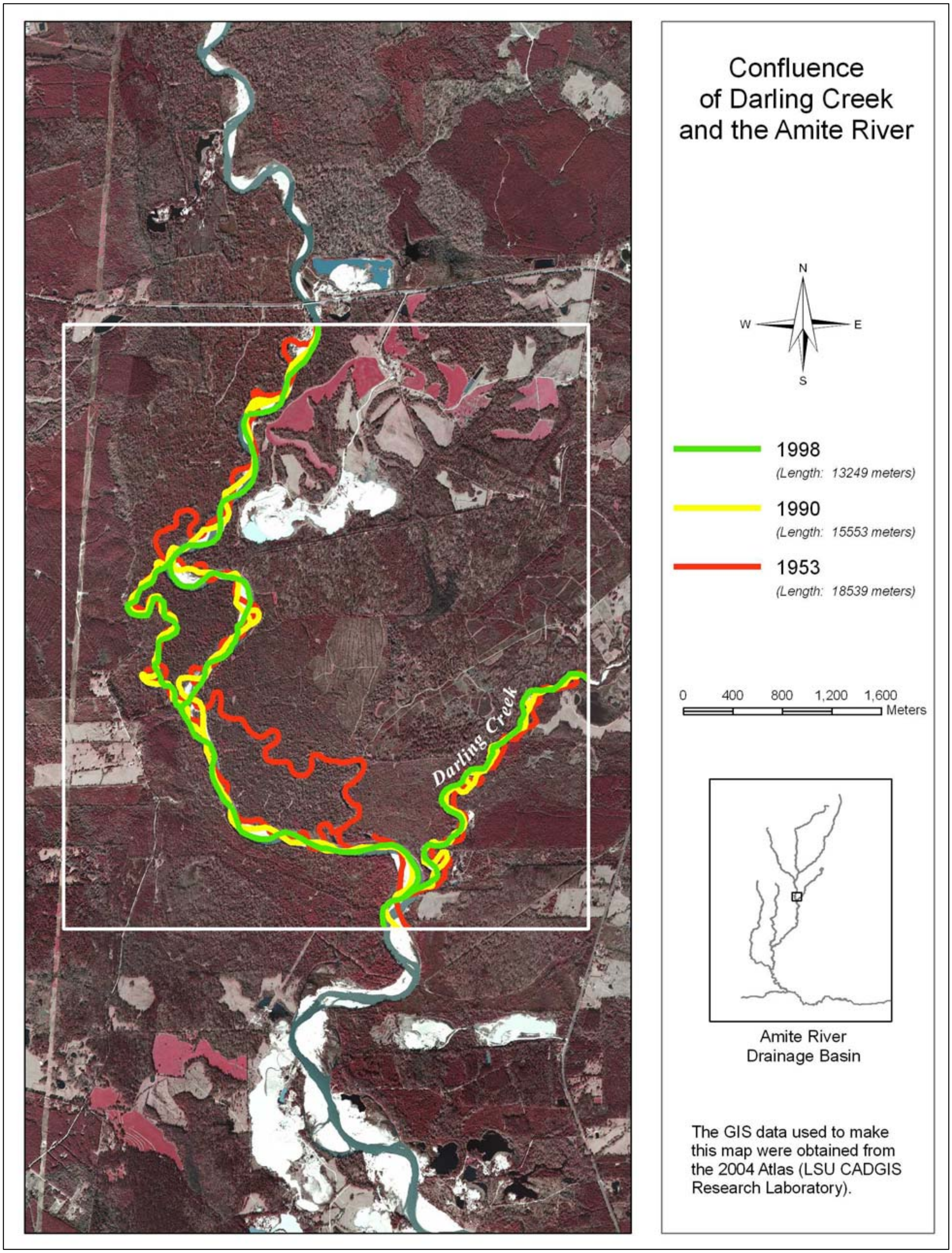


Figure 110. Changes in planform in vicinity of Darling Creek confluence between 1953 and 1998.

Figure 111. 1953 and 1998 aerial photography of the Louisiana Hwy 37 crossing of the Amite River near Grangeville, LA.

vegetation, absence of divided flow, and point bar development. The 1953 photography shows a pipeline crossing the river approximately 1.7 km downstream of the bridge. Near the pipeline crossing, there is evidence of bifurcation and a short reach of divided flow. The 1998 photograph exhibits extensive mining on both sides of the river, channel widening and straightening, loss of bank-line vegetation and divided flow. The bridge appears to cross a dry area of the channel as noted in the previous section on the field studies. Planform changes along this reach are shown in Figure 112.

Figure 113 is the 1953 and 1998 photographs of the Amite River further downstream of the Louisiana Highway 37 crossing near Grangeville, LA. The roughly east-west highway in the lower right corner of the 1998 photograph is Louisiana Highway 16. In the 1953 photograph, there are several small mined areas along the lower reaches and the channel appears

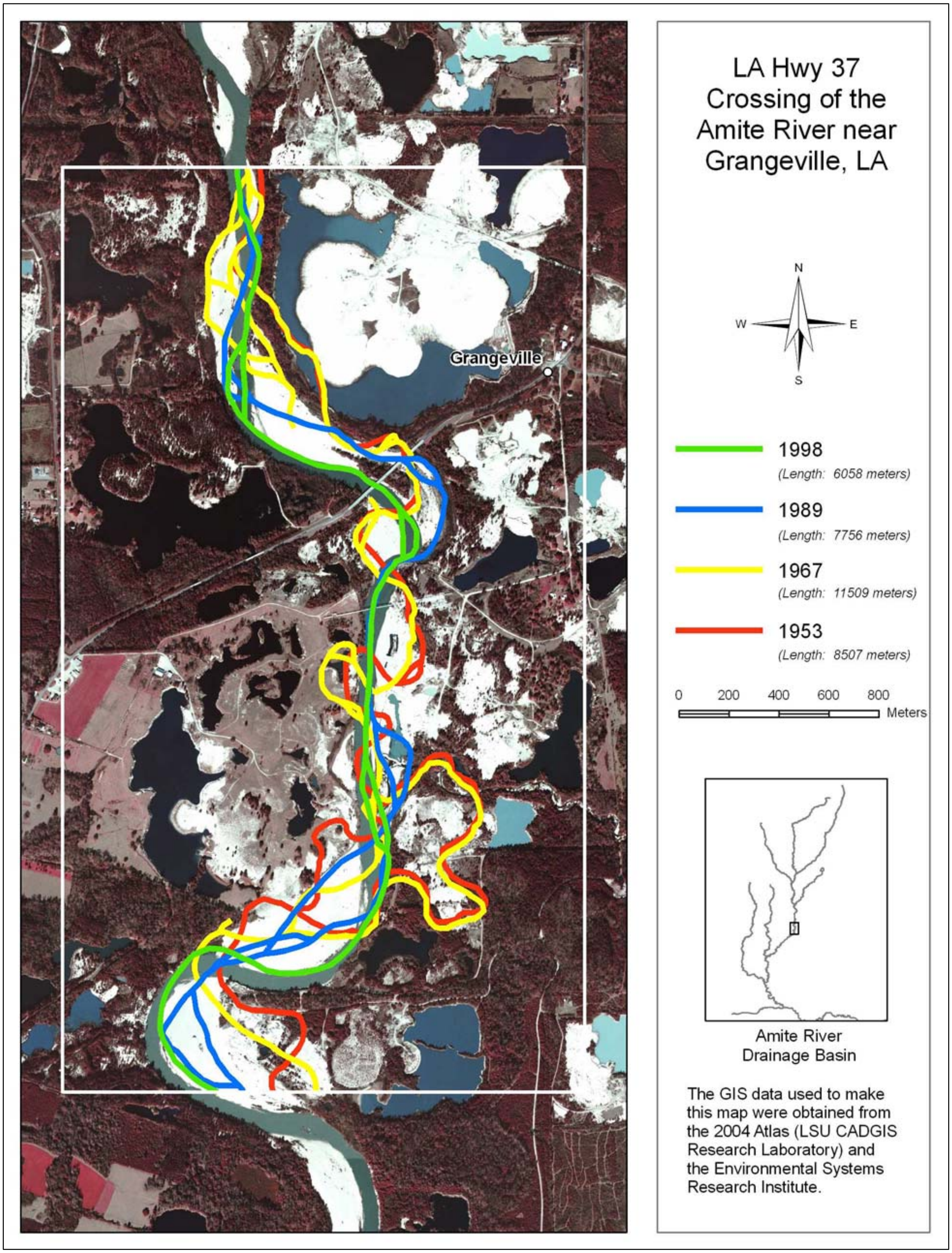


Figure 112. Planform change between 1953 and 1998 along the Grangeville Reach.

stable with a meandering configuration, good bar development, and well-established bank-line vegetation. In the 1998 photograph, numerous large mines are evident on both sides of the channel. It is apparent that severe channel widening and straightening has occurred along with divided flow and loss of bank-line vegetation. Planform changes are shown in Figure 114.

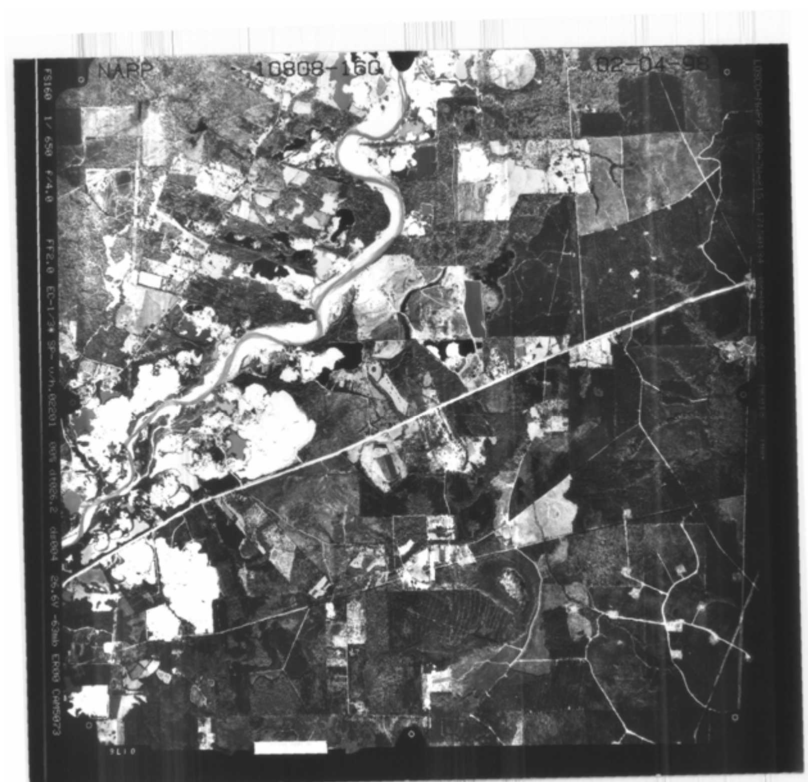
Confluence of Comite River and Amite River

The convergence of these rivers lies approximately 30 m upstream of the Louisiana Highway 190 crossing of the Amite River near Denham Springs, LA. Figure 115 shows the 1967 (a) and 1998 (b) photographs of this reach, which is downstream of the mined reaches. The highway in the lower part of both views is I-12 and the next crossing to the north of I-12 is Louisiana Highway 190. The Comite River can be seen entering the Amite River from the west. The 1967 and 1998 views show that the Amite River exhibits bank-line vegetation, a sinuous channel, and absence of significant point bar development. The 1998 photograph shows significant land-use changes since 1967 due to urbanization in the Baton Rouge (west) and Denham Springs (east) areas. Planform changes are shown in Figure 116.

Lower reaches and confluence of Bayou Manchac and the Amite River

Figure 117 is 1953 (a) and 1998 (b) aerial photographs of a portion of the lower reaches of the Amite River, including the confluence of the Amite River with Bayou Manchac. This particular portion of the Lower Amite River is located approximately 7 km upstream of Port Vincent, LA. Horseshoe Bend, a well known natural landmark in this area, is found at the lower right corner of the 1953 photograph and it is the major reference feature on both the 1953 and 1998 views. The additional linear reference features seen in the 1998 view are the power transmission line in the north and the pipeline crossing downstream of Horseshoe Bend. Bayou Manchac enters the Amite River from the west downstream of the pipeline crossing. The Amite River in the 1953 view appears stable with well vegetated banks and minor point bar development. The channel in the 1998 view also appears stable; however, the reach is more urbanized. Planform changes are shown in Figure 118.

a.



b.

Figure 113. 1953 (a) and 1998 (b) photographs of the Amite River downstream of the views presented in Figure 111.

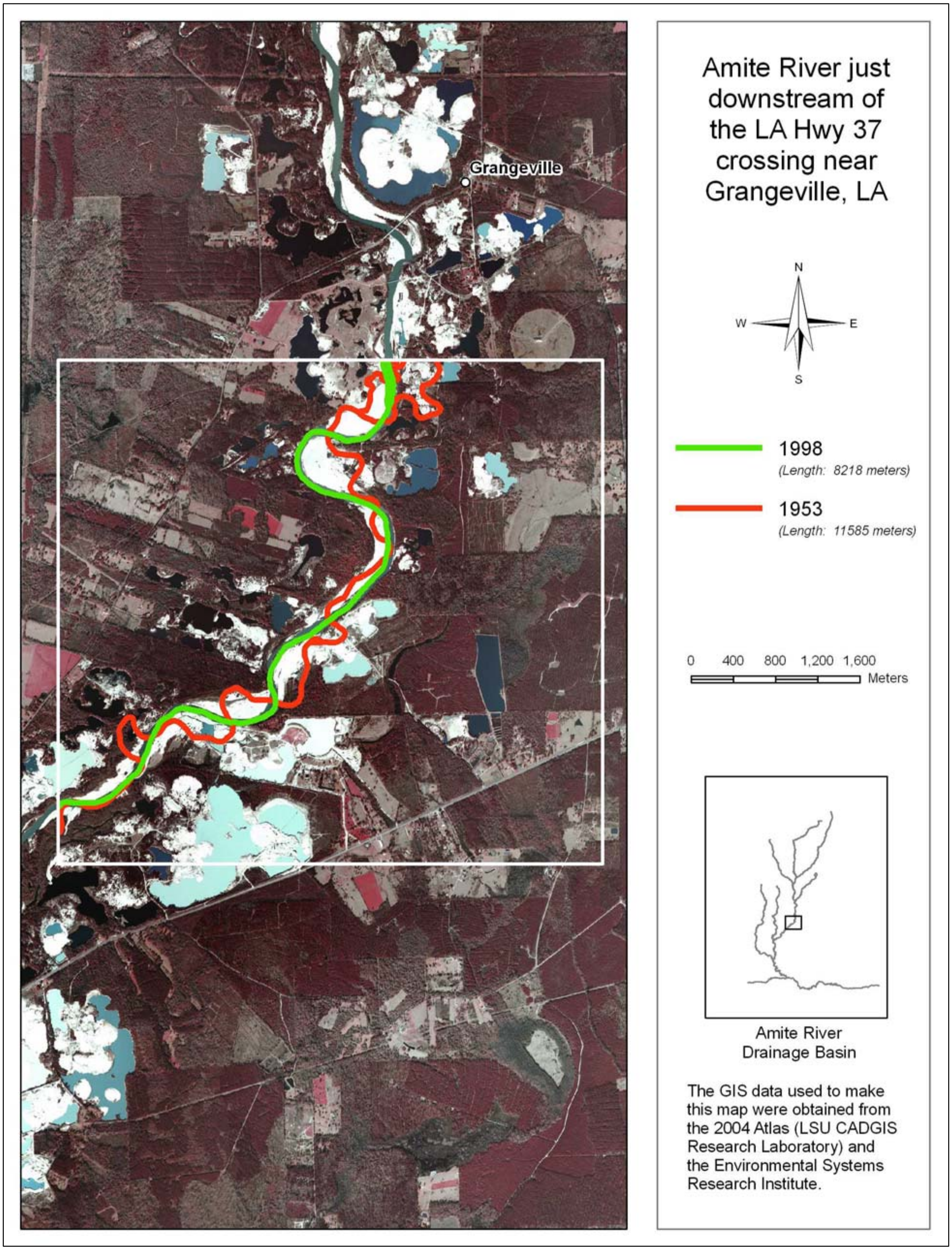
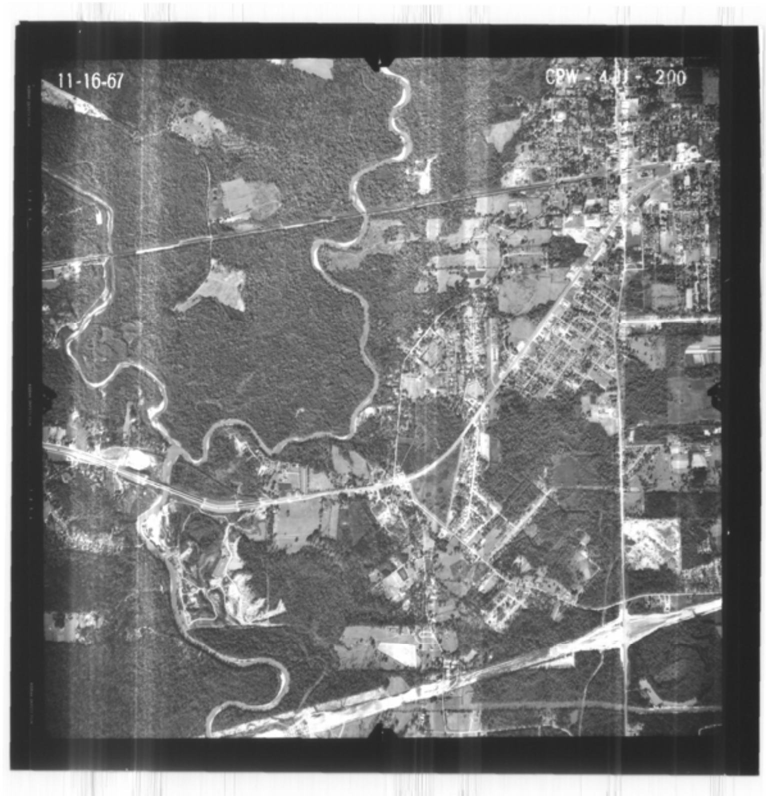


Figure 114. Planform changes south of Grangeville downstream of the Louisiana Highway 37 crossing between 1953 and 1998.



a.

b.

Figure 115. 1967 (a) and 1998 (b) photographs of the Amite and Comite rivers and the I-12 and Louisiana Highway 190 crossings.

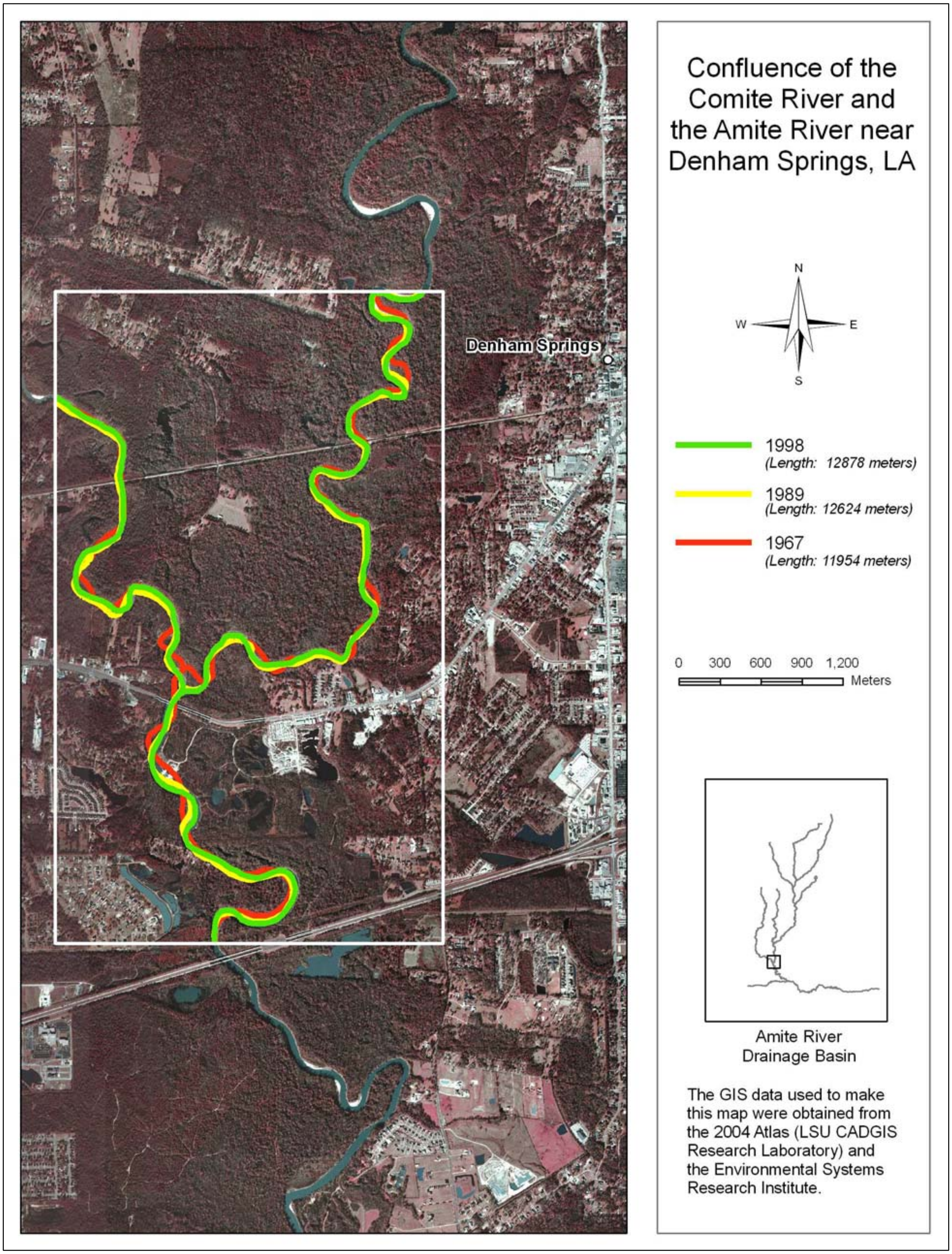
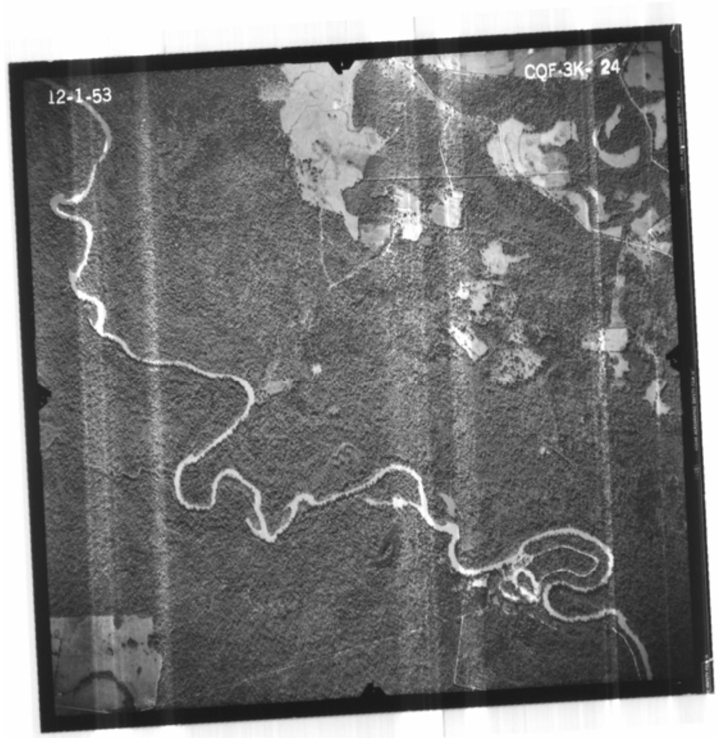


Figure 116. Planform changes in the vicinity of confluence of the Amite and Comite rivers between 1967 and 1998.



a.

b.

Figure 117. 1953 (a) and 1998 (b) aerial photographs of the Amite River reach approximately 7 km upstream of Port Vincent, LA. The prominent meander bend (Horseshoe Bend) is apparent in both views. Two crossings are shown in the 1998 view, a power transmission line to the north and a pipeline to the south of Horseshoe Bend. Bayou Manchac enters the Amite River from the west a short distance downstream of the pipeline crossing.

Reach of the Lower Amite River in the vicinity of Port Vincent, LA

Figure 119 shows the 1989 aerial photo of the Lower Amite River reach in the vicinity of Port Vincent, LA, located in the urbanized area on the left bank near the center of the view. No photography was available prior to 1989. The tributary entering from the east in the lower center of the view is Colyell Bay. The Amite River channel in this photograph appears to be somewhat less sinuous than that seen upstream. There are three meander cut-offs present but otherwise, there are no indications of instability.

The Amite River Diversion Canal

Figure 120 depicts 1989 (a) and 1998 (b) aerial photographs of the Amite River Diversion Canal where it bisects the Amite River a few kilometers south of Port Vincent, LA. No aerial photography was available prior to 1989. The canal was built between 1957 and 1964 for the purpose of flood-control by diversion of floodwaters from the Amite River directly to Lake Maurepas. The aerial photographs show two meander cutoffs, which were probably constructed as a part of the diversion project. There does not appear to be significant change in channel planform nor land-use between 1989 and 1998 as indicated in Figures 120 and 121.

Summary of observed changes in Amite River planform

Table 2 shows the channel lengths for each of the studied reaches in term of the year of the aerial imagery. The percent change in channel length is based upon the comparison of latest versus earliest available image. These data indicate that mined reaches downstream and upstream of Grangeville have experienced a decrease in channel length of approximately 28 to 29 percent. The Darling Creek reached exhibited a decrease of nearly 28 percent. A small decrease (approximately 5 percent) occurred on the reach at the confluence of the East Fork and the West Fork. Those reaches downstream of the mined areas exhibited small increases in channel length.

Hydrology

The USGS stream discharge and stage data from stream gauge stations on the Amite and Comite rivers were collected and evaluated in terms of understanding temporal effects of mining on stream discharge. These data included annual mean streamflow (discharge), peak annual streamflow, and peak annual gauge height and are presented in this report in English

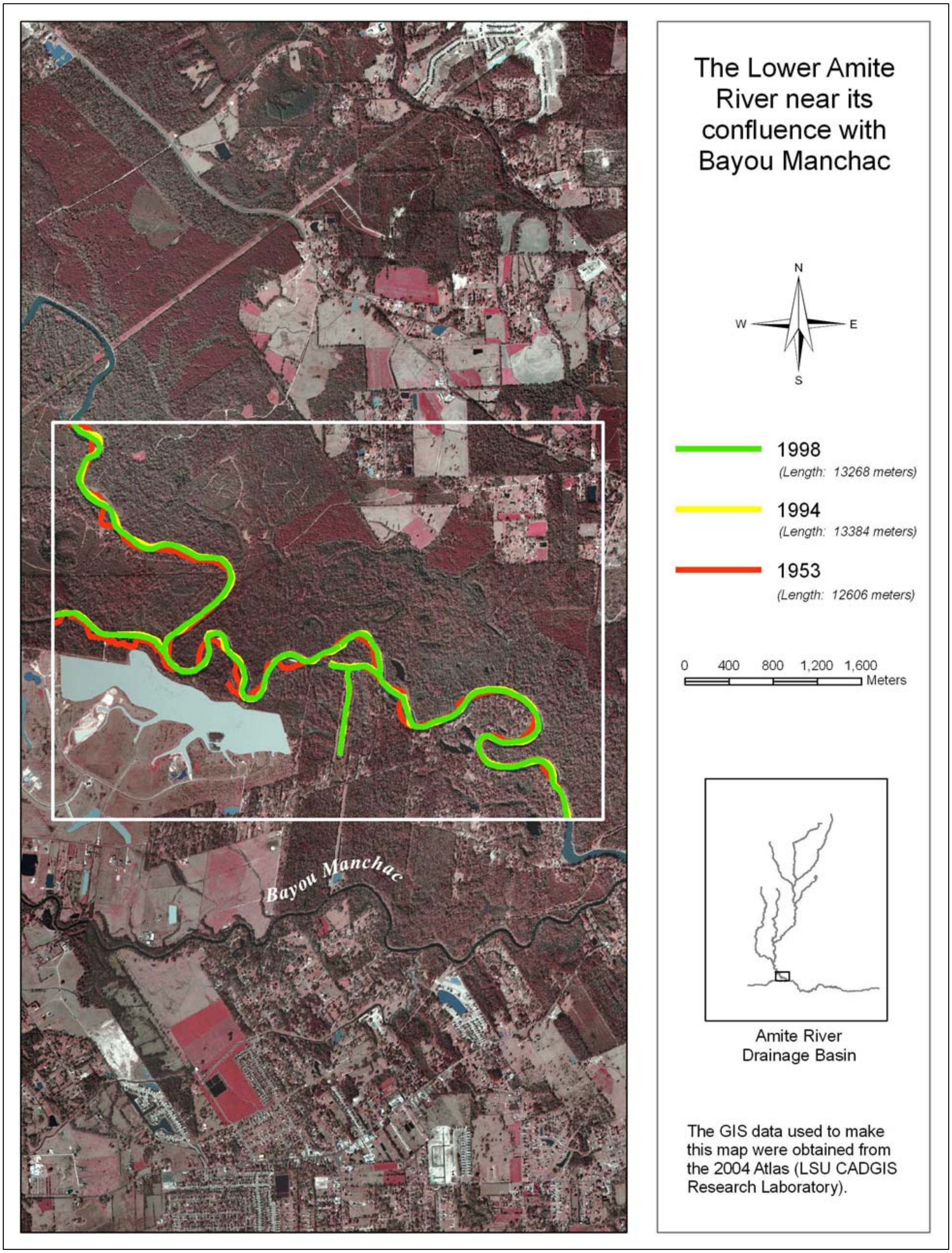


Figure 118. Planform changes in the vicinity of Bayou Manchac between 1953 and 1998.

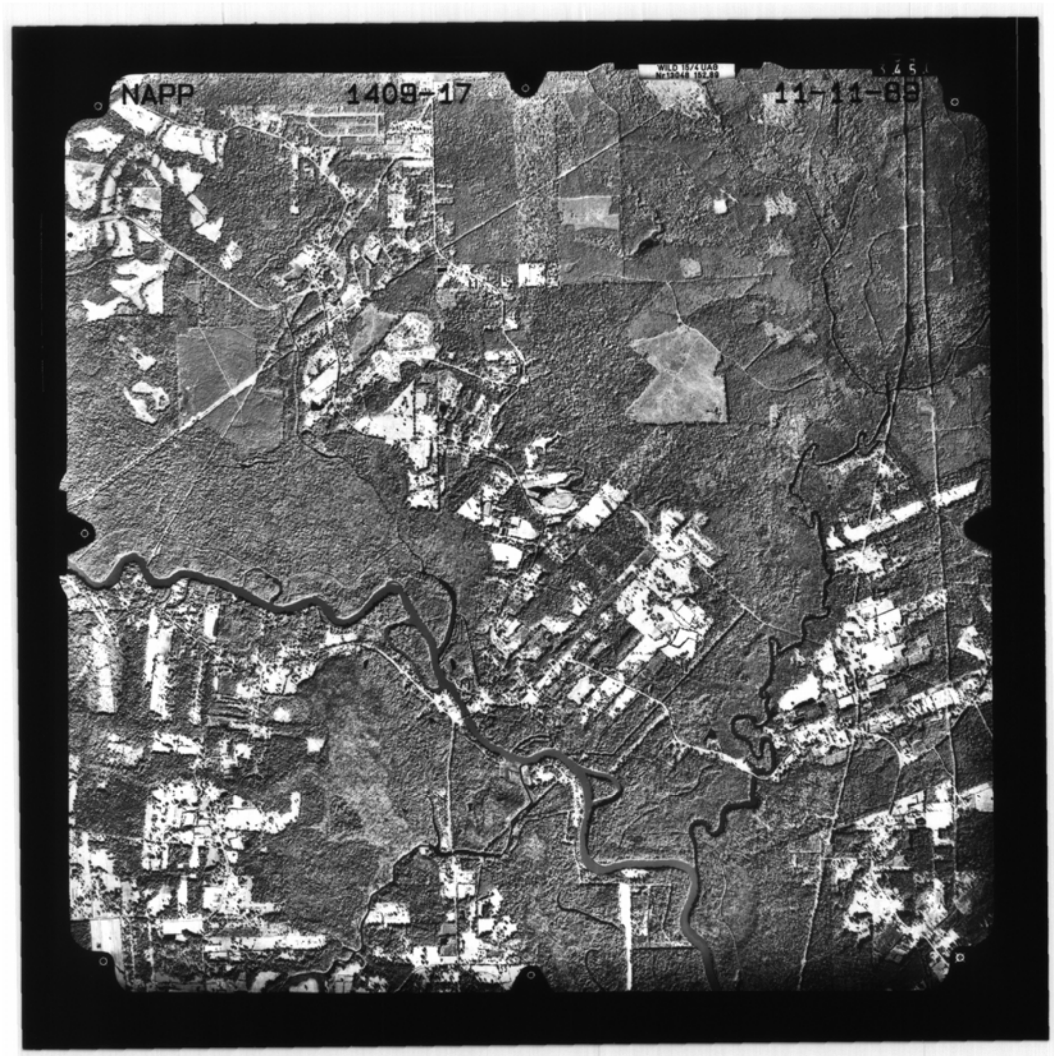


Figure 119. 1989 aerial photograph of the Amite River
in the vicinity of Port Vincent, LA.

units of cubic feet per second (cfs) for streamflow and feet (ft) for gauge height. Both peak annual, annual mean streamflow, and gauge height are plotted versus year. A linear regression trend line is included on each graph. The gauge data are presented sequentially beginning with the most upstream gauge.

East Fork of the Amite River near Peoria, MS

This gauge station is the only current station in the Amite River headwaters and is the most recently established station within the basin. Peak annual streamflow and peak annual gauge height data are shown in Figure 122. Mean annual streamflow data were not available. These gauge data, as well as that of subsequently described stations, are scattered and

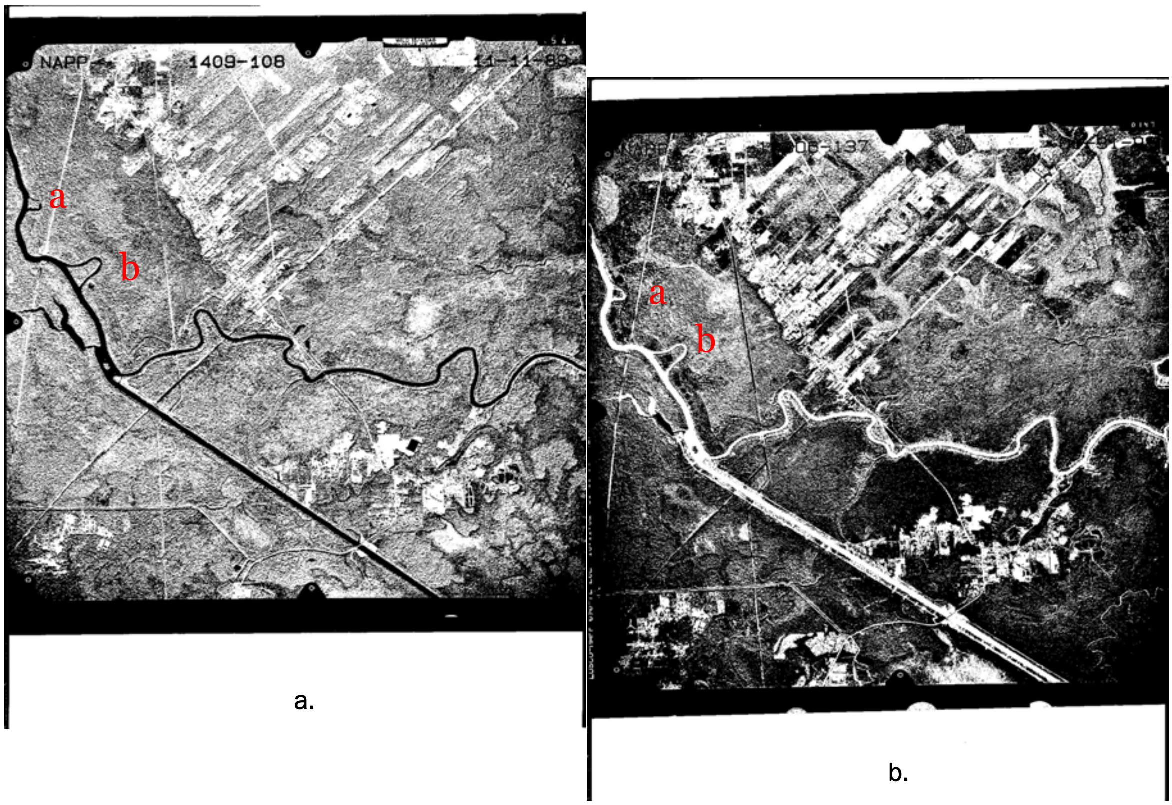


Figure 120. 1989 (a) and 1998 (b) aerial photographs of the Amite River Diversion Canal downstream of Port Vincent, LA (note points "a" and "b" are common points and major meander cutoffs).

the regression lines should be considered approximate. The data in Figure 122 suggest that both peak annual streamflow and peak annual gauge height increased over the last several years.

Amite River: The Louisiana Highway 10 Bridge crossing near Darlington, LA

This station is the most northerly station on the Amite River in Louisiana and is located upstream of the principal mined reaches. Gauge data shown in Figure 123 indicate a slight annual mean streamflow increase (Figure 123a), constant peak annual streamflow (Figure 123b), and a decrease in peak annual gauge height (Figure 123c). This bridge failed in 1999 during which both the peak annual streamflow and the peak annual gauge height were not particularly high.

Amite River: The Louisiana Highway 37 Bridge crossing near Grangeville, LA

This gauge station is located near the center of the principal mined reach. Peak annual streamflow and peak annual gauge height are shown in Figure 124. Peak annual streamflow was recorded from the early 1950s

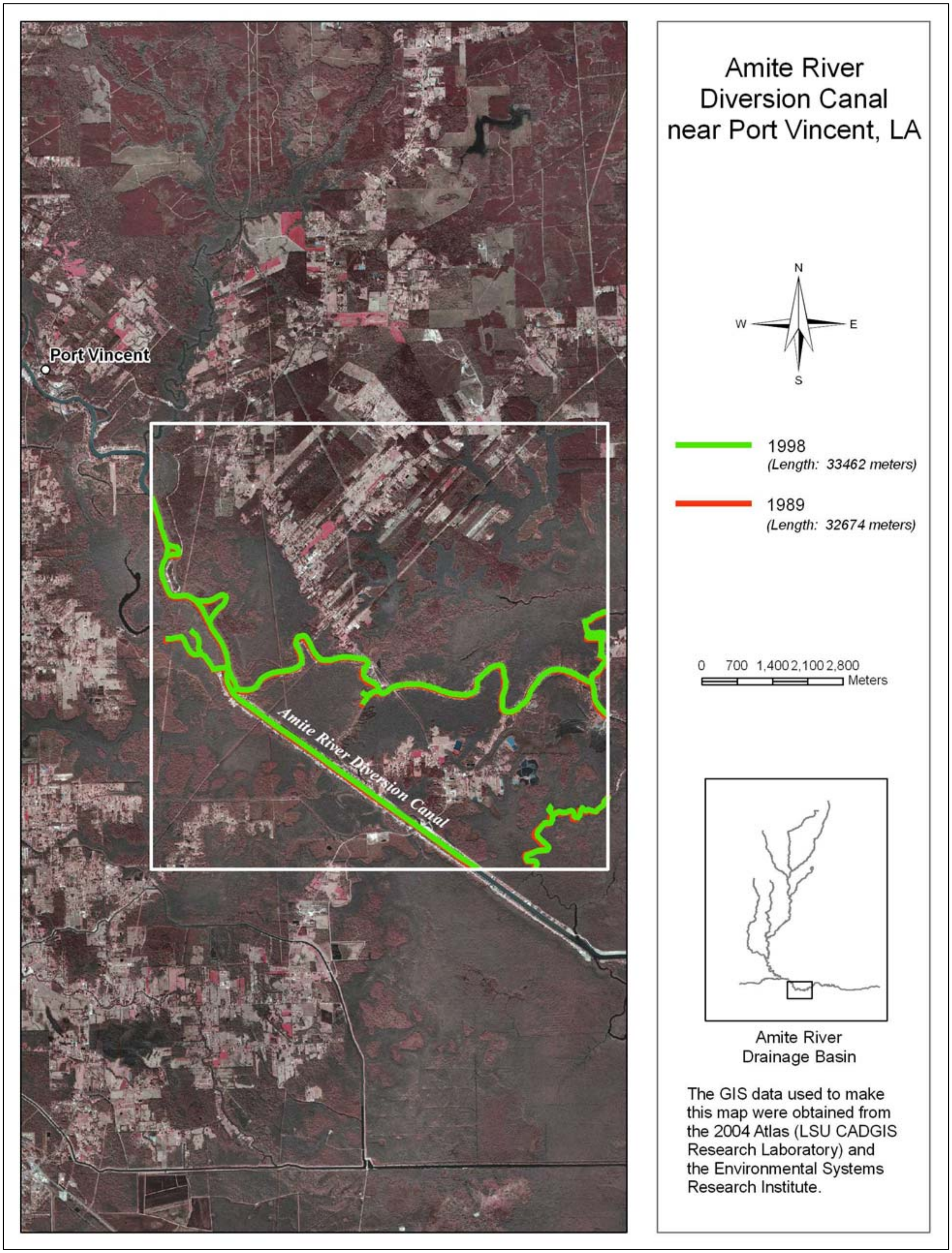


Figure 121. Planform changes in vicinity of Amite River Diversion Canal between 1989 and 1998.

Table 2. Summary of changes in channel length.

Reach	Reach Length (m)				
	Year				
	1953	1967/1978	1989/1990/1994	1998	Percent Change[a]
No Mining (Upstream of Mined Reach)					
East and West Fork Confluence	14203	14667	14052	13464	- 5.2
Darling Creek Confluence	18539	--	15553	13429	- 27.6
Mined Reach					
Grangeville	8507	11509	7756	6058	- 28.8
South of Grangeville	11585	--	--	8218	- 29.1
No Mining (Downstream of Mined Reach)					
Comite River Confluence	--	11954	12624	12878	+7.7
Bayou Manchac Confluence	12606	--	13384	13268	+ 5.3
Amite River Diversion Canal	--		32674	33464	+ 2.4

[a] Percent change in stream length (m) between earliest and latest image.

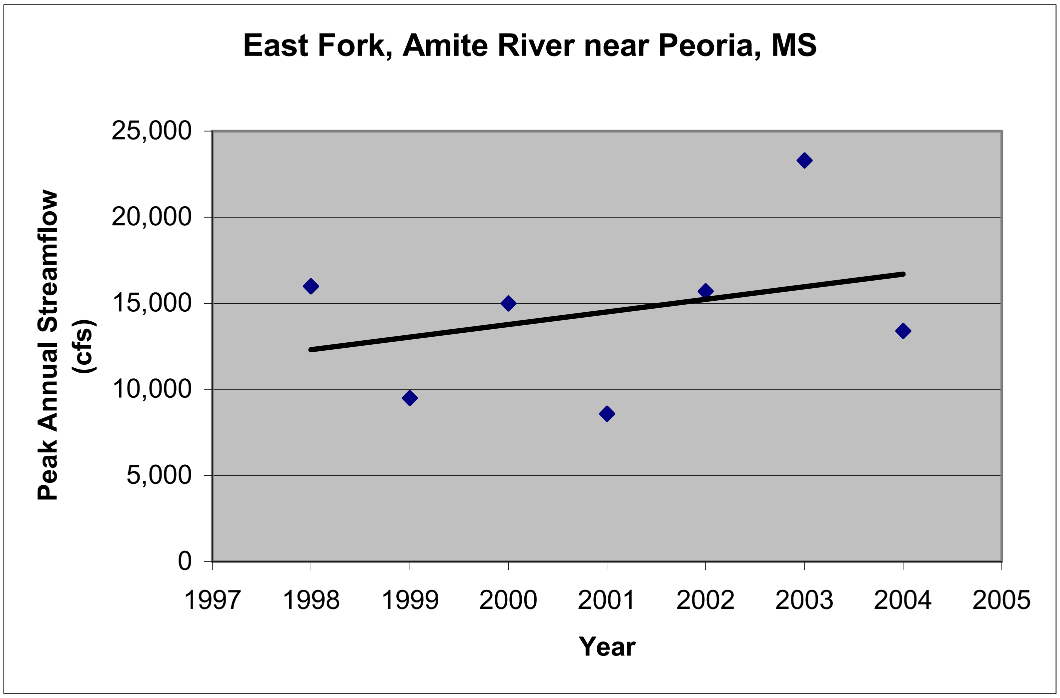
through the early 1960s (Figure 124a) and exhibits a significant decrease in streamflow. Peak annual gauge height also decreased after the mid-1980s. Both decreases may be attributable to the widening of the channel by mining.

Amite River: The Louisiana Highway 64 Bridge crossing near Magnolia, LA

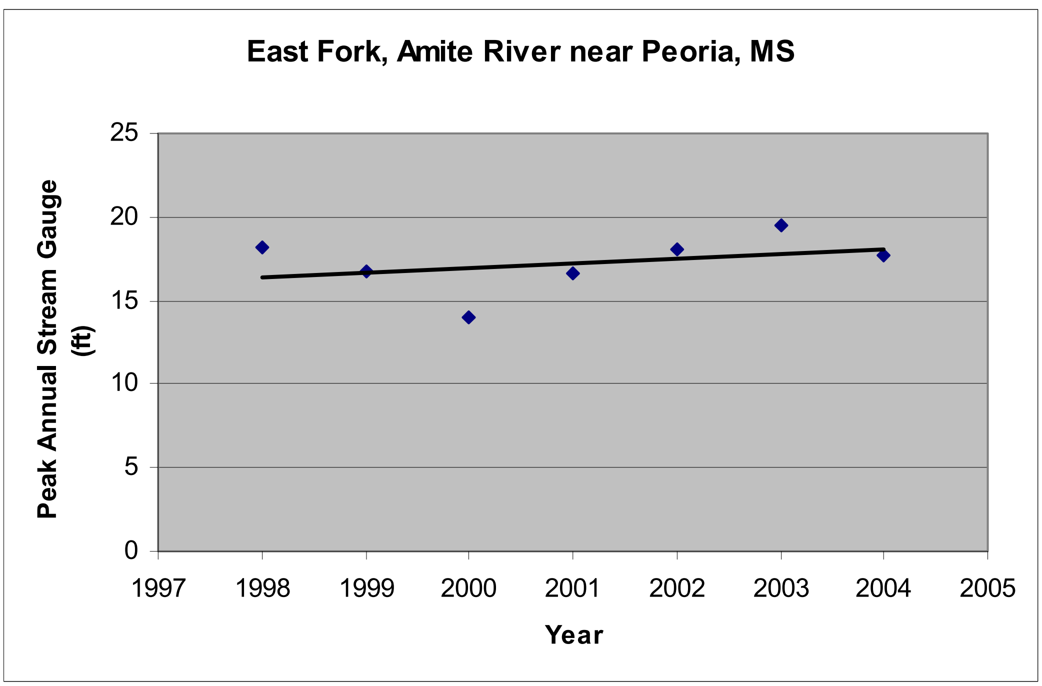
This gauge is located downstream of the principal mined reach, but there are scattered mines both upstream and downstream of this gauge station. Peak annual streamflow and peak annual gauge height trends (Figure 125) both exhibit increases with time. This trend is particularly apparent for peak annual gauge height.

Amite River: The Louisiana Highway 190 Bridge crossing near Denham Springs, LA

This site is downstream and well beyond active mining operations. It is, however, approximately 50 m downstream of the Amite River and the Comite River confluence.

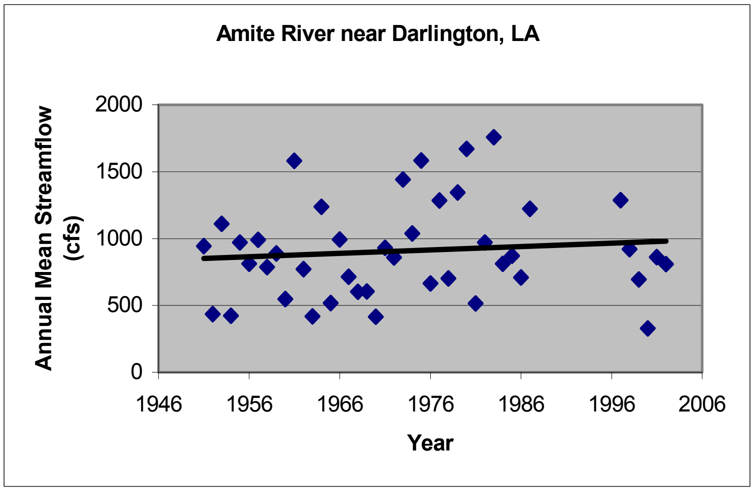


a.

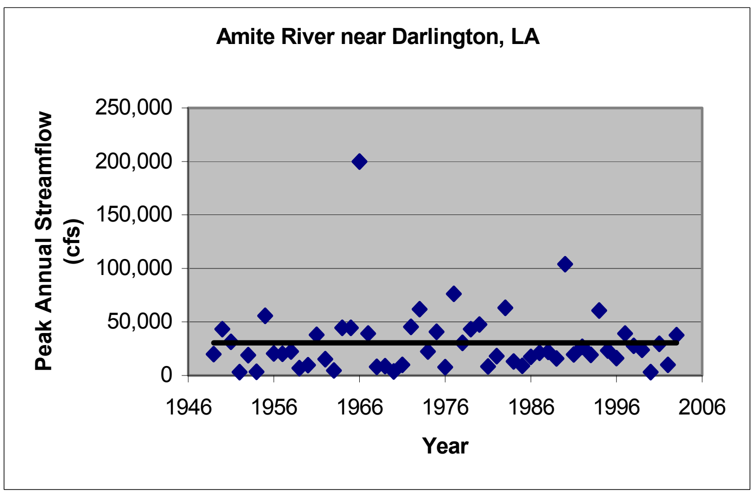


b.

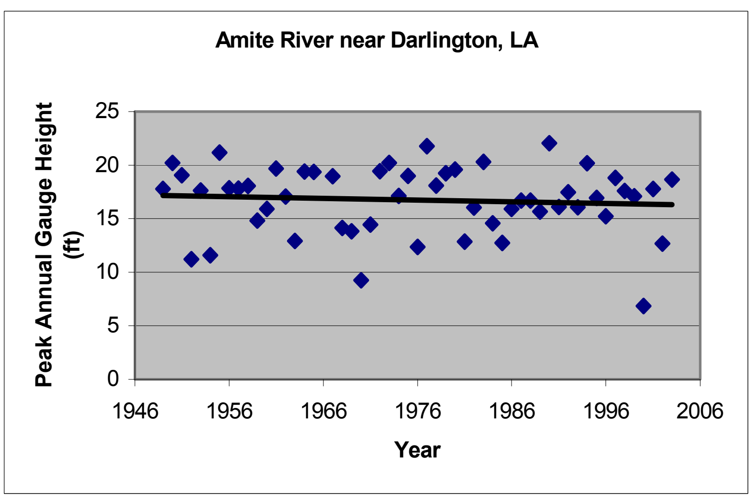
Figure 122. Peak annual streamflow (a) and peak annual gauge height (b), East Fork of the Amite River near Peoria, MS.



a.

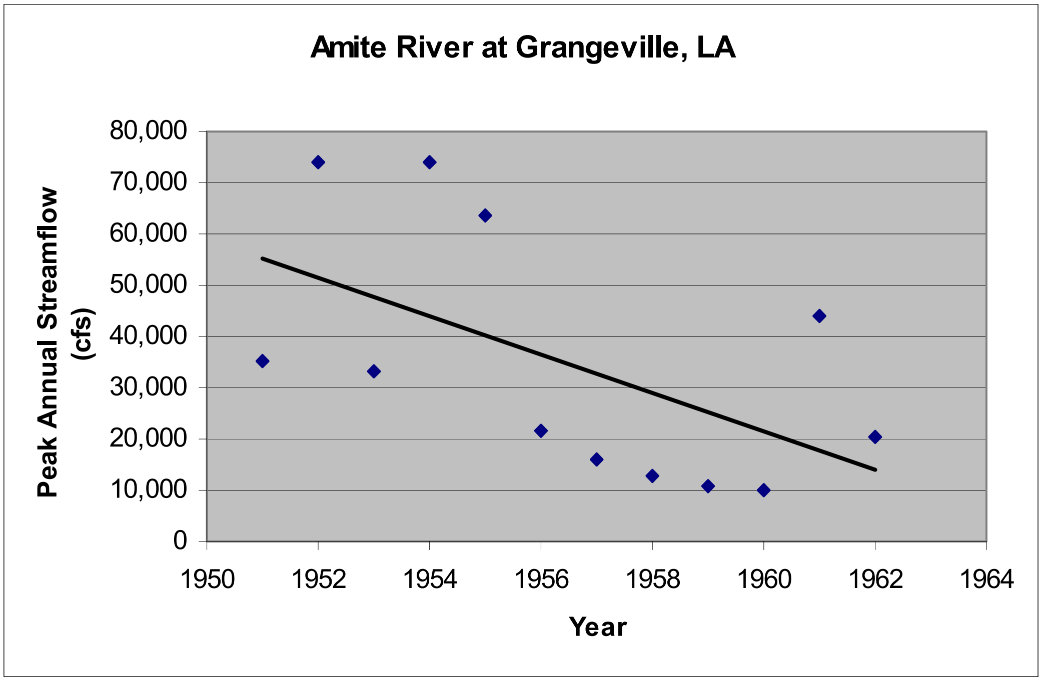


b.

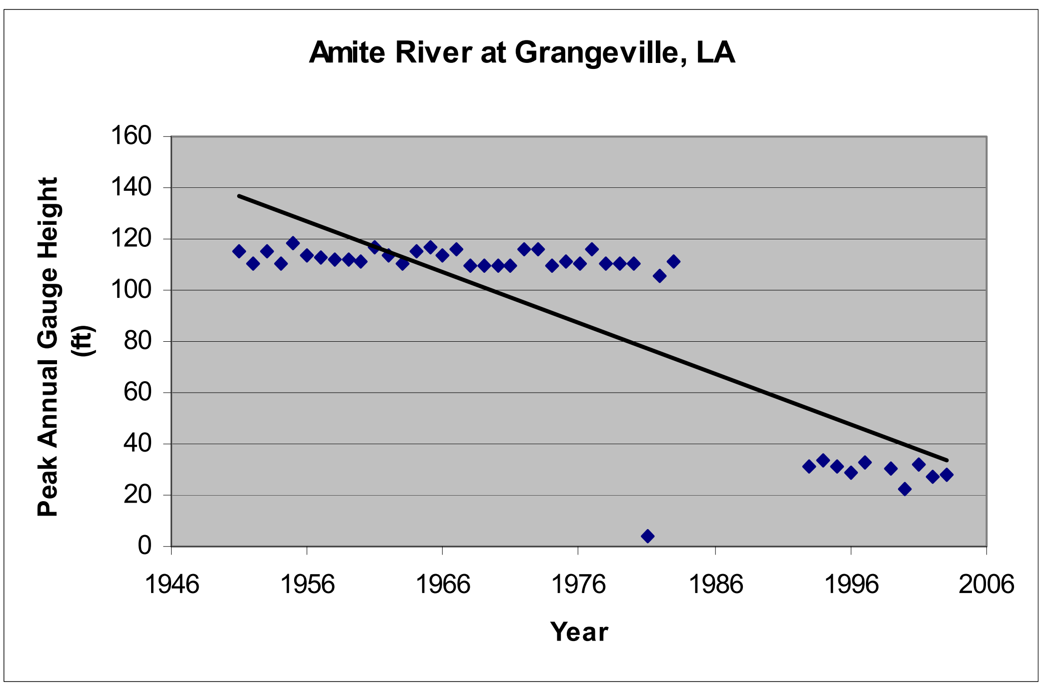


c.

Figure 123. Annual mean streamflow (a), annual peak streamflow (b), and peak annual gauge height (c) for the Amite River at the Louisiana Highway 10 crossing near Darlington, LA. The Darlington flood stage is 7.27 ft.

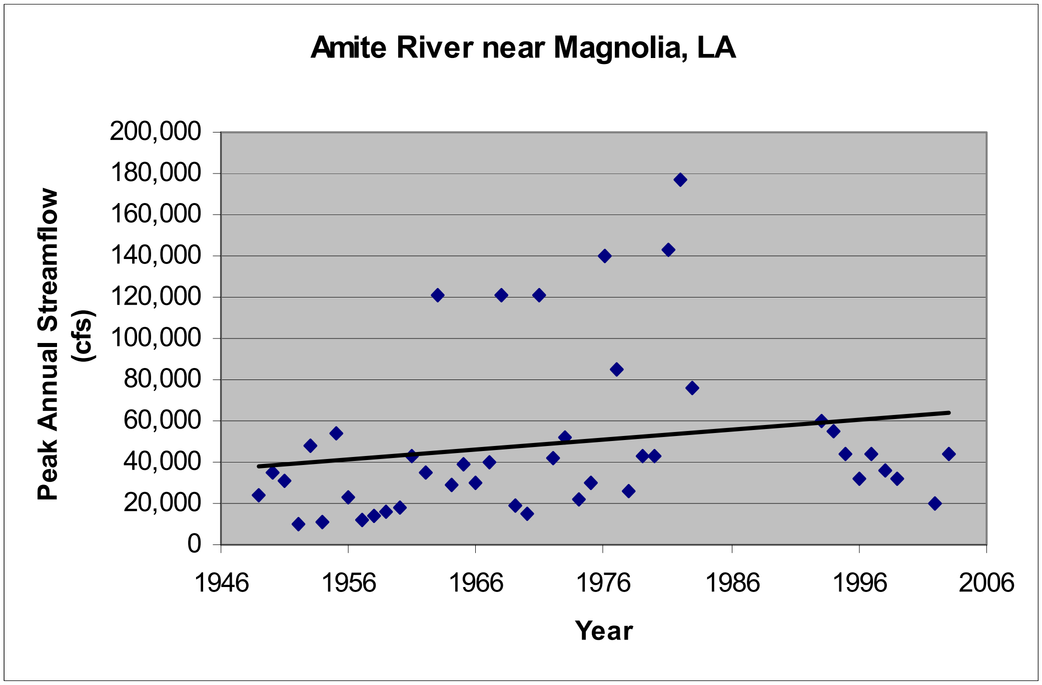


a.

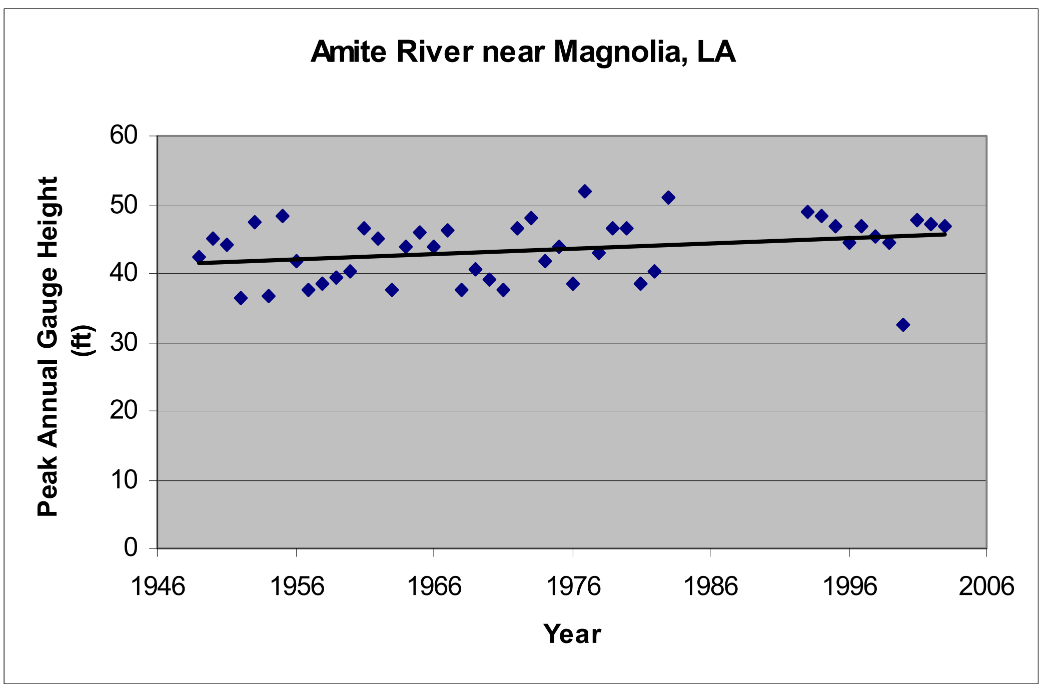


b.

Figure 124. Peak annual streamflow (a) and peak annual gauge height (b) for the Amite River at the Louisiana Highway 37 Bridge Crossing near Grangeville, LA. The flood stage at this station is approximately 35 ft.



a.



b.

Figure 125. Peak annual streamflow (a) and peak annual gauge height (b) for the Amite River at the Louisiana Highway 64 Bridge Crossing near Magnolia, LA. The flood stage at this station is 34.66 ft (NGVD).

Figure 126 shows the annual mean streamflow (a), peak annual streamflow (b), and peak annual gauge height (c) all of which, particularly peak gauge height, exhibit trends, which increase with time. This site is located in an urbanized area, which includes Denham Springs to the east and Baton Rouge to the west.

Amite River: The Louisiana Highway 42 Bridge crossing near Port Vincent, LA

This site is located upstream of the Amite River Diversion Canal and available gauge data are shown in Figure 127. Trend data for both peak annual streamflow (Figure 127a) and peak annual gauge height (Figure 127b) decrease with time. These decreases are probably due to the diversion canal.

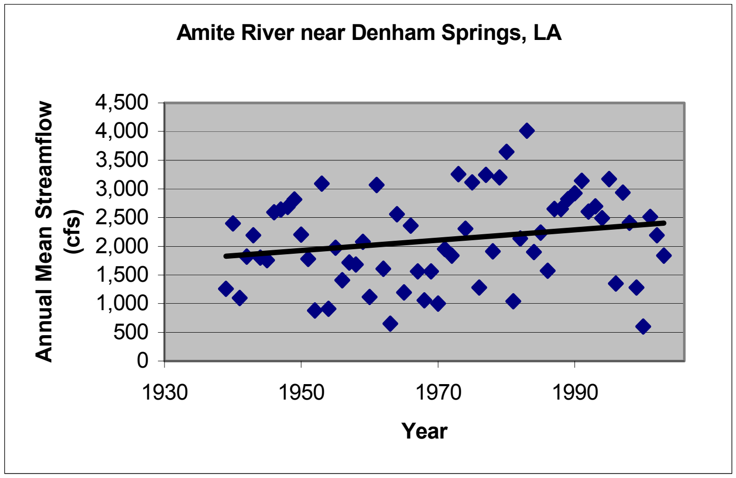
Table 3 was prepared to provide some insight as to the effects of mining on flooding. The data include the five largest, historic discharges recorded at five gauge stations, two of which are along the mined reach and three are downstream of this reach. The year 1989 was arbitrarily selected to identify the number of record discharges that had occurred prior to and after that year. The table shows that along the mined reach there were less record floods after 1989, whereas downstream of this reach the number of record flood events was nearly the same before and after 1989.

Comite River: The Louisiana Highway 10 Bridge crossing near Clinton, LA

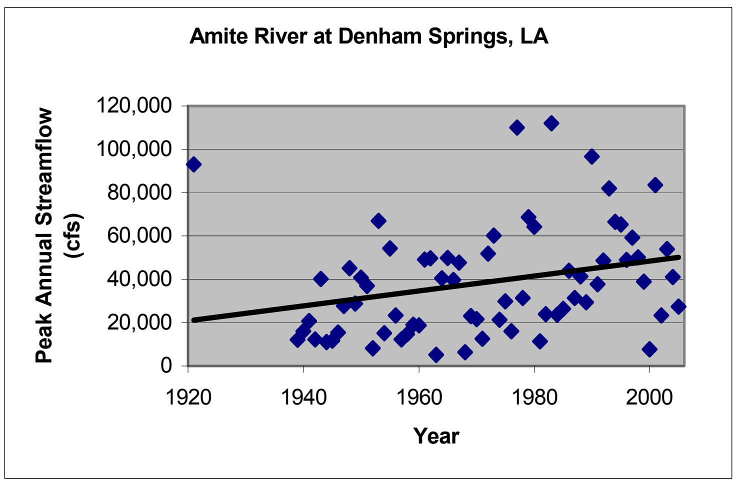
This station is located in a mainly rural area and is furthest upstream station in the Comite River Basin. Peak annual streamflow data (Figure 128a) are incomplete so the trend line is not significant. However, peak annual gauge height data (Figure 128b) are complete and indicate virtually no change over time.

Comite River: The Louisiana Highway 67 Bridge crossing near Olive Branch, LA

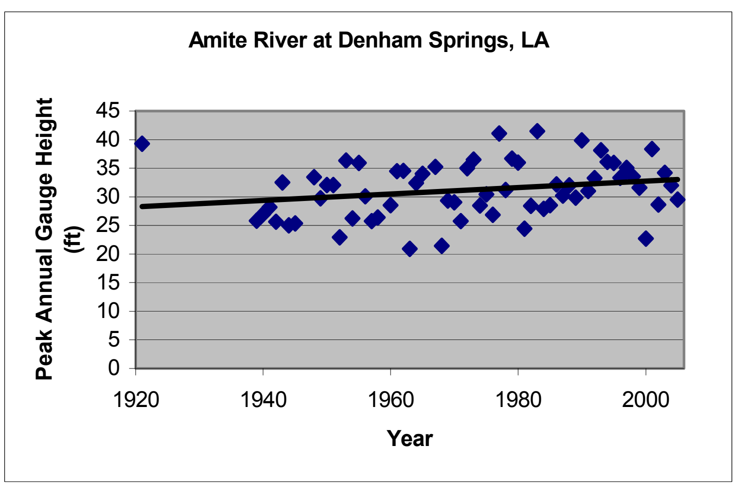
This station is located in a predominantly rural area. Gauge data are given in Figure 129. Both annual mean (Figure 129a) and peak annual streamflow (Figure 129b) have increased over time, whereas peak annual gauge height (Figure 129c) has decreased over time. A temporal increase in stream discharge accompanied by decreased gauge height is most likely an indication of channel erosion. Furthermore, an increase in stream



a.

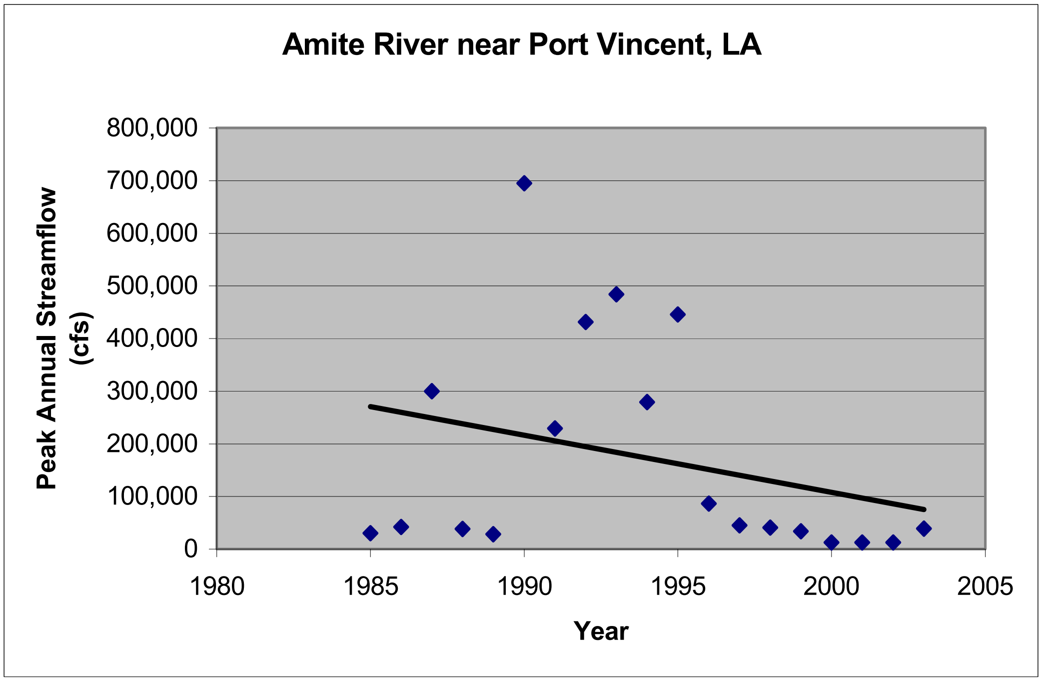


b.

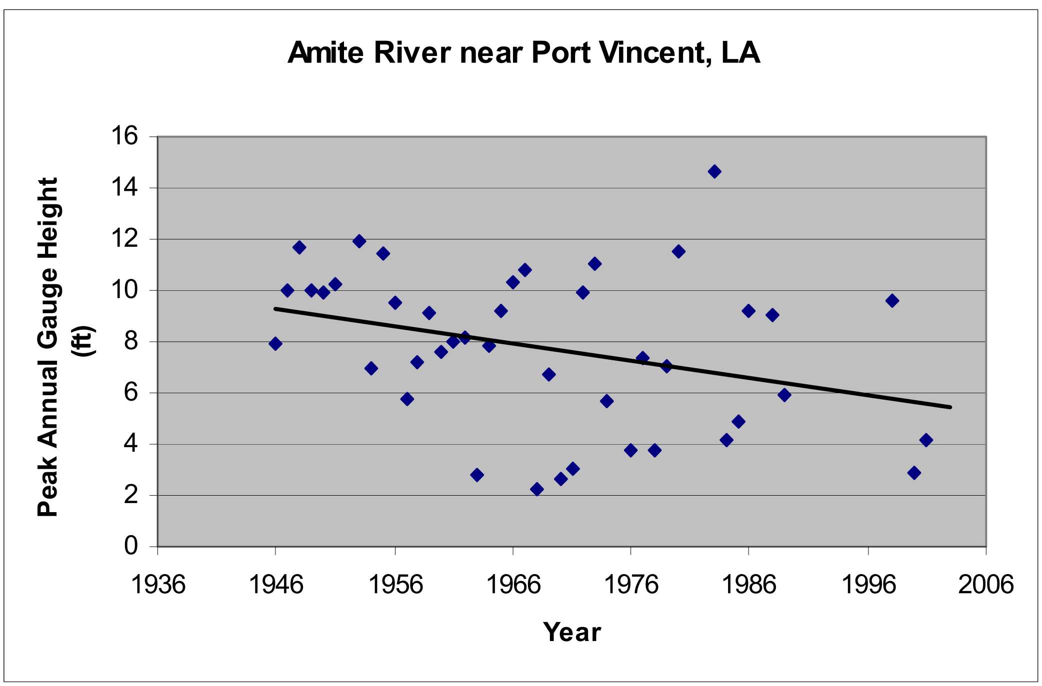


c.

Figure 126. Annual mean streamflow (a), peak annual streamflow (b), and peak annual gauge height (c) for the Amite River at the Louisiana Highway 190 Bridge crossing near Denham Springs, LA. The flood stage at this station is 20.81 ft (NGVD).



a.



b.

Figure 127. Peak annual streamflow (a) and peak annual gauge height (b) of the Amite River at the Louisiana Highway 42 Bridge crossing at Port Vincent, LA. The flood stage at this station is 3.54 ft (NGVD).

Table 3. The distribution of the five highest, historic stream discharges, pre- and post-1989, for the Amite River.

USGS Gauge Stations	Number of the Five Highest Discharges Occurring:	
	Pre-1989	Post-1989
No Mining (Upstream of Mined Reach)		
Darlington	4	1
Mined Reach		
Grangeville	5	0
No Mining (Downstream of Mined Reach)		
Magnolia	2	3
Denham Springs	3	2
Port Vincent	2	3

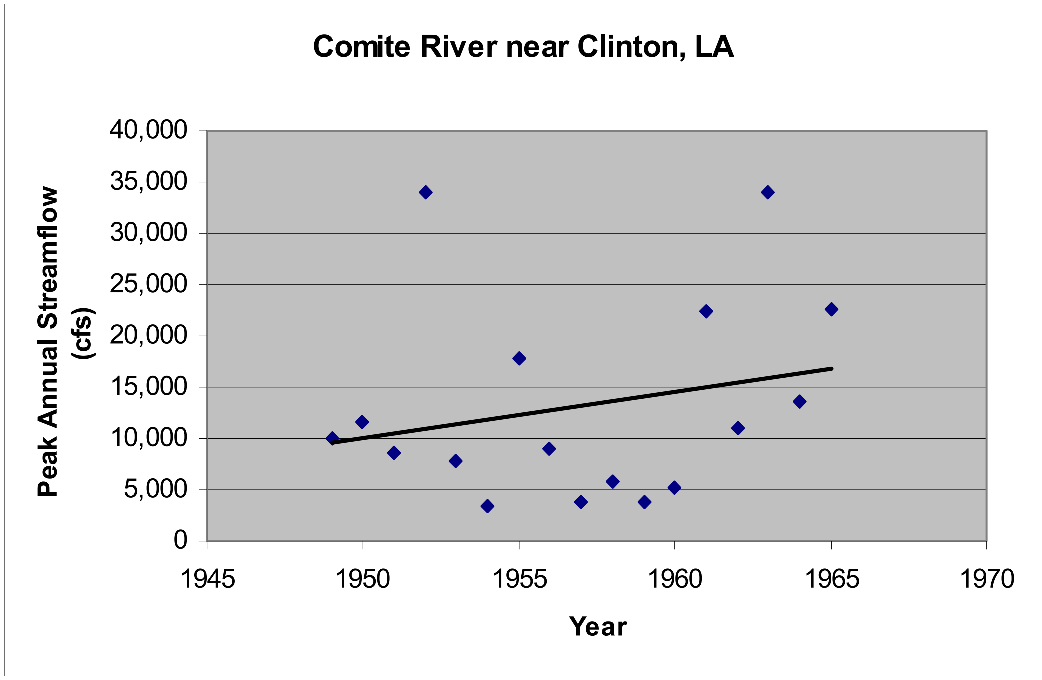
discharge seen on the Olive Branch gauge may indicate that there may be some significance to the peak annual streamflow trend line shown in Figure 128a at the Clinton gauge upstream.

Comite River: The Louisiana Highway 64 Bridge crossing near Zachary, LA

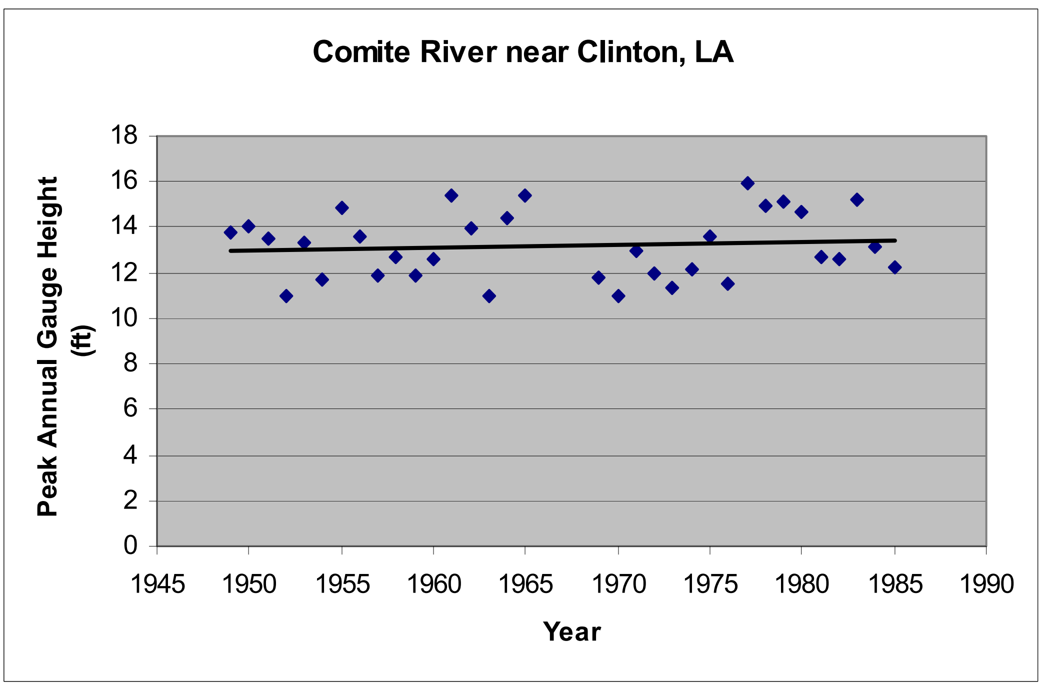
This gauge station is also located in a rural area. Gauge data shown in Figure 130a are incomplete but there is an indication of an increase in peak annual streamflow over time; however, the peak annual gauge height (Figure 130b) has remain relatively constant.

Comite River: The Louisiana Highway 37 Bridge crossing near Comite, LA

This gauge station is located in a highly urbanized area with the town of Comite on the left bank and Baton Rouge suburbs on the right. Both annual mean and peak annual streamflow shown in Figures 131a and 131b, respectively, increase with time. However, there is a decrease in peak annual gauge height (Figure 131c). An increase in discharge accompanied by a decrease in stage is an indication of channel erosion.

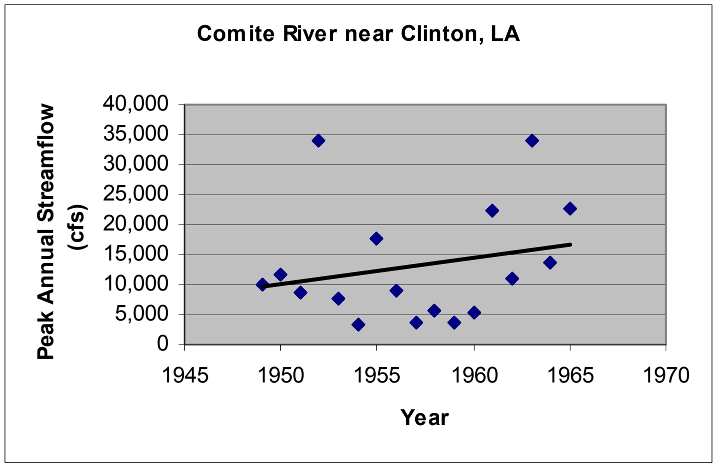


a.

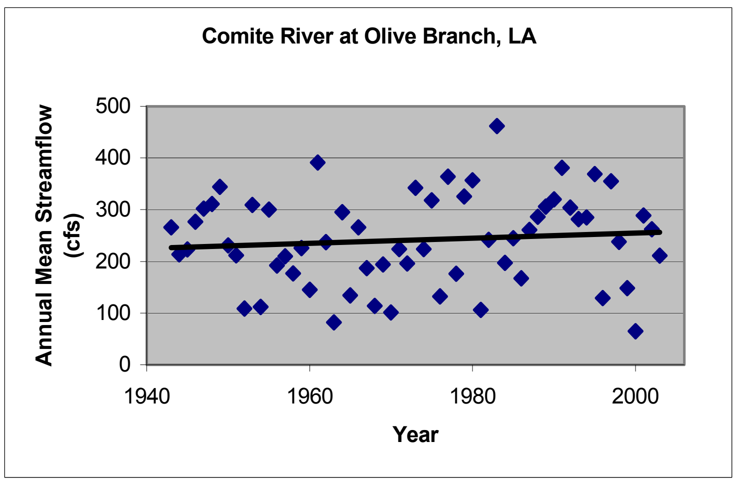


b.

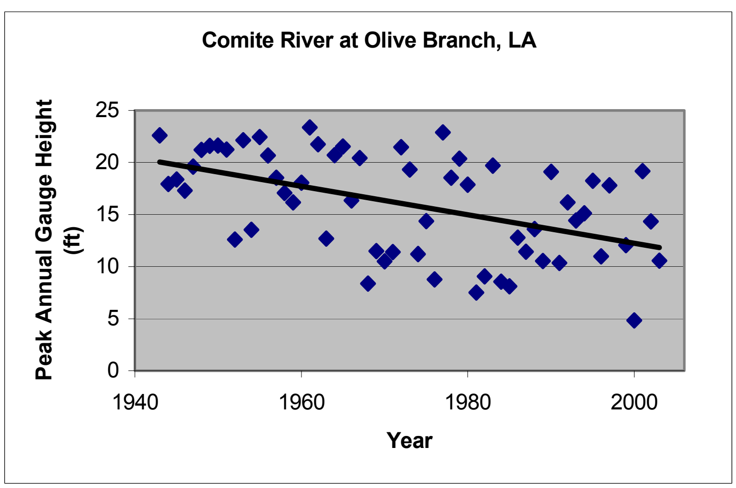
Figure 128. Peak annual streamflow (a) and peak annual gauge height (b) for the Comite River and Louisiana Highway 10 Bridge crossing near Clinton, LA.



a.

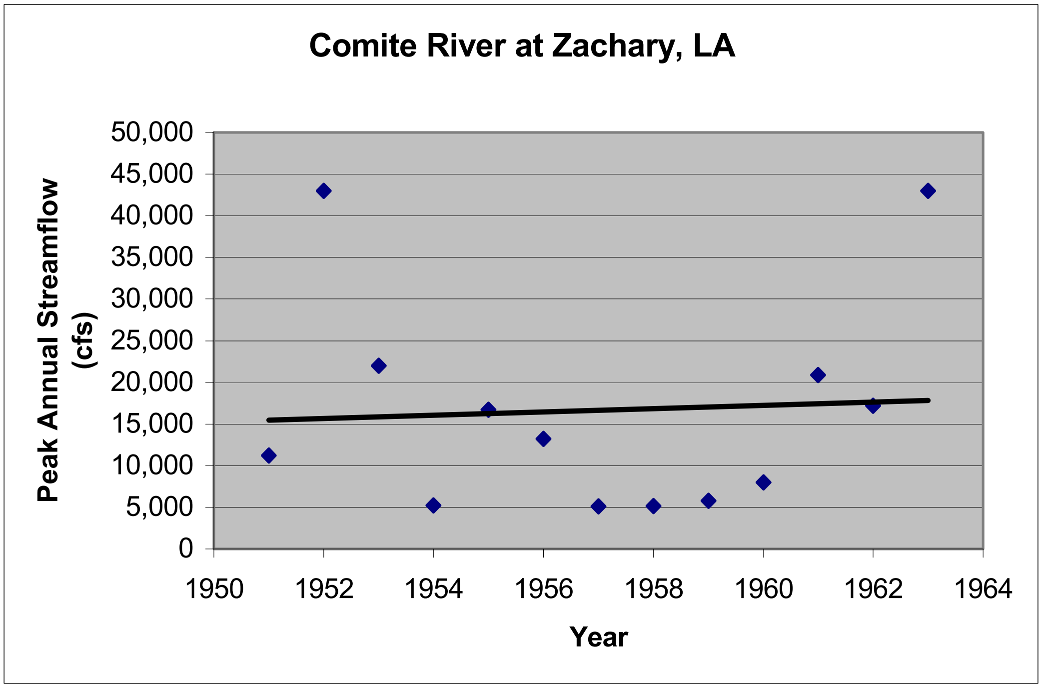


b.

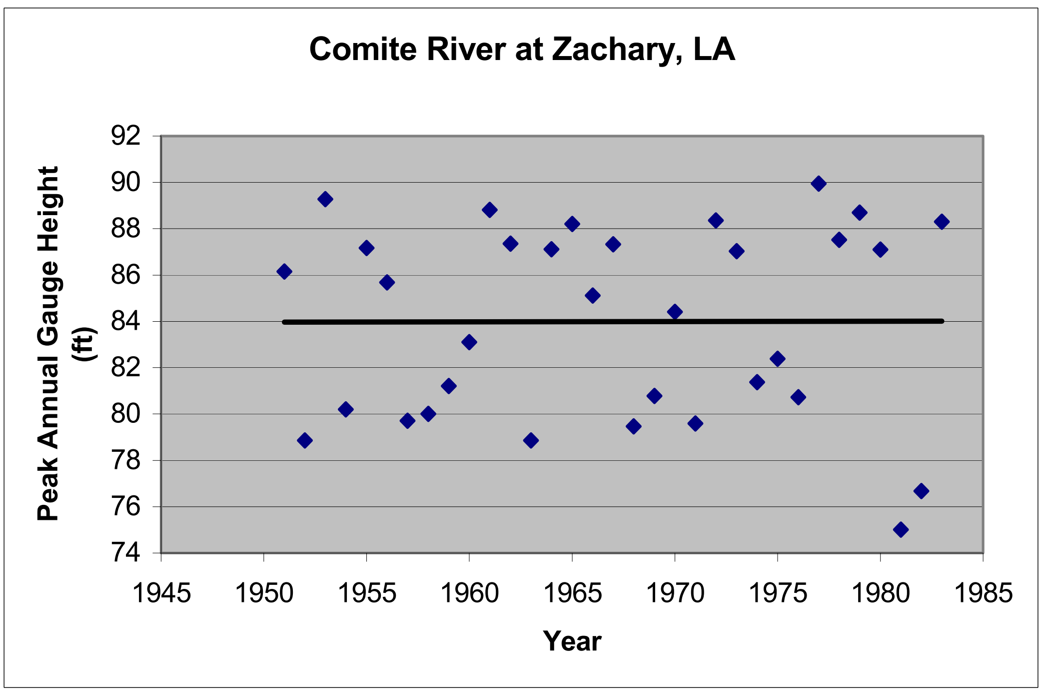


c.

Figure 129. Annual mean streamflow (a), peak annual streamflow (b), and peak annual gauge height (c) of the Comite River at the Louisiana Highway 67 Bridge crossing near Olive Branch, LA.

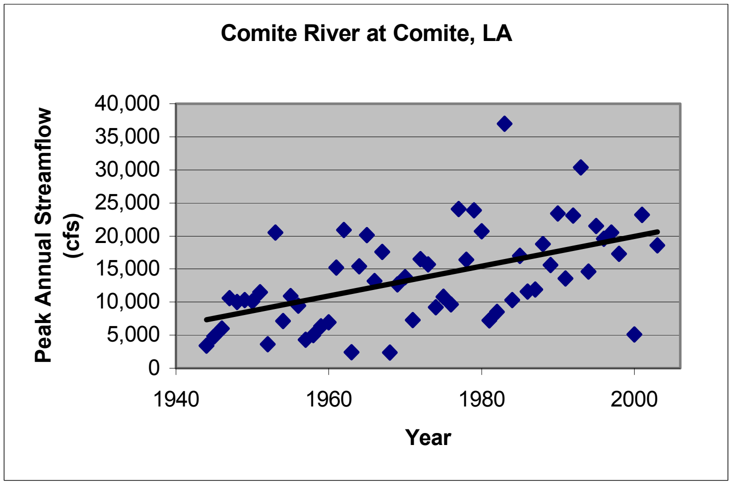


a.

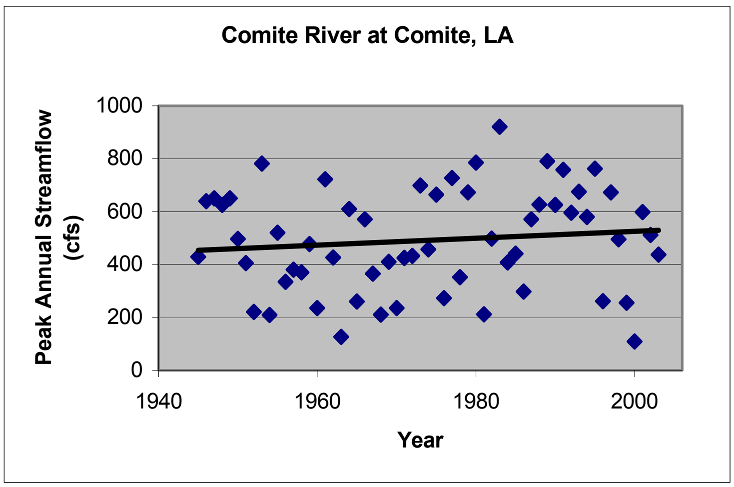


b.

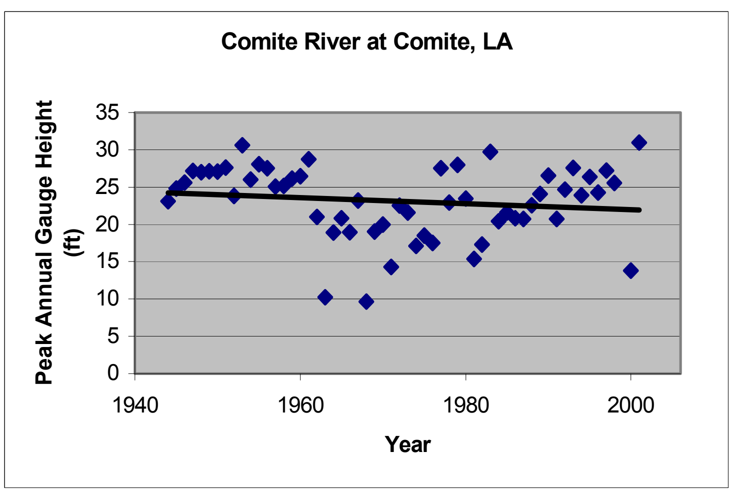
Figure 130. Peak annual streamflow (a) and peak annual gauge height (b) for the Comite River at the Louisiana Highway 64 Bridge crossing near Zachary, LA.



a.



b.



c.

Figure 131. Annual mean streamflow (a), peak annual streamflow (b), and peak annual gauge height (c) for the Comite River at the Louisiana Highway 37 Bridge crossing near Comite, LA.

4 Discussion and Summary of Conclusions

Planform and gradient changes on the mined reach of the Amite River

Data from field studies, imagery and bridge surveys indicate significant erosion and changes in stream planform. These changes may be summarized by direct comparison of the planform of the river pre-mining versus successive periods of time as shown in Figure 132. The illustrated area is along a mined reach upstream of Grangeville, LA, and due east of Gilead, LA. The pre-mining image (1967) illustrates well-developed point bars and well-vegetated cut banks. The post-1967 views reveal an increase in point bar size and by 1991, significant cutoffs on the meander bends. By 2004, the river had changed from meandering to nearly straight having been reduced in length by approximately 27 to 29 percent. Imagery and bridge survey data, as well as field data, indicate that the channel has become wider by as much as 233 percent. Bridge survey data, however, do not indicate significant change in channel bed elevation at the crossing sites. Another result, derived from these data, is that the gradient of the channel has increased due to decreased sinuosity. The bank erosion has, thus, been caused by increased water velocity due to the increased gradient.

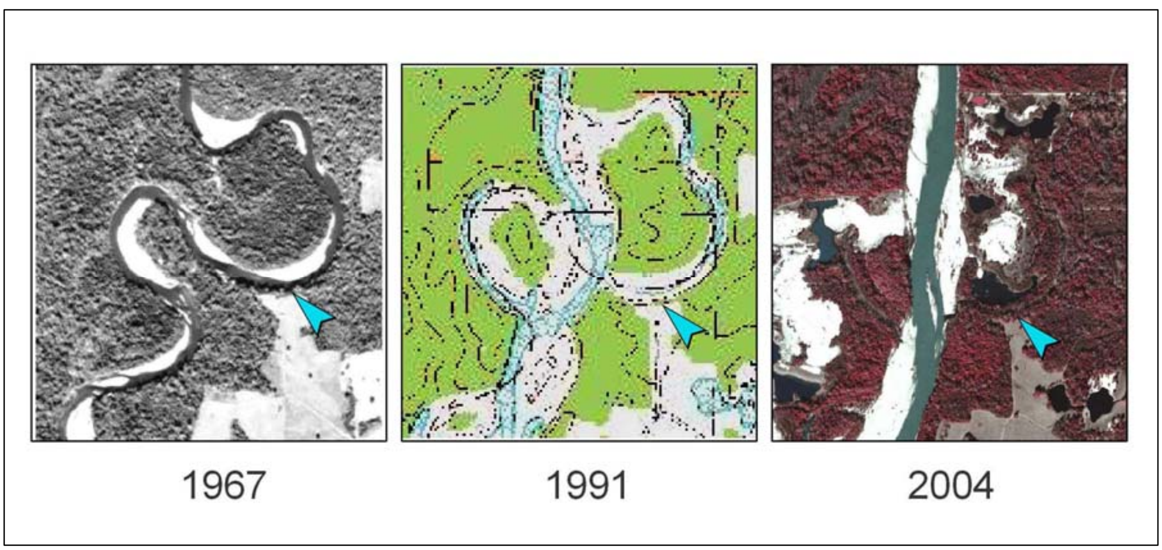


Figure 132. Planform changes exhibited by the Amite River since the pre-mining period in 1967 (aerial photo), after mining commenced during 1991 (topographic map) and 2004 (Atlas satellite image). Arrows indicate matchpoints on the maps and imagery.

Cause of planform change

Field studies and imagery have shown that reaches of the river occupy mined areas, divided flow exists in the channel, and bank erosion occurs on both sides of the channel. These data suggest that changes in planform may be explained by breaching of the mined areas during high river stages as shown in Figure 133. The former thalweg of the river is shown as a solid line and the former or current mined areas shown as circles. During high stages the river shifts into the mined areas (dashed line) similar to a natural meander cutoff. The channel shift results in straightening of the river, higher water velocity, and increased erosion on both sides of the channel. The changes in planform and gradient exhibited on the Amite River appear similar to those described by Smith and Winkley (1996) on the Lower Mississippi River and attributed to artificial cutoffs.

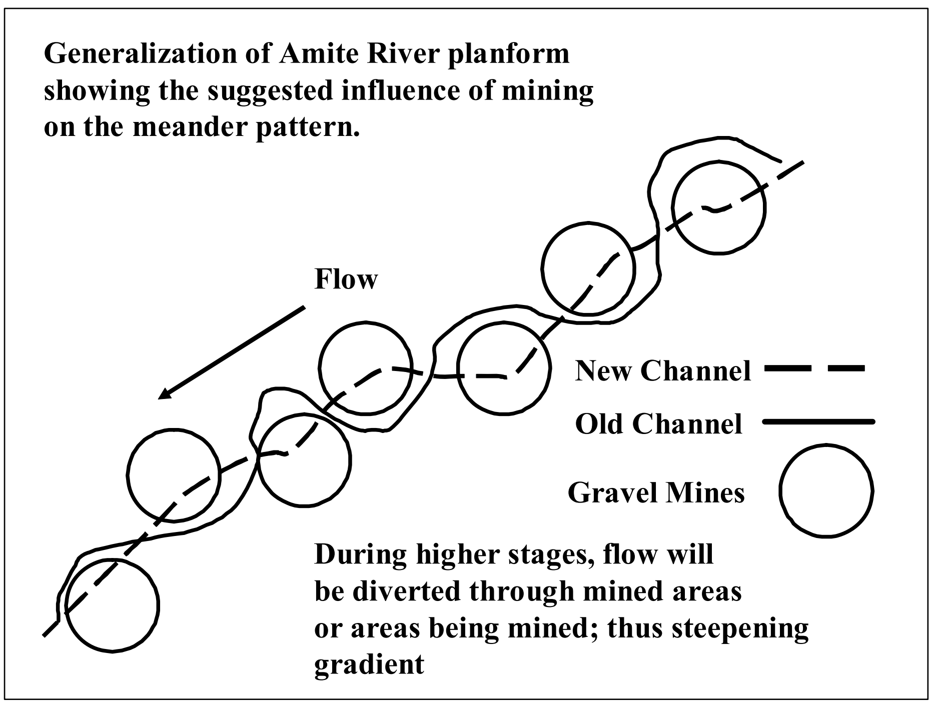


Figure 133. Proposed explanation of planform changes due to mining.

Amite River tributaries on the mined reach

Field studies have shown that bank erosion occurred on Darling Creek, which enters the Amite River within the mined reach north of Grangeville (Figure 1). The erosional processes that explain the erosion on the Amite River main stem may not be applicable to erosion on Darling Creek. Even so, the Amite River erosion has certainly affected the mouth of Darling Creek. As the Amite River became wider, erosion occurred at the mouth of the tributary as shown in Figure 134. The widening of the Amite River caused the gradient of the tributary to increase forming a knickpoint and the upstream progression of erosion (headcutting).

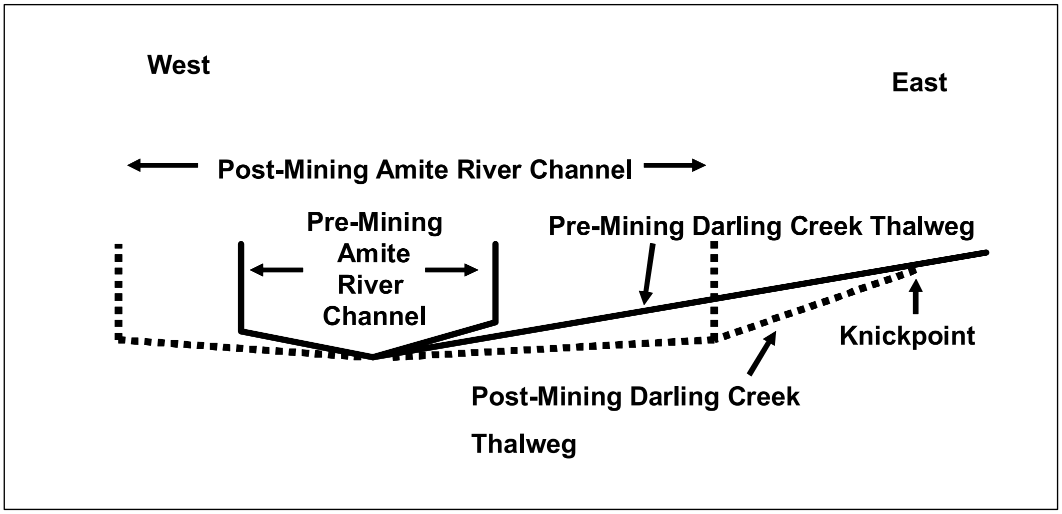


Figure 134. Generalized west-east cross-section of the Amite River and tributary along the mined reach.

Physical kickpoints are often identified in stream channels by the presence of waterfalls or rapids, particularly if erosion resistant materials are present in the channel. No knickpoints were identified during the field studies. However, most observations of the channel were made at crossing sites. Thus, one cannot positively conclude that physical knickpoints are not present. The water stage may be too high for knickpoint exposure and, more likely, once the mined reach became over-steepened, erosion proceeded upstream in erosive, alluvial material without encountering erosion-resistant material in the channel.

Amite River main stem and tributaries upstream of the mined reach

Field studies and imagery have shown that erosion occurred on the main stem of the Amite River upstream of the mined reach and on the tributaries as well. Imagery demonstrated that the stream length decreased by approximately 5 percent in the vicinity of the East Fork and West Fork confluence and at Felixville, the channel width has increased by 25 percent. These data indicate that there has been an increase in channel gradient along this upstream reach. As in the case of the tributaries along the mined reach, a knickpoint was formed and headward erosion progressed upstream as shown in Figure 135.

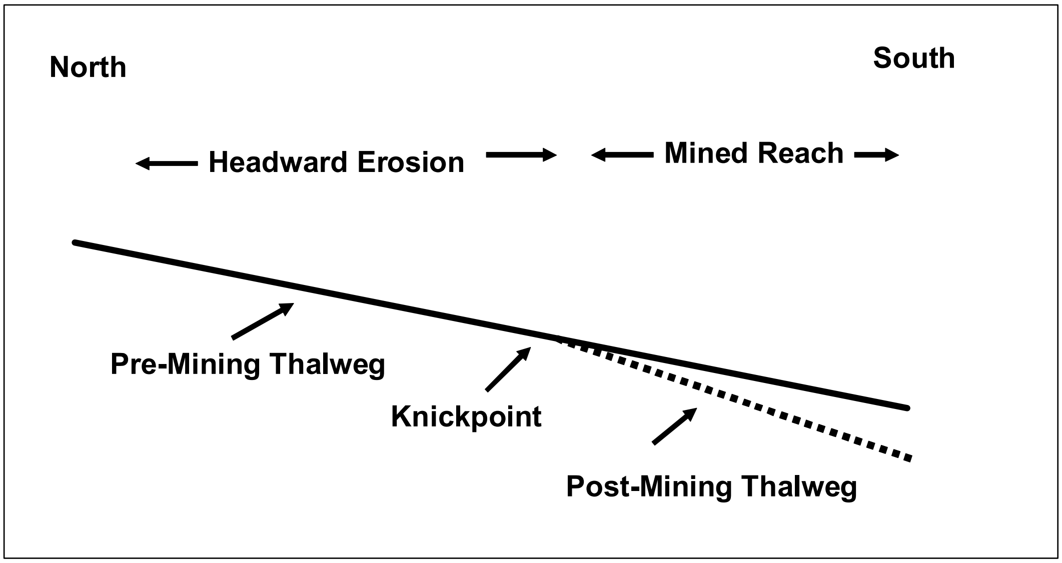


Figure 135. Generalized north-south cross-section of the Amite River showing the knickpoint resulting from the steepened gradient on the mined reach.

Amite River main stem and tributaries downstream of the mined reach

Field studies indicated that there was no significant erosion occurring on the main stem of the river nor on the tributaries with the exception of the Comite River (discussed in the next section). On the basis of imagery, the downstream reach exhibited an increase in stream length, which ranged from approximately 2.4 to 7.7 percent. Although field studies of this reach did not reveal significant erosion, bridge survey data revealed that channel width had increased by 40 to 60 percent. The increase in channel width may have been caused by increased sediment discharge due to upstream mining.

The Comite River

Erosion occurring on the Comite River is not considered to be related to mining activities because the confluence of the Comite River and the Amite River lies downstream of the mined reach and headward erosion has progressed upstream on the Amite River. Even so, field studies did indicate some erosion occurring on the downstream reach of the Comite River. However, the most significant erosion occurred further upstream in the vicinity of Clinton, Olive Branch, and Zachary, LA. In these reaches, the channel exhibits eroded banks, divided flow, and bank vegetation lying in the water. The cause of the erosion may be explained by the USGS stage and discharge data for the sites previously named. The USGS data for the Olive Branch station are particularly meaningful in that a historical increase in stream discharge is accompanied by a historical decrease in stream stage (gauge height). The increase in stream discharge is believed to be due to increased run-off caused, in turn, by land-use/land-cover changes within the drainage basin, namely urbanization. The increased discharge has deepened the channel resulting in lower stages. The erosional process is gullying, which results in headward erosion. Headward erosion on the Amite River has been triggered by activities downstream, whereas the erosion on the Comite River has been triggered by activities (urbanization) occurring upstream.

Ancillary consequences of mining

Landloss

The LDTD bridge survey data show that, from Felixville downstream to Denham Springs, the Amite River width ranged from approximately 30 to 50 m in the 1970s. However, by the 1990s, the width of the river had increased to 70 to 100 m. Thus, the widening of the stream channel has resulted in significant loss of riparian land. This increase in channel width has also negatively impacted bridges in Louisiana and Mississippi.

Bridge and other crossings

Field studies found significant scour of bridge abutments at crossings on the main stem of the Amite River, as well as the tributaries, along and upstream of the mined reach in Louisiana and Mississippi. Along the mined reach, the need to extend the bridge at Grangeville has also been described. Field studies also noted the need to protect the power pylon near Felixville from erosion. There are approximately 25 pipeline crossings on the Amite River and tributaries upstream of Denham Springs (Figure 1); and one exposed pipeline was noted near Magnolia. The inadvertent or intentional rupture of a pipeline crossing the river would have significant adverse financial, environmental, and health and welfare consequences.

Fluvial habitats

Along the mined reach and upstream of this reach, the widening of the river channel and consequent loss of bank-line vegetation and canopy has, at least temporarily, degraded this habitat by increasing water temperatures. Erosion has, most likely, resulted in a less stable and firm channel bed, which may adversely impact sessile fauna. One may assume that the wider channel would, during most of the year, exhibit more shallow water depths. If true, this would also lead to higher water temperatures and possibly impair fragile fauna. It would seem reasonable to conclude that the mining operations may also contribute to higher turbidity in the water column along the mined reach and downstream of this reach.

Recreation

Photographs taken along the mined reach show scenic attributes once present along this reach prior to mining have been significantly degraded. Loss or degradation of fluvial habitats would have a negative impact on sport or commercial fisheries and the numerous in-channel bars, lower water levels, and snags would have similar effects on small-craft boating.

Flooding

The limited evaluation of the USGS record flood data indicated that the widening of the stream channel along the mined reach has reduced flooding along this reach, whereas the data for the reach downstream of the mined reach suggest that the upstream mining has not influenced downstream flood stages.

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14. ABSTRACT

The Amite River is a Gulf Coastal Plain stream in southwestern Mississippi and eastern Louisiana. Since the early 1970s, riparian sand and gravel mining has been conducted on a 48-km reach of the river centered on Grangeville, LA. Riparian mining has been considered responsible for instability and changes in the hydraulic and geomorphic regime of the river and local extirpation of the inflated heelsplitter mussel.

Field and rotary-wing aerial studies were conducted along the main stem of the river and along the principal tributaries including Beaver Creek, Darling Creek, and the Comite River. These studies indicated that the greatest erosion was occurring along the mined reach; however, erosion was also occurring upstream of the mined reach and along tributaries along and upstream of the mined reach. Erosion was less prevalent downstream of the mined reach; however, erosion was present on the Comite River which enters the Amite River downstream of the mined reach. Bridge survey data for the Amite River showed that the channel width upstream, along and downstream of the mined reach had, respectively, increased by as much as 25, 50 and 60 percent. Historical, rectified panchromatic aerial photography revealed that stream length upstream and downstream of the mined reach, between 1953 and 1998, had decreased, respectively, by as much as 5 and 29 percent. During the same period, the reach downstream of the mined reach had increased by as much as 7 percent.

(Continued)

15. SUBJECT TERMS

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14. ABSTRACT (continued)

Historical, stream gauge data were examined for six stations along the main stem of the Amite River and four stations on the Comite River. These data for Amite River stations above the mined reach did not reveal a significant trend; however, the data for the one station along the mined reach showed a significant decrease in both peak annual stream flow and peak annual gauge height. Two stations downstream but near the mined reach revealed increases in peak annual streamflow, annual mean streamflow, and peak annual gauge height. The most distal station from the mined reach indicated decreased peak annual streamflow and peak annual gauge height. The Comite River stream gauge data indicated that there have been historic increases in annual mean streamflow and peak annual streamflow; however, peak annual gauge height significantly decreased or remained relatively constant. These data support the notion that the processes acting on the Comite River are distinct and unrelated to riparian mining.

The Comite River erosion is considered to be caused by increased runoff and gully development due to land use/land cover changes related to increased urbanization in the Baton Rouge area. The Amite River erosion is attributed entirely to riparian mining. The shortening and straightening of the river is considered to be due to the movement of water into the riparian mines during high-water events. Thus, these high-water discharges tend to cut off or straighten the bends in the river similar to, but on a larger scale than that of natural meander cutoffs.

15. SUBJECT TERMS

Amite River
Channel degradation
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Fluvial habits
Gravel mining
Gullying
Imagery
Riparian mining
Streambank erosion
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