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Geomorphic Investigation of the Great Bend Region, Red River

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Geomorphic Investigation of the Great Bend Region, Red River

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Abstract

The U.S. Army Engineer District, Vicksburg, conducted feasibility studies to rehabilitate the levees along the Red River from Fulton, AR, to the Arkansas-Louisiana state line. In support of these studies, research was performed by the U.S. Army Engineer Research and Development Center to provide a geomorphic framework for cultural resources in the project area. This research had three specific objectives: (1) identify and map geomorphic features in the study area on 1:24,000 scale maps, (2) define geomorphic processes that are active in the study area, and (3) reconstruct the geomorphic development of the study area to understand the significance of geomorphic features in terms of both locating previously unknown archaeological sites and discovering buried sites. Field investigations and aerial photography were used to interpret the geomorphology. Approximately 6 percent of the known archeological sites are located above the floodplain on valley slopes or bluffs. The remaining 94 percent of the sites are associated with the floodplain of the various fluvial components that form the study area. Forty-six percent of floodplain sites are located adjacent to crevasse channels. Other known archaeological sites are primarily located on the natural levee or adjacent point bars.

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Contents

Abstract.....	ii
Figures and Tables.....	vi
Preface	vii
1 Introduction	1
1.1 Background and study area.....	1
1.2 Purpose and scope.....	1
1.3 Previous investigations.....	1
2 Procedure.....	5
2.1 Approach	5
2.2 Geomorphic mapping.....	6
2.3 Field studies.....	6
2.3.1 Objectives and approach.....	6
2.3.2 Boring logs.....	7
3 Geology and Geomorphology	8
3.1 Geologic setting	8
3.2 Geomorphic surfaces and environments.....	8
3.2.1 Introduction	8
3.2.2 Bluff slopes and tertiary sediments	10
3.2.3 Terrace (Pi)	10
3.3 Floodplain geomorphic environments.....	11
3.3.1 General	11
3.3.2 Point bar (PB)	11
3.3.3 Natural levee	13
3.3.4 Abandoned course.....	14
3.3.5 Abandoned channel.....	15
3.3.6 Backswamp (BS).....	16
3.3.7 Alluvial architecture	17
4 Soil Geomorphology.....	18
4.1 Introduction.....	18
4.2 Soil-forming processes	18
4.3 Soil-forming factors	19
4.3.1 Climate.....	19
4.3.2 Organisms	19
4.3.3 Topography.....	20
4.3.4 Parent material	20
4.3.5 Time	20
4.4 Soil geomorphology	20

4.5	Soil summary	22
5	Geomorphic Chronology.....	23
5.1	Introduction.....	23
5.2	Pleistocene.....	23
5.3	Holocene	23
5.3.1	Older meander belt (Hrm2)	24
5.3.2	Intermediate meander belt (Hrm1.1 and 1.2)	25
5.3.3	Modern meander belt (Hrm1.0).....	25
5.4	Historic	25
5.5	Geomorphic mapping and chronology	27
5.6	Geomorphic mapping units.....	28
6	Significance of Geomorphology to Cultural Resources	30
6.1	Introduction.....	30
6.2	Procedure.....	30
6.2.1	Use of GIS in cultural resource assessment.....	31
6.2.2	Data requirements for cultural resource assessment.....	32
6.2.3	Archaeological site definition	34
6.2.4	Characteristics of an archaeological site	34
6.3	Distribution of known archaeological sites	35
6.3.1	Landforms	35
6.3.2	Distribution of cultural components	36
6.3.3	Paleo sites	37
6.3.4	Archaic sites.....	37
6.3.5	Fourche Maline sites.....	37
6.3.6	Caddo sites.....	37
6.4	Prediction of site occurrence	38
6.5	Site preservation and destruction	39
6.6	Geomorphic evidence and archaeological significance of sedimentation rates	40
6.6.1	Geomorphic evidence and sedimentation model	40
6.6.2	Discussion	41
7	Summary and Conclusions	43
7.1	Geomorphology.....	43
7.2	Archaeological significance.....	43
	References.....	45
	Appendix A: Geomorphic Maps.....	49
	Appendix B: Geomorphic and Geologic Cross Sections.....	59
	Appendix C: Red River Boring Log Reference Table	72
	Appendix D: Soil Borings.....	83

Appendix E: Radiometric Age Dates	168
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Report Documentation Page

Figures and Tables

Figures

Figure 1. Levee project map from Fulton, AR, to Arkansas-Louisiana state line with Fulton Quadrangle study area.	2
Figure 2. Depositional environments of a meandering river.....	9
Figure 3. Schematic and aerial view (from Saucier 1994) of a typical point bar depositional environment.	12
Figure 4. Schematic and aerial view (from Saucier 1994) of a typical natural levee depositional environment.....	14
Figure 5. Schematic and aerial view (from Saucier 1994) of a typical abandoned course depositional environment.	15
Figure 6. Schematic and aerial view (from Saucier 1994) of a typical abandoned channel depositional environment.....	16
Figure 7. Schematic and aerial view (from Saucier 1994) of a typical backswamp environment.	17
Figure 8. An artist's conception of the Great Raft. Note the overflow anabranch and distributary channels (Veatch 1906).	26
Figure 9. Location and limits of Poston Lake (Veatch 1906).	27
Figure 10. Distribution of archaeological sites by landform.	36

Tables

Table 1. Geomorphology of the project area.....	9
Table 2. Pleistocene terrace correlation chart.....	11
Table 3. Expected distribution of cultural resources by meander belts.	38
Table 4. Geomorphology of the Red River Levee Rehabilitation Project area.....	41

Preface

This study was conducted for the U.S. Army Engineer District, Vicksburg under MIPR CELMK-PD-Q-94-5990 to conduct a geomorphic investigation of the Red River from Fulton, AR to the Arkansas-Louisiana state line. The program manager was Mr. Erwin Roemer, Vicksburg District.

The work was performed by a predecessor organization of the Geotechnical Engineering and Geosciences Branch (GEGB) of the Geosciences and Structures Division (GSD), U.S. Army Engineer Research and Development Center, Geotechnical and Structures Division (ERDC-GSL), Louisiana State University, and San Diego State University. At the time of publication, Mr. Chris Price was Chief, GEGB; Mr. James Davis was Chief, GSD; and Dr. Maureen K. Corcoran was the Acting Technical Director for Water Resources Infrastructure Research. The Deputy Director for ERDC-GSL was Dr. William P. Grogan, and the Director was Mr. Bartley P. Durst.

COL Ivan P. Beckman was the Commander of ERDC, and Dr. David W. Pittman was the Director.

1 Introduction

1.1 Background and study area

The U.S. Army Engineer District, Vicksburg, conducted feasibility studies to rehabilitate the levees along the Red River from Fulton, AR, to the Arkansas-Louisiana state line. The proposed project was designed to raise and strengthen the existing levee system along the Red River below Denison Dam. Rehabilitation between Fulton, AR, and the Louisiana state line consists of separate items representing reaches of levee. The geomorphology of the Red River Valley, Great Bend Region, is discussed in general, while the site-specific details were extracted from geomorphic maps and cross sections. Figure 1 shows the location mapped in the Great Bend region by this study.

1.2 Purpose and scope

The purpose of this investigation was to provide a geomorphic framework for cultural resources research in the project area. There were three specific objectives of this investigation: (1) identify and map geomorphic features or landforms in the study area on 1:24,000 scale base maps, (2) define geomorphic processes that are active in the study area, and (3) reconstruct, to the extent possible, the geomorphic development of the study area to understand the significance of geomorphic features in terms of both locating previously unknown archaeological sites and discovering buried sites.

1.3 Previous investigations

Several studies relate either directly or indirectly to the project area. The Red River has attracted exploration since early European expansion into North America. In 1687, René-Robert Cavelier, Sieur de La Salle, a French explorer, camped upstream of the Great Bend on the Red River (Santeford 1994). Louis Juchereau de St. Denis, a French-Canadian explorer and entrepreneur, established the trading post of Natchitoches in 1714 at the toe of the Great Raft (Guardia 1933). In 1719, Bernard de la Harpe, another French explorer, traveled farther up the Red River to the confluence of the Sulphur River and established a trading post in the region from 1719 to 1778 (Santeford 1994).

Figure 1. Levee project map from Fulton, AR, to Arkansas-Louisiana state line with Fulton Quadrangle study area.

“Historically, the amount of interest in the ... Red River is directly related to the perceived value of land in question” (Jacobs 1985). The land area later to become Miller County, AR, became part of United States territory in 1803 with the Louisiana Purchase. The report by Dunbar (1804) is an example of President Thomas Jefferson’s scientific interest in the newly acquired territory. In 1806, Jefferson sent Thomas Freeman and Dr. Peter Curtis to further explore the Red River Valley. Details of the expedition with a description of the Miller County area are found in Flores (1984). Other early 19th century accounts (Stoddard 1812; Darby 1816; and Flint 1833) described the anastomosing flow of the Red River due to the effects of the log jams known as the Great Raft. Captain Henry Shreve removed the raft as far as Coats Bluff (later named Shreveport) in the 1830s. The U.S. Army Corps of Engineers (USACE) completed removal of the log jam rafts to the Arkansas-Louisiana state line in 1873. Lt. Woodruff’s report (USACE 1873) to Congress gives a photographic record of river conditions in the region.

The period of modern investigation may be said to begin with the work of Veatch (Schultz and Krinitzsky 1950). Veatch’s (1906) report describes the geological history of the region and focused on raft processes and responses. Some of the classical geological investigations of the Red River Valley were conducted downstream of the levee rehabilitation reach. Fisk (1938) introduced the fundamentals of differentiating the Holocene alluvium into depositional environments and the Pleistocene into a four terrace sequence. Fisk’s concepts were extended up the river in Schultz and Krinitzsky (1950), which included the alluvial geology, geological history, and their geological engineering significance. Harms et al. (1963) studied the stratification and sedimentary structure of point bars in the Shreveport, LA, vicinity.

Abington (1973) described and analyzed the Red River’s changing meandering morphology. Abington’s process-response model concluded that the Red River meandering is reducing its sinuosity and is in transition to a braided regime. Smith and Russ (1974) provided geological maps and cross sections at a scale of 1:62,500 that provide the most complete geological mapping of the study area until the present geomorphic investigation. Russ (1975) is the accompanying text to the Smith and Russ (1974) mapping. Russ (1975) offered a chronology for five meander belts in the lower Red River Valley with the youngest belt being less than 600 years B.P.

Smith (1982) extrapolated Russ's framework to describe the geomorphic development of Bayou Bodcau and its significance to locating archeological sites. Pearson (1982) offered a working hypothesis of the meander belts of the Red River in the Great Bend region to archeological site potential and preservation proposing the idea of the modern, intermediate, and older meander belts. Jacobs (1981, 1985) differentiated five terraces and related archeological potential of each surface. Soils of Miller County, AR, were mapped in 1984 and in adjacent Hempstead County in 1979. Harvey et al. (1987) conducted both geomorphic and hydraulic analysis of the Red River above Shreveport. Saucier and Snead's (1989) synoptic 1:1,100,000 scale Quaternary Geology of The Lower Mississippi Valley Map depicts the latest two meander belts in the Great Bend region (i.e., Hrm1 and Hrm2). Earlier, Saucier (1974) stated that "... the chronology of the meander belts for this stream is quite tentative."

Albertson (1992) conducted engineering geology mapping south of the project area to locate sources of construction material and to provide foundation data for engineering structures associated with the proposed Shreveport to Daingerfield navigation project. Albertson and Dunbar (1993) conducted detailed geomorphic mapping for the proposed navigation project and related it to the archaeological significance of the area. Recent work by Heinrich (1993) and Guccione (1995) described geomorphology and sedimentation rates in other parts of the river system.

2 Procedure

2.1 Approach

The geomorphic evaluation of the Great Bend study area was approached by:

1. reviewing previous literature, including geological and soil maps
2. interpreting geomorphology from aerial photographs
3. conducting field reconnaissance and shallow auger borings
4. compiling existing subsurface boring data that included USACE revetments and levee studies, Arkansas Department of Transportation (DOT) borings, and water wells
5. constructing geomorphic cross sections
6. synthesizing data into soil geomorphic maps with inferred age relationships
7. incorporating pertinent data into a geographic information system (GIS)
8. comparing temporal landforms to the known archeological record

The study was conducted in several phases. Following the literature review, a preliminary investigation involved geomorphic mapping based on a field reconnaissance of the project area. Building on the first three steps of the geomorphic evaluation, both site specific stratigraphic and chronological characteristics about the different depositional environments within the study area were determined in steps 1, 5, and 6. Essential information (e.g., soil, geology, and archeological site data) was entered in a GIS database to better maintain and interpret the data. The GIS serves as an analytical tool to examine soil-geomorphic and archeological relationships. The GIS is a dynamic document (i.e., it will change with time as additional data are incorporated into it and new attributes are defined). Once a GIS structure is established, it can be modified to meet many purposes of land-use planning and resource management. The GIS, as originally created, is described in Chapter 6 of this report, and its use for relating geomorphic landforms and processes to both known and potential cultural resources is explained.

2.2 Geomorphic mapping

The first objective of the geomorphic mapping was to identify the geomorphic features within the study area. Mapping was performed at a scale of 1:24,000 using a U.S. Geological Survey (USGS) quadrangle as a base map. Geomorphic features were defined and delineated primarily by analysis of topographic data, soil survey information, and aerial photography (i.e., black and white photography flown in 1959, 1983, 1989, and 1990). Some information sources, such as historic maps, were examined but not rigorously analyzed. In addition to these data, the geomorphic mapping was based and guided by previous studies conducted by the U.S. Army Engineer Waterways Experiment Station (WES) (Smith and Russ 1974; Smith 1982; Saucier and Snead 1989; Albertson 1992; and Albertson and Dunbar 1993). These studies served as the foundation for the aerial photographic interpretation. The results of the geomorphic mapping are in Appendices A and B of the report.

2.3 Field studies

2.3.1 Objectives and approach

The objectives of the field studies were to confirm the results of the geomorphic mapping and conduct soil sampling of selected geomorphic environments. Soil samples were used to develop both specific stratigraphic and chronological properties in the study area. Two visits were made to the project area as part of the field work. A general reconnaissance was conducted during this first phase to evaluate the results of previous geomorphic mapping. During the field investigation, auger soil sampling was conducted of selected geomorphic environments to correlate general soil properties with various geomorphic environments. Soils data were used to define sedimentological characteristics of different geomorphic environments to aid in reconstructing the evolution of the study area. Soil samples were visually inspected and logged on-site. Additional soils information was obtained from boring data and published literature. Boring data included existing Vicksburg District borings and borings drilled during the levee rehabilitation project (see Appendix C for reference table). Published soil data consisted of county soil survey bulletins from the Soil Conservation Service (1979, 1984).

2.3.2 Boring logs

Logs of auger borings drilled during this study are presented in Appendix D. Boring logs contain descriptions of soil type, color (Munsell), texture, soil structure, consistency, and stratigraphic thickness. Boring locations are identified on the logs and are shown on the geomorphic maps.

3 Geology and Geomorphology

3.1 Geologic setting

The Red River headwaters are in the arid High Plains of eastern New Mexico in an area named the Llano Estacado. The Red River flows east and forms the Texas-Oklahoma border. In Arkansas, the river turns south at Fulton and forms the Great Bend. Geomorphic development of the Red River Great Bend Region is the result of geologic processes operating during the last 65 million years. Surface deposits in the study area are Tertiary (2 to 65 million years) to Quaternary (2 million years to present) in age. Tertiary sediments were deposited by fluvial-deltaic processes similar to processes active in present-day Louisiana. These sediments were incised by numerous Pleistocene and younger fluvial systems, such as Red River meander belts. This study focuses on the geomorphic processes that have been active during the past 10,000 years.

3.2 Geomorphic surfaces and environments

3.2.1 Introduction

Geomorphic evaluation identified three major geomorphic surfaces within the study area. These surfaces are differentiated according to physical characteristics, apparent age, and types of processes that are active on each of these surfaces. These surfaces are identified in Table 1 as the floodplain, terraces, and bluffs and are further subdivided into depositional environments and/or geologic formations as shown in Table 1 and Figure 2. The approximate age of each surface and the types of geomorphic processes that are active are identified in Table 1.

Table 1. Geomorphology of the project area.

Surface	Landform (Formation)	Age	Geomorphic Process
Floodplain	Point bar	H	LA
	Backswamp (Hb)	H	VA-BT-SF
	Abandoned course	H	LA-VA
	Abandoned channel	H	LA-VA
	Natural levee	H	VA-SF
Terrace	Abandoned floodplain (Pi)	P	E-SF
	Deweyville terrace (Pd)	P	VA-BT-SF
	Prairie terrace (Pp)	P	E-SF
	Montgomery terrace (Pi)	P	E-SF
Bluffs	Claiborne group (Tc)	T	E-SF
	Wilcox group (Tw)	T	E-SF
	Midway group (Tm)	T	E-SF

AGE: H = Holocene, P = Pleistocene, T = Tertiary.

PROCESS: VA = Vertical accretion, LA = Lateral accretion, BT = Bioturbation, SF = Soil Forming Processes, E = Erosion.

Figure 2. Depositional environments of a meandering river.

3.2.2 Bluff slopes and tertiary sediments

Surface outcrops of Tertiary sediments in the study area are restricted to the bluff slopes and summits. The Tertiary sediments were defined by a sharp break in the topography between the floodplain surface and the bluff slopes. Boundaries separating the Tertiary units are based on Smith and Russ (1974). These Tertiary formations are fluvial-deltaic, near shore, and marine sedimentary sequences. Geologic formations that make up the valley slopes are identified on the geomorphic maps and in Table 1. The Tertiary Claiborne, Wilcox and Midway groups consist of interbedded deposits of sand, clays, lignitic silts, and lignite. Overlying the Tertiary units in the valleys are Pleistocene and Holocene fluvial sediments.

3.2.3 Terrace (Pi)

A terrace is an abandoned floodplain surface that is elevated above the present river's floodplain. A terrace consists of a relatively flat or gently inclined surface that is bound on one edge by a steeper descending slope and on the other edge by a steeper ascending slope (Bates and Jackson 1980). Terraces generally border the present floodplain or may be preserved as topographic islands or remnants within the present floodplain. Terraces are differentiated on previous geomorphic maps (Smith and Russ 1974).

In the Red River Valley, five terraces have been differentiated in Texas (Jacobs 1981) and six in Louisiana (Russ 1975). The recognized terraces from Louisiana (Russ 1975; Smith and Russ 1974) nomenclature are (from oldest to youngest) Williana or Citronelle, Bentley, Montgomery, Prairie-upper, Prairie-lower, and Deweyville. Pleistocene terraces in the study area were identified as Qtm or Montgomery by Smith and Russ (1974). However, this report uses the revised nomenclature developed by Saucier and Snead (1989) and identified the terraces as Pleistocene intermediate (Pi) terraces. Refer to Table 2 for a Pleistocene Terrace correlation chart.

Table 2. Pleistocene terrace correlation chart.

Fisk (1938)	Russ (1975) Smith and Russ (1974)	Jacobs (1981)	Used in this Report Saucier and Snead (1989)
	Deweyville (Qtd)	T1	Deweyville Complex (Pd)
Prairie	Prairie-lower surface (Qtp2)	T2	Prairie Complex (Pp)
	Prairie-Upper surface (Qtp1)		
Montgomery	Montgomery (Qtm)	T3	Intermediate Complex (Pi)
Bentley	Bentley	T4	Upland Complex (Pu)
Williana	Williana (Citronelle)	T5	

Terraces mapped in the study area are flat or gently inclined surfaces that occur adjacent to the floodplain. Mapped terraces on the geomorphic maps are interpreted as depositional terraces. In general, the boundary between the terrace and the floodplain was mapped by noting the sharp scarp between the two surfaces. This boundary was then further refined by incorporating soils data from the available county soil survey bulletins, land use interpreted from aerial photography, and site investigations conducted in the field. The Pd surface is at about the same level or buried by the Holocene floodplain. The Pp terrace stands approximately 20 ft (6 m) above the floodplain. The Pi terrace surface stands approximately 40 ft (12 m) above the floodplain.

3.3 Floodplain geomorphic environments

3.3.1 General

The following paragraphs describe the physical appearance and processes that form individual types of geomorphic features encountered in the study area. This is a summary of information published in textbooks of geomorphology (e.g., Chorley et al. 1984) and is included here to make this report more useful to non-geologists.

3.3.2 Point bar (PB)

Point bar deposits are lateral accretion deposits formed as a river migrates across its floodplain. River channels migrate across their floodplain by eroding the outside or concave bank and depositing a sand bar on the inside or convex bank (Figures 2 and 3). With time, the convex bar grows in size, and the point bar is developed. Associated with the point bar are a series of arcuate ridges and swales. The ridges are formed by lateral

channel movement and are relic sandy lateral bars separated by low-lying swales. Swales are locations where fine-grained sediments accumulate.

Point bar deposits are as thick as the total depth of the river that formed them. These deposits are finer graded upward in the deposit from the maximum size of the river's bed load (coarse sand and/or fine gravel) to fine-grained soils (clay) at the surface.

The basal or coarse-grained portion of the point bar sequence (i.e., point bar substratum) is deposited primarily by lateral accretion while the fine-grained or upper portion of the point bar sequence (i.e., point bar top stratum) is deposited by overbank vertical accretion.

Figure 3. Schematic and aerial view (from Saucier 1994) of a typical point bar depositional environment.

Point bar deposits in the Red River Valley are the dominant and most dynamic environment within the project area. Point bar limits were defined primarily from interpretation of photography and from boring and topographic data. Older point bar deposits are removed from the zone of active lateral accretion and are receiving sediment primarily by vertical accretion.

Primary characteristics of the active point environment are the well developed ridge and swale topography and its proximity to the main channel. In the Red River Valley, ridge and swale topography is especially well developed. Another primary characteristic of the point bar environment is the prominent sandy point bars along the main channel.

Sandy point bars are easily recognized on aerial photography and topographic maps.

Sediment types defined by borings identify a typical point bar sequence as grading upward from poorly-graded or uniform sands at the base to silty sands, silts, and clays near ground surface. These deposits are usually variable horizontally, especially where ridge and swale topography is well developed or relic chutes (high-water channel across the point bar neck) are present. Older Red River point bar deposits contain a much thicker and finer top stratum.

Boring data indicate that point bar deposits are separated into two distinct units based on sediment types (i.e., a thin predominantly fine-grained upper unit or point bar top stratum (silt and clay) deposited by vertical accretion and a thick coarse-grained lower unit or point bar substratum (silty sand and sand) deposited by lateral accretion). Point bar top-stratum deposits are approximately 15- to 20-ft (5.0 to 7.0 m) thick. The substratum, in comparison to the top stratum, is much thicker and forms almost the entire thickness for this environment.

3.3.3 Natural levee

Natural levee deposits form by vertical accretion when the river overtops its banks during flood stage and sediment suspended in the flood flow is deposited immediately adjacent to the channel. The resulting landform is a low, wedge-shaped ridge with the greatest thickness adjacent to the river (Figures 2 and 4). Natural levee thickness decreases away from the river until it eventually merges with other floodplain deposits.

Natural levee deposits in the project area are approximately 5- to 20-ft (2 to 6 m) thick and, along the Red River, may range several miles in width. A reconnaissance investigation identified silt and sand as the pre-dominant soil types associated with natural levee deposits.

Natural levee deposits generally contain a low organic content because oxidation has reduced organic materials to a highly decomposed state. Soils are typically brown to reddish brown. Small calcareous nodules are frequently associated with these deposits as a result of groundwater movement through the permeable levee soils. Natural levee soils are generally well drained and have low water contents and a stiff to very stiff consistency.

Figure 4. Schematic and aerial view (from Saucier 1994) of a typical natural levee depositional environment.

Natural levee deposits were mapped as a separate environment on the geomorphic maps because this environment is present throughout the floodplain to some extent. Natural levee deposits are an important geomorphic process in the study area, especially as a foci for cultural resources. Knowledge about top-stratum thickness is helpful in understanding and evaluating buried archaeological sites.

3.3.4 Abandoned course

An abandoned course is a river channel that is abandoned in favor of a more efficient course (Figure 5). A course must contain a minimum of two meander loops for the channel to be classified as an abandoned course on the geomorphic maps. Abandoned courses are abundant throughout the project area. An abandoned course forms when the river's flow path is diverted to a new position on the river's floodplain. This event usually is a gradual process and begins by a break or a crevasse in the river's natural levee during flood stage. The crevasse forms a temporary or crevasse channel that may, over time, develop into a more permanent channel. Eventually, the new channel diverts the majority of flow, and the old channel progressively fills. Final abandonment begins as coarse sediment fills the abandoned channel segment immediately downstream from the point of diversion. Complete filling of the abandoned course is a slow process that occurs first by lateral accretion and then later by overbank deposition and

vertical accretion. The complete filling process may take several hundred to several thousand years to complete. In some instances, complete filling may not occur as relict and upland drainage preserves partial stream flow through the course.

Figure 5. Schematic and aerial view (from Saucier 1994) of a typical abandoned course depositional environment.

Abandoned courses and associated abandoned channels collectively form a meander belt on the floodplain of the river. Meander belt deposits consist of a several miles wide massive point bar sequence divided by various abandoned channels and courses that collectively form the meander belt. The frequency and location of the meander belt segments, which will be discussed later, are useful for determining the Holocene chronology of floodplain development.

3.3.5 Abandoned channel

Abandoned channels are relict channel loops that are abandoned when the river cuts across its point bar (Figures 2 and 6). The cutoff produces an oxbow lake. The process by which the river abandons the loop occurs either gradually as a neck cutoff or during a single flood event as a chute cutoff. A chute is a high-water channel across the point bar of the channel. Abandoned channels mapped by this study may be either well-defined classic oxbow loops or loop segments. Abandoned channels are abundant throughout the project area.

Figure 6. Schematic and aerial view (from Saucier 1994) of a typical abandoned channel depositional environment.

Channel filling is a gradual process. It occurs initially by lateral accretion when the channel is still connected to the main course. After the main channel has migrated away from the abandoned segment, vertical accretion then dominates. During times of high-water flow, suspended sediment is transported to the abandoned channel. Abandoned channels associated with the present meander belt are generally hydraulically connected to the main channel and are still in the process of filling. In contrast, abandoned channels on the older surfaces are filled or almost completely filled. Thickness of channel fills range from 25 to 30 ft (8 to 10 m). Abandoned channels that are not filled continue to receive sediment by overbank deposition during the peak flood season, which may occur for only a brief time each year.

3.3.6 Backswamp (BS)

Backswamp deposits form by periodic flooding and vertical accretion of new sediment. The primary geomorphic process occurring in this environment is vertical accretion of new sediment by annual flooding, pedogenesis, and bioturbation. These processes combine to form a characteristic soil profile and lithology. In general, soil types are predominantly gray to dark red-gray clay interbedded with silt and decayed roots and wood fragments. Backswamp deposits are 20- to 30-ft (6 to 10 m) thick.

Backswamp deposits in the project area are located in poorly drained forested areas bordering the point bar environments (Figures 2 and 7). This environment is approximately 25 percent of the study area. Backswamps are common in the Red River Valley and have been covered with lacustrine deposits.

Figure 7. Schematic and aerial view (from Saucier 1994) of a typical backswamp environment.

3.3.7 Alluvial architecture

The previous sections described the landscape components or geomorphic depositional environments. This section will portray the landform relationship in the subsurface. Twelve cross sections (Plates 1-12 in Appendix B) were compiled from available boring data. Individual plots of the boring data are in Appendix D. The location of each cross section is shown on the geomorphic maps. The horizontal distance in feet represents running distance along the cross section and not levee stationing. Examination of sections reveals the alluvial sediment incised the Tertiary sediments (Tu). Abandoned channels and point bars are seen in the sections. Backswamps are located away from the active and abandoned channels.

Natural levee deposits drape most of the floodplain. Beneath and within the natural levee deposits is an inferred paleosurface. The paleosurface is a suggested level to explore for covered archeological sites.

4 Soil Geomorphology

4.1 Introduction

An important characteristic that distinguishes landforms is the development of a mature soil profile(s) by pedogenic processes. The presence or absence of a soil profile reflects the types of geomorphic processes that are active in the area and the age of the soil sequence (Birkeland 1984). A definite relationship was established during the study between geomorphic surfaces and soil materials. The understanding of the relationship increases the ability to predict location and probability of archaeological sites and pattern of soil genesis on a given surface. Landscape stability is evident by a well-defined soil imprint. Soil data from the soil surveys (Soil Conservation Service (SCS) 1979, 1984) were used to infer the degree of stability of the Red River landforms. Because burial of sites is important to archeological surveys, the recognition of buried soil horizons and surfaces is considered.

4.2 Soil-forming processes

Soil-forming processes are governed by the physical properties of the soils, the environmental influences of the geomorphic system, and the duration of the geomorphic processes. Soil genesis on each surface can be viewed as consisting of two steps: (1) the accumulation of parent materials and (2) the differentiation of horizons in the profile (Simonson 1959). The primary parent material in this study is alluvium with colluvium and hill-slope sediments being secondary sources. Horizon differentiation in the parent material is a result of four basic kinds of changes occurring throughout the system. According to Simonson (1959), these are additions, removals, transfers, and transformation. Physical properties of the underlying soils and the soil profile are variable because of differences in (a) topography and slope, (b) the types of vegetation that are growing on the surface, (c) the land-use characteristics of the area (e.g., crop land versus timber), (d) variations in climate, (e) composition of the underlying parent materials, and (f) the time involved in which the soil has formed. These variations control the different types of geomorphic and pedogenic processes that are involved in soil formation, and they govern the soil profile that will be developed. Changes are brought about by the effects of the soil-forming factors.

4.3 Soil-forming factors

The five soil-forming factors have been studied and are expressed in Equation 1 by Jenny (1961).

$$s = f(cl, o, r, p, t \dots) \quad (1)$$

where s denotes any soil property. The soil-forming factors in parentheses, mostly groups of factors, are defined as follows.

cl = climate change

o = organisms and their frequencies

r = relief or topography

p = parent material, defined as state of soil at soil formation time zero

t = age of soil, absolute period of soil formation

$\dots$ = additional, unspecified factors.

A discussion of each factor follows.

4.3.1 Climate

Climate is considered by many to be the most important factor in the development of soil characteristics. It accounts for the present and historical effects of rainfall, temperature, and wind on soil features. A significant point in considering the effect of climate is its cyclical nature, variance in time, and amounts of inputs.

4.3.2 Organisms

The organism factor is composed of the fauna and flora of the region. As with climate, both past and present influences of plants and animals are visible in the present soil. Plants are involved in the initial development of soils through mechanical and chemical weathering. Throughout the succession of a soil, the properties of organic carbon, nitrogen, pH, bulk density, color, and structure are affected by plants. The influence of animal populations can be seen by the mixing brought about by the activities of burrowing species. Grazing species and even man impacts the soil to an extent through cultivation and compaction.

4.3.3 Topography

Topography refers to the surface shape of a landform. It includes the gradient, length and width, slope orientation, and convexity or concavity. It affects soil hydrology, runoff or run-on, erosion or deposition, and in conjunction with climate, vegetation. These attributes govern soil properties, such as clay distribution, depth of weathering, profile development, and organic matter and chemical variance.

4.3.4 Parent material

Parent material refers to unconsolidated organic and mineral materials in which soils form (U.S. Department of Agriculture (USDA) 1993). It is the material present when soil genesis is initiated. The nature and original properties of the parent material are important to the development of soil properties. It determines many of the chemical, mineralogical, and physical limits of a soil. It influences the types of clay developed and the structure, texture, color, and natural fertility of soils. These properties in turn create variability in drainage, available moisture, and vegetation.

4.3.5 Time

“Time here refers to passage of time...and in itself has no influence on the landscape; rather it records the accomplishments of the system” (Schumm 1977). Time in this context is important only to help establish a starting and stopping point and to compute process rate (Daniels and Hammer 1992). Weathering of the parent material and development of soil features are aligned with time. Parent materials and soil features vary in the amount of time needed to produce soil material. Determining these times for a given parent material or feature to develop can, in some cases, assist in ascertaining relative age. For example, the absence of a soil profile indicates a soil that has been recently deposited and has not had sufficient time to develop a profile.

4.4 Soil geomorphology

The soil series will be discussed in terms of the geomorphic position and geoarcheological significance. Each of these different soil series has a unique soil profile characterized by diagnostic physical, and/or chemical properties. The diversity of the soil series for different landforms reflects, in part, differences in mapping conventions between the various counties and differences in soil type due to geography and variations associated

with the soil forming variables (e.g., time, parent material, climate, biological activity). Because of the great variety of soil series associated with the different landforms, specific or exact relationships between soil series and landform type are not possible. Rather, general soil properties and characteristics can be differentiated for the various landforms.

The study area consists of soil classes, ultisols, alfisols, vertisols, mollisols, inceptisols, and entisols. The Tertiary bluff and slopes consist of ultisols, such as the Bowie, Briley, and Sacul series, and alfisols, such as the McKamie and Muskogee. These soils reflect long-term pedogenesis and, thus, stability. Numerous Archaic sites have been located on Buzzard Bluff. However, the fact that ultisols are poor agriculture soils may explain the lack of Caddo sites.

Other alfisols are the Rilla, which are associated with natural levee deposits of former Red River channels. The Rilla reflects natural levee deposition along portions of Finn Bayou and Red Chute. The soil profile in a typical Rilla silt loam is an argillic horizon at 1.2 ft (0.35 m).

Vertisols, such as the Billyhaw series, are developed on backswamp surfaces. Another clay soil associated with backswamps is the Perry. The Perry clay is an inceptisol reflecting weak soil profile development. The profile of Perry clay reveals a buried B horizon at 1.75 ft (0.5 m). The Billyhaw and Perry clay are associated with the Finn Bayou Meander belt (Heinrich 1993). The clay veneer masked the meander belt features and probably a buried site associated with settlement along the Finn Bayou course.

Other soils have mollic epidosols and are classified as mollisols, such as the Latanier and Caspiana. Discussions with Louisiana SCS staff suggest that the organic enrichment of these mollisols is possibly associated with the Great Raft, which accelerated organic and overbank deposition in the Red River Valley. The Caspiana is found on the flanks or distal portions of natural levees. The soil profile of the Caspiana shows a discontinuity at 2.2 ft (0.66 m). The Latanier contains a contrasting texture at approximately 3.3 ft (1 m).

Entisols exhibit the least amount of soil development and are, therefore, considered the most recent in age. Included in the entisol class are the Severn silt loam, Kiomatia loamy fine sand, and Oklared fine sandy loam.

The Severn is associated with a natural levee while the Kiomatia and Oklared series seem associated with historic and modern meander point bars. The Severn's profile reflects cumulative sedimentation with outfaced pedogenesis. Lithologic and color discontinuities at approximately 0.75 ft (0.25 m) indicate a possible buried surface in the Severn. The Kiomatia also reflects a change in deposition but deeper at 4 ft (1.3 m). The Oklared's profile reveals a depositional break at 3.8 ft (1.2 m). Considering the lack of soil development and, thus, relative recent age of these soils, only historic and proto-historic sites are possible.

4.5 Soil summary

The principal soil geomorphic processes are vertical accretion of new sediment from annual flooding, pedogenesis (soil formation), and bioturbation. These processes combine to produce a characteristic soil profile and lithology in each landform. In general, soil profiles are better developed in older deposits than in the active point bar setting.

Classification of soils by SCS indicates that inceptisols, mollisols, and alfisols are the major soil groups for the older surface, while entisols are associated with the younger environment. The geomorphic importance associated with both argillic and mollic soil horizons in the Finn Bayou area is that these soil horizons represent a stable surface and require a certain amount of time to develop. Exactly how much time is needed to develop either of these characteristics is unknown as it relates to the complex interchange between the different soil forming variables. Geomorphic significance of soil horizons in terms of this study is that the Finn Bayou surfaces have been stable long enough for pedogenic processes to imprint and alter the underlying fluvial deposits.

5 Geomorphic Chronology

5.1 Introduction

Another objective of this study was to define the geomorphic chronology of the project area to the extent possible with the known data. The chronology is based on the available soils and geological data, results of the geomorphic mapping, borings (Appendix D), radiometric age (Appendix E) data from this study, and comparisons of archeological site records. The geomorphic history of the area is defined by the distribution and extent of the underlying geologic units, the floodplain sediments that overlie these formations, and the soils that have formed and modified these different landscape elements.

5.2 Pleistocene

The Red River was not directly affected by continental glaciation during the Pleistocene. Therefore, the fluvial system did not directly receive glacial melt water or related sediments. Instead, geomorphic processes operating in the study area were controlled by climatic variations associated with Pleistocene glaciation. Climatic changes influenced the base level on the Red River and its tributaries. Because the outlet for the Red River during the latter part of the Pleistocene was by way of the Mississippi River Valley, indirect effects of glaciation (i.e., glacial melt water, glacial sediment, and sea level changes) would have influenced the Red River's discharge to the Mississippi River and its link to the Gulf of Mexico. The end result of this complex interchange between Pleistocene climate changes and associated base level response has been the creation and incision of a well-defined drainage basin into the underlying Tertiary sediments. At the beginning of the Holocene, the Red River alluvial valley and its larger tributaries had developed a series of descending stepped terraces that were formed as a result of both aggrading and degrading fluvial cycles and a well-defined floodplain with associated environments of deposition. Within the boundaries of the study area, the mapped terraces are the Pleistocene Deweyville (Pd), Praire (Pp), Montgomery (Pm), and Intermediate (Pi) (Saucier and Snead 1989).

5.3 Holocene

During the Holocene, the Mississippi River built five meander belt courses in its alluvial valley (Saucier 1974; Saucier and Snead 1989). In the Red

River Valley, six remnant meander belts are preserved (Smith and Russ 1974; Russ 1975; Saucier 1974; and Saucier and Snead 1989). The most recent Red River course to the Mississippi River may have formed sometime between 500 and 1,000 years BP through Moncla Gap (Russ 1975). Pearson (1986) suggested this change may have occurred even earlier, perhaps as early as 1,800 years BP based on archaeological data. Hall (1990) indicates that approximately 1,000 years BP, a regional climate change occurred from moist to dry in the southern Great Plains. The response by the Red River to this climate change may have led to channel incision that helped to promote increased bank erosion. Floodplain incision, bank erosion, and valley-wide lateral migration may have introduced a large influx of sediment and trees into the lower Red River Valley to form the Red River Raft.

Saucier and Snead (1989) compiled previous mappings of the Lower Mississippi Valley and its tributaries. This synoptic view of the region indicates two meander belt deposits (i.e., Hrm1 and Hrm2). These meander belts are the youngest two of the six recognized belts (Saucier and Snead 1989). A preliminary geomorphic study relating the distribution of prehistory archaeological records was conducted by Pearson (1982). The work is part of a multi-hypothesis in the valley's evolution and prehistoric landscape adaption. Pearson infers three meander belts: modern, intermediate age, and older belts.

5.3.1 Older meander belt (Hrm2)

Saucier and Snead (1989) mapped the Finn Bayou abandoned channels and course as Hrm2. The age of the Finn Bayou meander belt (Pearson 1982) is tentative but is associated with Pearson's older meander projected to be older than 3,000 years BP. A radiometric date of 4610 ± 60 years BP was recorded from a Hrm2 overbank deposit (Appendix E). Archaeological data indicate Late Archaic (5,000 to 2,500 BP) and Fourche Maline (2,500 to 1,000 BP) sites adjacent to Finn Bayou. Based on Jacobs (1981), Heinrich (1993) suggested that Hrm2 could have flowed from 4,000 to 6,000 years BP. Until additional investigations produce radiometric dates, the presumed dates are plausible. The geomorphic features along Hrm2 are mixed with overbank clay deposits. It is inferred that the effect of the Great Raft added additional vertical accretion deposits. Archeological sites are expected to be buried along this meander belt.

5.3.2 Intermediate meander belt (Hrm1.1 and 1.2)

Pearson's (1982) intermediate belt is part of Saucier and Snead's Hrm1. Geomorphic analysis during this study concurs that, based on oxbow filling, the Hrm1 can be differentiated into Hrm1.1 and Hrm1.2. Pearson's (1982) chronology suggests that the intermediate belt was formed 200 to 2,000 years BP. Additional data for this study suggest that the age of Hrm1.2 is 4,000 to 1,200 years B.P. Hrm1.1 is tentatively estimated at 1,200 to 200 years B.P. Hrm1.2 oxbows are recognized by their partial filling. The Hrm1.2 abandoned channels usually are flooded part of year and contain cypress swamps. Pearson (1982) included Red Lake on the eastern valley wall as part of the intermediate belt. An alternative hypothesis is that Red Lake and other eastern wall abandoned channels could be remnants of a Little River meander flowing during the time of Hrm2 deposition.

5.3.3 Modern meander belt (Hrm1.0)

The modern meander belt has been active for the last 200 years (Pearson 1982). Review of historic maps shows the present meander belt to be active. For example, Old River Lake, Adam's Cut-off, and First Old River Lake were part of the channel in the 1840s. Willow Lake and Scott Lake were abandoned before 1840. The oxbow lakes or abandoned channels in Hrm1.0 are open with only partial filling. Examination of the Fulton Quadrangle topographic map also reveals the active meandering of the Red River. For example, the Miller County-Hempstead County line represents the 1876 channel. Even comparison of the 1951 quadrangle to the photo-revised 1970 and 1975 maps shows areas of 2,000 ft migration in approximately 20 years. Thus, the modern meander belt is not likely to contain prehistoric sites.

5.4 Historic

By the early 1800s, the lower Red River was blocked by a series of log jams known as the Great Raft or the Red River Raft. The southern portion of the study area was affected by the Red River Raft. The Red River Raft was a series of log jams nearly 100 miles long that had accumulated on the point bars of the river and formed numerous interconnected river channels in the upper Red River Valley (Figure 8). An account of rafting described by Flint (1833) is presented in Smith (1982).

Figure 8. An artist's conception of the Great Raft. Note the overflow anabranch and distributary channels (Veatch 1906).

The Red River Raft led to the formation of numerous valley margin lakes within the Red River Valley and alluvial valleys of its tributaries (Flint 1833). The raft was an important mechanism for the formation of the large lakes that covered the southern part of the study area during historic time. This study will not consider the history of the raft other than its significance to lake formation as it is beyond the scope of this investigation. Further information about the raft is available from numerous historic accounts and papers (Darby 1816; Flint 1833; Veatch 1906; Caldwell 1941; and Mills 1978).

Poston Lake covered much of the lower study area by the early 1800s as shown by Figure 9 (Veatch 1906). It is judged that the maximum lake limits for Poston Lake were established during historic time, near the levels indicated by Figure 9. Beneath the limits of raft lakes, lacustrine deposits buried the former floodplain of the Red River. The thickness of these lacustrine sediments was identified as approximately 3.2 ft (0.98 m) (Albertson and Dunbar 1993). Lacustrine deposits may be even thicker, depending on distance from sediment source areas.

Figure 9. Location and limits of Poston Lake (Veatch 1906).

After 40 years of intermittent action, removal of the Great Raft was completed in 1873 by USACE to make the Red River navigable. Removal of the Great Raft caused the Red River to degrade its channel headward and drained the large lakes, such as Poston Lake that had formed behind the raft (Figure 9).

Formation of raft lakes would have flooded the existing floodplain. The Hrm2 former floodplain with its abandoned courses and channels would have been buried and masked with a veneer of lacustrine sediments. Therefore, this study suggests that existing archaeological sites would have been buried by lake formation, where they are present.

5.5 Geomorphic mapping and chronology

A geomorphic map was prepared to reflect the geomorphic chronology. The Holocene map units follow the general designations of Saucier and Snead (1989) and Pearson (1982) with the addition of detail appropriate to 1:24,000 floodplain mapping for geoarchaeological site prediction. The Holocene floodplain consists of Red River meander belts (Hrm), natural levees (Hrl), and backswamps (Hb). Two meander belts Hrm1 and Hrm2 are identified (Saucier and Snead 1989). Modifying Pearson's (1982) model, subunits of Hrm1 are delineated as Hrm1.0, Hrm1.1, and 1.2. The

abandoned Hrm2 has surficial expression but is covered by a mappable thickness of abandonment phase backswamp clay. The Little River also produced two meander belts (Hlm) and associated natural levees (Hll). Pleistocene deposits Pm (Pd, Pp, and Pi) and Tertiary Groups (Tc, Tw, and Tm) are delineated but not investigated during this project.

5.6 Geomorphic mapping units

HRm. Present and former channel and point bar deposits of Red River meander belts. Surficial deposits range from fine sand to silt loam to clay depending on landscape position in the meander belt topography. Meander belt deposits may be veneered by fine-grained overbank deposits of natural levee, channel fill, swale fill, and backswamp origin. Multiple meander belts are identified. Meander Belt 1 has discrete subunits 1.0, 1.1, and 1.2 with locally mappable cross-cutting or accretionary phases. Hrm2 is covered by backswamp clay.

HRI. Natural levee deposits of the Red River associated with overbank deposition near channels. Local crevasse splay and crevasse channel deposits are included within the unit. Sediment textures range from sandy and silty adjacent to channels and grade to silty and clayey in distal areas. Natural levees are locally associated with Meander Belt 1 subunits.

Hb. Backswamp sediments deposited in distal areas of the Red River floodplain. Sediments range from clay to silty clay loam.

HRcc. Crevasse channel deposits of major prominent flood basin channels. Sediment texture ranges from sandy to silty.

HRcl. Natural levee associated with crevasse channels (Hcc). Sediment texture is silty to clayey.

Haf. Alluvial fans associated with small tributaries along the valley wall. Sediment texture varies with sediment supply of the tributary basin.

HLm. Present and former meander belt deposits of the Little River.

HSm. Present and former meander belt deposits of the Sulphur River.

Hu. Undifferentiated alluvium of small streams.

HLm. Present and former meander belt deposits of the Little River. Surficial deposits range from fine sand to silt loam to clay depending on landscape position in the meander belt topography. Meander belt deposits may be veneered by fine-grained overbank deposits. Two meander belts are identified.

Pm. Pleistocene Montgomery Terrace

Pd. Pleistocene Deweyville Complex

Pp. Pleistocene Prairie Complex

Pi. Pleistocene Intermediate Complex

Tc. Tertiary Claiborne Group

Tw. Tertiary Wilcox Group

Tm. Tertiary Midway Group

6 Significance of Geomorphology to Cultural Resources

6.1 Introduction

The most important objective of this study was to determine the archaeological significance of the geomorphic features, especially in terms of locating previously undiscovered sites. The major goals of this objective are to identify and define the principal archaeological site/landform associations and to classify the landforms according to their site potential, provide guidance for locating sites that are of specific ages or cultural components, and identify areas that have high potential for site destruction or preservation by natural geomorphic processes.

The approach that was used to define the relationships between known archaeological sites and geomorphic features involved identifying the known archaeological sites, evaluating geomorphic site data from the recorded sites, and identifying important characteristics that relate the archaeological sites to geomorphic features. These characteristics were then evaluated to predict locations of undiscovered sites according to their geomorphic context.

It is important to emphasize that the primary purpose of this analysis was to show general relationships between the various landforms that comprise the study area and archaeological sites contained within this area. This study was not meant to be an archaeological analysis but rather to reveal trends of geoarcheologic preservation.

6.2 Procedure

Archaeological site data were obtained from the Vicksburg District's Environmental Resources Branch, Coastal Environments Inc., and published reports for the Arkansas Archeological Survey. There are 324 known archaeological sites in the Great Bend region. The database of all known sites includes characteristics that were compiled from the geomorphic maps and site descriptions. These characteristics are site number, site name, quadrangle map, cultural components, diagnostic artifacts, site description type (e.g., surface scatter, ceramics, historic debris), and size. Because of their sensitivity, the locations for the known archeological sites are not individually identified on the geomorphic maps.

Site locations, along with the previous characteristics, were entered into a GIS database for analysis. Using overlay comparisons, relationship of sites to landforms and meander belts were analyzed spatially and temporally by cultural component. The GIS analysis treats sites that occur on two or more landforms as two or more sites.

6.2.1 Use of GIS in cultural resource assessment

A GIS is a powerful tool used to manage and manipulate geographically referenced data and information. Software and hardware GIS packages vary in analytical capabilities and database structure. The decision of which one to use is based on the type and amount of data, the desired product, and the GIS format. To construct the Red River GIS and database, ARC/INFO 7.0.2 developed by the Environmental Systems Research Institute (ESRI 1994) was used. The interchangeable format between ARC/INFO Unix and ARC/INFO PC was considered essential in view of the fact that the GIS will be used as a management tool.

The framework for the GIS consists of various coverages that can best supply answers to proposed queries. Coverages refer to a GIS map and represent only one of them. Each theme must be assigned attributes or information that pertains to a particular feature. For example, an archeological site is digitized into the database as a polygon. Attributes, such as cultural affiliation, occupation, and chronology, can then be assigned to form a data structure. Until this information is added, the coverage has little value in the GIS.

The intent of the GIS is to provide support both in interpretation and maintenance of pertinent data concerning cultural resource assessment. The major analysis technique will be the combination or linkage of data layers to analyze or display spatial queries. For example, archeological sites, elevation, and geomorphology may be combined to locate sites situated on a selected landform occurring at a determined elevation. Predictive modeling based on established facts can then aid in future cultural resource investigations and management. By understanding the environment (e.g., geology, geomorphology, and soils of known sites), the GIS is able to locate potential areas containing these same parameters.

Data in the GIS exist in either raster or vector format. Raster data are cellular data structures composed of rows and columns, whereas vector data are coordinate-based data structure used to represent linear map

features. In raster data, attributes are associated with each grid cell, but in vector data, attributes are assigned to each feature. Both played an important role in construction of the Red River GIS.

The following is a list of digital databases assembled for the project.

- Raster maps
 - Topography
 - Aerial photography
- Vector maps
 - Geomorphology
 - Geology
 - Soils
 - Elevation
 - Levees
 - Archeological sites
 - Geochronology
 - Borings
 - Surface water

The GIS can be queried based on attributes assigned to these coverages and linkage between the coverages. When planning a GIS, the purpose of the project supports the queries and is considered when constructing a GIS. It is possible, however, that future projects may require additional information to support different objectives. Additional attributes for existing coverages can be added or new links between coverages can be established. New coverages can also be added, if needed. The following questions are just a few examples the Red River GIS is capable of answering at this time.

- On what type of landform is a particular archeological site situated?
- What is the minimum or maximum elevation of an archeological site?
- What is the lithology of a particular geologic formation?
- What is the chronology and area of a particular archeological site?
- What percentage of archeological sites is situated a given distance from a levee?

6.2.2 Data requirements for cultural resource assessment

Many factors contribute to preservation or destruction of archeological sites, and each must be considered for proper management of these

resources. Fortunately, the scope of the project included field interpretation as well as analyses from available data. An initial reconnaissance of the study area showed that the management system should be based on geomorphology, geology, soils, elevation, levees, and mapped archeological sites. Interpretation of both aerial photography and further field investigations provided verification of previous data. In the following paragraphs, these data are discussed in terms of their source and characteristics.

6.2.2.1 Geomorphology

Field investigations and aerial photography provided the interpretation for the geomorphology theme. A soil auger was used to retrieve samples at various depths throughout the study area. Sampling locations were chosen to confirm previous interpretations and to clarify conflicting analyses. A boring log was then constructed from soil sample descriptions. Each feature was digitized as a separate polygon and then assigned attributes. Previous geomorphological mapping by Smith and Russ (1974) and existing boring data were considered in this interpretation. Geomorphologic interpretation was discussed in Chapter 3.

6.2.2.2 Geology

The 1:62,500 scale map was scanned using a Tangent Drum Scanner to ensure a more accurate digitization of features. Geologic age, formation name, and feature type were included in the data structure.

6.2.2.3 Soils

Soil information was taken directly from existing 1:20,000 county soil maps generated by the USDA Soil Conservation Service (1984, 1979) for Miller and Hempstead counties. Soil information was referenced using the Red River course from the topographic map, discussed later, to provide an accurate overlay of this map to other coverages.

6.2.2.4 Elevation

Elevation was digitized from the 7.5-min (1:24,000) USGS topographic quadrangles. The area covered by the terrace (Pi) was not considered essential in the interpretations and, therefore, was not included in the data.

6.2.2.5 *Levees*

The levees were included in the database as a significant feature. In addition, a buffer reflecting the right-of-way was included. In this way, project specific queries relating to engineering impacts can be made.

6.2.2.6 *Archeological sites*

Coastal Environments Inc. provided location and descriptive data on archeological sites in the southern portion of the quadrangle. Additional locations can be added to the database as they are acquired.

6.2.3 Archaeological site definition

An archaeological site was defined as a location where artifacts have been found. This definition of a site does not differentiate sites of settlements. That is, a site can be a location where settlement has occurred, or it can be a location that was occupied only once and artifacts were left. This nonrestrictive definition is used because of the nature of archaeological site data. For some sites, exact locations or other important information in the site descriptions are missing, or the data are wrong. In addition, it is possible for a single large site to be represented in the record as multiple sites that were recorded at different times by different individuals or organizations.

The primary objective of using the archaeological site data is to show the general relationships between the prehistoric sites and the landforms. It will be left to the archaeologists to interpret information about the site beyond its geomorphic characteristics. It is important to emphasize that the site catalogue has not been field checked. Basic trends are defined about the landforms by the archaeological site data in this section of the report.

6.2.4 Characteristics of an archaeological site

Artifacts that make up the archaeological site have by their distribution and position within the site certain temporal and spatial qualities. These qualities are defined by geographic, stratigraphic, and ethnographic characteristics of the artifacts (Gould 1987).

Both the stratigraphic and geographic characteristics describe physical qualities about the site itself. Geographic characteristics describe the spatial context between artifacts and their relationships to other artifacts

and their environment. Stratigraphic characteristics define the temporal or chronological order of the artifacts and relate these characteristics to the site occupation. Defining the geomorphic setting of the site is an important first step in evaluating geographic and stratigraphic characteristics of the site.

This study describes mainly the geographic (environmental or geomorphic) characteristics of the known archaeological sites. The identification of the site geomorphology is important to understanding the overall site archaeology because different landforms are dominated by certain types of geomorphic processes. These different kinds of processes will affect or control the distribution of archaeological sites and associated artifacts.

Neither stratigraphic nor chronological characteristics of individual archaeological sites were fully addressed by this study. The geomorphic analysis in this investigation will provide a general stratigraphic or chronological framework to evaluate the individual sites. A more detailed evaluation of individual sites will require the acquisition and analysis of further soil borings from the landforms on which individual sites are located. Soil borings will identify important sedimentological and soil forming characteristics and may provide datable materials for further determining chronological boundaries.

The last major criterion of an archaeological site is the ethnographic characteristics. These characteristics are determined by the archaeologist. The ethnographic characteristics of the artifacts and the site are concerned with human qualities of the site. Ethnographic characteristics relate human occupation to their associated activities and to the different types of cultures. However, before ethnographic characteristics can be fully understood, the geographic and stratigraphic characteristics must be fully defined and evaluated.

6.3 Distribution of known archaeological sites

6.3.1 Landforms

The distribution of prehistoric sites as a function of the different landforms in the study area on which the sites are located is presented in Figure 10. Approximately 6 percent of the known archaeological sites are located above the floodplain on valley slopes or bluffs. The remaining 94 percent of the sites is associated with the floodplain of the various

fluvial components that form the study area. Forty-six percent of floodplain sites are located adjacent to crevasse channels. Other known archaeological sites are primarily located upon natural levee or point bars adjacent to the Hrm1.1 and Hrm1.2 channels or on the Hrm2 surface. Additional sites on the Hrm2 surface in this river reach may be buried by vertical accretion of sediment.

Figure 10. Distribution of archaeological sites by landform.

6.3.2 Distribution of cultural components

Available archaeological site data for the purpose of this study were divided into cultural component types (i.e., Paleo, Archaic, Fourche Maline, and Caddo). Figure 10 displays the distribution of the culture component across the landscape. Historic sites were not evaluated in this study as prehistoric sites are the primary focus of this investigation and because other factors may govern the distribution and occurrence of historic sites. Historic sites are best defined and evaluated by conducting a detailed historic assessment and inventory of the study area. The Caddo culture ranges from approximately 1,000 to 150 years BP, and Fourche Maline culture ranged from 2,500 to 1,000 years BP. Archaic sites in the southeastern United States generally range from approximately 9,000 to

2,500 years BP, and Paleo-Indian sites are older than 9,000 years BP. The table in Appendix C indicates that some sites contain multiple occupations. Sites that are identified as multiple occupations (i.e., Paleo, Archaic, Fourche Maine, and/or a Caddo) are located along Finn Bayou and Red Chute (Hrm2).

6.3.3 Paleo sites

Four sites contain Paleo-Indian artifacts. These sites are located primarily on Buzzard Bluff (Tw). Three Paleo-Indian sites are located on Tertiary deposits (Figure 10), and the other is located along a crevasse channel.

6.3.4 Archaic sites

One hundred eighty sites or 55 percent of the sites in the GIS contained Archaic artifacts. Approximately 8 percent of the known Archaic sites are located on the summit or slopes (Figure 10). The remaining sites (92 percent) are located on the floodplain. Archaic sites are primarily found on crevasse channels (Hcc) and the Hrm2 meander belt. Apparently, the entire landscape was used by the Archaic cultures. Additional archaic sites may be concealed in the older floodplain (Hrm2) from burial by vertical accretion.

6.3.5 Fourche Maline sites

One hundred fifteen of the known sites or 35 percent of the sites in the GIS contained Fourche Maline artifacts. Fourche Maline sites (5 percent) have been located on Tertiary units. The other 95 percent of sites are primarily located on the floodplain. Sixty percent are along meander belts: Hrm2 (8 percent), Hrm1.2 (30 percent) and Hrm1.1 (22 percent). Other sites are located along crevasse channels (31 percent) (Figure 10). Fourche Maline culture seems to have habituated across the landscape, using both upland and floodplain sites. It is likely that additional sites exist beneath the vertical accretion deposits. For example, a Fourche Maline site (3LA25) was buried 1.5 m (Schambach 1982).

6.3.6 Caddo sites

One hundred twenty-four known sites or 38 percent of the sites in the GIS contain Caddo culture components. The sites located along Hrm1.2 meander belt features comprise 45 percent. Caddo sites are located along

Hrm1.2 and comprise 33 percent in the Great Bend region. Late Caddo sites also exist along the modern meander belt Hrm1.0 (Pearson 1982).

6.4 Prediction of site occurrence

The distribution of the known archaeological sites as identified in the preceding illustrations indicates that sites are not random but are clearly associated with specific landforms in the project area. Geomorphic relationships identified for the known sites can be used to locate and interpret previously undiscovered sites and guide the subsequent archaeological analysis of the individual sites and the entire study area. Geomorphic relationships identified by this study should help to improve the efficiency of later cultural resource investigations in the project area and maximize the results obtained. In addition to locating undiscovered sites, geomorphic relationships will aid the archaeologist in defining the ethnographic site characteristics. Considering the distribution of known sites, the expected distribution of sites is presented in Table 3.

Table 3. Expected distribution of cultural resources by meander belts.

Map unit	Surface culture	Buried culture, <2 m	Buried culture, >2 m
Hrm1.0	No	No	No
Hrm1.1	Yes	Possible	Doubtful
Hrm1.2	Yes	Probable	Possible
Hrm2	Yes	Probable	Possible
Hrl1.1	Yes	Possible	Doubtful
Hrl1.2	Yes	Probable	Possible
Hb	Possible	Doubtful	Doubtful
Hc	Yes	Probable	Possible
Hlm1	Yes	Yes	Possible
Hlm2	Yes	Yes	Possible
Pm, Pd, Pp, Pi	Yes	Doubtful	No
Tc, Tw, Tm	Yes	Doubtful	No

Artifacts are most likely to be encountered on the natural levees of abandoned channels associated with the Hrm2, Hrm1.2, and Hrm1.1 courses. Artifacts may be located either on these landform surfaces or as part of the sediments that form these landforms. Lack of sites upon the older floodplain surfaces may be due to vertical accretion of sediment.

Further investigations on the Hrm2 surface in the Finn Bayou segment are probably needed. Geomorphic data indicate that some abandoned channels and courses comprising this surface possibly formed during the early Holocene. Archaeological site data may provide additional evidence to the age of the various floodplain components. Backswamp veneers over older meander belts have possible potential for buried sites.

Summits (Tc, Tw, and Tm) and terraces (Pp and Pi) have high potential for surface sites. Because Tertiary summits and slopes and Pleistocene terraces are stable to erosive landforms, buried sites are not to be expected.

6.5 Site preservation and destruction

In the project area, a number of processes is or has been at work either preserving or destroying the evidence of prehistoric groups. Most evidence of these processes is the result of historic man, such as cultivation of the soil, timbering, construction of roads, buildings, and levees, and removal of the Red River Raft. However, natural processes have also played a key role in the preservation or destruction of the archeological record. Some geomorphic processes, such as lacustrine sedimentation or fluvial sedimentation, may serve to preserve the record through burial. Erosional processes may destroy sites by redistribution or destruction of the surfaces where sites occur. In the following paragraphs, the archeological significance of several processes is discussed.

An understanding of fluvial sedimentation rates is important in evaluating artifact decay and preservation characteristics. Knowledge about sedimentation rates is also important in understanding the stratigraphic or chronological significance of the archaeological record. Rapid sedimentation will promote the preservation and superposition of artifacts and features that result from serial occupation of sites (Ferring 1986). In contrast, slow sedimentation rates will result in the accumulation of archaeological debris as mixed assemblages and increase the potential for artifact decay by both chemical and physical causes.

Therefore, it is important to understand, at least in general terms, local sedimentation rates to address the potential for site preservation and the types of sites that will be preserved. Sedimentation rates in the project area were interpreted from geomorphic evidence and are based on field observations and analysis of the available data. Guccione (1995) published sediment rates for the Item 2 and 3 area. She found 1.18 in. (3 cm) per year

in a decade scale for proximal natural levee, 0.01 in. (0.3 cm) per year on a decade to century scale for distal natural levees, and 0.001 in. (0.003) cm per year on a century to millennium scale for backswamp. Careful application of sediment rates requires thinking about both the temporal and spatial locations of the site. Sedimentation is a function of distance to the active channel and episodic overbank deposition.

6.6 Geomorphic evidence and archaeological significance of sedimentation rates

6.6.1 Geomorphic evidence and sedimentation model

Geomorphic mapping and published data were the principal means of determining sedimentation rates in the study area. Types of evidence include sedimentary structure, soil profile development, bioturbation, and fossil preservation. The types of evidence and a general knowledge of the different processes operating within each landform make it possible to estimate sedimentation rates for the landforms identified in Table 3.

Sedimentation rates in the study area must be considered in terms of the present day and when the landform was formed. Erosion and sediment transport are occurring throughout the project area. Sedimentation rates on the Red River floodplain area are also considered to be high, estimated at approximately 3 ft (1 m) per 1,000 years (Smith 1982). In addition, because of the Red River Raft, sedimentation accelerated the aggrading of the Red River in the southern portion of the project area by adding 3 to 4 ft (0.91 to 1.22 m) of lacustrine sediment during the past 500 years (Albertson and Dunbar 1993). In contrast, the lowest sedimentation rates occur on the terraces and backswamp areas removed from semiannual flooding. Valley slopes and summits are mainly locations of weathering and erosional processes.

Site preservation and destruction characteristics of the different landforms, as a function of sedimentation, were evaluated for different types of archaeological artifacts in Table 4. Artifacts are animal bones, shell, charcoal, ceramics, crystalline lithics, and granular lithics. Landforms were evaluated according to their ability to enhance preservation or accelerate decay. The interpretations made in Table 4 were based on the deterioration of archaeological sites primarily by chemical weathering in a humid environment with the main preservation influence by burial from fluvial sedimentation.

Table 4. Geomorphology of the Red River Levee Rehabilitation Project area.

Surface	Landform - formation	Age ^a	Geomorphic process ^b	Rate ^c	Archaeological artifacts ^d					
					AB	SH	CH	CE	CL	GL
Floodplain	Point bar (Hrm1)	H	LA	M-R	B	B	B	B	N	N
	Point bar (Hrm2)	H	LA-VA-BT-SF	M	B	B	B	B	N	B
	Raft Lake/Backswamp	H	VA	M-R	E	E	A	E	N	N
	Abandoned course	H	LA-VA	M	E	E	A	E	N	N
	Abandoned channel	H	LA-VA	M	E	E	A	E	N	N
	Natural levee (Hr11)	H	VA	M-R	A	A	A	A	N	N
	Natural levee (Hr12)	H	VA-BT-SF	M-R	A	A	A	A	N	N
Terrace	Abandoned floodplain (Pi)	P	E-SF	L	A	A	A	A	N	N
Bluffs and slopes	Tertiary geology, (Tw) Wilcox group	T	E-SF	L	A	A	A	A	N	N

^a Age: H = Holocene, P = Pleistocene, T = Tertiary.

^b Geomorphic process: VA = Vertical accretion, LA = Lateral accretion, SF = Soil forming processes (Pedogenesis), BT = Bioturbation (organic mixing by vegetation and organisms), E = Erosion.

^c Rate of deposition: L = Low, M = Medium, R = Rapid.

^d Archaeological artifact: AB = animal bones, SH = shell, CH = charcoal, CE = ceramics, CL = crystalline lithics, GL = granular lithics, A = accelerates decay, E = enhances preservation, B = both; may accelerate decay or enhance preservation, N = neutral or no effect.

6.6.2 Discussion

Preservation and destruction qualities of landforms are site dependent and are based on a number of interdependent variables. These variables include soil pH, soil moisture, wet aerobic or anaerobic environments, types of microorganisms and macroorganisms present, sediment movement, and soil loading. The relationships between these variables are complex. They can vary slightly and result in different decay properties for different artifact types. Hamilton (1987), Steele (1987), Vaughn (1987) and Mathewson and Gonzales (1988) described the effects that each of these variables has on artifact deterioration in archaeological sites. The majority of artifacts identified in the archaeological site descriptions are lithics.

Chemical weathering promotes the decay of bone, shell, charcoal, and pottery. Stone artifacts are not affected. With increasing sedimentation and burial, artifact preservation is greatly enhanced as burial reduces the rate at which chemical weathering occurs. Archaeological sites are most

threatened on the summits and on the side slopes where sedimentation rates are very low or where erosion is the dominant process.

Archaeological sites are more likely to be protected adjacent to or near the main channel where maximum sedimentation and burial occurs. Sites that are in close proximity to the main channel and not in the direct path of lateral migration by the river are buried by vertical accretion. Other factors to be considered in a discussion of artifact preservation and decay for geomorphic systems include flooding effects, groundwater movements, and fluvial scouring. Flooding can accelerate artifact decay by altering both the chemical and physical processes normally operating. Artifacts may be affected by groundwater movements and associated chemical reactions. Terraces are especially affected by groundwater movements as they are composed primarily of unconsolidated sediments and are hydraulically connected to the main channel. Other indirect and potentially adverse effects of flooding on archaeological sites include riverbank caving following a rapid river drawdown.

There are no strict rules governing archaeological site preservation or destruction as a function of the respective landforms and associated geomorphic processes. Various trends or generalizations that have previously been identified can be used as guidelines in evaluating the archaeological significance of the different landforms. Specific areas or individual archaeological sites should be examined and evaluated on the merits of each site.

7 Summary and Conclusions

7.1 Geomorphology

Geomorphic mapping has identified three primary landform surfaces (i.e., bluffs, terraces, and the floodplain) that are further subdivided according to environments of deposition or underlying geology. Bordering the floodplain of the different fluvial systems in the study area are topographically higher Pleistocene terrace and valley slopes composed of Tertiary age sediments. Three Pleistocene age terraces were identified and mapped adjacent to the main Red River Valley. The major floodplain environments of deposition, point bar, abandoned channel, abandoned course, backswamp, and natural levees were identified or mapped as separate environments of deposition.

The development of the study area began during the late Tertiary and early Pleistocene. Fluvial downcutting and lateral migration by the various stream courses created a well-defined alluvial valley and floodplain. Terraces are situated along the valley walls midway between the Tertiary uplands and the floodplain. Geomorphic data and published works (Russ 1975; Pearson 1982; and Saucier and Snead 1989) indicate two to three meander belts in the study area. The older meander belt Hrm2 surface may extend in age from approximately 4,000 years BP to possibly the middle Holocene. The intermediate meanders (Pearson 1982), designated Hrm1.2 in this report, are possibly 4,000 to 1,200 years BP. Meander belt Hrm1.1 is estimated to represent 1,200 to 200 years BP. The modern meander belt (Hrm1.0) is approximately 200 years BP to present.

Formation of the Red River Raft during late prehistoric and early historic times blocked channel flow on the Red River and created a series of large lakes. Poston and Swan lakes were formed as a result of the raft. Historic and geomorphic data indicate that the lakes were formed less than 500 years ago.

7.2 Archaeological significance

Historic archaeological sites were not evaluated by this study. The majority of prehistoric archaeological sites is located on terraces and valley slopes and former abandoned channels adjacent to Finn Bayou.

It is probable that sites may be buried beneath vertical accretion. Vertical accretion processes throughout the Holocene could have buried sites to 10 ft (3.05 m) based on similar sites reported for the Red River Valley (Smith 1982).

Caddo sites generally correlate with natural levee deposits associated with the meander belts. These sites are located on natural levees of abandoned channels and courses connected to the Hrm1.1 and Hrm2 meander belts.

Archaic sites are concentrated mainly along crevasse channels and the Finn Bayou course. Additional Archaic sites within the floodplain may be buried by vertical accretion of sediment, and/or the landforms that comprise the floodplain may be younger at some locations. The potential for archaeological sites at the surface and in the subsurface in the Finn Bayou area is considered to be very favorable. Both surfaces and buried sites are highly probable for Hrm2 and Hrm1.2 surfaces. Other locations occur in close proximity to crevasse channels.

Existing data suggest that the different floodplain components may extend into the late Holocene. Exact chronological boundaries are not possible with the limited data presently available. The archaeological record may provide additional evidence to determine more specific chronological boundaries and ages for the various floodplain features.

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Appendix A: Geomorphic Maps

Projection: Universal Transverse Mercator, Zone 15
Grid: Township and Range Grid with Section Numbers
Datum: 1927 North American Datum
Units: Meters
Latitude and Longitude Coordinates were generated for reference.
Background image is a scanned USGS 7.5' Quadrangle.

SCALE 1 : 24000

Projection: Universal Transverse Mercator, Zone 15
Grid: Township and Range Grid with Section Numbers
Datum: 1927 North American Datum
Units: Meters
Latitude and Longitude Coordinates were generated for reference.
Background image is a scanned USGS 7.5' Quadrangle.

SCALE 1 : 24000

Fouke, NE Quadrangle

- KEY TO MAP UNITS
- H8m — Present and former channel and point bar deposits of Red River meander belts. Meander belt 1 has discrete temporal subunits 1.0, 1.1 and 1.2, with locally mappable cross-cutting or accretionary phases. Hm2 is covered by backswamp clay. Meander belts are differentiated by following depositional environments:
- ac — abandoned channel
 - aco — abandoned course
 - nl — natural levee
 - pb — point bars
 - sp — crevasse splay
- H8G — Natural levee deposits of the Red River associated with overbank deposition near channels but without specific chronology.
- Hb — Backswamp sediments deposited in distal areas of the Red River flood plain.
- H8cc — Crevasse channels form alluviations across backswamps.
- H8cl — Crevasse levee associated with crevasse channels.
- Haf — Alluvial fans deposits of small streams along the valley walls.
- H1m — Present and former meander belt deposits of the Little River.
- H5m — Present and former meander belt deposits of the Sulphur River.
- Hs — Undifferentiated alluvium of small streams.
- Pd — Pleistocene Deweyville Complex.
- Pp — Pleistocene Prairie Complex.
- Pi — Pleistocene Intermediate Complex.
- Pm — Pleistocene Montgomery Terrace.
- Tc — Tertiary Claiborne Group.
- Tw — Tertiary Wilcox Group.
- Tm — Tertiary Midway Group.

- CHRONOLOGY
1.0 Modern	0 to 200 years B.P.
1.1 Late Prehistoric	200 to 1200 years B.P.
1.2 Intermediate	1200 to 4000 years B.P.
2. Old	> 4000 years B.P.
- Boring
- Levee
- N Cross Section

This map was produced by Applied Research Associates, Inc. using ArcInfo GIS software. The map was digitized using Intergraph Microstation software. Source data was obtained through interpretation by Alberson et al. USACE Waterways Experiment Station.

Projection: Universal Transverse Mercator, Zone 15
Grid: Township and Range Grid with Section Numbers
Datum: 1927 North American Datum
Units: Meters
Latitude and Longitude Coordinates were generated for reference.
Background image is a scanned USGS 7.5' Quadrangle.

US Army Corps
of Engineers

Appendix B: Geomorphic and Geologic Cross Sections

Plate 3

Plate 5

Plate 6

Plate 7

Plate 8

Plate 9

Plate 10

Plate 11

Plate 12

Appendix C: Red River Boring Log Reference Table

Table of Contents

Boyd Hill Quadrangle.....	72
Canfield Quadrangle	74
Doddridge Northeast Quadrangle	75
Doddridge Southeast Quadrangle.....	76
Fouke Northeast Quadrangle.....	77
Fulton Quadrangle	77
Garland Quadrangle.....	80
Spring Hill Quadrangle	81

Usage Boring No.	Reference Boring No.	Report Name	Mile No.	Quadrangle
1	374 L-5	Kenny Revetment	374	Boyd Hill
2	374 L-6	Corps of Engineers New Orleans	374	Boyd Hill
3	374 L-7	Corps of Engineers New Orleans	374	Boyd Hill
4	374 L-8	Corps of Engineers New Orleans	374	Boyd Hill
5	374 L-9	Corps of Engineers New Orleans	374	Boyd Hill
6	374 L-10	Corps of Engineers New Orleans	374	Boyd Hill
7	380 R-1	Mays Lake Realignment	381.5-377.	Boyd Hill
8	380 R-2	Corps of Engineers New Orleans	381.5-377.	Boyd Hill
9	380 R-3	Corps of Engineers New Orleans	381.5-377.	Boyd Hill
10	380 R-4	Corps of Engineers New Orleans	381.5-377.	Boyd Hill
11	384 R-1	Red Lake Revetment	384	Boyd Hill
12	384 R-1U	Corps of Engineers New Orleans	384	Boyd Hill
13	384 R-2	Corps of Engineers New Orleans	384	Boyd Hill
14	384 R-3	Corps of Engineers New Orleans	384	Boyd Hill
15	384 R-2U	Corps of Engineers New Orleans	384	Boyd Hill
16	384 R-4	Corps of Engineers New Orleans	384	Boyd Hill
17	373 R-3	Kenny Revetment	374	Boyd Hill
18	373 R-4	Corps of Engineers New Orleans	374	Boyd Hill
19	373 R-5	Corps of Engineers New Orleans	374	Boyd Hill
20	373 R-6	Corps of Engineers New Orleans	374	Boyd Hill
21	373 R-7	Corps of Engineers New Orleans	374	Boyd Hill
22	373 R-8	Corps of Engineers New Orleans	374	Boyd Hill
23	380 R-2	Beck Revetment	380	Boyd Hill
24	380 R-3	Corps of Engineers New Orleans	380	Boyd Hill
25	380 R-4	Corps of Engineers New Orleans	380	Boyd Hill
26	380 R-5	Corps of Engineers New Orleans	380	Boyd Hill
27	380 R-6	Corps of Engineers New Orleans	380	Boyd Hill
28	380 R-7	Corps of Engineers New Orleans	380	Boyd Hill
29	380 R-8	Corps of Engineers New Orleans	380	Boyd Hill
30	380 R-9	Corps of Engineers New Orleans	380	Boyd Hill
31	383 L-1	Boyd Revetment	383.1	Boyd Hill
32	383 L-2	Corps of Engineers New Orleans	383.1	Boyd Hill
33	383 L-3	Corps of Engineers New Orleans	383.1	Boyd Hill
34	383 L-4	Corps of Engineers New Orleans	383.1	Boyd Hill
35	383 L-5	Corps of Engineers New Orleans	383.1	Boyd Hill
36	383 L-6	Corps of Engineers New Orleans	383.1	Boyd Hill
37	708	Arkansas Lignite Investigations	I-82	Boyd Hill
38	709	Info. Cir. 28-C 1985	I-82	Boyd Hill
39	258	Info. Cir. 28-C 1985	Rt. 29	Boyd Hill
40	257	Info. Cir. 28-C 1985	Rt. 29	Boyd Hill
41	Bridge No. 5617	Arkansas State Highway Commission	Rt. 29	Boyd Hill
42	W-7	Geological Investigation Map	n/a	Boyd Hill
43	W-8	USGS 1:62500 Lewisville	n/a	Boyd Hill

Usage Boring No.	Reference Boring No.	Report Name	Mile No.	Quadrangle
44	W-18	USGS 1:62500 Lewisville	n/a	Boyd Hill
45	B5	Item 5	n/a	Boyd Hill
46	B9	Item 5	n/a	Boyd Hill
47	B10	Item 5	n/a	Boyd Hill
48	B11	Item 5	n/a	Boyd Hill
49	B12	Item 5	n/a	Boyd Hill
50	B13	Item 5	n/a	Boyd Hill
51	B14	Item 5	n/a	Boyd Hill
52	B15	Item 5	n/a	Boyd Hill
53	B16	Item 5	n/a	Boyd Hill
54	B17	Item 5	n/a	Boyd Hill
55	B18	Item 5	n/a	Boyd Hill
56	B19	Item 5	n/a	Boyd Hill
57	B20	Item 5	n/a	Boyd Hill
58	B21	Item 5	n/a	Boyd Hill
59	B22	Item 5	n/a	Boyd Hill
60	B23	Item 5	n/a	Boyd Hill
61	B24	Item 5	n/a	Boyd Hill
62	B25	Item 5	n/a	Boyd Hill
63	B26	Item 5	n/a	Boyd Hill
64	B27	Item 5	n/a	Boyd Hill
65	B28	Item 5	n/a	Boyd Hill
66	B29	Item 5	n/a	Boyd Hill
67	B30	Item 5	n/a	Boyd Hill
68	B31	Item 5	n/a	Boyd Hill
69	B32	Item 5	n/a	Boyd Hill
70	B33	Item 5	n/a	Boyd Hill
71	B34	Item 5	n/a	Boyd Hill
72	B35	Item 5	n/a	Boyd Hill
73	B36	Item 5	n/a	Boyd Hill
74	B37	Item 5	n/a	Boyd Hill
75	B38	Item 5	n/a	Boyd Hill
76	B39	Item 5	n/a	Boyd Hill
77	B40	Item 5	n/a	Boyd Hill
78	B1	Item 9 Below Dension Dam	n/a	Boyd Hill
79	B2	Item 9 Below Dension Dam	n/a	Boyd Hill
80	B3	Item 9 Below Dension Dam	n/a	Boyd Hill
81	B4	Item 9 Below Dension Dam	n/a	Boyd Hill
82	B5	Item 9 Below Dension Dam	n/a	Boyd Hill
83	B6	Item 9 Below Dension Dam	n/a	Boyd Hill
84	B7	Item 9 Below Dension Dam	n/a	Boyd Hill
85	B8	Item 9 Below Dension Dam	n/a	Boyd Hill
86	B9	Item 9 Below Dension Dam	n/a	Boyd Hill

Usage Boring No.	Reference Boring No.	Report Name	Mile No.	Quadrangle
87	B10	Item 9 Below Denson Dam	n/a	Boyd Hill
88	R23	Whitney Autin Soil Borings	n/a	Boyd Hill
89	R44	Louisiana State University	n/a	Boyd Hill
90	R33	Louisiana State University	n/a	Boyd Hill
91	R32	Louisiana State University	n/a	Boyd Hill
92	R36	Louisiana State University	n/a	Boyd Hill
93	R37	Louisiana State University	n/a	Boyd Hill
94	R40	Louisiana State University	n/a	Boyd Hill
95	R38	Louisiana State University	n/a	Boyd Hill
96	R46	Louisiana State University	n/a	Boyd Hill
97	R47	Louisiana State University	n/a	Boyd Hill
98	R45	Louisiana State University	n/a	Boyd Hill
99	R41	Louisiana State University	n/a	Boyd Hill
100	R43	Louisiana State University	n/a	Boyd Hill
101	R39	Louisiana State University	n/a	Boyd Hill
102	R42	Louisiana State University	n/a	Boyd Hill
1	352 L-1	Maniece Bayou Revetment	352.5	Canfield
2	352 L-2	Corps of Engineers New Orleans	352.5	Canfield
3	352 L-3	Corps of Engineers New Orleans	352.5	Canfield
4	352 L-4	Corps of Engineers New Orleans	352.5	Canfield
5	352 L-5	Corps of Engineers New Orleans	352.5	Canfield
6	352 L-6	Corps of Engineers New Orleans	352.5	Canfield
7	350 R-4	Corps of Engineers New Orleans	350	Canfield
8	350 R-5	Corps of Engineers New Orleans	350	Canfield
9	350 R-6	Corps of Engineers New Orleans	350	Canfield
10	350 R-7	Corps of Engineers New Orleans	350	Canfield
11	350 R-8	Corps of Engineers New Orleans	350	Canfield
12	350 R-9	Corps of Engineers New Orleans	350	Canfield
13	350 R-100	Corps of Engineers New Orleans	350	Canfield
14	350 R-11	Corps of Engineers New Orleans	350	Canfield
15	Bridge No. 450	Arkansas Highway Comm.-Dooley Creek	Rt.29	Canfield
16	355.5 L-1	Swan Lake Revetment	355.5	Canfield
17	355.5 L-2	Corps of Engineers New Orleans	355.5	Canfield
18	355.5 L-3	Corps of Engineers New Orleans	355.5	Canfield
19	355.5 L-4	Corps of Engineers New Orleans	355.5	Canfield
20	SL-1-83U	Corps of Engineers New Orleans	355.5	Canfield
21	SL-2-83U	Corps of Engineers New Orleans	355.5	Canfield
22	788	Arkansas Lignite Investigation	n/a	Canfield
23	787	Info. Cir. 28-C 1985	n/a	Canfield
24	786/1154	Info. Cir. 28-C 1985	n/a	Canfield
25	W-13	Geological Investigation Map	n/a	Canfield
26	W-4	USGS 1:62500 Bradley	n/a	Canfield
27	W-8	USGS 1:62500 Bradley	n/a	Canfield

Usage Boring No.	Reference Boring No.	Report Name	Mile No.	Quadrangle
28	B35	Item 9 Below Dension Dam	n/a	Canfield
29	B36	Item 9 Below Dension Dam	n/a	Canfield
30	B37	Item 9 Below Dension Dam	n/a	Canfield
31	B38	Item 9 Below Dension Dam	n/a	Canfield
32	B39	Item 9 Below Dension Dam	n/a	Canfield
33	B40	Item 9 Below Dension Dam	n/a	Canfield
38	GL-10-84	Goose Lake Realignment	348	Canfield
39	GL-1-84U	Corps of Engineers New Orleans	348	Canfield
40	GL-11-84	Corps of Engineers New Orleans	348	Canfield
41	GL-2-84U	Corps of Engineers New Orleans	348	Canfield
42	GL-3-84U	Corps of Engineers New Orleans	348	Canfield
43	GL-12-84	Corps of Engineers New Orleans	348	Canfield
44	GL-4-84U	Corps of Engineers New Orleans	348	Canfield
45	GL-13-84	Corps of Engineers New Orleans	348	Canfield
46	GL-5-84U	Corps of Engineers New Orleans	348	Canfield
47	GL-14-84U	Corps of Engineers New Orleans	348	Canfield
48	GL-6-84U	Corps of Engineers New Orleans	348	Canfield
49	GL-7-84U	Corps of Engineers New Orleans	348	Canfield
50	GL-8-84U	Corps of Engineers New Orleans	348	Canfield
51	GL-9-84U	Corps of Engineers New Orleans	348	Canfield
52	GL-15-84	Corps of Engineers New Orleans	348	Canfield
53	GL-16-84	Corps of Engineers New Orleans	348	Canfield
54	GL-117-84	Corps of Engineers New Orleans	348	Canfield
55	R69	Whitney Autin Soil Boring	348	Canfield
56	R70	Louisiana State University	348	Canfield
57	R71	Louisiana State University	348	Canfield
58	R72	Louisiana State University	348	Canfield
59	R73	Louisiana State University	348	Canfield
60	R74	Louisiana State University	348	Canfield
61	R75	Louisiana State University	348	Canfield
62	R76	Louisiana State University	348	Canfield
63	R85	Louisiana State University	348	Canfield
1	DR-1-94U	Dickson Revetment	343-346	Doddridge NE
2	DR-2-94U	Corps of Engineers Vicksburg	343-346	Doddridge NE
3	DR-3-94U	Corps of Engineers Vicksburg	343-346	Doddridge NE
4	DR-4-94U	Corps of Engineers Vicksburg	343-346	Doddridge NE
4	DR-5-94U	Corps of Engineers Vicksburg	343-346	Doddridge NE
6	DR-6-94U	Corps of Engineers Vicksburg	343-346	Doddridge NE
7	DR-7-94U	Corps of Engineers Vicksburg	343-346	Doddridge NE
8	DR-8-94U	Corps of Engineers Vicksburg	343-346	Doddridge NE
9	DR-9-94fU	Corps of Engineers Vicksburg	343-346	Doddridge NE
10	DR-10-94U	Corps of Engineers Vicksburg	343-346	Doddridge NE
11	DR-11-94U	Corps of Engineers Vicksburg	343-346	Doddridge NE

Usage Boring No.	Reference Boring No.	Report Name	Mile No.	Quadrangle
12	BBR-1-88	Brown Bend Realignment	339-342	Doddridge NE
13	BBR-2-88	Brown Bend Realignment	339-342	Doddridge NE
14	BBR-3-88	Brown Bend Realignment	339-342	Doddridge NE
15	BBR-4-88	Brown Bend Realignment	339-342	Doddridge NE
16	BBR-5-88	Brown Bend Realignment	339-342	Doddridge NE
17	BBR-6-88	Brown Bend Realignment	339-342	Doddridge NE
18	OR-1-85	Oak Revetment Extension	348-346	Doddridge NE
19	OR-2-85	Corps of Engineers Vicksburg	348-346	Doddridge NE
20	OR-3-85	Corps of Engineers Vicksburg	348-346	Doddridge NE
21	OR-4-85	Corps of Engineers Vicksburg	348-346	Doddridge NE
22	803	Arkansas Lignite Investigations	n/a	Doddridge NE
23	804	Info. Cir. 28C 1985	n/a	Doddridge NE
24	W-1	Geological Investigation Map	n/a	Doddridge NE
25	W-9	USGS 1:62500-Doddridge	n/a	Doddridge NE
26	W-10	USGS 1:62500-Doddridge	n/a	Doddridge NE
27	W-13	USGS 1:62500-Doddridge	n/a	Doddridge NE
28	W-8	USGS 1:62500-Doddridge	n/a	Doddridge NE
29	W-6	USGS 1:62500-Doddridge	n/a	Doddridge NE
30	R54	Whitney Autin Soil Borings	n/a	Doddridge NE
31	R55	Louisiana State University	n/a	Doddridge NE
32	R56	Louisiana State University	n/a	Doddridge NE
33	R57	Louisiana State University	n/a	Doddridge NE
34	R58	Louisiana State University	n/a	Doddridge NE
35	R59	Louisiana State University	n/a	Doddridge NE
36	R60	Louisiana State University	n/a	Doddridge NE
37	R61	Louisiana State University	n/a	Doddridge NE
38	R62	Louisiana State University	n/a	Doddridge NE
39	R77	Louisiana State University	n/a	Doddridge NE
40	R78	Louisiana State University	n/a	Doddridge NE
41	R79	Louisiana State University	n/a	Doddridge NE
1	805	Arkansas Lignite Investigation	n/a	Doddridge SE
2	1164	Info. Cir. 28-C 1985	n/a	Doddridge SE
3	806	Info. Cir. 28-C 1985	n/a	Doddridge SE
4	807	Info. Cir. 28-C 1985	n/a	Doddridge SE
5	225A	Info. Cir 28-C 1985	n/a	Doddridge SE
6	328 R-7	Missionary Revetment	326.4	Doddridge SE
7	328 R-8	Corps of Engineers New Orleans	326.4	Doddridge SE
8	328 R-9	October 1977	326.4	Doddridge SE
9	328 R-10	October 1977	326.4	Doddridge SE
10	328 R-11	October 1977	326.4	Doddridge SE
11	328 R-1	Halfmoon Revetment	329-325	Doddridge SE
12	328 R-2	Corps of Engineers New Orleans	329-325	Doddridge SE
13	328 R-3	Corps of Engineers New Orleans	329-325	Doddridge SE

Usage Boring No.	Reference Boring No.	Report Name	Mile No.	Quadrangle
14	328 R-4	Corps of Engineers New Orleans	329-325	Doddridge SE
15	335 R-5	Spring Bank Revetment	335.5	Doddridge SE
16	335 R-6	Corps of Engineers New Orleans	335.5	Doddridge SE
17	335 R-7	August 1979	335.5	Doddridge SE
18	335 R-8	August 1979	335.5	Doddridge SE
19	W-3	Geological Investigation Map	n/a	Doddridge SE
20	W-2	USGS 1:62500 Doddridge	n/a	Doddridge SE
1	701	Arkansas Lignite Investigation	n/a	Fouke NE
2	702	Info. Cir. 28-C 1985	n/a	Fouke NE
3	703	Info. Cir. 28-C 1985	n/a	Fouke NE
4	704	Info. Cir. 28-C 1985	n/a	Fouke NE
5	705	Info. Cir. 28-C 1985	n/a	Fouke NE
6	706	Info. Cir. 28-C 1985	n/a	Fouke NE
7	707	Info. Cir. 28-C 1985	n/a	Fouke NE
8	Bridge No. 860	Arkansas Highway Comm.-McKinney Bay	Rt. 82	Fouke NE
9	R25	Whitney Autin Soil Borings	n/a	Fouke NE
10	R26	Louisiana State University	n/a	Fouke NE
11	W-6	Geological Investigation Map USGS 1:62500 Fouke	n/a	Fouke NE
12	W-3	Geological Investigation Map USGS 1:62500 Fouke	n/a	Fouke NE
13	W-4	Geological Investigation Map USGS 1:62500 Fouke	n/a	Fouke NE
14	W-9	Geological Investigation Map SGS 1:62500 Fouke	n/a	Fouke NE
15	R28	Whitney Autin Soil Borings	n/a	Fouke NE
16	R27	Louisiana State University	n/a	Fouke NE
17	R34	Louisiana State University	n/a	Fouke NE
18	R35	Louisiana State University	n/a	Fouke NE
1	FR-1	RR Waterway - Fulton Revetment	401.7-402.3	Fulton
2	FR-2	Corps of Engineers - April 1987	401.7-402.3	Fulton
3	OR-1	RR Waterway-Mo Pac 30 Revetment	403	Fulton
4	OR-2	Corps of Engineers Soils Report	403	Fulton
5	OR-3	August 1983	403	Fulton
6	OR-4	August 1983	403	Fulton
7	OR-5	August 1983	403	Fulton
8	OR-6	August 1983	403	Fulton
9	OR-7	August 1983	403	Fulton
10	OR-8	August 1983	403	Fulton
11	397L-1	RR Waterway - Bushy Revetment	397	Fulton
12	397L-2	Corps of Engineers Soils Report	397	Fulton
13	397L-3	November 1978	397	Fulton
14	397L-4	November 1978	397	Fulton

Usage Boring No.	Reference Boring No.	Report Name	Mile No.	Quadrangle
15	397L-5	November 1978	397	Fulton
16	397L-6	November 1978	397	Fulton
17	397L-7	November 1978	397	Fulton
18	397L-8	November 1978	397	Fulton
19	398.2 R-1	RR Waterway - Kuykendall Revetment	397 to 399	Fulton
20	398.2 R-2	Corps of Engineers Soils Report	397 to 399	Fulton
21	398.2 R-3	July 1983	397 to 399	Fulton
22	398.2 R-4	July 1983	397 to 399	Fulton
23	398.2 R-5	July 1983	397 to 399	Fulton
24	398.2 R-6	July 1983	397 to 399	Fulton
25	398.2 R-7	July 1983	397 to 399	Fulton
26	398.2 R-8	July 1983	397 to 399	Fulton
27	398.2 R-9	July 1983	397 to 399	Fulton
28	BDD4-1-94U	RR Below Dension Dam	n/a	Fulton
29	BDD4-2-94U	Corps of Engineers Vicksburg	n/a	Fulton
30	BDD4-3-94U	Maps and Boring Logs November 1994	n/a	Fulton
31	BDD4-4-94U	Maps and Boring Logs November 1994	n/a	Fulton
32	BDD4-5-94U	Maps and Boring Logs November 1994	n/a	Fulton
33	BDD4-6-94U	Maps and Boring Logs November 1994	n/a	Fulton
34	BDD4-7-94U	Maps and Boring Logs November 1994	n/a	Fulton
35	BDD4-8-94U	Maps and Boring Logs November 1994	n/a	Fulton
36	BDD4-1-94B	Maps and Boring Logs November 1994	n/a	Fulton
37	BDD4-2-94B	Maps and Boring Logs November 1994	n/a	Fulton
38	BDD4-3-94B	Maps and Boring Logs November 1994	n/a	Fulton
39	BDD4-4-94B	Maps and Boring Logs November 1994	n/a	Fulton
40	BDD4-5-94B	Maps and Boring Logs November 1994	n/a	Fulton
41	BDD4-6-94B	Maps and Boring Logs November 1994	n/a	Fulton
42	BDD4-6A-94B	Maps and Boring Logs November 1994	n/a	Fulton
43	BDD4-7-94B	Maps and Boring Logs November 1994	n/a	Fulton
44	BDD4-8-94B	Maps and Boring Logs November 1994	n/a	Fulton
45	BDD4-9-94B	Maps and Boring Logs November 1994	n/a	Fulton
46	BDD4-10-94B	Maps and Boring Logs November 1994	n/a	Fulton
47	BDD4-11-94B	Maps and Boring Logs November 1994	n/a	Fulton
48	BDD4-12-94B	Maps and Boring Logs November 1994	n/a	Fulton
49	BDD4-13-94B	Maps and Boring Logs November 1994	n/a	Fulton
50	BDD4-14-94B	Maps and Boring Logs November 1994	n/a	Fulton
51	BDD4-15-94B	Maps and Boring Logs November 1994	n/a	Fulton
52	BR3797A	Arkansas State Highway Int. 30	I-30	Fulton
53	BR3797B	pp 122-123, 8-27-63	Gill. Ditch	Fulton
54	R-1	Whitney Autin - Soil Borings	n/a	Fulton
55	R-2	Louisiana State University	n/a	Fulton
56	R-3	Louisiana State University	n/a	Fulton
57	R-4	Louisiana State University	n/a	Fulton

Usage Boring No.	Reference Boring No.	Report Name	Mile No.	Quadrangle
58	R-5	Louisiana State University	n/a	Fulton
59	R-6	Louisiana State University	n/a	Fulton
60	R-7	Louisiana State University	n/a	Fulton
61	R-8	Louisiana State University	n/a	Fulton
62	R-9	Louisiana State University	n/a	Fulton
63	R-10	Louisiana State University	n/a	Fulton
64	R-11	Louisiana State University	n/a	Fulton
65	R-12	Louisiana State University	n/a	Fulton
66	R-13	Louisiana State University	n/a	Fulton
67	R-14	Louisiana State University	n/a	Fulton
68	R-15	Louisiana State University	n/a	Fulton
69	R-16	Louisiana State University	n/a	Fulton
70	R-17	Louisiana State University	n/a	Fulton
71	R-18	Louisiana State University	n/a	Fulton
72	R-19	Louisiana State University	n/a	Fulton
73	R-20	Louisiana State University	n/a	Fulton
74	R-21	Louisiana State University	n/a	Fulton
75	R-22	Louisiana State University	n/a	Fulton
76	AH-2	Geological Investigation Map	n/a	Fulton
77	AH-4	USGS Scale 1 = 62500	n/a	Fulton
78	AH-5	USGS Scale 1 = 62500	n/a	Fulton
79	GS-8	USGS Scale 1 = 62500	n/a	Fulton
80	BDD5-1-95G	RR Waterway Below Dension	n/a	Fulton
81	BDD5-2-95G	Dam - Item 5	n/a	Fulton
82	BDD5-3-95G	Corps of Engineers Soils Report	n/a	Fulton
83	BDD5-4-95G	March 8, 1995	n/a	Fulton
84	BDD5-5-95G	March 8, 1995	n/a	Fulton
85	BDD5-6-95G	March 8, 1995	n/a	Fulton
86	BDD5-7-95G	March 8, 1995	n/a	Fulton
87	BDD5-8-95G	March 8, 1995	n/a	Fulton
88	BDD3-5-94U	RR Waterway Below Dension	n/a	Fulton
89	BDD3-6-94U	Dam - Item 3	n/a	Fulton
90	BDD3-7-94U	Corps of Engineers Soils Report	n/a	Fulton
91	BDD3-14-94B	October 1994	n/a	Fulton
92	BDD3-15-94B	October 1994	n/a	Fulton
93	BDD3-16-94B	October 1994	n/a	Fulton
94	BDD3-17-94B	October 1994	n/a	Fulton
95	BDD3-18-94B	October 1994	n/a	Fulton
96	BDD3-19-94B	October 1994	n/a	Fulton
97	BDD3-20-94B	October 1994	n/a	Fulton
98	BDD3-21-94B	October 1994	n/a	Fulton
99	BDD3-22-94B	October 1994	n/a	Fulton
100	R30	Whitney Autin - Soil Borings	n/a	Fulton

Usage Boring No.	Reference Boring No.	Report Name	Mile No.	Quadrangle
101	R31	Louisiana State University	n/a	Fulton
102	R29	Louisiana State University	n/a	Fulton
103	R86	Louisiana State University	n/a	Fulton
104	R87	Louisiana State University	n/a	Fulton
42	CL-1-87U	Candler Lake Revetment Extension	365-364	Garland
43	CL-2-87U	Corps of Engineers Vicksburg	365-364	Garland
44	CL-3-87U	Corps of Engineers Vicksburg	365-364	Garland
45	CL-4-87U	Corps of Engineers Vicksburg	365-364	Garland
46	B41	Item 5	n/a	Garland
47	B42	Item 5	n/a	Garland
48	B43	Item 5	n/a	Garland
49	B44	Item 5	n/a	Garland
50	B45	Item 5	n/a	Garland
51	B11	Item 9 Below Denson Dam	n/a	Garland
52	B12	Item 9 Below Denson Dam	n/a	Garland
53	B13	Item 9 Below Denson Dam	n/a	Garland
54	B14	Item 9 Below Denson Dam	n/a	Garland
55		Item 9 Below Denson Dam	n/a	Garland
56	B15	Item 9 Below Denson Dam	n/a	Garland
57	B16	Item 9 Below Denson Dam	n/a	Garland
58	B17	Item 9 Below Denson Dam	n/a	Garland
59	B18	Item 9 Below Denson Dam	n/a	Garland
60	B19	Item 9 Below Denson Dam	n/a	Garland
61	B20	Item 9 Below Denson Dam	n/a	Garland
62	B21	Item 9 Below Denson Dam	n/a	Garland
63	B22	Item 9 Below Denson Dam	n/a	Garland
64	B23	Item 9 Below Denson Dam	n/a	Garland
65	B24	Item 9 Below Denson Dam	n/a	Garland
66	B25	Item 9 Below Denson Dam	n/a	Garland
67	B26	Item 9 Below Denson Dam	n/a	Garland
68	B27	Item 9 Below Denson Dam	n/a	Garland
69	B28	Item 9 Below Denson Dam	n/a	Garland
70	B29	Item 9 Below Denson Dam	n/a	Garland
71	B30	Item 9 Below Denson Dam	n/a	Garland
72	B31	Item 9 Below Denson Dam	n/a	Garland
73	B32	Item 9 Below Denson Dam	n/a	Garland
74	B34	Item 9 Below Denson Dam	n/a	Garland
75	R48	Whitney Autin LSU Soil Borings	n/a	Garland
76	R49	Whitney Autin LSU Soil Borings	n/a	Garland
77	R50	Whitney Autin LSU Soil Borings	n/a	Garland
78	R51	Whitney Autin LSU Soil Borings	n/a	Garland
79	R52	Whitney Autin LSU Soil Borings	n/a	Garland
80	R53	Whitney Autin LSU Soil Borings	n/a	Garland

Usage Boring No.	Reference Boring No.	Report Name	Mile No.	Quadrangle
81	R63	Whitney Autin LSU Soil Borings	n/a	Garland
82	R64	Whitney Autin LSU Soil Borings	n/a	Garland
83	R65	Whitney Autin LSU Soil Borings	n/a	Garland
84	R66	Whitney Autin LSU Soil Borings	n/a	Garland
84	R67	Whitney Autin LSU Soil Borings	n/a	Garland
86	R68	Whitney Autin LSU Soil Borings	n/a	Garland
1	252	Arkansas Lignite Investigation	n/a	Spring Hill
2	1168	Info. Cir. 28-C 1985	n/a	Spring Hill
3	251	Info. Cir. 28-C 1985	n/a	Spring Hill
4	250	Info. Cir. 28-C 1985	n/a	Spring Hill
5	249	Info. Cir. 28-C 1985	n/a	Spring Hill
6	248	Info. Cir. 28-C 1985	n/a	Spring Hill
7	SA-1	Geological Investigation Map-Hop	n/a	Spring Hill
8	390 R-3	Hervey Revetment	389.2	Spring Hill
9	390 R-4	Corps of Engineers New Orleans	389.2	Spring Hill
10	390 R-5	March 1977	389.2	Spring Hill
11	Bridge No. 6127	Arkansas State Highway Comm.-Goss Creek	Rt. 174	Spring Hill

Appendix D: Soil Borings

R-01

Sec 2 T14S R27W

Fulton

11-14-1994

G.S.E. 264.1

RED RIVER FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-02

Sec1 T14S R27W

Fulton

11-14-1994

G.S.E. 254.9

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-04

Sec6 T14S R26W

Fulton

11-14-1994

G.S.E. 252.0

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-05
 Sec26 T13S R27W
 Fulton
 11-14-1994
 G.S.E. 262.1

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-06
 Sec11 T14S R26W
 Fulton
 11-14-1994
 G.S.E. 248.0

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-07

Sec14 T14S R26W

Fulton

11-14-1994

G.S.E. 242.1

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-12
Sec11 T.14S R26W
Fulton
11-15-1994
G.S.E. 242.1

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-13

Sec32 T13S R26W

Fulton

11-16-1994

G.S.E. 254.9

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-14
 Sec4 T14S R26W
 Fulton
 11-16-1994
 G.S.E. 252.0

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-16
 Sec15 T14S R26W
 Fulton
 11-16-1994
 G.S.E. 245.1

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-18
 Sec14 T13S R27W
 Fulton
 11-16-1994
 G.S.E. 259.8

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-19
 Sec19 T--N R--W
 Fulton
 11-16-1994
 G.S.E. 252.0

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-22
 Sec25 T14S R27W
 Fulton
 11-17-1994
 G.S.E. 250.0

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-26

Sec 3 T14S R26W

Fouke NW

06-26-1995

G.S.E. 243.1

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-28
 Sec 8 T15S R26W
 Fulton
 06-26-1995
 G.S.E. 236.9

R-30
 Sec24 T14S R27W
 Fulton
 06-27-1995
 G.S.E. 251.0

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-31
 Sec23 T14N R27W
 Fulton
 06-27-1995
 G.S.E. 253.0

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-32

Sec31 +15S R25W

Boyd Hill

06-27-1995

G.S.E. 233.9

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-34
 Sec34 T15S R26W
 Fouke NE
 06-27-1995
 G.S.E. 227.0

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-35
 Sec33 T15S R26W
 Fouke NE
 06-28-1995
 G.S.E. 228.0

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-36

Sec3 T16S R25W

Boyd Hill

06-28-1995

G.S.E. 230:0

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-37

Sec36 T15S R25W

Boyd Hill

06-28-1995

G.S.E. 230.0

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-38

Sec26 T15N R25W

Boyd Hill

06-28-1995

G.S.E. 234.9

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-39

Sec24 T15S R25W

Boyd Hill

06-28-1995

G.S.E. 232.0

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-40

Sec27 T15S R25W

Boyd Hill

06-28-1995

G.S.E. 237.9

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-41

Sec9 T15S R25W

Boyd Hill

06-29-1995

G.S.E. 242.1

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-42
 Sec8 T15S R25W
 Boyd Hill
 06-29-1995
 G.S.E. 240.2

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-43

Sec9 T15S R25W

Boyd Hill

06-29-1995

G.S.E. 237.9

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-44
 Sec9 T15S R25W
 Boyd Hill
 06-29-1995
 G.S.E. 243.1

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-45
 Sec40 T15S R25W
 Boyd Hill
 06-29-1995
 G.S.E. 242.1

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-46

Sec15 T15S R25W

Boyd Hill

06-29-1995

G.S.E. 242.1

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-47
 Sec14 +15S R25W
 Boyd Hill
 06-29-1995
 G.S.E. 242.1

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-48
 Sec30 T16S R25W
 Garland
 06-30-1995
 G.S.E. 220.1

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-49

Sec29 T16S R25W

Garland

07-17-1995

G.S.E. 227.0

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-50
 Sec29 T15S R25W
 Garland
 07-17-1995
 G.S.E. 225.1

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-53
 Sec13 T17N R24W
 Garland
 07-17-1995
 G.S.E. 217.8

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-54
 Sec11 T18S R26W
 Doddridge NE
 07-17-1995
 G.S.E. 215.9

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-56

Sec15 T18S R26W

Doddridge NE

07-18-1995

G.S.E. 214.9

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-58

Sec 22 T18N R26W

Doddridge NE

07-18-1995

G.S.E. 210.0

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-59
 Sec27 T18S R26W
 Doddridge NE
 07-18-1995
 G.S.E. 211.9

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-61

Sec30 T18N R26W

Doddridge NE

07-18-1995

G.S.E. 210.0

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-63
 Sec35 T16S R25W
 Garland
 01-19-1995
 G.S.E. 225.1

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-64
 Sec35 T16S R25W
 Garland
 07-19-1995
 G.S.E. 230.0

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-65
 Sec34 T16N R25W
 Garland
 07-19-1995
 G.S.E. 225.1

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-66

Sec23 T17S R25W

Garland

07-19-1995

G.S.E. 220.1

R-67
 Sec15 T17S R25W
 Garland
 07-19-1995
 G.S.E. 220.1

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-69

Sec34 T17S R25W

Canfield

07-19-1995

G.S.E. 220.1

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-70
 Sec4 T18S R25W
 Canfield
 07-20-1995
 G.S.E. 219.2

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-71

Sec4 T18S R25W

Canfield

07-20-1995

G.S.E. 219.2

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-72
 Sec17 T18S R25W
 Canfield
 07-20-1995
 G.S.E. 219.2

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-73
 Sec16 T18S R25W
 Canfield
 07-20-1995
 G.S.E. 219.2

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-74
 Sec30 T18S R25W
 Canfield
 07-20-1995
 G.S.E. 214.9

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-75
Sec29 T18S R25W
Canfield
07-20-1995
G.S.E. 214.9

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-76
 Sec29 T18S R25W
 Canfield
 07-20-1995
 G.S.E. 212.9

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-77

Sec36 T18S R26W

Doddridge NE

07-21-1995

G.S.E. 213.9

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-78

Sec1 T19S R26W

Doddridge NE

07-21-1995

G.S.E. 210.0

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-79

Sec4 T19S R26W

Doddridge NE

07-21-1995

G.S.E. 212.9

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-80
Sec10 T19S R26W
Doddridge SE
07-21-1995
G.S.E. 210.0

R-81
 Sec33 T19S R26W
 Doddridge SE
 07-21-1995
 G.S.E. 205.1

RECEIVED FROM FIELDWORK, ARKANSAS STATE UNIVERSITY, ARKANSAS

R-82
 Sec33 T19S R26W
 Doddridge SE
 07-21-1995
 G.S.E. 206.0

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-84

Sec3 T20N R26W

Doddridge SE

07-22-1995

G.S.E. 200.1

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-85

Sec2 T18S R18W

Canfield

07-22-1995

G.S.E. 214.9

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-86
 Sec12 T14S R26W
 Fulton
 07-23-1995
 G.S.E. 245.1

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

R-87
 Sec11 T14S R26W
 Fulton
 07-23-1995
 G.S.E. 250.0

RED RIVER, FULTON, ARKANSAS TO LOUISIANA STATE LINE

Appendix E: Radiometric Age Dates

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-10.5; lab mult.=1)

Laboratory Number: Beta-90042

Conventional radiocarbon age: 780 +/- 60 BP

Calibrated results:
(2 sigma, 95% probability) cal AD 1170 to 1300

Intercept data:

Intercept of radiocarbon age
with calibration curve: cal AD 1265

1 sigma calibrated results:
(68% probability) cal AD 1220 to 1285

References:

- Pretoria Calibration Curve for Short Lived Samples*
 Vogel, J. C., Fuls, A., Visser, E. and Becker, B., 1993, *Radiocarbon* 35(1), p73-86
A Simplified Approach to Calibrating C14 Dates
 Talma, A. S. and Vogel, J. C., 1993, *Radiocarbon* 35(2), p317-322
Calibration - 1993
 Stuiver, M., Long, A., Kra, R. S. and Devine, J. M., 1993, *Radiocarbon* 35(1)

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.9; lab mult.=1)

Laboratory Number: Beta-90043

Conventional radiocarbon age: 4520 $\pm$ 60 BP

Calibrated results: cal BC 3365 to 3025 and
(2 sigma, 95% probability) cal BC 2970 to 2940

Intercept data:

Intercepts of radiocarbon age
with calibration curve:

cal BC 3320 and
cal BC 3220 and
cal BC 3180 and
cal BC 3165 and
cal BC 3130

1 sigma calibrated results: cal BC 3350 to 3090
(68% probability)

References:

- Pretoria Calibration Curve for Short Lived Samples*
 Vogel, J. C., Fuls, A., Visser, E. and Becker, B., 1993, *Radiocarbon* 35(1), p73-86
A Simplified Approach to Calibrating C14 Dates
 Talma, A. S. and Vogel, J. C., 1993, *Radiocarbon* 35(2), p317-322
Calibration - 1993
 Stuiver, M., Long, A., Kra, R. S. and Devine, J. M., 1993, *Radiocarbon* 35(1)

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-27.3;lab. mult=1)

Laboratory Number: Beta-90044

Conventional radiocarbon age: 260 +/- 60 BP

Calibrated results:
(2 sigma, 95% probability) cal AD 1485 to 1690 and
cal AD 1735 to 1815 and
cal AD 1925 to 1950

Intercept data:

Intercept of radiocarbon age
with calibration curve: cal AD 1655

1 sigma calibrated results:
(68% probability) cal AD 1535 to 1545 and
cal AD 1635 to 1670 and
cal AD 1780 to 1795 and
cal AD 1945 to 1950

References:

- Pretoria Calibration Curve for Short Lived Samples*
 Vogel, J. C., Fuls, A., Visser, E. and Becker, B., 1993, *Radiocarbon* 35(1), p73-86
A Simplified Approach to Calibrating C14 Dates
 Talma, A. S. and Vogel, J. C., 1993, *Radiocarbon* 35(2), p317-322
Calibration - 1993
 Stuiver, M., Long, A., Kra, R. S. and Devine, J. M., 1993, *Radiocarbon* 35(1)

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-21.7; lab mult.=1)

Laboratory Number: Beta-90045

Conventional radiocarbon age: 3200 +/- 60 BP

Calibrated results: cal BC 1605 to 1380 and
(2 sigma, 95% probability) cal BC 1335 to 1330

Intercept data:

Intercept of radiocarbon age
with calibration curve: cal BC 1440

1 sigma calibrated results: cal BC 1515 to 1410
(68% probability)

References:

- Pretoria Calibration Curve for Short Lived Samples*
 Vogel, J. C., Fuls, A., Visser, E. and Becker, B., 1993, *Radiocarbon* 35(1), p73-86
- A Simplified Approach to Calibrating C14 Dates*
 Talma, A. S. and Vogel, J. C., 1993, *Radiocarbon* 35(2), p317-322
- Calibration - 1993*
 Stuiver, M., Long, A., Kra, R. S. and Devine, J. M., 1993, *Radiocarbon* 35(1)

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.1; lab mult.=1)

Laboratory Number: Beta-90046

Conventional radiocarbon age: 4610 $\pm$ 60 BP

Calibrated results: cal BC 3515 to 3285 and
(2 sigma, 95% probability) cal BC 3245 to 3105

Intercept data:

Intercept of radiocarbon age
with calibration curve: cal BC 3360

1 sigma calibrated results: cal BC 3490 to 3455 and
(68% probability) cal BC 3375 to 3340

References:

- Pretoria Calibration Curve for Short Lived Samples*
 Vogel, J. C., Fuls, A., Visser, E. and Becker, B., 1993, *Radiocarbon* 35(1), p73-86
A Simplified Approach to Calibrating C14 Dates
 Talma, A. S. and Vogel, J. C., 1993, *Radiocarbon* 35(2), p317-322
Calibration - 1993
 Stuiver, M., Long, A., Kra, R. S. and Devine, J. M., 1993, *Radiocarbon* 35(1)

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-31.2; lab mult.=1)

Laboratory Number: Beta-90047

Conventional radiocarbon age: 1260 +/- 70 BP

Calibrated results: cal AD 650 to 960
(2 sigma, 95% probability)

Intercept data:

Intercept of radiocarbon age
with calibration curve: cal AD 775

1 sigma calibrated results: cal AD 680 to 875
(68% probability)

References:

- Pretoria Calibration Curve for Short Lived Samples*
 Vogel, J. C., Fuls, A., Visser, E. and Becker, B., 1993, *Radiocarbon* 35(1), p73-86
A Simplified Approach to Calibrating C14 Dates
 Talma, A. S. and Vogel, J. C., 1993, *Radiocarbon* 35(2), p317-322
Calibration - 1993
 Stuiver, M., Long, A., Kra, R. S. and Devine, J. M., 1993, *Radiocarbon* 35(1)

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-29.1; lab mult.=1)

Laboratory Number: Beta-90048

Conventional radiocarbon age: 280 +/- 60 BP

Calibrated results:
(2 sigma, 95% probability) cal AD 1470 to 1680 and
cal AD 1745 to 1805 and
cal AD 1935 to 1950

Intercept data:

Intercept of radiocarbon age
with calibration curve: cal AD 1650

1 sigma calibrated results:
(68% probability) cal AD 1520 to 1570 and
cal AD 1630 to 1665

References:

- Pretoria Calibration Curve for Short Lived Samples*
Vogel, J. C., Fuls, A., Visser, E. and Becker, B., 1993, *Radiocarbon* 35(1), p73-86
- A Simplified Approach to Calibrating C14 Dates*
Talma, A. S. and Vogel, J. C., 1993, *Radiocarbon* 35(2), p317-322
- Calibration - 1993*
Stuiver, M., Long, A., Kra, R. S. and Devine, J. M., 1993, *Radiocarbon* 35(1)

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-27.7; lab mult.=1)

Laboratory Number: Beta-90049

Conventional radiocarbon age: 100 +/- 60 BP

Calibrated results:
(2 sigma, 95% probability) cal AD 1665 to 1950

Intercept data:

Intercepts of radiocarbon age
with calibration curve: cal AD 1890 and
cal AD 1905

1 sigma calibrated results:
(68% probability) cal AD 1680 to 1745 and
cal AD 1805 to 1935

References:

- Pretoria Calibration Curve for Short Lived Samples*
 Vogel, J. C., Fuls, A., Visser, E. and Becker, B., 1993, *Radiocarbon* 35(1), p73-86
A Simplified Approach to Calibrating C14 Dates
 Talma, A. S. and Vogel, J. C., 1993, *Radiocarbon* 35(2), p317-322
Calibration - 1993
 Stuiver, M., Long, A., Kra, R. S. and Devine, J. M., 1993, *Radiocarbon* 35(1)

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: estimated C13/C12=-25:lab mult.=1)

Laboratory Number: Beta-90050

Conventional radiocarbon age*: 250 +/- 70 BP

Calibrated results: cal AD 1475 to 1825 and
(2 sigma, 95% probability) cal AD 1835 to 1880 and
cal AD 1915 to 1950

* C13/C12 ratio estimated

Intercept data:

Intercept of radiocarbon age
with calibration curve: cal AD 1655

1 sigma calibrated results: cal AD 1535 to 1545 and
(68% probability) cal AD 1635 to 1675 and
cal AD 1770 to 1800 and
cal AD 1940 to 1950

References:

- Pretoria Calibration Curve for Short Lived Samples*
Vogel, J. C., Fuls, A., Visser, E. and Becker, B., 1993, *Radiocarbon* 35(1), p73-86
- A Simplified Approach to Calibrating C14 Dates*
Talma, A. S. and Vogel, J. C., 1993, *Radiocarbon* 35(2), p317-322
- Calibration - 1993*
Stuiver, M., Long, A., Kra, R. S. and Devine, J. M., 1993, *Radiocarbon* 35(1)

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				5b. GRANT NUMBER W81EWF80730125	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Paul E. Albertson, Maureen K. Corcoran, Whitney Autin, John Kruger, and Theresa Foster				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
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14. ABSTRACT The U.S. Army Engineer District, Vicksburg, conducted feasibility studies to rehabilitate the levees along the Red River from Fulton, AR, to the Arkansas-Louisiana state line. In support of these studies, research was performed by the U.S. Army Engineer Research and Development Center to provide a geomorphic framework for cultural resources in the project area. This research had three specific objectives: (1) identify and map geomorphic features in the study area on 1:24,000 scale maps, (2) define geomorphic processes that are active in the study area, and (3) reconstruct the geomorphic development of the study area to understand the significance of geomorphic features in terms of both locating previously unknown archaeological sites and discovering buried sites. Field investigations and aerial photography were used to interpret the geomorphology. Approximately 6 percent of the known archeological sites are located above the floodplain on valley slopes or bluffs. The remaining 94 percent of the sites are associated with the floodplain of the various fluvial components that form the study area. Forty-six percent of flood-plain sites are located adjacent to crevasse channels. Other known archaeological sites are primarily located on the natural levee or adjacent point bars.					
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16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES 185	19a. NAME OF RESPONSIBLE PERSON Maureen K. Corcoran
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