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Geomorphic History of the Atchafalaya Backwater Area: Upper Deltaic Plain Development

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Geomorphic History of the Atchafalaya Backwater Area: Upper Deltaic Plain Development

A Dissertation

Submitted to the Graduate Faculty of the
University of New Orleans
in partial fulfillment of the
requirements for the degree of

Doctor of Philosophy
in
Engineering and Applied Science

by

Louis D. Britsch III

B.S. Nicholls State University, 1981
M.S. Tulane University, 1984

December, 2007

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Abstract

Earlier researchers have produced conceptual models of Mississippi River delta plain development which divide the deltaic plain into upper and lower reaches. The upper deltaic plain has been described as an area composed mainly of lacustrine, lacustrine delta, backswamp, and crevasse channels, with minimal distributary development. The lower deltaic plain is characterized by numerous distributaries forming distributary systems and lobes. Detailed geomorphic mapping and chronologic reconstruction within the Atchafalaya Backwater Area of the upper deltaic plain of the Mississippi River has led to the recognition of a complex network of distributary development related to three distinct distributary systems that formed in the upper deltaic plain over the past 2500 years. These systems do not fit previous models of upper deltaic plain development. The East Atchafalaya Basin Protection Levee blocked Atchafalaya River water and sediment from entering the study area and burying these older distributary systems, preserving their surface expression and allowing their identification. Results show that distributary systems can be a major contributor to upper deltaic plain development and that these systems are not always related to the lower delta plain delta switching process. A stable Mississippi River position and a favorable gradient in the study area over the past 4,000 years appear to be responsible for the geomorphic development of the study area.

Keywords: upper deltaic plain, Mississippi River, distributary system, geomorphic

Introduction

The Mississippi River deltaic plain has been the focus of numerous investigations which documented the geomorphic development and proposed models for delta development. These previous investigations recognized delta systems in the lower deltaic plain which developed as bayhead and shelf-edge deltas where marine processes were acting at their margins. Detailed geomorphic mapping within the upper deltaic plain of the Mississippi River has led to the delineation of three distributary systems, allowing new observations about the formation and character of upper deltaic plain deposits. The East Atchafalaya Basin Protection Levee blocked Atchafalaya River sediments from entering the study area and burying these older distributary features, preserving their surface expression and allowing their identification. Detailed geomorphic examination of this northwestern portion of the deltaic plain has not been conducted to date. Previous investigations have focused on the development of delta lobes and distributary systems within the lower deltaic plain. This dissertation focuses on the geologic events which led to the formation of upper deltaic plain distributary systems. The study area contains deltaic sediments related to at least three episodes of late Holocene (~ last 4000 yrs.) delta development above Pleistocene sediments. This has resulted in a complex setting in which to investigate upper deltaic plain evolution and the resulting geomorphic landscape.

The three main objectives of this dissertation are to: a) define and delineate the geomorphic features and outline the facies character of the upper deltaic plain deposits in the study area; b) reconstruct, to the extent possible, the chronologic development of the distributary systems; and c) define the geologic events which led to their development.

Multiple delta lobe progradations in the late Holocene has resulted in a complex geomorphic setting on the deltaic plain characterized by a variety of depositional environments. Understanding the geomorphic development of the deltaic plain provides insight into how deltas form, the chronology and duration of delta lobe development, sea level history, depositional environments, and human occupation of the coast.

Background

Regional Physiographic Setting

The geomorphic development of coastal Louisiana is closely related to shifting Mississippi River courses since the slowing of Holocene post-glacial sea level rise (Fisk, 1955; Frazier, 1967; and Coleman and Gagliano, 1964). The Mississippi River has changed its course several times during the last 7,000 years, leading to the development of the Mississippi River deltaic and chenier plains. The deltaic plain is composed of several major delta complexes, two of which (the Plaquemines/Modern and Atchafalaya) are still active (Fig. 1). Delta plains have been identified as first-order elements of the Holocene sedimentary package and are built of multiple delta complexes (Roberts, 1997). Delta complexes are constructed from overlapping delta lobes over 1,000 to 2,000 year time spans, and represent second-order stratigraphic elements. Delta lobes are third order elements of the stratigraphic hierarchy and are linked to a trunk distributary. Fourth order subdeltas form delta lobes by filling interdistributary bays with sediment from distributaries branching off the trunk distributary of the delta lobe. The result is that multiple subdeltas overlap to create delta lobes, which in turn overlap to create a delta complex. Dominant physiographic features of the deltaic plain include abandoned courses and distributaries and their associated natural levees, swamps, marsh, hundreds of lakes and bays, and barrier islands. Elevations range from near mean sea level in the marshes to 25 ft (7.6 m) on the natural levees adjacent to the Mississippi River.

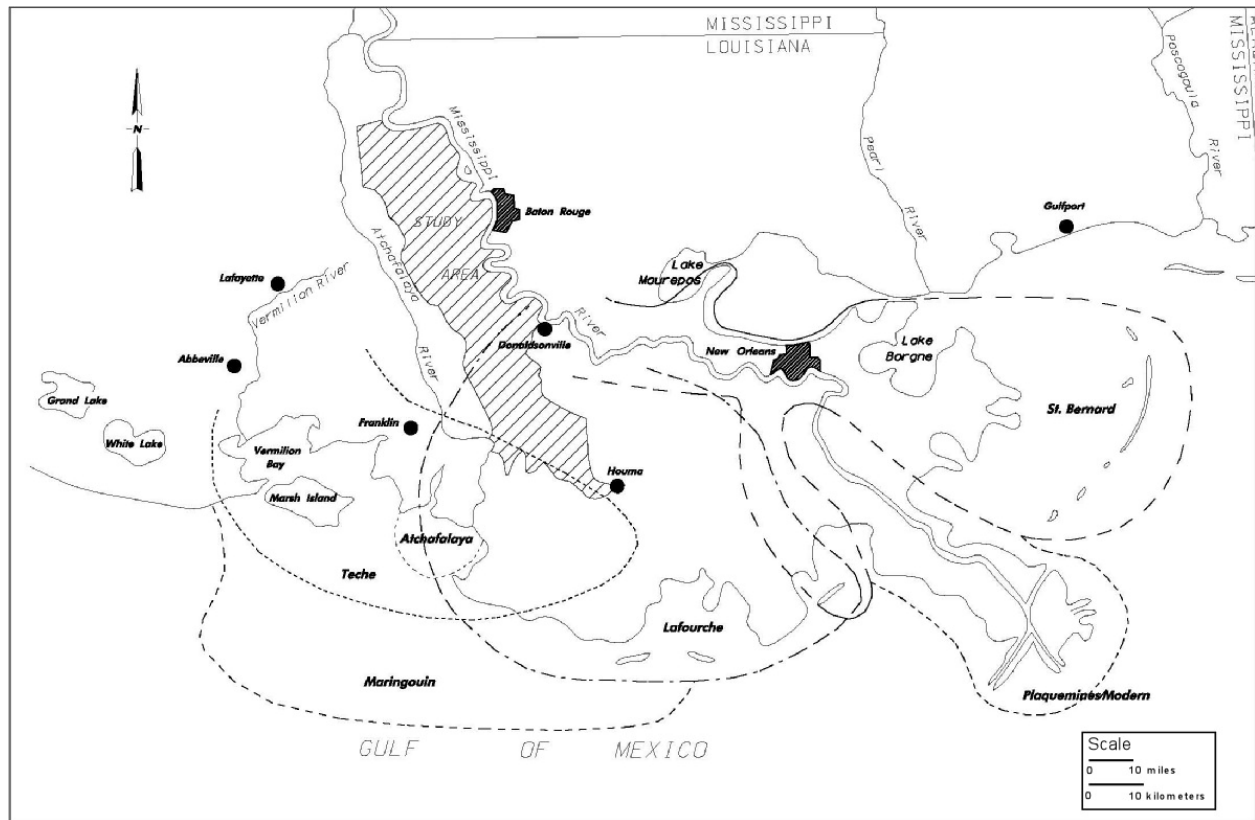


Figure 1. Delta complexes of the Mississippi River deltaic plain (modified from Frazier, 1967). The hatched area denotes location of study area.

Recognition that the deltaic plain is formed by an orderly progression of events related to shifting Mississippi River courses led to the identification and characterization of the “delta cycle” (Scruton, 1960; Frazier, 1967). The “delta cycle” is a dynamic and cyclic process that alternates between periods of progradation and a subsequent regression of deltaic headlands as deltas are abandoned, reworked, and transgressed by marine waters (Penland et al., 1988; Roberts, 1997). Figure 2 illustrates the stages in the development of a major delta lobe through its regressive and transgressive phases, from stream capture to submarine shoals. Many variables act to determine the phase of the “delta cycle” active at any one location. Time since initiation of stream capture, sediment supply, rate of accommodation space creation, relative sea

level change, and rate of discharge are some of the variables responsible for development of the deltaic plain (Roberts, 1997).

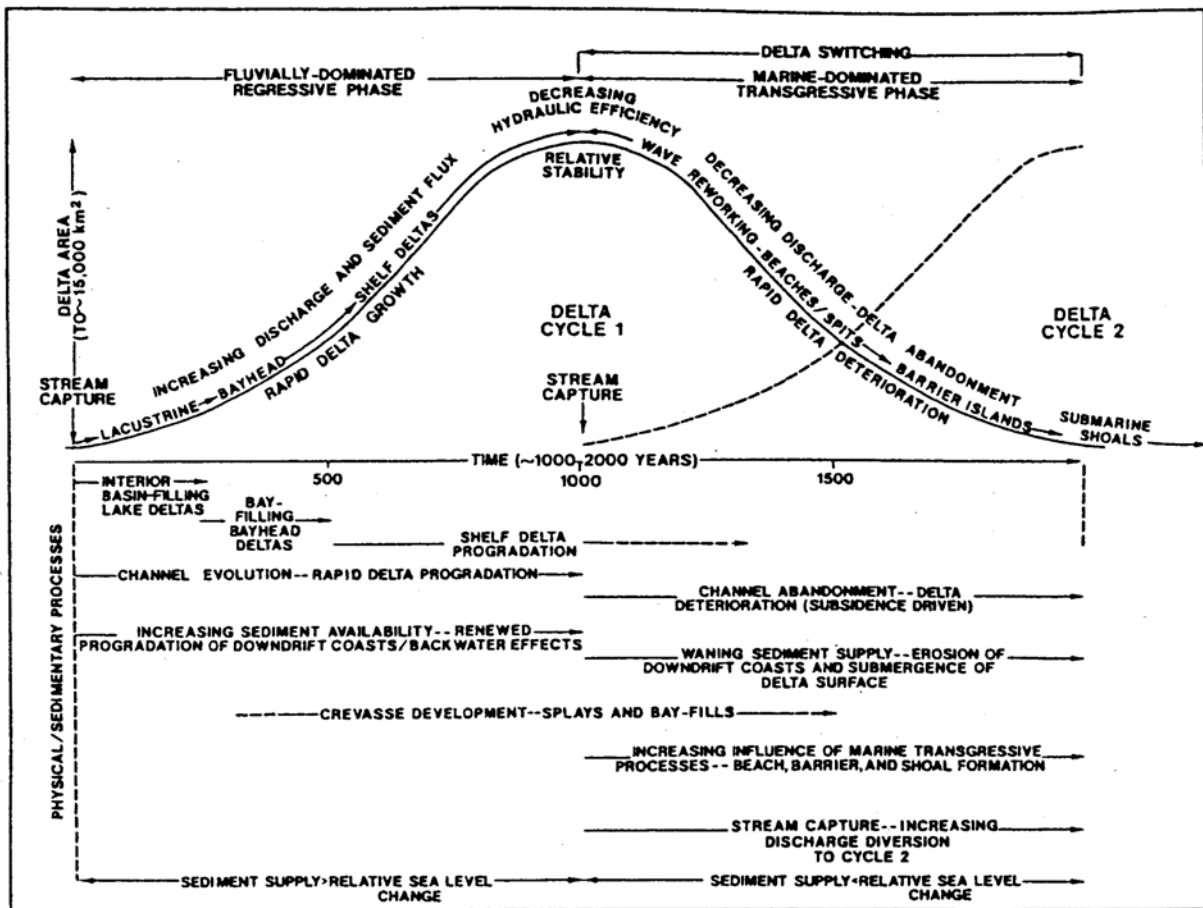


Figure 2. Conceptual model of the delta cycle showing growth and decay of individual delta lobes (from Roberts, 1997).

Throughout most of the last 7000 years the “delta cycle” has created more land by building deltas (regressive phase) than was destroyed by relative sea level rise and erosional processes (transgressive phase). Since the early 1900’s man has had a major influence on many of the key elements controlling the “delta cycle”. The Old River Control Structure has eliminated the delta switching process by maintaining the Mississippi River in its present course. Flood protection levees built in the early 1900’s confine the flow of the Mississippi River

eliminating overbank flooding and the nutrients and sediments that accompany these floods. Also, the suspended sediment load of the Mississippi River has declined by approximately 50 percent between the 1930 to 1952 period and the 1963 to 1982 period (Kesel, 1988). This decline has been attributed to bank stabilization by revetments, dams constructed on the Missouri River and other large tributaries, and other erosion control measures.

As the natural delta-building process was restrained, relative sea level rise and erosion (transgressive processes) began to dominate the coastal landscape. Within this environment of diminished delta building, man began a period of extensive development in the coastal zone beginning in the 1950's. Man-made alterations to the natural landscape such as dredging of navigation and access canals, construction of roads and levees within the wetlands, and drainage projects altered the natural hydrology compounding the negative effects of relative sea level rise and wetland erosion. Land loss rates exceeding $40 \text{ mi}^2/\text{yr}$ (104 km^2) were documented for the 1958 to 1974 period with high rates of loss continuing today (Dunbar et al., 1992).

Coastal Louisiana is characterized by depositional environments and shoreline configurations representing various phases of the "delta cycle". Presently, most of the Louisiana coastal zone is in the marine-dominated, transgressive phase of the "delta cycle". Only the Modern and Atchafalaya Deltas are in the fluvially-dominated, regressive phase. However, both of these deltas are limited in their development by man's influence. The Atchafalaya River discharge is limited to 30% of the combined Mississippi and Red River flow, retarding growth of the Atchafalaya and Wax Lake Deltas.

Regional Geomorphic Development

Because the study area is part of the larger Atchafalaya Basin and because its history is so closely linked to that of the Basin, a general description of Atchafalaya Basin development is necessary to fully understand the development of the study area.

The Atchafalaya Basin is a large shallow depression approximately 950 mi² (2460 km²) in area, bounded by present and former Mississippi River courses (Fig. 3). The Basin trends in a generally northwest-southeast direction. The most prominent physiographic features in the Basin are natural levees bordering the Atchafalaya River and present and former Mississippi River courses such as Bayou Teche and Lafourche. Elevations on these levees range from +35 ft (10.7 m) in the northern portions of the basin and decrease to +5 ft (1.5 m) in the extreme southern portion. The Atchafalaya Basin consists mainly of natural levees, swamps and lakes. The lakes are mainly confined to the southern half of the Basin with Six Mile Lake, Grand Lake, Lake Verret, Lake Palourde, and Lake Fausse Pointe representing the most prominent.

Early Holocene

Knowledge of the study area for the period beginning approximately 10,000 years B.P. is primarily dependant on borehole data. Hundreds of engineering borings drilled predominantly for levee and highway construction help define the subsurface stratigraphy. Borings show that the subsurface consists of a coarse-grained basal unit known as the substratum and an overlying fine-grained unit commonly called the topstratum (Fisk, 1944).

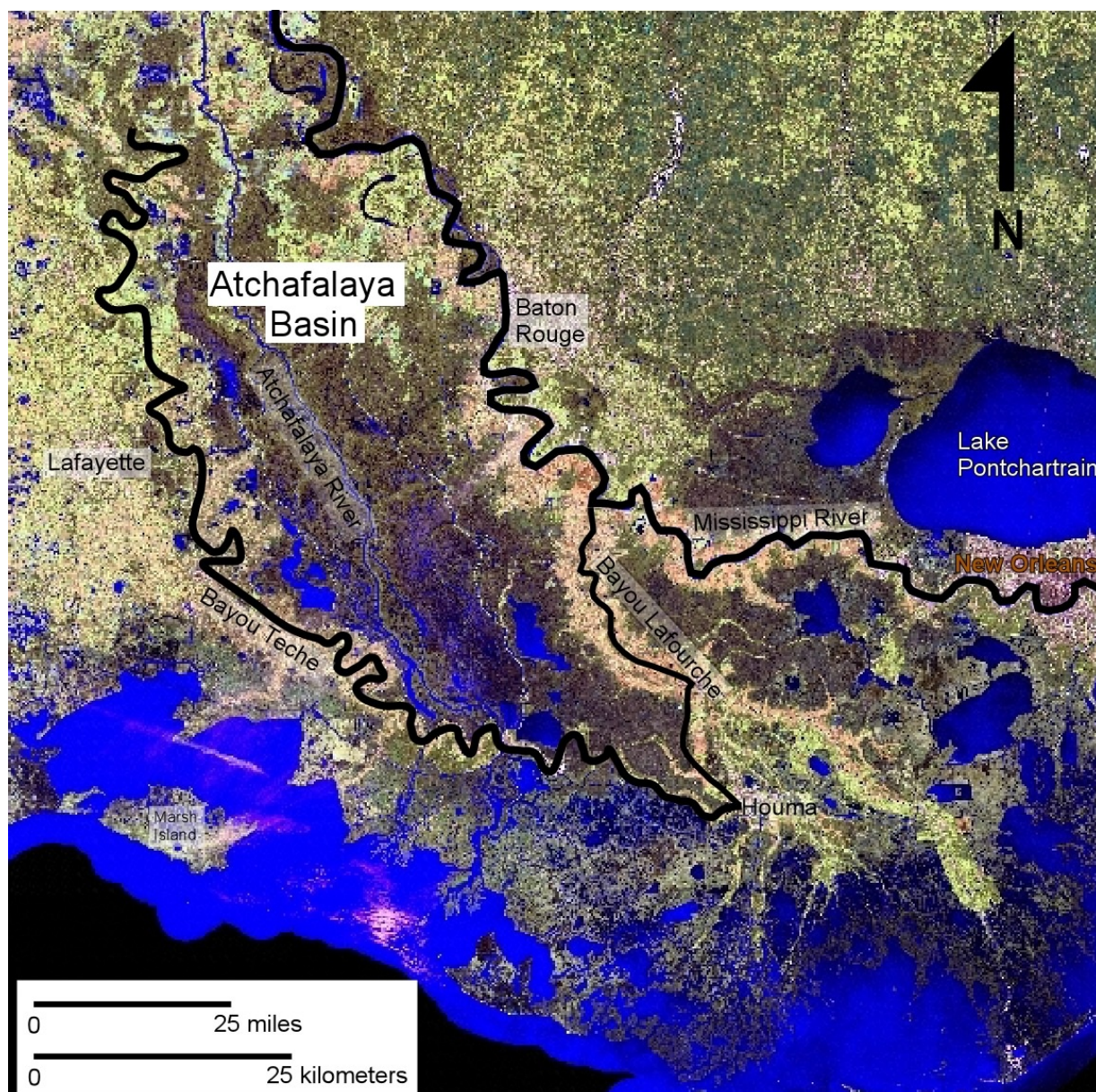


Figure 3. Location of Atchafalaya Basin situated in topographically low area between the present Mississippi River and Bayou Teche (former Mississippi River course).

The substratum consists of coarse sands and gravels deposited in the entrenched valley system during the falling and early rising sea level stages following the last Pleistocene glaciation. The substratum represents braided stream deposits that in the northern portion of the basin occur at an average depth of approximately 82 ft (25 m). In the southern portion of the basin, depth to

substratum sands averages approximately 115 ft (35 m). Depending on location within the basin, substratum sands and gravels vary in thickness from approximately 150 ft (46 m) in the northern reaches to more than 350 ft (107 m) in the southern end (May, 1983; Kulp et al., 2002)).

Directly overlying the substratum is the topstratum, a thick fine-grained unit consisting predominantly of sandy clay, silty clay, and clay. Backswamp and lacustrine deposits comprise most of the topstratum (Coleman, 1966; Krinitzsky and Smith, 1969). From subsurface data, the early basin can be defined as a broad backswamp and shallow lacustrine region bordered by major fluvial systems of the Mississippi and Red Rivers. Periodically, this low basin area received riverine water that deposited the fine-grained sediments that characterize the basin topstratum deposits. The stratigraphy of the Atchafalaya Basin reveals that the basin was occupied by shallow lakes and broad backswamp throughout much of the Holocene. This large, low basin provided a favorable setting for Mississippi River crevasses seeking a gradient advantage, leading to the distributary system development defined in this dissertation.

WES borings and radiographic data from previous studies define a complex subsurface of interfingering swamp and lacustrine (including lacustrine delta) facies throughout the vertical sequence of topstratum deposits. Radiocarbon data from numerous borings within or near the basin date the topstratum at generally less than 10,000 year B.P. (McFarlan, 1961; Frazier, 1967; Coleman, 1966; Krinitzsky and Smith, 1969; and Smith et al., 1986).

The first advance of a major fluvial system into the basin in the last 7,000 years was the Maringouin system. Sea level at this time was less than 7 ft (2m) below the present level (Tornqvist et al., 2004). Fisk (1944) interpreted Bayou Maringouin and eastern basin backswamp drainage patterns as belonging to this system. Frazier (1967) defined a Maringouin system buried in the mid portion of the basin only a few kilometers east of the present

Atchafalaya River. Kolb and Van Lopik (1958) concluded that during this same time period, the trunk channel of the Sale-Cypremort delta was the major fluvial system active in the basin and was located along the eastern basin margin. Saucier (1974) suggested that the Maringouin system in the basin area was confined to the western side of the alluvial valley, near the vicinity of the later Teche-Mississippi course. Data from Waterways Experiment Station borings (May, 1983) and previous studies reviewed during this investigation were unable to substantiate the conclusions expressed by the above authors. Rising sea level and subsequent floodplain deposits have masked any evidence of this early system. Additional subsurface exploration work is required before definitive statements about a pre-Teche system can be made.

The oldest near-surface deposits in the Atchafalaya Basin are related to the former Teche-Mississippi course, active from approximately 5,800 to 3,500 years B.P. (Frazier, 1967). Sea level during this time was at or very near the present level. Generally, the upper 30 ft (9.0 m) of basin deposits are related to the Teche and later courses (see Table 1). Many current drainage patterns are probably related to the Teche system, particularly crevasse channels which emptied into the interior basin region during flood flow periods. Abandonment of the Teche system, followed by growth of the Lafourche System, filling of Grand and Six Mile Lakes, and recent masking by lacustrine and lacustrine delta deposits have made interpretation and recognition of Teche distributary and crevasse channels in the Atchafalaya Basin difficult or impossible with existing data.

<u>Elevation in Feet Below MSL</u>	<u>Elevation in Meters Below MSL</u>	<u>Approximate Time Range Before Present</u>	<u>Major Mississippi River Courses-Deltas</u>
0-15	0-9.5	Present to 3500	Modern, LaFourche, and Teche
15-30	4.5-9.1	3500 to 5500	Teche
30-75	9.1-22.9	5500 to 8500	Maringouin
75-130	22.9-39.6	8500 to 10000	Pre-Maringouin, Early Holocene
130-270	39.6-82.3	10000 to 35000	Pleistocene Miss. River

Table 1. Approximate vertical chronology for Atchafalaya Basin deposits.
Modified from Frazier (1967).

Late Holocene and Prehistoric Geomorphic Development

The present physiography of the Atchafalaya Basin is the result of a long chain of late Holocene and historic events, both natural and anthropogenic. The first major event took place approximately 1,500 to 2,000 years B.P. with closure of the Atchafalaya Basin by the Lafourche deltaic network. Closure was accomplished when the Little Bayou Black-Bayou du Large distributary intersected the former Teche-Mississippi course (Bayou Black) at Houma (Fig. 4).

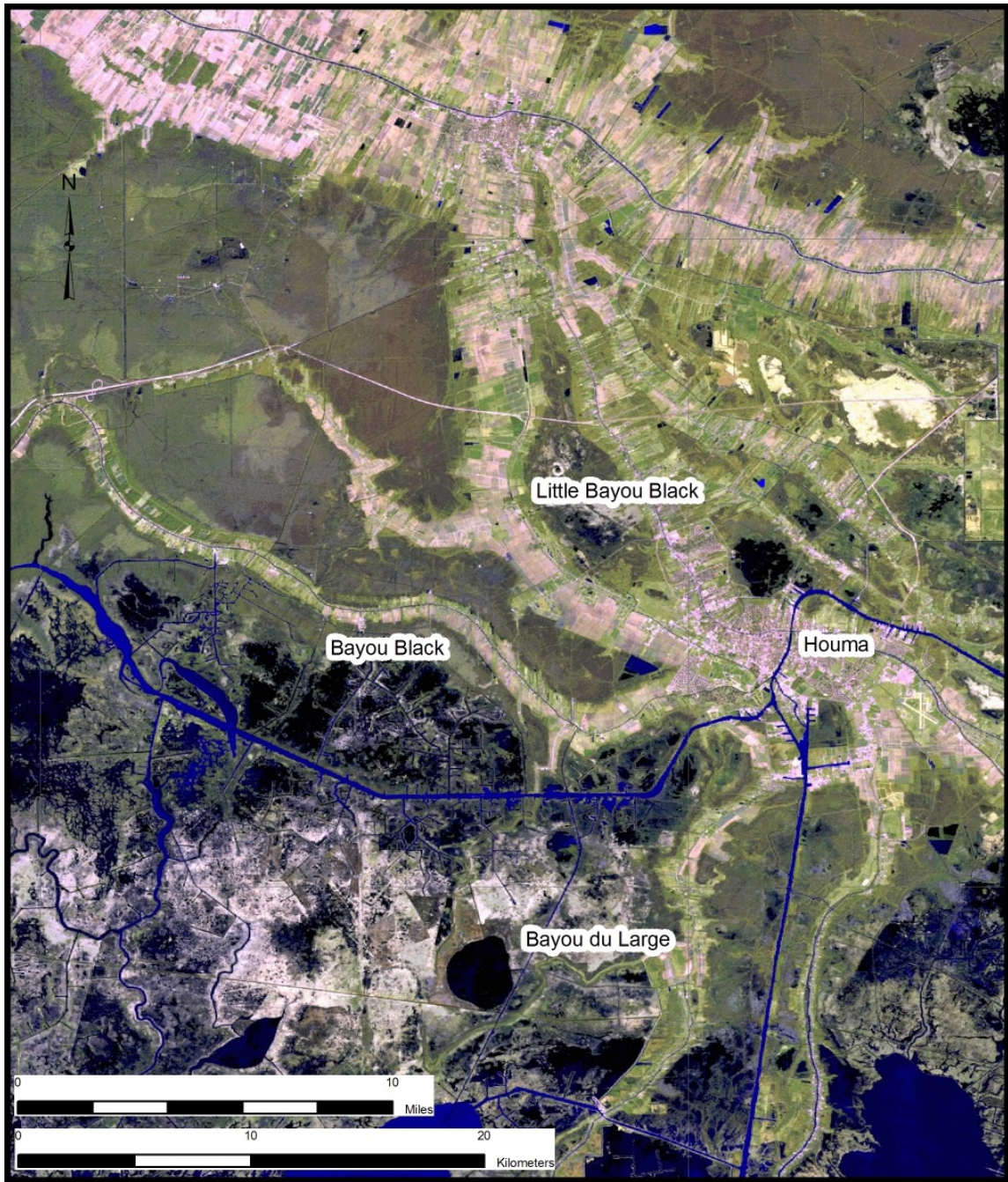


Figure 4. Area of Atchafalaya Basin closure. The Little Bayou Black and Bayou du Large distributaries prograded south across Bayou Black (Teche-Mississippi course) at Houma isolating the basin from marine processes.

Subsequent closure of the Atchafalaya Basin was responsible for development of an extensive lake system within the southern portion of the floodway. Surface drainage was denied an exit to the Gulf and began ponding behind the Teche alluvial ridge (natural levee of the Teche course). Growth of the lake system was further aided by local basin subsidence and wind-wave generated erosion. It is estimated that the lake system required at least several hundred years to develop, if not longer. Eventually, the ponded drainage became sufficiently high to overtop the natural levee on the north bank of the Teche course, or used and enlarged former Teche crevasse channels at Patterson and Morgan City (Smith et al., 1986). Drainage from the basin to the Gulf initially followed the old Bayou Teche- Black course southeast and into the Lafourche distributary, Bayou du Large. Formation of the Lower Atchafalaya River at Morgan City occurred by crevassing sometime after establishment of basin drainage through the Teche course, when flood flow from the Little Bayou Black and Bayou du Large distributary backed up drainage in the Bayou Teche-Black course (Fisk, 1952; Smith et al., 1986) (Fig. 7).

The second major development in the chain of events leading to the modern basin occurred slightly more than 500 years ago when the active Mississippi River meander loop known as Old River-Turnbull Island intersected Bayou DeGlaze and Lettsworth, a former Mississippi River course (Fisk, 1940). Intersection by the Mississippi River of the Bayou DeGlaze and Lettsworth course captured the Red River flow; the Red River was using the older abandoned Mississippi River course to empty into the present Mississippi River further to the south. Formation of the Atchafalaya River soon followed and required flood flow from the active Mississippi River to flow upstream in the former Bayou DeGlaze and Lettsworth course and crevasse the natural levee bordering the northern edge of the basin near Simmsport.

Continued Mississippi River flow through the Simmsport crevasse soon established the Atchafalaya River and Basin as a Mississippi River distributary and modern Red River course (Fisk, 1952).

Historic Development

The third major event in the evolution of the present physiography of the basin is the result of human activity in the region. Little physiographic change appears to have occurred within the basin or floodway between the birth of the modern Atchafalaya River and early occupation by European settlers in the early to mid 1800's. As Fisk (1952) noted when comparing early Louisiana state maps (Darby, 1816; Hardee, 1870) with a much earlier map dated 1578 by Monk Ptolmey, who accompanied Desoto's expedition to the mouth of the Atchafalaya River in 1542, no substantial change appears to have occurred in the study area from the mid 1500's to before 1900.

Three major stages of human activity have occurred in the basin leading to the present physiography: (1) initial occupation by European settlers and development of agricultural, fishing, and timber resources; (2) development of major transportation networks into the basin interior such as improved navigation for steamships and major railroad routes; and (3) development of the basin for a flood control program in response to the 1927 Mississippi River flood. Collectively, the following summary of events has formed the modern Atchafalaya Basin (Fisk, 1952; Gibson, 1982).

- The completion of Shreves cutoff in 1831 divided the Atchafalaya River from primary Mississippi River flow, forming Old River and Turnbull Island cutoff (Fig. 5).

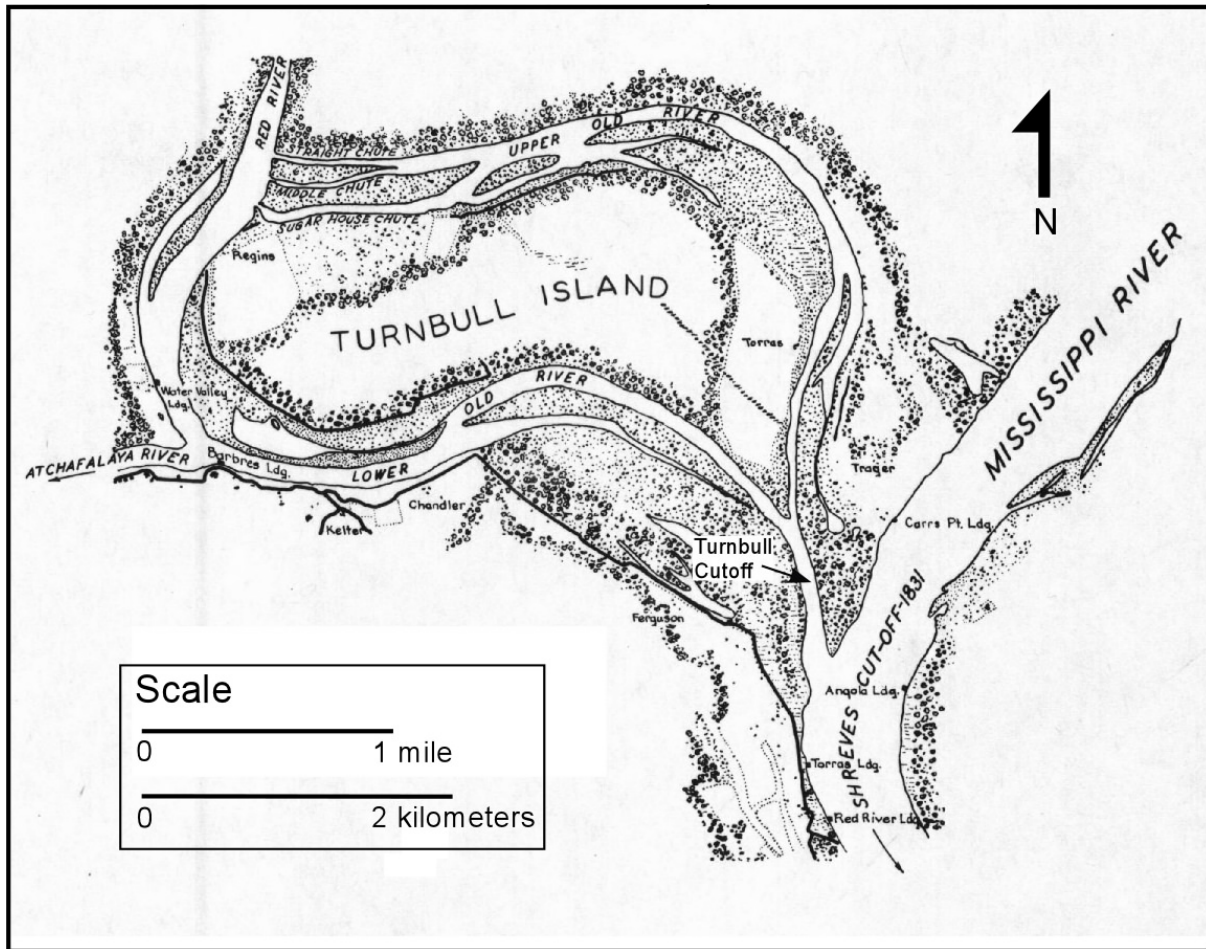


Figure 5. Location of Shreves Cutoff and Turnbull Island Cutoff which divided the Atchafalaya River from primary Mississippi River flow. From Fisk, 1952.

- A log raft on the Atchafalaya River was removed to accommodate steamship navigation between the Atchafalaya and Mississippi Rivers (timber removal began in 1839 and was eventually completed in 1861).
- Private, state, and federal dredging of Old River was conducted between 1855 and 1940 to maintain a navigation channel between the Atchafalaya and Mississippi Rivers.

- Private agriculture interests leveed the upper segments of the Atchafalaya River to protect against increased flooding from larger volumes of Red River and Mississippi River diversion; levee construction by 1910 extended along both sides of the Atchafalaya River to Krotz Springs and by 1937 reached its present limits.

- The Atchafalaya Basin was designated a major floodway by 1928 Act of Congress following the 1927 flood. By this act, the Atchafalaya Basin was to receive slightly less than 50 percent or approximately $41,600 \text{ m}^3/\text{sec}$ ($1,470,000 \text{ ft}^3/\text{s}$) of a projected $86,700 \text{ m}^3/\text{sec}$ ($3,065,000 \text{ ft}^3/\text{s}$) Mississippi River flood. The results of this congressional act produced the following general changes and/or flood control measures:
 - (1) Guide levees and navigation structures were constructed along the east and west flanks of the Atchafalaya Basin from Old River to Morgan City. The entire enclosed flood containment area measures approximately 4150 km^2 (1,600 sq miles) and was completed in the early 1950's.
 - (2) A shorter, more hydraulically efficient route to the Gulf was created by constructing a single main channel through the upper and middle basin regions, causing diversion of primary flow into Grand Lake and abandonment of drainage through Upper and Lower Grand Rivers. Channel dredging began in early 1930's and was completed in 1940's.
 - (3) Morganza Floodway was completed in the early 1950's to divert an additional $17,000 \text{ cu. meters/sec}$ ($600,000 \text{ ft}^3/\text{s}$) into the basin approximately 20 river miles south of Old River.

- (4) Wax Lake Outlet completed in 1941 to divert 7,600 m³/sec (270,000 ft³/s).
- (5) Old River Control Structure was completed in 1963 to regulate flow into the basin at 30 percent of the Mississippi River discharge. The structure currently prevents capture of Mississippi River flow by the Atchafalaya because of the favorable gradient advantage down the Atchafalaya Basin (Fisk, 1952).

Man's historic activity in the basin has significantly altered the region from a predominantly wetland to an increasingly terrestrial environment. Prior to man's activity, sluggish streams, swamps, and extensive lakes characterized the study area. At present, this same region is characterized by extensive natural levees along numerous major channels, newly emergent land areas at the expense of a shrinking lake system, and growing subaerial deltas in Atchafalaya Bay.

Study Area

The study area is located in the south-central portion of Louisiana, west of the Mississippi River (Fig.6) in the Atchafalaya River Basin, east of the East Atchafalaya Basin protection levee. It is bounded on the north by the Mississippi River, on the south by Bayou Black, and on the east by the Mississippi River, Bayou Lafourche, and Little Bayou Black (Fig. 7). The study area is contained in portions of Ascension, Assumption, Iberia, Iberville, Lafourche, Pointe Coupee, St. Martin, St. Mary, Terrebonne, and West Baton Rouge parishes, covering an area of more than 1300 mi² (3367 km²). The study area is situated within the northern portion of the upper deltaic plain as defined by Coleman and Wright (1971) (Fig. 8).

The upper deltaic plain forms the apex of the delta and its surface generally lies above the effective level of tidal influence, where riverine processes dominate.

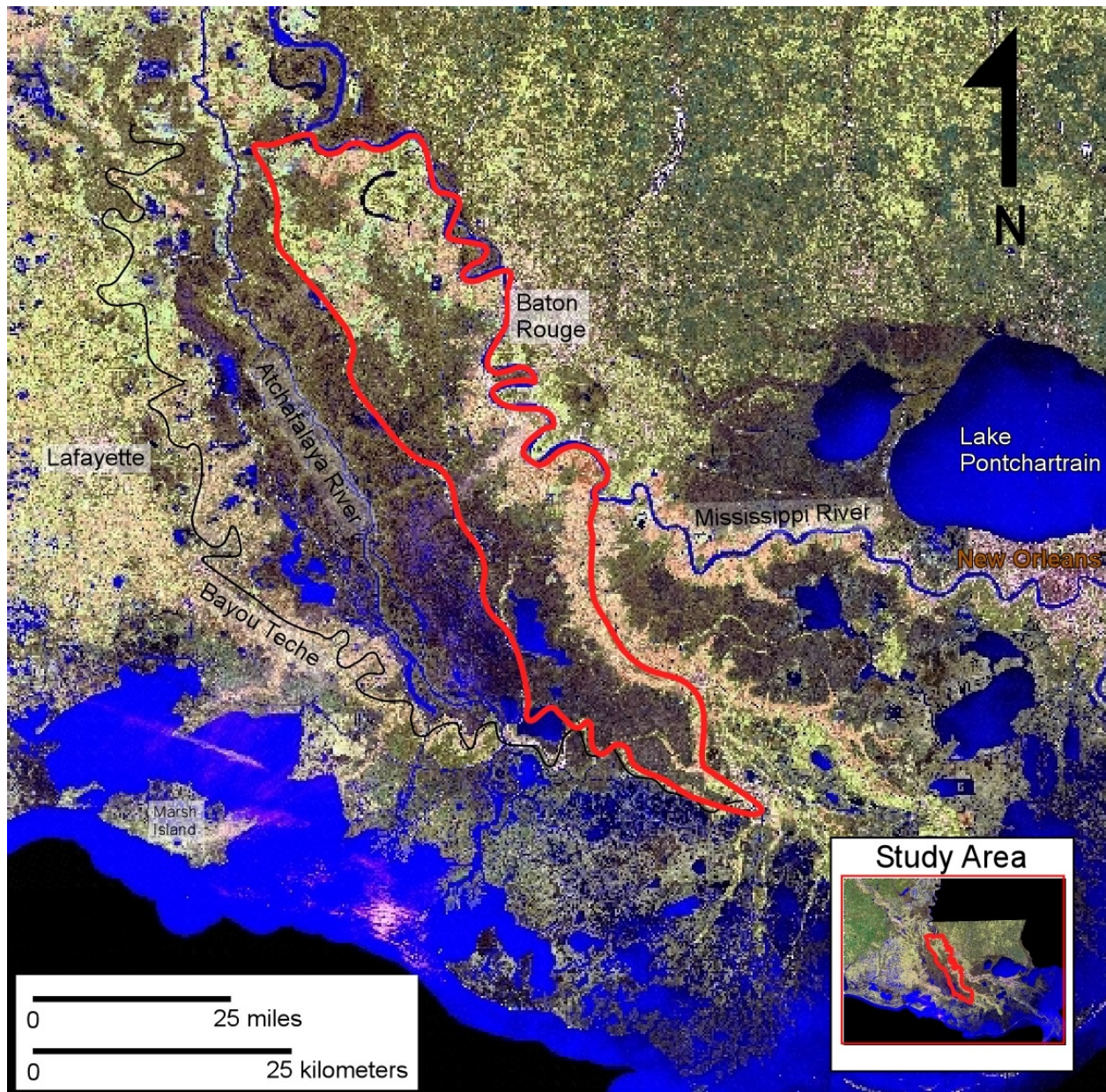


Figure 6. Base map showing the location of the study area within south-central Louisiana.

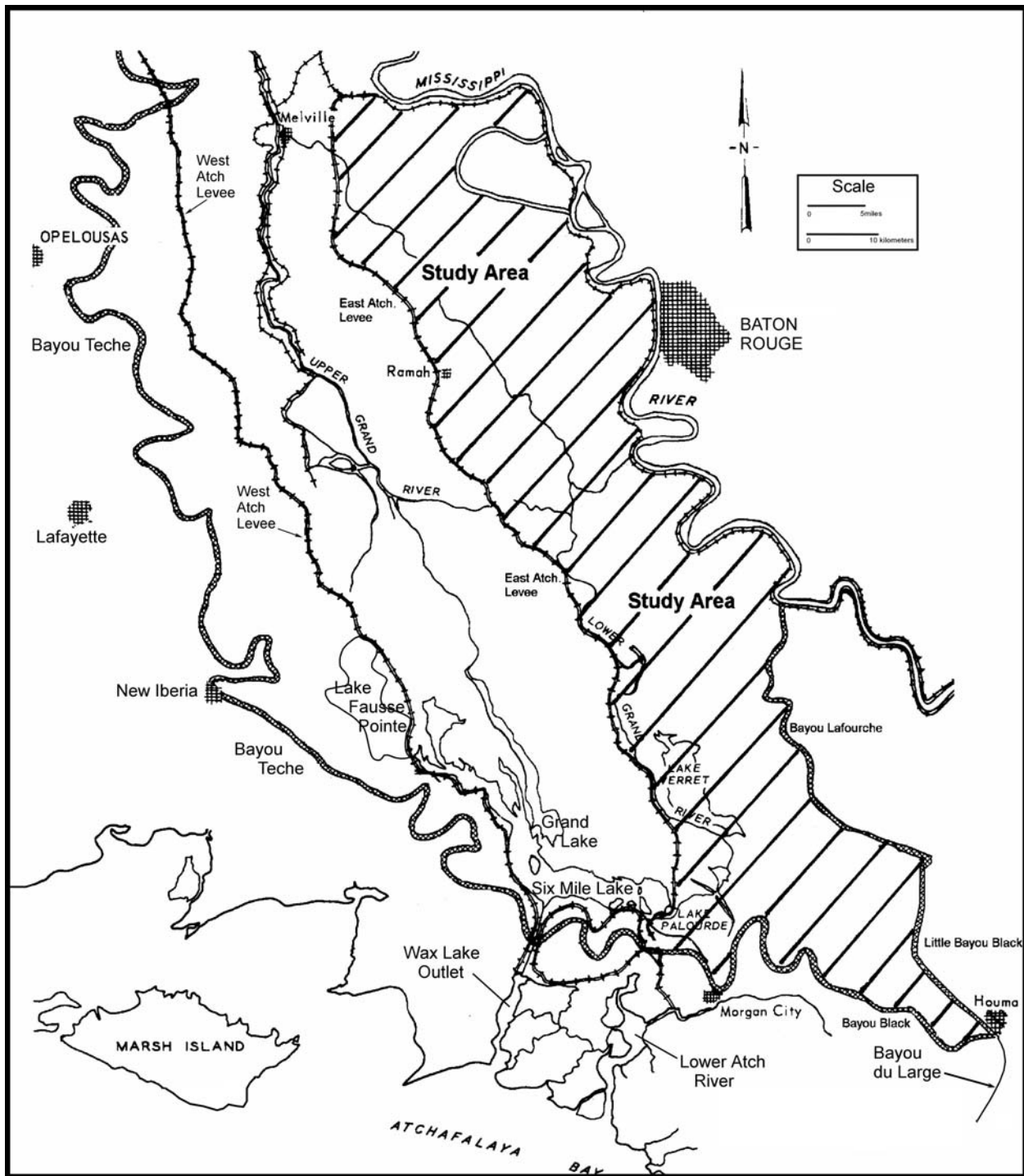


Figure 7. Location of study area between East Atchafalaya Basin protection levee, the Mississippi River and Bayou Lafourche.

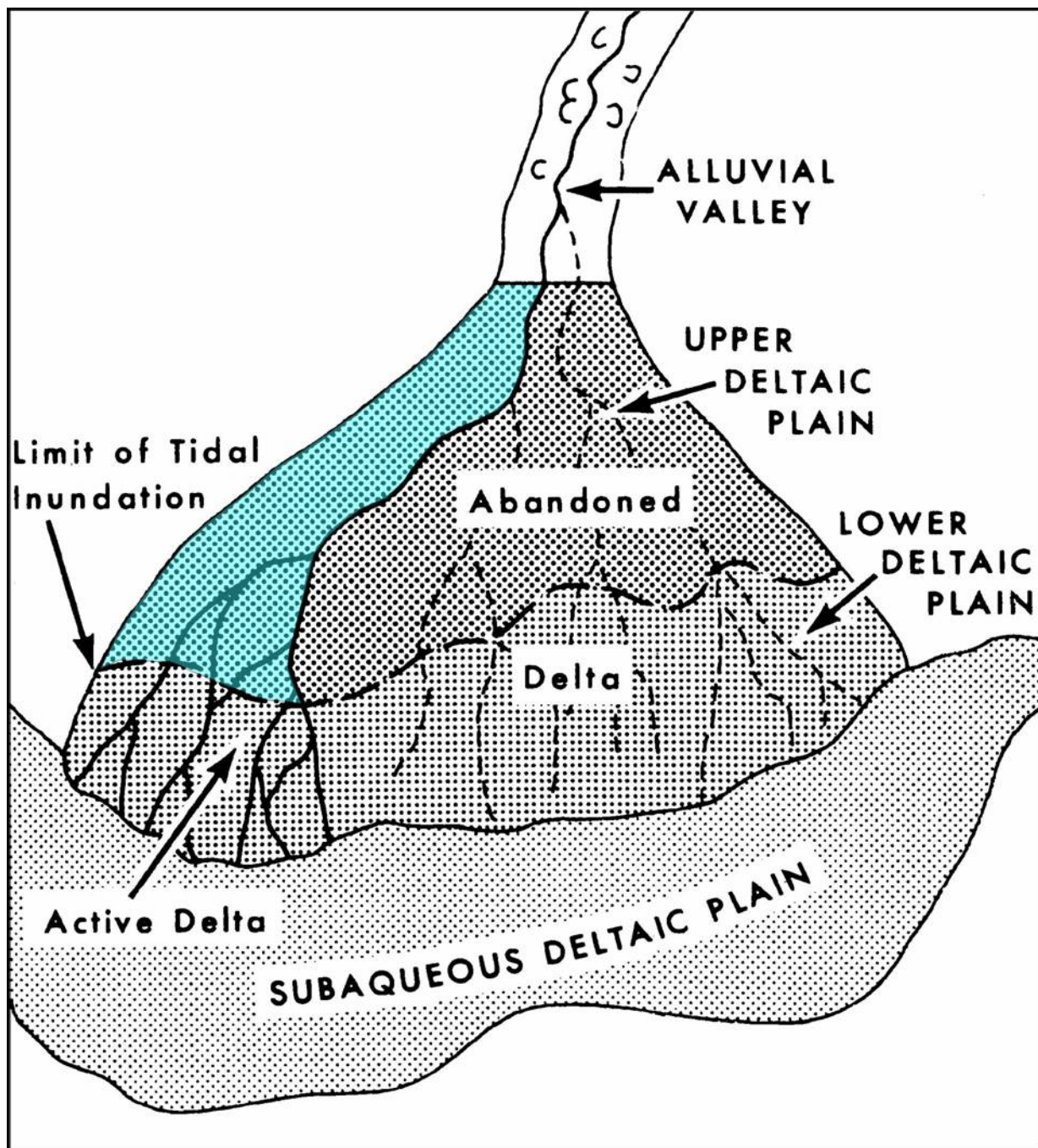


Figure 8. Simple conceptual model showing components of the deltaic plain modified from Coleman and Wright (1971). Present study area location is approximated within their proposed framework in the upper deltaic plain and highlighted in blue. The upper deltaic plain is characterized by a lesser number of distributaries as compared to the lower deltaic plain, little or no tidal influence, and is dominated by lacustrine, lacustrine delta and backswamp deposition.

Previous Studies

Geologic and Geomorphic Investigations of the Atchafalaya Basin

The study area encompasses two major geomorphic components of the Mississippi River deltaic plain: the eastern portion of the Atchafalaya Basin and the northwestern portion of the upper Mississippi River deltaic plain. The eastern portion of the Atchafalaya Basin is now cut off from Atchafalaya River flow by the East Atchafalaya Basin Protection Levee. Previous studies related to both of these geographic regions are pertinent. The most significant geologic study concerning the Atchafalaya Basin was prepared for the Mississippi River Commission (MRC), U.S. Army Corps of Engineers by the U.S. Army Engineer Waterways Experiment Station (WES) and published in 1952. This study was a detailed geological investigation conducted under the general supervision of H. N. Fisk. This report describes the geologic history of Atchafalaya River development and the influence of basin deposits on Atchafalaya River behavior. A detailed review of the published literature prior to the 1950's is summarized in this report. Of particular importance to this study was the "Reports on the Geology of Iberville and Ascension Parishes" by Howe et al. (1938). This report includes detailed information on the geologic history and the distribution of archaeological sites in the Atchafalaya Basin.

More recent geologic studies in the Atchafalaya Basin include radiographic analysis of cores from deep borings (Coleman, 1966; Krinitzsky and Smith, 1969; Krinitzsky, 1970; Krinitzsky and Lewis, 1972). Radiographic analysis refined identification of sedimentary facies in the thick fine-grained deposits comprising the basin. Smith et al. (1986) constructed a detailed evolutionary succession of the geomorphic development of the Atchafalaya Basin. This report contains stratigraphic and chronologic data and a reconstruction of events that led to the

evolution of the study area. Tye and Coleman (1989) described the nature of lacustrine delta formation in the Atchafalaya Basin by investigating the development of the Lake Fausse Pointe delta on the southwestern border of the Atchafalaya Basin (see Fig. 7). They concluded that lacustrine-deltaic sediments record periods of rapid basin alluviation, and constitute a large portion of the alluvial deposits within this fluvially dominated sedimentary basin. McMakin et al. (1994) is a report of borrow areas in the vicinity of the study area which provided valuable insight into the reconstruction of the geomorphic development of the study area. Their report contains some geomorphic mapping and chronologic information for a portion of the Bayou Plaquemine and Pierre Part Distributary Systems in the study area which was a valuable resource during this investigation. A report by Goodwin and Associates (1993) and a report by Earth Search (1994) provide additional information on the historical development of the extreme northern most portion of the study area.

Cultural Resource Investigations

In conjunction with the numerous geologic and historic reports on the Atchafalaya Basin, McIntire's (1958) archaeological study of coastal Louisiana provides insight into early man's activity and geomorphic development of the study area. Gibson (1982) conducted a detailed cultural resource investigation on the east and west Atchafalaya Basin Guide Levees which clearly demonstrates the importance of the basin physiography as a primary influence in shaping the actions of early cultures. Gagliano and Van Beek (1975) examined man's recent use of the Atchafalaya Basin providing a wealth of data regarding the physical, chemical, and biological nature of the area.

Mississippi River Delta Development

The mode of basin filling by deltas on the Gulf Coast has been defined by Scruton (1956, 1960). He recognized that there is an order and pattern to delta building which results in a characteristic stratigraphic sequence. Penland et al. (1988) described the growth and decay of individual delta lobes from stream capture to submerged shoals. Fisk (1944), Fisk and McFarlan (1955), Kolb and Van Lopik (1958), Frazier (1967), and Saucier (1994) using aerial photographs, borings, and radiocarbon dating have made detailed investigations concerning the chronological sequence of deltaic progradation. More recently, Tornqvist et al. (1996) offered a revised chronology for Mississippi River subdeltas, which relied upon some data from the study area. Causes of river avulsion, including gradient advantage, channel reoccupation, and substrate composition, are discussed by Aslan et al. (2006).

Historic Maps and Surveys

Also of importance to the present study were early accounts from the first settlers or explorers in Louisiana and their maps and surveys. Among these, Darby's (1816) early map of the state of Louisiana (Fig. 9), Abbott's (1863) map of the Atchafalaya Basin (Fig. 10), and another state map believed to be Hardee's (1870) shown in Fig. 11, were used in reconstructing the early physiography of the study areas.

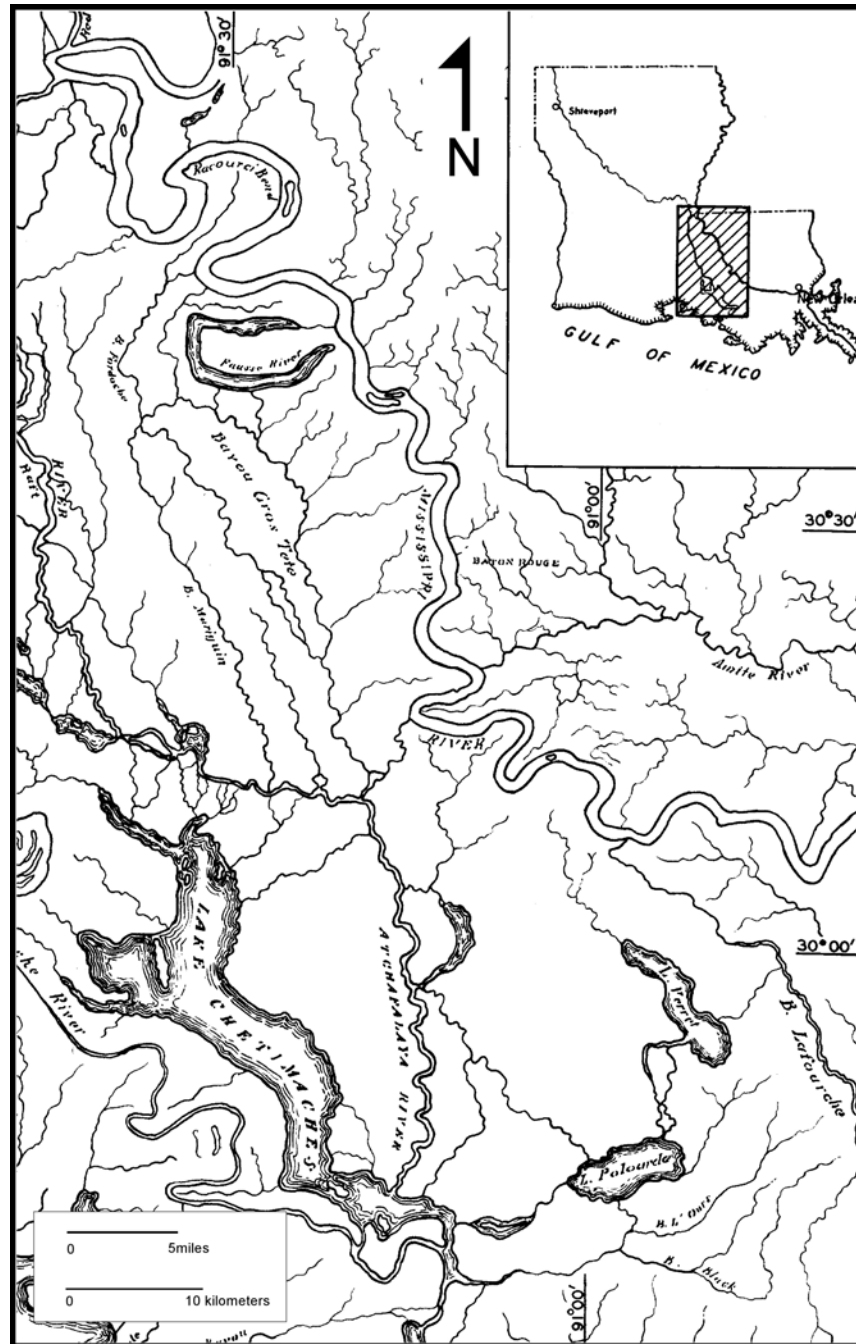


Figure 9. Excerpt from map by Darby (1816) showing location of major rivers and distributaries in and around the study area. The study area is generally located from Fausse River in the northern portion of the map to Lake Palourde in the southern portion.



Figure 10. Excerpt from map by Abbott (1863) showing prominent geomorphic features in and around the study area. Study area is generally located from False River (north end of map) to Lake Palourde (south end of map), west of the Mississippi River.

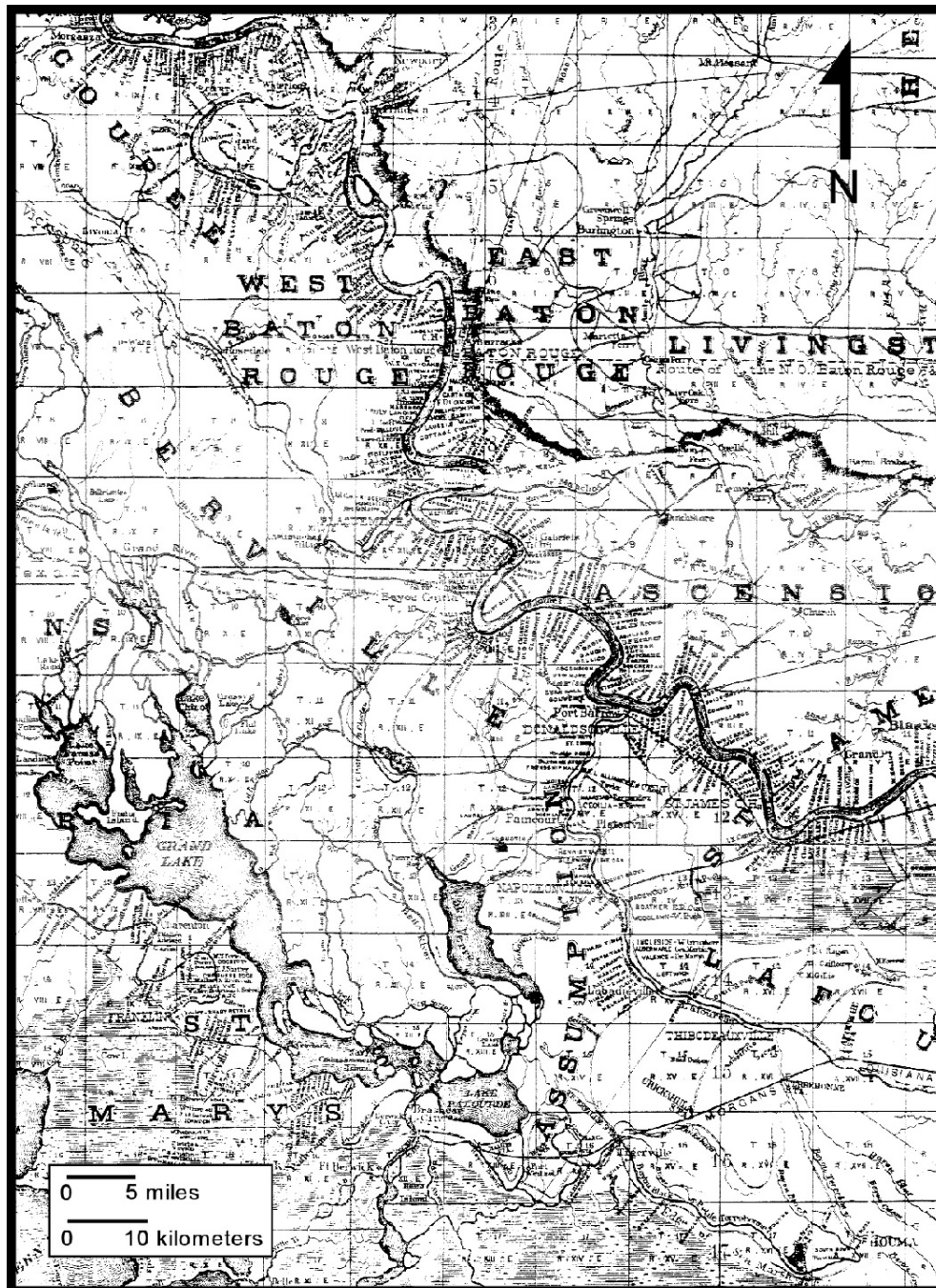


Figure 11. Excerpt from map by Hardee (1870) showing prominent geomorphic features in and around the study area. Study area is generally located from False River (north end of map) to Lake Palourde (south end of map), and west of the Mississippi River.

Methods

Geomorphic Mapping

The complex depositional history of the study area is responsible for the creation of a diverse geomorphic landscape. The first, and primary objective, of this study was to define and delineate on maps the geomorphic features (i.e. natural levee, abandoned distributary channel, etc.) of the study area. This was accomplished through an analysis of aerial photographs, subsurface data (boring logs), hydrographic surveys, several historic maps, and field observations. Color infrared aerial photographs (flown in December 1985 and October 1998 at the approximate scale of 1:24,000) and black and white photographs (flown in December 1958 at the approximate scale of 1:24,000) were overlain by 7-1/2-min USGS quadrangles, which served as the base maps, so that both the aerial photograph and the quadrangle could be viewed simultaneously during mapping. Geomorphic features were physically inked onto the base maps and coded by type (e.g. natural levee, backswamp, etc.). These maps were then digitized to produce a digital map displaying the surface geomorphic features of the study area (Plates 1, 2, and 3 in Appendix). Historic maps were used to help identify and substantiate landform delineations made from the aerial photographs. During the geomorphic mapping it became apparent that the study areas surficial geomorphology was composed predominantly of distributary systems rather than the lacustrine delta and backswamp deposits described in previous studies (Tye and Coleman, 1989).

Chronologic Reconstruction

The files of the Louisiana State Historic Preservation Office were searched to locate all prehistoric sites in the study area and to obtain the cultural data associated with each. All known archaeological sites and their cultural affiliation were plotted on 7-1/2-min USGS quadrangles for subsequent analysis. Specific locations of the archaeological sites are shown on the geomorphic maps (Plates 1, 2, and 3 in Appendix). Previous investigations have found that archaeological sites in the Atchafalaya Basin and Mississippi River deltaic plain are most often associated with natural levees bordering abandoned distributaries (McIntire, 1958; Smith et al., 1986). This association was also found in the study area. Figure 12 shows the cultural chronology for south Louisiana, and the approximate age range of each culture. The estimated ages of each culture shown in Figure 9 are calendar years B. P. equivalent. The delta lobe chronologies discussed in previous investigations (e.g. Fisk, 1944, Frazier, 1967), and used in this investigation, are based on radiocarbon years B. P. The differences between calendar ages and radiocarbon ages can distort the chronologies of individual features and the interpretations based on them. However, for the period between 0 and 4000 years ago, calendar years B. P. and radiocarbon years B. P. are in close agreement, especially for the period around 2000 years ago (Bartlein et al., 1995). Therefore, for the purposes of this dissertation, calendar years B. P. and radiocarbon years B. P. are assumed equivalent. For individual distributaries, courses, and the systems they comprise, the estimated age of the cultural components was used to assign minimum ages. These ages, and the relationships between geomorphic features, became the basis for developing the chronology of distributary system development.

Period	Culture	Date	Phases		
			Eastern Coast	Central Coast	Western Coast
Historic	Various Historic Tribes	A.D. 1800	← Various Historic Tribes →		
Protohistoric	↑ Mississippian Plaquemine	A.D. 1600	Delta Natchezan	Petit Anse	Bayou Chene
Mississippi		A.D. 1400	Barataria	Burk Hill	
	Coles Creek	A.D. 1200	St. Gabriel	Three Bayou	Holly Beach
Coles Creek		A.D. 1000	Bayou Ramos	Morgan	Jeff Davis
		A.D. 800	Bayou Cutler	White Lake	Welch
Baytown	"Coastal Troyville"	A.D. 600	Des Allemands	?	Roanoke
		A.D. 400	Grand Bayou		
Marksville	Issaquena-like	A.D. 200	Magnolia	Veazey	Lake Arthur
	Marksville	0	Labranche		
Tchula	Tchefuncte	200 B.C.	Beau Mire	Jefferson Island	Lacaseline
		400 B.C.	Pontchartrain		
Late Archaic	Poverty Point	600 B.C.	Garcia	Beau Rivage Rabbit Island	?
		800 B.C.			
		1000 B.C.	Bayou Jasmine		
		1200 B.C.			
		1400 B.C.			

Figure 12. Cultural chronology of south Louisiana, after Weinstein and Gagliano (1985). This cultural chronology forms the basis for determining the periods of distributary system development in the study area.

Results and Interpretation

Geomorphic Features/Depositional Environments

The following geomorphic features/depositional environments were identified and mapped during this study. Their distribution and age (based on cultural occupation and stratigraphic location) forms the basis for the geomorphic reconstruction of the study area.

Natural Levees

The highest elevation features in the study area are natural levees. Natural levees are vertical accretion deposits formed when the river flows overbank during flood stages, and sediment suspended in the flood flow is deposited immediately adjacent to the channel (Kolb and Van Lopik, 1958). The resulting landform is a low, wedge-shaped ridge paralleling the channel and decreasing in thickness away from the channel. The best developed natural levee deposits are generally located along the Mississippi River and the abandoned Lafourche-Mississippi course. Natural levee deposits range from several hundred to several thousand feet in width. Natural levee thickness varies from less than 5 ft (1.5 m), along minor distributaries, to more than 30 ft (7.6 m) along reaches of the Mississippi River or the relic Lafourche-Mississippi course and Teche-Mississippi courses (May, 1983; May et al., 1984). Natural levee deposits generally decrease in grain size away from the river.

Natural levee deposition has ceased in the study area today due to artificial levee construction along the Atchafalaya and Mississippi Rivers. Surface extent of the natural levee deposits in the study area are shown on the geomorphic maps.

Surficial natural levee deposits were identified on color infrared aerial photographs by a change in vegetation type from lower to higher elevation. Many of the natural levees associated with distributaries in the study area are buried by subsequent deposition associated with more recent delta growth (Plates 1, 2, and 3 in Appendix). Buried natural levees were identified by their associated distributary channels and indian middens which remain above the surface.

Point Bar

Rivers migrate laterally to attain a dynamic equilibrium relationship between the various flow conditions, type and amount of sediment load, bed and bank materials, and the channel slope (Kolb and Van Lopik, 1958). Meandering channel migration occurs as the outside bank or "cut bank" is eroded, and a lateral sandbar is deposited along the inside bank. As migration progresses, the inside of the meander becomes a series of ridges (relict lateral bars) and swales (resulting troughs between the ridges). Collectively, the series of ridges and swales comprises the point bar landform that frequently dominates the landscape of an alluvial valley formed by an actively meandering river. Point bar deposits are as thick as the total depth of the channel that formed them and fine upward texturally from the maximum size of the bedload material (fine gravel and coarse sand) through sand, silt, and clay (at the top of the deposit). The sand in the base of the point bar is deposited through lateral accretion (channel migration), and the finer silt and clay deposits overlying the coarse base are the product of vertical (overbank) accretion during floods. Point bar deposits are located along the Mississippi River, the former Lafourche and Teche-Mississippi courses and along some of the major distributaries in the study area (Plates 1, 2, and 3 in Appendix). They were identified from the channel migration histories and from boring data.

Abandoned Channel

Abandoned channels are a minor depositional environment in the study area. Abandoned channels or natural cutoffs usually occur during times of flood in two ways. A highly sinuous meandering channel may cut off a single loop by cutting through its narrow neck and plugging the arms of the abandoned channel with its bedload material, usually sand. These "neck cutoffs" result in the formation of an "oxbow" lake that fills slowly with fine-grained sediment.

Abandoned channels may also form during high flow when the main flow is diverted through a prominent swale or chute on the point bar or accretion bank, or the flow breaks through the natural levee of a loop and rejoins the main course on the opposite, downstream segment of the loop. As flow becomes concentrated in this new channel, the old channel is gradually abandoned and filled with sediment. False River and Cane Bayou/Clause Bayou, found in the northern portion of the study area represent the only abandoned channels identified in the study area (Plate 1 in Appendix). Historic maps identify these as former channels.

Abandoned Course

Similar to the abandoned channel is the abandoned course, a relict channel segment which generally contains multiple connected meanders. The major difference between the two is the mode of abandonment. Unlike the abandoned channel, an abandoned course is formed when the main flow path is diverted to a completely new position on the floodplain creating a new "meander belt" consisting of the course and its associated point bar and abandoned channel deposits. The abandonment process is known as channel diversion or avulsion (Saucier, 1994) and may happen gradually or in response to a single flood. Channel diversions usually occur gradually as an increasing amount of flow is diverted through the new, more hydraulically

efficient channel and the old channel progressively fills with sand, silt, and clay. In the study area, only one abandoned course was mapped along the Lafourche-Mississippi course (Plate 3 in Appendix). Historic maps identify this as a former course.

Crevasse Channels and Splays

Crevasse channels are ephemeral channels originating as breaks in the natural levees of active rivers during periods of high flow. Crevasse channels extend away from the main channel and are generally shallow and usually characterized by broad natural levees. These small channels usually terminate in the backswamps or low areas flanking the active main channel and discharge flood flow and sediment into these areas. In a general sense, crevasse channels function similar to the much larger distributary channel except on a much smaller or localized scale and usually receive flow only during high discharge periods. Numerous crevasse channels and splays are found adjacent to the Mississippi River in the northern portion of the study area (Plate 1 in Appendix). Channels radiating from sites along the Mississippi River and topographic expression of the splay deposits were used to identify crevasse deposits.

Distributary Channels

Distributary channels are channels that diverge from the trunk channel dispersing or "distributing" flow away from the main course. By definition, distributary channels do not return to the main channel on an alluvial plain or delta (Bates and Jackson, 1980). However, numerous exceptions defined by the present study and specific examples in the literature indicate that this relationship is not necessarily valid in the distributary channel classification (Shlemon, 1972; Wells and Roberts, 1981; van Heerden and Roberts, 1980). Distributary channels originate

initially as crevasse channels during high flow periods when the trunk channel is unable to accommodate the large volume of discharge. If the flood is of sufficient duration, a permanent distributary channel is soon established through the initial crevasse channel. Active distributary channels are distinguished from the smaller crevasse channel by two fundamental differences: distributing channels have perennial flow and generally terminate at a semi permanent base level (a large body of open water) in contrast to crevasse channels which have flow during high discharge periods and which lead into adjacent swamps or marsh. Distributary channels typically diverge from the main channel at low angles (usually less than 60 degrees) and may carry a substantial amount of flow (20 to 40 percent) from the main channel, whereas crevasse channels usually break at right angles through natural levees and typically carry no more than 10 percent of main channel discharge. Abandonment of the distributary channel or distributary network occurs, either as a major course shifts up valley or by flood flow crevassing a short distance upstream of the abandoned channel segment. Abandonment usually occurs because of an improved gradient advantage by the new course to a regional base level.

On aerial photographs, abandoned distributaries were recognized by their associated natural levees and diminished channel width. Abandoned distributaries in the study area generally trend in a south and southwesterly direction. When possible, distributary channels are identified on the geomorphic maps by their association to particular distributary systems. Natural levee deposition along the Mississippi River has masked former distributary channels in the northeastern section of the study area (Plates 1, 2, and 3 in Appendix).

Backswamp

Backswamp is the predominant depositional environment in the study area. Backswamps are poorly drained, tree-covered low areas, bounded by natural levee ridges. Backswamp areas received fine-grained sediment during periods of high flow when the natural levees are overtopped and flood waters bring fine-grained suspended sediment into low areas away from the active channel. Backswamp deposits are typically composed of massive or thick bioturbated clay sequences (Plates 1, 2, and 3 in Appendix).

Geomorphic Development of Study Area

The second objective of this dissertation was to reconstruct the geomorphic evolution of the study area. The following paragraphs describe the chronologic sequence of events which influenced the geomorphic development of the study area. The complex nature of fluvial-deltaic deposition in the study area and the lack of chronostratigraphic data makes it difficult to accurately assess the absolute ages of individual distributary systems. Borings from previous Corps studies show an abundance of subsurface swamp and lacustrine deposits and an absence of marsh deposits with relative absence of datable material in the study area (Krinitzsky and Smith, 1969). Therefore, archeological evidence, although not definitive throughout much of the study area, combined with the geomorphic data, forms the basis for assigning relative ages to individual distributaries and distributary systems. In addition, some geomorphic mapping for a portion of the study area had been conducted by McMakin (1994).

Early Distributary Systems (4,000 to 2,500 years B.P.)

At this time the Teche-Mississippi course was already well established along the western and southern portion of the Atchafalaya Basin (Saucier, 1994). Along the eastern border, a second distributary course (St. Bernard-Mississippi) of the Mississippi River occupied approximately the same location as present (Saucier, 1994). Teche-Mississippi flow was being diverted to the east in Meander Belt No. 1 as the St. Bernard Delta was beginning to form. The study area was likely an interdistributary estuary receiving overbank flow from the St. Bernard-Mississippi course and exchange with Gulf waters from the vicinity of Houma. The low elevation, basinal nature of the study area, due to its position between the Mississippi River and the abandoned Teche-Mississippi course, provided a favorable environment for the development of upper deltaic plain deposits through crevassing and distributary development (see Fig. 6). In the northern portion of the study area active crevassing was occurring along the Mississippi River. False River and the area bounded by Cane Bayou/Bayou Clause represent abandoned channels which were likely active during this period (Plate 1 in Appendix). Numerous crevasse channels and splays originate on the south side of these features. An unburied Marksville site (WBR3) is located on the cutbank of the Cane Bayou/Bayou Clause abandoned channel. This site dates this channel, and probably the False River channel, to at least 2,000 to 1,800 years B.P. The channel is probably several hundred years older because WBR3 is located immediately adjacent to the cutbank and is not buried by natural levee deposits indicating that the site was occupied either just prior to abandonment or just after. A distributary originating on the south bank of the Mississippi River crosses the abandoned channel of Cane Bayou/Bayou Clause. The distributary has two Coles Creek sites (WBR23 and WBR26) along its natural levees within the limits of the abandoned channel. This distributary clearly post dates the abandoned channel and

was active at least between 1,300 and 800 years B. P. Archaeological evidence demonstrates that the Cane Bayou/Bayou Clause channel was abandoned at least 1,500 years prior to the False River channel which was cut off from the Mississippi river in 1722. Certainly, other crevasses and distributaries entered the study area from the Mississippi river courses bordering the basin, but most of these features have been deeply buried by subsequent deposits in the subsiding basin. Radiocarbon dates from backswamp deposits within the Atchafalaya Basin suggest that surfaces related to this period of deposition are approximately 10 to 20 feet (3 to 6 m) below MSL at present (see Table 1).

Bayou Plaquemine Distributary System (2,500 to 100 years B.P.)

Along the southern border of the study area (see Plate 3 in Appendix) distributaries entered the study area from Bayou Black (Teche-Mississippi River). Bayou Ramos and Chacahoula Bayou represent distributaries active during the early part of this period along Bayou Black. These distributaries are designated as D_T to identify them as Teche-Mississippi distributaries. Sites containing Marksville components (SMY136 and TR5) date these distributaries from at least 2,000 to 1,800 years B.P.

Approximately 2,500 years B.P. the Bayou Plaquemine Distributary System prograded into the study area from the west bank of the Mississippi River at Plaquemine, LA (Plate 2 in Appendix). This system originated as a crevasse which remained open long enough for distributary development. Bayous Plaquemine and Jacob, Upper Grand River, and Lower Grand River are major distributaries related to the Plaquemines Distributary System (see Plate 2 in Appendix). Distributaries related to the Plaquemine Distributary System are designated by D_P on the geomorphic maps. Well developed natural levees approximately 1/2 mi (.8 km) wide and

+10 ft (3 m) in elevation border these distributaries. It has been postulated by Howe et al. (1938) that the original channel from the Mississippi River occupied the entire area now bounded by Bayous Plaquemine and Jacob; the width of a Mississippi River course. Due to more recent masking by natural levee deposits it is difficult to determine the validity of this premise. Borings taken between the two channels could determine if a much larger channel existed previously.

Other distributaries likely associated with this system in the vicinity of Bayous Jacob and Plaquemine have been buried by subsequent deposition and may be up to 15 ft (4.6 m) beneath the present surface in the backswamp areas. Boring data from previous investigations indicates that the Bayou Plaquemine Distributary System prograded into a lacustrine/backswamp environment (May et al. 1984).

Farther south (see Plates 2 and 3 in Appendix), several distributaries branch off of Lower Grand River which are likely related to the Bayou Plaquemine Distributary System. These are Choctaw Bayou, Chopin Chute, Bayou Sorrell, Bayou Postillion, Bayou Natchez, and Big Goddel Bayou. Natural levee deposits associated with these channels reach elevations of approximately +5 ft (1.5 m) and as much as 0.25 mi (.4 km) wide on each bank. These deposits are probably less than 10 ft (3 m) thick. Bayou Natchez has the most prominent natural levee deposits of the southern distributaries related to the Bayou Plaquemine System. The size of the natural levees may be a result of repeated reoccupations by subsequent distributary systems which for some reason did not reoccupy nearby distributaries. Another explanation is that this area has been subjected to faulting and associated subsidence making geomorphic reconstruction difficult without further investigations (McMakin et al., 1994).

The Schwing Place Mound (IV 13), located on a distributary which branches off of Lower Grand River in a southeasterly direction, contains Tchefuncte age artifacts (Plate 2 in Appendix). Just downstream from this distributary along Lower Grand River is the Bayou Sorrell distributary which branches off in a southwesterly direction. The Bayou Sorrell mound (IV4) adjacent to this distributary also contains Tchefuncte artifacts. If these cultural associations are correct, this would date these distributaries, as well as the Bayou Plaquemine Distributary System, as being at least between 2,000 and 2,500 years B.P. Both of these sites may also contain Poverty Point components (McMakin et al., 1994). If so, these distributaries as well as the Bayou Plaquemine Distributary System may have been active at least 3,500 years B.P.

A Marksville site (AS1) located at the divergence of Bayou Natchez and Big Goddel Bayou Distributaries (Plate 2 in Appendix) and another Marksville site (AS3) found just north of the Big Goddel Bayou-Bayou Pierre Part intersection (Plate 3 in Appendix) indicate that the southern portion of the Bayou Plaquemine System was active at least 1,800 to 2,000 years B.P. The Bayou Plaquemine Distributary System covers an area of approximately 180 sq. mi. (466 sq. km.) within the study area. There is some geomorphic evidence (Upper Grand River and Bayou Sorrell abandoned distributaries) that the Bayou Plaquemine Distributary System extended west of the western boundary of the study area (see Plate 2 in Appendix). However, sedimentation related to Atchafalaya River flow has buried most evidence making further delineation impossible.

The distal portion of the Bayou Plaquemine Distributary System is located beneath the northwestern portion of Lake Verret. Minor distributary flow probably continued in most of the distributaries related to this system until Bayou Plaquemine was dammed at the turn of the 20th century.

Approximately 2,000 years B.P., after the Bayou Plaquemine Distributary System began prograding into the study area, the Lafourche-Mississippi course began prograding south towards Houma, from near Donaldsonville (Smith et al., 1986). This was probably the most important geologic event affecting the Atchafalaya Basin, and the study area, because it led to the closure of the Basin by the Lafourche deltaic network. Closure was accomplished when the Little Bayou Black-Bayou du Large distributary course intersected the former Teche-Mississippi course (Bayou Black) at Houma (Fig. 4 and Plate 3 in Appendix). Surface drainage was denied an exit to the Gulf, and water began ponding behind the Teche alluvial ridge leading to the development of an extensive lake system. Lake Fausse Point, Grand Lake, Six Mile Lake, and Lake Palourde are lakes formed by this ponding. These lakes are all west of the study area, but it is into these lakes that much of the distributary flow entering the study area was directed.

It is estimated that the lake system required at least several hundred years to develop, if not longer. Eventually, the ponded drainage became sufficiently high to overtop the natural levee on the north bank of the Teche course, or used and enlarged former Teche crevasse channels at Patterson and Morgan City. Drainage from the basin to the Gulf initially followed the old Bayou Teche-Black course southeast and into the Lafourche distributary Bayou du Large. Formation of the lower Atchafalaya River at Morgan City occurred by crevassing sometime after establishment of basin drainage through the Teche course, when flood flow from the Little

Bayou Black and Bayou du Large distributary backed up drainage in the Bayou Teche-Black course (Smith et. al., 1986).

Pierre Part Distributary System (2,000 to 300 years B.P.)

The Pierre Part Distributary System prograded into the study area from the east side of Bayou Lafourche between the towns of Belle Rose and Klotzville (see Plate 3 in Appendix). This system is characterized by numerous anastomosing distributaries associated with at least 3 episodes of distributary development originating from an active area of crevassing along Bayou Lafourche. Distributaries related to this system are designated as D_{PP} on the geomorphic maps. The exact location of the crevasse channel/channels has been obscured by subsequent deposition and development.

Geomorphic and archaeological evidence suggests that the first distributary development related to this system occurred in the southern portion and is associated with the Grand Bayou Distributary (Fig. 13). Grand Bayou and its associated distributaries trend west and south into the study area and are surrounded by backswamp deposits. The Grand Bayou site (AS 13) is located on the natural levee of Grand Bayou and contains Marksville and more recent components indicating that this portion of the Pierre Part Distributary System was active at least 1,800 to 2,000 years B.P. Recent subdelta chronologies derived from radiocarbon dating of peat deposits (Tornqvist, 1996) suggest that Lafourche subdelta development did not begin until approximately 1500 years B.P. Archaeological and geomorphic data related to the Pierre Part Distributary System indicate that the age of Lafourche subdelta development presented by Tornqvist is too young by at least 300, and as much as 500 years.

The second episode of distributary development is associated with Bayou Crouix and several other distributaries in the northern portion of this system. Bayou Crouix and its associated distributaries trend southeast and then south following the course now defined by Bayou Pierre Part (Fig. 13). Archeological sites situated on the natural levees of Bayou Crouix (AS31 and AS32) suggest that this distributary and those surrounding it are between 1,300 and 800 years B.P.

The third distinguishable phase of development is related to the Bayou Corne distributary located between the two previous areas of distributary development (see Fig. 13). A site containing Coles Creek components (AS 29) dates this distributary as being at least 1,300 to 800 years B.P. This distributary crosses the Grand Bayou Distributary ridge and intersects the Bayou Croix ridge before turning south where it becomes Bayou Pierre Part. The fact that it crosses and intersects these previous distributaries also indicates that it is the most recent of the distributaries in this system to develop.

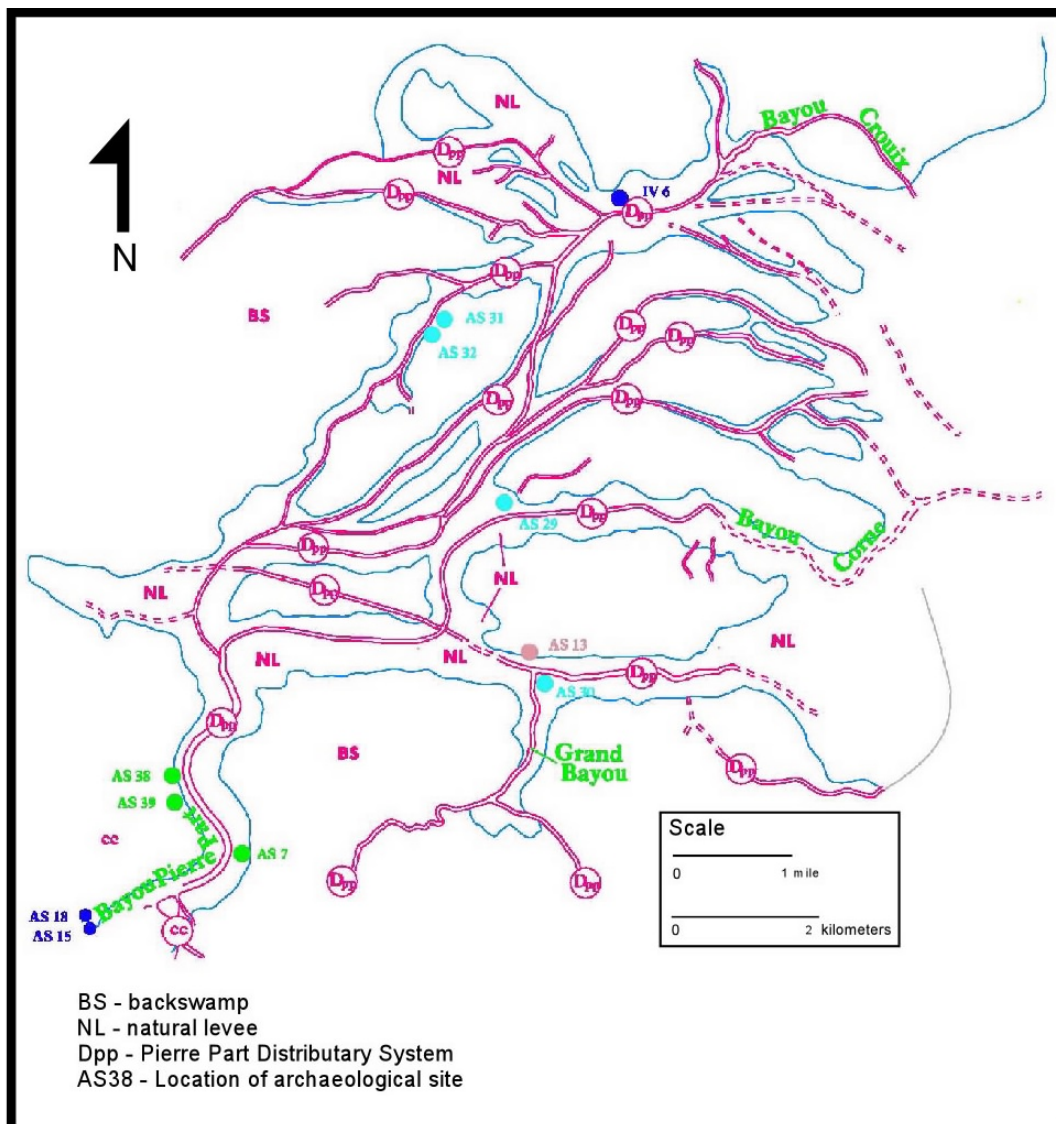


Figure 13. Geomorphic and archaeological evidence suggests that the Pierre Part Distributary System developed in three phases. Grand Bayou and its associated distributaries prograded first, followed by Bayou Croux, and finally Bayou Corne.

The branching and anastomosing pattern of the distributaries related to the Pierre Part Distributary System indicates that this system most likely prograded into a shallow water, lacustrine setting surrounded by backswamp.

Bayou Pierre Part continues south, crosses the Bayou Natchez Distributary and intersects Big Goddel Bayou, both distributaries of the Bayou Plaquemine System (Plate 3 in Appendix). Just north of this intersection is an archeological site containing Marksville components (AS 3) indicating a minimum age for this segment of between 2,000 and 1,800 years B.P. However, since the northernmost (Bayou Crouix) and central (Bayou Corne) distributaries once flowed down Bayou Pierre Part it is impossible to tell which distributary the Marksville site dates. However, this site is most likely associated with the Bayou Crouix distributary because geomorphic mapping indicates that it is older than Bayou Corne (Fig. 13). Bayou Pierre Part continues south past the intersection for approximately 6 miles and then bifurcates into distributaries named Bayou Magazille and Bayou Long which end in the vicinity of Lake Palourde (see Plate 3 in Appendix). These distributaries mark the southern-most surficial deposits associated with the Pierre Part Distributary System. The Pierre Part Distributary System covers an area of approximately 180 sq. mi. (466 sq. km.) in the study area.

The Pierre Part Distributary System was obviously an area of active crevassing from at least 2,000 years until probably 300 years B.P. as shown by the large number of distributaries emanating from a relatively short reach and the number of archeological sites containing multiple occupations from Marksville through Plaquemine cultures.

Fordoche Distributary System (1,600 to 300 years B.P.)

The most recent distributary system to enter the study area is the Fordoche Distributary System. This system entered the study area as a crevasse on the Mississippi River which became a major distributary named Bayou Fordoche. Bayou Fordoche flowed in a southeasterly direction and branched into numerous distributary channels. This branching pattern indicates

that much of the northern part of the study area was shallow open water when this system became active. Bayous White, Black, Grosse-Tete, Tommy, Cholpe, Maringouin, Hooper, Blue, and Upper Grand River are all distributaries related to the Fordoche Distributary System (see Plate 1 in Appendix). Distributaries related to this system are designated as D_F on the geomorphic maps. The oldest known archaeological sites associated with this system (PC1, PC11, PC17, PC18) are of the Troyville culture which would date this system as being at least between 1,600 and 1,300 years B.P.

The southernmost distributaries related to this system reoccupied distributaries of the Plaquemine Distributary System. Bayou Plaquemine, Upper and Lower Grand River and all the distributaries continuing south of these received flow from the Fordoche Distributary System (Plate 2 in Appendix). The Fordoche System also reoccupied the southern most distributaries of the Pierre Part System (Bayous Long and Magazille) (Plate 3 in Appendix). Deposition related to this system buried many of the surfaces related to the Plaquemine and the southern portion of the Pierre Part Systems. The Fordoche System was active until approximately 300 years B.P. as evidenced by the numerous archaeological sites containing artifacts from the Plaquemine culture. The Fordoche System was the last major distributary system to enter the study area, and covers an area of approximately 520 sq. mi. (1347 sq. km.) in the study area. There is some geomorphic evidence (Bayou Ballahack and Bayou Black abandoned distributaries) that the Bayou Fordoche Distributary System extended west of the western boundary of the study area (see Plate 1 in Appendix). However, sedimentation related to Atchafalaya River flow has buried most evidence making further delineation impossible.

Several individual distributaries have entered the study area from the eastern boundary. Most originated as crevasses from the Lafouche-Mississippi course. The few sites located along these distributaries (AS8, AS27, AS28) contain Coles Creek artifacts providing a minimum date of 1,300 to 800 years B.P. for these distributaries.

Lake Verret (Plate 3 in Appendix) appears to have formed within the low area created by the southern end of Plaquemine, Pierre Part, and Fordoche Distributary Systems on the west and the natural levee deposits of Bayou Lafourche on the east. Drainage from the surrounding natural levee deposits flowed into this interdistributary basin creating this shallow lake. Subsidence and subsequent deposition has obscured, and wave erosion has destroyed, the distal remnants of numerous distributaries surrounding the lake.

The next major development in the chain of events leading to the present geomorphic setting occurred approximately 500 years B.P. when the active Mississippi River meander loop known as Old River-Turnbull Island intersected Bayou DeGlaze and Lettsworth, a former Mississippi River course (Fisk, 1940). Intersection by the Mississippi River of the Bayou DeGlaze and Lettsworth course captured the Red River flow. The Red River was using the older abandoned Mississippi River course to empty into the present Mississippi River further to the south. Formation of the Atchafalaya River soon followed and required flood flow from the active Mississippi River to flow upstream in the former Bayou DeGlaze and Lettsworth course and crevasse the natural levee bordering the northern edge of the basin near Simmsport. Continued Mississippi River flow through the Simmsport crevasse soon established the Atchafalaya River and Basin as a Mississippi River distributary and modern Red River course.

Atchafalaya and Red River flow likely entered the study area during high flow periods through reoccupation of distributary channels. However, the Plaquemine, and Fordoche

distributary systems and their associated natural levees restricted much of the flow from entering the study area. More significant flow and associated deposition probably came from continued crevassing on the Mississippi River which entered the study area through the existing distributary network.

False River (Plate 1 in Appendix) was part of the active Mississippi River channel until 1722 when it was cut-off creating the abandoned channel present today. Active crevassing appears to have occurred until it was cutoff from Mississippi River flow. No known archaeological sites are located adjacent to this abandoned channel in the study area. This area may not have been a preferred location due to the frequency of crevassing. However, crevasse splay deposits may have buried any existing sites by up to 10 ft (3 m) of material.

Little physiographic change appears to have occurred within the study area between the birth of the modern Atchafalaya River and early occupation by European settlers in the early to mid 1800's. As Fisk (1952) noted when comparing early Louisiana state maps (Darby, 1816) with a much earlier map dated 1578 by Monk Ptolemy, who accompanied Desoto's expedition to the mouth of the Atchafalaya River in 1542, no substantial change appears to have occurred in the study region from the mid 1500's to before the turn of the present century.

Three major stages of human activity have occurred in the basin and the present study area leading to the present physiography: (1) initial occupation by European settlers and development of agricultural, fishing, and timber resources; (2) development of transportation networks into the basin interior (highways along major distributaries, access canals for the oil and gas industry, and navigation canals.) and (3) development of the basin for a flood control program in response to the 1927 Mississippi River flood. Prior to construction of the EABPL and the Mississippi River levees the study area received floodwaters from the Atchafalaya River

as well as the Mississippi River. These floodwaters flowed through the existing distributary network adding sediments to natural levee and especially backswamp environments. After completion of the levee system the study area was cut off from active river flow and deposition. The study area presently acts as a drainage basin for the surrounding alluvial plain. The drainage patterns are primarily controlled by existing distributary networks, man-made canals, and roads found throughout the study area. No appreciable sediment deposition has occurred since the levee system surrounding the study area was constructed.

Discussion and Conclusions

The shifting nature of the Mississippi River in south Louisiana is responsible for creating a unique geologic setting in the study area that was favorable for the development of upper deltaic plain distributary systems. The location of the Teche-Mississippi course on the western edge of the alluvial valley and the Mississippi River in its present position, coupled with subsiding backswamp and lacustrine deposits, created an extensive topographic low, with a favorable gradient, into which distributary systems prograded (Fig. 6). This low basin was subsequently isolated from the Gulf by progradation of the Lafourche-Mississippi course south across the abandoned Teche-Mississippi course near Houma approximately 1500 to 2000 years B.P. (Smith et al., 1986).

Three distributary systems have prograded in to the study area in the past 2500 years (Fig. 14). Each of these systems was active for several hundred years as indicated by geomorphic and archaeological evidence. The high density of distributaries that developed during the 2500 year period is evidence that most of this upper deltaic plain deposition was initiated by crevassing and avulsion rather than lateral channel migration and overbank flooding. This is in agreement with the observations of Aslan et al. (2006) regarding the mechanisms of floodplain development, wherein they suggest that the alluvial valley has changed from a crevassing/avulsion dominated floodplain to one constructed by mainly overbank flooding.

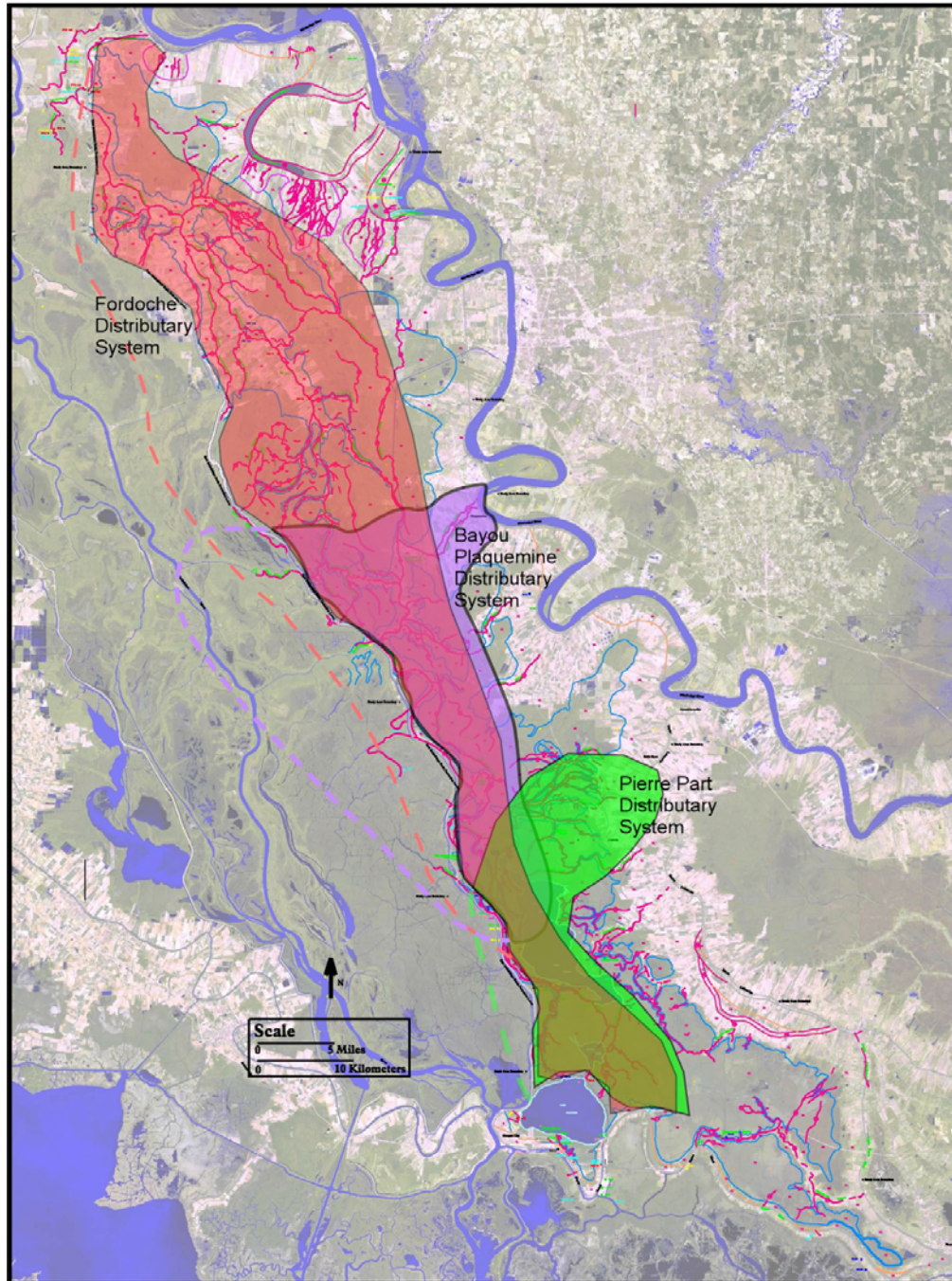


Figure 14. Location of the Fordoche, Bayou Plaquemine, and Pierre Part Distributary Systems which prograded into the study area within the past 2500 years.

These distributary systems developed north of distributary systems that were documented by previous investigators (Fisk, 1944; Kolb and Van Lopik, 1958; and Frazier, 1967; May, 1983). Importantly, these distributaries appear to have developed during a time period when bayhead and shelf deltas were forming farther south along coastal Louisiana. Upper deltaic plain deposits have been generally associated with formation by rapid (<100 years) lacustrine delta progradation, across a relatively small area (Tye and Coleman, 1989). Data from this study suggests however, that under certain conditions, large areas of upper deltaic plain can be built by distributary systems that develop during thousands of years time period. Distributary system development in this upper deltaic plain setting is not unlike the deltaic development commonly associated with the lower deltaic plain. However, borehole data of the study area between the East Atchafalaya Basin Protection Levee and Bayou Lafourche indicate the presence of thick (~100ft (33m)) backswamp, lacustrine, and substratum deposits. These stratigraphic intervals lie below the abandoned distributary and natural levee deposits of the surficial distributary systems noted in this study (Fig. 15). This is in contrast to the thick prodelta and interdistributary deposits that are associated with and underlie distributary systems in the lower deltaic plain (Kulp et al., 2005). Additionally, because the distributary systems of the study area developed in the upper deltaic plain, away from marine influence, geomorphic features such as headlands, beach ridges, barrier islands, and tidal inlets are absent. The absence of typical lower deltaic plain stratigraphy and coastal geomorphic features suggestive of marine reworking provides strong evidence for identifying distributary systems that formed in the upper deltaic plain.

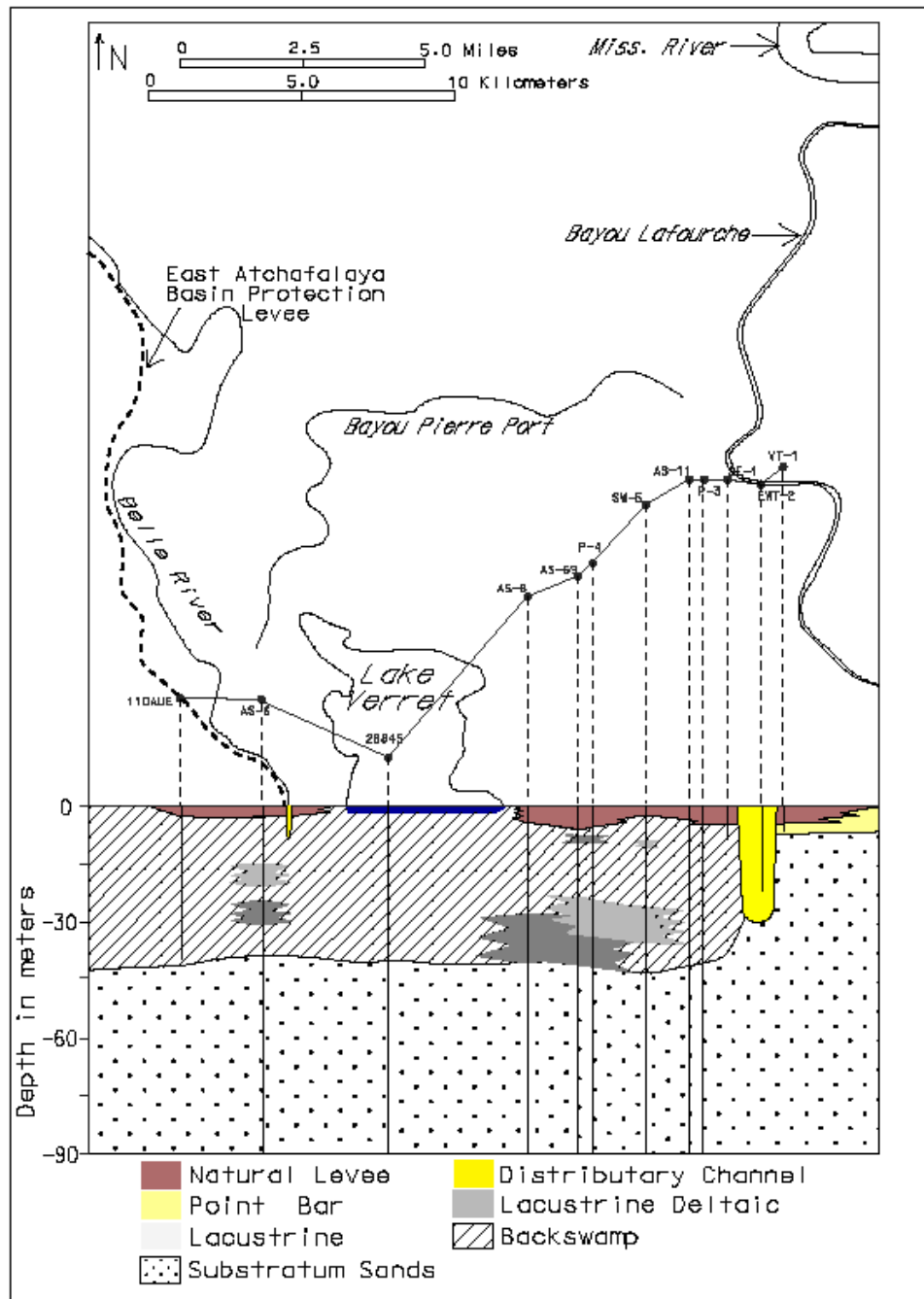


Figure 15. Cross section showing the character of deposits underlying distributary systems in the study area within the upper deltaic plain. Modified from May (1983).

The unique geologic setting of the study area, coupled with the stable position of the Mississippi River for approximately the past 4000 years, led to the development of these three distributary systems in the upper deltaic plain. This model for upper deltaic plain development should be considered when describing buried deltaic deposits related to major river systems. Extensive distributary systems built during several hundred, or even thousands of years can develop within the upper deltaic plain as has been shown by this study. The presence and recognition of extensive distributary systems in the stratigraphic record does not solely indicate deposition in the lower deltaic plain setting.

The study area has received deposition from several sources over the past several thousand years. These include the Teche-Mississippi River, Lafourche-Mississippi River, Modern Mississippi River, and the Atchafalaya River. The resultant landscape is a complex network of abandoned distributaries, natural levees, backswamp, and lakes. The chronologic reconstruction was based on the ages of cultural resources found throughout the study area, geomorphic evidence, and results of previous investigations. The following sections provide the key results of this research.

Geomorphic Mapping

Geomorphic mapping in the study area resulted in the identification of 7 geomorphic environments. These geomorphic environments comprise a landscape that is predominantly backswamp dissected by abandoned distributary channels and their associated natural levees. These environments were deposited in a topographically low area located between the Mississippi River on the north and east, the Lafourche-Mississippi course on the east, and the

Teche-Mississippi course on the west and south. This area offered a gradient advantage leading to active crevassing and distributary development in the past 4000 years.

Distributary System Development

At least 3 distributary systems entered the study area from different locations beginning approximately 2,500 years B.P. Flood flow periodically entered the study area until the early 1900's when flood protection levees were constructed. Numerous individual distributaries, unrelated to distributary systems, entered the study area from the Mississippi River, Bayou Lafourche, and Bayou Black. During this same period, in the southern portion of the deltaic plain, active delta lobe development was occurring at Bayou Des Families and Bayou Sauvage of the St. Bernard Delta and Bayous Terrebonne, Blue, and Black of the Lafourche Delta (Frazier, 1967).

Development of Upper Deltaic Plain Distributary Systems

Development of distributary systems in the study area does not fit previous models of upper deltaic plain development. Results show that distributary systems can be a major contributor to upper deltaic plain development and that these systems are not always related to the lower delta plain delta switching process. A stable Mississippi River position and a favorable gradient in the study area over the past 4,000 years appear to be responsible for the geomorphic development of the study area.

The unique geologic setting of the study area serves as a model for the development of distributary systems in the upper deltaic plain during centennial time scales and spatial scales of hundreds of square kilometers. These systems were probably not mapped in detail by previous studies because they are located in the upper deltaic plain where lacustrine delta and backswamp, not distributary system, deposition usually dominates the landscape.

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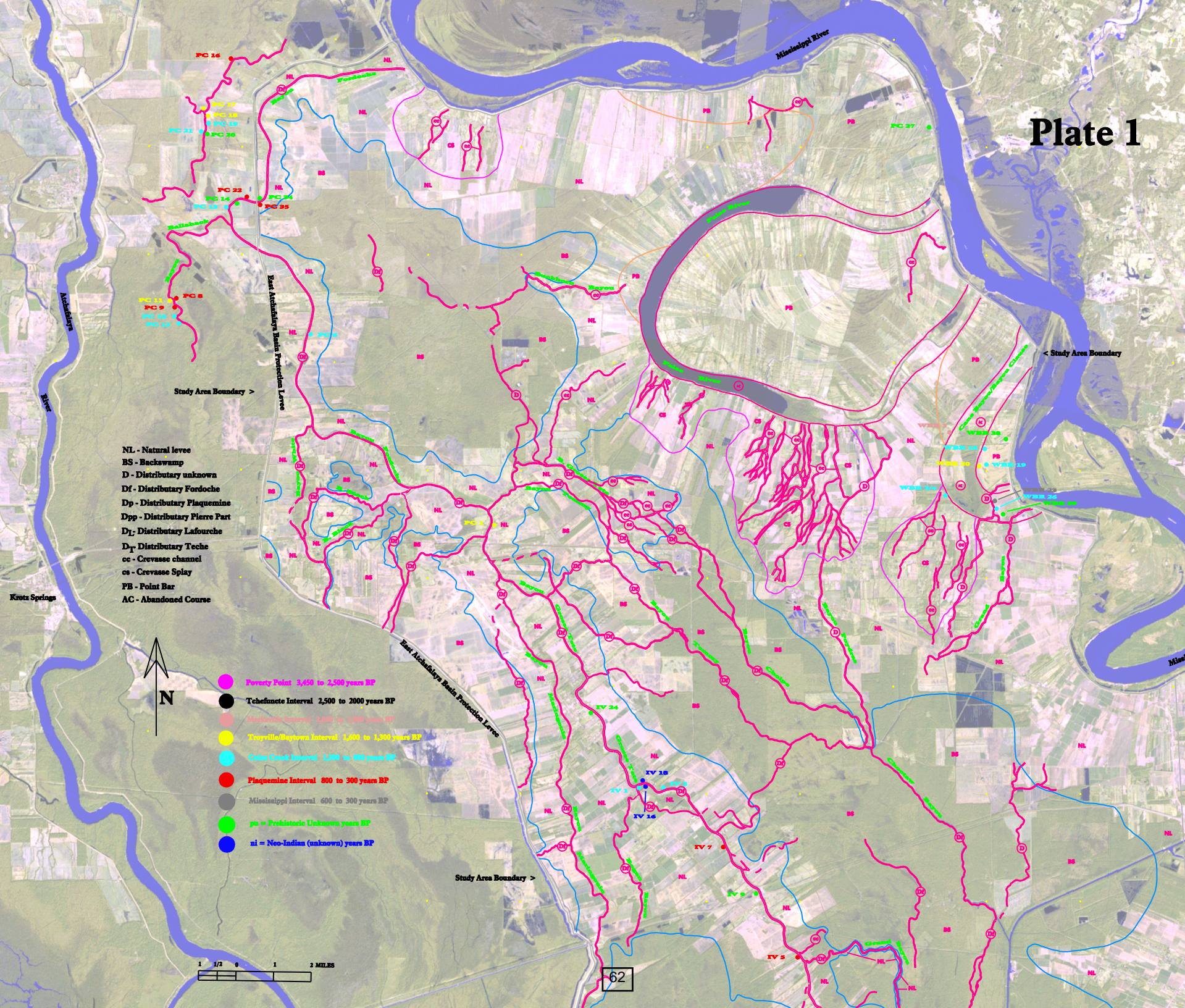
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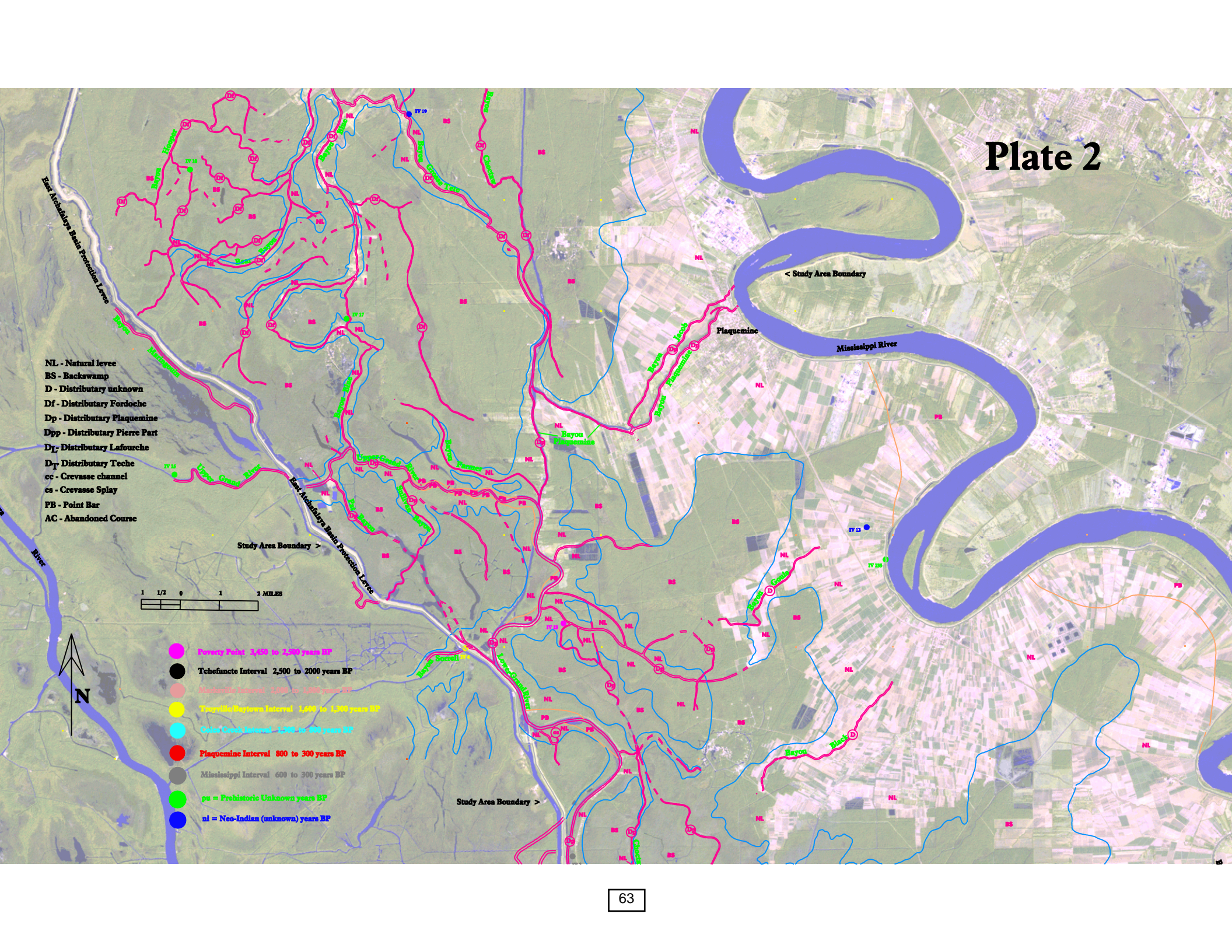
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Appendix

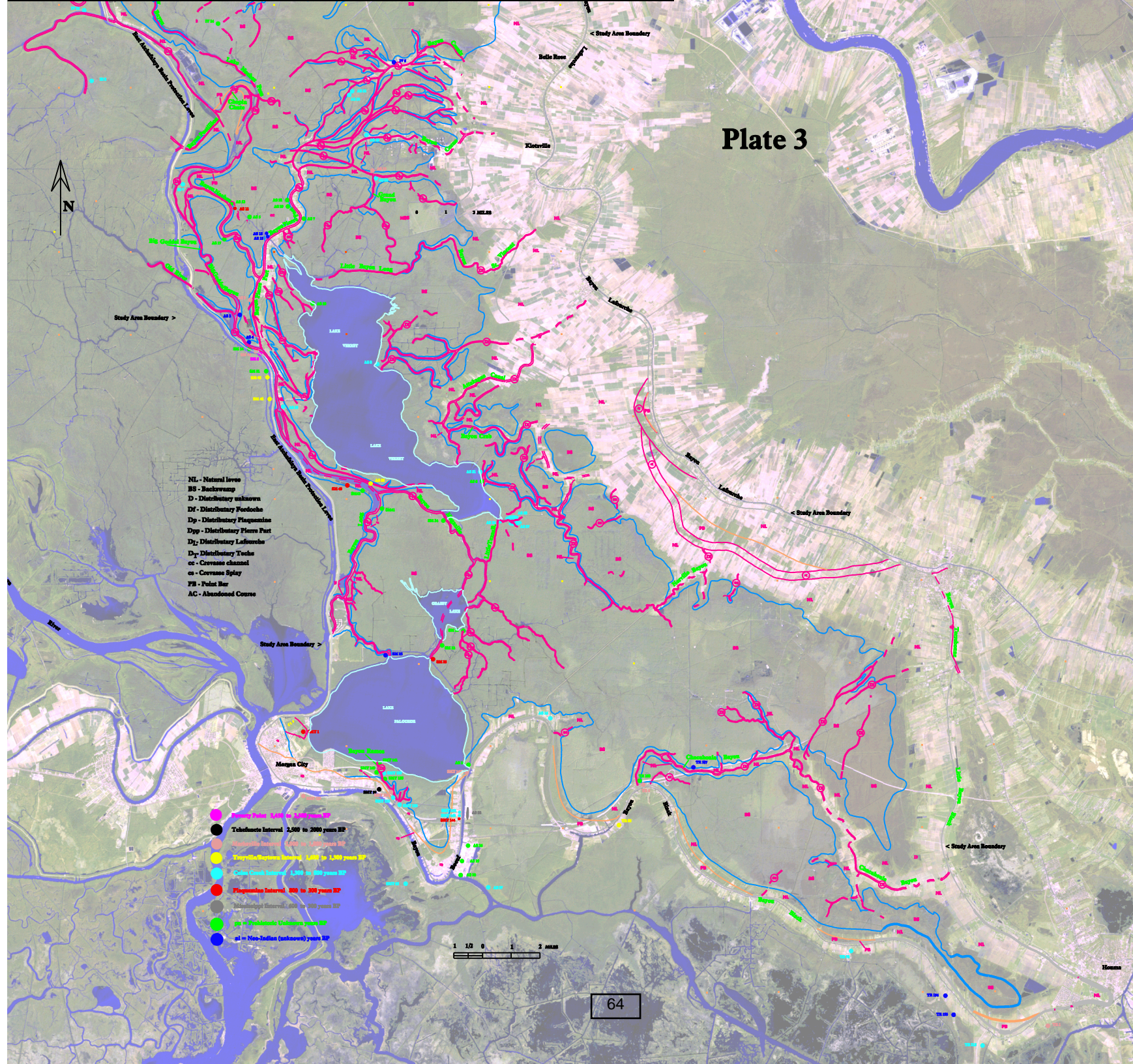
Plate 1



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Plate 3



Vita

Louis Delphin Britsch III was born on December 28, 1958, in New Orleans, LA, the first of Dr. Louis and Mary Britsch's six children. He was raised in Chauvin, LA, approximately 50 miles southwest of New Orleans.

Louis graduated from Nicholls State University in Thibodaux, LA with a B.S. in Geology in 1981. He enrolled at Tulane University in New Orleans, LA in the fall of 1981 and began classes towards an M.S. degree in Geology. His thesis, titled "Migration of Isles Dernieres: Past and Future," began his interest in coastal geology and geomorphology. He graduated from Tulane in 1984.

After graduating from Tulane, Louis accepted a job with the U.S. Army Corps of Engineers, Waterways Experiment Station in Vicksburg, MS. He spent six years at the Waterways Experiment Station working on projects related to the geomorphic development and stratigraphy of the Louisiana coastal plain and documenting and quantifying the dramatic land loss that occurred in the 20th century. During this period, his daughters Lauren and Emily were born.

In 1990, Louis, his wife Sheila, and daughters Lauren and Emily, returned to New Orleans after accepting a job with the Corps of Engineers in New Orleans as a Geologist in the Geotechnical Branch. Work in New Orleans centered on flood protection and navigation projects as well as coastal geomorphology. In 1995, his third daughter, Audrey, was born. In 2002, Louis returned to school at UNO as part of the Corps long-term training program to pursue his doctorate. He finished his coursework in 2004 and passed his defense in November 2007.