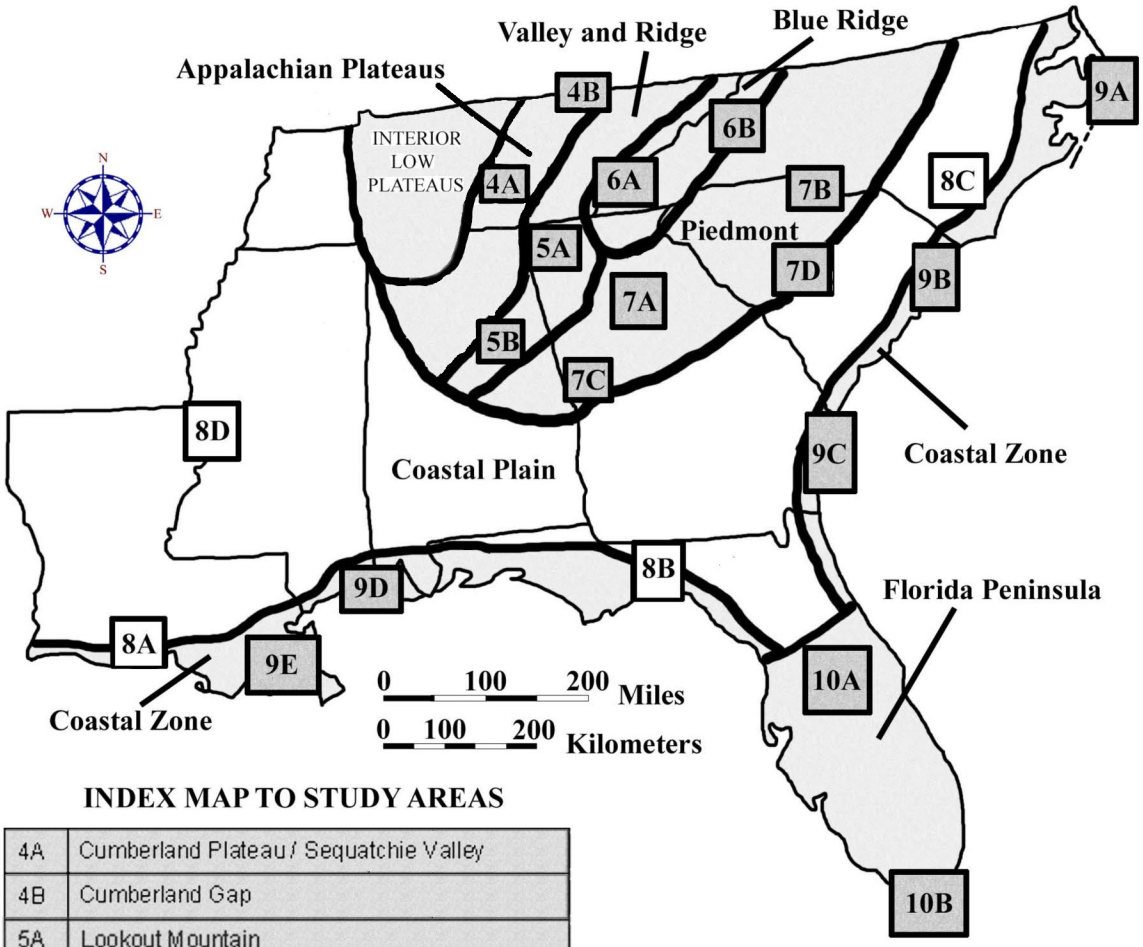
CHAPTER 8

COASTAL PLAIN REGION



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BACKGROUND INFORMATION

Description of Landforms, Drainage Patterns, and Geological Processes

Characteristic Landforms of the Coastal Plain

Looking at it in overview, the **Coastal Plain** seems to form a single homogeneous region, covering all areas in the Southeast along either the Atlantic coast or the coast of the Gulf of Mexico. There are distinctive and easily identifiable Coastal Plain sedimentary units present as far north as New Jersey which continue southward and westward to traverse all the southeastern coastal states before terminating in Texas. And if one includes the geologically related **Coastal Zone** region, the percentage coverage of the Coastal Plain exceeds 60% of the area of several states. There are differences, however, between the Atlantic and Gulf Coastal Plains. The Atlantic Coastal Plain begins at a distinctive Fall Line Zone boundary which separates the region from the adjacent Piedmont region to the north and west. The Gulf Coastal Plain, including the Mississippi Embayment that extends northward into Missouri, cuts across and covers older rocks from several different landform regions along its path. Many texts further divide the Coastal Plain into sub-regions based on differences in vegetation cover, land use, or topographic **relief**. Several of these sub-regions extend across several states, but the overriding dividing factor, with the most influence on land use patterns, is based on land elevation above sea level. The boundary between the Coastal Plain and the Coastal Zone is often indistinct and harder to pinpoint, but is usually placed at the location of the farthest inland extent of tidal fluctuations and salt water incursions from the ocean into rivers and other waterways.

The Atlantic Coastal Plain is usually divided into two large sub-regions. The higher elevation Upper (or Inner) Coastal Plain can resemble in some ways the landscape of the **Piedmont**, as the **topography** can be rather hilly in places, and the landscape can be heavily dissected by stream erosion. The width of this sub-region varies from 10 to 40 miles (16 to 64 km). Local topographic relief is usually measured in tens of feet, and slopes range from gentle to moderate. Elevations vary from 300 feet (91 meters) near the Piedmont boundary to about 125 feet (38 meters) at the boundary with the Lower (or Outer) Coastal Plain. This boundary is usually marked by a distinctive terrace, or scarp (escarpment), that appears as a broad, low ridge line that represents a former position of the shoreline. In the Carolinas and Georgia, this ridge is called the Orangeburg Scarp.

The much flatter and almost featureless Lower (or Outer) Coastal Plain slopes gradually towards the Atlantic Ocean in a series of at least seven steps or **terraces**, separated by escarpments which reflect temporary sea level positions throughout relatively recent (Pliocene and Pleistocene) geologic time. An additional escarpment is currently forming along the present-day sea level position. Elevations range from 125 feet (38 meters) along the Orangeburg Scarp to near sea level, and local topographic relief is seldom more than 20 feet (6 meters).

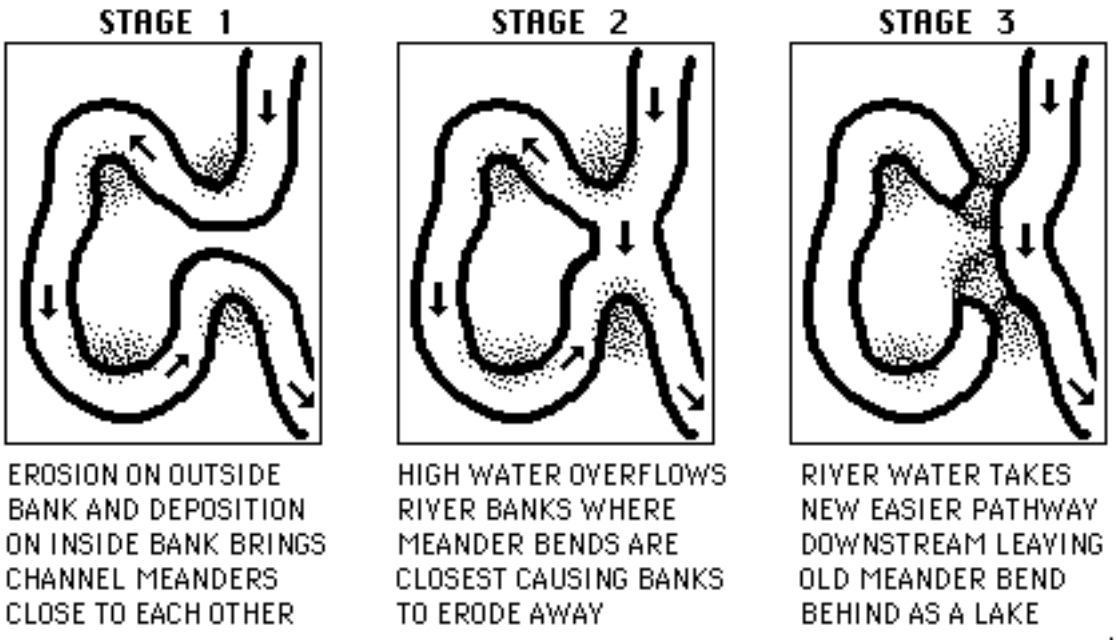
The Gulf Coastal Plain also displays Upper (or Inner), and Lower (or Outer) sub-regions, but lacks a well delineated Fall Line Zone. The Upper sub-region consists of flat lying sediments that have been carved by rivers into a complex mosaic of hills and valleys that can feature locally significant topographic relief. This sub-region reaches a width of nearly 150 miles (240 km) in Mississippi and Alabama where it also features distinct parallel bands of different rock types and elevations. In Louisiana, this upland region is often referred to as the Red River Rolling Lands. The nearly level Lower Gulf Coastal Plain is characterized by a large number of **meandering** streams and rivers with broad **floodplains** that deposit sediment over the area. However, there are very few hills or valleys to break up the monotony of the landscape.

River **floodplains** represent one of the Coastal Plain's most intriguing and mystifying natural environments. Floodplains consist of more than just **swamps**. While the edges of a floodplain may exhibit steep hills or bluffs, which may rise quite a distance above the river level, the floodplain itself contains few significant areas of topographic **relief**. They are essentially flat, low-lying, featureless expanses broken only by river **meanders**, **oxbow lakes**, and slightly elevated parallel ridges, called **levees**, which form along riverbanks. **Levees** form when swiftly flowing river water overtops the banks, slows down, and drops its coarsest sediment near the river's edge. Also within the floodplains are low swampy depressions called **sloughs**, usually filled with mud. Most of this landscape has been created by the deposition of sediment from flooded rivers as they overtop the **levees** and spread out over the surrounding bottomland. As the water spreads out, it loses energy and can no longer carry its previous full load of sediment.

River **meanders** form because the low slope or gradient favors deposition of sediment in the main channel. Such deposition can divert the main flow of the river and cause its path to bend. Once a bend forms, the force of the water flow will erode sediment from the outside of the curve and deposit additional sediment on the inside of the curve, called a **point bar**. The resulting bending of the channel path creates a U-shaped feature whose curvature is continuously made more extreme through time. Eventually, during times of high water, the river may swell and flood over the banks, cutting a new straight channel across the narrow neck of a meander and leaving behind a crescent-shaped abandoned meander, full of water, called an **oxbow lake**. The term oxbow refers to a curved wooden yoke or collar used to harness oxen. Most Coastal Plain rivers meander extensively across their floodplains and have left behind a large number of oxbow lakes and old meander scars as evidence of their former channel locations.

The geological process of stream meandering gradually widens the floodplain as new channels form and new meander bends cut deeply into the adjacent bluffs. Most floodplains contain a large number of old oxbow lakes, some located a great distance from the present-day river. However, it is not necessarily true that the oxbow lakes farthest from the present day channel are the oldest. The main river channel may have wandered back and forth across the entire floodplain many times during recent geologic history. A better estimate of relative age can be obtained by measuring the amount of open water still present in the lakes. Many of the older oxbow lakes have partially filled in with sediments and are now grown over with trees. Lakes with deeper open water are usually younger.

Figure 8-1: Stages in the Formation of an Oxbow Lake



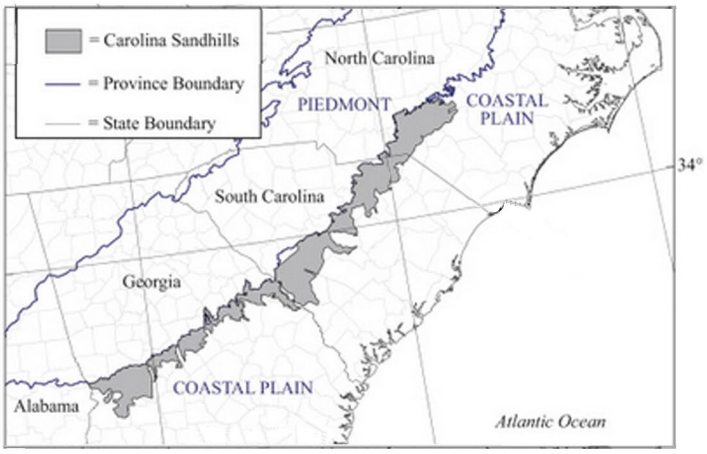
Geographic Features and Localities of Special Interest

A surprisingly wide variety of landscape features can be found in the Coastal Plain Region, an area not usually given much credit for spectacular scenery. Many of these diverse **landforms** are only visible up close as they tend to blend in with the predominately flat terrain and dense vegetation characteristic of most of the region. Most of these landforms have features which reveal the particular environment in which they were formed. For example, wide, level plains mark former sandy ocean bottom **shelf deposits**; low, linear hills and adjacent depressions imply ancient **barrier island** deposits and adjacent marshes; gravel deposits on top of low hills mark locations of former river beds; and rapid drops in elevation (escarpments) indicate positions of former shorelines where wave action scoured and eroded into older terraces. These escarpments are particularly easy to recognize, as they outline broad, nearly flat depositional surfaces which tilt slightly towards the Atlantic Ocean and create a series of landform belts roughly parallel to the present coastline.

The Carolina Sand Hills is a narrow, irregular band of rolling hills that run diagonally across Georgia and the Carolinas roughly adjacent to the Fall Line Zone boundary with the Piedmont. These rounded gentle sloping hills are the remains of sandy and clayey sediment deposits left between 55 and 100 million years ago when sea level was much higher than it is today and the newly opened Atlantic Ocean covered a large portion of the Southeastern states. Elevations range from 250 to 450 feet (76 to 137 meters) above sea level and are usually higher than the adjacent Piedmont landscape. The Sandhills **topography** corresponds to the ancient shoreline, which is recognizable today primarily by old sand dune remnant deposits. During that ancient era, **weathering** and erosion of the **Blue Ridge** and **Piedmont** rocks and soils provided clays and sands that were carried by

water and deposited at the mouth of rivers. Ocean waves and tides reshaped the sediments to form beaches and sand ridges, the remains of which are still visible today. Other marine sediments were also deposited offshore, in the ancient flooded coastal plain, creating the nearly horizontal strata of sedimentary rocks that are characteristic of the many sub-regions found within the rest of the **Coastal Plain**. It should be noted that some recent geologic studies have suggested that the Sandhills deposits are actually much younger than previously reported.

Figure 8-2: Location of the Carolina Sand Hills

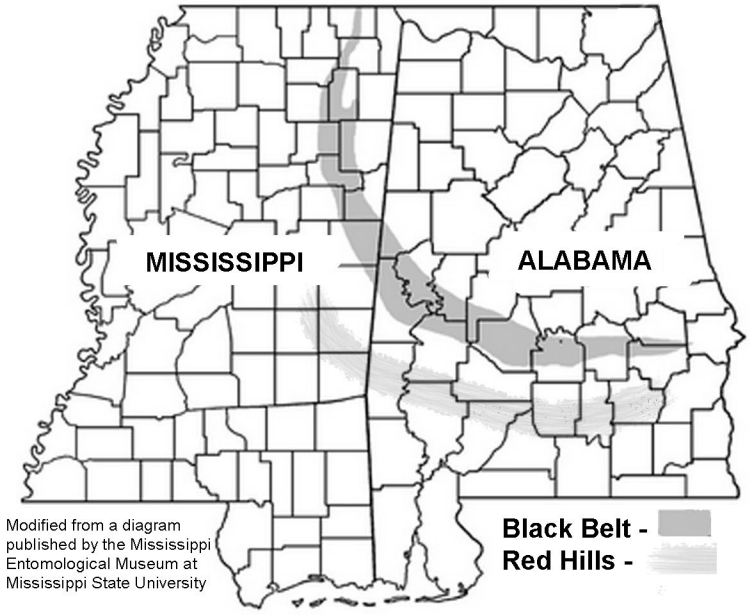


One of the most unusual landforms anywhere in the world occurs in both the Upper (Inner) and Lower (Outer) Coastal Plain sub-regions, primarily in North and South Carolina, but also in parts of Georgia, northern Florida, and Virginia. Carolina Bays form sets of elliptically shaped shallow depressions that occur either individually or collectively with the long axes of the depressions all pointing in the same northwest-southeast direction. Many of the bays contain standing water, but others are dry and some have been drained for agricultural use. The true extent of these remarkable features was not recognized until the advent of aerial photography. At ground level, the bays are difficult to recognize because of the dense overgrowth and boggy nature of the ground. Over 500,000 individual bays have been documented in the Coastal Plain region. The name 'Carolina Bay' was given to these depressions because of the abundance of bay trees in and around the wetland areas. There has been much scientific controversy over the origin and age of the bays, but the favored theory involves an extra-terrestrial encounter, possibly with a comet that broke into fragments when it passed through earth's atmosphere before impacting the earth's surface.

The Black Belt of Mississippi and Alabama is approximately 310 miles (499 km) long and up to 25 miles (40 km) wide, but becoming quite narrow at its northern and eastern ends. The entire region is underlain by a carbonate rock type called the Selma Chalk formed from upper Cretaceous Period marine deposits. The chalk weathers into a variety of rich soil types which support prairies, forests, and agriculture. The Black Belt is bordered to the south and west by the Red Hills, once part of a marine sea. The hills reach up to 510 feet (155 meters) above sea level, an elevation that is quite unusual for the Gulf

Coastal Plain. The Alabama and Conecuh Rivers and their tributaries have cut deeply through these hills, creating areas of high plateau dissected by deep ravines.

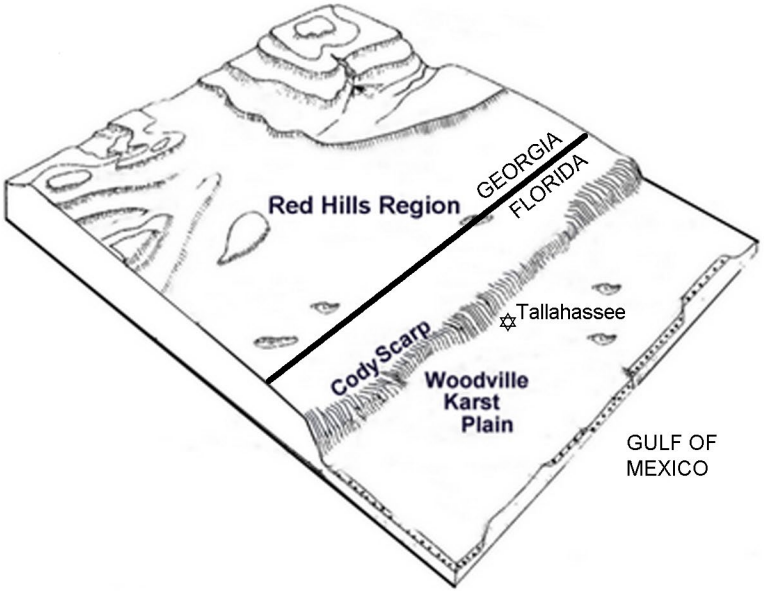
Figure 8-3: Location of the Black Belt of Mississippi and Alabama



Another unusual landform has formed in the Coastal Plain of Southeast Louisiana. Salt Domes have created a unique geography that displays a special array of topographic features that are not found in other coastal regions of the country. Pillars of salt slowly rise from deep underground, gradually working their way through various geological formations until they reach the surface and form small rounded hills or 'islands' that are surrounded by low-lying marshland. Several of these salt dome islands rise over 130 feet (40 meters) above the marshes and provide a distinctly different habitat from the prevailing lowlands. The domes are not all the same size; the smallest measure only about six acres (2.4 hectares), while the larger domes can cover more than 7,000 acres (2,833 hectares). The salt domes also provide excellent traps for underground oil and gas that have provided a valuable economic resource for the petroleum industry and for Louisiana.

The Woodville Karst Plain covers over 288,000 acres (116,000 hectares) stretching from just south of Tallahassee in the Florida Panhandle to the Gulf Coast. The region is not only a significant part of the Floridian aquifer system, but also displays one of the most extensive and active areas of Karst Topography in the Southeast. As part of the Lower (or Outer) Coastal Plain sub-region, the Woodville Karst Plain slopes gently towards the Gulf of Mexico from its northern edge along the Cody Scarp. The area is underlain by limestone, capped by a thin layer, usually less than 20 feet (6.1 meters), of quartz sand. The porous sands allow acidic rainwater to move rapidly into and through the soluble carbonate rocks, creating a series of interconnected caves, underground rivers, and springs. The area also features disappearing streams, natural bridges, and thousands of sinkholes, and many of the Karst features are still evolving.

Figure 8-4: Location of the Woodville Karst Plain



A large feature that covers much of the states of Louisiana and Mississippi, as well as impacting several other states, is the Mississippi River Alluvial Plain. The Mississippi River is one of the major rivers of the world. Its drainage basin covers all or part of 31 states and two Canadian provinces. Two types of sediments are important in this region. Alluvial plain sediments, mostly sand, gravel, and silt, were deposited by the Mississippi River and its tributaries to form a broad undulating plain adjacent to the river. Additional layers of similar sediment were deposited as the river migrated back and forth across the floodplain. The second important sediment type is **loess**, a Quaternary Period deposit that covers the older sediments along a higher-elevation band adjacent to the eastern margin of the Mississippi River Alluvial Plain. **Loess** is a type of glacially produced silt that was picked up and deposited by the wind in this area following the last Ice Age.

Rock Types and Geologic History

All parts of the Coastal Plain are underlain by nearly horizontal sedimentary rock layers, primarily of marine origin, that were formed from underwater deposits of mud, silt, and **limestone** which were buried and later experienced both **compaction** and **cementation**. Although much of the area is now above sea level, allowing a limited amount of erosion to take place, the largest percentage of land is still occupied by floodplains of both major and minor river systems that reveal the region to be primarily one of deposition currently. Major rock types include both marine and terrestrial sandstone, limestone, shale, chert, and phosphate rock. In a few places, especially in the Sandhills region, a resistant cementing agent like quartz or hematite has permeated the sandstone to produce highly durable rocks that have formed locally significant hills. The loess deposits bordering the Mississippi River Alluvial Plain are also highly resistant to erosion and form high bluffs along the east side of the floodplain.

All Coastal Plain sediments, other than the modern river floodplain deposits, were originally laid down when sea level was much higher than its present position. But the Coastal Plain has also experienced several periods of much lower sea level when significant stream erosion took place throughout the region. Geologic evidence from wells and surface exposures indicates that sea level has fluctuated through many such cycles during the Cenozoic Era of geologic time. The greatest flooding episode probably occurred during the Eocene Epoch, about 40 million years ago, when limestone was deposited in a marine continental shelf environment far from the shoreline. At that time, the shoreline was located well north of the Fall Line Zone and perhaps reached as far as the base of the **Blue Ridge** Mountains. During the succeeding Oligocene and Miocene Epochs, sea level fell dramatically as ice caps began to form in Antarctica and Greenland, and the Appalachian Mountains continued to slowly rise higher. The shoreline location during Miocene time was probably situated many miles seaward of the present coastline.

Most of the marine sediments in the Atlantic Coastal Plain were deposited on top of an older surface of igneous and metamorphic rocks identical to those exposed in the Piedmont. In areas closer to the source, these sedimentary layers took on a more terrestrial depositional character, showing properties more common to river and floodplain deposits. In a similar fashion, the Gulf Coastal Plain sediments were deposited on top of older rocks of many different types. Because the land surface has sloped gradually seaward, both now and in the past, the Coastal Plain sediments are much thicker near the coast (averaging about 3,000 feet [914 meters]), than they are near the **Fall Line Zone**, where they thin to practically nothing. Deeper water sediments are found seaward while shallower water and more terrestrial sediments occur in the landward direction. However, even along the coast, sediment thicknesses vary considerably. **Tectonic** uplift near the North Carolina state line, along what is called the Cape Fear Arch, has allowed only about 400 feet (122 meters) of Coastal Plain sediment to accumulate on top of the Piedmont crystalline rocks near Myrtle Beach, South Carolina. In comparison, Hilton Head Island, near the Georgia/ South Carolina border, has experienced much greater subsidence and overlies sediment thicknesses exceeding 4,000 feet (1,219 meters). The Mississippi River embayment, which has experienced almost continual tectonic subsidence throughout the Cenozoic Era, has accumulated sediment thicknesses over 32,000 feet (10,000 meters).

The Quaternary Period ice ages caused several more sea level fluctuations during the last million years of geologic time, producing many of the terrace ridges found on the Lower Coastal Plain. Although the ice sheets did not reach as far south as South Carolina, expansion and retreat of continental glaciers alternately lowered and raised sea level as ice formed on the continents and then melted. Some of the terraces and associated escarpments near the present coast represent interglacial ages of higher sea level when features such as marshes, deltas, beaches, and barrier islands formed somewhat inland from the modern ocean coastline. Although erosion has modified these features considerably, they can often be recognized by their soil types. Several river paths in the Southeast appear to have been diverted by such old terrace features. The Edisto River in South Carolina is a prime example of a river that used to flow directly into the Atlantic Ocean, but is now blocked by a terrace and has had to find a new course to the ocean.

Folklore

Because the Coastal Plain region covers such a large portion of the Southeast, the diversity of cultures occupying the region has been equally large. Immigrants to the region include French Canadians in Louisiana, Spanish settlers in Florida, English plantation owners in the Carolinas, and Black Africans brought to the region as slaves. Each cultural group brought their own particular lifestyles, beliefs, and folklore. Although Native Americans occupied almost all of this land before Europeans arrived, they too represented many diverse nations occupying different regions and practicing different customs and traditions.

One of the most distinctive cultures of the Coastal Plain is the Cajun tradition, a blend of French, Spanish, Native American, and other European and African influences. Each of these ethnic groups added their distinctive customs and stories to the region as they struggled to adapt to a new and challenging environment. Creoles, native born descendants of French and/or Spanish ancestry, are well known for their unique cooking styles and distinctive music, including zydeco. Many legends tell of the journey of the original French Canadian settlers, banished from Acadia in Nova Scotia in 1755 by the English rulers, to their new home in Louisiana. The most famous of these is the poem "Evangeline" by Henry Wadsworth Longfellow; however, an earlier version of the story, recounted by Judge Felix Voorhies, has a less happy ending.

The Legend of Evangeline

--Adapted from a version passed down by the Voorhies family--

The grand'mere of Judge Felix Voorhies befriended and reared an orphan girl, Emmeline Labiche, in the Canadian home of the Acadians. A few days over sixteen, Emmeline was about to marry a man of their village, Louis Arceneaux. The banns had been published. Then, the day before the marriage, they were forced on to several waiting ships as part of the exile. Louis, resisting, was injured and carried away; Emmeline screamed and fell to the ground. She and her benefactor were taken to another ship, and their party landed in Maryland. There they had a somewhat less difficult time than was the lot of many of the others, for they fell among families who were sympathetic and helpful. But Louis was not there, and often the saddened Emmeline talked of him, and wondered whether he had lived; if so, where he was now. After several years, the party heard, like others, of Louisiana and, after much debate and over the protest of their Maryland friends, they made the perilous trip, by land and water, to the Attakapa country. Here, contentment awaited most of the party; for Emmeline, there was something else.

She stepped off the boat with the rest, but she paid little attention to the scene or to the exclamations of others. Her face as usual was sad.

Suddenly she halted. There, under a heavy oak, was the man for whom she had wept during these drab years. She ran to him; he rose, recognition and then pain in his face. She reached out he turned half-away, and spoke in a muffled voice: He had pledged himself to someone else. He had waited - - - but after all that time- - - He walked away.

From that day, the life of Emmeline was lived in dim light. Her manner became strange, alternating between melancholy and tremulous excitement. She wandered along the Teche, picking moss from the live oaks, flowers from the edge; and then she wept and talked of the old land and of her marriage the next week to Louis. . . . . .

African American communities throughout the Coastal Plain region are also well known for their rich heritage of oral traditions, music and dance, as well as 'soul food'. Musical contributions date back to the days of slavery when work songs and spirituals were sung to break the monotony of fieldwork. Many of these songs blended African tunes with other musical styles and included the use of unique instruments like the banjo and harmonica. The roots of blues and black gospel music run deep in the Black Belt of Mississippi and Alabama and were popularized by artists such as Tommy Johnson, Mississippi John Hurt, Rufus Thomas, and B. B. King. White musicians such as Elvis Pressley introduced this music to a much wider audience in several early rock and roll recordings that popularized the so-called 'Memphis Sound'. Many blues singers also migrated from Mississippi to Chicago where they built successful music careers, performing with stars such as Muddy Waters and Willie Dixon.

Everyday I Have The Blues
--Lyrics by B. B. King--

Everyday, everyday I have the blues
Ooh everyday, everyday I have the blues
When you see me worryin' baby, yeah it's you I hate to lose

Whoa nobody loves me, nobody seems to care
Whoa nobody loves me, nobody seems to care
Well worries and trouble darling, babe you know I've had my share

Everyday, everyday, everyday, everyday
Everyday, everyday I have the blues
When you see me worryin' baby, yeah it's you I hate to lose

Whoa nobody loves me, nobody seems to care
Whoa nobody loves me, nobody seems to care
Well worries and trouble darling, babe you know I've had my share

White European immigrants brought much of their literary and musical heritage with them when they settled in the Coastal Plain. However, there soon developed distinctive cultural differences between rich plantation owners and poorer Whites, often referred to as 'rednecks', who often could only find work as tenant farmers or construction

workers. These lower-class White workers are credited with popularizing a uniquely American story type known the 'tall-tale' work legend, centered around fictitious characters with unusual strength or other special powers. While the best known examples of such legends, like Paul Bunyan and Casey Jones, come from other regions, several stories relate to Coastal Plain work projects, such as this one, related by author Jody Tinsley, that references the building of dams and reservoirs in South Carolina.

The Legend of Big Bubba and the Fishing Hole
--excerpted from a story by Jody Tinsley--

When Bubba was a baby, he was a big, big baby. It took a whole herd of cows to keep him in milk. A cotton mill near the Fall Line Zone ran extra shifts to make his diapers. When he cried, folks thought it was a hurricane.

As he grew up, thank goodness, he learned to control himself. He smiled instead of laughing and frowned instead of crying. He walked slowly and carefully so as not to bump into the church and knock off the steeple or squash the farm animals.

But one thing he couldn't control was his appetite. It wasn't big. It wasn't huge. It was enormous. His family planted a special cornfield just to grow his grits. He got permission to pick poke salad and blackberries from the roadsides in five surrounding counties. And Bubba hunted and fished to keep himself fed.

He had a dozen hunting dogs, and they would help him catch about 25 deer or 150 rabbits or so, which was just enough to make him a nice lunch or light supper. But the other hunters in the area didn't much care for Bubba's hunting trips. They liked Bubba, but they didn't like him hunting out all the game.

So Bubba turned to fishing more and more. He'd go to the river and catch about 50 big old catfish and make a catfish stew. But he trampled the banks so much while fishing that he began to feel bad about it. And his big boat blocked the river from bank to bank which caused flooding. "I need a bigger fishing hole," he said, softly, "something really big."

Over the next few months, Bubba worked hard and built all the reservoirs anyone could ask for. He dug holes; he made dams; he moved earth; he built canals to connect the reservoirs and rivers together. And finally, when the work was done, Bubba slid his boat from Lake Moultrie into Lake Marion, carving out a ditch and creating the Diversion Canal in the process, and he finally relaxed on the open water with his fishing pole. And if you're ever on Lake Moultrie late at night and hear loud noises like thunder, but without any storm, you've probably heard Bubba grumbling about the big one that got away.

Historical Events

The history of the Coastal Plain region is as diverse as its geography. Even the region's first inhabitants, the Native Americans, occupied different regions, hunted different game, grew different crops, and interacted with the early European explorers in different ways. The first European colonists settled in the Coastal Zone in the mid 1500's, in port cities that had good harbors. As the population grew, more and more settlers

moved inland to start establishing plantations and begin producing crops for export. However, most people were still living alongside rivers that were the main means of transportation in the area. Several Spanish parties, most notably under Hernando de Soto, headed northward from Florida in search of gold and other riches. By the year 1700, the English controlled the Carolinas, the Spanish controlled Florida, and the French controlled the Mississippi River valley. The French Acadian refugees, expelled from Nova Scotia in Canada in 1755, settled the low-lying floodplains of South Louisiana.

The Coastal Plain features many archeological sites that provide evidence of Native American villages and middens (essentially dumping grounds for refuse) as well as remnants of fortifications and artifacts from early European colonists. Although few major cities were established in this region, small towns sprung up nearly everywhere and a widespread plantation culture requiring slave labor flourished throughout the Coastal Plain until the time of the Civil War. Interactions between the Native Americans and the Europeans alternated between friendly and hostile, however both groups benefitted from the trade relationships that developed. The commodity most prized by Europeans was deerskins, which the Native Americans could provide in great number. Records indicate that up to 150,000 deerskins per year passed through the Charles Town harbor in South Carolina during much of the 18th century. In return, the Native Americans received metalware such as pots, pans, knives, and firearms. Unfortunately, contact with Europeans also introduced epidemics of smallpox and measles among the natives.

The Coastal Plain was home to several important battles during the American Revolution, but only three states in the Southeast took part, Georgia, South Carolina, and North Carolina. Most of the fighting in these states actually took place between American citizens of different political persuasion, not against the British. In many areas of the Southeast, loyalists (tories) who supported England actually outnumbered the patriots. Many of these battles involved one of South Carolina's most famous military heroes, General Francis Marion. He became a popular folk hero because of the unconventional tactics he used to win battles. Those tactics were similar to what we would call guerrilla warfare today, and were very different from what the British army expected to face.

While most of the early fighting took place in the Piedmont Region, by 1781, most of the action had shifted to Coastal Plain battlefields. On May 11, 1781, Patriot General Thomas Sumter was defeated at Orangeburg, South Carolina by British Lieutenant Colonel Lord Francis Rawdon. On September 8, 1781, Patriot Major General Nathanael Greene and Francis Marion lost the Battle of Eutaw Springs, the final Revolutionary War battle in South Carolina, to Lord Rawdon, but in the process the British army was so depleted that they were forced to withdraw to Charles Town a short time afterwards. After the end of the war, on December 14, 1782, the British army left Charles Town for the last time, along with close to 4,000 South Carolina loyalists and 5,000 slaves.

The Louisiana Territory was acquired from France in 1803 and Florida was acquired from Spain in 1819 to complete the consolidation of United States territory in the Southeast. Tennessee became a state in 1796, Louisiana in 1812, Mississippi in 1817, Alabama in 1819, and Florida in 1845.

During the Civil War, all of the southeastern states seceded from the United States and joined the Confederacy. Control of Vicksburg, Mississippi was a major goal of the Union forces but the city withstood repeated attacks and eventually became the last section of the Mississippi River controlled by the Confederacy. In 1863, Confederate troops and the citizens of Vicksburg withstood a forty-seven day siege before surrendering to General Ulysses S. Grant on July 4th. By the end of 1863 the Union controlled the entire Mississippi River corridor, several coastal strongholds, and most of the state of Tennessee. The march of General William T. Sherman through Atlanta to the sea in 1864, and later through Columbia, South Carolina in 1865 was designed to destroy the railroad lines that allowed the Confederacy to transport supplies and troops. In the process, Sherman left a wide path of destruction through many major towns as well as the countryside and effectively ended the conflict in the southeast.

The Reconstruction period was a time of turmoil as one by one the states of the Confederacy were re-admitted back into the Union. A single crop, cotton, ruled the economy of much of the region. Seeing little future for themselves in the South, large numbers of African Americans migrated to urban areas in the North to fill many of the low-wage industrial and manufacturing jobs that were plentiful in the early 1900s. During the Great Depression of the 1930s, very few benefits were provided to the mostly Black residents living in the Coastal Plain and this region has continued to include some of the most economically depressed and disadvantaged portions of the Southeast.

For many years after World War II, most of the southeastern states remained racially segregated. However, the fight for equality and Civil Rights involved several landmark events that occurred in Coastal Plain locations. The court case known as Brown vs. Board of Education that ended segregation in public schools included petitioners from the Coastal Plain county of Clarendon in South Carolina, and the cities of Selma and Montgomery, Alabama are also located in the Coastal Plain region.

Influence of Topography on Commerce, Culture, and Tourism

Until the coming of the railroads, rivers were the only reliable means of transportation in the Coastal Plain region. In addition to facilitating commerce and trade, these rivers were also used for a variety of smuggling operations, both of commodities and of people. However many of these rivers are surrounded by floodplain swamps, especially in the Lower Coastal Plain. These swamplands are typically uninhabited because they are too wet for most agricultural or other land uses. While these wetlands were a nuisance to some travelers, they were a sanctuary for others. The swamps made great hiding places for soldiers trying to escape capture or runaway slaves traveling north to freedom along what has been termed the ‘Underground Railroad’. During daylight, these slaves slept in the swamps, and with nightfall began to follow designated river systems northward. On their journey they were assisted by abolitionist sympathizers who provided food, clothing, and hiding places. While some slaves successfully reached freedom by following these routes, it posed a great risk not only to the escaping slaves, but also to the Whites who assisted them.

Word of the existence of the Underground Railroad, and other escape routes, spread rapidly among the slave population, but such information could not be discussed openly for fear of discovery and punishment. Geographic landmarks, trail routes and other instructions were often hidden in code within stories and songs that slaves shared with each other. The song, "Follow the Drinkin' Gourd," contains an example of such a code. Runaway slaves and white sympathizers would sing this song to remind themselves about certain landmarks and travel directions essential to their journey. Codes hidden in songs could be easily memorized and shared without any fear of detection. In addition to being a source of hope and encouragement, this song also contained such practical advice as "keep to the river," "sleep by day," and most importantly, "follow the drinkin' gourd." The "drinkin' gourd" refers to the stars in the night sky which make up the Big Dipper, a group of stars called an asterism, in the constellation Ursa Major. Those stars always shone in the northern sky, pointing the way towards freedom.

Follow the Drinkin' Gourd
--traditional--

Think I heard the Angel say; Follow the Drinkin' Gourd
Stars in the heaven gonna show you the way; Follow the Drinkin' Gourd

Step by step keep a travelin' on; Follow the Drinkin' Gourd
Sleep in the hearth till the daylight is gone; Follow the Drinkin' Gourd

When the sun comes back and the first quail calls; Follow the Drinkin' Gourd
The old man is a waitin' for to carry you to freedom; Follow the Drinkin' Gourd

Well the river bank makes a mighty good road; The dead trees show you the way
Left foot, peg foot, travelin' on; Follow the Drinkin' Gourd

Follow that river till the clouds roll by; Follow the Drinkin' Gourd
Keep on movin' as you look to the sky; Follow the Drinkin' Gourd

When the great big river meets the little river; Follow the Drinkin Gourd
For the old man is a-waiting for to carry you to freedom; Follow the Drinkin Gourd

Well the river ends between two hills; Follow the Drinkin' Gourd
There's another river on the other side; Follow the Drinkin' Gourd

There's a new day comin and it won't be long; Follow the Drinkin' Gourd
All God's children got to sing this song; Follow the Drinkin' Gourd

CHORUS:
Follow the Drinkin' Gourd; We're gonna' follow the Drinkin' Gourd
Keep on a travelin' that muddy road to freedom; Follow the Drinkin' Gourd

For people living near floodplain swamps, the unique landscape seems to seep into their local culture and also provides a perfect terrain for hunting and fishing activities. The level topography, rich soil, and abundant nutrient supply, coupled with the lack of agricultural activity, also contributes to the growth of large stands of tall trees. The

difficulty of harvesting timber in the middle of a swamp has allowed several sections of virgin forests to be preserved in several Southeastern states. The most well-known of these stands is found in Congaree National Park in South Carolina which contains record size trees of several different species. Mr. Booker T. Sims lived his entire life by the Congaree Swamp in South Carolina and shared some of his experiences during an interview with Sandy Morgan when Mr. Sims was 70 years old.

Interview with Mr. Booker T. Sims
--excerpted from notes taken by Sandy Morgan--

I've been going into the swamp since I was about three or four years old. I would go with my daddy fishing. We would dig for worms and then fish. There were always plenty of worms. We fished in the creeks. At this time we were fishing for eels. Nobody fishes for eels today in the swamp. There aren't any more eels. We would also fish for catfish. We could fill up a bucket with fish in no time!

There wasn't any road into the swamp. We followed a footpath. We always went late in the day and fished at night. When I was older, my friends and I would go and fish at night. We would have a good ole time. We built a fire on the bank and cooked those fish as we caught them. Sometimes we stayed all night.

Being in the swamp was a way of life for my daddy. I loved it too. My daddy and I would hunt in the swamp also. We would hunt mainly squirrels and coons. The interesting thing about the swamp back then is that mosquitoes did not bother you like they do today. We didn't have any insect repellent back then, but those mosquitoes just didn't bother us like they do today!

The trees in the swamp are huge. Sometimes people would think they had found a tree bigger than the ones in the swamp, but they never did. My daddy said that there weren't any trees bigger than those in the swamp!

My daddy spent a lot of time in the swamp. One day he went to fish and just died sitting right there on the bank of Weston Lake. I found him there dead and had to carry him out. I guess he died doing what he liked to do most. My daddy believed that Weston Lake did not have a bottom. He told us a story about a huge hungry sturgeon to keep us from getting too close to the edge of the lake.

Settlers in southern Louisiana had a different type of topography to deal with. The initial settlements were separated from the uplands and from each other by the area's inhospitable swamps and marshlands, so boat travel was the only real transportation option. Communities were often clustered along levees of rivers and a number of engineering projects were begun to try and stabilize the courses of waterways. The low elevations and high water table also forced the inhabitants to build above-ground graveyards and cemeteries. Settlers in the Upper Coastal Plain of Louisiana and the other Southeastern states were able to avoid the problem of too much water and therefore were able to establish large agricultural plantations. Where wetlands did exist, as in Carolina Bays, these features were often drained and used for farmland.

Commercial boat traffic on meandering rivers like the Mississippi, flowing along the Louisiana and Mississippi border, constantly encountered problems whenever the main channel shifted position and sand bars either appeared or disappeared with little or no warning. Commercial barge traffic is still a major business on the Mississippi River and this issue continues to plague commercial riverboat captains even today. Samuel Clemens (Mark Twain) describes some of these issues in his book "Life on the Mississippi."

Life on the Mississippi

--by Mark Twain, excerpted from Chapter titled "Cut-Offs and Stephen"--

The water cuts the alluvial banks of the river into deep horseshoe curves; so deep, indeed, that in some places if you were to get ashore at one extremity of the horseshoe and walk across the neck, half or three quarters of a mile, you could sit down and rest a couple of hours while your steamer was coming around the long elbow, at a speed of ten miles an hour, to take you aboard again.

When the river is rising fast, some scoundrel whose plantation is back in the country, and therefore of inferior value, has only to watch his chance, cut a little gutter across the narrow neck of land some dark night, and turn the water into it, and in a wonderfully short time a miracle has happened: to wit, the whole Mississippi has taken possession of that little ditch, and placed the countryman's plantation on its bank (quadrupling its value), and that other party's formerly valuable plantation finds itself away out yonder on a big island; the old watercourse around it will soon shoal up, boats cannot approach within ten miles of it, and down goes its value to a fourth of its former worth.

When the water begins to flow through one of those ditches I have been speaking of, it is time for the people thereabouts to move. The water cleaves the banks away like a knife. By the time the ditch has become twelve or fifteen feet wide, the calamity is as good as accomplished, for no power on earth can stop it now. When the width has reached a hundred yards, the banks begin to peel off in slices half an acre wide. The current flowing around the bend traveled formerly only five miles an hour; now it is tremendously increased by the shortening of the distance.

[Through this process] In the space of one hundred and seventy-six years the Lower Mississippi has shortened itself two hundred and forty-two miles. That is an average of a trifle over one miles and a third per year.

Although the Coastal Plain is not known for having spectacular scenery, tourism is still a major economic factor in some areas. Several companies offer riverboat excursions on the Mississippi River and some other waterways, and many reservoirs throughout the region offer excellent swimming, boating, and fishing opportunities. Many former plantations have been restored and offer public tours of both the mansion houses and their gardens. National and state forests provide opportunities for hiking, bird-watching, and hunting; and state and national parks have preserved various historical sites and pristine portions of unique ecosystems like the Carolina Sandhills and the Carolina Bays.

Climate and Water Resources

The climate of the Coastal Plain Region varies from temperate, in North Carolina to humid subtropical along the Gulf Coast. The region typically has a 200-250 day growing season and an average annual rainfall of 35-50 inches (89-127 cm). Precipitation is fairly well distributed throughout the seasons, but hurricanes often bring torrential downpours in late Summer and early Fall, and droughts occasionally create problems over a period of years. Winter snowfall is rare. Tornados often impact the area in the Spring. Some areas with very sandy soil, such as in the Carolina Sandhills, mimic a desert climate because rainfall percolates through the sand so rapidly that the surface soil dries out quickly. Certain locations, particularly in the Upper Gulf Coastal Plain, are seasonally dry enough to sustain a wide expanse of acreage resembling prairie grasslands and savannahs.

As the rivers enter the Coastal Plain from the Piedmont, they begin to meander and to form broad floodplains or bottomlands. These areas are often seasonally flooded and serve as important water storage and **aquifer** recharge areas. Such floods can occur eight to ten times per year. Groundwater is easily and uniformly available from the deep coastal sedimentary rock layers, and wells commonly yield up to 200 gallons (757 liters) per minute. Some flowing (artesian) wells also occur, particularly in the Upper Coastal Plain. Although the quantity of water is not a problem, the quality of both ground and surface water is a concern in many areas of the Coastal Plain.

Once considered only as a breeding ground for mosquitoes and snakes, wetlands are now appreciated as one of the region's most precious natural resources. Wild boars, raccoons, bobcats, waterfowl, and barred owls are just a few of the wildlife inhabitants that depend on river bottom forests for survival, creating a rich and diverse unique habitat area for both sportsmen and naturalists. In addition to wildlife habitat, these wetlands provide other important ecological functions, among which are flood control, ground water recharge, soil nutrient replenishment, and pollution filtration. In seasons of heavy rainfall, approximately ten times a year, the swamps provide a wide flat area to accommodate water that spills over the banks of the rivers. By slowing the water down, a greater percentage of floodwater is able to soak into the ground, raising the water table and depositing additional sediments. Pollutants in the water tend to settle out and become trapped in the newly deposited sediment, and as a result, the water leaving a floodplain swamp is usually much cleaner than the water entering it.

Population growth and increased development around swamp areas has generated a relentless pressure to replace the presumably useless swamps with something of more immediate benefit to society. As a result, many swamp lands were drained and ditched, a process which removes the water, the lifeblood for a functioning ecosystem. Many of the remaining swamp lands in the Coastal Plain are now protected by law and serve as a last refuge for many threatened and endangered species. The same types of development pressure and pollution concerns have threatened water quality in karst regions as well.

Soils and Agriculture

Coastal Plain soils form on top of a variety of sediment types, from coarse sand to fine clay, and are usually strongly acidic. Residual soils form in place from chemical **weathering** and the leaching process tends to dissolve ions from soil minerals and contribute to the rapid development of clearly defined soil profiles. Many of these dissolved ions accumulate in the 'B' soil horizon layer and impart a distinctive color to the subsoil. The geographic origin of many of these sediments was the Piedmont Region, so the mineralogy of the Coastal Plain soils is very similar to that found in the crystalline source rocks. Some soils form on floodplain deposits composed of alluvial sediment. These transported soils have very different properties from the residual soils. The abundant moisture and thick vegetative cover common in the Coastal Plain provide a source of replenishment of soil minerals lost to weathering so the quality of the 'A' soil horizon layer can be maintained.

Most residual soils possess a **loamy** to sandy clay subsoil and good surface drainage but display only moderate to poor internal drainage. The inherent fertility and organic content of these soils are classified as moderate, but where drainage is good, a favorable soil texture is produced. This fact tends to make Coastal Plain soils some of the best farmland in the Southeast. Soil wetness varies from well drained to very poorly drained, partly due to differences in the original sediment layers and partly due to the elevation of the soil above the ground water table. The best drained soils are found on elevated sandy marine and fluvial deposits in the Upper Coastal Plain. The most poorly drained soils are found near the coast where broad expanses of muddy marsh and floodplain deposits are barely above the water table. Many of these soils with high water tables develop a mottled clay-like layer called a gley layer.

Transported bottomland soils are also quite fertile. When river water overflows its banks, it is already laden with rich topsoil washed down from the mountains and from upstream farmlands. The flood leaves behind a record of its presence in the form of distinctive yellow, brown, and black mud and silt deposits in the floodplain. Elevation differences of even a few inches (centimeters) can result in the formation of significantly different soils with different moisture content.

Agricultural practices have developed somewhat differently in the Upper and Lower Coastal Plain sub-regions. In the higher elevation Upper Coastal Plain, approximately 20% of the land is considered to be prime farmland. About half of this is covered in cropland and about half in forest. The major cash crops are cotton, corn, and soybeans. Farms tend to be large and spread out over a variety of Coastal Plain landscape features with the exception of river floodplain swamps. In the lower elevation Lower Coastal Plain, poor drainage makes large acreages of land unsuitable for row crops. This land, however, is very well suited for growing timber, and both hardwood trees and pines have been planted extensively throughout the region. Farmland is usually restricted to drier levees and isolated uplands that form broad drainage divides separating the wet coastal marshes and floodplain swamps. About 12% of the area is considered to be prime farmland, and about half of this is open land with the remainder being forested.

Almost 50 percent of the Coastal Plain Region is used as cropland or pastureland. This area is the largest row crop farming area of the Southeast, with corn, soybeans, melons, and peanuts being the favored crops. However, non-food crops like cotton, tobacco, and naval stores (turpentine) dominate the agricultural economy of the region. Cotton is grown throughout the entire Coastal Plain region, but North and South Carolina produce most of the tobacco grown in America.

Although cotton cultivation was attempted by the earliest settlers in the region, cotton did not dominate agriculture and plantation life in the Southeast until the 1790's when, with the invention of the cotton gin, the age-old problem of finding a labor-effective way to separate the seeds from the fibers was solved. By 1810, cotton farming had expanded until it was being grown in every state in the Southeast, but over 50% still came from a single state, South Carolina. Even after the Civil War, many freed slaves stayed in the cotton fields as sharecroppers, working the only job they ever knew. Most cotton production today is concentrated in South Carolina, Georgia, Northeast Alabama, and the Mississippi River bottomlands of the Yazoo Valley. In the late 1900s, soybeans had replaced cotton as the primary crop in many of these agricultural areas.

The growing, processing, selling, transporting, and thinking about cotton by so many people created a way of life known as the "cotton culture" that dominated the lives of most Coastal Plain farmers until the 1960's. Growing cotton always meant more than just making money from the crop, for as Ben Roberston said in his book Red Hills and Cotton, "Cotton with us is almost human...Sometimes I think a Southerner's idea of heaven is a fine cotton-growing country. . . ." Although cotton is no longer grown in as many places as it used to be, its legacy remains in the exhausted fields and severely eroded gullies found in many parts of the region.

Almost all of the Southeastern landscape was forested when European colonists first arrived. A few notable exceptions were some of the sandy uplands of the Upper Coastal Plain and the Louisiana coast west of the Mississippi Delta. Native Americans had also cleared some areas for agriculture, through the use of fire. Although Coastal Plain forests are dominated by pines, many other kinds of trees play a secondary role. On higher ground in the Upper Coastal Plain, especially on bluffs overlooking rivers, a pine-hardwood forest dominates, consisting of loblolly pine, hickory, and various oaks. On lower ground, the wetter conditions are preferred by white oak, laurel oak, water hickory, cypress, and tupelo gum. True swamps, especially in Carolina Bays and river floodplains, are dominated by baldcypress and tupelo gum stands. Swamp trees often display flared bases for support, and adaptations like cypress knees project above the water or wet soil.

Even though the Coastal Plain is largely forested, there are several scattered areas of open grasslands called savannahs or prairies, most notably in the Lower Coastal Plain, that are dominated by various grasses and sedges. Wetter prairies are associated with a high water table or ponding of water for considerable periods of time, and can contain longleaf pine or pond cypress trees. Forest fires during dry periods are another important factor contributing to savannah formation, because fire destroys competing vegetation and encourages the growth of fire-tolerant species.

Early settlers saw an unending forest and considered it as an obstacle to expansion, and after years of attack with ax, fire, and plow, the original forests virtually disappeared. Considered a highly labor-intensive activity, logging before the Civil War was restricted to small localized plots controlled by plantation owners. After the Civil War, with the ending of slavery, logging activity within the region declined precipitously. Most of the land previously used for logging lay open. Forested areas in the region today consist mostly of second or third growth hardwoods or pine trees planted for pulpwood.

Mining and Resource Extraction

Sand and gravel production is the most common mining activity in all of the Coastal Plain, but it is also one of the most important resources in the region in terms of total economic value. The primary industrial use of sand and gravel is as an aggregate in concrete and asphalt. Other uses include sandblasting, filtration, glassmaking (pure sand only), and fill material. Clay is also mined extensively in the Coastal Plain. Clays are used in the manufacture of bricks and cement. A particular type of silica-rich clay, opaline claystone, also known as fuller's earth, is found in a few specific localities. Fuller's earth is a highly absorbent form of clay that becomes even more absorbent when heated to very high temperatures. It is marketed as an oil and grease absorbing agent in the rubber, plastics, and cleaning industries, but is perhaps best known as the major absorbing component of kitty litter.

Several rock formations exposed in the Coastal Plain contain significant amounts of limestone, and many limestone quarries dot the landscape in the Atlantic Coastal Plain. However, much of this limestone is actually a mixture of lime and clay, called marl, which is ideal for the production of Portland Cement. Some limestone is marketed as crushed rock and building stone. The Coastal Plain in the panhandle of Florida consists mainly of limestone layers that create extensive areas of Karst Topography and serve as a major groundwater entryway for the Florida Aquifer System. Other limestone deposits, especially in the Lower Coastal Plain, consist primarily of coquina, a rock composed of a mixture of broken shell fragments cemented together by lime. A final type of limestone deposit is chalk, a dense, impermeable carbonate deposit that underlies the Black Belt of Alabama and Mississippi. This chalk weathers into a layer of rich, fertile, black topsoil.

The first step in mining hard rock limestone is to remove the trees, soil, and other overburden from the top of the limestone formation. Bulldozers are normally used for this operation. In order for the quarry to be profitable, the limestone must be fairly close to the surface. Dynamite or other explosives are normally used to blast the rock into small pieces which are then hauled to processing areas to be ground up, sorted, and mixed with other materials when appropriate. The deeper the quarry extends, the more difficult it is to bring the material to the surface. Another common problem is water seepage. Because the formation is porous and a good aquifer, almost every quarry has great volumes of water flowing out of the fractured rock into the bottom of the pit. Pumps must be operated almost continuously to keep the lower portions of the quarry dry. When a quarry is abandoned, water will seep in to form a deep pond. These ponds are unsafe for swimming because of their great depth and the loose rock normally found around their edges.

The phosphate industry was once important in some Lower Coastal Plain counties but has not been particularly active during the past fifty years. In the late 1800's and early 1900's phosphate sands and pebbles were dredged from the river basins of several Coastal Plain rivers. The primary use of this material was for agricultural fertilizer. Although huge amounts of phosphate reserves probably still exist in both onshore and offshore sediments of the Coastal Plain, most beds are only a few inches thick and mining is no longer economically feasible.

In the western part of the Sandhills Region in Georgia and South Carolina, large deposits of kaolin clay have been mined extensively. This clay is of great economic importance and is used unprocessed in the manufacture of ceramics and refractory materials and in its processed form in such diverse materials as rubber, paint, paper, fertilizer, and pesticides. Many millions of years ago, abundant feldspar mineral grains in exposed granite landscapes in the Piedmont were altered to the mineral kaolinite through chemical weathering processes. The loosened grains were then transported by water and deposited in thick layers, which were then buried by other sedimentary deposits deeply enough to be compressed into solid rock. Later erosion has uncovered the clay deposits, providing easy access for today's mining activities. All of the kaolin mining is surface, or open-pit, mining. This type of mining is very economical for the industry, but often leaves large holes in the ground that are unsightly and can be dangerous as well. Often, industry representatives and civic leaders can come up with innovative ways to utilize abandoned kaolin mines. Some have been filled with household trash and garbage, then outfitted with wells and pipes to collect methane generated by decomposition of the landfill contents. The methane is piped to a nearby kaolin processing plant to heat the ovens. Eventually these pits will be filled in completely and planted in grass or trees.

Other resources occur sporadically in the region. A very small peat industry exists in a few places. The peat is extracted from bog and floodplain deposits along coastal rivers. It is marketed as a soil conditioner and can also be used in wastewater treatment as a filter. Bauxite deposits in Alabama and Georgia are used to make aluminum. And minor amounts of gypsum are mined in the Mississippi River Alluvial Plain.

The discovery of petroleum and need for oil sparked by the Industrial Revolution started an economic boom in several Gulf Coast states. Although a few oil wells were drilled in Texas around 1900, the real beginning of commercial oil production in the southeast was the discovery of the East Texas oil field in 1930. Since then, huge reserves have been found underneath Louisiana and Mississippi as well as offshore beneath the Gulf of Mexico. Originally, much of the natural gas that was discovered while drilling for oil was burned off and wasted. Today, natural gas is used in many parts of the country as an alternative clean fuel and is in great demand. Sulfur and rock salt are also found in great quantities in Louisiana and Texas in association with oil field operations.

PLACES TO VISIT IN THE COASTAL PLAIN

Casey Jones Railroad Museum State Park. P.O. Box 186 Yazoo City, MS 39194. For information call 1-800-381-0662 or search online at http://www.yazoo.org/Casey.htm

Congaree Swamp National Park. 100 National Park road Hopkins, SC 29061-9118. For information call 803-776-4396 or search online at http://www.nps.gov/cosw/.

Lafayette Natural History Museum 433 Jefferson St., Lafayette, LA 70501. For information call 337-291-5544 or search online at http://www.lsndc.org/index.php/component/cpx/?task=resource.view&id=475565 .

Leon Sinks Geological Area. 11152 NW SR 20, Bristol, FL 32321. For information call Appalachicola Ranger District, 850-643-2282 or search online at https://www.fs.usda.gov/recarea/apalachicola/recarea/?recid=75300 .

Natchez Trace Parkway. 2680 Natchez Trace Parkway, Tupelo, MS 38804. For information call 800-305-7417 or search online at http://www.nps.gov/natr/. (Only visitor center is in Tupelo at Parkway milepost 266)

Shadows on the Teche Museum and Sugar Plantation. 317 East Main Street, New Iberia, LA 70560. For information call 337-369-6446 or search online at https://shadowsontheteche.org/ .

Singletary Lake State Park. 6707 NC Route 53 E, Kelly, NC 28448. For information call 910-669-2928 or search online at https://www.ncparks.gov/singletary-lake-state-park/home .

Spring Creek Springs Area. At the end of SR 365, about 25 miles south of Tallahassee. The largest submarine spring's "surface boil" can be seen at public boat launching ramp. https://www.visitwakulla.com/resources/communities/spring-creek-fl/ .

Tabasco Brand Factory Tour & Museum on Avery Island. Highway 329, Avery Island, LA 70513. For information call 337-373-6139 or search online at https://www.tabasco.com/visit-avery-island/tabasco-tour/ .

Vicksburg National Military Park. 3201 Clay Street, Vicksburg, MS 39183. For information call 601-636-0583 or search online at

Wakulla Springs State Park. 465 Wakulla Park Dr., Wakulla Springs, FL 32327. For information call: 850-561-7276 or search online at https://www.floridastateparks.org/WakullaSprings .

Woods Bay State Park. 11020 Woods Bay Rd., Olanta, SC 29114. For information call 843-659-4445 or search online at https://southcarolinaparks.com/woods-bay .

REFERENCES AND RESOURCES 🗁

SELECTED PRINT RESOURCES

Barry, J.M., (1997). Rising Tide – the great Mississippi flood of 1927 and how it changed America. New York, NY: Simon and Schuster.

Bastion, David F., (1995). Grant's canal – the Union's attempt to bypass Vicksburg. Shippensburg, PA: Burd Street Press.

Bourque, Darrell, 1995, Plainsongs, Cross-Cultural Communications. New York, NY: Merrick Publishers.

Halbouty, M. K., 1979, Salt Domes, Gulf Region of the United States and Mexico, 2nd ed. Houston, TX: Gulf Publishing Company.

Harrell, V.C. (1986). Vicksburg and the river. Vicksburg, MS: Harrell Publishing.

Hendry, C.W. Jr. and Sproul, C.R. (1966). *Geology and groundwater resources of Leon County, Florida*. Bulletin No. 47. Tallahassee, FL: Florida Geological Survey.

Hillard, Sam B. (1984). Atlas of Antebellum Southern Agriculture. Baton Rouge, LA: Louisiana State University Press.

Jenny, Hans. (1941). Shared. Chicago, IL: University of Illinois Press.

Joyner, Charles. (1999). Shared Traditions: Southern History and Folk Culture. Chicago, IL: University of Illinois Press.

Kaczorowski, Raymond T. (1977). The Carolina Bays: A Comparison with Modern Lakes. Unpublished dissertation. Technical Report No. 13-CRD. Coastal Research Division Department of Geology, University of South Carolina.

Kane, Harnett T., 1943, The Bayous of Louisiana. New York, NY: Bonanza Books.

Krinitzsky, E. L., and Turnbull, W. J. (1967). Loess deposits of Mississippi. GSA Special Paper #94. Boulder, CO: Geological Society of America.

Ross, Thomas E. (1987). *A Comprehensive Bibliography of the Carolina Bays Literature*. The Journal of the Elisha Mitchell Scientific Society (103:1).

Savage, Henry (1982). The Mysterious Carolina Bays. Columbia, SC: University of South Carolina Press.

Twain, Mark. (1967). Life on the Mississippi. Minneapolis, MN: Dillon Press.

Wilds, John, C. L. Dufour, and W. G. Cohan, 1996, Louisiana Yesterday and Today. Baton Rouge, LA: Louisiana State University Press.

Wisenbaker, Michael. (1998). Aboriginal settlement in the Apalachee Region of Florida. Tallahassee, FL: Florida Geological Survey.

SELECTED INTERNET RESOURCES (all sites were functional and accessible in 2003)

http://www.tabasco.com
This site gives information about Tabasco sauce and how it is made. It also offers a video tour of Avery Island, Louisiana.

https://atlas.ga.lsu.edu
This site gives the user access to maps, downloads, links, and web services for a variety of publicly available GIS datasets for the state of Louisiana.

https://www.lsu.edu/leeric/
This site provides a clearinghouse for technical and non-technical environmental and energy information for Louisiana that can be utilized by K-12 teachers.

https://www.lrce.org
This website provides student-centered teacher development and classroom resource support in all subjects for Louisiana teachers.

https://www.divedui.com/pages/woodville-karst-plain-project
This site provides information on the Woodville Karst Plain Project, whose mission is to explore, survey, connect, and protect the flooded underwater cave systems of the region.

https://wakullasprings.org/
This site is managed by the Friends of Wakulla Springs and offers a virtual tour video as well as a virtual trail walk, a 'gator cam', and other activities.

https://www.ncpedia.org/carolina-bays
This site provides general information about Carolina Bays and makes specific reference to the Bladen Lakes, NC region.

https://ncseagrant.ncsu.edu/coastwatch/previous-issues/2015-2/autumn-2015/carolina-bays-another-mans-treasure/
This site provides an easy to understand overview of Carolina Bays and their ecology.

http://www.groundwater.org/GWBasics/gwbasics.htm
This page gives a basic but detailed description on groundwater, including what it is, how much we depend on it, the hydrologic cycle, and how to preserve groundwater resources.

http://capp.water.usgs.gov/gwa/gwa.html
This website is full of information that allows the user to look at a regional summary of aquifers. The user can also access various maps and figures that show the location of the aquifer on a standard map. All states in the SE MAPS region are covered on the site.

https://www.battlefields.org/learn/civil-war/battles/vicksburg
This site has information about the Battle of Vicksburg, the larger campaigns in the area, and offers a series of historical maps, videos and biographies.

http://www.cwc.lsu.edu/cwc/links/links12.htm
This website provides links to various agriculture-based topics dealing with the South around the time of the Civil War. Some links include: Rice and Cotton Culture.

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Tabasco-Sauce Maker Remains Hot after 125 Years

By Mark Robichaux On a remote Island deep in the Louisiana swampland, the McIlhenny family has spent the past 125 years quietly churning its peppers into one of the hottest sellers around: Tabasco sauce. In that time, the family has never changed the recipe. It shuns advances in food technology and workers still hand-pick the peppers. But the strategy - if it can be called that - has worked. McIlhenny Co., based on Avery Island, has captured and kept the biggest market share in hot sauces - almost a third - even though the brew costs considerably more than most other brands.

McIlhenny has an enviable position. Tabasco sauce is sprinkled on foods from chili to chop suey in more than 100 countries. Packages are printed in 15 languages. The Japanese, the second biggest users, dash the sauce on spaghetti and pizza. About half the volume is sold to Americans. So popular is the sauce that many think the brand name is generic. The name is actually a Mexican word; "Grandpere just liked the sound of it," says vice president Paul McIlhenny.

The U.S. hot-sauce market has nearly doubled in the past five years; estimates vary from $37 million to $69 million for 1989. Profiting from surging interest in Tex-Mex and Cajun food and spicy chicken wings, most hot sauces have done well. Nonetheless, many chefs insist on Tabasco, mainly because it is so concentrated. "I may use 10 drops," says celebrated Louisiana chef Paul Prudhomme, who's cooked with Tabasco for 33 years now. "It pushes the natural flavor of the food. There's an afterglow in your mouth."

Driven from Avery Island by the Civil War, Edmund McIlhenny returned to find the family home and surrounding sugar fields in ruins. Among the only things left standing were the pepper plants. He found that by grinding the peppers, aging them and adding vinegar and salt, he could make a pepper sauce; a novelty that gave zest to the bland food prevalent after the war. In 1869, Mr. McIlhenny poured the sauce in some 350 bottles - mostly old cologne bottles - and the rest is history.

RATIONALE

The salt domes of southeast Louisiana create a unique geography that features an array of topographic features not found in other parts of the Coastal Plain. These pillars of salt actually have risen to form "islands" in the marshland. Coastal Plain habitats associated with the salt dome region are exceptionally important, both aesthetically and economically, to the state. They are in delicate balance with both natural and human-driven processes. The geography has controlled how immigrants to the region developed the land and utilized the environment. The names, languages, and customs of these ethnic groups have intermingled to produce a unique cultural montage. The unique geography of southeast Louisiana has made the state one of the chief producers of rice, sugar cane, fur, fisheries (crawfish, shrimp, catfish, oysters, etc.), and in earlier times, lumber. The salt, sulfur, and hydrocarbon resources occurring in and around the salt domes provide an important source of income for the Louisiana economy.

PERFORMANCE OBJECTIVES

1. Recognize a salt dome island by its geographic features.
2. Determine elevation and relief by contours.
3. Construct a topographic profile.
4. Locate features by longitude and latitude and by Standard Land Survey System.
5. Understand how habitat change occurs, its consequences, and how to prevent it.
6. Recognize cultures that have settled south Louisiana by variety of place names.
7. Describe why and how salt domes form.
8. Understand relationship between salt domes and mineral and energy resources.
9. Understand connections between Louisiana's economy and its wetlands.
10. Become familiar with McIlhenny Tabasco story and its relationship to Avery Island.

SAMPLE ASSESSMENT RUBRICS

EXAMPLE #1 (relates to Performance Objective #1)

Ask students to draw and label a rough sketch of a typical salt dome showing both cross-sectional and map views. Also include adjacent sedimentary rock layers. *A correct answer should closely resemble these diagrams – including upward slant of layers at salt.*

A (level 4) – cross-section and map view sketched correctly
B (level 3) –cross-section & map view basically correct but some details missing.
C (level 2) – cross-section and/or map view have some problems; or adjacent rocks not drawn in correctly; or cross-section & map view don't match.
D (level 1) – significant problems with either cross-section, map view or both; or adjacent rocks missing completely or misplaced badly.
F (level 0) – cross-section and/or map view missing completely or drawing indicates no significant comprehension of connection between them.

EXAMPLE #2 (relates to Performance Objective #8)

Ask students to list four economically valuable geologic resources that are associated with salt domes. *Correct answers include: petroleum, oil, natural gas, sulfur, salt, gypsum. Teachers may decide to accept 'Tabasco' as a correct answer although it is not technically a geologic resource.*

A (level 4) – Four resources identified correctly.
B (level 3) – Three resources identified correctly.
C (level 2) – Two resources identified correctly.
D (level 1) – One resource identified correctly.
F (level 0) – No resources identified correctly.

Cartographic Product Information

MAP 8A: Louisiana Salt Domes

TITLE: Avery Island, LA (topographic map)
DATA SOURCE: Delcambre USGS 1:24,000 Quadrangle
DATE: 1994
SCALE: 1:26,000 [1 inch = 2,167 feet] [1 cm ~ 275 meters]
OTHER IMPORTANT DATA:
- The contour interval of this map is 5 feet.
- A 'bayou' is a very slowly moving stream, river, or other body of water.
- The green areas represent forested locations.

POINTS OF SPECIAL INTEREST:
- Avery Island is located in the lower right corner of the map.
- Jefferson Island is located along Lake Peigneur in the upper left corner of map.

OTHER FEATURES TO LOOK FOR:
- Elevation differences between Avery and Jefferson Islands and rest of map area.
- The distribution patterns of houses and settlements relative to elevation of area.
- Most straight-line waterways are artificially dug or have been straightened.

TITLE: Avery and Weeks Islands Wetland and Upland Habitat Maps (computerized)
DATA SOURCE: USGS National Wetlands Research Center; NASA/USL Regional Application Center; RAC980012 & RACP990053
DATE: 1956, 1978, 1988
SCALE: 1:160,000 [1 inch = 13,333 feet] [1 cm = 1,600 meters]
OTHER IMPORTANT DATA:
- These maps are computer generated which is why they show pixellation.
- Some of the colors on the legend are hard to distinguish from each other; use information from surrounding habitats to determine the best identification.

POINTS OF SPECIAL INTEREST:
- Avery Island is the circular feature in the upper-left portion of the map.
- Weeks Island is the circular feature in the lower-center portion of the map.
- The body of water in the lower-left part of the map is Weeks Bay (an embayment of the Gulf of Mexico).

OTHER FEATURES TO LOOK FOR:
- The maps show some clear trends over time involving migration of habitat types.
- Notice the rapid disappearance of fresh-water marsh habitat over time.

Cartographic Product Information

IMAGE 8A: Louisiana Salt Domes

TITLE: Avery Island, LA (photoquad [aerial photograph])
DATA SOURCE: USGS National Wetlands Research Center; NASA/USL Regional Application Center; RAC980012 & RACP990038
DATE: 1994
SCALE: 1:26,000 [1 inch = 2,167 feet] [1 cm ~ 275 meters]
OTHER IMPORTANT DATA:
- This image is a false-color infrared photograph, so all true colors are shifted.
- This is a summer image, with leaves on trees, so forests will appear as red color.
- Water containing sediment will appear light blue; clear water will appear black.

POINTS OF SPECIAL INTEREST:
- Avery Island is located in the lower right corner of the map.
- Jefferson Island is located along Lake Peigneur in the upper left corner of map.

OTHER FEATURES TO LOOK FOR:
- Houses and settlements are located on higher elevation levees next to bayous.
- Farm fields are almost always laid out in a linear pattern.

TITLE: Salt Domes, LA (Thematic Mapper [satellite image])
DATA SOURCE: EOSAT Landsat Thematic Mapper
DATE: 1995
SCALE: 1:110,000 [1 inch ~ 1.7 miles] [1 cm ~ 1.125 kilometers]
OTHER IMPORTANT DATA:
- This image is a false-color infrared image, so all true colors are shifted.
- This is a late winter image, no leaves on trees, so forests will appear dark.
- Water containing sediment will appear light blue; clear water will appear black.

POINTS OF SPECIAL INTEREST:
- Avery Island is the circular feature in the upper-left portion of the image.
- Weeks Island is the circular feature in the upper-center of the image.
- Jefferson Island is located along Lake Peigneur in extreme upper-left corner.
- City of New Iberia is just north of image area in top center.
- Bayou Teche runs diagonally across upper right corner of image.
- U.S. Highway 90 runs parallel to Bayou Teche closer to center of image.

OTHER FEATURES TO LOOK FOR:
- Houses and farm fields are located on higher elevation levees next to bayous.
- Straight-line waterways are either artificially dug or have been straightened.
- The open water in the lower half of the image is part of the Gulf of Mexico.

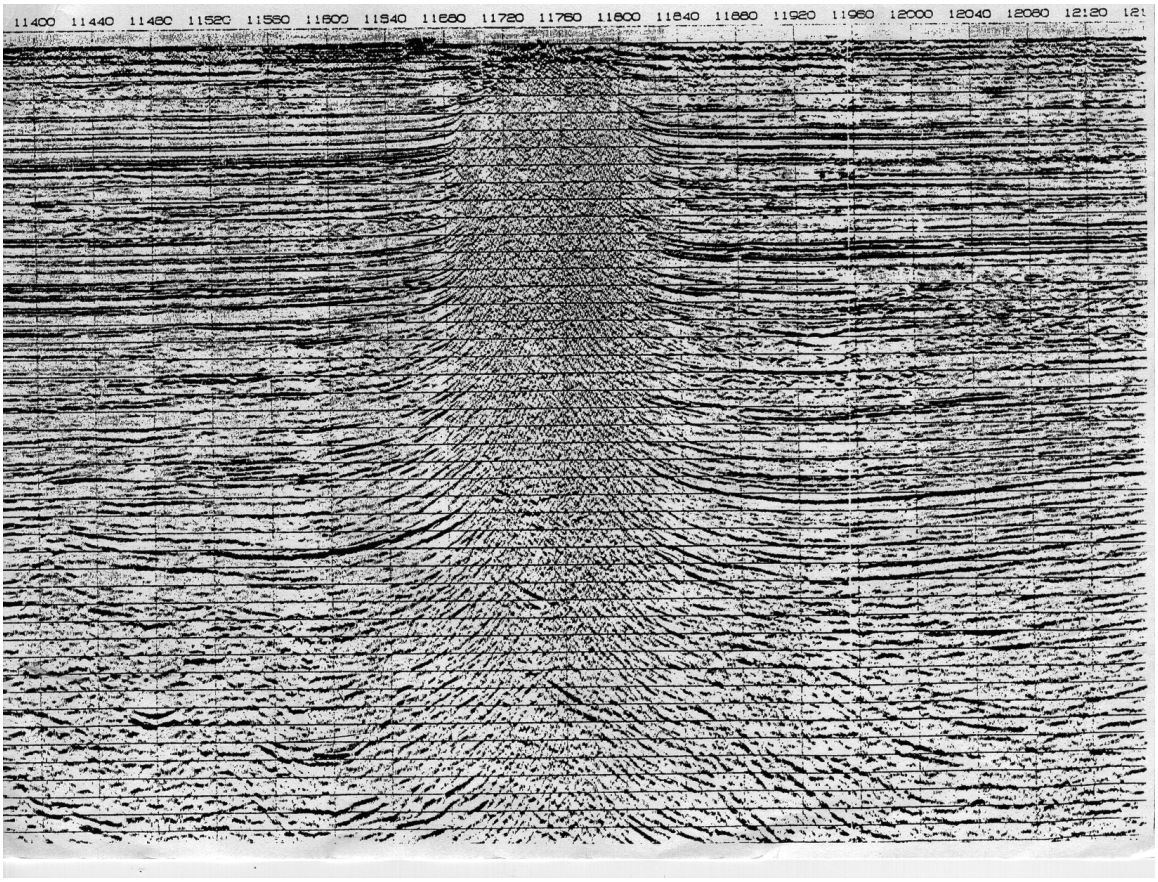
Salt Dome Geology and Geography

Louisiana's near-featureless marshes and adjacent water bodies span the entire coastal section of the Outer (Lower) Coastal Plain. They vary in width from 25 kilometers (15.5 miles) to 80 kilometers (50 miles). There is, in fact, less than 4 meters (13 feet) difference in height between marsh habitats and adjacent natural levees, **cheniers**, and beaches. Relief is often less than 0.3 meter/kilometer (1.5 foot/mile) over hundreds of square kilometers. A one-meter shift in elevation is enough to move from soft, wet soils of the wetland marshes to firm habitable land. The "Five-Island" region of south Louisiana, named for the linear arrangement of five salt domes, is a fine example of how a shift in elevation makes a great difference in the type of habitats the area exhibits. Here, near-surface salt domes, such as Avery, Belle Isle, Côte Blanche, Jefferson, and Weeks Islands, rise to more than 40 meters (130 feet) above the surrounding marshes. They are the region's most conspicuous features.

The study area is a landscape dominated by broad, gently sloping natural levees, marshes, swamps, and exposed salt domes. Flanking the natural waterways on both sides are natural levees. The crest of these levees is near the stream, river or bayou's bank. The backslope is generally so slight that it is not easily recognized. A levee's height and width are directly proportional to the size of the water body that created them. During a flood, a stream's velocity decreases away from the main channel, permitting the heavy and coarse sediments to be deposited on the bank near the river. Through recurring floods, the river or bayou's banks are elevated higher and higher, producing an easily defined system of natural levees that served the region's agricultural, transportation, and settlement needs. In addition, frequent flooding diverted sediments into the surrounding lowlands, commonly through crevasses, elevating the surface at a rate that was able to counteract subsidence and sea-level rise.

The Pleistocene upland/terrace portion of the Louisiana Coastal Plain has an elevation that approaches seven meters (23 feet) above sea level. These elevations are used primarily for agriculture. The highest features are the domal structures punched up by shallow, cylindrical salt intrusions. These salt pillars have transverse cross sectional areas that vary from 25,000 square meters (six acres) to 30 square kilometers (7,360 acres). Most pillars lie deep beneath the surface, but some that have risen near the surface have pushed up conspicuously rounded hills, the so-called "salt domes." The salt originates from a layer buried 8.3 kilometers (five miles) beneath the surface. At this depth, the salt is under great pressure, and because it is less dense than the overlying layers of mud and sand, it deforms plastically and rises along zones of weakness. Seismic surveys reveal the presence of the salt pillar deep underground and also illustrate the fact that the upward movement of the pillar has deformed the surrounding rock layers so they bend upward along the contact zone with the salt.

Figure 8A-1: Seismic Reflection Profile of a Salt Pillar



The "Five-Islands" - Jefferson, Avery, Weeks, Côte Blanche, and Belle Isle - are all near-surface salt intrusions that mark a linear alignment of islands across south Louisiana. They form distinct natural landmarks in the relatively flat, featureless marsh and prairie that typify the region. Like all visible intrusive features, these domes vary in height, cross-sectional area, and surface topography, which can be complex and little related to stream erosion. Instead, it would appear to be more the result of subsurface salt-solution collapse and faulting along the crest of the rising salt plug. Within the forested uplands of the five exposed salt domes, cypress, tupelo, willow, and water oak dominate the vegetative community. Wax myrtle, marsh elder, groundsel bush, and sable palmetto characterize other forested tracts, called scrub-shrub wetlands.

Living With the Land

The earliest evidence of human activity in south Louisiana is associated with a site on Avery Island. Stone tools, which have been radiocarbon dated, suggest this site is more than 11,000 years old. Detailed written records are nonexistent, so each group is "finger printed" by their material culture, such as their stone tools or ornamental pottery. The artifacts found in or on the ground provide the data to unravel the regional settlement succession. The cultural remains, therefore, provide many clues in assessing the natural setting during aboriginal time.

Pre-historic Native Americans established their villages on the area's natural levees, exposed salt domes, beach ridges, and other high-ground features. Several thousand relic midden sites - defined as an accumulation of refuse around an Indian dwelling place – have been identified within the coastal lowland. The Native-Americans were quite instrumental in showing the European colonists how to survive in Louisiana's alluvial wetlands. The first Europeans to settle these low-lying floodplains of south Louisiana were a group of rural Roman-Catholic French-Canadian refugees, the Cajuns, or Acadians. They were driven from French Canada by the English in 1755 during what is known as *"Le Grand Dérangement."* The Acadians enjoyed the seclusion and solitude provided by their new homeland. They became farmers, trappers, and fisherman.

The Acadians were followed by Isle□os (Canary Islanders), Austrian, Slavic, Chinese, German, Philippine, Irish, Latin American, African American, and Italian settlers. These varied populations have created a cultural montage of ethnic communities across coastal Louisiana. Each cultural group brought with them widely differing customs, which became muted over time as each group struggled to adapt to the unique environmental challenges of the region. Many of the literary contributions of Louisiana authors, such as Darrell Bourque, focus on the physical characteristics of the landscape.

Beyond Catahoula Lake
--Plainsong by Darrell Bourque—

Every fall I go to an old friend's house
who helps me tree my land. I drive
the flat, bare woods of Attakapas country.

Pass the level plains, stretched out

like drying skins on the sides of silvered barns
and on to Catahoula Lake. Woods again, dark
and thick rim the swamp. We start easy

through winding channels. Talk of the Indians
who called the long river Atchafalaya.
We pole through hyacinths. See the moccasin,
great and lolling in spots of sun.
He tells me of the rooms of iris burning

lilac, blue, and yellow in the spring and how
I should come out some time for them.
Pointing to a mound on the horizon

He shouts against a cold November wind

from the back of his flat-bottomed boat
as we rush headlong into red where we drift,
take the rusty cypress seedlings,

and carry home Atchafalaya fires.

Landowners along the region's rivers and bayous typically had long, narrow tracts of land that fronted the river and extended back away from it - locally called *arpents*, which is a French length measurement equal to about 58.5 meters (192 feet). This land-division system allowed each property owner to have river frontage - an important commodity during this time - as produce and materials were primarily moved to market by way of the river. In addition, the depth of the property guaranteed landowners had access to the natural levee's rich alluvial soils as well as the timber and other resources of the region's backswamps. Early settlers had land holdings a few arpents wide and 40 arpents long.

Later settlements followed the same pattern, but rather than moving as the environment, or the river course, changed, the inhabitants worked to manage the region's natural waterways to stabilize them and to prevent change and guarantee the continued viability of the settlements. European settlers took full advantage of the region's resource base. As a result, many cultural components survive - dispersed and agglomerated settlements, linear hamlets, T-towns and grid cities, plantations, folk houses, boats, whitewashed fences and barns, above-ground graveyards, and other elements of the region's material culture. To some, these elements are not important; to others they are links to their heritage. As the region's population expanded, rural settlement clusters began to discover their own economic niche. Each community acquired its own distinctive employment identity, from agricultural nodal points, to oil and gas support centers, to ports and seafood processing centers. The economy benefited from the abundant renewable and nonrenewable resource base. The survival of many of these communities attests to the tenuous nature of living within the coastal lowlands. They have survived hurricanes, employment cycles, and emigration; they have adapted to their conditions. Author Harnett Kane describes one of the more unique communities.

The Longest Village Street

--excerpted from 'The Bayous of Louisiana' by Harnett T. Kane--

BAYOU LAFOURCHE, say Louisianians, is the longest village street in the world; and I don't know of any place that has attempted to refute that claim. It covers 120 curling miles, and along practically all that length it is impossible to ride or walk and be out of sight or hearing of a house or houseboat, both filled with people. For mile on mile, a single line of homes hugs the waterway on one bank, and sometimes on the other as well. Here and there towns appear, but often it cannot be determined when a town ends and mere residences on the bayou begin. The string becomes double for a time, the second following the curve of the stream like the first; and then it thins again. How many houses stand in this file, nobody knows. Some have declared that not even Holland of the old days had a greater multiplicity of rural people per linear mile.

Lafourche may also be defined as an attitude. Other Louisianians see or hear a thing, smile and say: "That's Lafourche for you." It is as contented a place as I have ever found - good-natured, quick-talking, never pretending to be anything other than what it is; and pre-eminently it ranks as the bayou of the small man, a

man who is busy enough at his duties but seldom too busy to enjoy a pleasant time with his friends.

The Lafourchais describe his manner of elbow-to-elbow existence by saying that the boys can toss a baseball along the bayou from one front yard to the next without losing it between the beginning and the end. (I made no personal test, but if the boys have moderately good pitching arms, I suspect that it can be done.) And one day a farmer told me the story of the day the news of the First World War armistice reached Lafourche, back in 1918. Octave, up at the northern end, received a telegram. He had a cousin, way down at the other limit, who would want to hear this news, yes. Octave started toward his car, when Arsène, his neighbor, stuck his head out of the window to ask what was the matter. Octave told him: "La guerre est finie!" Arsène ran to his other window and called the word to Gustave, next door. Gustave gulped and ran to his window. Before the hour was past the news had gone from house to house; and when Octave, chugging as fast as he could, reached his destination at the lower line, his cousin came out and cried: Octave, you have heard? "La guerre est finie!" And *that's* Lafourche for you.

Exploration and Exploitation of Resources

Salt domes are features of major economic importance. Salt, sulfur, and natural gas and petroleum, the latter being the most valuable of Louisiana's mineral resources, are associated with salt intrusions. One salt intrusion, Avery Island, has spawned a multi-million dollar pepper industry (Tabasco Sauce). The exact dimensions of the salt pillars are unknown. However, the total quantity estimated in some domes, such as Avery Island, is thought to be in excess of two billion tons of salt. But the surrounding wetlands also contain many economically valuable resources. South Louisiana's favorable climate and fertile alluvial soils, allow almost every crop indigenous to the western hemisphere to be raised here. The wealth gained from hydrocarbons, commercial fishing and trapping, industrial development, and tourism do not overshadow the value of agricultural products. The dominant commercial crops today are sugarcane and rice.

As early as the 1730s, French Creoles were beginning to exploit the wetlands, in particular, its timber and shells. The timber came from the area's vast bald cypress *(Taxodium distichum)* and tupelo gum *(Nyssa aquatica)* forest - the two primary tree species in Louisiana swamps. The shells used by the French Creoles was derived from the wetland's numerous Native-Americans shell middens. The shells found in these middens are from a clam known as *Rangia. Rangia* was a primary food source for the Native Americans in this area and is thus their shells form a major component of many of their middens. The Creoles recovered the shell material, which was then burned and converted to lime for use primarily in construction endeavors in the colony.

The commercial fish and shellfish harvest is valued at 680 million dollars annually. This represents about forty percent of the nation's supply. This one industry alone employs 40 thousand Louisianians. Louisiana's crawfish crop is valued at 12.1 million. Alligator hides bring in 2.6 million dollars. The alligator meat adds additional revenue. Called by the Spanish *el largarto* (the lizard) the alligator *(Alligator*

mississipiensis) has been harvested commercially since the mid-1800s. As late as 1890, some 280,000 alligator skins were being processed annually in the United States. Between 1880 and 1904, hide hunters significantly reduced the species. For a period of time in Louisiana alligators were a protected species. However, alligators have now recovered to a point where Louisiana has a controlled alligator hunt in September. During 1997 about 25,000 alligators were harvested from more than 100 commercial alligator farms. Waterfowl hunting is valued at 58 million annually. Twenty-seven percent of the state's population is employed by commercial recreation businesses.

Few people recognize Louisiana is North America's largest fur producer. In the early 20th century, Louisiana's annual harvest was greater than Alaska and Canada combined. The pelts harvested in Louisiana include many species, such as the muskrat, nutria, raccoon, mink, otter, opossum, fox, and bobcat. At first, colonial fur buyers regarded the muskrat as worthless. It remained unwanted until 1914 when pelts began to appear on the fur market. In a relatively short period of time the muskrat was destined to become Louisiana's preeminent furbearer - a title it ultimately relinquished to the nutria.

Unlike the indigenous muskrat, the nutria (South American coypu) is an alien animal. After escaping captivity in 1938 from enclosures on Avery Island, this Argentinean rodent has expanded its range to include most of Louisiana's swamps and marshes. By the 1950s trappers were annually marketing nearly 80,000 nutria pelts. Today, the nutria is considered a nuisance and is blamed, in part, for wetland loss because they tend to cause "eatouts" where the vegetation is virtually wiped out. Since the fur trade business is currently depressed, some groups are looking for ways to control and reduce nutria populations. One inventive proposal was to improve the nutria's public image and market its meat to grocery stores and the general public.

Sugarcane was first introduced into Louisiana in 1751. Although planters tried unsuccessfully to manufacture sugar, the original cane crops were used primarily for chewing. Development of a process for granulating sugar in 1794 allowed sugarcane to become a commercial crop in Louisiana. With establishment of this new industry, indigo production was abandoned. Rice, introduced in the early 1700s, was commercially exported to Europe until the late 1800s. Although sugarcane and rice continue to be important products, increase in production costs is causing many mills to close. Farmers have had to alter their traditional transportation patterns, as the cost of transporting cane from the field to the mill becomes excessive. Farmers must abandon the industry, produce another agricultural crop, or sell out. Growers who continue to produce cane often have to haul their produce 50 kilometers (30 miles) or more to a mill.

Intensive bald cypress exploitation began after the Timber Act of 1879 repealed the Homestead Act of 1866. As a direct result of the Act's repeal, vast cypress/tupelo tracts were sold for less than $1.25 a hectare ($.60 an acre). Consequently, by 1890 a sizable percentage of Louisiana's swamps were managed by the forest-products industry. Ingress and timber removal were major issues. Access problems were resolved by excavating canals to the logging sites. Removal of the cut timber was accomplished by using steam engines aboard pullboats that dragged logs into a dredged channel. To

utilize a pullboat effectively, lumber companies dredged both the primary and secondary watercourses leading to logging sites. These dredged areas incorporated a series of intersecting channels with fan-shaped cable runs radiating out from points along the access routes. These radial designs were etched into the landscape by the cables required to "snake" the logs into the principal channel. These canals and pullboat scars remain, although many of these logging operations occurred more than fifty years ago. These distinctive designs can be detected on aerial photography and provide an accurate record of past lumbering operations. In a larger sense, these scars are an indicator on the once robust cypress trade and the near complete depletion of virgin cypress/tupelo swamps.

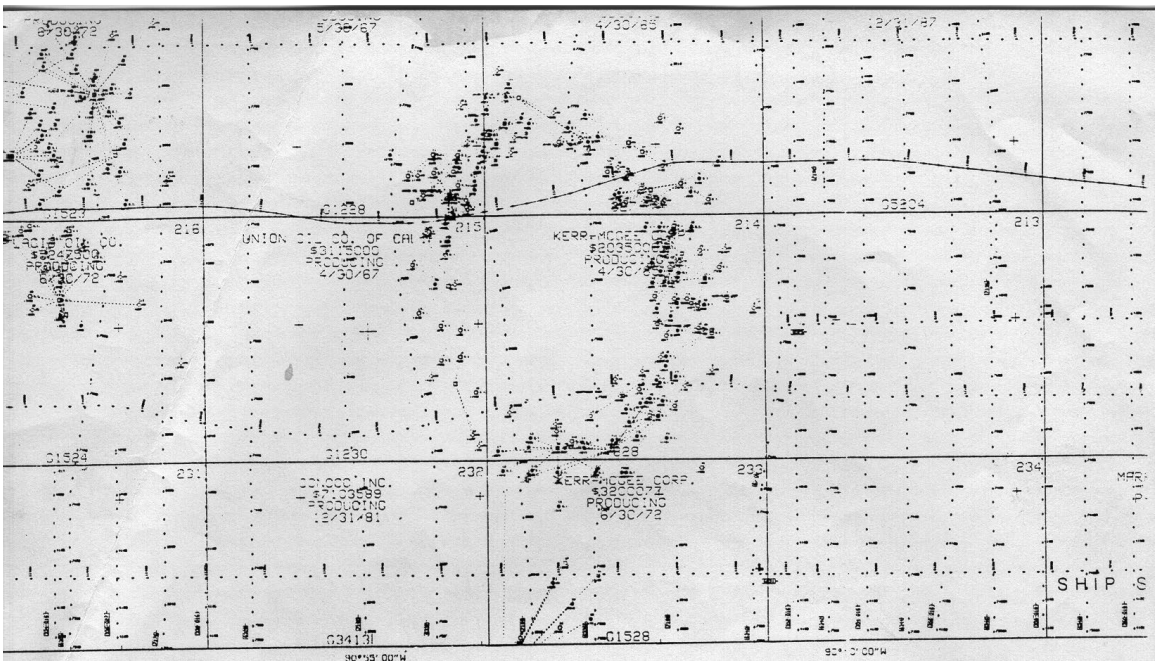
Other innovative engineering techniques have been used to try and stabilize the waterways and the marshlands. Local governments have invested in water-control structures, levee fortification, locks and gates on key natural and engineered waterways, extensive pump systems and forced-drainage projects, as well as canals and ditches to improve flood control. If marshes continue to wash away, billions of dollars of business in Louisiana will wash away with them. Not only will Louisiana citizens suffer both economically and recreationally, people all over North America will also be affected. Louisiana marshlands serve as the habitat for sixty-six percent of the nation's migrating waterfowl. Where these birds will go if the marshlands are lost is a mystery.

Mariners sailing off the coast of Louisiana and Texas in the 1600s recorded one of the earliest known natural oil seeps. They shrugged it off as unimportant, as there was no market for the substance they witnessed. The seepage, however, provided a tiny clue to the vast storehouse of hydrocarbons trapped in the earth's crust, extending from the uplands through Louisiana's swamps and marshes, and into the subaqueous habitats of the Gulf of Mexico. As the oil and gas industry expanded, each move into a new geographic area often required considerable change in how oil and gas were recovered. This led to advances in the science and technology supporting the exploration and development of Louisiana's petrochemical resources.

In August 1901, the Jennings Oil Company drilled the first producing oil well in Louisiana - less than a year after the discovery at Spindletop in southeast Texas. Even though the Jennings/Evangeline field was a success, other promising fields were regarded as just too much trouble to exploit. However, by the 1920s, oil and gas wildcatters were starting to look at south Louisiana's subsurface geology. Wetland exploration required boats, barges, and port facilities. But these elements did not become available until the 1930s. Access was critical, so suction or bucket dredges were used to cut channels through the swamps and marshes. Pipeline corridors were also cut through the marsh peat. For more than 50 years, the oil and gas industry's dredging built a maze of navigation and oil field canals in order to access their oil fields. These associated canal and pipeline rights-of-way represent a labyrinth of tributary lines that coalesce into an integrated, complex network of transport arteries. These arteries allow the petrochemical industry to gain access to the more than 32,000 oil and/or gas wells in the 789 fields, in the 25 coastal parishes.

However, all of these artificially engineered waterways also have a harmful effect, in that they can provide conduits for the encroachment of salt water into valuable freshwater marshland.. Boat traffic in these engineered canals also causes erosion problems along the banks of the waterways. Many of the oil wells are concentrated around the salt domes, as seen in this map view of a Gulf Coast oil field. The well locations are indicated by the darker black marks that form a somewhat circular pattern around the dome.

Figure 8A-2: Map View of Salt Dome Oil Field



Activity 8A-1: Salt Dome Geology and Geography

POWER THINKING EXERCISE - "Disappearing Dome"

Locate the Avery Island salt dome (circular feature in lower-right corner) on the Avery Island topographic map on MAP 8A, LOUISIANA SALT DOMES. Also, on that same map, locate the Jefferson Island salt dome next to Lake Peigneur (upper-left corner). Note that Avery Island exhibits the standard circular pattern of a salt dome while Jefferson Island has a much smaller and more irregular shape.

With a wipe-off pen, draw a circle around the shoreline of Lake Peigneur, but on the east side of the lake, draw this circle far enough away from the shoreline so it also includes Jefferson Island on the inside of the circle. How does the area of the circle you drew compare with the area of Avery Island? Based on the geology of this region, your best guess is that Jefferson Island was once a circular salt dome about the same size as Avery Island. But if that theory is true, what happened to the rest of Jefferson Island? And how did Lake Peigneur form?

Discuss in your group what events might have caused the disappearance of most of Jefferson Island and the formation of the lake. Share your theories with the class and list all of the theories in order from 'most probable' at the top to 'least probable' at the bottom.

Materials
MAP 3B, GEOLOGICAL SETTING
MAP 8A, LOUISIANA SALT DOMES
IMAGE 8A, LOUISIANA SALT DOMES
Figure 8A-1, "Seismic Reflection Profile of a Salt Pillar"
protractor
Ruler marked in centimeters
Wipe-off Pens

PERFORMANCE TASKS

(Icon Key) Overview = ✈; Science = ☼; Math = 💻; History = 🕮; Language Arts = ✍

1. **Construct topographic profile across Avery Island. ✈**
   Make a profile of height and habitat/land use along a transect across Avery Island.

a. Divide the class into cooperative groups. Each group will construct a north-south profile of the landscape from the point nearest the ocean (bottom of the Avery Island topographic map on MAP 8A, LOUISIANA SALT DOMES), crossing Avery Island, and extending into land primarily used for agriculture.

b. Lay your ruler (with centimeter markings) on the map so that it is perpendicular to the bottom of the map and transects the high point on Avery Island shown above the "v" in Avery (the name of the town).

c. At each centimeter mark on your ruler, determine the approximate elevation along your transect line and the type of vegetation found at that point. Record your data in the table provided below. The Avery Island photoquad on IMAGE 8A, LOUISIANA SALT DOMES may be helpful in determining the specific types of vegetation.

d. Record the height data on a graph. You must determine the best vertical scale to use in constructing this graph. The horizontal scale will be the same as that of the topographic map. If you have access to a computer with graphing software, by all means use it. What is the highest point along your profile line? Where is it located?
e. Now add the vegetation type data to the graph. You can simply label the type of vegetation on the graph found at each point along the profile or color code the profile using colored pencils.

Data Table to use in Making Topographic Profile
("cm mark # 1" is at the south end of your profile line)

cm mark #	elevation (ft)	vegetation type
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

cm mark #	elevation (ft)	vegetation type
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

2. **Speculate about unusual juxtaposition of geologic units.** ☼
Locate the town of New Iberia, Louisiana on MAP 3B, GEOLOGICAL SETTING (look near the Gulf Coast where Iberia, Vermilion, and Lafayette Parishes all come together). New Iberia is the closest named town to Avery Island on that map. What is the age of the sediments underlying New Iberia (refer to map legend)? Geologists have dated the salt deposits underlying Avery Island as having forming during the Jurassic Period of the Mesozoic Era of geologic time. These salt beds were later buried under several miles of river and marine sediment that put the salt layers under tremendous pressure. Normally, older rock is found underneath younger rock, but at Avery Island, the older rock is higher in elevation and sticks up above the younger surrounding rock. Use your knowledge of geological processes to speculate about how such an unusual situation could occur. Present your theory to the class and compare it with the theories from other groups.

3. **Determine azimuth trend of salt dome occurrences.** 💻
On the Avery Island topographic map on MAP 8A, LOUISIANA SALT DOMES, locate by longitude and latitude coordinates, to the nearest minute, the center of Avery Island. Are there any other salt domes shown on this map? If so, give its/their name(s) and describe its/their location relative to Avery Island. Now locate Avery Island on both the Avery Island photoquad and the Salt Domes satellite image on IMAGE 8A, LOUISIANA SALT DOMES. How many other salt domes can you locate on these images? Use a wipe-off pen to draw a straight line connecting all of the salt dome 'islands' you found on the Salt Domes Image. Assume this line

represents a zone of weakness in the underlying rock layers. Use a protractor to determine the azimuth (linear direction measured clockwise on a 360° compass).

It turns out that these are not the only salt domes in Louisiana. Find, on MAP 3B, GEOLOGICAL SETTING, several small green circles in Bienville and Winn Parishes in northern Louisiana. These circles represent somewhat larger and younger salt domes, but their shape and origin is the same as for the Avery Island Salt Dome. How many circles did you find? What is the geologic age of these North Louisiana salt deposits (refer to map legend)? Use a wipe-off pen to draw a 'best-fit' straight line through the center of these locations and use a protractor to determine the azimuth (linear direction measured clockwise on a 360^{o} compass) of that zone. How does the azimuth direction of the Northern Louisiana salt domes compare with the azimuth direction of the Southern Louisiana salt domes? What conclusions can you draw from your results?

4. **Design map to find hiding place for pirate treasure.** 🕮

The famous pirate Jean Lafitte is known to have taken refuge in south Louisiana from time to time in the early 1800s. Now, suppose you were a pirate operating in south Louisiana around that same time. After a successful raid on a British merchant ship in the Gulf of Mexico, at a location directly under the 'compass rose' graphic on the Salt Dome satellite image on IMAGE 8A, LOUISIANA SALT DOMES, you must hide the treasure chest quickly before you are discovered by naval patrols. You must pick a safe spot to bury the treasure and design a treasure map with enough detail that one of your crew can find the treasure if you are unable to return to the area. Use references to landmarks, compass bearings, descriptions of terrain, or coordinate points to construct a map containing directions for your crew. Remember that pirates generally did not want just anyone to be able to use their treasure maps to find their hidden treasure; draw your map in such a way that only your own group members will be able to use it. When you have completed your map, exchange maps with another group and see if you can follow their directions to find their treasure

5. **Write travel log describing trip from Delcambre to Avery Island.** ✍

Your school in the town of Delcambre has scheduled a field trip to tour the Tabasco Factory on Avery Island. Locate Delcambre (far left-center of map) and Avery Island (lower-right corner of map) on the Avery Island topographic map on MAP 8A, LOUISIANA SALT DOMES. Also locate these same two sites on the Avery Island photoquad on IMAGE 8A, LOUISIANA SALT DOMES. Your Language Arts teacher has given you an assignment to write a travel journal log detailing the sights you would see on your trip to Avery Island. Use information from the topographic map to determine the route you would take to get to your destination. Use a wipe-off pen to trace this route on the map. Use information from the map and the photoquad to describe the different landscapes you will encounter as you make the trip.

ENRICHMENT

(Icon Key) Overview = ✈; Science = ☼; Math = 💻; History = 🕮; Language Arts = ✍

1. **Research separation of water, oil, natural gas around salt pillar.** ☼
   The origin of oil and gas is not directly related to salt, but the salt dome serves as a trap where water, oil, and natural gas can accumulate along its flanks. To model this process, you should perform an experiment that will demonstrate the relative densities of oil, water, and natural gas. First, you should boil water in a beaker, the bottom of which has been lined with solid Crisco® shortening. Observe the results of this demonstration and note the final order, bottom to top, of the water, oil (represented by melted Crisco®), and natural gas (represented by water vapor).

2. **Research geologic history of salt deposits in Gulf of Mexico.** ☼
   Use local library or internet resources to research the formation of the Mesozoic Era salt deposits that formed in the Gulf of Mexico. Use a paleogeographic map to explain why and how salt was deposited in this shallow enclosed sea. Explain why the salt domes in northern Louisiana are a different age than the salt domes near Avery Island. Are all the salt domes restricted to land areas, or do they also exist underwater in the Gulf of Mexico?

POWER THINKING EXERCISE - "Domestic Decision"

Study the landscape of the Avery Island topographic map on MAP 8A, LOUISIANA SALT DOMES. If you had to live somewhere in the area covered by this map, which of these three communities would be your first choice: Avery Island, Derouen, or Delcambre? Which community would be your second choice? Think of things you could do in one town and not in another. Make a list of 'pros' and 'cons' of each location before announcing your final decision. Be prepared to explain the reasons for your choice. Consider factors such as the average elevation of each community above sea level, the ease of transportation in and out of the town, the surrounding land use, and the population density. Also consider what type of work you might find in each community, or how long a commute you would have if you worked someplace else.

Materials
MAP 8A, LOUISIANA SALT DOMES
IMAGE 8A, LOUISIANA SALT DOMES
story, "Legend of Evangeline" on page 8-8
story, "Beyond Catahoula Lake" on page 8A-7
Wipe-off Pens

PERFORMANCE TASKS

(Icon Key) Overview = ✈; Science = ☼; Math = 💻; History = 🕮; Language Arts = ✍

1. **Investigate land use along Bayou Teche. ✈**
   Locate Bayou Teche on the Salt Domes satellite image on IMAGE 8A, LOUISIANA SALT DOMES (it is the waterway running diagonally across the upper-right corner of the image). According to the "Legend of Evangeline" on page 8-8, after arriving in south Louisiana Evangeline (Emmeline Labiche) spent her days wandering along Bayou Teche. Why were her walks confined only to the banks of the Bayou? What geologic term best describes the 'banks of the Bayou'? How did this feature form?

   What types of land use occur today along the banks of Bayou Teche? How wide is the strip of land on either side of the Bayou that is suitable for habitation and development? Why is the main highway not located right next to the Bayou?

2. **Compare and contrast topography of wetlands and higher ground. ☼**
   With a wipe-off pen, draw an east-west line on the Avery Island topographic map on MAP 8A, LOUISIANA SALT DOMES, so that you have divided the map into equal top and bottom halves. Divide your class so that half of the groups are analyzing the top half of the map and the other groups are analyzing the bottom half. Also locate these same features on the Avery Island Photoquad on IMAGE 8A, LOUISIANA SALT DOMES. Refer to the topographic map symbols chart in Chapter 2 as needed. Share your group's landscape analysis with the rest of the class.

For groups examining the north half of the map:
Describe the topography of this area. What bayous are responsible for draining the land area? What is the direction of water flow in the bayous? How did you determine the direction the water is flowing? What is the highest and lowest land elevation in the north half of the map? Determine the elevation drop (in feet) of Bayou Petite Anse from the top of the map to where it enters the wetland. What is the elevation of Bayou Petite Anse where it meets the Armenco Branch Canal? Locate the Broussard Cemetery (just southeast of the community of Derouen). What is the elevation of the cemetery? What is the elevation difference between the cemetery and the bayou? Using the scale bar (feet) in the map legend, determine the distance (in feet) from the cemetery to the closest point on the Bayou Petite Anse? Why do you think cemeteries are built on high ground in this area?

For groups examining the south half of the map:
Describe the topography of this area. What bayous are responsible for draining the land area? What is the direction of water flow in the bayous? How did you determine the direction the water is flowing? What is the highest and lowest land elevation in the south half of the map? Locate the Avery Island Cemetery, due west of the town of Avery Island. What is the elevation difference between the highest elevation of Avery Island and the Avery Island Cemetery? What is the elevation difference between the cemetery and the wetland area surrounding Avery Island? Using the scale bar (feet) in the map legend, determine the distance (in feet) from the cemetery to the closest wetland waterway? Why do you think the cemetery was located here?

3. **Investigate types of land divisions used in south Louisiana.** 💻

Trace with a blue wipe-off pen the path of Bayou Petite Anse from the town of Derouen southward to the Railroad track bridge, just before the wetlands begin, on the Avery Island topographic map on MAP 8A, LOUISIANA SALT DOMES. With a red wipe-off pen, trace all the land division lines that intersect this portion of Bayou Petite Anse (these are the red dashed and dotted lines ----- - ----- - ----- - ----- that define a property area labeled with a red number in the center). How would you describe the geometric pattern of these land divisions adjacent to the Bayou? These divisions are called "arpents". Based on the geometry, why would arpents be a good way to divide up land for farmers and settlers in the 19th century? Calculate the area of three different arpents of your choice (pick a large one, a small one, and an "average" one).

Trace the five-foot contour line around Avery Island with a blue wipe-off pen. With a red wipe-off pen, trace the land division lines that are located below and to the southeast of the island (these are the thin red dashed lines - - - - - - running mostly in north-south and east-west directions that also define a property area labeled with a red number in the center). These boundaries were established using the more common township and range land-division system. Why do you think this portion of the topographic map was divided into township and range land divisions and the northern section along Bayou Petite Anse was divided into arpents? Ignoring that section 25 (of the township and range survey) south of Avery Island is truncated by an arpent boundary on its northeast corner, determine by measurement the idealized area of this

section (i.e., you'll need to extend the boundaries to complete the section square). What is the actual area of section 25 in the southeast corner of the map? (**HINT**: the northeast corner of the section is truncated by arpent 53, the area of which will have to be subtracted from your idealized area measurement).

4. **Explain persistence of French cultural isolation in region.** 🕮
   Read the story, "Beyond Catahoula Lake" on page 8A-7. Identify several references in the story that give clues about the isolated nature of communities in this area. Explain why there has been such a strong, persistent French culture preserved in this part of southern Louisiana? Refer to landform features on the Avery Island topographic map on MAP 8A, LOUISIANA SALT DOMES and the Avery Island photoquad on IMAGE 8A, LOUISIANA SALT DOMES to help explain your answer.

5. **Investigate towns and landforms with French names.** ✍
   Most towns and geographic features in a region are usually named by the first people to make their homes in that area. As southern Louisiana's first permanent settlements were established by French immigrants, it makes sense that most of the names listed on the Avery Island topographic map on MAP 8A, LOUISIANA SALT DOMES would be French in origin. Geographic features like waterways are also designated by French terms such as Bayou and Coulee. Discuss in your group how to recognize French-sounding names. Note that the French spellings may be significantly different than that of the corresponding English words. Scan the topographic map and list ten towns or natural features that your group believes are probably French in origin. Also list at least three names of towns or natural features that your group believes are NOT French in origin. Compare your lists with those of other groups.

ENRICHMENT

(Icon Key) Overview = ✈; Science = ☼; Math = 💻; History = 🕮; Language Arts = ✍

1. **Relate poetry of Darrell Bourque to southern Louisiana landscapes.** ✍
   Read the poem by Darrell Bourque entitled "Beyond Catahoula Lake" on page 8A-7. Also use local library resources or the internet to access additional poems and stories by Darrell Bourque. Identify ways that these literary works relate to the landscapes of southern Louisiana. Using that same general style, create your own poem about life in southern Louisiana. If someone in your group is artistic, you may also create one or more illustrations to accompany your poem.

2. **Investigate state symbols of Louisiana.** 🕮
   Use local library resources or the internet to research and identify Louisiana's state bird, flower, tree, stone, fish, animal, wild game bird, fruit, shell, gemstone, fossil, reptile, and insect (be sure to check out the Louisiana Almanac). Which of these state symbols would you probably see or encounter on a tour of Avery Island? Explain your answer. Relate each of these state symbols to either the local environment or the history of the region wherever possible.

Activity 8A-3: Exploration and Exploitation of Resources

POWER THINKING EXERCISE - "Wetland Worries"

Locate the area of wetlands (indicated by the small blue 'marsh' symbols) on the bottom half of the Avery Island topographic map on MAP 8A, LOUISIANA SALT DOMES. Devise a method of estimating the total area of the wetlands in units of square feet. You may choose to use the TRANSPARENT PLASTIC GRID, a specific mathematical formula, or some other practical method of estimation. Refer to the map scale bar as needed.

A recent report from the Louisiana Department of Natural Resources indicates that this area of the state is losing its wetlands at the rate of 10,000,000 square feet per year. At that rate, using your previous estimate of the total wetland area shown on the map, how long will it take for all of the wetlands to disappear from this area? Do you really expect all these wetlands to totally disappear? Explain your reasoning. What are some potential impacts of urbanization and industrialization of wetlands? If wetlands are converted into farmland, would their extinction be justified? Defend your answers.

Materials
MAP 8A, LOUISIANA SALT DOMES
IMAGE 8A, LOUISIANA SALT DOMES
Figure 8A-1, "Seismic Reflection Profile of a Salt Pillar"
Transparent plastic sheet (minimum dimensions 8.5" x 11")
Wipe-off Pens

PERFORMANCE TASKS

(Icon Key) Overview = ✈; Science = ☼; Math = 💻; History = 🕮; Language Arts = ✍

1. **Analyze location pattern of oil/gas wells in relation to salt domes. ✈**
   Locate all oil and gas wells on the west side of Avery Island on the Avery Island topographic map on MAP 8A, LOUISIANA SALT DOMES. The symbol for a well is a small open circle " o ". Mark the location of each well with a wipe-off pen and analyze the distribution pattern of the wells in relation to the Avery Island Salt Dome. Are any wells located near the center of Avery Island? Explain the reason behind this distribution of oil and gas wells around Avery Island? Trace the canals at the base of the west side of Avery Island with a blue wipe-off pen. What feature is located within and at the end of most of the canals? What impact would these canals have on the marsh environment? Can you locate other oil fields on this topographic map? If so, name them and compare their distribution pattern of wells with Avery Island.

2. **Explain location of wells along outer margin of salt pillar. ☼**
   Examine Figure 8A-1, "Seismic Reflection Profile of a Salt Pillar" and notice what happens to the horizontal sedimentary layers as they get close to the boundary with the salt pillar. Cover that entire diagram with a sheet of transparent plastic and use a black wipe-off pen to outline one or more of these sedimentary layers (make sure your layer

is at least ½ inch thick). You can assume that the sedimentary layer is porous and contains a combination of water, oil, and natural gas. Also outline the top and bottom boundaries of the same sedimentary layer on the opposite side of the salt pillar. Be sure to indicate in your tracing what happens when the layers approach and finally meet the salt pillar. Note that oil is less dense than water and natural gas is less dense than oil. Based on this information, show where oil, water, and natural gas would most likely accumulate in your sedimentary layer by marking these places on the plastic sheet with different color wipe-off pens. Use red to represent oil, blue for water, and green for natural gas. Why is it not productive to drill wells in the center of the salt dome?

3. **Describe trends of habitat change over time.** 💻

Study the three Avery and Weeks Island Wetland and Upland Habitat Maps on MAP 8A, LOUISIANA SALT DOMES. Avery Island is located near the center of the maps; Weeks Island is located in the lower-center of the maps. Refer to the color key to identify specific habitat types. If any of these terms are unfamiliar to you, consult a book or website about wetlands. The WETMAAP web site [http://www.wetmaap.org] has examples of all habitats referenced in the map key. Also compare the habitat maps to the Salt Domes satellite image on IMAGE 8A, LOUISIANA SALT DOMES. Answer the questions posed in the Habitat-Change Chart below and the general questions that follow.

Habitat-Change Chart

Question	1956	1978	1988
Which habitat types surround Avery Island?			
Which habitat types surround Weeks Island?			
Which habitat types are present on Avery Island?			
Which habitat types are present on Weeks Island?			

Summarize the changes in habitat between 1956 and 1988.
- What habitat type decreased the most in this period of time?
- What habitat type increased the most in this period of time?
- Was any habitat replaced with human or urban structures?
- How did agricultural areas change in this period of time?

4. **Differentiate between natural and artificial waterways.** 🕮

Examine the different types of waterways shown on the Avery Island topographic map on MAP 8A, LOUISIANA SALT DOMES. As a general rule, waterways labeled as "bayou" or "coulee" are usually naturally occurring features. Waterways labeled as "canal" are usually artificial. Note the various drainage patterns of bayous, coulees, and canals on the map and come up with a generalized statement as to how you can differentiate between natural and artificial waterways (other than their name). Why

would people want to construct artificial waterways when there are so many natural waterways already present in the region?

Based on your generalized statement above, identify each of the following un-labeled waterways as either 'natural' or 'artificial'. Be prepared to justify your classification.

Un-labeled Waterway	natural	artificial
waterway running east-west along northeast side of Avery Island		
waterways within Avery Island Oil Field on west side of Island		
waterways in extreme lower-left corner of topographic map		
waterways surrounding town of Poufette in exact center of map		

5. **Debate merits of changing name of Avery Island.** ✍
A member of the Avery Island town council has suggested that since Avery Island is not actually an island, its name should be changed. Another member has suggested that, because Avery Island was first settled by French-speaking colonists, the island should have been given a more French-sounding name. Consider the pros and cons of each argument and decide whether you think either the "Avery" or the "Island" part of the name (or both parts) should be changed. If so, suggest a new name and explain why you chose it. Be ready to give logical reasons for your opinions. If you believe the name of the town should stay the same, be prepared to defend that position as well.

ENRICHMENT

(Icon Key) Overview = ✈; Science = ☼; Math = 💻; History = 🕮; Language Arts = ✍

1. **Research Tabasco® farming and its impact on habitat change.** 🕮
Use local library or internet resources to research the farming practices of the Tabasco® industry and assess their impact on land use and habitat change on Avery Island. Be sure your search includes referencing the official Tabasco® company web site: <http://www.tabasco.com/html/historian_co_history.html>.

2. **Research mining disasters at Jefferson Island and Belle Isle.** 🕮
Two major mining disasters occurred in the region covered by the Avery Island topographic map on MAP 8A, LOUISIANA SALT DOMES. The Belle Isle event that occurred in March, 1968 killed twenty-one miners. The Jefferson Island event that occurred on November 20, 1980, caused no fatalities. Locate Jefferson Island on the topographic map (in extreme upper-left corner of map). Belle Isle is located several miles southeast of Avery Island and is not shown on this map.

Use local library or internet resources to research the events at these two disaster sites. In what ways were the situations similar and in what ways were they different. Why did one event cause so many deaths while the other had no fatalities?

TALLAHASSEE DEMOCRAT

March 15, 1964

The Wakulla Volcano - A Major Mystery

By Hallie Boyles. In August 1886, an earthquake struck Charleston, South Carolina. It was felt as far away as Tallahassee, Florida; but more importantly, the quake caused the disappearance of a phenomenon which had intrigued folks in Florida for years; the Wakulla Volcano.

The mysterious site was known for sending up a column of smoke, and sometimes fire, that rose from the dark swamps some 25 miles from Tallahassee.

The mystery was first reported in Spanish colonial days and later the back-country folks talked wildly of a pirates' den deep in the jungle. Sailors referred to it as the 'old man of the swamp smoking his pipe'. Some slave tales explained the smoke as coming from the devil's tar kiln. Other folks thought the smoke came from the campfires of runaway slaves or army deserters. The smoke could be seen from the top of the capitol dome in Tallahassee.

In the 1870s, a New York Herald Tribune reporter formed a search party and hired the best guides, but had to turn back exhausted. As the story goes, he died on the way back to Tallahassee.

The first two men who are known to have seen the actual crater of the 'volcano' reached the site and reported rocks as big as houses strewn over an area about four miles wide. They described it as a 'gruesome place' near great sinks that was covered with piles of burned rock that appeared to have been blown out of the ground. They also reported that there were no trees in the surrounding area, and no stumps that would have shown logging activity.

Clarence Simpson of the State Geological Survey later made several trips to the site and reported that the rocks were flint and limestone and not of volcanic origin. One unconfirmed theory is that natural gas may have seeped through the rocks and been set on fire by lightning.

RATIONALE

The Woodville Karst Plain is a flat to gently undulating surface covered with deposits of clean quartz sand that thinly mantle the underlying limestone formations. The site focuses on the unique landscape features and groundwater networks formed by the Suwannee Limestone and the St. Marks Formation. Both formations are important Coastal Plain units that constitute a significant part of the Floridian aquifer system, one of the largest fresh-water aquifer systems in the southeastern United States. The karst plain contains many old, well developed cave systems and sinkholes that are either permanently or intermittently flooded, but also exhibits features that are still evolving and creating new surprises for residents. Major cave systems form underground labyrinths that eventually transfer fresh groundwater to a system of springs that empty into the Gulf of Mexico.

The City of Tallahassee and the surrounding area contain a significant number of historical and archeological sites that chronicle the long cultural history of the region. Outside of Tallahassee, the area hosts an agrarian and tourism-based economy and also lies on a major migratory bird flyway. Coastal marshes provide a resting place and food for the birds.

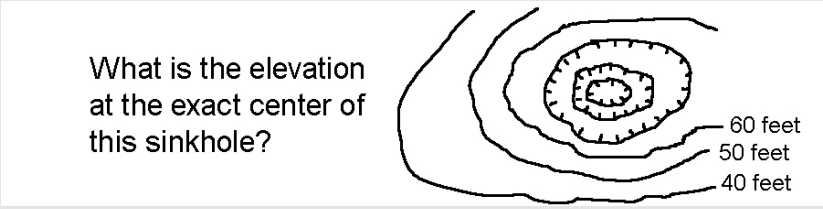
PERFORMANCE OBJECTIVES

1. Recognize Karst landform features on topographic maps and aerial photographs.
2. Determine elevation of groundwater table in Karst areas by estimating pond elevations.
3. Explain distribution pattern of limestone rock in Florida by relating to geologic history.
4. Assess environmental impact of depositing hazardous materials in Karst areas.
5. Evaluate environmental and economic impact of damming rivers to form lakes.
6. Calculate probability of sighting specific waterfowl species using Refuge data.
7. Interpret meaning of color variations in open water and wetland areas on lithographs.
8. Use fishing tales and outdoor stories as a springboard for storytelling and writing.
9. Trace patterns of groundwater flow through cave systems using map information.
10. Make inferences about Native American culture through study of artifacts.

SAMPLE ASSESSMENT RUBRICS

EXAMPLE #1 (relates to Performance Objective #2)

Give students a copy of the diagram shown below and ask them to estimate the elevation of the bottom of the sinkhole.



A (level 4) – elevation given is between 30 and 40 feet but not equal to 30 or 40
B (level 3) – elevation given is exactly 40 or 30 feet.
C (level 2) – elevation given is between 20 and 30 feet but not equal to 20 or 30.
D (level 1) – elevation given is below 60 feet but above 40 feet.
F (level 0) – elevation given is above 60 feet but below 20 feet or not given at all.

EXAMPLE #2 (relates to Performance Objective #10)

Ask students to name four common Native American artifacts that are often found in sinkholes. *Some possible correct answers include: stone knife, arrowhead, stone drill, stone jewelry, seashells, carved bone implements, mastodon bones, spear points, stone or bone scrapers, stone axe, and deer-antler tools.*

A (level 4) – four correct responses given
B (level 3) – three correct responses given
C (level 2) – two correct responses given
D (level 1) – one correct response given
F (level 0) – no correct responses given

Cartographic Product Information

MAP 8B: Woodville Karst Plain

TITLE: Woodville Karst Plain, FL (topographic map)
DATA SOURCE: Crawfordville East, Spring Creek, Tallahassee, and Lake Munson USGS 1:24,000 Quadrangles
DATE: Crawfordville East, Spring Creek, Tallahassee: 1972. Lake Munson: 1976
SCALE: 1:50,000 [1 inch ~ .8 miles] [1 cm ~ .5 kilometers]
OTHER IMPORTANT DATA:
- The contour interval of the top section of this map is 10 feet. (everything above towns of Lakeside and Belair and Lake Munson)
- The contour interval of the rest of this map is 5 feet. (everything below towns of Lakeside and Belair and Lake Munson)
- Depressions (sinkholes) are indicated by contour lines with hachure marks.

POINTS OF SPECIAL INTEREST:
- Red shading at top of map indicates urban area (city of Tallahassee).
- Leon Sinks Geological Area is just above the Leon County / Wakulla County line near the left margin of the map (just NE of words "Leon Co.").
- Wakulla Springs is labeled (near the exact center of the map).
- Spring Creek is labeled (along the bottom-center edge of the map)

OTHER FEATURES TO LOOK FOR:
- Wide distribution of sinkholes (some contain water; others do not).
- Streams that disappear and then reappear lower on the map.

TITLE: Leon Sinks, Wakulla Springs, Spring Creek, FL (topographic maps)
DATA SOURCE: Lake Munson, Crawfordville East, Spring Creek USGS 1:24,000 Quadrangles
DATE: Lake Munson: 1976; Crawfordville East & Spring Creek: 1972
SCALE: 1:10,000 [1 inch ~ 857 feet] [1 cm ~ 100 meters]
OTHER IMPORTANT DATA:
- The contour interval of these maps is 5 feet.
- Depressions (sinkholes) are indicated by contour lines with hachure marks.

POINTS OF SPECIAL INTEREST:
- Leon Sinks: sinkholes (some wet and some dry) and disappearing stream.
- Wakulla Springs: sinkholes (some wet and some dry).
- Spring Creek: thirteen freshwater springs contribute water to Gulf of Mexico.

OTHER FEATURES TO LOOK FOR:
- St. Marks National Wildlife Refuge (on Spring Creek Map) is waterfowl area.

Cartographic Product Information

IMAGE 8B: Woodville Karst Plain

TITLE: Woodville Karst Plain, FL (NAPP mosaic [aerial photographs])
DATA SOURCE: NAPP CIR photographs: Rolls 8238, 8240, and 8241
DATE: 1994
SCALE: 1:50,000 [1 inch ~ .8 miles] [1 cm ~ .5 kilometers]
OTHER IMPORTANT DATA:
- This image is a false-color infrared photograph, so all true colors are shifted.
- This is a summer image with leaves on trees so forested areas look red.
- Clear water shows up as black; water with lots of sediment looks cloudy-blue.
- Straight lines separating different colors are actually photo edges within mosaic.

POINTS OF SPECIAL INTEREST:
- Leon Sinks is left of the large gray area (almost square) in upper-center of photo.
- Wakulla Springs is in lower-center of photo (look for Wakulla Creek).
- Spring Creek is at extreme bottom-center of photo.

OTHER FEATURES TO LOOK FOR:
- Note the large amount of land that is uninhabited.

TITLE: Leon Sinks, Wakulla Springs, Spring Creek, FL (NAPP [aerial photographs])
DATA SOURCE: NAPP CIR Photographs #8240-16, #8238-43, #8238-28
DATE: 1994
SCALE: 1:10,000 [1 inch ~ 857 feet] [1 cm ~ 100 meters]
OTHER IMPORTANT DATA:
- These images are false-color infrared photographs, so all true colors are shifted.
- These are summer images with leaves on trees so forested areas look red.
- Clear water shows up as black; water with lots of sediment looks cloudy-blue.

POINTS OF SPECIAL INTEREST:
- Black Sink and Big Dismal Sink are in the upper-center of Leon Sinks photo.
- Cherokee Sink is located at bottom-center of Wakulla Springs photo.
- The white areas near Gulf of Mexico on Spring Creek photo are sandy areas.

OTHER FEATURES TO LOOK FOR:
- Notice many changes in land use between 1976 (maps) and 1994 (photographs).

Leon Sinks

The landscape in this Big Bend region of Florida is naturally divided into two distinct areas by the Cody Scarp: The Northern Highlands and the Woodville Karst Plain. The Cody Scarp is a prominent, east-west oriented, ancient shoreline feature that stretches from the western panhandle almost to Jacksonville. The topographic relief of the Cody Scarp can rise as much as 150 feet in elevation over a mile of horizontal distance. The rolling hills north of the scarp (the Northern Highlands) are comprised of reddish, unconsolidated, clayey, sandy sediments, with elevations ranging from about 50 to 75 feet at the toe of the scarp to about 300 feet above sea level at the Florida-Georgia border. These sediments form rich soils that support lush vegetation. Stream erosion has etched steep-walled channels into the sediments. Many large, shallow lake basins have been created by dissolution of buried limestone, resulting in slight subsidence of the overlying siliciclastic sediments. Historically, the City of Tallahassee was built north of the Cody Scarp, on the Northern Highlands. Only within the last few years has urban growth been pushing housing developments southward onto the Woodville Karst Plain.

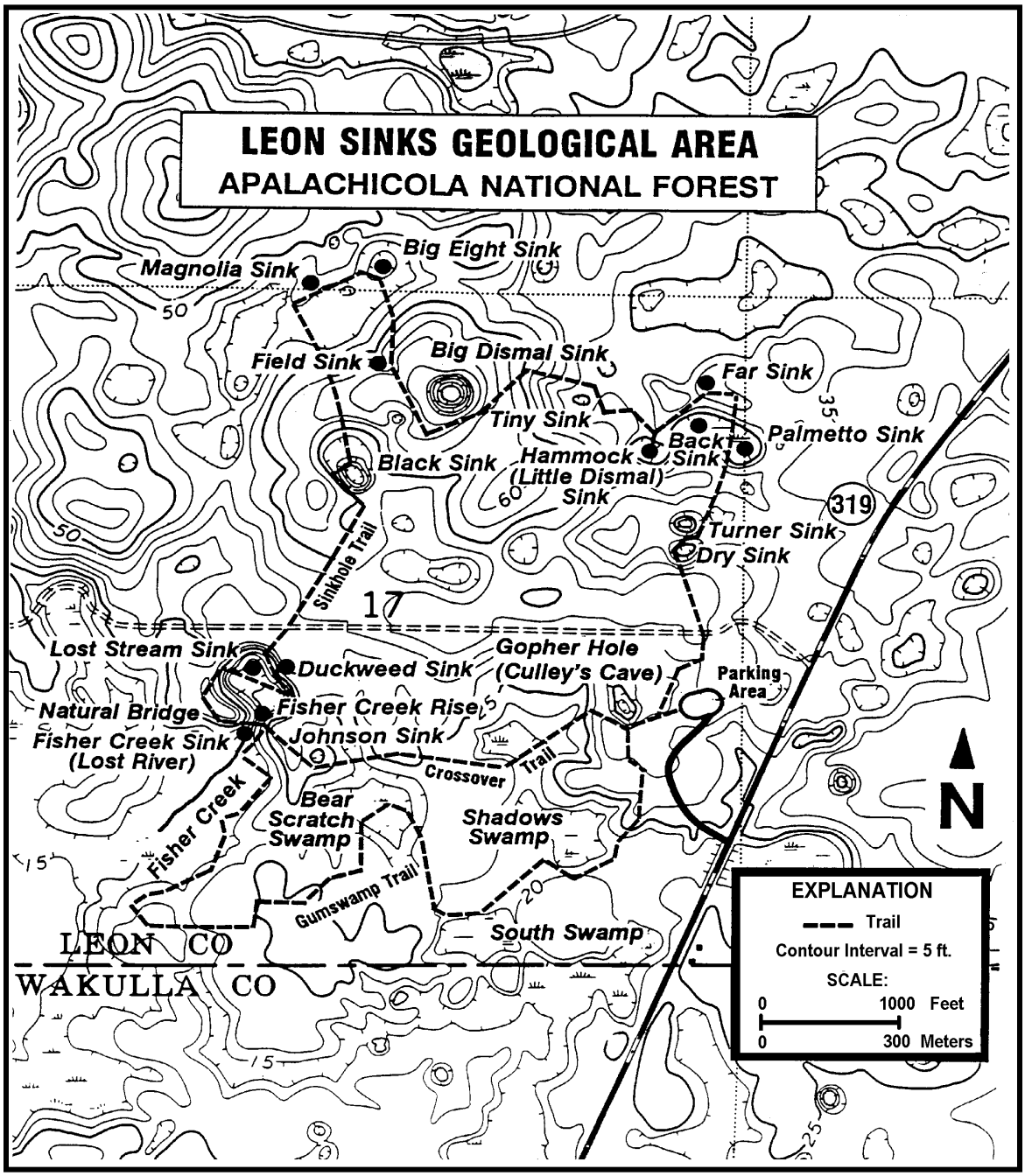
Not far from Tallahassee, spectacular examples of karst topography are located in the Leon Sinks Geological Area. Sinkholes, **sinkhole lakes**, disappearing streams, caves, and solution valleys are all easily accessible. The entire region is underlain by limestone with just a thin covering of quartz sand. The limestones of the Suwannee Limestone and the St. Marks Formation formed in warm, shallow oceans, similar to those presently found in the Florida Keys and the Bahamas. Organic sources of carbonates were animals and plants, which utilized carbonate minerals to build the hard skeletal parts of their bodies. When these organisms died their carbonate remnants fell to the bottom of the sea, to be incorporated into the marine sediments. These tropical seas also produced enormous quantities of inorganic carbonate sediments, which precipitated out of the seawater to form thick deposits of lime-mud.

These limestone formations have high **porosity** and **permeability**, characteristics that enable them to store and transmit groundwater. Rocks that have these properties make good **aquifers**. Aquifers are subsurface zones of rocks or sediments that contain enough permeable material to yield useful quantities of water to wells or springs. These two formations represent the upper part of the Floridan aquifer system in this area. Because they underlie the entire region at shallow depths, wells can be easily drilled into them and homeowners, farmers, and cities can pump out large quantities of fresh water for crops and human consumption. Rain soaking into the ground continually replenishes, or recharges, the water in these aquifers.

Most rainwater is slightly acidic because it absorbs carbon dioxide and other gases from the atmosphere as it falls. Some of this rainwater soaks into the ground, becoming groundwater. As it percolates through the soil, the groundwater assimilates organic acids from plant roots and decaying vegetation. The result is a weak but effective

acid solution that will slowly dissolve any carbonate rocks that it contacts. Limestone is especially susceptible to dissolution by acidic water because it contains zones of weakness that serve as avenues of chemical attack that the acidic waters will enlarge and extend over time. As dissolution continues, conduits and open caverns or caves will penetrate the rock and allow water to flow relatively unimpeded for long distances.

Figure 8B-1: Map of Leon Sinks Geological Area



In any karst terrain, sinkholes are the most common features, as well as one of the most easily recognized. Removal of the carbonate bedrock, with the continuing enlargement of cavities, or the formation of caves, can ultimately lead to the collapse of overlying rocks or sediments. If the collapse is sudden and complete, an open sinkhole will result. If the soil overburden only partially subsides into underground cavities, swales will form at the surface, producing the hummocky, undulating topography that is typical of karst terrain. At some point in this process of dissolution of underground rocks, a normal surface drainage system will begin to be transformed into a dry or disappearing stream system. Continuing dissolution of the limestone will create more swales and sinkholes, which will divert more of the surface water into the underground drainage system. Eventually, all of the surface drainage may be diverted underground, leaving dry stream channels that flow only during floods, or disappearing streams that flow down swallow holes (sinkholes in stream beds) and reappear at distant points to flow onto the surface as springs or resurgent streams.

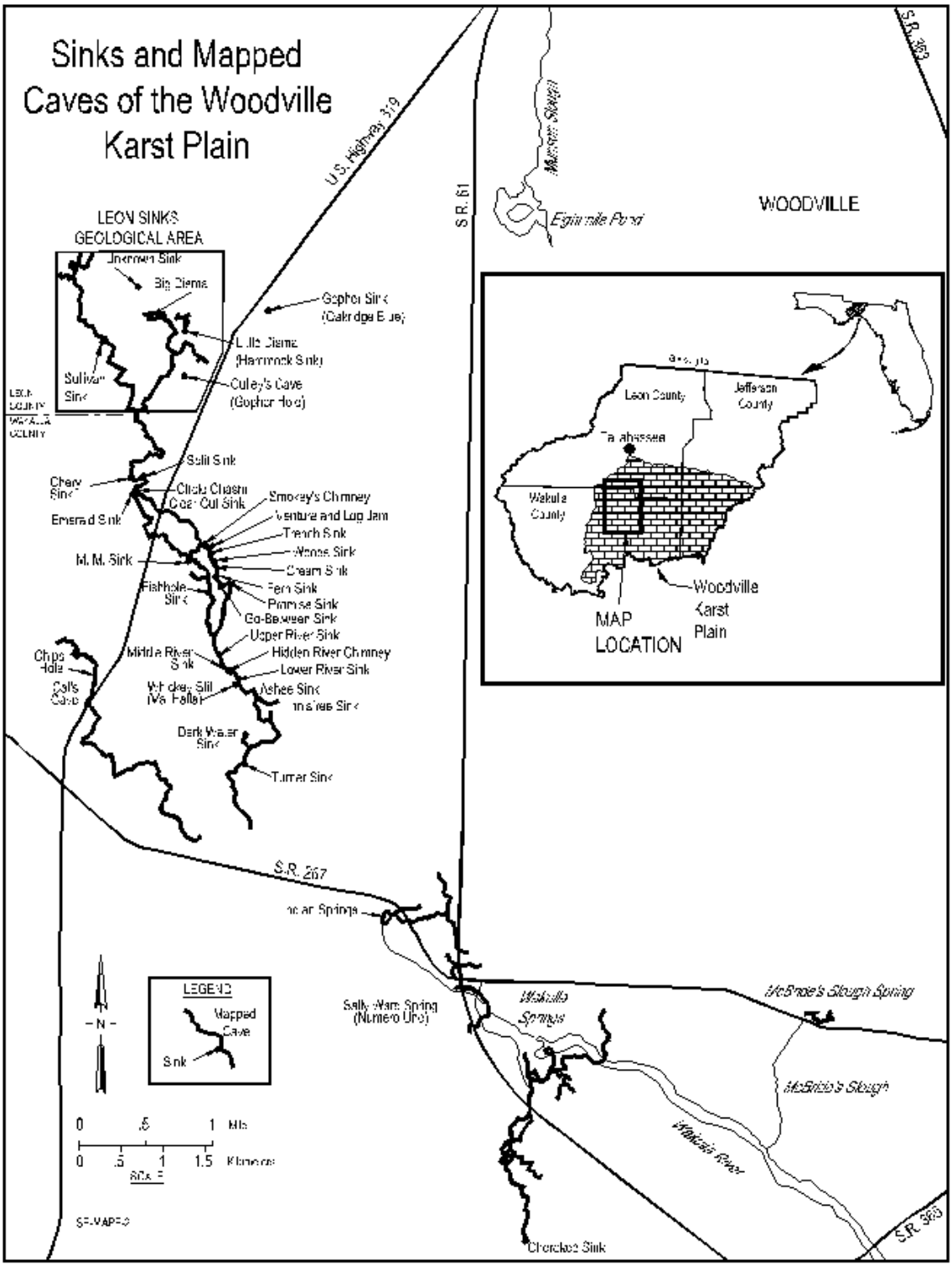
Open caverns, or caves, are some of the most interesting features in karst terrains. As long as caves are below the groundwater table, they will continue to enlarge as the dissolution of limestone continues. However, once the groundwater table drops below the cave level, a different process takes over. Acidic water, containing minerals in solution, that drips into an open cave will slowly evaporate, leaving behind a crusty accumulation of mineral salts, especially calcium carbonate (the mineral calcite). Stalactites, stalagmites, and other deposits, known collectively as dripstone, will eventually fill a cave completely if the process is not interrupted.

Caves also provide important specialized ecosystems for certain animals, such as bats. Several species, such as the eastern *pipistrelle*, the gray bat, and the southeastern bat, shelter as colonies in the protected environment of some Florida caves for at least part of the year. Bats are warm-blooded mammals and baby bats, called pups, are born like other mammals, not hatched from eggs like birds. Bat pups are nearly helpless at birth, only able to cling to their mothers or to the rocky roof of the cave. Bat mothers must nurse and protect their pups until they mature, but nursing pups face serious danger if their colony is disturbed. Like all mammals, bats must stay warm, and as tiny as they are (adults usually weigh only 4 to 16 grams) they can only do this in their cool cave by clinging to their mothers. If the colony is disturbed the mothers will suddenly fly, and there is a good chance that the bat pups will be shaken loose and fall to the floor of the cave. Their chances of being reunited with their mother before dying of cold and hunger are slim. To protect bat populations, access to caves in parks is controlled.

The Leon Sinks region has been a center of interest for scuba-equipped cave divers for several years. Many cave diving expeditions have explored the myriad underground drainage systems throughout the karst plain. They have discovered an amazing underground, and underwater, world. Some of the systems' conduits are cavernous in size, ranging from a few feet wide to over 150-feet wide; some "rooms" are big enough to contain a multi-story building. This is reported to be the longest mapped underwater cave system in the United States. The divers have established that underground conduits connect many of the karst plain's sinkholes. By swimming through

them, a few of these interconnected drainage conduits have been mapped for several miles; undoubtedly, many more connections will be made as exploration continues.

Figure 8B-2: Sinks and Mapped Caves of Woodville Karst Plain



An important component of any groundwater system is the precise elevation of the **groundwater table**, which is the top of the saturated part of the soil column. This term actually refers to the level in rock or soil above which water can only move downward, under the force of gravity, but does not remain. This boundary is not fixed but can rise or fall through time depending on long-term weather patterns. For example, during times of drought, the elevation of the groundwater table can be significantly lowered. Because wells must be drilled deep enough beneath the lowest elevation of the water table to guarantee that they can pump water at all times, even during times of drought, it is important to know the elevation of the water table. The elevation of the groundwater table can be measured directly to the standing water in wells, but it can also be approximated by observing water levels of lakes, swamps, and other bodies of standing surface water. As is true for any humid region, the water elevation in a river, lake, or swamp is approximately the same as the groundwater table elevation in the immediate vicinity.

Wakulla Springs

Wakulla Springs is the world's largest and deepest freshwater spring. It is rimmed by an ancient cypress swamp and hosts a variety of diverse wildlife including manatees and alligators. In ancient times, the springs served as watering holes for mastodons and fossil bones have been found in several of the sinkholes in the region. The State Park runs glass-bottomed boat tours, conducted by park rangers, to explore the main spring vent itself, as well as the ecosystem along the river below the spring. The quantity of fresh water that migrates through this underground drainage systems is enormous. Wakulla Springs is the headwater and main source for the Wakulla River. Its flow has been measured to be as much as 2,956,000,000 gallons per day.

Sinkholes are an excellent example of a specialized microenvironment. Plants in sinkholes are protected from storms and high winds and also benefit from moisture funneled in from surface drainage and from humid air released from underground caves. Cave environments maintain nearly constant temperatures and humidities year round, so during hot summers, cooler air from caves will keep sinkholes cooler than their surroundings. During winters, warmer air from caves will keep sinkholes' environments warmer than the surrounding area. One sinkhole in the Aucilla River, south of Tallahassee, was apparently a watering hole for mastodons, bison, bears, and even dogs, as bones of all these animals have been recovered by divers. Also found was an inch-wide stone knife and other artifacts that indicated ancient people also frequented the site as far back as 14,000 years ago. Researchers analyzed the carbon compounds in twigs in fossilized mastodon dung to date the bones and artifacts. Another important use of such fossils is to help geologists interpret environmental conditions in the past, when these organisms were alive.

Karst topography can influence land use patterns to some extent, but its most important effect is on groundwater flow. In this area, even where the Suwannee Limestone and the St. Marks Formation are not exposed at the surface, most wells for agriculture and drinking water supplies are drilled into these limestone aquifers. Not only

do wells in this area take advantage of the abundant supply of water stored in the aquifers' pores and cavities, but they also benefit from the high permeability or flow rates at which water can be pumped from the ground. The value of these fresh-water aquifers to the Big Bend region of Florida is incalculable. But, those very same hydrogeological properties that make the wells so prolific also makes them extremely susceptible to contamination by human activities. The special nature of karst terrains means that special procedures and safeguards must be instituted to protect and conserve the priceless fresh-water supplies that they contain. With so many large, interconnected passageways underground, it is very easy for pollution to spread quickly from one area to another; as flow rates for groundwater in karst terrain can exceed several miles per day. A single point-source of contamination can rapidly affect wells and water supplies in areas many miles away. Once pollution is introduced into this type of groundwater system, it is extremely difficult to contain the pollutant or to clean it up.

Landfills to dispose of domestic and municipal trash and garbage, and sometimes, hazardous materials, exist in all regions of Florida but they pose special risks to groundwater in the karst terrains of the state, such as here on the Woodville Karst Plain. Landfills are a legitimate environmental concern because of the high porosity and permeability of the underlying limestone. Any pollutants entering this rock could easily be carried away from the site to contaminate not just local drinking water supplies but also down-gradient to the underground aquifers that serve other parts of Florida.

Current Florida environmental protection regulations require that extensive engineering procedures be followed before any construction begins, during operation, and after landfill operations cease, to ensure maximum safeguards for both surface waters and groundwater aquifers. A major requirement is the placement of thick, plastic membranes in the bed of the landfill site. The liners will catch any liquid leachates that the waste materials generate, thereby preventing it from entering the underlying soils and aquifers.

Spring Creek

The karstified limestones in this region extend all the way to the Gulf of Mexico where they form the foundation beneath the coastal marshes. In fact, the limestone bands continue offshore beneath the Gulf of Mexico for quite some distance. Narrower bands of wetlands and marshes fringe the tidal stream channels and estuaries. The coastal marshes in this area have had to adapt to a different environment from other areas of the Gulf coast because of the huge amount of fresh water that is being added to the ecosystem. Thirteen such major underwater springs have been documented in Spring Creek and the adjacent Stuart Cove. The discharges of fresh water from all of these underwater springs has been estimated to be nearly 3,000,000,000 (3 *billion*) gallons *per day*. By comparison, the City of Tallahassee used only 9 billion gallons of water during the entire *year* of 1996. Whenever the water table is high in the adjacent karst plain, the discharges from the springs create "boils" that can raise the water surface of the creek almost a foot above its normal elevation. Another environmental factor is that the freshwater being introduced through the springs usually has a significantly different temperature from the surface of Spring Creek.

Despite the salinity difference, the predominant vegetation still consists of salt-tolerant species of *spartina* and *juncus* grasses, even though the salt content is very much diluted by the freshwater springs. The thick, intertwined roots of these plants form effective baffles to trap sediments carried into the marshes by streams and Gulf currents. Normal tidal range along this part of the coast is from 2 to 4 feet, causing continual flushing action in the streams, estuaries, and across the low-lying parts of the marshes. After they die, most of the plants' debris becomes incorporated into the marsh sediments. All of these factors result in the formation of organic-rich, peaty accumulations up to 5-feet thick in places. These vast expanses of marshy bog-lands created a veritable jungle that was practically impenetrable to anyone on foot.

Farther away from the coastline, the nutrient-poor surface sand deposits could support only sparse vegetation such as scrub oak, saw palmetto, spindly longleaf pines, and wiry grasses. But in sinkholes, or where the limestone outcropped at the surface, the carbonate bedrock acted as a natural fertilizer for the soil. Plants and trees that prefer an alkaline soil can grow to great size under these conditions, primarily due to the lack of competition from other more acid-loving species.

At least as far back as the early-1800s, a mysterious plume of smoke was seen to rise year-in and year-out from the coastal swamps near Spring Creek. This phenomenon, called the Wakulla Volcano, generated a lot of colorful local folklore. Surprisingly, its location was not near Wakulla Springs or even in Wakulla County. The name was derived from the word 'wakulla' which meant "mysterious" in the language of the Native Americans who originally inhabited this area. Whatever the source of the phenomenon might have been, all visible activity ceased following the Charleston Earthquake of 1886.

Archeologists have documented the arrival of early humans into this region of Florida. Nodules of chert or silicified limestone often form naturally within limestones and Native Americans frequently sought out these nodules as raw material for making lithic (stone) tools, such as spear and arrow points, knives and scrapers. Sinkholes, stream beds, and any other limestone exposures in the Woodville Karst Plain would have been good places to for these early inhabitants to search for such nodules.

The Spring Creek area is also home to the St. Marks National Wildlife Refuge which was established in 1931 to provide wintering habitat for migrating birds. The refuge preserves habitat for the American Alligator, the American Bald Eagle, the Red-Cockaded Woodpecker, and Longleaf Pine forests and savannahs that include some of the most biologically diverse groundcover in the Northern Hemisphere. In addition to its mandated resource management and conservation activities, the refuge also offers hunting, fishing, hiking, and other recreational opportunities for visitors.

Activity 8B-1: Leon Sinks

POWER THINKING EXERCISE - "Convoluted Connection"

A lot of tourists that visit the Woodville Karst Plain spend time at both the Leon Sinks Geological Area (where they see water sinking into the ground) and Wakulla Springs (where they see water emerging from the ground). There is a popular theory that the Leon Sinks water follows an extensive cave system underground and eventually re-surfaces at Wakulla Springs. Examine the cave system map shown on Figure 8B-2, "Sinks and Mapped Caves in the Woodville Karst Plain" and note where the mapped portion of the cave passages ends. Estimate this location on the Woodville Karst Plain topographic map on MAP 8B, WOODVILLE KARST PLAIN (use the highway routes shown on both maps as a guide). Mark this location on the topographic map with a wipe-off pen.

Figure 8B-2 also shows a few mapped cave systems located just north and west of Wakulla Springs. At first glance, the pattern of these two cave systems does not seem to line up exactly; but you do notice that although the two systems tend to follow convoluted paths, they do seem to flow in the same general direction. Note where the mapped section of the Wakulla Springs cave systems begins and mark that location on the topographic map with a wipe-off pen also.

Examine the karst landscape features shown on the topographic map and identify any clues that might support or oppose the theory that these cave systems are connected. If you conclude that the two systems probably are connected, draw on the map a possible underground route to Wakulla Springs. If you conclude the two systems are not connected, draw on the map other possible routes the cave systems might take. Explain your reasoning based on locations of surface features like sinkholes.

Discuss in your group if there is any experiment you could design that would either prove or disprove, without any doubt, whether the two cave systems are connected.

Materials
MAP 8B, WOODVILLE KARST PLAIN
IMAGE 8B, WOODVILLE KARST PLAIN
Figure 8-4, "Location of the Woodville Karst Plain"
Figure 8B-1: "Map of Leon Sinks Geological Area"
Figure 8B-2: "Sinks and Mapped Caves in the Woodville Karst Plain"
Wipe-off Pens

PERFORMANCE TASKS

(Icon Key) Overview = ✈; Science = ☼; Math = 💻; History = 🕮; Language Arts = ✍

1. **Identify karst features and patterns on map and aerial photograph. ✈**
   Compare the Leon Sinks topographic map on MAP 8B, WOODVILLE KARST PLAIN with the Leon Sinks aerial photograph on IMAGE 8B, WOODVILLE KARST PLAIN. Locate and mark with a wipe-off pen as many sinkholes as you can find on the topographic map by looking for closed-depression contour lines (elevation contour

lines with slash marks pointing inward). Now examine the aerial photograph and try to find as many of these sinkholes as you can. Are some sinkholes easier to locate on the photo than others? Explain why this might be. Remember that the photo is an infrared photo, which means true colors have been shifted to shorter wavelengths. What color would you expect a dry sinkhole to have on the photo? What color would you expect a wet sinkhole to have? (Remember that bodies of water carrying a lot of suspended sediment should be lighter blue than clear water, which normally appears black on infrared images.)

Do any series of sinkholes seem to occur in straight lines? What karst factors might control such a pattern? Locate the Lost Stream Sink on the left half of the topographic map. Note the surface stream that appears and then disappears. Also locate this same feature on the aerial photograph. How easy or hard is it to recognize? Explain your answer. Describe the connection between disappearing streams and sinkholes? Where does the water go when a stream "disappears?

2. **Locate position of Cody Scarp and note topographic effects.** ☼
Using the 1:50,000 scale portions of MAP 8B, WOODVILLE KARST PLAIN and IMAGE 8B, WOODVILLE KARST PLAIN, trace the boundary of the transition zone between the Northern Highlands geologic province and the Woodville Karst Plain, with a wipe-off pen. This boundary is approximated by the position of the toe of the Cody Scarp that, in the Tallahassee area, ranges from about 50 feet to 75 feet elevation above mean sea level. Figure 8-3, "Location of the Woodville Karst Plain," may be a helpful resource. Describe what you notice about the different nature of the elevation contour line patterns, to the north and to the south of this boundary. What do the contour line patterns tell you about the topography of the area?

Also, on the 1:50,000 scale portions of MAP 8B, and IMAGE 8B, trace the path of the surface water streams, using a wipe-off pen. (Start at the coast and trace the stream courses back inland to their beginnings, or **headwaters**.) At what elevation do most of the streams appear to originate? What relationship do the locations of the streams' headwaters have relative to the transition zone, the Cody Scarp. Is this a cause and effect relationship? If so, describe it? Speculate on what could account for such a relationship? (Hint: examine the elevation of open bodies of water in the upland area, such as in sinkholes and swamps.)

3. **Determine elevations and slope of ground water table.** 💻
Locate and mark, with a wipe-off pen, the following sinkhole features on the Leon Sinks topographic map on MAP 8B, WOODVILLE KARST PLAIN: Big Dismal Sink, Black Sink, Lost Stream Sink, Hammock Sink, Un-named Sink south of Hammock Sink, and Gopher Hole. Because of the high porosity of the limestone rock, we can assume that the water level in each of these sinks represents the elevation of the ground water table at that site. Use contour line information to determine the elevation of the water level in each sinkhole and enter your data in the table below.

Groundwater Elevation Table

sinkhole feature	water table elevation
Big Dismal Sink	
Black Sink	
Lost Stream Sink	

sinkhole feature	water table elevation
Hammock Sink	
Un-named Sink	
Gopher Hole	

On the Woodville Karst Plain topographic map on MAP 8B, WOODVILLE KARST PLAIN, locate the following features and mark them with a wipe-off pen:
- **Black Swamp**, southwest of Tallahassee at edge of Cody Scarp - elevation = 43 feet
- **Lake Munson**, south of Black Swamp - elevation = 24 feet
- **Eightmile Pond**, south of Lake Munson - elevation = 12 feet

Graph the slope of the ground water table in this region by assigning 'ground water table elevation' to the 'Y' axis and 'distance from Black Swamp' to the 'X' axis. Choose an appropriate scale for each axis, then plot your three ordered pairs (representing data points) on the graph. Use the given elevations as your 'y' coordinates and measure the map distance of each point from Black Swamp as your 'x' coordinates. Connect the three points on your graph with two straight lines (Black Swamp to Lake Munson and Lake Munson to Eightmile Pond). Are the slopes of these lines the same? Explain the factors that might affect the slope. Take an average of your two slope values to calculate the general slope of the ground water table.

Use your graph (and calculation of the slope of the ground water table) to extrapolate how far past Eightmile Pond you would have to travel (headed toward the Gulf of Mexico) to reach the point at which the elevation of the ground water table reaches zero (sea level). How far is that point from the actual shoreline of the Gulf of Mexico?

4. **Determine extent of cave mapping accomplished by scuba divers.** 🕮
Locate the Leon Sinks Geological Area on the 1:50,000 scale portion of MAP 8B, WOODVILLE KARST PLAIN, and on IMAGE 8B, WOODVILLE KARST PLAIN. [Hint: Leon Sinks Geological Area is just above the Leon County / Wakulla County line near the left margin of the map (just NE of words "Leon Co."). Use highway patterns and other land features to help you locate the same Area on the photograph.

The Woodville Karst Plain is underlain at shallow depths by limestone rocks that are riddled with voids, fractures, and tunnels called conduits. Countless sinkholes connect the underground conduits to the surface. For several years, scuba divers have been swimming through these underwater passages, mapping them and their associated sinkholes (refer to Figure 8B-2, "Sinks and Mapped Caves in the Woodville Karst Plain"). Locate on the map, and mark with a wipe-off pen, as many of the sinkholes that are named in Figure 8B-2 as you can. Are there any surface features, other than sinkholes, that provide clues that there are caves underneath? Explain your answer. Use the map scale to estimate the total length of the cave system that has been explored and mapped.

5. **Write travel log about a bat's journey through a cave.** ✍
   Caves are exciting places to visit. In most cases you must travel for long distances underground completely in the dark. Pretend you are a bat hiding in the deepest part of a cave in the Leon Sinks Geological Area. Write a descriptive travel log explaining how you would get out of the cave, what you would see on the way out, and what problems you might encounter on your trip. Use lots of adjectives to make your story more interesting.

   Locate a site on the Leon Sinks topographic map on MAP 8B, WOODVILLE KARST PLAIN that might contain the type of cave through which this journey might have occurred. Remember that if your bat plans to exit the cave through a sinkhole, there must not be water in that sinkhole (bats can't swim). Justify your selection and compare it to locations chosen by other groups.

ENRICHMENT

(Icon Key) Overview = ✈; Science = ☼; Math = 💻; History = 🕮; Language Arts = ✍

1. **Research limestone mining in Woodville Karst Plain.** ☼
   Write to a limestone quarry such as: Florida Crushed Stone Co., P.O. Box 668, Brooksville, FL 34605; or Rinker Materials, P.O. Box 5230, Hialeah, FL 33014. Ask for information about limestone deposits in their area. Also, ask them to send you a sample of the limestone rock they are mining, preferably with fossils. Soak the sample in water and measure how much water is absorbed into the rock's pores. Break off a very small piece of the rock and soak it in a container of vinegar or other weak acid. Do you observe any reaction? How long does it take for the sample to totally dissolve? Look up the chemical formula for the primary mineral that comprises the limestone and use this information to identify the gas bubbling off from the limestone?

2. **Research procedures and safety issues for scuba diving in caves.** 🕮
   Use local library or internet resources to research information on scuba diving, including the kinds of equipment you would need to do this type of exploring. Scuba diving in caves requires special skills and equipment and introduces numerous safety issues and concerns that are unique to the cave environment. Make a list of these safety issues and include a list of solutions to make the explorations safer.

Activity 8B-2: Wakulla Springs

POWER THINKING EXERCISE - "Pachyderm Pursuit"

Imagine you are a Native American hunter living about 10,000 years before the present. Mammoths, saber-tooth cats, and camels still roam this part of the North American continent. Both sea level and groundwater levels are lower than at present. Florida's climate is cooler and much drier than at present, and Wakulla Springs exists as a sinkhole lake, but is not a flowing spring. Although the lake does not flow out over the land surface, it is still a major watering hole for local wildlife and humans. In order to supply a large amount of meat for your winter provisions, you and your fellow hunters have set up camp not far from present-day Wakulla Springs. Because mammoths periodically come to the Wakulla Sink for water, your plan is to hide among the vegetation around the lake and stalk them there.

While you are imagining this scenario, you are also wondering why things were so different in the past. Discuss in your group the answers to the following questions and be prepared to defend your reasoning.

- **Why is the water in the Wakulla Sink not flowing out on to the surface?**
- **Why is the water good to drink if there is no outlet to the sinkhole lake? [why doesn't the water get stagnant and nasty just sitting there]**
- **Why do so many animals come to this particular sinkhole lake? [why would there be so many fewer watering holes in the past]**

Materials
MAP 8B, WOODVILLE KARST PLAIN
IMAGE 8B, WOODVILLE KARST PLAIN
Wipe-off Pens

PERFORMANCE TASKS

(Icon Key) Overview = ✈; Science = ☼; Math = 💻; History = 🕮; Language Arts = ✍

1. Analyze land use around Wakulla Springs. ✈

Analyze land use around the Wakulla Springs area by examining the Wakulla Springs topographic map and the Woodville Karst Plain topographic map on MAP 8B, WOODVILLE KARST PLAIN. Also reference the corresponding infrared aerial photographs on IMAGE 8B, WOODVILLE KARST PLAIN. Make a list of the five major land uses in this karst region. Which uses are affected positively by the presence of karst topography? Which uses are affected negatively? Will any of these uses either create or be affected by environmental problems in the future? Explain your answer.

With all the limestone underlying this region, you might expect to find a quarry operating somewhere, but there are none. [There are several limestone quarries farther north in the Woodville Karst Plain, near Tallahassee]. Discuss in your group why the Wakulla Springs area would not be the best place to locate a mining operation. What are the major differences between this area and the Tallahassee area? Share your results with the class.

2. **Recognize sinkholes on infrared aerial photograph. ☼**
Compare the Wakulla Springs topographic map on MAP 8B, WOODVILLE KARST PLAIN with the Wakulla Springs infrared aerial photograph on IMAGE 8B, WOODVILLE KARST PLAIN. Locate and mark on the map with a wipe-off pen as many sinkholes as you can find (look for closed-depression contour lines - elevation contour lines - with slash marks pointing inward). Try to find and mark all of these same corresponding sinkholes on the aerial photograph? Were you successful? How many of the sinkholes were easy to find? Explain how you were able to recognize these features. What color on the infrared image would you expect a sinkhole to have if there was water in it? (Remember that bodies of water carrying a lot of suspended sediment should be lighter blue than clear water, which appears black on infrared images.) What color on the infrared image would you expect a sinkhole to have if it were dry? Does the depth of a sinkhole make a difference in how easy it is to find?

3. **Calculate density of sinkholes. 💻**
There are two approaches to calculating the density of sinkholes occurring in a given area. Divide your class into groups and have half the groups calculate density using method #1 and the other half calculate density using method #2. Both groups will use the Wakulla Springs topographic map on MAP 8B, WOODVILLE KARST PLAIN.

METHOD #1
Count the total number of sinkholes visible on the topographic map (look for closed-depression contour lines - elevation contour lines with slash marks pointing inward). Then estimate the surface area covered by the entire map [refer to the scale bar and use units of square miles or square kilometers - remember; there are 5,280 feet in a mile and 1,000 meters in a kilometer]. Express your answer as "# of sinkholes per square mile" or "# of sinkholes per square kilometer". Report your answer to the whole class.

METHOD #2
Locate every sinkhole you can find on the topographic map (look for closed-depression contour lines - elevation contour lines with slash marks pointing inward). For each sinkhole you find, estimate its total surface area in either square feet or square meters. Consider the highest elevation contour line showing slash marks pointing inward to be the outer edge of the sinkhole. For nearly circular sinkholes, use the formula for finding the area of a circle to calculate your estimated area; for more irregularly shaped sinkholes, use formulae for finding areas of rectangles or triangles to calculate your estimated area. Add up the estimates of total areas covered by each sinkhole to get a total estimated land cover of sinkholes for the entire map area. Convert your estimate (in square feet or square meters) to square miles or square kilometers using the following conversion factors:

1 square foot ~ .00000003587 square miles
1 square meter ~ .000001 square kilometers

After each group reports its results, have a class discussion about which density measurement gives the best description of the actual landscape pattern of sinkholes. Is there a limit to how many sinkholes can fit into a specific geographic area? Does the size of individual sinkholes affect your density measurements?

4. **Evaluate placement of roads in karst areas.** 🕮
   With a wipe-off pen, trace the path of every highway shown on the Wakulla Springs topographic map on MAP 8B, WOODVILLE KARST PLAIN. With a different color pen, place a large dot wherever a road crosses or comes close to a sinkhole. What are the dangers associated with running a road through a sinkhole? Why do you think the Wakulla County Highway Department chose to route certain roads through sinkholes? Examine the highway running next to Cherokee Sink (near bottom of map). Do you think the road was originally straight or do you think the small curve around the edge of the sinkhole was part of the original route? Explain your reasoning. How soon will they have to re-route the road again as the sinkhole continues to expand?

5. **Write script for news report about opening of sinkhole.** ✍
   A newspaper ran the following account of an expanding sinkhole under the title "That Sinking Feeling." You are a television reporter from Tallahassee who has been sent to the site and assigned to cover this story. Write an outline of the script you would follow to film a five-minute video to send to the television station for later broadcast. Explain exactly what you would film (give details), in what order, and whom you would interview (write down what specific questions you would ask the eyewitnesses).

   "As if the recent heavy rains weren't enough, now residents of a mobile-home subdivision in southern Leon County are watching a sinkhole eat toward their homes. The sinkhole is about 20-feet wide, and filled with water to about three feet below the rim. One resident who lives about a block from the sinkhole, said he joined other curious residents to see the oddity on Saturday.' Lots of people were there,' he said. 'There were big yellow ribbons around it. We're concerned because it's in a residential area with lots of kids.' A spokesperson for the Tallahassee Fire Department said the department was notified at 3:55 p.m. Saturday. Firefighters went to look at the sinkhole, but decided it wasn't threatening any homes."

ENRICHMENT

(Icon Key) Overview = ✈; Science = ☼; Math = 💻; History = 🕮; Language Arts = ✍

1. **Research prehistoric environment and human activity.** ☼ 🕮
   Use local library or internet sources to gather information about the prehistoric environment that existed in the Woodville Karst Plain about 10,000 years ago. Pay special attention to the large mammals (mastodon, etc.) that lived in this area then. Also gather information about the prehistoric people that inhabited this region, their culture, and how they hunted.

2. **Research history of Wakulla Springs Lodge and State Park.** 🕮
   Wakulla Springs, Wakulla Springs Lodge, and the present day state park all have a cultural history that extends back into the 19th century, or even further. Research this rich and colorful history by contacting Wakulla Springs State Park or investigating their website.

Activity 8B-3: Spring Creek

POWER THINKING EXERCISE - "Water Wars"

Locate and trace, with a wipe-off pen, the path of Spring Creek on both the Woodville Karst Plain and Spring Creek topographic maps on MAP 8B, WOODVILLE KARST PLAIN. Also trace this creek on both the Woodville Karst Plain and Spring Creek aerial photographs on IMAGE 8B, WOODVILLE KARST PLAIN.

A prominent political figure from Central Florida has made a proposal to tap into the large, fresh water springs at Spring Creek and build pipelines to transport the water to densely populated urban areas downstate, such as the Tampa – Saint Petersburg metropolitan area, which is having major problems obtaining adequate public water supplies due to rapid population growth and seawater infiltration into groundwater wells.

The citizens of Leon and Wakulla Counties are alarmed at such a proposal. Some have organized a citizens' committee to petition the Governor to clarify the government's top-level policy regarding this issue. Other citizens have threatened to simply go ahead and sue the State; in essence, starting a "water war" to determine just who owns or controls their natural resources. Should this inter-basin transfer of water be allowed? What are some policy issues to be considered; for example, should the water be sold to the highest bidder? What might be the effects to this donor Gulf coastal region if the fresh water were removed from its ecosystem? What might be the effects to the client area's ecosystems from large quantities of imported fresh water?

HINT: Brackish coastal waters in estuaries and marshes are some of the most productive parts of marine ecosystems and food chains. Also, one Florida Department of Environmental Protection report noted that manatees had been seen around the springs.

Materials
MAP 8B, WOODVILLE KARST PLAIN
IMAGE 8B, WOODVILL KARST PLAIN
MAP 3F, CULTURAL SETTING
Newspaper article: "The Wakulla Volcano - A Major Mystery" on Page 8B-1
Wipe-off Pens

PERFORMANCE TASKS

(Icon Key) Overview = ✈; Science = ☼; Math = 💻; History = 🕮; Language Arts = ✍

1.Examine land and hydrologic features associated with Spring Creek. ✈

Examine the Spring Creek topographic map on MAP 8B, WOODVILLE KARST PLAIN and also examine the Spring Creek infrared aerial photograph on IMAGE 8B, WOODVILLE KARST PLAIN PLAIN. Also locate Spring Creek on the Woodville Karst Plain topographic map on MAP 8B and on the Woodville Karst Plain infrared aerial photograph on IMAGE 8B. What is the elevation of Spring Creek community? Based on information from the photo, make an estimate of the number of people who live in this community. Are there any clues about how residents might make a living?

Note several very straight, but narrow waterways in and around the Spring Creek community. Do you think these waterways are naturally straight, or are they artificial? Explain your reasoning. Locate and mark the semi-circular re-entrant where State Road 365 ends at the water's edge in Spring Creek at a public boat-launching ramp. (These circular or semi-circular re-entrants are the result of large underwater springs that discharge huge quantities of fresh water into the tidal, brackish coastal waters of the Gulf of Mexico.) Locate the thirteen marked underwater springs on the map. Are there any visible features on the aerial photograph that would help you locate the Springs? Are there any differences in the colors of different waterways? How would you interpret such color differences? Explain your answers.

2. **Locate boundary between coastal marshes and upland topography.** ☼
On the Spring Creek topographic map on MAP 8B, WOODVILLE KARST PLAIN, note that there are no sinkholes or depression contour lines anywhere on the map. The transition zone between the coastal marshlands and the upland karst topography does not begin until an elevation of at least 10 feet is reached. Find the Spring Creek area on the Woodville Karst Plain topographic map on MAP 8B and locate the 10 foot contour line. Trace that line with a wipe-off pen. Note that at elevations above 10 feet the topography begins to change and that between 10 and 30 feet, the contour lines are very close together in places. What might account for the relatively abrupt steep slope at those elevations? Defend your theory with evidence from the map.

As closely as you can, mark, with a wipe-off pen, the location of the same transition zone on the Woodville Karst Plain infrared aerial photograph on IMAGE 8B, WOODVILLE KARST PLAIN. Is there any indication on the photograph that a change in elevation has occurred (look for differences in land use and land cover)?

3. **Determine resolution of aerial photographs.** 💻
Study the Spring Creek infrared aerial photograph on IMAGE 8B, WOODVILLE KARST PLAIN and locate the smallest feature that you can find and identify it. [If you detect an object but cannot identify it, that object does not qualify.] To the best of your ability, estimate the length and or width of that object in feet (or meters). Note that the scale of this photograph is 1:10,000 (meaning one inch [or centimeter] on the map = 10,000 inches [or centimeters] in the real world).

Now study the Woodville Karst Plain infrared aerial photograph on IMAGE 8B, WOODVILLE KARST PLAIN and locate the smallest feature that you can find and identify it. To the best of your ability, estimate the length and or width of that object in feet (or meters). Note that the scale of this photograph is 1:50,000 (meaning one inch [or centimeter] on the map = 50,000 inches [or centimeters] in the real world).

The scale of the Spring Creek photograph is five times as large as the scale of the Woodville Karst Plain photograph [the fraction 1/10,000 is five times as large as the fraction 1/50,000]. Use your mathematical knowledge to prove that relationship.

Insert your previous data into the following chart and use mathematical extrapolation to make predictions about what would be the smallest resolvable object visible on the two hypothetical photographs listed. Be prepared to explain to the class how you were able to determine the estimated size of objects on the hypothetical photographs.

name of aerial photograph	photograph scale	size of smallest resolvable object
Spring Creek	1:10,000	
Woodville Karst Plain	1:50,000	
hypothetical photograph #1	1:100,000	
hypothetical photograph #2	1:500,000	

4. **Speculate about Native American culture and artifacts.** 🕮
Examine the various landscape features on the Woodville Karst Plain topographic map on MAP 8B, WOODVILLE KARST PLAIN and speculate on the best locations to look for Native American artifacts. Mark your most likely spots with a wipe-off pen and be ready to justify your reasoning for choosing these sites. What types of artifacts would most likely be preserved in this type of landscape? List reasons why these artifacts would have been left behind. Explain how these artifacts were preserved for you to find. List strategies you could use which would make your search for artifacts easier. Give some specific examples.

Also mark on the map places where you think local village sites probably would have been located and list reasons why these locations would make good village sites. Refer to the inset map of Native American Cultures on MAP 3F, CULTURAL SETTING. Which Native American nations inhabited the Woodville Karst Plain?

5. **Analyze newspaper article on Wakulla Volcano.** ✍
Read the newspaper article "The Wakulla Volcano - A Major Mystery" on Page 8B-1 and perform a critical analysis of the information given in that article. Why was the term 'volcano' used to describe the phenomenon even though geologists have long insisted that a real volcano could not exist in this part of Florida? Make a list of all the presumed causes of the smoke and fire that are cited in the article. Do you think any of these causes could provide a plausible explanation? If so, which ones?

ENRICHMENT

(Icon Key) Overview = ✈; Science = ☼; Math = 💻; History = 🕮; Language Arts = ✍

1. **Research Native American artifacts found in this region. 🕮**
   Use local library or internet resources to research the various types of Native American artifacts that have been found in the sinkholes of this part of Florida. Explain how and why each artifact was originally made and how information gathered from these artifacts can provide information about the culture and lifestyle of the local inhabitants.

2. **Research scientific explanations for Wakulla Volcano. ☼**
   The newspaper article, "The Wakulla Volcano - a Major Mystery," on Page 8B-1 focuses most of its reporting on the folklore surrounding the Wakulla Volcano. Use local library or internet resources to research the scientific studies that have been conducted in reference to this phenomenon. If there is an accepted scientific explanation for the 'volcanic' eruptions, give a short oral report to the class to present that information. If a specific location has been identified as the site of the 'volcano', mark that site on a map and share it with the class also.

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THE NEWS AND OBSERVER

March 31, 1997

Scientists Seek to Save Mysterious Depressions

By Stuart Leavenworth

PEMBROKE – Seen from the air, the coastal plain of the Carolinas looks pretty peculiar. Scattered across the landscape are thousands of bizarre egg-shaped ponds and swamps, all pointing in the same direction. A half million of these depressions stretch from New Jersey to Florida, but no one knows how they got there.

For nearly two centuries, scientists have been obsessed with those loopy landmarks, known as Carolina Bays. Some scientists have suggested meteor showers. Others believe the bays were formed by ancient schools of wallowing whales.

"Everybody loves a mystery, and the bays are a good one," said Thomas Ross, a geography professor at the University of North Carolina - Pembroke. "I've counted at least 18 different theories on their origins, and it seems I hear a new one every few months."

In recent decades, scientists have gradually reached agreement that winds – not whales – explain part of the mystery. Over thousands of years, prevailing winds have redistributed sediments within the bays, transforming round ponds into the shallow, elliptical depressions that we see today.

Even so, the bays still hold plenty of mysteries. Why, scientists ask, are some bays wet and others dry most of the year? Why do they support such a profusion of unusual plants and animals? And how did they get there in the first place?

When left intact, Carolina Bays are home to more than 30 endangered and unusual species, including rare salamanders and the Venus flytrap, a carnivorous plant that is found only in the Carolinas. Many worry that the wonders of Carolina Bays are slowly being buried as new roads, subdivisions and farms converge on the coastal region. Ross, the UNC geographer, adds "They have helped shaped our culture and environment in this part of the state,"

RATIONALE

Carolina Bays are interesting geological formations that have intrigued scientists for generations. Many theories have been suggested to explain the formation of the Bays, ranging from the difficult to accept ones - such as the Bays' being scooped out by giant turtles - to the difficult not to accept ones - such as the Bays' being formed by the impact of a comet. Another front-running theory suggests that the Bays were formed gradually from pre-existing ponds by the slow action of prevailing winds. However the Bays formed, they are organically rich and normally very wet. They support several rare and endangered plant and animal species and provide major wetland habitat for one of the most diverse biological communities of the Coastal Plain Region. If drained, the rich soils of the Bays can be used for farming. Except along the rim of the Bays, where the soil is sometimes almost totally sand, typical Bay soils are able to support the growth of both row crops and forest products. A few of the Carolina Bays remain in their natural state, and are preserved as parks, but the majority of them have been ditched and drained for agriculture or logging.

PERFORMANCE OBJECTIVES

1. Describe geographical and geological framework of Carolina Bays.
2. Describe biological and ecological characteristics of Carolina Bays.
3. Compare scientific and non-scientific theories of origin of Carolina Bays.
4. Analyze size, shape, spatial orientation, and topographic relief of Carolina Bays.
5. Use mathematical concepts to describe geometry and spatial orientation of Bays.
6. Classify Carolina Bay soil types based on moisture content and vegetative cover.
7. Compare and contrast current and past land uses of Carolina Bays.
8. Evaluate effectiveness of current efforts to preserve Carolina Bays in a natural state.
9. Document role of unusual plants and endangered species in Bay ecosystems.
10. Identify connections between local folk tales and geographic features of Bays.

SAMPLE ASSESSMENT RUBRICS

EXAMPLE #1 (relates to Performance Objective #1)

Ask students to list four characteristics of a typical Carolina Bay that can be observed on either a topographic map or an aerial photograph. *Correct answers include but are not limited to: elliptical shape, long axis runs northwest to southeast, wettest portion in center, very low topographic relief, sand rim [usually along southeastern edge], size of bay can vary considerably, often occur in groups.*

A (level 4) – four correct responses given
B (level 3) – three correct responses given
C (level 2) – two correct responses given
D (level 1) – one correct response given
F (level 0) – no correct responses given

EXAMPLE #2 (relates to Performance Objective #3)

Ask students to state and explain one 'scientific' theory about the origin of Carolina Bays and also state and explain one 'non-scientific' theory.

Scientific Theories include but are not limited to:

Meteorite (or comet) impact theory [object broke into many pieces before impact]
Prevailing winds caused elongation of existing depressions [piled up sand on rim]

Non-Scientific Theories include but are not limited to:

Giant turtles scooped out depressions [some bays too large for even a giant turtle]
Fish nests formed by schools of fish waving fins over submerged depressions [too many Bays to be accounted for – would require millions of fish]
Large sinkholes formed by ground water solution [can't be - no limestone in area]

A (level 4) – Correct theories given and explanations are clear and concise.
B (level 3) – Correct theories given but explanations incomplete or inadequate.
C (level 2) – Only one correct theory given with reasonable explanation; or two correct theories given with no reasonable explanations.
D (level 1) – No correct theories given, but explanation shows some understanding of process.
F (level 0) – No correct theories given, and explanations, if given, show no understanding of process.

Cartographic Product Information

MAP 8C: Carolina Bays

TITLE: AVHRR Bladen Lakes, NC (topographic map)
DATA SOURCE: Singletary Lake, White Lake, Elizabethtown North, Elizabethtown South USGS 1:24,000 Quadrangles
DATE: Singletary Lake and White Lake: 1986
Elizabethtown North and Elizabethtown South: 1987
SCALE: 1:24,000 [1 inch = 2,000 feet] [1 cm ~ 250 meters]
OTHER IMPORTANT DATA:
- The contour interval of this map is 5 feet.

POINTS OF SPECIAL INTEREST:
- White Lake is located near the center of the map.
- Singletary Lake State Park is located in the lower-center of the map.
- Bay Tree Lake State Park is located in the upper-right corner of the map.
- Black Creek Bay (has been ditched and drained) is located below Bay Tree Lake.

OTHER FEATURES TO LOOK FOR:
- Other Carolina Bays (not filled with water) are outlined by curved, dashed lines.
- The Cape Fear River runs diagonally across the lower-left quadrant of the map.
- Colly Creek/Swamp runs from north to south through the middle of the map.
- U.S. Lock and Dam #2 on Cape Fear River (Browns Landing) left edge of map.

Cartographic Product Information

IMAGE 8C: Carolina Bays

TITLE: Bladen Lakes, NC (NHAP [infrared aerial photograph])
DATA SOURCE: NHAP CIR Photographs 327-117 and 347-35
DATE: 1983
SCALE: 1:24,000 [1 inch = 2,000 feet] [1 cm ~ 250 meters]
OTHER IMPORTANT DATA:
- This image is a false-color infrared photo so all true colors have been shifted.
- This is a winter image, so trees do not have leaves and forests are not red color.
- Clear water (no sediment) shows up as black color.

POINTS OF SPECIAL INTEREST:
- White Lake is near the center of the photo.
- Singletary Lake is located in the lower-center of the photo.
= Black Creek Bay (has been ditched and drained) located in right-center of photo.

OTHER FEATURES TO LOOK FOR:
- Notice white sand rims on the southeastern side of some of the Carolina Bays.

TITLE: Bladen Lakes, NC (NALC [satellite image])
DATA SOURCE: EPA and USGS NALC Pathfinder WRS2 Path 15 Row 36
DATE: 1991
SCALE: 1:125,000 [1 inch ~ 2 miles] [1 cm ~ 1.25 kilometers]
OTHER IMPORTANT DATA:
- This image is a false-color image so all true colors have been shifted.
- This is a summer image, so trees have leaves and forests appear in red colors.

POINTS OF SPECIAL INTEREST:
- The area covered by the Bladen Lakes aerial photograph is in lower-right corner.

OTHER FEATURES TO LOOK FOR:
- The Cape Fear River runs diagonally across the center of the image.

TITLE: Bladen Lakes, NC (photomosaic [black & white aerial photographs])
DATA SOURCE: #ASCS - 1-72 DC Item 1, US Department of Agriculture
DATE: 1972
SCALE: 1:62,500 [1 inch ~ 1 mile] [1 cm ~ .65 kilometers]
OTHER IMPORTANT DATA:
- Lighter areas represent bare soil or farm fields; darker areas are forested.
- Open water shows up as solid black color.

POINTS OF SPECIAL INTEREST:
- White Lake is in upper-left quadrant of photo.
- Singletary Lake is located in lower-center of photo.
- Bay Tree Lake and Black Creek Bay are in upper-right corner of photo.

OTHER FEATURES TO LOOK FOR:
- The Cape Fear River runs across lower-left corner of map but is hard to see.

Anatomy of a Carolina Bay

Carolina Bays are elliptical depressions, found primarily in the **Coastal Plain** Region of North and South Carolina, which have intrigued residents since the arrival of the first settlers. Additional investigations have shown that nearly all of the Carolina Bays are smooth elliptical depressions only a few feet deep, with their long axis oriented in a remarkably consistent northwest to southeast direction. Most have a surrounding rim of sand that is especially obvious along the southeastern edge. These sand ridges usually have gentle slopes and rise only a few feet above the level of the Bay. In exceptional cases, sand rims may reach heights of 15 feet and widths of several hundred feet. However, in other cases ridges may be totally lacking. Bay size ranges from an area of only a few square feet to monster Bays having dimensions up to four miles long and two miles wide. Bays in the Carolinas average 2,210 feet in length and 1,430 feet in width. The depth of these basins lies anywhere from a couple of feet to as much as forty feet below the surface level of the surrounding Coastal Plain. Depth can be misleading, however, since most Bays contain thick accumulations of soil and peat deposits.

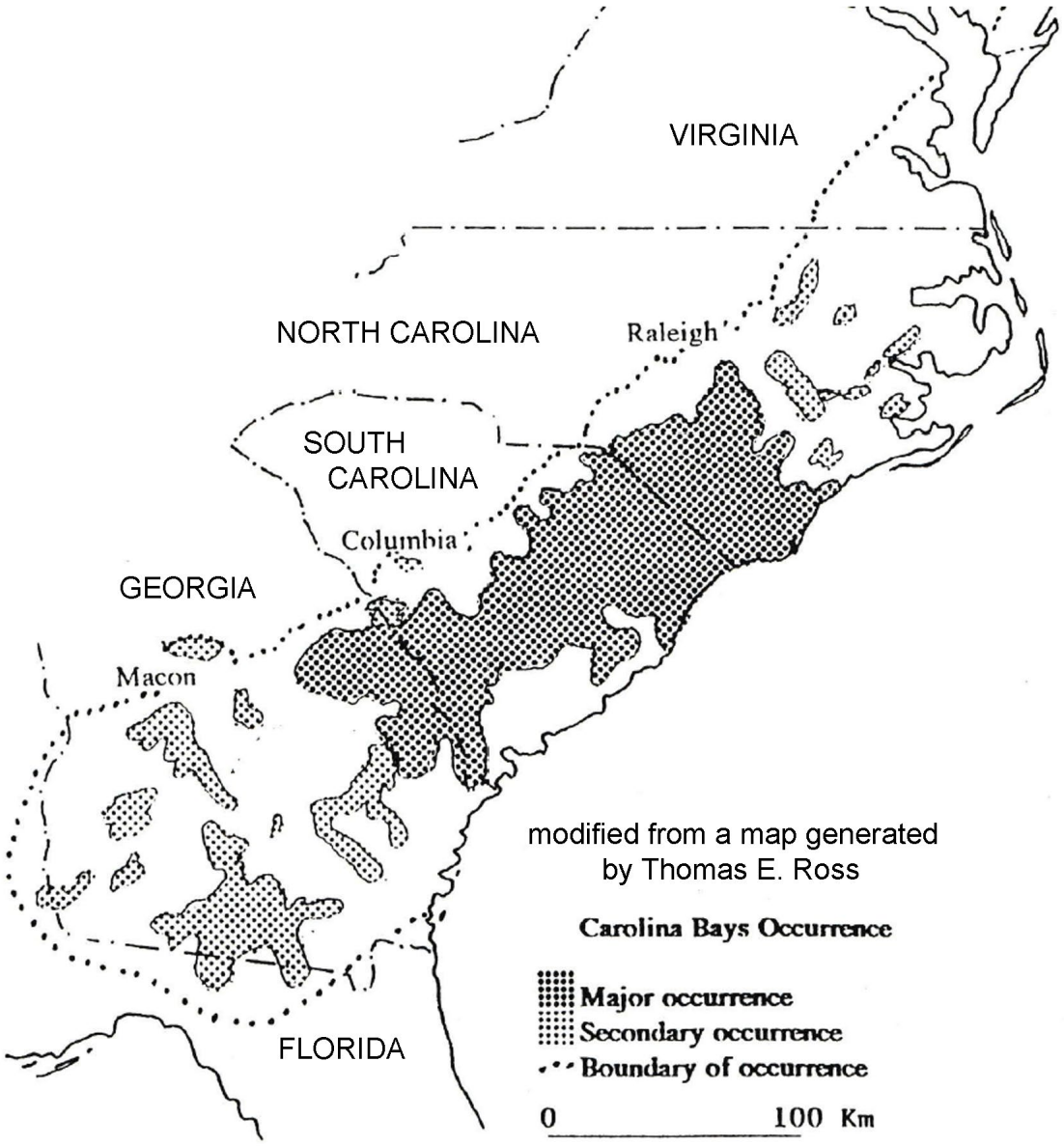
Because they are such subtle features, and because they are usually very **swampy** and hard to cross, most Carolina Bays generally went unnoticed by the local population. The exact number and geographic extent of Carolina Bays were not recognized until aerial photographs, first made by the United States Geological Survey in the 1930's, revealed that hundreds of these unique Bays existed from Southern New Jersey all the way to Northern Florida. They are distributed over an area of 25,000 square miles along a strip of Coastal Plain nearly 80 miles wide. Estimates for the total number of Bays now range as high as 500,000. Estimates of ages for Bays range from 6,000 to 60,000 or more years. Data obtained from the bottom-most sediments in the Bays indicates that most existed as open-water lakes many years ago and have since filled in with mud and vegetation. No Carolina Bay type features appear to be developing today.

Almost any large section of the Carolinas Coastal Plain will contain at least a few Carolina Bays. However, Bays are not uniformly distributed throughout this region. Some counties have several hundred known Bays while other counties have none. Only a few of the Bays are still in their natural state; most have been ditched and drained. The original outlines of drained and cultivated Bays are hard to locate and often can only be seen from the air. A few Bays have been preserved in close to pristine condition and several of these host state parks that may be visited by the public.

Several larger Carolina Bays, especially those that contain standing water, form significant landform features that have been given individual names. The Bladen Lakes area of North Carolina is particularly well known for its abundant grouping of large Bays that contain standing water all year long. These lakes are not fed by streams or springs, but depend on rainfall and runoff from the surrounding land. As a result, the water level in the lakes can fluctuate significantly throughout the year. In the distant past, nearly all

bays contained open water. But now, all of these lakes are gradually filling in with sediment, and with dead organic matter, and will someday be reduced to a moist bog. One of the Bladen lakes, Singletary Lake, is now only 44% of its original size.

Figure 8C-1: Geographic Distribution of Carolina Bays



Another term sometimes used to describe Carolina Bays is '**pocosin**', which is a Native American (Algonquian) name meaning "swamp on a hill." An early explorer in the region, John Lawson, described these pocosins in the early 1700s as swamps in which grew a "tall lofty Bay-tree, not the same as in England, these being in their Verdure all the Winter long." With the advent of aerial photography in the 1930's, a number of geologists and local citizens again became interested in these mysterious features that showed up so much more clearly from an aerial perspective.

The origin of Carolina Bays has long intrigued scientists and others, with many theories being proposed, investigated, and discredited or discarded. Listed below are several theories of origin that have been proposed over the years. Some are whimsical, having few if any observations to support them. Some of these early theories seem ridiculous to us today. Others are within the realm of possibility, having some data that do support them. Many of the early hypotheses have been eliminated because conclusive data did not match the theories. For example, the **limestone sinkholes** theory could never be substantiated because of the lack of any limestone deposits associated with the Bays. Here are some of the many theories of origin proposed for Carolina Bays:

- Basin scooped out by giant turtles
- Fish nests made by giant schools of fish waving their fins in unison
- An extraterrestrial origin where meteorite showers or comets struck the earth
- Large sinkholes formed in limestone solution areas
- Solution basins related to activity of artesian springs combined with wind action
- Natural circular depressions elongated by prevailing winds.

Of all the theories (hypotheses) that surround the origin of the Bays, the one that has captured the most attention and imagination is the suggestion of extraterrestrial origin. This theory, first proposed by Melton and Schriever in 1933, hypothesized that the Carolina Bays were caused by the impact of a cluster of meteorites striking the earth. The theory was based on the smooth elliptical shape, the peculiar rim of sand found predominantly on the southeastern edge, and a consistent northwest to southeast orientation of all the Bays.

Many geologists have conducted surveys trying to substantiate this theory. In 1952, Prouty carried out magnetometer surveys in an attempt to locate magnetic properties associated with meteorite material. His data were not conclusive. He also conducted projectile experiments using a .38 caliber bullet to determine if elliptical depressions could be made at a small angle of impact. The conclusion of his data was that a meteorite could produce an elliptical depression, but it would be 2-3 kilometers deep with an uneven bottom. The Bays, on the other hand, are flat-bottomed depressions only a few feet below the surface of the surrounding ground. After comparing the Carolina Bays with craters that were known to have been caused by meteorite impacts, most geologists now believe that the Carolina Bays were not caused this manner. An alternate possibility is that impacts related to comets or cometary fragments striking the earth may have been responsible. Because comets are almost entirely composed of frozen gases, there would be no fragments left behind to find.

The currently preferred theory hypothesizes a terrestrial origin for these Bays. Natural depressions in the Coastal Plain caused circular lakes to form [However, this theory does not explain what caused the 'natural depressions']. The prevailing winds over a lengthy period elongated the lakes into their present elliptical basin shapes. The winds also caused sand to be deposited on the perimeter of the Bays with the greatest amount deposited on the southeastern rim where the wind velocity decreased. This occurred before heavy vegetation covered the Bays. One piece of evidence that

substantiates this theory is that radioactive Carbon-14 dating indicates the Bays are not all the same age. These ages vary from 6,000 to 60,000 years, although other estimates suggest the Bays are much older. Using the terrestrial origin of circular depressions, coupled with prevailing winds, the Bays could very well have been formed over a long span of time.

Carolina Bays have characteristic soil assemblages that reflect the very moist conditions and which can be distinguished readily from each other and from surrounding soil types on aerial photographs. On most aerial photography, whether black & white, true color, or infrared false-color, wet soil generally appears darker due to the greater accumulations of darker organic matter. Note, however, that when winter cover crops have been planted, wetter soils usually support more vigorous plant growth and appear a deeper red or pink on infrared photographs than drier soils. Soil scientists consider factors such as landscape position, shades of bare soil, types of vegetation growing on the soil, and water drainage patterns when defining a soil type. Three distinct soil types are usually found in most of the larger Carolina Bays. While named differently in different states, they can be generically described as follows:

RICH BOGGY ORGANIC SOIL

This is often the dominant soil in large Bays, and it is also found in the center of smaller ones. Due to the lack of oxygen caused by water saturation, which slows decomposition, this soil is almost entirely composed of organic matter. Soil microbes need oxygen to break down the leaves and other plant litter that fall to the soil surface. Over the years, an organic rich "A" horizon layer accumulates that is several feet thick. This soil appears dark in most aerial photos. While some pine trees grow in it, they cannot compete well with the better adapted more prolific deciduous vegetation. When drained, it becomes a highly productive agricultural soil.

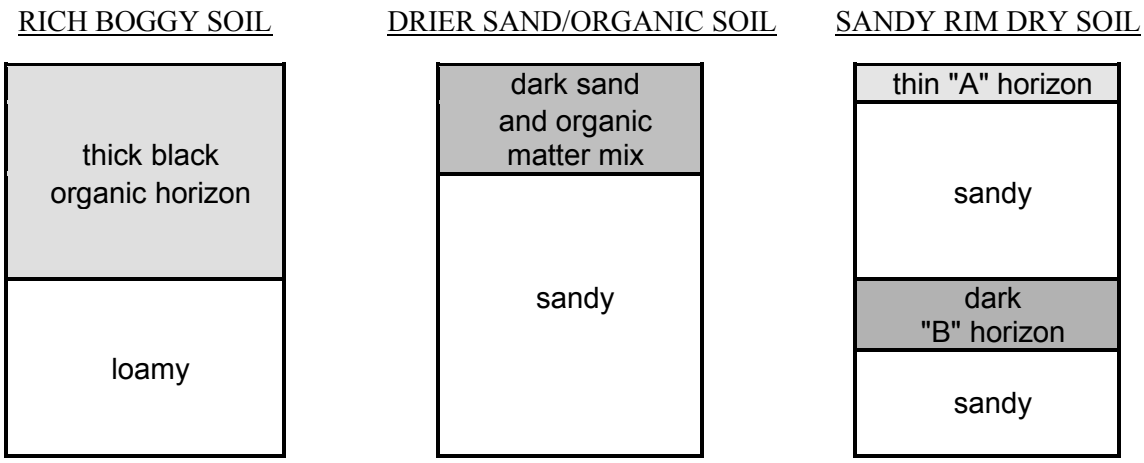
DRIER MIX OF SAND AND ORGANIC MATTER SOIL

This soil is found along the boundaries of large Bays and occupies most or all of the area of smaller Bays. It is slightly higher in elevation than the boggy soils and is therefore slightly drier. It also has a high organic matter content but also contains a lot of sand. It more easily supports loblolly pine trees and also forms productive agricultural land when drained. The land appears dark in most aerial photos, but not as dark as the boggy soil. In infrared aerial photos (taken in winter), the drier soils will appear much redder than the other types due to the abundance of evergreen trees such as pines.

SANDY RIM DRY SOIL

This soil is sometimes found on the sandy rims of Carolina Bays. It is rather unusual in that its subsurface "B" horizon layer is full of organic acids combined with aluminum ions that were leached from overlying horizons. While the surface color can be bright and appear almost white, the color of the "B" horizon layer is often brown or black, like topsoil, but it is found about four feet below the soil surface. For several reasons, including acidity and possible aluminum toxicity, this is not a good soil for plant growth and is only sparsely covered by scrubby pines, blackjack oak, and turkey oak. It appears very light in most aerial photos due to the high sand content and its dryness.

Figure 8C-2: Typical Carolina Bay Soil Types



Like most distinctive landform features, Carolina Bays have been described extensively in both scientific and popular literature. It is interesting to compare the style of writing used in both types of publications as the different accounts are intended for very different target audiences. Here are two examples.

Objective (Scientific) Description of Carolina Bays
--excerpted from an article in *Science* magazine by L.C. Glenn--

Having noted on a surveyor's map several lake-like expanses at the head of some very small stream, I began inquiries and visited several of the largest. The term bay is applied and by it is meant a perfectly flat, clayey area with a surface some two to four feet below the general level of the country and varying from a few acres in size to stretches a mile or two long and a half mile or more in width; the smaller ones being much more numerous and having usually an area of 20 to 30 acres. A few are approximately round in shape, though most are usually ovoid or elliptical, and are covered with vegetation-stained water from a few inches to a foot deep according to the season. Growing in the water, where the bay is uncleared, are cypress, juniper or black-gum trees with a moderately thick swamp undergrowth.

Subjective (Popular) Description of Carolina Bays
--excerpted from an article in *South Carolina Wildlife* written by Glenn Oeland--

From the air they look like impressions made in the earth's surface by a giant egg, ovals of dark greenery surrounded by patchworks of tilled farmland. The Bays are a wetland oasis supporting a rich variety of plants and animals. About one-third of the bay is covered by a watery prairie of **marsh** grasses and water lilies, a sunny environment preferred by alligators and wading birds. The larger portion of the bay is a dense swamp forest of cypress and tupelo gum trees, a shaded realm inhabited by water snakes, wood ducks, and barred owls. The dense thicket of evergreen bay trees swells right to the edge of the swamp, but there it comes to an abrupt halt. Sporadic openings in the green vegetative curtain provide an intimate glimpse of the swamp at its wildest, a chance to experience one of nature's genuine mysteries.

Land Use and Environmental Issues

In 1765, the Pennsylvania botanist John Bartram wrote of seeing "bay swamps" in South Carolina. He reported that local Native American fishermen utilized the buckeye tree's branches and leaves to make a highly effective fish narcotic used to stun fish before catching them. They also used the seeds of the buckeye trees for making eyes for the deer masks they wore while stalking deer. In these and many other ways, Native Americans made extensive use of these **wetlands** and their diversified biological productivity without changing them in any significant way.

Once Europeans arrived, the rich organic soils that underlie most Carolina Bays attracted large numbers of farmers and led them to ditch and drain the Bays in order to convert them to agriculture. Once a ditch is dug through a Bay, water will seep out of the surrounding soil, under the influence of gravity, to seek a lower elevation. Of course the ditch must cut through the rim of the Bay to empty into a lower elevation stream that then will carry the water out of the area. Eventually the Bay will dry out enough so that the soil can be plowed and crops can be planted. Once the standing water is removed and the water table is lowered, the organic rich soils respond by producing abundant crops. The shallow water table also helps to prevent crops from drying out during summer droughts.

A similar procedure was followed to provide access for loggers to harvest the valuable hardwood timber that grew in the center of many Carolina Bays. The large stands of valuable cypress trees were normally inaccessible to large-scale lumbering operations in the 1800's and early 1900's due to the swampy surroundings. Later on, lumber companies would try to ditch and drain a Bay when possible, then build plank roads over the spongy landscape. After cutting the timber, the logs were dragged out of the Bay by horses or mules, or later by tractors. Some Bays still show the scars of the ditching and the paths of tramways even after decades of restoration efforts.

Carolina Bays are the dominant freshwater wetland feature of the Coastal Plain. But not all Bays provide the exact same **habitat** conditions. Some Bays are wet all of the time, supplied by springs, producing a bog-like ecosystem with its associated unique mix of plant and animal species. These Bays maintain an acidic environment with very low oxygen levels. Various species of blueberries, wild azaleas, hollies, loblolly bays, pond pines, and abundant vines and briers thrive in those unique habitat characteristics. Some wet Bays also contain rare insectivorous plants such as the Venus fly trap, pitcher plant, and sundew. In turn, this lush vegetation has attracted various species of wildlife, ranging from the small tiger salamanders and tree frogs, to much larger bobcats and alligators. The thick underbrush also offers a safe haven to deer. Other Bays are dry much of the time providing a more grassy savanna-like habitat. Rare plant species are also found in drier Bays. Examples include mock bishop's weed, quill-leaf, rose coreopsis, and spoonflower. Higher areas around the sand rims provide habitats for turkey oak, longleaf pine, blueberry and holly.

In 1936, through a federally financed work program, the National Park Service bought portions of the land surrounding Singletary Lake for a recreational demonstration

project. Both Singletary Lake and nearby Bay Tree Lake have been preserved as natural areas by the state of North Carolina. Nearby Black Creek Bay is an example of a bay that was ditched and drained and is now used for agriculture. The swamps associated with many Carolina Bays were fearsome places for many of the local tenant farmers, who passed down tales of strange happenings in the woods, especially at night. One such tale involves several sightings of a 'Lizard Man' who would roam through the Bays and devour anyone caught in the swamp at night.

Another Sighting of Lizard Man

--excerpted from an article in *The Greenville Piedmont* newspaper, July 1988--

A County sheriff's deputy and a Highway Patrol trooper say their experience responding to a report of a Bigfoot sighting before daylight Sunday left them convinced that "something is out there." They believe that whatever is out there watched as they stepped out of their car to examine garbage strewn onto a dirt road near the Swamp. They also examined a broken tree limb dangling about 9 feet overhead before they got back in the car, drove down the road and turned around.

When they returned to the site, the officers said, they found that something had walked across their tire tracks, leaving a fresh set of the three-toed, 14-by-7 inch prints before it entered the woods. Trooper Mike Hodge, a former marine who has been with the patrol for 1 ½ years, said, "If a prankster were out there and the law pulled up, they would have gotten out of there."

But County Sheriff Liston Truesdale, skeptical to the core, said he believes the tracks were a prankster's work, designed to keep the Lizard Man mania alive. "Whoever did it sure did a convincing job," Truesdale said with a chuckle. "They were just some weird tracks," said Hodge. "They were too consistent to be fake. They were deep down in that hard dirt." "I stomped in the road, and I couldn't make a track," Deputy Wayne Atkinson said. "I put my foot in the track and I'm 6-foot, 3 ½ inches tall and I lacked touching that limb by about 3 feet."

Truesdale seems to be growing weary of the Lizard Man, described as a red-eyed, tall, green creature by a local youth, but Deputy Atkinson says, "I'll be back, you can bet on that. I'm going to stay on it until I find out what's out here. If it is a prankster, I've got one thing to say: He'd better cut it short."

Activity 8C-1: Anatomy of a Carolina Bay

POWER THINKING EXERCISE - "Dating Dilemma"

You are an Assistant Park Ranger at Singletary Lake State Park in the Bladen Lakes area of North Carolina. One of the campers at the park has asked you if all the Carolina Bays in the park are the same age. You hadn't heard that particular question before, so you tell the camper that you will investigate and then get back to them with an answer.

There are three Carolina Bays that are part of Singletary Lake Park. Locate Singletary Lake on both the Bladen Lakes topographic map on MAP 8C, CAROLINA BAYS and the Bladen Lakes NHAP photograph on IMAGE 8C, CAROLINA BAYS. Singletary Lake is located in the bottom-center portion of the map. Also locate the two smaller, un-named Carolina Bays just east of Singletary Lake (the Carolina Bay margins are marked by curved dashed lines on the map).

You don't have time to sample organic-rich soil from each Bay to send off for Carbon-14 testing (the camper would be long gone by the time you got the test results back), so you will have to look for clues on the map and the photo. Examine the geometry of each Carolina Bay to help determine which Bay is the oldest and which is the youngest. Be prepared to explain your reasoning to the camper.

Materials
MAP 8C, CAROLINA BAYS
IMAGE 8C, CAROLINA BAYS
Story: "Objective (Scientific) Description of Carolina Bays" on Page 8C-9
Story: "Subjective (Popular) Description of Carolina Bays" on page 8C-9
Wipe-off Pens

PERFORMANCE TASKS

(Icon Key) Overview = ✈; Science = ☼; Math = 💻; History = 🕮; Language Arts = ✍

1. **Investigate physical properties of Carolina Bays. ✈**
   Locate the following Carolina Bays on the Bladen Lakes topographic map on MAP 8C, CAROLINA BAYS. Gather the requested data and fill in the Index Chart below. Note that unaltered Carolina Bays will appear as oval depressions indicated by curved dashed lines marking the boundaries. Bays that have been altered for logging or agriculture may appear more irregular in shape. Measure the length (in feet) of the long axis of each Bay and record the compass direction (orientation) of the long axis of each Bay. Also indicate land use by analyzing if the Bay has been disturbed or not.

   #1 = White Lake (near center of map)
   #2 = Singletary Lake (lower-center of map)
   #3 = Cotton Head Bay (just south of White Lake)
   #4 = Horsepen Bay (extreme upper-right corner of map)
   #5 = Bay Tree Lake (extreme upper-right corner of map)
   #6 = Black Creek Bay (just south of Bay Tree Lake)

CAROLINA BAY INDEX

NUMBER OF BAY	LENGTH OF LONG AXIS (IN FEET)	DIRECTION (COMPASS ORIENTATION OF LONG AXIS)	TYPE OF LAND USE
1			
2			
3			
4			
5			
6			

Which variables are nearly the same for all Bays? Which variables are different from Bay to Bay? Explain why you think those similarities or differences exist.

2. **Determine elevation of water table in Bays.** ☼

Locate White Lake, Singletary Lake, and Bay Tree Lake on the Bladen Lakes topographic map on MAP 8C, CAROLINA BAYS. Use contour line information to determine the approximate elevation of the water surface in each lake. Also determine the approximate elevation of the highest point on the rim of each Bay. Finally, determine the location (if there is one) at which water exits each lake.

What does this information tell you about the elevation of the Ground Water Table in this region? What is the approximate ground elevation in Colly Swamp (runs north to south across the map east of White Lake)? Can you determine the direction of ground water flow from this data? Explain your answer. Which Bay has the highest rim?

3. **Estimate surface area of elliptical Carolina Bay.** 💻

Most Carolina Bays have an elliptical geometric shape. Of the several Bays shown on the Bladen Lakes topographic map on MAP 8C, CAROLINA BAYS, the most perfectly elliptical Bay seems to be Old House Bay (located in the lower-right corner of the map). There are several methods by which the area of a geometric shape, or a geographical region, can be calculated or estimated. Divide your class into groups and assign "method #1" to half of the groups and "method #2" to the other half.

METHOD #1

Use the mathematical formula for calculating the area of an ellipse [$\mathbf{A} = \pi \cdot \mathbf{a} \cdot \mathbf{b}$].

[**A** = area π = 'pi' [3.1416] **a** = ½ length of 'long' axis **b** = ½ length of short axis]
(measure 'long' and 'short' axes in feet; express 'area' in units of square feet)

METHOD #2

Estimate the area of the Bay using the Transparent Grid Overlay. Use the small squares on the Grid. Count the number of whole squares that correspond to the land surface, then add fractions of squares where appropriate. Refer to the scale bar on the map to find the information necessary to calculate the number of square miles in one square unit of the overlay. Report your final area estimate in units of square miles.

Which method is simplest? . . quickest? . . the most accurate? Explain your answers.

4. **Document land-use changes in Carolina Bays over time.** 🕮
   Locate Black Creek Bay on the Bladen Lakes topographic map on MAP 8C, CAROLINA BAYS (upper-right corner just below Bay Tree Lake). Now locate Black Creek Bay on all three photographs on IMAGE 8C, CAROLINA BAYS. Note that the Black & White photograph is dated 1972, the NHAP photograph is dated 1983, and the NALC satellite image is dated 1991. Identify any changes that have occurred in Black Creek Bay during that time interval. How many of these changes were due to human activity? How many of these changes occurred naturally?

5. **Compare objective and subjective descriptions of Carolina Bays.** ✍
   Read carefully through both articles printed on page 8C-9 that describe the features of Carolina Bays. One was written for a scientific journal, while the other was written for a more general audience. Both are describing the same Carolina Bays. What are the similarities and differences between the two styles of writing? What landform features are mentioned by both writers? Are the landscape features described the same way? Explain any differences in the authors' approaches.

   Select a local landform feature that you know well. Write two descriptions of this feature, one an objective scientific description, the other a more subjective description. Which one was easier for you to write? Why?

ENRICHMENT

(Icon Key) Overview = ✈; Science = ☼; Math = 💻; History = 🕮; Language Arts = ✍

1. **Research competing theories of Carolina Bay formation.** ☼
   The two most popular explanations for the origin of Carolina Bays are the comet impact theory and the theory that prevailing winds caused elongation of existing natural depressions. Use local library or internet resources to research these two theories and make a list of 'pros' and 'cons' for each. After considering your data, explain which theory you favor and why.

2. **Research rare and unusual plants found in Carolina Bays.** ☼
   Carolina Bays contain a variety of rare and/or endangered plants that thrive under the unusual bog-like acidic conditions that dominate the habitat. Examples include insectivorous plants like the Venus fly-trap, pitcher plant, and sundew, as well as other plants like bishop's weed, quill-lead, rose coreopsis, and spoonflower. Select one plant from this list and use local library or internet resources to research the environmental requirements of that plant. Explain how the Carolina Bay environment fits those requirements.

Activity 8C-2: Land Use and Environmental Issues

POWER THINKING EXERCISE - "Swamp Search"

A Hollywood motion picture studio has decided to do a re-make of the old monster movie Creature from the Black Lagoon using Singletary Lake State Park as their filming location. You are put in charge of the local arrangements, since the movie makers have never been to a Carolina Bay before and know nothing about real swamps. Use the Bladen Lakes topographic map on MAP 8C, CAROLINA BAYS and the Bladen Lakes aerial photograph on IMAGE 8C, CAROLINA BAYS to locate places the film crew will need to visit to get the right scenery for the following movie scenes:

Scene 1 - a dark, swampy, forested area where you can't even see the sky through the thick foliage

Scene 2 - an open water area where lots of sunlight gets through and you could film a small boat capsizing

Scene 3 - a wide, open, sandy area where the crew can build a bonfire safely so the actors can keep the monster away

Remember that for every actor you see in a movie there are many more workers behind the scenes running cameras, fixing lights, holding cue cards, preparing meals for crew and cast, and doing a variety of other tasks. For each scene, explain how you will get the entire film crew to the proper location, what problems you will encounter once you get there, and how you will overcome them.

Materials

MAP 8C, CAROLINA BAYS
IMAGE 8C, CAROLINA BAYS
Newspaper article: "Scientists Seek to Save Mysterious Depressions" on page 8C-1
Background Information on Soil Types, page 8C-8
Figure 8C-2, "Typical Carolina Bay Soil Types"
story, "Another Sighting of 'Lizard Man'," page 8C-11
Wipe-off Pens

PERFORMANCE TASKS

(Icon Key) Overview = ✈; Science = ☼; Math = 💻; History = 🕮; Language Arts = ✍

1. **Identify point-source and non point-source pollution in Bays. ✈**
   Locate White Lake, Singletary Lake, and Black Creek Bay on the Bladen Lakes topographic map on MAP 8C, CAROLINA BAYS. Briefly describe the major land use at each of these locations. What types of point-source pollution would you expect to find in each of these Bays? What types of non point-source pollution would you expect to find in each of these Bays? Explain how different land uses contribute to different types of environmental problems from pollution. Propose a local pollution abatement solution that would be best suited to each of the three locations.

2. **Trace boundaries of soil types in Carolina Bay. ☼**
Locate Cotton Head Bay (just south of White Lake) on both the Bladen Lakes topographic map on MAP 8C, CAROLINA BAYS and the Bladen Lakes aerial photograph on IMAGE 8C, CAROLINA BAYS. Use the soil type descriptions given on page 8C-8 in the Background Information as well as the information provided in Figure 8C-2, "Typical Carolina Bay Soil Types". Examine closely the infrared aerial photograph of Cotton Head Bay and trace with a wipe-off pen the boundaries of the three soil types in and around that Bay. Be prepared to explain your reasoning.

3. **Construct line plot graph of Singletary Lake biota. 💻**
The ability to organize, summarize, and communicate numerical information is a necessary skill in many situations, especially science projects and science laboratory reports. You will often find data presented in charts or tables, but one of the most efficient and revealing presentations of data is in the form of a graph. One of the simplest types of graph is the line plot.

---
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

The table below summarizes the relative diversity of flora and fauna at Singletary Lake State Park. To visualize relative levels of diversity on a line plot, place markers or symbols on a horizontal line containing a scale of numbers. Since the smallest number in your data is 5, and the largest is 96, the scale might run from 0 to 100. Some estimation will be required in placing your markers or symbols on the line plot. Identify gaps, clusters, or outliers (a lone point far from others) in your plotted data.

BIOTA OF WOODS BAY STATE PARK		
GROUP	**VARIETIES**	**SYMBOL**
Trees	16	S
Scrubs	20	B
Herbs	25	A
Ferns	5	W
Mammals	6	O_1
Reptiles	15	D
Amphibians	10	O_2
Birds	96	Y

4. **Document environmental problems mentioned in news article. 🕮**
Read carefully the newspaper article on page 8C-1, "Scientists Seek to Save Mysterious Depressions." Summarize the land-use changes that are cited in this article as being potential problems for the long-term viability of these Carolina Bays. Study carefully several of the large bays visible on both the Bladen Lakes topographic map on MAP 8C, CAROLINA BAYS and on the Bladen Lakes aerial photograph on IMAGE 8C, CAROLINA BAYS and mark with a wipe-off pen all occurrences of the types of environmental problems noted in the article. Which Bays are most in danger? Which Bays are in the least amount of danger? Can you suggest any policy changes or government regulations that would slow the rate of destruction of these Bays?

5. **Suggest possible location for Lizard Man story.** ✍
   Read the story on page 8A-11 titled, "Another Sighting of 'Lizard Man'." Explain how the landforms mentioned in the story relate to the Carolina Bays environment. Identify on the Bladen Lakes aerial photograph on IMAGE 8C, CAROLINA BAYS a location where you think this story might have taken place. (You may also refer to the Bladen Lakes topographic map on MAP 8C, CAROLINA BAYS if needed),

   Using the same location, write another newspaper article related to a different 'Lizard Man' sighting, but date it far enough in either the future or the past so that you will have some changes to report. Choose an appropriate title (headline).

ENRICHMENT

(Icon Key) Overview = ✈; Science = ☼; Math = 💻; History = 🕮; Language Arts = ✍

1. **Use equation to describe the shape of Bay Tree Lake.** 💻
   The following equation is used to define an idealized ellipse:

$$1 = \frac{y^2}{a^2} + \frac{x^2}{b^2}$$

   Locate Bay Tree Lake on the Bladen Lakes topographic map on MAP 8C, CAROLINA BAYS. Draw a line lengthwise across the Bay so that it divides the Bay into equal halves. This line is called the major axis. Draw a line across the Bay perpendicular to the major axis, so that it divides the Bay into equal quarters. This line is called the minor axis. From the intersection of the major and minor axes, measure the distance (in feet) along the major axis to the edge of the Bay. This distance is "a" in the formula above, the semi-major axis. The measured distance (in feet) from the intersection of the axes along the minor axis to the edge of the Bay is "b" in the formula above, the semi-minor axis. Substitute these distance figures into the formula.

   Use the transparent grid overlay to identify several (x, y) coordinate pairs along the edge of the ellipse. Orient your grid so that the semi-major axis "a" corresponds to the "y" axis in your coordinate system, and use the intersection of the major and minor axes as the origin (0,0). Use the scale of the map to determine the x and y distances associated with these coordinate pairs. Substitute your x and y values into the formula above. How close is your calculated value to 1? The answer will be 1 if the Bay is an exact ellipse. How close to a perfect ellipse is Bay Tree Lake?

2. **Research logging practices in Carolina Bays.** 🕮
   Many Carolina Bays have been ditched and drained so logging operations could reach the valuable cypress wood near the center of the wetland. Use local library or internet resources to research logging operations in these difficult-to-reach locations. What alterations did the loggers have to make to the landscape to make logging possible?

THE GREENVILLE NEWS

January 13, 2002

Foreigners flock to River Delta to sing the blues

By Ron Grossman

Clarksdale, MS – It is about 17 miles from the room where Bessie Smith died to the grave of Sonny Boy Williamson, father of the blues harmonica. It would be hard to imagine a more obscure stretch of anonymous back roads.

Yet to devotees of America's musical heritage, this region, the cradle of the blues, is almost sacred. Fans of an art form that preserves the history of what it was like to be Black in America find their way here from halfway around the world. Looking for the abandoned country churchyard where Sonny Boy rests, they might hum his minor-key warning to a straying lover:

"You gotta treat me better or it gotta be your funeral and my trial." At the site of Bessie Smith's final hours, they may recall the Queen of the Blues' lament:

"I've lived a life but nothing I've gained / Each day I'm full of sorrow and pain."

Although Americans come too, the area is a year-round destination for Australians, Europeans, and Japanese who are mesmerized by the fact that the birthing place of the blues was one small section of the Mississippi River Delta.

Many pilgrims stay in the town of Clarksdale at the Riverside Hotel, run by proprietor Frank Ratliff, who likes to be known as "Rat." The Hotel originally served as the Black infirmary in an era when White institutions were off-limits. After World War II, Rat's late mother converted it into a boarding house, which became a hangout for local musicians. Rat's version of the story is that the blues as a musical form was largely worked out on the premises.

As for Sonny Boy's grave (he died in 1965), the monument displays evidence he hasn't been forgotten; half a dozen harmonicas share space with letters from fans.

RATIONALE

The Mississippi River was the major transportation route for the central part of North America during the period of exploration and settlement. As the river changed its course over and over again, a broad alluvial plain developed with very fertile soil deposited by the river during times of flood. Because of the rich soil and convenient river transportation, many plantations and towns were established along the river. The end of slavery and the associated Plantation Era after the Civil War did not change life very much for many of the small farmers in the region who then became sharecroppers on the same land. Many of these tenants later emigrated to northern cities to work in factories. This region is also known as the home of the 'blues', a style of Black music that eventually entered the mainstream.

The city of Vicksburg is located on bluffs along the Mississippi River at the southern tip of the "Delta." The bluffs made the city easy to defend and gave it protection from floods. During the Civil War, control of Vicksburg was a major goal of the Union. In 1863, Confederate troops withstood a 47-day siege before surrendering to General Ulysses S. Grant.

PERFORMANCE OBJECTIVES

1. Explain relationship between land use and topography in alluvial plain setting.
2. Predict locations of future meander bend cut-off events.
3. Determine sediment load of water by analyzing color differences on infrared images.
4. Construct topographic profile and analyze results.
5. Estimate radius of curvature of various meander bends.
6. Estimate area affected by flooding during the Great Flood of 1927.
7. Assess Union and Confederate battle strategies during Siege of Vicksburg.
8. Analyze the use of artificial levees to protect certain areas from flooding.
9. Express negative life experiences in blues song format.
10. Practice interviewing techniques and incorporate interviews into newspaper article.

SAMPLE ASSESSMENT RUBRICS

EXAMPLE #1 (relates to Performance Objective #2)

Give students a copy of the Yazoo Basin topographic map on MAP 8D, MISSISSIPPI RIVER ALLUVIAL PLAIN and ask them to circle a meander bend that is likely to experience a cut-off event in the near future. Also ask them to explain why they picked that particular meander bend. *Meander bends most likely to experience cut-offs are those with a horseshoe shape where the channels at the open end of the horseshoe are very close together. The best explanation is that fast moving flood waters will cause greater erosion along the outside bend of the meander and the sharper the bend, the greater the erosion. If the bends at the open ends of the horseshoe are very close to each other, it will not take much more erosion to cut completely through*.

A (level 4) – meander selection appropriate and explanation is clear and correct
B (level 3) – meander selection appropriate but explanation not completely clear
C (level 2) – meander selection appropriate but explanation not clear, or wrong; or selection is not the best even though explanation may be correct
D (level 1) – meander selection not appropriate and explanation not clear
F (level 0) – meander selection not appropriate and explanation wrong or missing

EXAMPLE #2 (relates to Performance Objective #7)

Give students a copy of Figure 8D-3, "Location of Grant's Canal, 1862" and ask them to list the three attempts by Union forces to defeat the Confederate city of Vicksburg and to state the result of each attempt. *Best answers are: Naval attack from river = unsuccessful; construct canal to bypass city = unsuccessful; attack by land (put city under siege) = successful.*

A (level 4) – three attempts listed and all results given correctly
B (level 3) – three attempts listed, but not all results are given correctly
C (level 2) – two attempts listed and results given correctly
D (level 1) – two attempts listed, only one result given correctly; or only one attempt listed with result given correctly or not
F (level 0) – no attempts listed

Cartographic Product Information

MAP 8D: Mississippi River Alluvial Plain

TITLE: YAZOO BASIN, MS (topographic map)
DATA SOURCE: Jackson USGS 1:250,000 Quadrangle
DATE: 1955 (photorevised 1973)
SCALE: 1:250,000 [1 inch ~ 4.75 miles] [1 cm ~ 3 kilometers]
OTHER IMPORTANT DATA:
- The contour interval of this map is 50 feet.
- On the flat alluvial floodplain, some dashed extra contour lines have been added.

POINTS OF SPECIAL INTEREST:
- The Mississippi River flows north to south in the western portion of the map.
- The city of Vicksburg is located in the lower-center of the map.
- The city of Yazoo City is located in the upper-right corner of the map.
- Vicksburg National Military Park is located a few miles northeast of Vicksburg.

OTHER FEATURES TO LOOK FOR:
- Small round circles south of Yazoo City represent oil wells.
- Numerous oxbow lakes and meander cut-offs occur in the flat alluvial plain.

TITLE: YAZOO CITY, MS (topographic map)
DATA SOURCE: Yazoo City USGS 1:24,000 Quadrangle
DATE: 1998 (provisional edition)
SCALE: 1:24,000 [1 inch = 2,000 feet] [1 cm ~ 250 meters]
OTHER IMPORTANT DATA:
- The contour interval of this map is 20 feet.

POINTS OF SPECIAL INTEREST:
- The city of Yazoo City is located along the right edge of the map.

OTHER FEATURES TO LOOK FOR:
- Blue area in center of map west of Yazoo City is a fish farm.
- Numerous oxbow lakes and meander cut-offs occur in the flat alluvial plain.

TITLE: VICKSBURG, MS (topographic map) and VICKSBURG PROFILE LINE
DATA SOURCE: Long Lake and Vicksburg West USGS 1:24,000 Quadrangles
DATE: 1962
SCALE: 1:24,000 [1 inch = 2,000 feet] [1 cm ~ 250 meters]
OTHER IMPORTANT DATA:
- The contour interval of this map is 20 feet.
- On the flat alluvial floodplain, some dashed extra contour lines have been added.
- The map has been turned sideways to fit (north is to the left).

POINTS OF SPECIAL INTEREST:
- Grant's Canal is located in the lower-right corner area of the map.
- The city of Vicksburg is located along the top boundary of the map.

OTHER FEATURES TO LOOK FOR:
- The Vicksburg Profile Line runs east to west along the right edge of the map.

Cartographic Product Information

IMAGE 8D: Mississippi River Alluvial Plain

TITLE: YAZOO BASIN, MS (NALC [satellite image])
DATA SOURCE: EPA and USGS NALC Pathfinder WRS2 Path 23 Rows 37 and 38
DATE: 1992 (Row 37) and 1991 (Row 38)
SCALE: 1:250,000 [1 inch ~ 4.75 miles] [1 cm ~ 3 kilometers]
OTHER IMPORTANT DATA:
- This image is a false-color infrared image, so all true colors have been shifted.
- This is a summer image, with leaves on trees, so forested areas look red.
- Clear water is black on an infrared image; water with sediment is milky-blue.

POINTS OF SPECIAL INTEREST:
- The Mississippi River flows north to south in the western portion of the image.
- The city of Vicksburg is located in the lower-center of the image.
- The city of Yazoo City is located in the upper-right corner of the image.

OTHER FEATURES TO LOOK FOR:
- Numerous oxbow lakes and meander cut-offs occur in the flat alluvial plain.

TITLE: VICKSBURG, MS (NAPP [infrared aerial photograph])
DATA SOURCE: NAPP CIR Photograph 10804-30
DATE: 1998
SCALE: 1:24,000 [1 inch = 2,000 feet] [1 cm ~ 250 meters]
OTHER IMPORTANT DATA:
- This image is a false-color infrared photo, so all true colors have been shifted.
- This is a summer image, with leaves on trees, so forested areas look red.
- Clear water is black on an infrared image; water with sediment is milky-blue.

POINTS OF SPECIAL INTEREST:
- The city of Vicksburg is located along the right side of the photograph.

OTHER FEATURES TO LOOK FOR:
- Several of the cut-offs shown on this photograph were artificially constructed.

TITLE: GEOLOGIC MAP OF MISSISSIPPI and GEOLOGIC CROSS SECTION
DATA SOURCE: Mississippi Geological Survey [cross-section by Alvin R. Bicker, Jr.]
DATE: 1969 (geologic map) and 1970 (cross-section)
SCALE: 1:250,000 [1 inch ~ 21 miles] [1 cm ~ 13.2 kilometers]
OTHER IMPORTANT DATA:
- This colors on the cross-section do not match the colors on the map or the legend.
- On the geologic map, the distribution of loess covers several different rock units.
- The Richton Salt Dome on the cross-section is not shown on the geologic map.

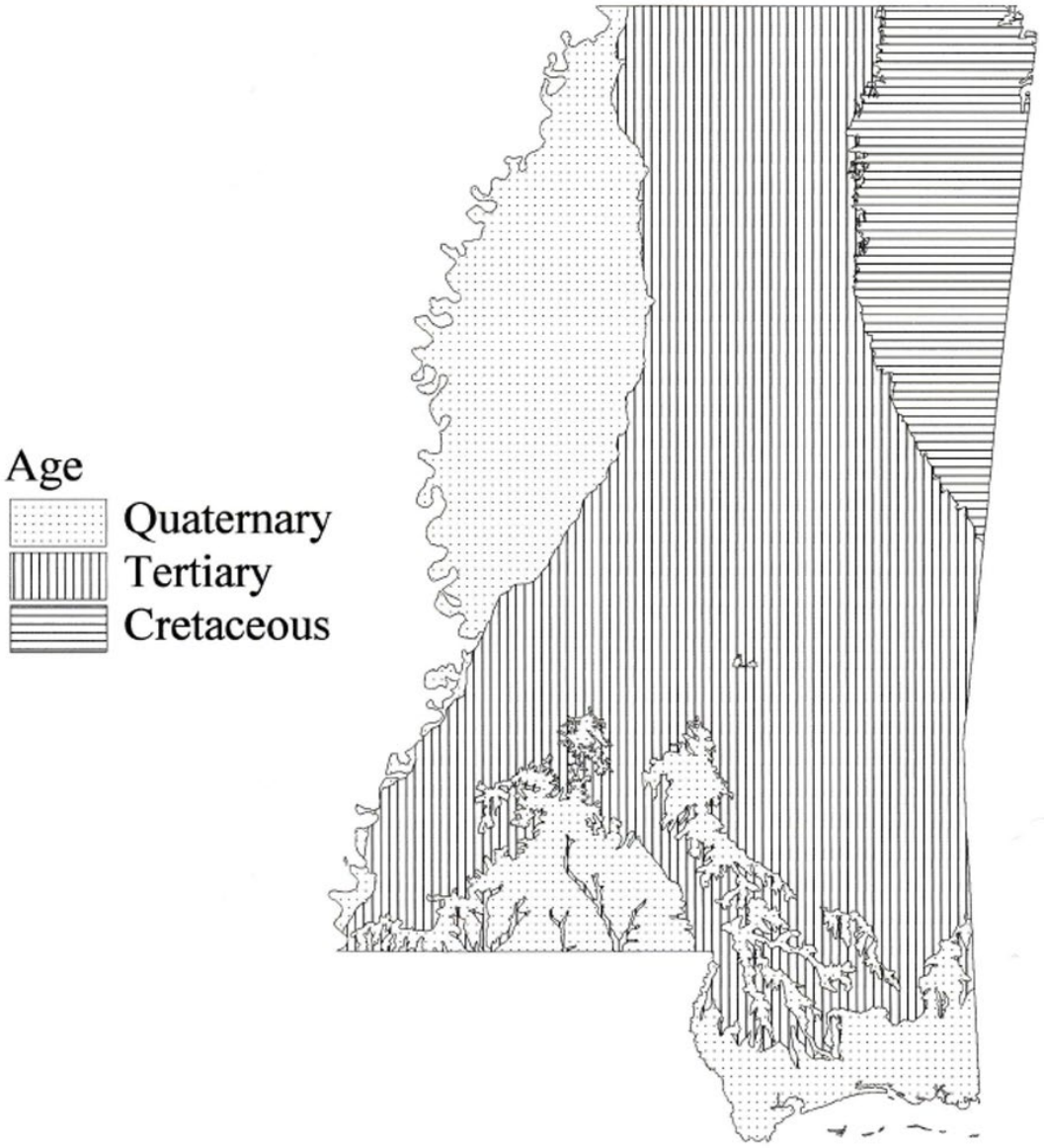
POINTS OF SPECIAL INTEREST:
- The Black Warrior Basin (on cross-section) produces abundant coal, oil and gas.

OTHER FEATURES TO LOOK FOR:
- Coastal Plain geologic units are older to north & east; younger to south & west.

Geology and Geography

At the end of the Paleozoic Era plate tectonic movements caused the continents of Africa and North America to collide, resulting in the creation of the Appalachian Mountains that reached heights similar to today's Himalayan Mountains. Early in the Mesozoic Era, continental rifting split North America and Africa into separate continents that then moved away from each other as the Atlantic Ocean opened. The Coastal Plain, including the Mississippi Embayment, which today contains the Mississippi River and its alluvial plain, and the Gulf of Mexico also began forming at this time.

Figure 8D-1: Ages of Coastal Plain Sediments in Mississippi



Most of Mississippi is underlain by Mesozoic and Cenozoic sediments that were eroded from the Appalachian Mountains and then deposited in the Embayment. A small area of Paleozoic sedimentary rocks, that is not part of the Coastal Plain region, is also present in the extreme northeastern corner of the state. Shallow seas covered the region during most of this time. The position of the shoreline moved back and forth many times so that the sediments that were deposited alternated between sand, gravel, silt, clay, and limestone. Cretaceous and Tertiary sedimentary rock layers tend to outcrop in curved patterns decreasing in age away from the northeastern part of the state closest to the Appalachian Mountains. Quaternary sediment records the most recent geologic history of Mississippi. These sediments were primarily brought in through the Mississippi River system and deposited on top of the pre-existing geologic layers after Mississippi finally emerged from the sea.

During the Pleistocene Ice ages sea level was lowered significantly and the Mississippi River became entrenched into the Tertiary and Cretaceous sediments at a level more than 100 feet (30 meters) below the present land surface. As sea level rose again, at the end of the Ice ages, the entrenched channels filled with sediment and built up the present-day alluvial plain.

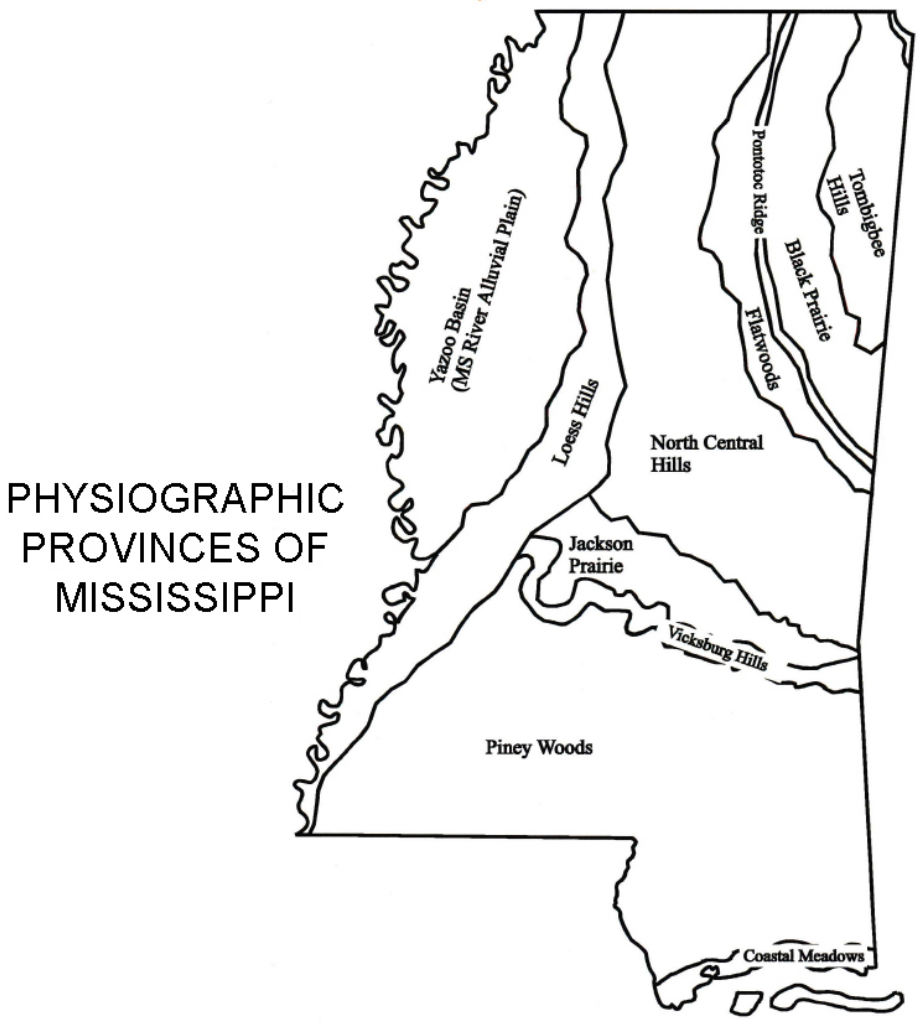
Even as deposition continued at the surface of the Mississippi River embayment, the rate of land subsidence was not the same everywhere in the Coastal Plain. Continuing tectonic activity in the area resulted in differential subsidence of the earth's crust causing some parts of the region to receive significantly thicker deposits of sediment than other parts. The Black Warrior Basin represents one such area of much greater subsidence. Stretching from the Alabama border almost to the Mississippi River, this basin has accumulated nearly 25,000 feet of sediment and contains vast resources of oil and gas as well as important coal reserves. One major oil field is located near Yazoo City.

Two types of recent sediments dominate the Mississippi River Alluvial Plain. Sediments deposited by the Mississippi River and its tributaries form a broad undulating plain adjacent to the river. These sediments, mostly sand, gravel, and silt, were spread out over a large area as the rivers migrated back and forth across their floodplains. Whenever these rivers did flood, the coarser sediments dropped out first, forming natural levees along the river banks. Finer grained sediment could be carried farther from the river channel where its deposits helped to build up the floodplain and enrich the soil. Because of the meandering pattern of most rivers in the alluvial plain, features such as oxbow lakes, point bars, and meander cut-offs are very common.

The second important Quaternary sediment type found in this region is loess, a type of windblown silt that covers the older sediments along a band adjacent to the eastern margin of the Mississippi River Alluvial Plain. Following the last Ice Age, about twenty thousand years ago, much of the northern reaches of the Mississippi drainage basin had been stripped of vegetation, so there was nothing left to stop the prevailing winds from picking up huge amounts of glacial silt that had been left behind when the ice retreated. Much of that sediment ended up in the Mississippi River and was carried away to the Gulf of Mexico, but even more was transported by huge dust storms and deposited

across the Midwest and along the eastern edge of the Mississippi Alluvial Plain. Loess deposits are composed of angular fragments of quartz, feldspar, and other mineral grains that are sometimes cemented by a type of calcium carbonate similar to chalk. The soil color is typically yellowish-gray. Although very porous and easily eroded, the compacted deposits often form steep, nearly vertical faces, without slumping, and eventually weather to form extremely fertile soils.

Figure 8D-2: Location of Loess Hills Bordering Alluvial Plain



Agriculture, River Management, and the Blues

The Mississippi River is one of the major rivers of the world. Its drainage basin covers all or part of 31 states and two Canadian provinces. The name itself, 'Mississippi,' is derived from a Native American term for "Father of Rivers." European explorers and settlers followed the Mississippi River to what is now the central region of the United States and beyond, founding settlements that eventually made it possible for the United States to expand its territory all the way to the Pacific Ocean. The economic development

of this entire region was based on having the Mississippi River as a transportation route for agricultural and industrial products.

But the Mississippi River was not always cooperative. An entire fleet of riverboats and barges was needed to transport cotton and other commodities up and down the river, but an abundance of fallen trees, shoals and sand bars required knowledgeable pilots who were familiar with the river. Skilled riverboat pilots were in great demand as they either knew or could sense how to navigate the ever changing maze of obstacles, an especially challenging task after major floods had shifted the main channel, washed trees and other debris into the river, or cut off old, familiar meander bends completely.

Cotton has always been a major crop in Mississippi. The highest acreage ever recorded was in 1930 when over 4 million acres of cotton were planted and over 2 million bales were produced. Surprisingly, the first cotton plantings in the 1700s into the early 1800s were not very successful. But the development of a Mexican hybrid seed around 1930 improved crop yield tremendously and Mississippi soon became the nation's top cotton-producing state. The high profitability of cotton created enormous population growth in the years before the Civil War. In 1800, the White population of the Mississippi Territory was only about 5,000 (and this included the territory of Alabama). By 1860, the White population had swelled to over 350,000 and the slave population increased even more, to 440,000.

The Civil War devastated Mississippi's cotton growers. Many plantations lay in physical ruin and the loss of the slave labor force made it nearly impossible to turn a profit. The answer here, as in many other areas of the South, was the sharecropping system. Former slaves entered into annual lease contracts with landowners by which they agreed to work the fields all year long for a small share of the profits come harvest time. Poor Whites found themselves in a similar situation when mounting debts forced them to sell off their small farms to large landholders. Landlords often demanded that sharecroppers grow almost nothing but cotton. The sharecropping system effectively ended when a mechanical cotton-picking machine was developed by International Harvester Company in 1947. Within twenty years, nearly all Mississippi's sharecropping farmers were put out of business. Many headed north to seek employment in factories.

The portion of the Mississippi River Alluvial Plain in northwest Mississippi has traditionally been called the "Delta" but should not be confused with the actual modern delta of the Mississippi River forming today where the river enters the Gulf of Mexico. This "Delta" stretches from Vicksburg, Mississippi to Memphis, Tennessee, and is the self-described "Home of the Blues." This type of music originated in the Black communities of Mississippi from roots in African musical traditions, African-American work songs, and spirituals. It has been described as music that expresses a wide range of emotions and musical styles. "Feeling blue" is conveyed in songs that complain about injustice, lost love, and in general a longing for a better life. But some Blues music is more upbeat and can celebrate pleasure and success. Many Black musicians left the fields of Mississippi to seek their fortunes in the bars and music halls of cities like Memphis. Others migrated to northern cities like Chicago and became famous there.

The pattern of drainage within the "Delta" (technically the Yazoo Basin) is generally southward, but can be very convoluted, reflecting the influence of a complex topography dominated by abandoned meander belts of the Mississippi River. Prior to construction of modern levees, major Mississippi River floods would have inundated most or all of the Yazoo Basin periodically. However, the levees that prevent Mississippi River overbank flooding do not solve the flooding problem completely. High water stages on the Mississippi River still block the drainage of tributary streams and backs up those waters until they flood. The construction of levees is part of an attempt by civil engineers to stabilize the main channel of the Mississippi River. However, the higher the levees are built, the higher the river level will rise until the main channel of the river is higher in elevation than the surrounding floodplain. If storm waters manage to break through these levees, truly catastrophic flooding can result.

The Great Mississippi Flood of 1927

--excerpted from a report published by the National Weather Service--

The Great Mississippi Flood of 1927 actually began in August 1926 and the waters did not completely recede until August 1927. This was the most destructive flood in United States history. At one point the Mississippi River was nearly 80 miles wide near Vicksburg, MS. The primary cause of the flooding was an unprecedented amount of heavy rainfall across the Central U.S. that seemed to last for months. As runoff waters from different tributaries combined, water levels overwhelmed the levees protecting the Mississippi Valley floodplains. In Mississippi, the worst flooding occurred on April 21, 1927 when the Mounds Landing levee broke north of the city of Greenville. In only ten days, one million acres of land across the Mississippi Delta Region were immersed under water at least 10 feet deep.

The Federal government coordinated efforts to rescue 330,000 people from rooftops and other high places. Large numbers of African American field workers were left stranded on the intact portions of the levees. White planters were concerned that if these workers were relocated, they might never return to work the fields. In fact, many Blacks did take the opportunity to escape to northern cities like Chicago, bringing their stories of the misery of the flood to enrich the traditions of blues music.

Property damage was estimated at 350 million dollars (equal to more than 5 billion dollars today). Total economic losses were equivalent to almost one-third of the Federal budget at the time. Out of this catastrophe was born the Flood Control Act of 1928, which gave the Federal government full authority over the containment of the Mississippi River and its tributaries.

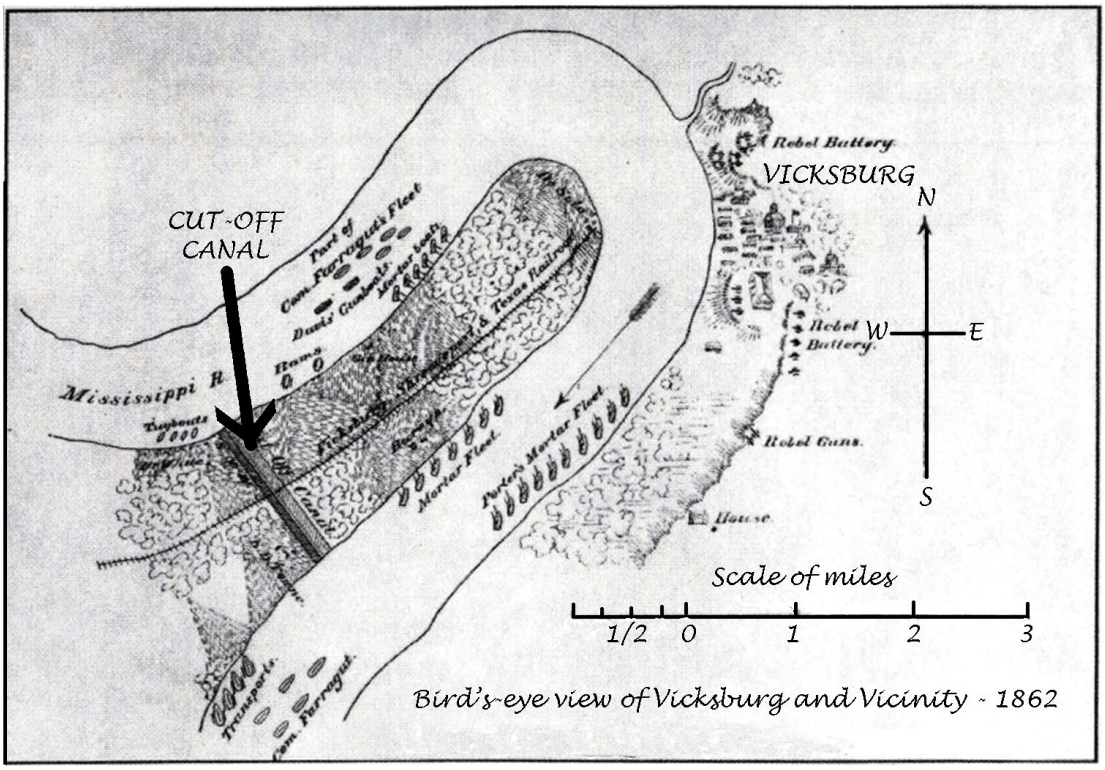
Vicksburg and the Civil War

The geologic setting of Vicksburg played a critical role in the western front of the Civil War. In 1862, Vicksburg was located on a meander loop of the Mississippi River. The city was located on high bluffs overlooking the river. Union ships had to travel past

Vicksburg's cannons to sail from New Orleans to Memphis and other cities further north. Several attempts by the Union Navy to defeat Vicksburg from the river failed.

A plan was devised to construct a canal across the neck of the river meander. If this project had succeeded, the movement of water through the canal would have caused a cutoff to occur and the Mississippi River would no longer actually flow past the city and port of Vicksburg and would leave the city literally high and dry. Two attempts were made, the first under the command of Brig. Gen. Thomas Williams, and the second under the direction of General Ulysses S. Grant. Both attempts failed but the first one came very close to succeeding. A 3,000-man infantry brigade, supplemented by over 1,000 slaves conscripted from nearby plantations, managed to excavate the canal to a depth of 13 feet and a width of 18 feet. However diseases such as dysentery, malaria, and various fevers, along with heat exhaustion and sun stroke, soon overwhelmed the work force and construction was halted. During this time, the water level in the Mississippi River kept dropping to a near record low. When Grant revived the project several months later, the workers encountered rising river levels that broke through the dam at the head of the canal, and flooded the canal. The floodwaters brought in so much sediment that the canal filled up faster than the workers could dig it out.

Figure 8D-3: Location of Grant's Canal, 1862

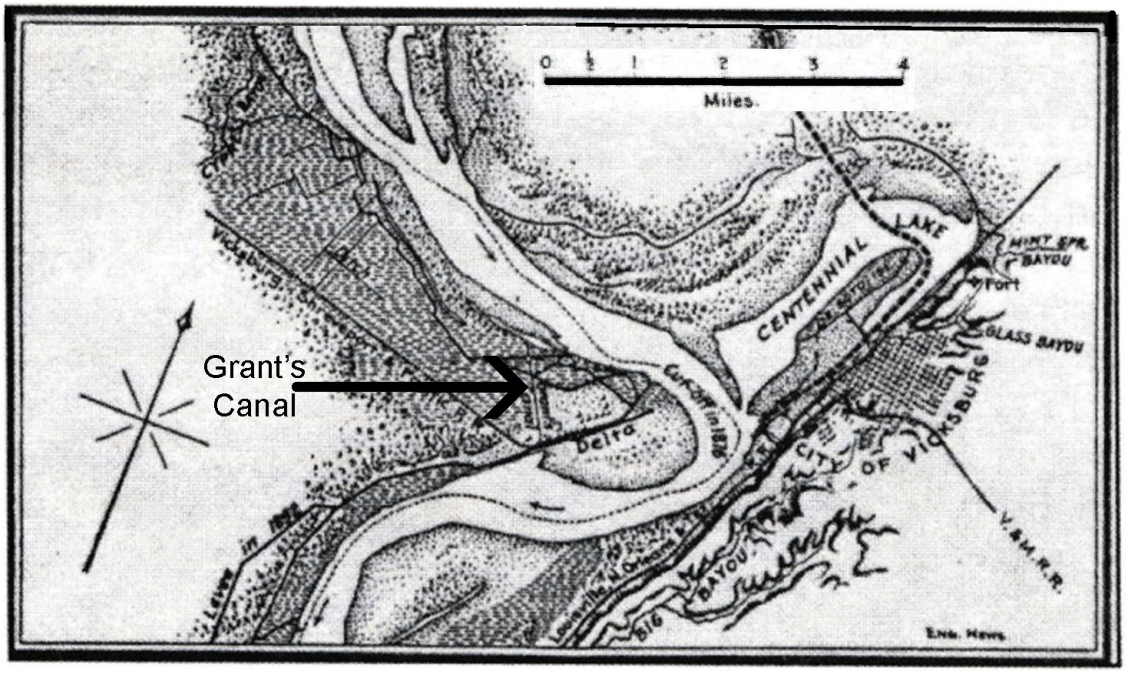


After the failure of Grant's Canal, the only alternative left was an attack by land. The siege of Vicksburg that followed was one of the major turning points in the Civil war. The bluffs at Vicksburg were composed of loess deposits, which can be excavated easily but are nevertheless capable of holding up steep slopes. The Union army was able

to dig protective entrenchments in the loess. The citizens of Vicksburg also dug caves that served as "bomb shelters" during the siege. The source of drinking water for Vicksburg came from surface streams flowing into the city from the east, where the Union army had its encampment. One of the tools used by the Union army to break the siege was to contaminate the stream water after it flowed past their own encampment but before it reached the Confederate army and citizens of Vicksburg.

Ironically, in 1876, during the presidency of General Grant, a natural cutoff of the Mississippi River meander at Vicksburg occurred near the location of the failed canal. The city was cut off from river access until 1903 when an artificial channel was constructed by the U.S. Army Corps of Engineers to divert the Yazoo River to Vicksburg to provide a flow of water from the abandoned meander to the Mississippi River.

Figure 8D-4: Location of Natural Cut-off, 1883



Activity 8D-1: Geology and Geography

POWER THINKING EXERCISE - "Concealed Connection"

While examining the Geologic Map of the State of Mississippi on IMAGE 8D, MISSISSIPPI RIVER ALLUVIAL PLAIN you notice that the outcrop patterns of the various Coastal Plain formations seem to all run roughly parallel to each other, forming different colored stripes on the map. But you also notice that the brown, yellow, and red rock units seem to run up against the purple layer (alluvium) and just end there. You recall that alluvial deposits are formed from sediments that were laid down by rivers as they meandered across a floodplain. You also recall that the Mississippi River system flows through an area known as the Mississippi Embayment that has experienced long-term tectonic subsidence. The strange patterns on the map arouse your curiosity and you start to wonder what rocks might actually be hiding under the alluvial deposits that have covered them up.

The Geologic Cross Section of Eastern Mississippi, also found on IMAGE 8D, provides some more information about the connections of the Cretaceous and Tertiary age sedimentary units to each other, but it is constructed from data on the eastern side of the state so it won't be of much direct help in answering your question.

Use some logical reasoning to speculate how the outcrop pattern of the brown and yellow rock units might extend underneath the alluvial cover. Use a wipe-off pen to draw your presumed contact lines between these formations onto the Geologic Map. Be prepared to explain your reasoning.

Materials
MAP 8D, MISSISSIPPI RIVER ALLUVIAL PLAIN
IMAGE 8D, MISSISSIPPI RIVER ALLUVIAL PLAIN
story "Life on the Mississippi" page 8-15
Drawing compass
Wipe-off Pens

PERFORMANCE TASKS

(Icon Key) Overview = ✈; Science = ☼; Math = 💻; History = 🕮; Language Arts = ✍

1. **Trace loess deposition pattern on Geologic Map. ✈**
   Study the Geologic Map and legend on IMAGE 8D, MISSISSIPPI RIVER ALLUVIAL PLAIN and locate the deposits of loess. Briefly describe how loess is formed and how it ended up where it did. Use a wipe-off pen to outline this region on the Geologic Map. Why are the loess deposits not assigned their own separate color? Why do the loess deposits end at the boundary with the purple colored alluvial deposits? Why do you think the eastern edge of the loess region is located where it is? Be prepared to explain your answers by making references to the origin and properties of loess.

2. **Explain why oil field is located near Yazoo City. ☼**
   Locate the Black Warrior Basin on the Geologic Cross Section of Eastern Mississippi on IMAGE 8D, MISSISSIPPI RIVER ALLUVIAL PLAIN. Recall that the Black Warrior Basin contains large quantities of oil and gas deposits in the deeply buried Paleozoic sedimentary rocks. Measure the distance from the NORTH end of the cross-section to the spot immediately over the deepest part of the Black Warrior Basin. Measure that same distance along the cross-section line drawn on the Geologic Map and mark an "X" with a wipe-off pen at that location. Now measure that same distance, starting from the top of the map, along the eastern edge of the purple colored 'alluvium' region. Mark a "Y" with a wipe-off pen at that location.

   Your mark "Y" should be either in or very close to Yazoo County (county names are listed on the geologic map). Refer to the Yazoo Basin topographic map on MAP 8D, MISSISSIPPI RIVER ALLUVIAL PLAIN and locate the oil field 15 miles south of Yazoo City (near upper-right corner of map). Oil wells are indicated by small black circles. Do you think there is any connection between the oil and gas in the Black Warrior Basin and the oil field near Yazoo City? Explain your answer. Why do you think the oil wells were drilled at this location and not farther east?

3. **Estimate radius of curvature of meander bends. 💻**
   Select any six meander bends on the Yazoo Basin topographic map on MAP 8D, MISSISSIPPI RIVER ALLUVIAL PLAIN. The meander bends can be part of active river systems or they can be part of oxbow lakes that have been cut off from the main river channel. At the location of each meander, place a drawing compass so that the 'point arm' of the compass is situated near the center of the land inside the meander bend and the 'pencil arm' of the compass is free to trace the path of the meander channel. Using trial and error, find the location of the point arm that gives the pencil arm the best fit tracing of the actual meander channel. Use the scale bar on the map to measure the distance between the 'point arm' and the 'pencil arm' of the compass. That distance is defined as the 'radius of curvature' for that particular meander.

   When you have recorded your six 'radius of curvature' values, calculate an average and compare your average with that of other groups. Would you expect all meanders to have a similar 'radius of curvature'? Explain your reasoning.

4. **Explain features associated with fish farms. 🕮**
   Locate the two large, irregularly shaped blue areas on the Yazoo City topographic map on MAP 8D, MISSISSIPPI RIVER ALLUVIAL PLAIN. Note the features associated with these facilities that are labeled as "wells" and "levees." A small label, in blue letters, on the right side of the larger blue area, identifies this feature as a 'fish farm.' Explain why this particular location was chosen for the fish farm. Also explain why levees and wells are needed for such an operation.

5. **Identify location where story could have taken place. ✍**
   Read through the story "Life on the Mississippi" on page 8-15 and pay close attention to all of the landscape references used by the author. Follow the course of the

Mississippi River from north to south on both the Yazoo Basin topographic map on MAP 8D, MISSISSIPPI RIVER ALLUVIAL PLAIN and the Yazoo Basin satellite image on IMAGE 8D, MISSISSIPPI RIVER ALLUVIAL PLAIN. Locate a specific place along the river channel where you think the events of the story might have taken place. List all the geographic elements of the story that can be found at this site.

ENRICHMENT

(Icon Key) Overview = ✈; Science = ☼; Math = 💻; History = 🕮; Language Arts = ✍

1. **Research major meander cut-offs along Mississippi River.** 🕮
   Use local library or internet resources to research several of the major meander cut-off events that have occurred on the Mississippi River in the last 100 years. Are there certain periods during this time interval when cut-offs occurred more frequently or less frequently than usual? Are there specific causes associated with major events or do they occur randomly? Are there certain regions along the Mississippi River that experience more events than other regions?

2. **Investigate resources found in Black Warrior Basin.** ☼
   The Black Warrior Basin in Mississippi and Alabama is one of the major oil and gas producing areas in the South. Use local library or internet resources to investigate the nature and extent of the oil fields. What specific geologic formations hold the most oil and gas? How deep do wells have to be drilled to reach these layers? What methods are used to retrieve the oil and gas from the wells? How is the oil transported to refineries?

Activity 8D-2: Agriculture, River Management, and the Blues

POWER THINKING EXERCISE - "Cut-off Countdown"

You are living along the Big Sunflower River near the town of Holly Bluff (located in upper-center of Yazoo Basin topographic map on MAP 8D, MISSISSIPPI RIVER ALLUVIAL PLAIN). You are part owner in a souvenir shop in the town of Waltersville (located in lower-center of Yazoo Basin topographic map just north of Vicksburg) that fronts on the Yazoo River. You make the round trip from Holly Bluff to Waltersville once every week by boat. A few years ago, a major meander cut-off occurred just northwest of Waltersville and shortened your boat trip by five minutes. You know that such meander cut-offs are frequent occurrences in this region and can't wait to see the next one so you can trim more time off your long commute.

Use a wipe-off pen to trace your commuting route down the Big Sunflower River to its junction with the Yazoo River, and then continue to follow the Yazoo River until you get to Waltersville. Examine all of the meander bends that you encounter along this route. Where do you think the next cut-off event will occur? Mark this location on the map with a wipe-off pen. How long do you think it will take for the river to cut through the meander? Is there anything you could do to make it happen faster? Explain your answers.

Materials
MAP 8D, MISSISSIPPI RIVER ALLUVIAL PLAIN
IMAGE 8D, MISSISSIPPI RIVER ALLUVIAL PLAIN
Newspaper article: "Foreigners flock to River Delta to sing the blues," page 8D-1
Story: "The Great Mississippi Flood of 1927," page 8D-9
Wipe-off Pens

PERFORMANCE TASKS

(Icon Key) Overview = ✈; Science = ☼; Math = 💻; History = 🕮; Language Arts = ✍

1. **Explain distribution of land uses in relation to topography. ✈**
   Examine the distribution of agricultural fields, roadways and communities on the Yazoo Basin satellite image on IMAGE 8D, MISSISSIPPI RIVER ALLUVIAL PLAIN. Also reference the Yazoo Basin topographic map on MAP 8D, MISSISSIPPI RIVER ALLUVIAL PLAIN to get more specific information about the relationships between these locations and the regional topography. In general terms, describe the topographic conditions that favor human habitation and agriculture. Also in general terms, describe the topography of the areas that have been left in their natural state. Why do most of the more developed areas of land use seem to lie along major rivers?

2. **Speculate about reasons for artificial cut-offs. ☼**
   Locate the Yazoo River and the city of Yazoo City on the Yazoo City topographic map on MAP 8D, MISSISSIPPI RIVER ALLUVIAL PLAIN. Note that in 1953, the Jonestown Cut-off was constructed with elevated levees on either side. This new channel completely cut off the old meander bend that used to go through the city of

Yazoo City. The old channel is still there, but filled with a disconnected series of linear ponds. Why would the city want to lose its direct access to the river? Speculate about the pros and cons of constructing the artificial channel. Note that close to the midpoint of the artificial channel is an area labeled "Yazoo Co Port." Why would the city want to move its port facilities to the Jonestown Cut-off?

3. **Estimate areal extent of Great Flood of 1927.** 💻
Read through the story, "The Great Mississippi Flood of 1927" on page 8D-9. Mention is made that during the height of the flood, the Mississippi River near Vicksburg was nearly 80 miles wide. Locate Vicksburg on the Yazoo Basin topographic map on MAP 8D, MISSISSIPPI RIVER ALLUVIAL PLAIN (in lower-center of map) and also locate Yazoo City (in upper-right corner of same map). About halfway between Vicksburg and Yazoo City is the town of Germania on the eastern edge of the alluvial plain. If the Mississippi River was 80 miles wide at this point, approximately how much of the land area on this map would the water have covered? Express your estimate as a percentage.

   The flood account also mentions that the water was at least 10 feet deep everywhere on the floodplain. If we assume that the elevation of most of the low areas was between 75 and 80 feet, then the floodwater level could have easily approached 100 feet above sea level. Land areas above 100 feet would not be flooded, which is why the African-American field workers could find safety on the levees. Trace with a wipe-off pen every 100-foot contour line that you can find on the map and describe the general location of those higher-elevation land areas.

4. **Explain effect of meander cut-offs on state boundary lines.** 🕮
The Mississippi/Louisiana state border follows the Mississippi River from top to bottom on the Yazoo Basin topographic map on MAP 8D, MISSISSIPPI RIVER ALLUVIAL PLAIN. Unfortunately, whenever a meander bend is cut off, the boundary does not change. Locate two oxbow lakes, Eagle Lake and Albemarle Lake, (in the left-center portion of map) and note that the state boundary line still follows the abandoned channels. Trace this boundary line with a wipe-off pen. Explain some of the problems that can arise because boundary lines are no longer in the channel of the Mississippi River where they belong. Also explain why the state legislatures of Mississippi and Louisiana do not shift the boundary lines every time a new meander cut-off occurs on the river.

5. **Interview survivors of Great Flood of 1927.** ✍
Divide your class into groups of four. Read through the account of "The Great Mississippi Flood of 1927" on page 8D-9. Select one person to be the interviewer and the other three people to fill the following roles: A Black field worker; a White planter; and a government official. The interviewer should ask questions of each person to get their perspective on the flood and take notes on their answers. Focus on the personal impact of the flood on the life of the person being interviewed. The entire group should then help write an article suitable for publication in a newspaper.

ENRICHMENT

(Icon Key) Overview = ✈; Science = ☼; Math = 💻; History = 🕮; Language Arts = ✍

1. **Research blues musicians mentioned in newspaper article.** 🕮
   Read the newspaper article "Foreigners flock to River Delta to sing the blues" on page 8D-1. Write down the names of all the blues musicians referenced in the article. Select one of these persons and research their life history. Use local library or internet resources to find additional information. Did the person you chose stay in Mississippi their entire life or move to a northern city like Chicago? Look up the lyrics to one or more of their most famous songs or performances.

2. **Investigate engineering criteria for building levees.** 💻 ☼
   Most rivers in the Mississippi River Alluvial Plain, including the Mississippi River, were bounded originally by natural levees. However, once the alluvial plan was settled, additional artificial levees were constructed to keep out the floodwaters that threatened the area several times each year. Use local library or internet resources to answer questions such as:
   - What earth materials (or other materials) are levees usually made of?
   - How high above normal river level are levees usually built?
   - How wide are most levees at their top?
   - How far do levees need to extend downriver without any breaks?
   - Why are roads often built on top of levees?

Activity 8D-3: Vicksburg and the Civil War

POWER THINKING EXERCISE - "Logical Location"

You have been hired by a group of French fur traders to construct a military outpost near the location of the present-day city of Vicksburg in the early 1800s. They report being ambushed many times by Native American warriors as they sailed around the big meander bend at this site. When you arrive at the designated location, you notice that a series of high bluffs run all along the eastern bank of the Mississippi River. Assume that Figure 8D-3, "Location of Grant's Canal, 1862" accurately maps the position of the meander bend and the location of the loess bluffs in the early 1800s.

You are considering two possible locations to construct your fort. The first is along the outer bend of the meander near the site labeled "Rebel Battery" on the map. The other possibility is further south along a straight section of the river channel. Both locations are situated on top of the loess bluffs at equal heights above the river. Which location will you choose? List advantages and disadvantages of each site and defend your decision.

Materials
MAP 8D, MISSISSIPPI RIVER ALLUVIAL PLAIN
IMAGE 8D, MISSISSIPPI RIVER ALLUVIAL PLAIN
Background information on Grant's Canal: page 8D-10
Figure 8D-3: Location of Grant's Canal, 1862
Wipe-off Pens

PERFORMANCE TASKS

(Icon Key) Overview = ✈; Science = ☼; Math = 💻; History = 🕮; Language Arts = ✍

1. **Compare Union and Confederate positions at Vicksburg Battle. ✈**
   Refer to Figure 8D-3, "Location of Grant's Canal, 1862," and the Vicksburg topographic map on MAP 8D, MISSISSIPPI RIVER ALLUVIAL PLAIN, to locate the positions of the Union and Confederate forces before the siege of Vicksburg began during the Civil War. The Union army first tried to assault the city from the river. Why was this not a good idea? What topographic features favored the Confederate army? After the failure of Grant's Canal, the Union army finally attacked by land from the east and kept the city under siege for six weeks until the city finally surrendered. Union troops reportedly contaminated the streams flowing into Vickburg that provided drinking water for the city. Identify the most likely streams on the topographic map that would have been used for this attack.

2. **Draw topographic profile and relate to Battle of Vicksburg. ☼**
   Use the Vicksburg Profile Line on the bottom of MAP 8D, MISSISSIPPI RIVER ALLUVIAL PLAIN to construct a topographic profile across the Mississippi River. Place the edge of a piece of paper along the straight line located in the center of the Profile Line map (make sure the paper is long enough to cover the entire length of the profile line). Draw a vertical axis perpendicular to the edge of the paper and mark it

off in equal increments of 10 feet, starting with 70 and ending with 250. Record the elevation of every contour line that crosses the profile line as a dot on your graph. Then connect the dots to complete your topographic profile.

What is the highest point along your profile line? Where is it located? Based on your profile data, explain why a direct assault on the city from the river side would have been extremely difficult, dangerous, and unsuccessful.

3. **Compare shortcut of Grant's Canal with natural cut-off of 1876.** 💻
On the Vicksburg topographic map on MAP 8D, MISSISSIPPI RIVER ALLUVIAL PLAIN, trace, with a wipe-off pen, the route of the Mississippi River as it flowed in 1862. Reference Figure 8D-3, "Location of Grant's Canal, 1862" to see this route. With a different color wipe-off pen, trace the route that boats could have taken using Grant's Canal (assuming that it would have been completed). With a third color wipe-off pen, grace the current route of the Mississippi River through the natural cut-off that occurred in 1876.

   Place a piece of string along each of your three traced lines and measure the length of each route (be sure you begin and end at the same point for all three lines). Which shortcut would have been the shortest? How much time do you think a boat would save by taking that shortcut? Explain how you arrived at your answer.

4. **Compare sediment load of Yazoo and Mississippi Rivers.** 🕮
Locate the Mississippi River and the Yazoo River Diversion Canal on the Vicksburg topographic map on MAP 8D, MISSISSIPPI RIVER ALLUVIAL PLAIN and also on the Vicksburg infrared aerial photograph on IMAGE 8D, MISSISSIPPI RIVER ALLUVIAL PLAIN. Note that the water in the river is a different color than the water in the diversion canal. Which of these waterways is carrying the most sediment? Explain your reasoning. Is this answer what your would have predicted? Do you think you would see the same result if you examined dozens of other infrared aerial photographs taken at different times during the year? What is the source of this sediment? Note that the water in Centennial Lake is the same color as the water in the Diversion Canal. How can you explain this fact considering the two bodies of water are not connected at all? Also note that the water from the Diversion Canal does not immediately mix with the water in the Mississippi River. Speculate about why mixing does not occur here.

5. **Express emotions about digging a canal in a blues song format.** ✍
Read the paragraph about the digging of Grant's Canal in the background information provided on page 8D-10. Note that the workers, both soldiers and conscripted slaves, were exposed to many diseases, including heat exhaustion, in addition to the already hard manual labor of digging the canal with only hand tools. In this environment, singing the blues would be a natural thing to do. Imagine yourself as a conscripted slave, both tired out and sick at the end of the workday, complaining about their troubles by composing a short blues song or poem. Either recite your poem to the class or put it to music and perform the song with instrumental accompaniment.

ENRICHMENT

(Icon Key) Overview = ✈; Science = ☼; Math = 💻; History = 🕮; Language Arts = ✍

1. **Explain why Yazoo River Diversion Canal was built. 🕮**
   Locate the Yazoo River Diversion Canal on the Vicksburg topographic map on MAP 8D, MISSISSIPPI RIVER ALLUVIAL PLAIN. This massive engineering project diverted water from the Yazoo River through the city of Vicksburg after the Centennial Cut-off left the city without access to the Mississippi River. Use local library or internet resources to discover why it was so important for Vicksburg to regain water access to the river. How many years did it take to complete the project? How much did the project cost?

2. **Research Siege of Vicksburg. 🕮**
   Use local library or internet resources to research the Siege of Vicksburg in 1862. Identify the military leaders who were involved and summarize the battle tactics that were used by both sides. Identify where specific battles took place and locate as many of these places as you can on the Vicksburg topographic map on MAP 8D, MISSISSIPPI RIVER ALLUVIAL PLAIN. Locate the streams that were the source of drinking water for the city and investigate how the Union forces were able to contaminate the water. What was the response of the citizens of Vicksburg when the Union forces prevailed and the city surrendered?