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THE TIMES-PICAYUNE

In Harm's Way

Part 1 of a Series

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Water is never far from New Orleanians. Just outside the city, saltwater intrusion is destroying marshes, including this one near the Bayou Bienvenue-Florida Avenue Canal between New Orleans and St. Bernard Parish. Now that cypress trees and other vegetation have died, erosion will accelerate, further stripping the region of its natural protections against hurricanes.

(PHOTO BY ELLIS LUCIA / The Times-Picayune)

It's only a matter of time before south Louisiana takes a direct hit from a major hurricane. Billions have been spent to protect us, but we grow more vulnerable every day.

INSIDE PART 1

IN HARM'S WAY

With the land around us constantly sinking, our natural storm protection is disappearing. Levees protect us, but they're not enough.

GOING UNDER

GRAPHIC SPECIAL: What would have happened if Hurricane Georges hadn't turned aside at the last moment?

LAST LINE OF DEFENSE

GRAPHIC SPECIAL: Computer models show that even storms weaker than Category 3 could break through the levees.

NUMBERS GAME

GRAPHIC SPECIAL: Each year the world's tropical waters spawn more than 50 cyclonic storms. History says we're due.

NATURE'S ULTIMATE WEAPON

GRAPHIC SPECIAL: A look inside the formation and power engine of the hurricane.

LAST ISLAND'S WALTZ

A few years before the Civil War, wealthy vacationers waltzed the night away as a hellish storm churned toward them.

WRITTEN OFF

A hurricane levee is intended to protect much of southeast Louisiana, but will leave a number of communities to face the flood outside the walls.

STORM REMINDERS

A mass grave marks the small island overcome by a hurricane.

EVOLVING DANGER

The risk is growing greater, and no one can say how much greater

THREATENING SKIES

GRAPHIC SPECIAL: The 12 most notable storms to hit Louisiana

NATURE INTERRUPTED

GRAPHIC SPECIAL: The geological history of southeastern Louisiana, and the natural and man-made assaults on the marshlands that protect us.



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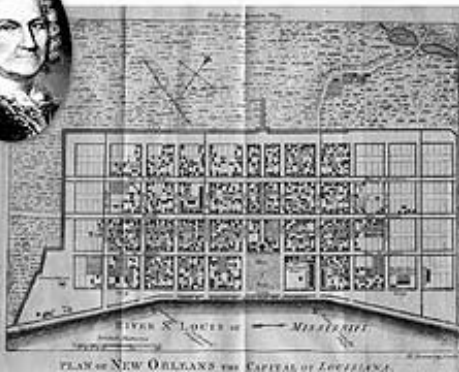
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FATEFUL DECISION:

Nearly 300 years ago, Jean Baptiste le Moyne, sieur de Bienville, settled along a strip of land between the Mississippi River and the marshes south of Lake Pontchartrain. While the location would prove ideal for commerce, it left the city vulnerable to hurricanes and flooding.

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IN HARM'S WAY

By John McQuaid and Mark Schleifstein
Staff writers

On the night of Aug. 10, 1856, a powerful hurricane struck Last Island off the southern tip of Terrebonne Parish. The sea rose in the darkness and trapped hundreds of summer vacationers visiting the popular resort. Wind-driven waves 8 feet high raked the island and tore it in two.

By morning, everything standing upright was broken, splintered and washed away, including all of the island's trees, its casinos, a hotel and the summer homes of wealthy New Orleans families. More than 200 people died. Many were crushed and others drowned after being struck by wreckage in the maelstrom.

LAST ISLAND'S WALTZ

As hotel guests waltzed away the night, gale winds began whipping outside. The next morning, the guests awoke to a hellish fury.
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Claire Rose Champagne's great-great-grandmother Amelie Voisin and a baby daughter were among those lost in the storm. Other family members survived and eventually abandoned Last Island — today the Isles Dernieres archipelago — for Dulac, a fishing village 30 miles inland up Bayou Grand Caillou. But there was no escape from the storms, which have followed the family inland over five generations.

In 1909, Champagne's fisherman grandfather was out at sea when another hurricane lashed the Louisiana coast with 110-mph winds that propelled a 10-foot wave of water through Dulac.

"My grandmother and (her) children were left at home and saved themselves by climbing into the attic of the house," she said. "Forty people tied ropes to the house and to two oak trees, then all stayed in the attic — women and children and some men. After the hurricane the government sent some tents for people to live in." Her grandfather made it back alive, but about 350 people along the coast died in the storm.

Hurricanes are a common heritage for Louisiana residents, who until the past few decades had little choice in facing a hurricane but to ride it out and pray.

Today, billions of dollars worth of levees, sea walls, pumping systems and satellite hurricane tracking provide a comforting safety margin that has saved thousands of lives.

But modern technology and engineering mask an alarming fact: In the generations since those storms menaced Champagne's ancestors, south Louisiana has been growing more vulnerable to hurricanes, not less.

Sinking land and chronic coastal erosion — in part the unintended byproducts of flood-protection efforts — have opened dangerous new avenues for even relatively weak hurricanes and tropical storms to assault areas well inland.

"There's no doubt about it," said Windell Curole, general manager of the South Lafourche Levee District, who maintains a hurricane levee that encircles Bayou Lafourche from Larose to the southern tip of Golden Meadow. "The biggest factor in hurricane risk is land loss. The Gulf of Mexico is, in effect, probably 20 miles closer to us than it was in 1965 when Hurricane Betsy hit."

These trends are the source of a complex and growing threat to everyone living in south Louisiana and to the regional economy and culture:

- The combination of sinking land and rising seas has put the Mississippi River delta as much as 3 feet lower relative to sea level than it was a century ago, and the process continues. That means hurricane floods driven inland from the Gulf have risen by corresponding amounts. Storms that once would not have had much impact can now be devastating events, and flooding penetrates to places where it rarely occurred before. The problem also is slowly eroding levee protection, cutting off evacuation routes sooner and putting dozens of communities and valuable infrastructure at risk of being wiped off the map.
- Coastal erosion has shaved barrier islands to slivers and turned marshland to open water, opening the way for hurricane winds and flooding to move inland. Hurricanes draw their strength from the sea, so they quickly weaken and begin to dissipate when they make landfall. Hurricanes moving over fragmenting marshes toward the New Orleans area can retain more strength, and their winds and large waves pack more speed and destructive power.
- Though protected by levees designed to withstand the most common storms, New Orleans is surrounded by water and is well below sea level

at many points. A flood from a powerful hurricane can get trapped for weeks inside the levee system. Emergency officials concede that many of the structures in the area, including newer high-rise buildings, would not survive the winds of a major storm.

- The large size of the area at risk also makes it difficult to evacuate the million or more people who live in the area, putting tens of thousands of people at risk of dying even with improved forecasting and warnings. The American Red Cross will not put emergency shelters in the area because it does not want to put volunteers or evacuees in danger.
- The Army Corps of Engineers says the chance of New Orleans-area levees being topped is remote, but admits the estimate is based on 40-year-old calculations. An independent analysis based on updated data and computer modeling done for The Times-Picayune suggests the risk to some areas, including St. Bernard and St. Charles parishes and eastern New Orleans, may be greater than the corps estimates. Corps officials say the agency is studying the problem with an updated model.

It all adds up to a daunting set of long-term economic, engineering and political challenges just to maintain the status quo. Higher levees, a massive coastal-restoration program and even a huge wall across New Orleans are all being proposed. Without extraordinary measures, key ports, oil and gas production, one of the nation's most important fisheries, the unique bayou culture, the historic French Quarter and more are at risk of being swept away in a catastrophic hurricane or worn down by smaller ones.

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WATER ALL AROUND US: BARRIER LINES - A floodwall divides Orleans Avenue from the Orleans Avenue Outfall Canal, one of the many drainage canals that channel storm water into Lake Pontchartrain. In a catastrophic storm, the lake would back up into the canals, giving the floodwaters a beeline straight into the heart of the city.
 (PHOTO BY ELLIS LUCIA / The Times-Picayune)

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'People here can't move'

Decades after her ancestors struggled to survive storms, Champagne finds herself reliving the past. For her and for many people, evacuations and hurricane floods have become regular events.

Three times in the past 17 years, she and her husband, Buddy, have endured storm surges that put water waist-deep or higher in their house across from Bayou Dularge in Theriot, more frequent flooding with higher water than had ever been seen in the area. Dispossessed for months at a time, they lost antique furniture and switched to plastic chairs. They

abandoned carpets for linoleum. Photo albums, trophies, even a nativity scene they kept on display in the house were all swept away — except for the baby Jesus recovered from the back yard.

For a while, Champagne organized her neighbors and attended public meetings with government officials to try to get more hurricane protection — before finally deciding to rely on prayer.

"One time a man from New York or Washington asked me where I was from, and I told him. He said, 'Lady, move away from there,'" she said. "That made me furious. We can't move. People here can't move. Everything we worked for and our ancestors worked for is here. We want to pass it on to our children."

The Mississippi River delta's flat, buckling geography makes it uniquely vulnerable to hurricanes, which destroy with wind, rain, tornadoes and a tidal wave known as storm surge. High winds account for most hurricane damage elsewhere. Louisiana is vulnerable to both winds and floods. When a giant storm surge hits the shallows near the shoreline, the only direction the water can move is up. Like water sloshing against the wall of a bathtub, a storm surge running into a steep, solid coast rises suddenly, then dissipates. Along a gradual slope like the Mississippi River delta's, the surge doesn't rise as high but can penetrate dozens of miles inland.

There currently is no defense against a surge from a major storm, a Category 4 or Category 5 hurricane on the Saffir-Simpson scale used by meteorologists. Such storms can generate surges of 20 to 30 feet above sea level — enough to top any levee in south Louisiana. Sustained winds from major storms — 131 mph to 155 mph for a Category 4, even more for a Category 5 — can shred homes and do damage to almost any structure.

Fortunately, such storms are relatively rare events. Hurricane Camille, which struck the Mississippi Gulf Coast in 1969, and an unnamed 1935 storm that hit the Florida Keys were the only Category 5 storms to strike the U.S. coast in the past century. Fifteen Category 4 hurricanes made landfall on U.S. soil during that time.

For lesser, more common storms, natural and man-made defenses exist, such as levees to keep out storm waters, and barrier islands and marshes also block and dampen storm surges.

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WATER ALL AROUND US: LAKE VIEWS - Along with the river, the 630-square-mile Lake Pontchartrain dominates the landscape of New Orleans. In the event of a hurricane, it also presents the dominant danger. Some hurricane experts fear that even a moderate hurricane could churn up the lake, causing a sloshing effect that would top the levee, leaving much of New Orleans under water, possibly for months. If the levee were topped, houses such as those near Lakeshore Drive between Canal and Wisner boulevards, could be completely underwater.

(PHOTO BY ELLIS LUCIA / The Times-Picayune)

Levees choke delta growth

The problem for south Louisiana is that the natural protections are rapidly deteriorating, and that in turn is weakening man-made defenses, mainly because the entire delta region is sinking into the Gulf of Mexico. The Louisiana coast resembles a bowl placed in a sink full of water. Push it down, or just tip it slightly, and water rushes in.

Inland areas now see deeper flooding more often from storms. Tropical Storm Frances pushed a 4.5-foot storm surge into St. Charles Parish in

1998, putting U.S. 90 under water for a week, for example. The coast's sinking profile has emergency managers fretting that low points will be cut off during an evacuation -- including Interstate 10, which drops 12 feet below sea level at the railroad underpass near the Jefferson Parish line.

"The big thing that has put coastal processes in fast forward here in Louisiana relative to other systems is the rapid sinking of the land, subsidence," Louisiana State University coastal geologist Greg Stone said. "That makes it a fascinating place. What takes centuries to millennia in another place, here is happening in a decade."

Sinking is largely a natural process: The earth deposited by the river crushes the soft soil below it, and abandoned delta areas slowly disappear under water. But humans have accelerated it. Ironically, flood-protection levees are one of the chief man-made causes of subsidence. When the corps started systematically leveeing the river in the 19th century, it cut off the region's main source of silt, the raw material of delta-building. The weight of large buildings and infrastructure and the leaching of water, oil and gas from beneath the surface across the region have also contributed to the problem.

The Mississippi River delta is subsiding faster than any other place in the nation. And while the land is sinking, sea level has been rising. In the past 100 years, land subsidence and sea-level rise have added several feet to all storm surges. That extra height puts affected areas under deeper water; it also means flooding from weaker storms and from the outer edges of powerful storms spreads over wider areas.

The marshes that ring New Orleans have sunk the quickest. "We live on a platform given us by the Mississippi River," Curole said. "But Yscloskey, New Orleans, all the way to western Terrebonne Parish, we're all in the same boat, and it's sinking."

The combination of sinking land and rising sea level has put the Mississippi River delta on average 2 feet lower relative to sea level than it was 60 years ago, according to studies by University of New Orleans geologists. According to data that UNO researchers gathered for The Times-Picayune, the marshes around Bayou Teche are more than 2 feet, 9 inches lower than they were in 1942. At Schooner Bayou to the west, the figure is more than 1 foot, 4 inches. The New Orleans lakefront has been comparatively lucky, sinking 5 inches in that time.

By 2100 the area will be an additional 3.2 feet below sea level, according to a paper analyzing future trends in sea-level rise and subsidence by scientists at the U.S. Geological Survey, the National Geodetic Survey and other agencies.

Most of the region's original settlements were built on a network of ridges that were relatively safe from flooding. Now they're going under.

"Areas near Shell Beach (in St. Bernard Parish) that didn't flood during (Category 5 Hurricane) Camille did flood during (Category 2 Hurricane) Georges," said University of New Orleans geologist Shea Penland. "The ridges had subsided, trees had died because of saltwater intrusion, and the wetlands are converting from a brackish marsh system to a fragmented salt marsh."

The owners of Campo Marina at Shell Beach have raised the dock and marina shed a total of 3 feet since it opened in 1960.

"Water started coming over the steps, so we raised it. Ten years later it came over the steps again and we raised it. And it still comes up," owner Ken Campo said.

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WATER ALL AROUND US: RIDING HIGH - The Mississippi River is currently about 15 feet above sea level, or about 2 to 5 feet above ground in the French Quarter and Algiers Point. Here, a cargo ship towers high above the river, its deck more than 120 feet above the water. (PHOTO BY ELLIS LUCIA / The Times-Picayune)

Models predict dire floods, erosion

Computer modeling shows how the threat of flooding has spread and deepened across a wide area. Using digitized maps of the delta landscape from the 1800s up to a projected map for 2020, Louisiana State University engineers Joseph Suhayda and Vibhas Aravamathan showed how flooding from a hypothetical storm got deeper and spread steadily westward and northward as erosion and subsidence took their toll.

Houma, dry in a 1930 simulation of a Category 3 hurricane, would be surrounded by water in the same storm in 2020. At the same time, flood levels are lower along the coast because there is no longer anything to block the water and cause it to build up; it all flows inland.

As the Mississippi delta sinks, the coastline grows ragged. Saltwater flows farther inland and kills sensitive plants that hold the marshes together. Human activities -- such as canal-building, drilling and dredging -- have sped up the fragmentation of marshes and worn down barrier islands.

Erosion has created a distinct set of problems. Unlike subsidence, erosion doesn't make flooding much deeper or worsen direct hits by major storms. But it has amplified the weaker storms and glancing blows by stronger ones because there is less marsh to slow the floodwaters and wind. Storms in turn tear up marshes and islands and accelerate the cycle of decay.

Marshes are a rough surface that produces drag on moving masses of water and wind, causing a storm-surge wave to lose energy and height and the wind to die down as they move inland. As the marsh disappears, so does the benefit.

Scientists working for the state Department of Natural Resources measured some of these effects during Hurricane Andrew in 1992. Andrew's surge height dropped from 9.3 feet at Cocodrie to 3.3 feet at the Houma Navigation Canal 23 miles to the north. For every mile of the marsh-and-water landscape it traversed, it lost 3.1 inches of height, sparing some homes farther north from more flooding.

Barrier islands are low-lying, eroding outcroppings of delta, but their role in storm surges looms large. Every extra mile of barrier beach and each vertical inch keeps some water from flowing inland during a storm. Even small changes in the islands' shape change the speed and height of storm surges, tides and wave action behind them.

LSU scientist Suhayda has done computer modeling that shows that if barrier islands had not been there during Hurricane Andrew, then Cocodrie would have seen an extra foot of water. If island heights were raised and inlet channels between them narrowed, the surge hitting Cocodrie would have been cut by as much as 4 to 5 feet.

The widening areas of open water across south Louisiana may even allow storms to retain more strength as they move inland, said Hugh Willoughby, director of NOAA's Hurricane Research Division in Miami, though scientists have not yet closely examined the issue.

One example of this phenomenon may have been Hurricane Danny, which made landfall at Grand Isle in 1995. "Hurricane Danny was a tropical storm over Grand Isle and then it intensified," said Curole of the Lafourche levee district. "You can't find a record of any storm or hurricane before that that intensified after it crossed a barrier island."

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WATER ALL AROUND US: ROOFTOP LEVEL - A 17-1/2-foot is all that separates lavish homes, such as this one between marconi and Wisner boulevards, from Lake Pontchartrain. Just beyond the levee, street level is about 6 feet below the surface of the lake.
(PHOTO BY ELLIS LUCIA / The Times-Picayune)

'We're still recovering'

The emerging new landscape of open water and levees ringing cities and towns is in some ways more dangerous than the old.

The risks vary dramatically depending on where you live. Communities outside federally built hurricane levees -- which protect New Orleans, East Jefferson and parts of St. Bernard, the West Bank and Lafourche Parish -- have little protection from storm surges, depending mostly on smaller levees likely to be topped.

Hurricanes have frayed these communities over the years. Many residents -- mainly younger people -- have moved north. In Dulac, every other block contains businesses that never reopened after Hurricane Andrew pushed a 10-foot flood through town in 1992: a shrimper's supply

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store, a branch office of the energy exploration company Unocal, Dwayne's barber shop.

On Orange Street, damaged homes and trailers sit shuttered, waiting for the next flood to claim them. "We're still recovering," resident Donald Lirette said. "These houses are rotting because of water, abandoned now. They turn them into crackhouses."

Inside levees, the threat is different.

If enough water from Lake Pontchartrain topped the levee system along its south shore, the result would be apocalyptic. Vast areas would be submerged for days or weeks until engineers dynamited the levees to let the water escape. Some places on the east bank of Orleans and Jefferson parishes are as low as 10 feet below sea level. Adding a 20-foot storm surge from a Category 4 or 5 storm would mean 30 feet of standing water.

Whoever remained in the city would be at grave risk. According to the American Red Cross, a likely death toll would be between 25,000 and 100,000 people, dwarfing estimated death tolls for other natural disasters and all but the most nightmarish potential terrorist attacks. Tens of thousands more would be stranded on rooftops and high ground, awaiting rescue that could take days or longer. They would face thirst, hunger and exposure to toxic chemicals.

"We don't know where the pipelines are, and you have the landfills, oil and gas facilities, abandoned brine pits, hardware stores, gas stations, the chemicals in our houses," said Ivor van Heerden, assistant director of the LSU Hurricane Center. "We have no idea what people will be exposed to. You're looking at the proverbial witch's brew of chemicals."

Scientists address the risk

These complex dangers have inspired some to come up with audacious plans to avert disaster. LSU scientist Suhayda, for example, proposes bisecting New Orleans and Jefferson Parish from east to west with a flood wall rising 30 feet above sea level starting at the foot of Esplanade Avenue, running toward Lake Pontchartrain and then across the city along the Interstate 610 corridor into Metairie. That would create a "community haven" on the river side of the wall where those left behind could retreat, and would protect buildings from floodwaters entering from the lake.

Only in the past few years have government agencies and political and community leaders mobilized to address rising storm risks from the sinking coast and the potential catastrophe in the New Orleans area. The Federal Emergency Management Agency is preparing a plan for the unprecedented response that would be needed if the New Orleans bowl were flooded. The corps has begun a study to look at whether the levees surrounding the New Orleans area should be raised high enough to prevent that scenario. Local scientists, politicians and some business leaders have forged a consensus that the region's best shot for long-term survival is a major effort to rebuild lost marshes and barrier islands. But it would cost at least \$14 billion.

The region remains on a precipice. The lucky record of near misses could continue -- or run out. Between 1909 to 1926, for example, three major hurricanes and two smaller storms hit south Louisiana. A series of smaller storms over a few seasons could devastate many towns. A single major

storm could cripple New Orleans.

"A legitimate question to ask is: Given this kind of catastrophe, given the city is on its knees, many of its historic structures have been destroyed, considering the massive influx of federal dollars that will be required, do you rebuild it" said Walter Maestri, Jefferson Parish emergency services director. "I don't know the answer to that. Especially since we're below sea level and it can happen again the next week.

"That's a question for the elected political leaders I work for," he said, recalling the founding of New Orleans in 1718 by Jean Baptiste le Moyne, sieur de Bienville. "Planners need to think about that: Do we repeat Bienville's mistake?"

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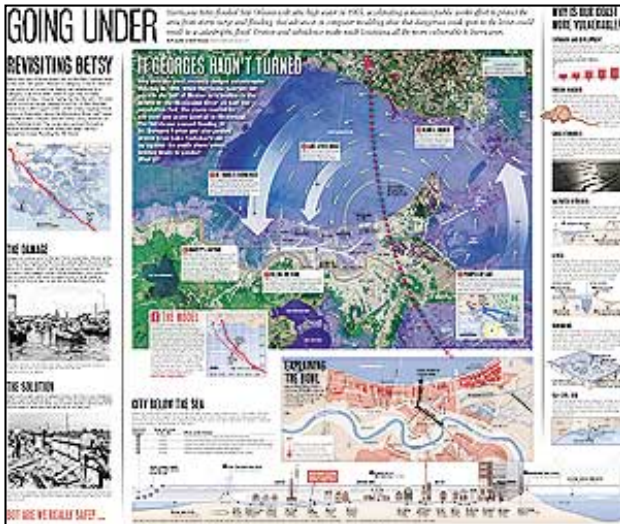
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Going Under

What would have happened if Hurricane Georges hadn't turned aside at the last moment? This graphic package shows what experts say.

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LAST LINE OF DEFENSE: HOPING THE LEVEES HOLD



LAST LINE OF DEFENSE: Hoping the levees hold

Army Corps of Engineers officials say hurricane levees in the New Orleans area will protect residents from a Category 3 hurricane moving rapidly over the area. But computer models indicate even weaker storms could find chinks in that armor.

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ILLUSTRATION JAMES M. SOTHERN, FROM HIS BOOK 'LAST ISLAND'

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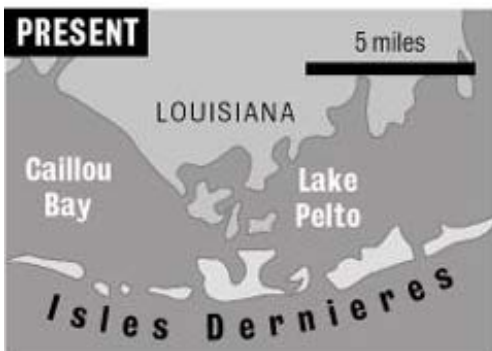
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LAST ISLAND'S WALTZ

A few years before the Civil War, one of the most legendary storms to strike the Louisiana coast destroyed Last Island. Each summer, wealthy New Orleanians would take the steamer down to the resort. On Aug. 9, 1856, as hotel guests waltzed away the night, gale winds began whipping outside. The next morning, the guests awoke to a hellish fury.



When the regularly scheduled steamer failed to arrive, vacationers realized they were trapped and that the Gulf would soon sweep over the island.

"The wind blew a perfect hurricane; every building upon the island giving way,





one

STAFF MAPS

after another, until nothing remained . . . men, women and children were seen running in every direction, in search of some means of salvation," according to Mr. Duperier, an eyewitness quoted in the Aug. 14, 1856, Daily Picayune.

The 1856 hurricane claimed at least 200 lives on Last Island, today a series of islets known by the French name Isles Dernieres.

"At about 4 o'clock, the Bay and Gulf currents met and the seas washed over the whole island . . . no words could depict the awful scene," the Daily Picayune wrote after the storm.



The Isles Dernieres as they appear today.
(PHOTO BY ELLIS LUCIA / The Times-Picayune)



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A tiny sliver of land is all that's left to tie Isle de Jean Charles to the rest of civilization. The road was paved in the 1970s, and in the 1990s was raised by 4 feet. Today, parts of the road are often under water during high tide. (PHOTO BY ELLIS LUCIA / The Times-Picayune)

Written Off

The Gulf is slowly swallowing Isle de Jean Charles and other south Louisiana towns. A new federal levee promises to save some but leaves others exposed to the elements that eventually will wipe them from the map. For the government, it's a question of cost vs. benefit. For residents, it's a question of survival.

By John McQuaid

Staff writer

ISLE DE JEAN CHARLES -- The road to the island is a narrow strip that runs two miles across open

water, buttressed on both flanks with hewn granite boulders. Broad savannas of marsh around it have withered and dissolved, and dead cypresses reach up out of the shallows like monstrous claws. In a high tide, water laps close to the asphalt. In a storm, the road disappears.

The road is the one physical link to the rest of America for Isle de Jean Charles and its community of Biloxi-Chitimacha-Choctaw

Indians, whose ancestors settled the wilderness of what is now Terrebonne Parish in the early 1800s. The first settlers may have come to "hide from the white folks that wanted to kill 'em," said Chief Albert Naquin. Or, according to one legend, to stash some of Jean Lafitte's pirate treasure.

Naquin has made the road into something of a personal crusade. He saw it built 50 years ago when he was a small child and the first trucks and cars made their way onto the island via a rutted dirt track across the marsh. He saw it inlaid with crushed clamshells by the 1960s and blacktopped in the 1970s. He wheedled bureaucrats to get it raised by 4 feet and reinforced in the 1990s.

But now Naquin's efforts to keep the island's lifeline open may turn out to have been for nothing. America -- or at least the federal government -- is giving up on Isle de Jean Charles. The community, along with others near the coast, will be left outside of a major federal levee project -- something many residents saw as the island's last shot at long-term survival in the face of strong hurricanes.

All of the island's structures and 240 souls could be washed away by a hurricane or even a tropical storm, and its situation is worsening because of the slow, relentless onslaught of salt water from the Gulf of Mexico.

Technically speaking, it's not even an island, but a ridge rising a few feet above the marshes, 23 miles inland from Timbalier Island on the coast. But it soon will be. Water encroaches from all four points on the compass. Parts of the island road, which connects to Pointe-aux-Chenes and solid land, have already sunk 6 inches in the two years since workers finished raising and fortifying it.

Its predicament recalls how hurricanes have helped shape the history of south Louisiana, sometimes wiping out entire towns, sometimes forcing people to pick up and leave.

In 1893, for example, a hurricane obliterated the tiny Cheniere Caminada settlement near Grand Isle, killing at least half the 1,600 inhabitants. Many were buried in a mass grave that still sits next to Louisiana 1. Hundreds of Cheniere Caminada survivors moved north to Leeville. But in 1915, another hurricane destroyed Leeville, killing dozens of people and wrecking 99 of 100 buildings.





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THEN: More than 800 people died in Cheniere Caminada near Grand Isle during the unnamed hurricane of 1893. Many of the victims were buried in Lady of Lourdes cemetery along what would become Louisiana Highway 1, in a mass grave, seen in this photo thought to have been taken shortly after the tragedy. The island and the storm would later form the basis for novel 'The Awakening' by Kate Chopin, who often visited the resort. (CHENIERE HURRICANE CENTENNIAL)

Reminders of the storm

According to lore, Cheniere Caminada's chapel bell began pealing on its own



TODAY: Graveyards, many holding victims

as an unexpected
and devastating

of the 1893 hurricane that wiped out the tiny Cheniere Caminada settlement near Grande Isle, are slowly disappearing into the swamp. Over the years, the erosion has accelerated as saltwater intrudes and kills oaks and other vegetation, there's nothing to hold the earth together.

hurricane blew ashore on Oct. 1, 1893. The town's priest, Father Ferdinand Grimaud, was long remembered for his heroism, gathering up parishioners, and urging them to safety. More than half of the resort and fishing village's 1,600 residents were killed in the storm. After the storm, many survivors moved farther inland.



TODAY: Even as the swamp devours everything in its path, new housing emerges in the distance, beyond a graveyard along Louisiana Highway 1 that is slowly disappearing.

(PHOTO BY ELLIS LUCIA / The Times-Picayune)



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Evolving Danger

Despite rising hurricane risks, the Army Corps of Engineers hasn't revised its levee designs for the New Orleans area, and some areas may be more vulnerable to floods than the Corps maintains.

By John McQuaid and Mark Schleifstein

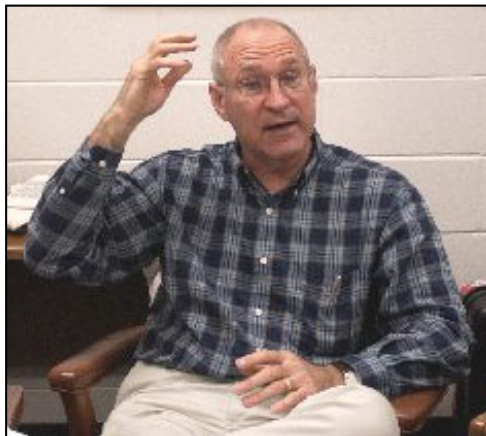
Staff writers

The New Orleans area's last line of defense against hurricane flooding is a 475-mile-long system of levees, locks, sea walls and floodgates averaging about 16 feet high. The Army Corps of Engineers says the system will protect the city and suburbs from a Category 3 hurricane that pushes in enough seawater to raise Lake Pontchartrain 11.5 feet above sea level -- high over the head of anyone standing on the other side of a levee.

That margin of error is critical because a storm that pushes the lake any higher can force water over the top of the levees and inundate the city. The water could quickly rise 20 feet or higher. People would drown, possibly in great numbers.

The corps doesn't know what that safety margin is anymore.

Generally speaking, the corps says the powerful, slow-moving storms capable of overwhelming the system are rare and the levees are



(PHOTO BY ELLIS LUCIA / The Times-Picayune)

"The city is exposed to as

safe. But corps engineers say their own safety estimates are out of date, and an independent analysis done for The Times-Picayune suggests some levees may provide less protection than the corps maintains.

The corps' original levee specifications are based on calculations made in the early 1960s using the low-tech tools of the day -- manual calculators, pencils and slide rules -- and may never have been exactly right, corps officials say. Even if they were, corps officials and outside scientists say levees may provide less protection today than they were designed for because subsidence and coastal erosion have altered the landscape on which they were built.

much as four times the risk of hurricane flooding as it is to river flooding . . . that's always been an odd issue to me. Why would the government think that water from the lake is less dangerous than water from the river?"

JOSEPH SUHAYDA
LSU engineering professor

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LEVEE-BUILDING IN 1908 - workers using mules and horses haul dirt to raise a levee in Jefferson Parish in 1908. The next year, an unnamed storm killed 353 people when a 15-foot storm surge inundated much of South Louisiana.

(CHENIERE HURRICANE CENTENNIAL)

Experts dispute corps' estimates

According to the rough statistical analysis done by engineering consultant Lee Butler, the risk of levee overtopping in some areas -- St. Bernard Parish, eastern New Orleans and the Lower 9th Ward -- may actually be close to double what the corps once thought it was. The corps disputes Butler's numbers but has no current alternative figures.

The agency is undertaking a new study to reassess the level of protection and another to determine whether the levees need to be raised still higher.

Measuring the risks of disaster is a technical feat that few understand. But such exercises are critical to the future of New Orleans. If the new corps study confirms that protection is less than previously thought, the answers could have major effects on issues such as flood insurance rates, future levee expansions, emergency planning, evacuation and long-term business decisions.

Thanks to its low, flat profile and its location on the Gulf of Mexico, south Louisiana is more at risk from a major natural disaster than most other places in the country. The risk of a catastrophic levee-topping flood in New Orleans is roughly comparable to the risk of a major earthquake in Los Angeles. Because of coastal erosion and subsidence, that risk is growing.

But judging that risk and how to protect against it can be difficult. Recent experience tends to confirm the idea that catastrophic hurricane floods are rare. Even if a powerful hurricane comes close to New Orleans, only certain storm tracks could flood all or part of the city and suburbs. Twelve storms rated Category 3 and above have hit the Louisiana coast in the past 100 years, but only four produced major flooding in the New Orleans area. The levee system was built largely in response to those storms, to prevent or reduce flooding in similar events.

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LEVEE-BUILDING IN 1968 - Three years after Hurricane Betsy, the Army Corps of Engineers began building the first concrete floodwalls along the east bank of the Inner Harbor Navigation Canal. Here, the floodwalls between Hayne Boulevard and Dwyer Road are built by placing concrete over steel pilings that were driven into existing levees earlier in 1968. (Staff file photo)

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Analysts quantify the unthinkable

Statisticians typically define the risk that something bad will occur by "return periods," the amount of time it takes on average for a given event to recur. The more often something occurs, the higher the risk. For example, many flood-protection projects are designed to shield people from the "100-year flood," which occurs in a given place on average every 100 years. That means that in any single year, the risk of that occurring is 1 in a 100, or 1 percent. If the average time between floods is 50 years, then the annual risk is double that: 1 in 50, or 2 percent.

Such statistical methods have a central role in levee design. The Corps of Engineers' original specifications say the lakefront levees would protect the city from a 300-year flood, defined as 11.5 feet above sea level, not including waves that crest even higher. The levees surrounding St. Bernard and the east side of eastern New Orleans are rated for a 200-year flood. The hurricane levee in Lafourche Parish is designed for a 100-year flood.

At first glance, those risks appear remote: Less than a 1-in-200 chance in a given year sounds like pretty acceptable odds. But they actually conform to risks that most people consider relatively common. For U.S. residents, for example, the annual odds of being attacked with a deadly weapon are 1 in 261, according to statistics compiled by Larry Laudan, a philosophy of science researcher now at the National Autonomous University of Mexico, in "The Book of Risks." The odds of someone older than 35 having a heart attack in a single year are 1 in 77. The odds of injuring oneself on a chair or bed are 1 in 400. By contrast, the chance of dying in an auto accident in a given year is 1 in 5,000, and the chance of dying in an airplane crash, 1 in 250,000.

The risk of hurricane flooding also is much higher than for river flooding, because the government has committed remarkable resources to protect the region from the river. The Mississippi River levees average more than 25 feet high and are rated for an 800-year flood. "The city is exposed to as much as four times the risk of hurricane flooding as it is to river flooding," said Louisiana State University engineering professor Joseph Suhayda. "That's always been an odd issue to me. Why would the government think that water from the lake is less dangerous than water from the river"

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LEVEE-BUILDING IN 2000 - Bobby Duthu helps build a floodwall on the edge of Bayou Segnette State Park near Westwego. The project is part of the \$90 million West Bank Hurricane Protection Levee that extends from Westwego to the Harvey Canal.

(PHOTO BY SUSAN POAG / The Times-Picayune)

Scientists rely on the past

To design a hurricane-protection system, engineers must look at historical data and try to figure out how high and how often water will rise at certain points. Then they can figure out how high to build the levees.

It sounds straightforward, but it is a complex challenge. Accurate hurricane data go back only 100 to 150 years. Statistically speaking, not very many hurricanes have hit the New Orleans area -- at least not enough to allow a solid projection into the future.

And the recent past isn't always an accurate basis for predicting the future. A Science magazine paper written last year by meteorologists

William Gray, Christopher Landsea and Stanley Goldenberg predicted that based on long-term trends in sea-surface temperature, the Atlantic Ocean is entering a 10- to 40-year period of more intense hurricane activity. That means more big storms may menace areas that are more heavily populated than during the previous such cycle, from 1920 to 1960.

Storm surges are even harder to analyze. Flooding can vary dramatically mile by mile, even lot by lot, depending on the storm, rainfall, land elevation, levee heights and proximity to waterways and drainage pumps. Storm surges flowing into Lake Pontchartrain literally slosh around, first raising water heights to the north and west, then on the south shore. A record-setting rainfall could swell water heights by a foot or more, something that could turn a relatively weak storm into a killer.

Hurricane flood statistics are even spottier because scientists often did not have the equipment positioned in enough places to measure high water during past storms. The landscape also is changing because of coastal erosion, sinking and even levee building. So a flood height from the past wouldn't be the same today.

These were the challenges the corps faced in the early 1960s when it determined most of the current levee heights around New Orleans without computers or modern knowledge of hurricane dynamics.

Engineers wanted to prevent a repeat of the flooding that hurricanes in 1915 and 1947 had caused in the city, according to Jay Combe, the coastal engineering chief for the New Orleans district of the corps. They needed a single, hypothetical storm to use in the design process, something that embodied the worst flooding conditions the area had experienced.

So they mixed and matched features of both earlier storms to devise something called the Standard Project Hurricane. The levees would be built to protect against that imaginary storm.

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Models envision the perfect storm

Meteorologists today say the Standard Project Hurricane could not exist in nature. It had a barometric pressure of 27.6 inches, the equivalent of a powerful Category 4 hurricane on today's Saffir-Simpson scale. But its maximum sustained winds were 100 mph, the equivalent of a relatively weak Category 2 hurricane. After running computer simulations in recent years, corps officials say the Standard Project Hurricane corresponds to a fast-moving Category 3 storm.

When they tried to predict how high a storm surge their imaginary storm would generate, engineers found the answers didn't match up with reality, Combe said. An estimate based on a statistical analysis of real floods showed higher storm surges were likely. So the engineers combined those two results. They decided the levees would protect against a potential flood of 11.5 feet above sea level. On top of that, they added several feet of "freeboard" to block higher waves from washing over the top, along with calibrated sloping, rocks and other features to reduce wave heights.

Combe defends the methods even while admitting that modern technology, and perhaps changes in the landscape, make them outdated. "Given the state of the art, the computing resources of the time, they did a crackerjack job," he said.

Butler basically agrees. "Those estimates are outdated, but they were very conservative," he said.

Today, engineers can fill in many of the gaps in the hurricane and flood data that challenged designers 40 years ago. Using computer models that incorporate current knowledge of hurricane and flooding dynamics, they can simulate past hurricanes in a modern landscape.

Then they can set levee heights to whatever level they find necessary. corps engineers are using such methods to reanalyze the levee system in the agency's new study. Butler, the engineer retained by The Times-

Picayune, helped pioneer such methods as a division chief for the corps' Waterways Experiment Station in Vicksburg, Miss. He is now a principal partner of VeriTech Inc., an engineering consulting firm, also in Vicksburg.

Butler estimated flood risks around New Orleans and its neighboring suburbs.

He used historical flood information, his own modeling data and figures from a 1996 corps modeling study. The study was not completed in part because of disagreements between corps engineers and modelers over some results, which the modelers say are accurate. He crunched these in a statistical program to generate predictions of flooding at five points around the New Orleans area and compared that with levee heights to get a rough estimate of the risk of water coming over.

The results tend to confirm the corps' estimate of the level of protection along the lakefront, Butler said, although he said the exact risk could not be pinned down without more study.

He said the risks may be significantly higher than the corps maintains -- perhaps double -- on the east side along levees protecting eastern New Orleans, the Lower 9th Ward, Arabi and Chalmette. Where the corps says the levees protect against a 200-year flood, Butler says it's more like a 100-year flood.

Levee heights along the Mississippi River-Gulf Outlet and Intracoastal Waterway in the area range from 17.5 to 19 feet. Butler's estimates put the 100-year flood level at 16.3 feet above sea level, meaning waves on top of that would wash over the top and flood areas inside.

The historical record tends to confirm these results, Butler said. "All along the levee, there has been very high water measured there for several storms, certainly in Betsy. If you had the right kind of storm come in there, you'd really be in trouble."

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Model's accuracy under fire

The corps agrees this is a weak spot because the area is closer and more open to the Gulf of Mexico than Lake Pontchartrain. "Flooding from a storm coming in on a track critical to New Orleans is more likely to occur in these areas outside the city," Combe said. "The MR-GO levee is more likely to be affected than the area in the lake itself."

Another reason flood heights tend to be higher there, Butler said, is that the levees protecting eastern New Orleans and St. Bernard converge in the shape of a V. When a storm pushes water into a narrowing space like that, the water tends to pile up and rise higher, increasing the risk of overtopping.

Combe and other corps officials disagree with this assessment. They have a scientific dispute about the accuracy of the computer model both Butler and the corps use to simulate storm surges, called AdCirc for "Advanced Circulation Hydrodynamic Model."

corps engineers think it tends to overestimate flood heights in some areas, especially where two levees meet at an angle, Combe said. But computer modelers, including Butler and others, defend their results and say they have been corroborated by historical data.

Combe suggested the model doesn't account for a flow away from the levee at the bottom of the water column, something that would reduce the volume of water next to the levee -- and the height.

University of Notre Dame engineer Joannes Westerink, one of the modelers Combe hired to work on the corps' current project, said he thought this effect would be relatively small. "Levees, land, a solid wall of buildings all cause storm surge to build up. But there is a return current: That effect does reduce it somewhat. . . . Is it 5 percent Is it 2 percent Is it 10 percent Our best estimates are that it's on the low end," Westerink said.

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Regardless, scientists in and out of the corps say a new study is necessary because of advances in technology and changes in the landscape. "We have lost acres and acres, square miles of land out there near the Gulf. So conditions and bathymetry (water depths) are different now," Combe said.

Why has it taken the corps this long to evaluate the problem? No clear bureaucratic mandate exists for reassessing the blueprints once levees are built. Congress appropriates money for levee construction based on corps studies that take years to complete. Dramatic changes or reassessments typically occur after major disasters, when political momentum generates for preventing a repeat.

"The government sort of does things strange," Combe said. "We do things in response to the direction of Congress and the president. Local sponsors say we need something done here, they pass a law, the president signs it, and we go to work. Going back later and looking at pieces of a project is something we have to look at, and we are looking at it and doing a more up-to-date analysis. We are in the process of redoing it. But the government wheels grind slow."

The disagreement over the computer analysis also dragged things out. A 1996 attempt to study Lake Pontchartrain-area levees broke down over that dispute and because of bureaucratic disagreements, according to Combe and others involved.

Meanwhile, sinking, erosion and sea-level rise mean that the odds of getting flooded have been getting worse across south Louisiana. "The frequency of flooding is increasing at all levels," Suhayda said. "You might find in 50 years that the risk of these infrequent events doubled. The 50-year event became a 25-year event, the 100-year event became a 50-year event."

'I'd get out of Dodge'

New avenues have opened for floodwaters entering the New Orleans area. The marshes and barrier islands of St. Bernard Parish have gradually disappeared, though not as much as in areas south of the city. As a result, more water can flow across them and into Lake Pontchartrain faster than 40 years ago. Since it opened in 1963, the MR-GO has eroded and widened to more than four times its original width in some areas. It now forms a giant sluice leading straight up to the city from the southeast, into the Intracoastal Waterway and ultimately into Lake Pontchartrain through the Inner Harbor Navigation Canal.

In any case, scientists say they want to know what the corps study finds, in part because they want to get a better grip on what the risks are for the sake of the city -- and for their own peace of mind.

"I think everyone familiar with this is sitting on pins and needles because nothing has happened in that lake for 50 to 60 years and you start to think, are we due?" Butler said. "And the answer I think is yes, statistically you're due. And that's scary. Based on my knowledge of hurricanes, I'd watch what happens very closely -- and I'd get out of Dodge."



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Although advanced warning systems have significantly reduced the loss of life from hurricanes, the cost in terms of destruction have jumped astronomically as coastal areas have become more developed. Here is a look at 12 notable storms that have lashed Louisiana. (Damage amounts are in current dollars. Wind speeds marked with an "*" were gusts recorded in New Orleans).

<p>1893</p>	<p>UNNAMED Landfall: Oct 1, 1893, at Grand Isle Category: 2 Damages: \$95 million Deaths: 2,000 Winds: 100 mph Storm surge: 15 feet</p>
--------------------	--

Many barrier islands were stripped of vegetation, and much of Grand Isle was destroyed. Waves at times washed over the Chandeleur Islands lighthouse, which stood 50 feet above sea level.

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UNNAMED
Landfall: Sept. 20, 1909, near Grand Isle
Category: 4
Damages: \$114 million
Deaths: 353
Winds: 110 mph
Storm surge: 15 feet

Although only a Category 2 when it came ashore, storm surge inundated much of southern Louisiana.

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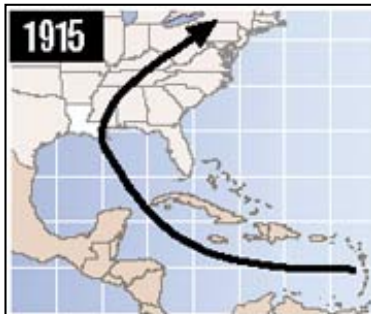
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Threatening Skies



UNNAMED

Landfall: Sept. 29, 1915, in Grand Isle

Category: 4

Damages: \$220 million

Deaths: 275

Winds: 130 mph*

Storm surge: 12 feet

A Category 2 when it came ashore, the storm flooded much of New Orleans, causing \$85 million in damages in the city.

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1947

UNNAMED
Landfall: Sept. 19, 1947, near Venice
Category: 4
Damages: \$873 million
Deaths: 51
Winds: 125 mph*
Storm surge: 15 feet

Although only a Category 1 when it came ashore in Louisiana, most of New Orleans was inundated, with much of Jefferson Parish under 6 feet of water.

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AUDREY

Landfall: June 27, 1957, at the Texas-Louisiana border

Category: 4

Damages: \$939 million

Deaths: 526

Winds: 144 mph

Storm surge: 12 feet

Waves at Cameron Parish reached as high as 20 feet above the storm surge. On the night before landfall, crawfish were seen fleeing by the thousands from the marshes around Cameron.

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1964

HILDA
Landfall: Oct. 2, 1964, in Salt Point
Category: 3
Damages: \$295 million
Deaths: 39
Winds: 116 mph
Storm surge: Unknown

The Gulf invaded Cocodrie, about 25 miles south of Houma, up to a depth of nearly 8 feet

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BETSY
Landfall: Sept. 9, 1965, at Grand Isle
Category: 4
Damages: \$7.7 billion
Deaths: 81
Winds: 125+ mph*
Storm surge: 16 feet

Unprecedented damage was reported by oil companies and public utilities. After New Orleans experienced its worst flooding in decades, levees were raised by 2 feet. Nearly 300 miles away in Monroe, winds exceeded 60 mph. Third-costliest storm in the United States, after Andrew (1992) and Hugo (1989).

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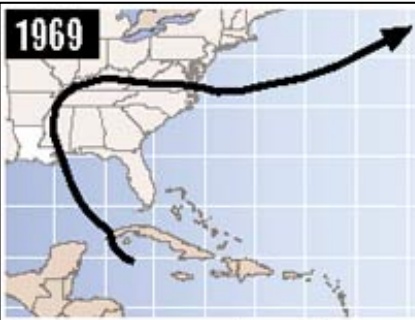
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CAMILLE
Landfall: Aug. 17, 1969, in Pass Christian, Miss.
Category: 5
Damages: \$6.9 billion
Deaths: 262
Winds: 190 mph
Storm surge: 25 feet

The second-most intensive storm and the 10th-costliest to hit the United States. Although Mississippi took the brunt of the storm, Venice to Buras saw almost total destruction as Category 5 winds of 160 mph hit lower Plaquemines.

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1985

DANNY, ELENA, JUAN
Landfall: Between Aug. 15-Oct. 27, 1985, striking at Pecan Island; near the mouth of the river; and near Bayou Lafourche
Category: All 1
Damages: \$4.1 billion
Deaths: 19
Winds: varied
Storm surge: 8 feet (Danny and Juan), 10 feet (Elena)

The state suffered through three hurricanes in 1985. Juan caused heavy damage due to flooding, topping levees in Lockport, Marrero, Westwego and Myrtle Grove.

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1992

ANDREW
Landfall: Aug. 24, 1992, on northern tip of Key Largo, Fla.
Category: 4
Damages: \$37.5 billion
Deaths: 40
Winds: 145 mph
Storm surge: 17 feet (9 feet in Louisiana)



Weakened to Category 3 by the time it hit two days later at Point Chevreuil in Louisiana. About 1.5 million people evacuated south Louisiana. The costliest storm in U.S. history, with about \$1.2 billion in damage in Louisiana.

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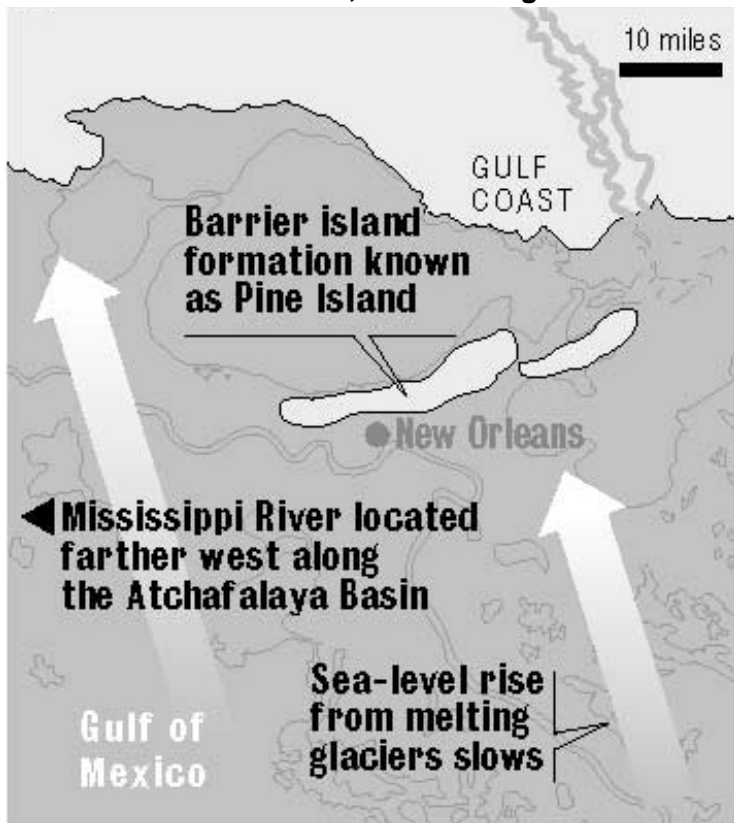
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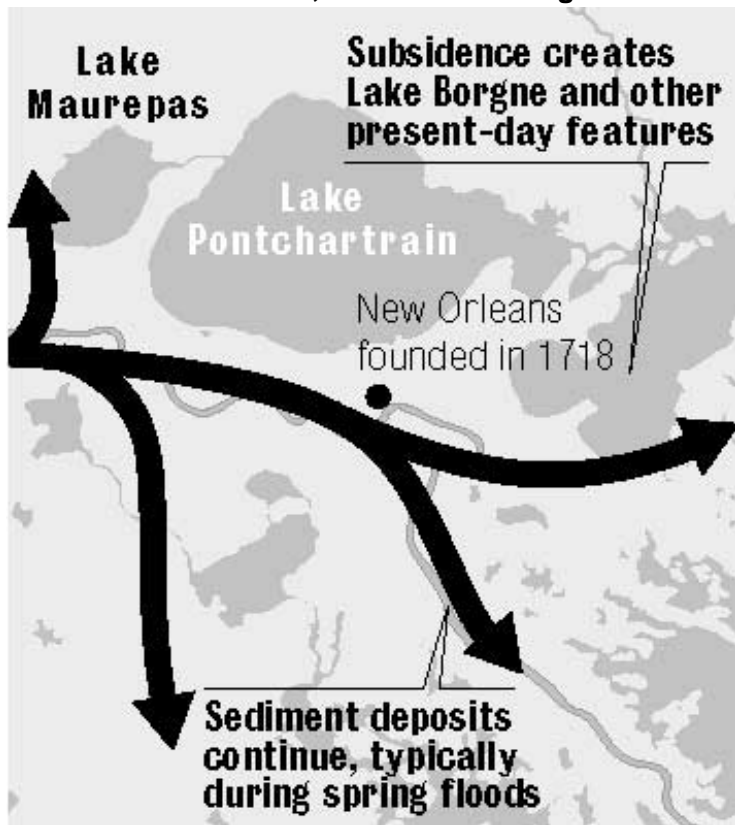
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LOUISIANA IN 2050 TO 2100

Levees prevent the Gulf from swallowing cities but can't protect them from hurricanes

Subsidence and sea-level rise allow the Gulf of Mexico to advance inland

Some experts say we will not be able to keep the River in its course and it will change course and merge with the Atchafalaya, robbing the area of drinking water as saltwater quickly intrudes up the old river path

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INTERRUPTING NATURE - CANALS



For centuries, countryside and marshland throughout Louisiana were carved up to create a series of canals that criss-cross the state for trapping, fishing, oyster farming or oil exploration. But the canals accelerated the natural erosion process, and today it's hard to tell where the canals end and where marshland or Gulf waters begin. (PHOTO BY ELLIS LUCIA / The Times-Picayune)

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INTERRUPTING NATURE - PIPELINES



Oil pipelines coated in concrete buried throughout south Louisiana. But today, many lie exposed in marshes where once-sold land has eroded around them.

(PHOTO BY ELLIS LUCIA / The Times-Picayune)

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INTERRUPTING NATURE - SALTWATER INTRUSION



The destruction initiated by man is perhaps best illustrated by the dying swamps that dominate many parts of south Louisiana. After river levees stopped the flow of fresh water to marshes, erosion and subsidence allowed saltwater to intrude. Soon, no vegetation can live, and nothing remains to hold the marsh together. Eventually, the area is the open Gulf. (PHOTO BY ELLIS LUCIA / The Times-Picayune)

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INTERRUPTING NATURE - NUTRIA



The marshes and levees are also under attack from a committed four-legged foe: the nutria. The creatures were imported into Louisiana for their fur, but after a few escaped into the wild, they quickly established themselves. By burrowing, the animals seriously weaken levees. (PHOTO BY JOHN McCUSKER / The Times-Picayune)

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THE TIMES-PICAYUNE

The Big One

—Part 2 of a Special Report—



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FILLING THE BOWL: Many New Orleanians remember how Hurricane Betsy inundated the 9th Ward, as seen in this photo. Yet under the right conditions, even a weaker storm could leave parts of New Orleans under as much as 20 feet of water for months. (FILE PHOTO BY G.E. ARNOLD / The Times-Picayune)

It's a matter of when, not if. Eventually a major hurricane will hit New Orleans head on, instead of being just a close call. It's happened before and it'll happen again.

**Stories by John McQuaid
and Mark Schleifstein**

Staff writers

Graphics by Daniel Swenson

Staff artist

INSIDE PART 2

THE BIG ONE

A major hurricane could decimate the region, but flooding from even a moderate storm could kill thousands. It's just a matter of time.

LEFT BEHIND

Evacuation is the most certain route to safety, but it may be a nightmare. And 100,000 without transportation will be left behind.

REVISITING GEORGES

Graphic special: A look at the track and effects of the 1998 hurricane that scared New Orleans.

THREATENING SKIES

Graphic special: A look at the 12 most notable storms that have lashed Louisiana.

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Graphic special: Explains how the dome of water that accompanies a hurricane can tower over levees and endanger residents.

LOOKING BACK AT GEORGES

A look back at the weekend New Orleans fled from Hurricane George, with stories, photos and video from The Times-Picayune and NOLA.com.

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The Hurricane Warning bulletin that sent New Orleanians fleeing in what was then a record evacuation.



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Even though Hurricane Georges was considered a near miss, it made its fury known in New Orleans. The hardest hit areas were the St. Bernard Parish and along Lake Pontchartrain in eastern New Orleans where about two dozen fishing camps were destroyed by the storm in September 1998. Here Blayne Badaeux, 10, walks over a pile of lumber and debris that used to be his uncle's fishing camp.

(PHOTO BY JENNIFER ZDON / The Times-Picayune)

THE BIG ONE

A major hurricane could decimate the region, but flooding from even a moderate storm could kill thousands. It's just a matter of time.

By Mark Schleifstein and John McQuaid

Staff writers

The line of splintered planks, trash and seaweed scattered along the slope of New Orleans' lakefront levees on Hayne Boulevard in late

September 1998 marked more than just the wake of Hurricane Georges. It measured the slender margin separating the city from mass destruction.

The debris, largely the remains of about 70 camps smashed by the waves of a storm surge more than 7 feet above sea level, showed that Georges, a Category 2 storm that only grazed New Orleans, had pushed waves to within a foot of the top of the levees. A stronger storm on a slightly different course -- such as the path Georges was on just 16 hours before landfall -- could have realized emergency officials' worst-case scenario: hundreds of billions of gallons of lake water pouring over the levees into an area averaging 5 feet below sea level with no natural means of drainage.

That would turn the city and the east bank of Jefferson Parish into a lake as much as 30 feet deep, fouled with chemicals and waste from ruined septic systems, businesses and homes. Such a flood could trap hundreds of thousands of people in buildings and in vehicles. At the same time, high winds and tornadoes would tear at everything left standing. Between 25,000 and 100,000 people would die, said John Clizbe, national vice president for disaster services with the American Red Cross.

"A catastrophic hurricane represents 10 or 15 atomic bombs in terms of the energy it releases. Think about it. New York lost two big buildings. Multiply that by 10 or 20 or 30 in the area impacted and the people lost, and we know what could happen."

Joseph Suhayda
LSU Engineer

"A catastrophic hurricane represents 10 or 15 atomic bombs in terms of the energy it releases," said Joseph Suhayda, a Louisiana State University engineer who is studying ways to limit hurricane damage in the New Orleans area. "Think about it. New York lost two big buildings. Multiply that by 10 or 20 or 30 in the area impacted and the people lost, and we know what could happen."

Hundreds of thousands would be left homeless, and it would take months to dry out the area and begin to make it livable. But there wouldn't be much for residents to come home to. The local economy would be in ruins.

The scene has been played out for years in computer models and emergency-operations simulations. Officials at the local, state and national level are convinced the risk is genuine and are devising plans for alleviating the aftermath of a disaster that could leave the city uninhabitable for six months or more. The Army Corps of Engineers has begun a study to see whether the levees should be raised to counter the threat. But officials say that right now, nothing can stop "the big one."

Like coastal Bangladesh, where typhoons killed 100,000 and 300,000 villagers, respectively, in two horrific storms in 1970 and 1991, the New Orleans area lies in a low, flat coastal area. Unlike Bangladesh, New Orleans has hurricane levees that create a bowl with the bottom dipping lower than the bottom of Lake Pontchartrain. Though providing protection from weaker storms, the levees also would trap any water that gets inside -- by breach, overtopping or torrential downpour -- in a catastrophic storm.

"Filling the bowl" is the worst potential scenario for a natural disaster in

the United States, emergency officials say. The Red Cross' projected death toll dwarfs estimates of 14,000 dead from a major earthquake along the New Madrid, Mo., fault, and 4,500 dead from a similar catastrophic earthquake hitting San Francisco, the next two deadliest disasters on the agency's list.

The projected death and destruction eclipse almost any other natural disaster that people paid to think about catastrophes can dream up. And the risks are significant, especially over the long term. In a given year, for example, the corps says the risk of the lakefront levees being topped is less than 1 in 300. But over the life of a 30-year mortgage, statistically that risk approaches 9 percent.

In the past year, Federal Emergency Management Agency officials have begun working with state and local agencies to devise plans on what to do if a Category 5 hurricane strikes New Orleans.

Shortly after he took office, FEMA Director Joe Allbaugh ordered aides to examine the nation's potential major catastrophes, including the New Orleans scenario.

"Catastrophic disasters are best defined in that they totally outstrip local and state resources, which is why the federal government needs to play a role," Allbaugh said. "There are a half-dozen or so contingencies around the nation that cause me great concern, and one of them is right there in your back yard."

In concert with state and local officials, FEMA is studying evacuation procedures, postdisaster rescue strategies, temporary housing and technical issues such as how to pump out water trapped inside the levees, said Michael Lowder, chief of policy and planning in FEMA's Readiness, Response and Recovery directorate. A preliminary report should be completed in the next few months.

Louisiana emergency management officials say they lobbied the agency for years to study how to respond to New Orleans' vulnerability, finally getting attention last year.

With computer modeling of hurricanes and storm surges, disaster experts have developed a detailed picture of how a storm could push Lake Pontchartrain over the levees and into the city.

"The worst case is a hurricane moving in from due south of the city," said Suhayda, who has developed a computer simulation of the flooding from such a storm. On that track, winds on the outer edges of a huge storm system would be pushing water in Breton Sound and west of the Chandeleur Islands into the St. Bernard marshes and then Lake Pontchartrain for two days before landfall.

"Water is literally pumped into Lake Pontchartrain," Suhayda said. "It will try to flow through any gaps, and that means the Inner Harbor Navigation Canal (which is connected to Breton Sound by the Mississippi River-Gulf Outlet) and the Chef Menteur and the Rigolets passes.

"So now the lake is 5 to 8 feet higher than normal, and we're talking about a lake that's only 15 or 20 feet deep, so you're adding a third to a half as much water to the lake," Suhayda said. As the eye of the hurricane moves north, next to New Orleans but just to the east, the winds over the lake switch around to come from the north.

"As the eye impacts the Mississippi coastline, the winds are now blowing south across the lake, maybe at 50, 80, 100 mph, and all that water starts to move south," he said. "It's moving like a big army advancing toward the lake's hurricane-protection system. And then the winds themselves are generating waves, 5 to 10 feet high, on top of all that water. They'll be breaking and crashing along the sea wall."

Soon waves will start breaking over the levee.

"All of a sudden you'll start seeing flowing water. It'll look like a weir, water just pouring over the top," Suhayda said. The water will flood the lakefront, filling up low-lying areas first, and continue its march south toward the river. There would be no stopping or slowing it; pumping systems would be overwhelmed and submerged in a matter of hours.

"Another scenario is that some part of the levee would fail," Suhayda said. "It's not something that's expected. But erosion occurs, and as levees broke, the break will get wider and wider. The water will flow through the city and stop only when it reaches the next higher thing. The most continuous barrier is the south levee, along the river. That's 25 feet high, so you'll see the water pile up on the river levee."

As the floodwaters invade and submerge neighborhoods, the wind will be blowing at speeds of at least 155 mph, accompanied by shorter gusts of as much as 200 mph, meteorologists say, enough to overturn cars, uproot trees and toss people around like dollhouse toys.

The wind will blow out windows and explode many homes, even those built to the existing 110-mph building-code standards. People seeking refuge from the floodwaters in high-rise buildings won't be very safe, recent research indicates, because wind speed in a hurricane gets greater with height. If the winds are 155 mph at ground level, scientists say, they may be 50 mph stronger 100 feet above street level.

Buildings also will have to withstand pummeling by debris picked up by water surging from the lakefront toward downtown, with larger pieces acting like battering rams.

Ninety percent of the structures in the city are likely to be destroyed by the combination of water and wind accompanying a Category 5 storm, said Robert Eichorn, former director of the New Orleans Office of Emergency Preparedness. The LSU Hurricane Center surveyed numerous large public buildings in Jefferson Parish in hopes of identifying those that might withstand such catastrophic winds. They found none.

Amid this maelstrom, the estimated 200,000 or more people left behind in an evacuation will be struggling to survive. Some will be housed at the Superdome, the designated shelter in New Orleans for people too sick or infirm to leave the city. Others will end up in last-minute emergency refuges that will offer minimal safety. But many will simply be on their own, in homes or looking for high ground.

Thousands will drown while trapped in homes or cars by rising water. Others will be washed away or crushed by debris. Survivors will end up trapped on roofs, in buildings or on high ground surrounded by water, with no means of escape and little food or fresh water, perhaps for several days.

"If you look at the World Trade Center collapsing, it'll be like that, but add water," Eichorn said. "There will be debris flying around, and you're going to be in the water with snakes, rodents, nutria and fish from the lake. It's not going to be nice."

Mobilized by FEMA, search and rescue teams from across the nation will converge on the city. Volunteer teams of doctors, nurses and emergency medical technicians that were pre-positioned in Monroe or Shreveport before the storm will move to the area, said Henry Delgado, regional emergency coordinator for the U.S. Public Health Service.

But just getting into the city will be a problem for rescuers. Approaches by road may be washed out.

"Whether or not the Airline Highway bridge across the Bonnet Carre Spillway survives, we don't know," said Jay Combe, a coastal hydraulic engineer with the corps. "The I-10 bridge (west of Kenner) is designed to withstand a surge from a Category 3 storm, but it may be that water gets under the spans, and we don't know if it will survive." Other bridges over waterways and canals throughout the city may also be washed away or made unsafe, he said. In a place where cars may be useless, small boats and helicopters will be used to move survivors to central pickup areas, where they can be moved out of the city. Teams of disaster mortuary volunteers, meanwhile, will start collecting bodies. Other teams will bring in temporary equipment and goods, including sanitation facilities, water, ice and generators. Food, water and medical supplies will be airdropped to some areas and delivered to others.

Stranded survivors will have a dangerous wait even after the storm passes. Emergency officials worry that energized electrical wires could pose a threat of electrocution and that the floodwater could become contaminated with sewage and with toxic chemicals from industrial plants and backyard sheds. Gasoline, diesel fuel and oil leaking from underground storage tanks at service stations may also become a problem, corps officials say.

A variety of creatures -- rats, mice and nutria, poisonous snakes and alligators, fire ants, mosquitoes and abandoned cats and dogs -- will be searching for the same dry accommodations that people are using.

Contaminated food or water used for bathing, drinking and cooking could cause illnesses including salmonella, botulism, typhoid and hepatitis. Outbreaks of mosquito-borne dengue fever and encephalitis are likely, said Dr. James Diaz, director of the department of public health and preventive medicine at LSU School of Medicine in New Orleans.

"History will repeat itself," Diaz said. "My office overlooks one of the St. Louis cemeteries, where there are many graves of victims of yellow fever. Standing water in the subtropics is the breeding ground for mosquitoes."

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Greg Schmidt left, and McKinley Cantrell look at Bruning's restaurant where the back of it is all but gone at West End near the Municipal Yacht Harbor the day Georges passed through.
(PHOTO BY ALEX BRANDON/ The Times-Picayune)

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Herculean pumping task

It probably will be at least four days after the hurricane before the corps attempts to begin removing water from the city, Combe said. After a 1947 hurricane flooded the east bank, it took several days for the lake to return to its normal average 14-foot depth, slowing efforts to drain floodwaters from Metairie and Kenner.

Pumping won't be an option. Swamped existing pumping systems in Orleans and Jefferson will be useless. Pumps can be brought in, but their capacity is limited.

"If one goes to construction equipment rental firms, you can rent pumps with a capacity of 6,000 to 8,000 gallons a minute, but that's just not enough capacity," Combe said. "After Betsy the corps employed six dredges with a combined capacity of 243,000 gallons per minute. It would take 44 hours to drain a half-inch of water from the New Orleans metro

area that way."

The most likely alternative is simply blowing holes in the levees or widening existing breaches. Breaches in the levee totaling a half mile would allow the water to drain in one day, Combe said. With a more modest effort, totaling 100 feet of openings, draining would take four weeks. If they do dynamite the levees, officials must also weigh the risk of another hurricane hitting in the short term against the urgency of getting the water out.

Water levels will drop only to the level of the lake, leaving areas lower than that with standing water that must be pumped out. Workers will then focus on restoring existing generators throughout the city that operate the pumping system.

Harold Gorman, executive director of the Sewerage & Water Board, said his agency thinks it can get most of its pumps working in a month, based on its experience in Hurricane Betsy in 1965. But it may take longer than that just to get replacement parts for the various pumps and electric motors used in local drainage systems. "You've got a lot of apples and oranges out there," Combe said. "Sometimes it takes six months just to get parts. Sometimes there are no off-the-shelf parts available."

It will take six months to pump out Jefferson Parish, Combe said. But at that point, areas of New Orleans will probably still be underwater and may take many more months to empty.

Getting the water out is just the first step to making the city livable, officials say. "Imagine the city of New Orleans closed for four to six months," said Jefferson Parish Emergency Preparedness Director Walter Maestri. "We'll have to re-evaluate all our sanitary systems, completely evaluate the water and purification systems, evaluate half to two thirds of all buildings to see if they were structurally damaged by water pressure and wind. Restoring electricity will be another complicated problem. Will houses catch fire when they throw the power switch All that's going to have to be handled."

With few homes left undamaged, Red Cross and FEMA officials will have to find property for long-term temporary housing for a possible 1 million refugees. After Hurricane Andrew, some of the 250,000 residents of south Miami-Dade County forced to find temporary housing remained in federally financed mobile homes for 2½ years.

"You'd have manufactured housing brought in and set up in Baton Rouge and Folsom and so forth," Maestri said. "It's going to have to be north of Mandeville and Covington, because they're probably going to have hurricane damage as well. They'll probably use military bases like Camp Shelby in Mississippi, too. They'll be urban refugee centers, where people will stay while officials do an analysis to say, 'Yes, you can come back' or 'No, you can't come back here.' "

New Orleans would face the future with most of its housing stock and historic structures destroyed. Hotels, office buildings and infrastructure would be heavily damaged. Tens of thousands of people would be dead and many survivors homeless and shellshocked. Rebuilding would be a formidable challenge even with a generous federal aid package.

"You wouldn't have an infrastructure, that's for sure," said Hucky Purpera, natural and technical hazards chief for the Louisiana Office of Emergency

Preparedness. "What would you be going back to Residents might be going back in, but would businesses rebuild They'll make decisions based on what's best for the company. And if you do decide to rebuild, do you rebuild there A lot of that we don't know."

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Hurricane Georges pushed a 8.5-foot storm surge through marshland in St. Bernard Parish, topping the 6-foot levee encircling the community of Florissant. Water rose 8 to 10 feet in some parts of the parish, and 17 families were left homeless.

(PHOTO BY RUSTY COSTANZA / The Times-Picayune)

Still home sweet home

But it's unlikely the city would be completely abandoned, economists and disaster experts say. Most cities do eventually recover from major disasters -- though no precedent exists for the wholesale destruction of "filling the bowl."

No single storm would wipe out the entire New Orleans area. If the east

bank floods, the west bank and St. Tammany Parish would take heavy damage from wind but be spared heavy storm-surge flooding. The city's location on the Mississippi River near the Gulf of Mexico would still be strategic for trade. Industrial plants upriver would remain largely intact.

"It's always recoverable. People own that property. They are not going to walk away. If someone does walk away, there will be a bank that will foreclose and ultimately resell that space," said Mary Comerio, a professor of architecture at the University of California, Berkeley, and author of a book on postdisaster reconstruction. "It will all be at fire-sale prices, and it will end up a different place, owned by different people."

After a Category 4 hurricane destroyed Galveston, Texas, in 1900, the entire island was raised 7 feet before rebuilding began. To avoid a repeat catastrophe, officials would likely consider how to hurricane-proof the city, or even think about moving it.

"We've not tried to tackle that yet," said Lowder, the FEMA official.

"What's the best way to -- I won't say rebuild -- but where do we go from here How can we make sure that our recovery doesn't put things back the exact same way they were"

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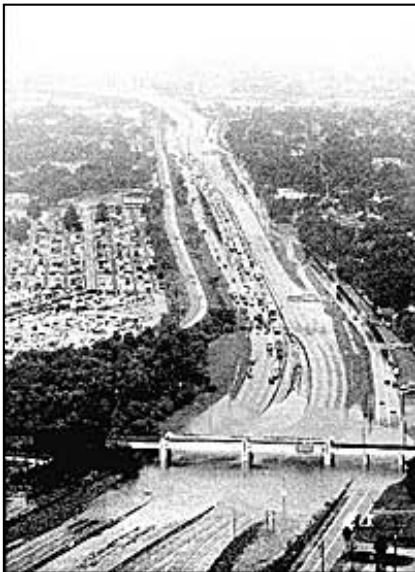
Once it's certain a major storm is about to hit, evacuation offers the best chance for survival. But for those who wait, getting out will become nearly impossible as the few routes out of town grow hopelessly clogged. And 100,000 people without transportation will be especially threatened.

By **John McQuaid and Mark Schleifstein**

Staff writers

Hurricane evacuations rarely go as planned. Storm tracks are hard to predict, and roads are not designed to handle the traffic flow, so huge traffic jams are a common result. In 1998 it took six hours for people leaving the New Orleans area in advance of Hurricane Georges to reach Baton Rouge, 80 miles away. The following year, Hurricane Floyd's constantly changing course spurred evacuations and bumper-to-bumper traffic on highways from Florida to North Carolina.

Moving entire populations out of harm's way is a time-consuming and unpredictable operation complicated by geography, demographics, human psychology, the limits of weather forecasting, and transportation problems that tie many cities in



A flooded underpass on I-10 westbound near the Orleans/Jefferson parish line was a critical choke point during Tropical Storm Frances.

(FILE PHOTO BY ALEX BRANDON / The Times-Picayune)

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knots even in perfect weather.

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Like every coastal area vulnerable to hurricanes, south Louisiana faces these challenges. But the Louisiana delta also has it worse than other coastal areas.

Because the entire region is susceptible to storm-surge flooding, hurricanes pose more danger to those left behind than in places where the coastal profile is higher.

"Evacuation is what's necessary: evacuation, evacuation, evacuation," Jefferson Parish Emergency Preparedness Director Walter Maestri said. "We anticipate that (even) with refuges of last resort in place, some 5 (percent) to 10 percent of the individuals who remain in the face of catastrophic storms are going to lose their lives."

The region's sinking coast and rising flood risk also make the task of getting people out harder than it is elsewhere. South Louisiana presents some of the most daunting evacuation problems in the United States because:

- The region's large population, including more than 1 million people in the New Orleans area, requires a 72- to 84-hour window for evacuation, well ahead of the time that forecasters can accurately predict a storm's track and strength.
- Few north-south escape routes exist to move residents away from the coast, and many of those include low-lying sections that can flood days before a hurricane makes landfall.
- Evacuees must travel more than 80 miles to reach high ground, meaning more cars on the highways for a longer time as the storm approaches.
- A large population of low-income residents do not own cars and would have to depend on an untested emergency public transportation system to evacuate them.
- Much of the area is below sea level and vulnerable to catastrophic flooding. Based on the danger to refugees and workers, the Red Cross has decided not to operate shelters south of the Interstate 10-Interstate 12 corridor, leaving refuges of last resort that offer only minimal protection and no food or bedding.

Emergency officials say they have made improvements since Hurricane Georges, but the changes have yet to be tested under real-world conditions, and many obstacles remain.

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Efficient evacuation key to survival

The predicament of the New Orleans area is part of a growing problem along the Gulf and Atlantic coasts. Hurricane evacuation planning and storm forecasting are better than they've ever been, but population growth, expanding development and coastal erosion are outpacing the gains, putting more people in danger and making it harder to move them out of the way.

Coastal areas across the United States have population densities five times the nation's average, according to the National Oceanic and Atmospheric Administration. About 50 percent of the nation lives within 50 miles of a coast, and that population is expected to continue growing.

The population and geographic pressures have forced emergency officials to take a harder look at the prospects for disaster. Two decades ago, few cities had evacuation plans. Now most coastal counties in the southeastern United States have comprehensive playbooks that choreograph the movements of vehicles and track the approach of high winds and storm surges down to the minute.

"Coastal populations have grown up dramatically, while road infrastructure relative to evacuation routes hasn't kept pace," said Louisiana State University assistant engineering professor Brian Wolshon, who studies the issue. "It wasn't that they didn't have plans in the past; it was that they weren't necessary. We needed plans adequate to deal with populations on the scale that we see now."

More lives depend on efficient and complete hurricane evacuations in the New Orleans area than anywhere else in the United States.

Unlike other vulnerable cities such as Miami, where high ground lies close to shore, south Louisiana lies at or below sea level and is at risk from storm surges that can suddenly catch people in fast-rising water that cuts off escape routes. Within New Orleans and parts of Jefferson Parish, the

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danger is even greater if a storm surge tops hurricane levees, a scenario that could kill tens of thousands of people.

For an evacuation of the New Orleans area to work, more than a million people have to travel at least 80 miles over an aging, low-capacity road system to reach high ground and shelter.

"In terms of what we call the safe zone, the I-10-I-12 corridor is roughly at a 25-foot contour line, which is the maximum storm-surge line," said state Department of Transportation and Development architect George Gele. "If you can get to the Interstate 10-12 corridor, you will be safe."

Of course, if everyone stopped there, those behind them would be stuck, and motels and housing are limited. Therefore, evacuation routes extend hundreds of miles north into Mississippi, up to Meridian and Jackson. During Hurricane Georges, thousands of Louisianians went as far north as Memphis, Tenn., and as far west as Dallas.

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Time is of the essence

Forecasters cannot come close to predicting a storm's landfall accurately beyond 24 hours. Three days before a hurricane hits, the official forecast can be off by as much as 250 miles in either direction -- the distance from New Orleans to a point between Pensacola and Panama City, Fla., to the east and Beaumont, Texas, to the west. That's a dramatic improvement from the 520-mile error rate of 30 years ago, but that advantage is partly negated by the larger populations that have to be evacuated.

Even 24 hours in advance, the average forecast error is about 85 miles, according to National Hurricane Center Director Max Mayfield, meaning 170 miles of coastline or more may be issued hurricane warnings at any one time.

"The decision-making and accounting for uncertainty in the forecast is the weakest link today on responding to hurricane threats," said Jay Baker, an associate professor of geology at Florida State University. "The earlier you start, the more uncertainty there is about where the storm is going to go, how severe it's going to be."

This creates a difficult situation for emergency managers. Delaying puts huge numbers of people at risk. Calling for an evacuation too early shuts down businesses needlessly, costing between \$1 million and \$50 million for every mile of coast evacuated, and possibly discourages people from leaving the next time.

"The effects on early evacuations due to false scares (are) so terribly important," said University of New Orleans sociologist Shirley Laska. "The lower parishes have grown to accept that," because evacuations occur so often, she said. But in the New Orleans area, people tend to be more skeptical, and false alarms compound that.

Evacuation times are squeezed even further because roads must be

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closed when the wind reaches gale force, from 39 to 54 mph, and it becomes unsafe to drive. At that point most hurricanes are just hours from landfall. Coastal erosion and sinking have created another problem. Some roads that didn't flood in the past now do, and those that flooded later now are underwater earlier.

"The last study done on the southeast area of the state used data from the late 1980s and was written in the early '90s," said Mike Brown, the state's deputy director of emergency preparedness. "I would not be surprised if the times (for evacuating safely) were to diminish on us as a result of the loss of wetlands."

Louisiana 1, for example, is the single escape route out of the lower reaches of Lafourche Parish and for thousands of workers on Gulf rigs based out of Port Fourchon. "Louisiana 1 is only a half foot above the normal summer high tide at the Leeville Bridge," said Windell Curole, general manager of the South Lafourche Levee District. "So, early in the ball game, Grand Isle, Port Fourchon and much of the rest of Lafourche Parish have to keep close track of storms."

With the threat of flooding and the potential for traffic jams, Curole and other officials fear the wrong set of circumstances could strand thousands of people in their cars in a powerful, fast-moving storm.

In New Orleans, another potential choke point looms. I-10 dips to 12 feet below sea level under a railroad trestle near the Jefferson Parish line and floods in heavy rains. "If it floods, it severs the I-10 evacuation," Gele said. "That is a very fragile point. That is a very critical situation."

The state transportation department is installing a pumping system to address the problem.

Once people are on the road, the challenge is avoiding bottlenecks. I-10 is the only highway that runs all the way through the area, so plans call for evacuees to move east or west along it before they move away from the coast. Moving east, evacuees go up I-59 toward Hattiesburg, Miss. Those going west travel up I-55 toward the north shore and into Mississippi or continue along I-10 to western Louisiana and Texas. Evacuees also can leave by the Lake Pontchartrain Causeway, but it is usually the first major road to be shut down because of high winds.

Officials in Louisiana are negotiating with their Mississippi counterparts about how to run evacuations across the border. Mississippi officials fear that an evacuation of the New Orleans area, starting earlier than one on the more sparsely populated Mississippi coast, could clog the highways before their evacuation even begins, trapping people on the coast.

The lack of alternative escape routes extends the evacuation time, giving emergency planners less margin for error than their counterparts in areas with more routes or fewer people.



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All lanes lead outward

The biggest innovation in New Orleans since Georges is a plan to use "reverse laning," turning parts of I-10 into one-way thoroughfares to cut traffic jams and evacuation times and to maximize the number of people leaving. The state transportation department has built crossover lanes to move traffic out of the city one-way going west out of Kenner and one-way east beginning in eastern New Orleans. Mississippi officials have established similar crossovers on I-59 just north of the Louisiana state line and just south of Laurel.

The Louisiana transportation department also has upgraded its flood-monitoring system, called Hydrowatch, which takes information from 154 stations across the area and uploads it to a satellite. From there, the department can access the data and integrate it into a Web site so officials and residents can monitor flooding in real time and see which roads become impassable as the water rises. The site also shows evacuation routes and road closures.

Workers also are installing monitors along highways that use the same system to monitor both weather conditions and traffic. With the satellite monitoring, emergency managers will be able to keep track of traffic flow as it waxes and wanes during an evacuation and respond immediately if problems crop up.

The risk of dying is so high that trying to ride out a storm is foolish, emergency managers say. Yet for various reasons, many people do not leave. In New Orleans, many residents don't own cars. Some are unaware of the danger. Some think they can judge it for themselves. About 44 percent of Orleans residents and 52 percent of Jefferson residents evacuated during Georges, according to a University of New Orleans survey. A separate Jefferson Parish study estimated that 60 percent of residents left the parish.

"I don't have a question about the fact that a lot of people are not going

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to leave, not just the 100,000 who don't have private transportation," said Terry Tullier, acting director of New Orleans' Office of Emergency Preparedness. "We think we're going to do our people a terrible disservice if we don't tell them the truth. And the truth is that when it happens, a lot of people are going to die."

Those who remain should not expect to find safe shelter, officials say. Few buildings in the area can withstand the forces of a Category 4 or 5 hurricane. "We don't have structures that can handle wind and water at those velocities and at that water height," Maestri said.

Emergency officials once counted on "vertical evacuations" to tall buildings as a way to escape flooding. But Florida's experience with Hurricane Andrew in 1992 has scuttled that policy. Andrew's winds blew windows out of many skyscrapers and heavily damaged the upper floors of many tall buildings. In 1996, sophisticated instrument packages dropped into hurricanes confirmed that wind speeds can be 50 mph stronger several hundred feet above ground level.

"Before 1993 we thought we could evacuate vertically into high-rise buildings. But we can't do that because of what Hurricane Andrew did to Miami-Dade. Our building codes, our buildings, are not as strong as theirs," Maestri said.

Don't bank on shelters

The American Red Cross, which runs federally designated emergency shelters, changed its policy in the mid-1990s after a shelter in South Carolina flooded and people inside nearly drowned. Now the agency bars shelters in areas that can be inundated by a storm surge from a Category 4 hurricane -- which is all of south Louisiana.

Local parishes plan to shelter only those with "special needs," people who cannot be moved. In New Orleans, the Superdome will be used for this purpose.

In lieu of traditional shelters, which offer food and bedding, some parishes plan to open "refuges of last resort" -- buildings that are not safe but are safer than homes. They can house at most a few hundred people per parish, officials say. Most others will be on their own, meaning that in a catastrophic storm more than a 200,000 people could be left at the mercy of the elements.

Faced with those numbers, New Orleans officials have backup plans to move people without transportation: Regional Transit Authority buses and National Guard vehicles would take people out of the city. But the untested plan has raised serious questions from critics who say it could endanger hundreds of thousands of residents.

In an evacuation, buses would be dispatched along their regular routes throughout the city to pick up people and go to the Superdome, which would be used as a staging area. From there, people would be taken out of the city to shelters to the north.

Some experts familiar with the plans say they won't work.

"That's never going to happen because there's not enough buses in the city," said Charley Ireland, who retired as deputy director of the New Orleans Office of Emergency Preparedness in 2000. "Between the RTA

and the school buses, you've got maybe 500 buses, and they hold maybe 40 people each. It ain't going to happen."

The plan has other potential pitfalls.

No signs are in place to notify the public that the regular bus stops are also the stops for emergency evacuation. In Miami Beach, Fla., every other bus stop sports a huge sign identifying it as a hurricane evacuation stop.

It's also unclear whether the city's entire staff of bus drivers will remain. A union spokesman said that while drivers are aware of the plan, the union contract lacks a provision requiring them to stay.

But RTA safety director Joseph Dorsey said the requirement is part of an operator's individual contract with the RTA. "Basically, when an operator is hired, there are certain things they agree to, such as working overtime hours when necessary and doing this job," Dorsey said. "They will participate."

A similar plan in Monroe County, Fla. -- the Florida Keys -- failed during Georges when drivers opted out. "The problem is that we may have the buses but we don't have the drivers," said Irene Toner, director of the county's emergency management office. "In Hurricane Georges we had 25 people on our bus-driver list and only five showed up."

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Mark Schleifstein can be reached at (504) 826-3327 or mschleifstein@timespicayune.com.



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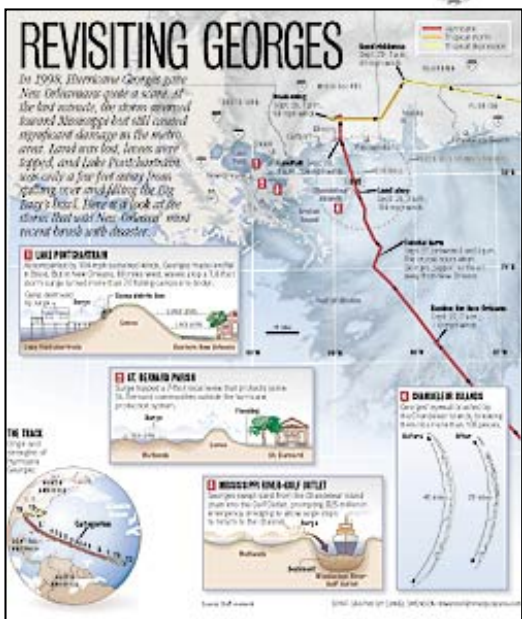
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Revisiting Georges

A look back at the track and some of the damage that put a scare into the New Orleans area in 1998.

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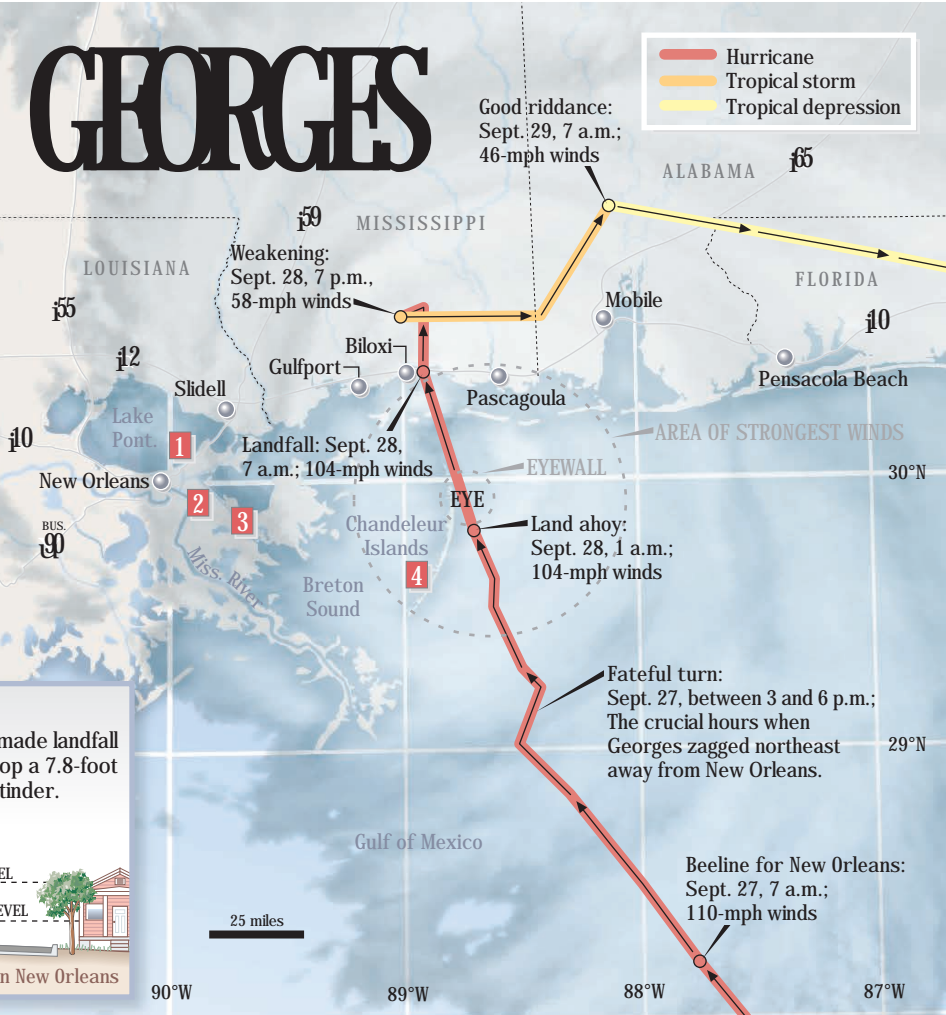
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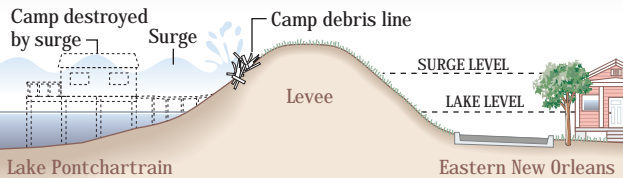
REVISITING GEORGES

In 1998, Hurricane Georges gave New Orleanians quite a scare. At the last minute, the storm swerved toward Mississippi but still caused significant damage in the metro area. Land was lost, levees were topped, and Lake Pontchartrain was only a few feet away from spilling over and filling the Big Easy's bowl. Here is a look at the storm that was New Orleans' most recent brush with disaster:



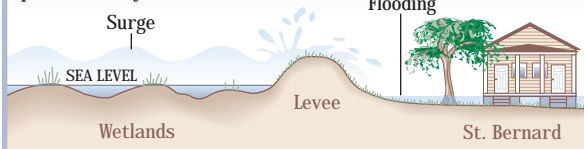
1 LAKE PONTCHARTRAIN

Accompanied by 104-mph sustained winds, Georges made landfall in Biloxi. But in New Orleans, 60 miles west, waves atop a 7.8-foot storm surge turned more than 70 fishing camps into tinder.



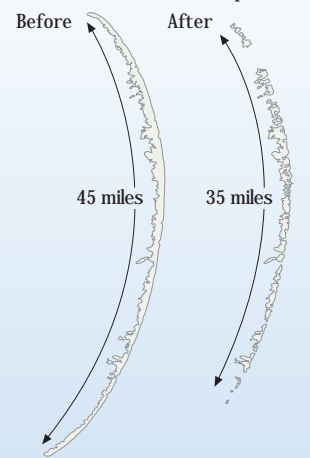
2 ST. BERNARD PARISH

Surge topped a 7-foot local levee that protects some St. Bernard communities outside the hurricane protection system.



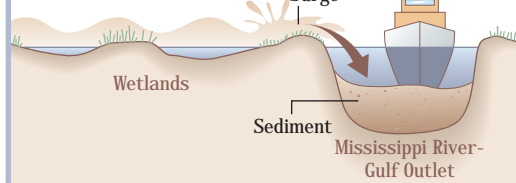
4 CHANDELEUR ISLANDS

Georges' eyewall brushed by the Chandeleur Islands, breaking them into more than 100 pieces.



3 MISSISSIPPI RIVER-GULF OUTLET

Georges swept sand from the Chandeleur Island chain into the Gulf Outlet, prompting \$25 million in emergency dredging to allow large ships to return to the channel.



THE TRACK
Origin and strengths of Hurricane Georges:



Source: Staff research

STAFF GRAPHIC BY DANIEL SWENSON/dswenson@timespicayune.com



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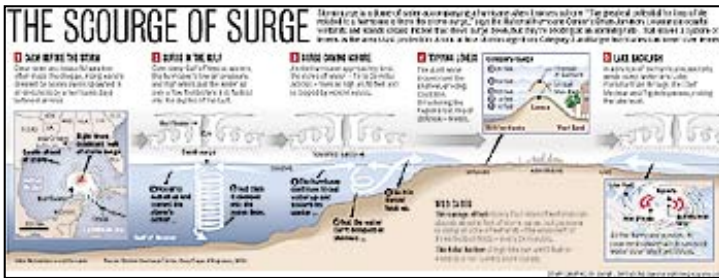
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THE SCOURGE OF SURGE

Storm surge is a dome of water accompanying a hurricane when it moves ashore, which experts say has the greatest potential for loss of life. This graphic takes a look at how the storm surge from Category 3 and greater storms can tower over levees.

Click links below for full-size versions of this graphic. Note: this graphic originally was a full-page-width newspaper presentation, so these files are relatively large.

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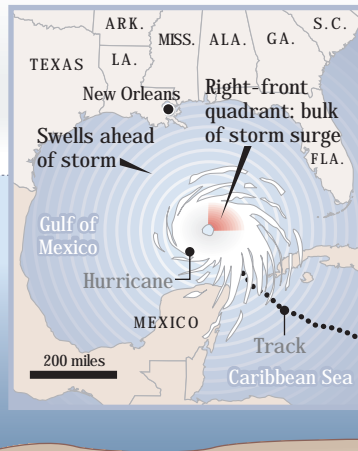
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THE SCOURGE OF SURGE

Storm surge is a dome of water accompanying a hurricane when it moves ashore. "The greatest potential for loss of life related to a hurricane is from the storm surge," says the National Hurricane Center's Brian Jarvinen. Louisiana's coastal wetlands and islands create friction that slows surge down, but they're eroding at an alarming rate. That leaves a system of levees as the area's last protection. A look at how storm surge from Category 3 and larger hurricanes can tower over levees.

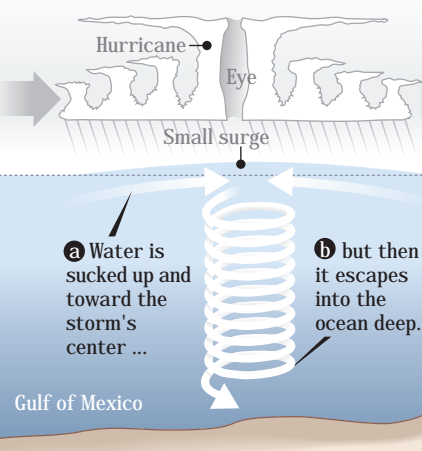
1 CALM BEFORE THE STORM

Clear skies and beautiful weather often mask the choppy, rising waters created by ocean swells spawned in all directions by a hurricane days before it arrives.



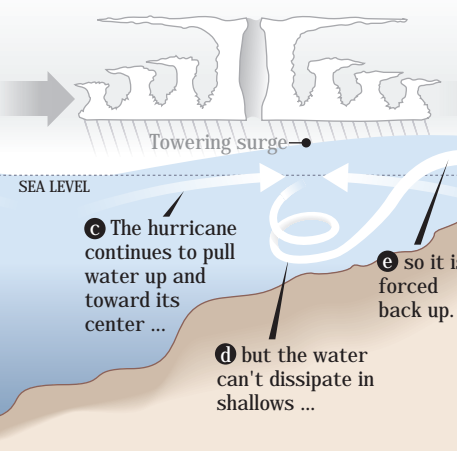
2 SURGE IN THE GULF

Over deep Gulf of Mexico waters, the hurricane's low air pressure and high winds pull the water up only a few feet before it is flushed into the depths of the Gulf.



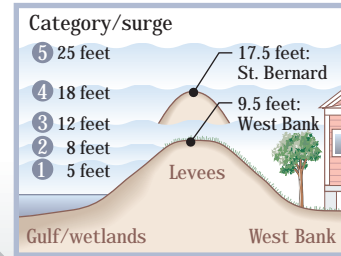
3 SURGE COMING ASHORE

As the hurricane approaches land, the dome of water - 15 to 25 miles across - rises as high as 30 feet and is topped by violent waves.



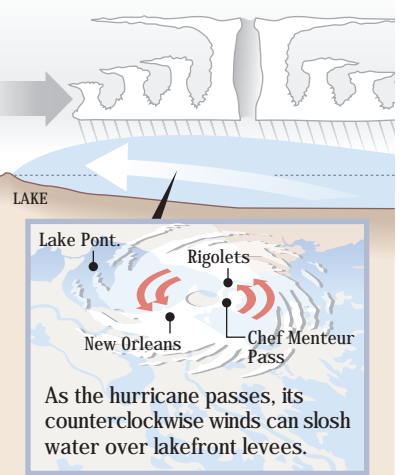
4 TOPPING LEVEES

The giant wave moves over the shallow, eroding coastline, threatening the region's last line of defense - levees.



5 LAKE BACKLASH

In advance of the hurricane, easterly winds pump water into Lake Pontchartrain through the Chef Menteur and Rigolets passes, raising the lake level.



WILD CARDS

The sponge effect: Every four miles of wetlands can absorb about a foot of storm surge, but Louisiana is losing an acre of wetlands - the equivalent of three football fields - every 24 minutes.

The tidal factor: A high tide can add 2 feet or more to a hurricane's storm surge.

Note: Illustrations are not to scale

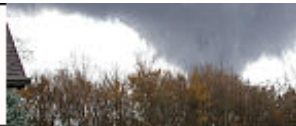
Source: National Hurricane Center, Army Corps of Engineers, NOAA

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Exposure's Cost

Part 3 of a Special Report



As more people build homes in flood-prone areas, the threat of widespread damage from a major storm grows. And as the threat increases, so does the cost to protect against storms. Here, developers in eastern St. Charles Parish built 4- to 5-foot levees around the Willowdale subdivision to protect against flooding from the canals that run past this 6,000-square-foot home. The levees offer some protection, but may be offset by the additional erosion and loss of wetlands created by the new development.

(PHOTO BY ELLIS LUCIA / The Times-Picayune)

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It's growing costlier to live and do business in our hurricane-prone coastal home. And as a result, **Louisiana's economy is feeling the pinch** from just the threat of major damage.

**Stories by John McQuaid
and Mark Schleftein**

Staff writers

Photos by Ellis Lucia

Staff photographer

Graphics by Daniel Swenson

Staff artist

INSIDE PART 3

EXPOSURE'S COST

In the wake of Sept. 11, insurance bills for risky areas - and Louisiana's coastal region is one of the riskiest - are stunning local officials.

BUILDING BETTER

Tougher building codes would ensure that more buildings in New Orleans would survive a catastrophic storm.

SEEKING SHELTER

Three years after Hurricane Floyd, some North Carolinians still live in temporary housing.



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Hurricane Katrina has caused severe damage and
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Insurance companies are pulling out. Oil and gas infrastructure is threatened. Flood-prone homes may be abandoned. Louisiana's economy is feeling the pinch from the risk of hurricane damage.

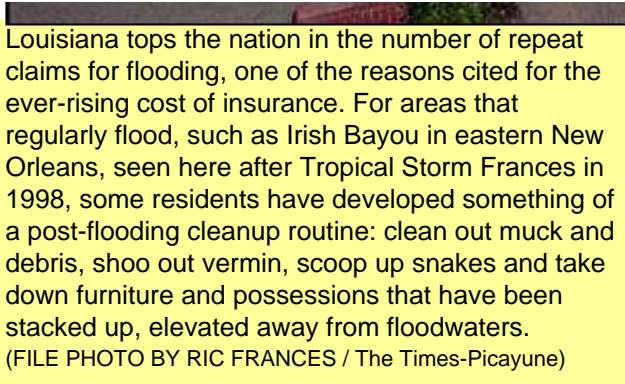
By John McQuaid and Mark Schleifstein

Staff writers

When insurance bills started coming due this spring, officials in local governments and school districts were stunned. In St. Charles Parish, premiums to insure the school district's properties more than tripled, forcing officials to devise a complex scheme to buy insurance from five different companies to keep costs down.

In Jefferson Parish, most of the buildings and other property owned by the government are not currently





(FILE PHOTO BY RIC FRANCES / The Times-Picayune)

insured at all. The parish could not find an insurance company to cover more than a third of the value of the \$300 million worth of property, and the cost of doing that was a budget-busting \$6 million in a total budget

Louisiana tops the nation in the number of repeat claims for flooding, one of the reasons cited for the ever-rising cost of insurance. For areas that regularly flood, such as Irish Bayou in eastern New Orleans, seen here after Tropical Storm Frances in 1998, some residents have developed something of a post-flooding cleanup routine: clean out muck and debris, shoo out vermin, scoop up snakes and take down furniture and possessions that have been stacked up, elevated away from floodwaters.

of \$318.5 million. Officials are trying to find a cheaper alternative. But if a hurricane strikes first, taxpayers could have to foot the bill.

After the Sept. 11 terrorist attacks, insurance companies took a second look at the risks they were willing to shoulder and how much they charged for taking them on. Because of the annual hurricane threat -- and the possibility of a storm that tops levees and inundates New Orleans and surrounding suburbs -- south Louisiana is one of the riskiest places in the United States.

"A lot of it has to do with insurance companies realizing the potential liability that they have, that one incident could wipe out a company's reserves," said St. Charles school district Comptroller Jim Malone. "If they insure in St. Charles, Jefferson and Orleans, then one hurricane large enough to have a significant amount of destruction could devastate their company."

The Sept. 11 effect accentuated a trend already under way among insurance companies: to make people, businesses and governments shoulder a bigger burden in risky areas, especially coastal zones prone to hurricanes.

"If folks choose to live along the coast, there is a need to have them bear some of the responsibility and risk of living in an area that is vulnerable to such an obvious peril," said Gary Stephenson, a spokesman for State Farm Insurance Co., which writes close to a third of Louisiana private property insurance business, and which for a time stopped writing policies in the hurricane-prone area south of Interstate 10.

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The oil and gas industry's nerve center near the open Gulf in Port Fourchon will be particularly at risk when a major storm hits. The region has become increasingly exposed to the threat of flooding, storm surges and wind damage because of coastal erosion. Not only could a storm surge cause significant damage, but the port facilities are linked to the mainland by a two-lane road that likely will be washed out in a big storm. (PHOTO BY ELLIS LUCIA / The Times-Picayune)

Stakes rise with the seas

Louisiana's insurance difficulties are part of a larger problem shadowing the south Louisiana economy: There is more to lose and there are more ways to lose it than ever before.

More people, buildings, industrial sites and infrastructure sit in potential paths of destruction, and those paths are widening thanks to sinking and erosion.

"We are continuing to lose land, and each acre, each square mile lost increases the risk of significant damage during a storm," said engineer Peter Smith of the firm Waldemar S. Nelson, who is directing a study on the economic impact of erosion and storm hazards for the Army Corps of Engineers that will be completed next year.

In the New Orleans area, meanwhile, levees protect against smaller storms but can trap the floodwaters from large storms and create almost unimaginable -- and unimaginably expensive -- damage.

Louisiana hasn't seen a storm with damage in the billions of dollars since Hurricane Betsy in 1965. But the companies operating in the state face a sometimes perverse logic: If the odds favor something bad occurring in the future, it costs money in the present.

As waters have advanced, south Louisiana has begun to feel a growing economic pinch from higher insurance premiums, home-building costs and public and private outlays to try to hurricane-proof everything from roads to oil and gas facilities.

The economic dynamic is complex. In the short run, some spending may stimulate the local economy. But the geological forces eroding the Mississippi River delta cannot be stopped. As costs rise, governments, businesses and individuals may ultimately have to weigh whether to keep spending or to give up.

Risk in south Louisiana varies depending on location. Towns in the marshes such as Cocodrie often flood but are small and don't rack up large-scale damage. However, a storm that floods the east bank of Orleans and Jefferson parishes, trapping water inside the levees, would cause damage on a scale unseen in the United States. Other places, such as St. Bernard or St. Charles parishes, fall somewhere between those extremes.

A 1998 report on Louisiana's insurance risks estimated the potential insured damage from a catastrophic storm at \$27 billion for just homeowner's and auto insurance, excluding flood damage and industrial and infrastructure losses sure to make up a large part of the cost. New Orleans insurance executive Woody Crews says a catastrophic flood in New Orleans and Jefferson Parish would result in \$100 billion to \$150 billion in damage, seven times the amount spent so far on the war in Afghanistan.

A generation ago or longer, those numbers would have been substantially lower. But today cities and towns sprawl over wider areas. More businesses and more infrastructure are in place. East Jefferson, a semirural area when a hurricane flooded it in September 1947, is now a densely populated suburb.

"In 1965, Betsy cost \$5 million to State Farm," Stephenson said. "Projections looking at the same storm say it would cost us \$1 billion today because there has been a huge proliferation of building on the same land, and the value of the land and what's on it has increased dramatically."

Rising insurance costs are the most obvious result of these trends. Two main sources of insurance are available: The federal government offers flood insurance through private companies, which themselves cover wind and other storm-related damage.



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Keeping roads passable and homes dry is a constant battle for state, local and federal officials. Here, St. Charles Parish officials and the National Guard hastily constructed a 2-foot levee to keep floodwaters from Tropical Storm Frances away from homes on Up the Bayou Road in Des Allemands in September 1998.
(PHOTO BY THOM SCOTT / The Times-Picayune)

Breaks for the coast cut

After Hurricane Andrew in 1992 stunned the insurance industry with unexpected 11-figure losses, insurance companies gradually restructured the way they cover coastal areas. Part of the effort is making sure they have sufficient resources to cover a catastrophe. They now use a combination of more readily available, but sometimes expensive, reinsurance coverage, risk-based securities and other ways of spreading the costs of the added risk.

A key element of the changes was to stop giving a break to coastal areas,

which had for years enjoyed rates subsidized by less-disaster-prone customers elsewhere in the country. Until Andrew, companies used crude estimates of potential storm damage based on their payouts from previous years.

"Using historical data does not give a good estimate of what our exposure is," said Jeff McCarty, a State Farm actuary. "At most we have 20 years of data, and during that period there has been a lot of exposure increase. It has also been something of a lull period for storms."

So companies contracted with computer modelers to develop sophisticated programs to map risk in coastal areas. One program, called EQECAT, uses 120 years of storm data to estimate the risk of hurricane-force winds hitting a given area. It then calculates the potential damage to insured properties, along with income from premiums and the costs of reinsurance, to get an estimate of annual claims for insurance companies in the long run.

The numbers run significantly higher than they did using older methods, insurers say, and have led to higher rates and deductibles, and sometimes have prompted companies to pull out of affected areas.

In Louisiana, private insurance coverage is retreating as waters rise. Sixteen companies now offer coverage south of I-10, compared with 60 before Andrew, according to acting state Insurance Commissioner Robert Wooley. Louisiana's costs put it near the top in terms of insurance premiums in the nation.

Rising insurance costs for homeowners in Louisiana's coastal areas have outpaced the rest of the state by 20 percent to 30 percent over the past decade, state Department of Insurance actuary Richard Piazza said. The biggest single change is in the deductible. Formerly a fixed amount, deductibles are now typically 2 percent to 5 percent of the value of the home, though that can be avoided if a customer pays higher premiums.

In Rapides Parish in central Louisiana, State Farm's insurance premium on a \$100,000 home with a \$500 deductible would be about \$880 depending on individual circumstances, Stephenson said. But in Jefferson Parish south of the Intracoastal Waterway, the cost is almost double: \$1,633 annually. Even in protected suburban areas, it's \$1,046.

Federal flood insurance can add another \$375 to \$1,500 for a \$100,000 single-family home, depending on whether it is in a flood hazard zone, putting total bills well over \$2,000 annually. The U.S. average for homeowner's insurance is currently \$533, according to the Insurance Information Institute.

The situation has put the state in a vicious cycle: The more risk there is, the higher rates go and the fewer companies there are willing to offer coverage. The fewer companies there are, the less competition there is to keep rates lower.

The state's own public insurance plans for homeowners -- intended as a last resort for those unable to get coverage elsewhere -- have ballooned from 0.4 percent of the market pre-Andrew to approximately 6 percent this year, Piazza said, because of rising costs and companies pulling out. Officials are looking at raising rates to get that percentage down again and now spend much of their time trying to persuade more companies to write policies in coastal areas, Wooley said.

"In Louisiana we're starting to run into an availability problem, especially below I-10," Wooley said.

In the past month, for example, one of a half-dozen Lloyd's of London syndicates offering insurance in the state pulled out of the homeowner's market in the area, leaving hundreds of homeowners scrambling to find new coverage.

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Even when homeowners build on stilts and resort to other measures to keep their homes high, dry and secure, they still face significant insurance premiums and the threat that they could become trapped by rising waters. Here, Jay Culotta of Denham Springs works on gutters and decking on a house in the Southern Comfort subdivision being built on the Houma Navigational Canal in Dulac. The community has been hart-hit by hurricanes over the past 100 years, but a proposed Corps of Engineers levee could offer new protection against storm surges.

(PHOTO BY ELLIS LUCIA / The Times-Picayune)

Oil infrastructure exposed

People get flood insurance through the federal government's National Flood Insurance Program, which makes people in high-risk areas pay more, especially coastal areas prone to

storm surges, which get a special designation in the program. But as private insurance companies once did, the national program still partly subsidizes flood-prone areas, which means that it redistributes the premiums from people in low-risk areas.

Louisiana ranks first in the country in the number of repeat flood claims and is a constant drain on the program. Bush administration officials and some members of Congress are pushing for changes that will force some properties with repeat claims out of the program and raise rates for the rest in flood-prone areas. In New Orleans, the city's Office of Emergency Preparedness has offered a half-dozen such properties along Napoleon Avenue the opportunity to raise their homes at cut rates, thanks to a federal program that will underwrite 25 percent of the cost.

Industrial insurance has risen in tandem with private homeowner's insurance, adding a drag on the state's industries and governments. Recent coverage problems for school districts and parish governments may ease somewhat if no major catastrophes occur in the near future. But the long-term trend is toward higher rates and spottier coverage.

One reason for rising jitters is that erosion is encroaching on structures that were once well inland. This is a growing problem for oil and gas facilities built in the marshes that are now exposed to elements they were never designed to withstand.

"Pipelines running through marshes are under additional wave stress and becoming more and more exposed. So is infrastructure in the bays," said Greg Stone, a geologist with Louisiana State University's Coastal Studies Institute who is working on a computer modeling study of the problem for the state Department of Natural Resources. "If it needs to stay, it needs to be retrofitted; otherwise it may not survive. If a worst-case scenario (storm) came through, believe me, the existing infrastructure is not set up to withstand it."

Much of Louisiana's original oil and gas infrastructure was built in marshes, where the initial petroleum strikes were made. Even as most drilling moved offshore, a large network of pipelines, wellheads, relay stations and other facilities remained.

The landscape has changed around them, leaving aging facilities in open water, vulnerable to everyday wave action and the prospects of more frequent flooding and more punishing storm surges. Structures above the waterline may be in the path of debris loosed in a storm: mud, tree trunks, cars, tanks, even houses.



The allure of waterfront property is strong for some. But the attraction to canal, lake and river vistas carries a price tag. Braces like the ones used on this trailer just south of the Golden Meadow community on Louisiana Highway 1 can help keep homes and fishing camps tethered during high winds.

(PHOTO BY ELLIS LUCIA / The Times-Picayune)

"If (a storm surge) is big enough, it will get up above the existing floor of platforms where the equipment is. So your equipment is more vulnerable," said Al Thomas, the president of PetroQuest Energy, a Lafayette oil and gas exploration company. "Today you'd design totally differently than you would 10 or 15 years ago, when you had a barrier island to take the brunt of a storm."

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'A false sense of security'

The problem also shows up below the waterline. Most pipelines were originally buried more than 3 feet down. But many marshes are now open water. Waves and currents scour the bottom and expose pipelines, especially during storms. This has raised the threat of spills from pipeline damage because of snagged anchors and other hazards of ship traffic, and the possibility of debris striking pipelines in a storm.



The area's oil and gas distribution and service sites have the same problem on a much larger scale. They house strategically important concentrations of equipment that could be damaged in a storm and cause a temporary disruption in the flow of energy. And if they took major damage in a storm, Smith said, their owners might conclude

While some of the region's large industrial plants, such as the Union Carbide plant in Taft on the Bonnet Carre Spillway, face a danger from river flooding, chemical plants and other industry located farther inland on high ground face a different threat. In the next big storm, experts say, many plants may see unexpected damage from the high winds and tornadoes that a hurricane spins

they are better off moving to another staging area, such as Texas.

off.
(PHOTO BY ELLIS LUCIA / The Times-Picayune)

Port Fourchon, the large oil and gas service center perched near the open Gulf a few miles west of Grand Isle, is crucial to many of the central Gulf's offshore facilities. A major storm surge could cause big damage. Worse, the port is linked to the mainland by Louisiana 1, a two-lane road likely to be washed out in a major storm.

As roads sink, the state and local governments must repeatedly spend just to keep them open.

Most of the region's chemical plants and other large industrial facilities are built on high ground and are relatively safe from flooding. But they feel the effects of erosion in the form of higher hurricane winds, which sustain speed farther inland than they used to. In the next big storm, plants may see unexpected problems from wind damage, a study by LSU Hurricane Center director Mark Levitan shows.

Most industrial sites are designed to withstand the winds of a Category 3 storm, which run from 111 to 130 mph. The study found that different construction firms had different interpretations of building standards for hurricane-force winds, and that there probably are wide variations in the strength of structures. Because it has been decades since winds that high hit the area, the study concluded, "the experience of relatively minor damage to plants during Category 1 storms in this period has perhaps lulled many into a false sense of security."

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BUILDING BETTER

Requiring that new structures be designed to survive Category 3 and stronger hurricane winds would save lives as well as buildings, and in the long run would save homeowners money.

By Mark Schleifstein

Staff writer

Jefferson Parish officials found a disturbing flaw last year in their plans to open "refuges of last resort" for people stranded in a major hurricane: Only a few interior areas in a handful of public buildings could be trusted to withstand the 155- to 200-mph winds of a Category 5 storm.

"We were not really surprised," said Louisiana State University Hurricane Center director Marc Levitan, who oversaw an engineering assessment of the parish buildings. "Even in Florida, with their much more strict building codes, they've had serious problems with a deficit in safe shelter space."

New Orleans authorities decided to abandon similar refuge plans after concluding that up to 90 percent of the buildings in the city are vulnerable to damage from the most powerful hurricanes. Jefferson Parish is moving forward cautiously, knowing space will be limited for those left behind.

Emergency officials in both parishes say they are hoping to persuade people to evacuate rather than end up huddled in buildings that might dissolve or explode in the teeth of nature's most powerful force.

"We just don't have the structures in the metro area that are constructed to take that kind of wind," Jefferson Parish Office of Emergency Preparedness director Walter Maestri said. "Our building codes have not required us to build buildings capable of withstanding 170- to 200-mph winds, and engineers are now saying there may be even higher winds. Here the standard is 100 mph. And of course a lot of our buildings, except for the newer buildings along Poydras Street (in New Orleans),

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were built prior to any code being in place at all."

But experts say that must change: As Florida upgraded its building code and strengthened enforcement after Hurricane Andrew in 1992 and California has long required buildings designed to survive major earthquakes, south Louisiana needs to make changes to protect property and provide basic shelter for those caught in the path of a killer storm.

"We at least ought to be looking at hardening (making buildings more resistant to high winds) as far as public buildings are concerned," said Hucky Purpera, chief of the natural and technical hazards division in the Louisiana Office of Emergency Preparedness. "Every high school that's built could become a shelter, or certainly a refuge of last resort to save lives."

Authorities say protection could be greatly improved with some basic changes, including design and construction practices that would add as little as \$2,000 to the cost of a new home or to retrofitting an existing one.

"For wind damage, it's relatively inexpensive to do these things, like hurricane clips and straps on beams and rafters to hold roofs on," Purpera said.

Legislative requirements

Next year the Southeast Louisiana Hurricane Task Force, which comprises city and parish emergency preparedness directors, will recommend that the Legislature consider requiring any new government buildings built south of Interstates 10 and 12 to be constructed to withstand the worst of hurricanes.

"They should be built to withstand a Category 5 hurricane, not only wind load, but from an elevation standpoint for storm surge," said Gerald Falgoust, director of the St. James Parish Office of Emergency Preparedness and former chairman of the task force committee that is recommending the strengthened building requirement. "There are things that can be done if some engineering takes place prior to a building being built."

The problems with structures considered as last-resort refuges in Jefferson Parish included wide expanses of glass that would allow wind to "blow up" a building if debris smashed through the windows, walls built without reinforcing bars necessary to withstand 150-mph to 175-mph winds, and roof beams that were too long to guarantee they wouldn't collapse in such winds, LSU's Levitan said.

In many cases, water damage to roofs and walls also made the buildings too vulnerable to the effects of winds, he said.

The state-approved building code used in Jefferson Parish requires buildings to withstand the effects of winds blowing at 100 mph for three minutes. That's the equivalent of a shorter gust of wind blowing at 120 mph. A Category 3 hurricane can be accompanied by sustained winds of 130 mph and much stronger gusts.

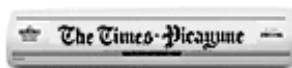
Falgoust said the Legislature shouldn't stop with strengthening requirements for public buildings. Building codes in the state should also be strengthened to reduce damage to private homes and businesses

from such storms, he said.

Purpera agreed, saying California's building code has been strengthened several times during the past 20 years as officials learned more about how to protect buildings from the effects of earthquakes.

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'We're way behind'

"We're way behind that, as far as preparing for a hurricane in Louisiana," Purpera said. "Architects aren't aware of what it takes to harden homes or buildings to withstand hurricanes in New Orleans, how to create a lot of individual refuges that could save lives."

Steven Bassett, a Palm Beach, Fla., mechanical engineer who helped Florida officials in their 10-year effort to rewrite the state's building code to address problems revealed by Hurricane Andrew, said strengthening the code will result in significant savings.

"States with substantial coastal regions should consider following Florida's lead," Bassett said. "To do so will improve building and housing integrity, save money through reduced storm-related property destruction and better protect the health and safety of those states' residents and visitors."

Florida's new code, and an even stronger code in Miami-Dade County, requires buildings on the beachfront to withstand sustained winds of 150 mph. Wind-speed requirements drop for buildings farther inland.

A preliminary study by Florida building officials of three large, expensive new homes found that the new state code added 3 percent to 10 percent to the cost, depending on whether the structures were built with masonry or wood, as well as the types of materials used to protect windows and other wall openings.

Levitan said such increased costs might be offset by lower insurance and repair costs over the life of the building.

"People think of building codes as a stick, but there's also a carrot coming with them," he said. "With a more strict building code, you might be able to get insurance, or pay less for it, or have a smaller deductible if the house is built to a better standard. Wind is the biggest single catastrophic loss that the insurance industry has to pay off," because

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flood damage is covered by the federal National Flood Insurance Program.

Improvements in building codes and their enforcement also can reduce the cost of flood insurance, as seen this year when a good code-enforcement record resulted in a 5 percent across-the-board reduction in flood insurance rates for New Orleans homeowners.

New Orleans is moving toward adopting the International Building Code and International Residential Code, which will require new buildings to withstand the effects of a 130-mph wind gust blowing for three seconds, a 10-mph improvement over the state's existing code.

Though the code requirements would seem to indicate a building would have to withstand the effects of a strong Category 3 hurricane, that assumption is inaccurate. Wind speeds in the Saffir-Simpson scale used to categorize hurricanes are based on one-minute averages, not gusts. Gusts can be as much as 50 mph stronger than the maximum sustained wind speeds, experts say.

During Hurricane Betsy and an unnamed 1947 hurricane, officials measured 125-mph sustained winds in New Orleans. The highest sustained winds measured in New Orleans reached 130 mph during a 1915 hurricane. Those winds ripped the steeples off a dozen churches and damaged thousands of other buildings in the city.

New Orleans also has the unique problem of protecting the centuries-old buildings in the French Quarter, which are both historic and a major tourist attraction.

Louisiana State Museum director James Sefcik, who manages many of the oldest buildings in the city, including the 18th century Cabildo and the Presbytere, said he is not too worried about damage from even the worst hurricanes.

"I don't have any doubts our buildings will take any level of hurricane," Sefcik said. "After the (1988) Cabildo fire, we instructed our architect to put the building back the way it was before. If you look at the Cabildo and the Presbytere, those cypress beams are about 14 inches thick, and they are pegged together, so it's unlikely anything is going to happen."

In advance of Hurricane Georges, he said, his staff boarded up the buildings in eight hours.

"We also can remove from the ground floor of buildings any artifacts that we feel would be at risk from rising waters in a day or day and a half," he said.

However, he is not so sure about other buildings in the Quarter. "I think that if their roofs are in bad repair, they're probably going to go. I think flying debris is probably going to be a serious problem. Lesser buildings, a lot of them are going to be damaged."

'Roofing was a problem'

Along Biscayne Bay in Miami-Dade County, by contrast, the building code required structures to be built to withstand winds of 150 mph even before Andrew. In interior parts of the state, the standard is 120 mph.

Still, thousands of buildings in south Florida were severely damaged or destroyed by Andrew's 135- to 145-mph winds.

Investigations after the storm found that much of the damage was the result of faulty construction and poor code enforcement.

"Roofing was a problem," said Bill delGrosso, emergency management coordinator for Miami-Dade County. "It had been installed with nail guns, and now we require screws. It's simple survivability things like that that really caused an awful lot of damage during Andrew, simply attaching roofs correctly."

But the biggest problem centered on the Miami-Dade County code's lack of a requirement to cover window openings, Bassett said.

Homes with windows that were not protected by shutters or shatter-resistant window glazing were supposed to be designed to withstand the pressure of high winds pouring into the structure. But they weren't, he said. Today all buildings in Miami-Dade County must be built with shutters or windows designed to withstand windblown debris. Coverings made of 5½-inch plywood also are acceptable.

Miami-Dade County, using a Federal Emergency Management Agency grant, also is installing shutters on several thousand homes owned by low-income residents, part of the county's strategy to have residents upgrade buildings to the point that they don't have to go to storm shelters.

The proposed changes in New Orleans' building code will require windows to be made of impact-resistant glass or to be protected by shutters, or that buildings withstand a 130-mph gust with or without window coverings. But adoption of the new code would not require retrofitting of older buildings. Building code administrator Curtis Mann said state law prohibits the city from applying codes retroactively unless more than 50 percent of the structure is being replaced.

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SEEKING SHELTER



North Carolina officials had expected to shut down their temporary housing program after 18 months, but 33 months later, there are nearly 70 families still living in temporary housing, such as here in Princeville, N.C.

(PHOTO BY ELLIS LUCIA / The Times-Picayune)

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After Hurricane Floyd inundated parts of North Carolina in

1999, thousands were left homeless. Today, nearly three years later, some people are still living in temporary trailers.

By John McQuaid

Staff writer

ROCKY MOUNT, N.C. -- Griffin Clark's string of bad luck began when Hurricane Floyd flooded her out of her apartment in a small public housing development in Tarboro, N.C. Then an old foot injury acted up and she had to get orthopedic surgery. Unable to work for a time, she lost her job at an auto parts plant. Unable to pay the bills, she filed for bankruptcy. Amid the problems, she was unable to find a new place to live.

So for two years -- long after Floyd had become just an unpleasant memory for most people -- she stayed in a mobile home provided by the Federal Emergency Management Agency for storm refugees in Rocky Mount, about 20 miles west of Tarboro.

"It's not much, but it's home," she said, sitting on a couch and looking down at the tattered carpeting in the living room one day in November. "It's been rough being so far from my real home, my friends. I've been trying to get out, rent an apartment back in Tarboro. But there's no place to get out to."

Clark finally moved out in March, 30 months after the hurricane struck. With help from a federal relief program, she bought one of the used FEMA mobile homes on a plot in a park once used for storm refugees, now converted to private use, just outside of Tarboro.

When a disaster wrecks homes, the federal government steps in with temporary housing, considered a last resort for those who cannot find anywhere else to stay. The idea is to provide basic shelter until homes can be repaired or rebuilt. But when the damaged buildings are public housing units and rental apartments occupied by poor people, owners or agencies may be slow to rebuild. They may never come back at all. With nowhere else to go, people with few financial resources can end up in temporary housing for a very long time.

North Carolina's post-Floyd problems with poverty and temporary housing give a hint of what New Orleans could face on a much larger scale if a catastrophic storm swamps the city. North Carolina's experiences also provide a rough road map of what emergency managers here would have to do to address the needs of newly homeless residents.

Based on the North Carolina example, the state and federal governments would end up running what would be the largest public housing program in the nation's history, allocating money and other resources to maintain large trailer and mobile home parks while waiting for inexpensive, alternative housing to be rebuilt in the city. That might not take place for years, if it occurs at all.

North Carolina's temporary housing program was supposed to shut down after 18 months. But it was extended twice, and 33 months later it is still operating after a second deadline expired. Officials had whittled the numbers down to 69 families at the start of June, and they are hoping to end the program this summer.



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Floodwaters from Hurricane Floyd filled the streets of Bellhaven, N.C., in 1998, damaging nearly a third of the town's residences. Bellhaven Town Manager Tim Johnson says the town is still recovering.
 (PHOTO BY ELLIS LUCIA / The Times-Picayune)

Flood leaves 10,000 homeless

North Carolina's 1999 deluge bears a rough resemblance to the "filling the bowl" scenario in New Orleans. The hurricane came on the heels of a tropical storm that dumped heavy rains and swelled local waterways. When Floyd strafed North Carolina -- the worst hit among the East Coast states that were declared disaster areas -- heavy rains, river flooding and a storm surge in coastal areas put 18,000 square miles of land under water. Dozens of towns were flooded, some for days, a few for weeks.

In Tarboro, "the roads filled up with water," Clark said. "There were frogs and snakes. I didn't have more than two days worth of clothes when we left. Water was coming up in the driveway. All we could see was water. It stayed up two to three weeks before we could get back in there. When we

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did, the whole apartment complex was flooded. What water didn't damage, mold got to. Steps collapsed. Everything was piled in the middle of the floor."

The hurricane's widespread flooding initially left more than 10,000 people homeless and heavily damaged 15,000 homes. If the levees are topped on the east bank of Orleans, Jefferson and St. Bernard parishes, by contrast, the disaster would be more confined geographically but would affect more people and structures. More than a 100,000 dwellings would be heavily damaged. Hundreds of thousands of people would initially be left homeless.

Days after Hurricane Floyd, after everyone stranded was rescued and the waters receded, North Carolina emergency managers realized they had no plans for how to handle the massive needs of the dispossessed. In spite of that handicap, they managed to mobilize fast. They formed an interagency committee to handle the response and manage the \$1.3 billion in disaster aid that would soon be coming through. They hired Doug Boyd, an ex-Army major, to run the program. Workers fanned out to canvass possible locations to build temporary trailer parks, preferably as cheaply as possible. FEMA initially moved in more than 1,800 travel trailers and, more gradually, 475 mobile homes to accommodate the approximately 5,000 people -- about 2,000 families -- in need.

South Louisiana would require a more massive national mobilization of resources, one that might even stress national inventories of trailers and mobile homes. FEMA and state agencies would truck thousands of those housing units into the region from points across the United States. Officials working on catastrophic disaster planning are looking at where the units might go and say it might have to be far from New Orleans -- rural Mississippi, for example, something that might put commuters in a bind or force some to quit jobs, if their jobs still exist.

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'Little towns' spring up

North Carolina officials set up 11 parks for travel trailers and the more permanent mobile homes. Some ended up in remote rural areas, others on unused properties in industrial areas on the edge of small towns -- generally, the least desirable spots around. "If you have to live in temporary housing, you can have it at three locations," Boyd said. "First, the best if you are the homeowner, put it on your own property. Second, a commercial site, a trailer park, close to your home. Third, group parks. For renters we had to build group parks."

Setting up and maintaining the parks was a complex job. It involved installing utilities, ensuring police protection and dealing with the needs of individual families.

"You're building little towns," Boyd said. "So you've got sewer, electrical stuff. You have to build the infrastructure before people can move in. We had to put everything in place -- had to build mailboxes, hire a transportation company to bring buses to take people to the hospital, grocery stores or other places they need to go."

The parks were crowded and unpleasant places to live, residents say. Some liken them to Third World refugee camps. "It was kind of like living in a neighborhood, but noisy," said Theresa Richardson, who lived in a park with her family for more than a year. "You were compacted together; everyone could hear your conversations, people walking by at all hours of the night."

For a time police units were assigned to some of the parks around the clock because of rampant crime. "You bring so many people close together, you got problems: domestic disturbances, drugs, prostitution," said Stan Ballantine, who manages the Fountain Industrial Park site.

Stuck with administering these quasi-towns, officials worked to move people out and shut them down. But that work has been slow and arduous because of a lack of affordable housing units for the poor. The sparsely populated rural area never had a lot of rental housing units, and now it has fewer.

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"Eight or nine family public housing complexes were destroyed as a result of Hurricane Floyd," said Eric Tolbert, the state director of emergency management. "In some cases the rebuilding process hasn't been started. Of those facilities there is only one that has started leasing, letting residents back in. . . . The procedure to go through and get approval to rebuild those units took a long time. With private rentals, owners are not, for whatever reason, going to rebuild it or don't want to lease to the tenant again."

New Orleans has 20,000 people living in public housing. In the wake of disaster, it's unclear how, or if, the federal government would move to redevelop the property immediately. Renters would also face an empty market at first, then one that might be rebuilt to suit the needs of those with higher incomes.

"Anywhere you have a relatively poor population, they are typically renters, so they have little control over whether places are rebuilt," said Betty Morrow, a sociologist with the International Hurricane Center at Florida International University in Miami and co-author of a book on the effects of Hurricane Andrew, which hit south Florida in 1992, devastating the working-class suburban area of Homestead.

Eventually, about 70 percent of single-family housing in Homestead was rebuilt, but less than half of the multifamily units, according to Mary Comerio, a professor of architecture at the University of California, Berkeley, and author of a book on disaster recovery.

Similar misfortunes befell low-income residents after the 1989 Loma Prieta, Calif., earthquake. "There were 8,000 to 10,000 housing units lost, which seems like a small number," Comerio said. "But they were almost all residential, low-income housing. They turned some Safeway (grocery store) they were using as temporary shelter into a homeless shelter. There was no alternative housing for those who lost their homes."

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Some reluctant to move

There are no clear rules governing how long people may stay in temporary housing, and North Carolina officials have not tried evicting anyone -- yet. People who remain are urged, but not forced, to move out and are given help navigating the complex terrain of public and private aid and loan programs -- not easy for people who have lost their homes and must start from scratch financially.

Some remaining residents are reluctant to move out. Under the program they pay no rent, water or sewer bills. However inconvenient it may be to live in an out-of-the-way trailer park, the alternatives may be more expensive and less comfortable. "I hate to say it, but some people get complacent," Boyd said. "They're paying only electricity and say, 'Why should I leave' "

But long-term tenants say they have trouble getting enough cash together to meet the requirements of apartment living, including the references and security deposits that are often required. "My finances have been up and down," said Rosemary Myrick, who was living with her two children in a mobile home park. They moved out to an apartment last month. "I just got a job as a cashier at a tire and auto shop. Now there's a problem with credit. (I'm) trying to get that straightened out. It's fine living here. It's home for me -- for the moment. I don't take anything for granted since the flood."

Some reasons for optimism exist. Assuming it's salvageable, a devastated New Orleans will almost certainly receive a massive influx of federal money that can provide some seeds to rebuild, though any effort would be arduous.

In North Carolina, post-Floyd programs have helped most of the dispossessed get their own housing. FEMA and state grants are available to buy homes. Private charities have also gotten involved. For example, after more than a year in temporary housing, Richardson took advantage of a program run by Habitat for Humanity. She and her husband put up a modest down payment and together contributed 500 hours of labor

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building a house. Last year they moved into a new, three-bedroom home on a residential street.

John McQuaid can be reached at (202) 383-7889 or john.mcquaid@newhouse.com.



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Hurricane Andrew left the most costly mess of any Hurricane in history, and delivering a wakeup call to emergency officials.

(NWS ARCHIVE PHOTO)

As more people settle on coasts and in other vulnerable areas, natural disasters have been getting more expensive.

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TEMPTING FATE

The double-strike of Hurricane Andrew, the costliest hurricane in history, was a wakeup call as to the increasing cost of populating at-risk areas.

MODEL SOLUTIONS

Powerful computers are working to predict where flooding and other damage will occur during hurricanes.

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GRAPHIC SPECIAL: View a computerized animated SLOSH model of what might happen if Hurricane Betsy hit today.

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Hurricane Andrew left thousands homeless and billions of dollars in damage as it shredded its way across Florida and on to Louisiana. (NWS ARCHIVE PHOTO)

Across the country, development in disaster-prone areas is accelerating in the path of hurricanes, floods, wildfires and earthquakes. It's a recipe for catastrophe.

By John McQuaid and Mark Schleifstein

Staff writers

Hurricane Andrew was a turning point in the modern history of natural disasters. In August 1992 the storm tore apart hundreds of houses in Homestead, Fla., leaving nothing but splintered beams and rubble across dozens of city blocks.

Andrew survived its first landfall, grew stronger and pummeled the small bayou communities and oil and gas rigs of Louisiana's Atchafalaya Basin.

Florida and Louisiana had seen big storms come and go. But as insurers

and government officials tallied the numbers in the following days and weeks, Andrew's most significant feature emerged: It had broken all U.S. records for disaster damage. The mounting toll in cleanup costs, wrecked property and lost business eventually hit \$30 billion.

The number crunchers were shocked at first. Most had never imagined such a total was possible. But in 1994 the record was quickly shattered by an earthquake that jolted Northridge, Calif., causing losses ultimately estimated at \$44 billion.

And it could have been a lot worse.

Both disasters hit relatively confined geographical areas in suburbs, sparing the large cities -- Miami and Los Angeles -- just miles away. Relatively few people died: 57 in the quake, 61 in the hurricane.

The earthquake was a moderate magnitude 6.7 on the Richter scale and lasted 15 seconds. Andrew was a powerful Category 4 storm, but it was moving fast and crossed inhabited areas of south Florida in minutes. By the time it hit a sparsely populated section of Louisiana, it had weakened considerably and was still moving fast, so it caused relatively little damage here.

Andrew and the Northridge quake opened a new era in which the United States will see such megadisasters become commonplace, emergency managers and experts say.

Because of population growth and a massive expansion of settlement into high-risk areas in the past generation, more people and more communities than ever are on the precipice of destruction. The wildfires burning across Colorado and Arizona in the past two weeks are just the latest example of this growing problem.

"History shows that the catastrophes we have had have become larger and larger," Federal Emergency Management Agency director Joe Allbaugh said. "It's due to development along the coast, increasing populations across the board. We have problems now with fires in the West. Traditionally the fire season doesn't start till summer. This time it started in January. . . . So we need to be in the business of preparing."

Development itself is making places more vulnerable to disaster. As people have tried to tame nature by building homes, redirecting water, suppressing fires and reshaping coastlines, they have disrupted or blocked natural processes. But you can't just lock nature in place, and these measures have accelerated cycles of destruction in unpredictable and dangerous ways.

"There's a tendency to see these events as chiefly the result of natural forces beyond human control," said Ted Steinberg, an environmental historian at Cleveland's Case Western Reserve University and author of "Acts of God," a book on disasters. "And obviously a tornado is a physical phenomenon. But what's disastrous about these events is that to a certain extent they're within human control because of policies we put into effect. We have a situation where natural forces lead to calamitous consequences that might otherwise be avoided."

In the wake of the Sept. 11 terrorist attacks, which helped send the federal budget spiraling into deficit, these trends raise questions about how the federal government will shoulder the costs of recovery from future

natural disasters if they regularly rise into the billions. Some states and local governments are taking a more aggressive stance in disaster prevention, and emergency managers say the trend is catching on. The changes could mean more costs for the New Orleans area, which depends heavily on federal programs to protect it.

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Hurricane Andrew brought flooding, high winds and tornadoes, such as the ones that raked through the LaPlace area, shown here.
(NWS ARCHIVE PHOTO)

Damage grows over U.S. history

For 300 years, people have worked to tame a vast, diverse and dangerous American landscape for settlement and safety -- often at the cost of lives and property when nature suddenly struck back.

A hugely powerful sequence of three earthquakes in 1811 and 1812 on the New Madrid fault running through the Midwest and South probably measured more than 8.0 on the Richter scale and was felt across the continent. But the earthquakes did little structural damage because there wasn't much to knock down. If a similar quake struck today, it would devastate St. Louis, Memphis and other large cities.

As the U.S. population increased, death tolls rose and damage worsened. When a hurricane hit Galveston, Texas, in 1900, the storm surge killed at least 8,000 people, 22 percent of the population of 35,000. More than half of Galveston's buildings were destroyed. The 1906 San Francisco

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earthquake measured between 7.7 and 7.9 on the Richter scale. The quake and subsequent fire killed more than 3,000 people out of a population of 400,000 and leveled portions of the city.

The 1927 Mississippi River flood inundated 27,000 square miles of the Midwest and South with water up to 30 feet deep. Although much of the flooded area was farmland, the water washed away 2,200 buildings and damaged thousands more. Early estimates put the death toll at 250, but some historians now say it was more than 1,000. About 700,000 people were left homeless in an event that prompted the federal government to launch major flood-control efforts along the river.

For the balance of the 20th century, the nation benefited from the innovations spawned by the industrial and electronic revolutions. Death tolls fell as building techniques and weather prediction improved and local governments developed ever more sophisticated civil defense and evacuation plans and the means to broadcast them.

Hurricanes, flooding, fires and earthquakes left their marks, but they have never surpassed the modern megadisasters that have taken place abroad. Hurricane Mitch, for example, struck Central America in 1998, killing more than 9,000 people and leaving more than 2 million homeless. The 1976 earthquake that leveled the entire city of Tangshan, China, killed more than 250,000.

But U.S. natural disasters have recently taken a dramatic turn for the worse. Though death tolls have remained low, the physical scale of destruction and its costs have shot upward. In the United States, for example, the total cost of all natural disasters averaged \$10 billion annually from 1975-1989, according to a 2002 National Academy of Sciences report. But during 1990-1998, the figure climbed to \$17.2 billion.

That means federal, state and local expenditures for preparation, cleanup and rebuilding are rising. The insurance industry has fretted and retrenched several times, cracking down on consumers each time, most recently after Sept. 11. Government policies and programs that once worked are breaking down or backfiring.

Landscape of risk

Louisiana is just one place where these trends have converged: Development and man-made alterations in the landscape have reduced natural protections such as wetlands. That process has outpaced the ability of governments to build new disaster protection such as levees and flood-control systems and to plan efficient evacuation routes.

These changes are shaping a landscape of risk across the United States, from the hurricane- and flood-prone Gulf and south Atlantic coasts to the annual ritual of wildfire evacuations in the West to the vast suburban areas on the West Coast vulnerable to earthquakes.

With an explosion of coastal development in the past generation, there are now more people living within a mile of a coastline than at any point in the past. In 1960, an average of 187 people were living on each square mile of U.S. coast, excluding Alaska. This population density increased to 273 per square mile by 1994 and is expected to reach 327 by 2015.

This trend puts more people in the path of hurricane winds and flooding. It also has made it harder to design evacuation routes that funnel large

populations away from the coast quickly, as New Orleans area residents learned in 1998, when about 325,000 people fought traffic jams to get out ahead of Hurricane Georges.

Development has worsened erosion of beaches all along the coast, creating a slow but steady march of the sea inland, exposing more structures to hurricane-force winds and flooding.

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Trees downed by Hurricane Andrew destroyed these homes north of Avery Island in Louisiana. Fortunately the residents had fled. (NWS ARCHIVE PHOTO)

Floods and fires inland

Inland, a similar dynamic has put more people in the path of more common flooding from rainstorms and rivers overflowing. Most cities lack the elaborate flood-protection system that the New Orleans area has -- levees, pumping stations, canals to route water out of town -- but many have accelerated development in and around flood plains without considering the consequences.

"Floods are not necessarily a harmful thing until humans build something in the way," said Larry Larson, executive director of the National Association of State Floodplain Managers. "Flood losses are not going down, they're going up because we're building too many structures at risk. We don't think of how development may change flooding dynamics. Today's flood level is not tomorrow's flood level. Changing the farm field or forest into a parking lot changes the runoff, and often that's not taken

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into account."

Every year, dangerous fires threaten and sometimes destroy communities that abut wilderness areas. Like hurricane warnings, evacuating from areas threatened by wildfires has become something of an annual ritual. This year's fires have already outpaced the record-setting 2000 season in acres burned. Fires currently burning in eastern Arizona and Colorado have destroyed close to 600 homes. Two years ago a wildfire sparked by accident during a controlled burn swept through part of Los Alamos, N.M., gutting 235 homes.

Fire plays an important role in the ecology of forest areas. It clears out deadwood and old trees, letting more light hit younger trees and reach the forest floor. Most unspoiled forests have a "fire regime" -- a cycle lasting anywhere from a year to a decade or longer -- in which flames return at regular intervals.

Improved firefighting capabilities, the need to exploit forests for lumber and the wish for safety led to a decades-long policy of suppressing fires on all federal lands in the West. The practice became routine on private lands as well. A denser, overgrown forest is a greater risk for wildfires. As a result, the rapidly-expanding borderland between suburbs and woods is turning into a tinderbox.

Earthquakes pose a problem distinct from other kinds of disasters. The risk is spread over much wider areas, and quakes are virtually unpredictable until seconds before they hit. Human activities do not contribute directly to the likelihood or intensity of a quake, but they do determine how much damage will occur.

Earthquake specialists say that communities generally underestimate their long-term earthquake risks and do little to prepare. There are good building codes, but few incentives for smaller cities and communities to adopt them. In larger cities, older housing stock typically doesn't meet current codes. So in many vulnerable spots, codes effectively don't exist.

Building codes are also designed primarily to keep buildings from collapsing on people, not to minimize damage.

"Building codes are designed to protect life safety," said Susan Tubbesing, executive director of the Earthquake Engineering Research Institute in Oakland, Calif. "That is really quite a low level, and unfortunately people take that as the upper rather than the lower bound."

Mounting losses and risks have handed the federal government an ever-growing responsibility for mopping up in what some worry will be a growing drain on federal resources.

In the first half of the 20th century, the U.S. government had virtually no role in disaster relief. When a hurricane struck Miami in 1926, it caused more than \$40 billion in damage in today's dollars. The federal government did nothing. In the postwar boom Congress passed the Disaster Relief Act of 1950, which provided postdisaster payments to local governments. Then as the scale of disasters grew and the federal government assumed a more prominent role in American life, it took on a central role.

Under the 1988 Robert T. Stafford Disaster Relief and Emergency Assistance Act, the law that defines the current federal and state roles in

disaster relief, the federal government is secondary to states. But states and localities don't have the resources to cope as the scale of disasters grows.

"It's supposed to be a backup, but the whole notion of a backup has gone away," said Mary Comerio, a professor of architecture at the University of California, Berkeley, and author of a book on disaster reconstruction policy.

State officials still officially run the show after a disaster strikes, but it's the federal programs that make a difference. The Federal Emergency Management Agency, or FEMA, coordinates the response of federal agencies during and after a disaster, and it distributes money and loans for rebuilding in the weeks and months afterward.

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Debris from Hurricane Andrew, which once covered the Highway 57 north of Cocodrie, has been scooped up during cleanup after the storm. (NWS ARCHIVE PHOTO)

Requests for aid rising

As disasters became more a focal point of national attention, of cable news and the Weather Channel, disaster response became increasingly popular -- and politicized.

During the 1990s, the Clinton administration restructured FEMA after a poorly coordinated federal response to Hurricane Andrew in Florida drew complaints from disaster victims. Recognizing that a quick and well-coordinated response to future disasters would bring practical benefits and political rewards, Clinton beefed up the agency's budget and refined its mission.

The federal role in disasters expanded still further, and with it the number of requests for disaster aid. From 1977 through 1981, the average number of presidential disaster declarations -- which open the spigots of federal aid -- was 25 per year. For the five years ending in 2001, that number had doubled to 50 per year. Some critics say the bar on what qualifies as a disaster has effectively been lowered, though the fact that

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there is more vulnerable real estate also plays a role.

Critics say federal policies stressing relief over disaster prevention have encouraged development in dangerous areas.

"The intent of these (disaster-relief) laws was not just to help victims who through no fault of their own are in the way of disasters," said University of Massachusetts geography and planning law professor Rutherford Platt, "but also to try to limit the exposure of new development and population to hazards.

"But in the last 15 years, the emphasis has been increasingly on helping the victims with much-publicized disaster declarations, and pulling back on sensible land-use planning and other solutions," he said.

Though FEMA's role as a taskmaster coordinating the emergency response of multiple agencies improved, disaster programs themselves have not been streamlined. The legacy of haphazard changes in the past several decades, disaster relief is the responsibility of at least 16 distinct programs in different departments. For reformers trying to track the federal role in disasters, it's almost impossible to get a total for the amount spent annually. Many individual programs, such as FEMA's flood-plain mapping and the Interior and Agriculture departments' fire-prevention efforts, are in disarray.

The system also makes most disaster-prevention grants available to communities only after they've suffered a disaster, something experts say gets it backward.

The disappearance of the federal budget surplus and the ongoing threat of large terrorist attacks have raised an alarming issue: The federal budget can ill afford a string of major disasters that cost tens of billions of dollars or more. State budgets, currently in a fiscal crunch, are ill-prepared to pick up the slack.

"The nut I'm out to crack is 'it's not going to happen here,' because it will," University of Colorado disaster sociologist Dennis Mileti said. "In San Francisco, we're looking at a quarter-of-a-trillion-dollar earthquake. If Andrew made a direct hit on Miami or New Orleans, we're talking something similar. We had a \$100 billion earthquake in Kobe (Japan, in 1995). There didn't used to be disasters that big. Now there are."

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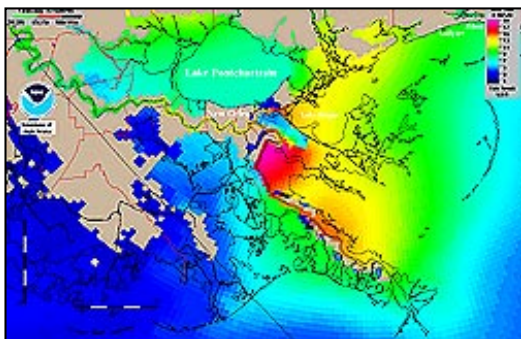
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MODEL SOLUTIONS



A computerized model offers a look at the storm surge flooding across the southeastern Louisiana area if Hurricane Betsy were to hit today.

[View the animation](#)

(NOAA SCREEN CAPTURE)

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Powerful computers now can predict where flooding will occur and what damage to expect. With that information, engineers can design better levees, and emergency preparedness officials can plan quicker evacuations and better relief efforts.

By John McQuaid and Mark Schleifstein

Staff writers

As Hurricane Georges shadowed the Gulf Coast 460 miles southeast of New Orleans early on a Friday morning in September 1998, Louisiana State University engineering professors Vibhas Aravamuthan and Joseph Suhayda huddled over a computer workstation in their campus office suite, sorting through terrifying scenarios of what the next few days might hold.

The National Weather Service had just issued its 5 a.m. advisory for Sept. 26, predicting that Georges, a Category 2 storm with winds of 105 mph, was expected to continue heading west-northwest at about 9 mph. The most likely track had it making landfall just to the east of New Orleans in less than 72 hours, a potentially devastating course that could flood large swaths of the metro area.

Aravamuthan plugged data on the likely track into a program running on his terminal that simulates hurricane storm surges. The professors waited

for two hours as the computer crunched the numbers and finally displayed a rainbow-colored, pixelated map that showed where to expect high water. In the simulation, the flood rose and topped the levee at a low point where U.S. 61 crosses west out of Jefferson Parish, sending water pouring into protected areas. The map showed three quarters of the east bank of Jefferson and Orleans parishes ending up underwater.

Suhayda consulted with the state Office of Emergency Preparedness, the Army Corps of Engineers and officials in Jefferson Parish, who accelerated a planned sandbagging of the weak spot. Some corps officials decided to cancel their plans to leave the area so they could stay to monitor potential trouble spots in the levee system.

Georges ultimately veered to the east and the New Orleans area was largely spared, except for flooding in St. Bernard Parish. But the episode shows just one of the ways that computer modeling is changing and refining emergency response plans that once relied mostly on guesswork.

Mapping and modeling software have made it possible not just to forecast hurricane tracks but to predict how the storms interact with a landscape, to show where flooding and wind will strike and what damage they might do.

"It's had a huge effect," said Jay Baker, an associate professor of geology at the Florida State University who studies hurricane evacuations. "It's the foundation of all evacuation planning studies that take place now. It's night and day. It used to be a real guessing game: You evacuate from low-lying areas. Now it's modeling."

The advances in computing power let programs take many different factors -- such as land elevations, wind speeds and ocean currents -- superimpose them and predict how they will interact. Today, government agencies and private companies use an array of these.

The ultimate aim is to mimic reality as closely as possible. But different programs have different purposes. Some are complex, high-tech exercises that meticulously account for every bump in the landscape, and they can take many hours or days to run. Others, like the LSU model, can be run quickly to generate information as events unfold.

Local emergency preparedness agencies use SLOSH (Sea, Lake and Overland Surges from Hurricanes) and a related program called HurrEvac to design evacuation routes and manage evacuations as they occur. The Federal Emergency Management Agency uses a program similar to LSU's to calculate flood risk for insurance rates. The corps is using a model called AdCirc (Advanced Circulation Model for Coastal Ocean Hydrodynamics) to examine its levee designs. Insurance companies use models to estimate the risk of wind damage.

Having a way to simulate hurricane flooding is especially useful because hurricanes are relatively rare and idiosyncratic events. They move across the coast in unique ways, bringing floods, winds and rainfall along varying paths. A storm's strength is only one factor in flooding. Water heights change quickly depending on wind, the storm's track and the obstacles encountered. So there isn't a good historical record that would allow scientists to judge how often a place might be flooded or how the next big storm might affect a given locale.

Without modeling, government agencies would be left to trial and error:

Build in response to past floods and wait for the next storm to hit to see whether they are right. With it, a modeler can draw a stretch of the coast and throw thousands of different storms at it from every possible direction to identify trouble spots.

The New Orleans area presents a unique problem for programmers. In most other places, the boundary between coast and sea is clear and the land rises above sea level relatively fast. But south Louisiana is flat with alternating areas of water and land. Much of the land, including heavily populated areas, is below sea level. Some places are surrounded by levees. The Mississippi River, smaller waterways and canals snake through the area.

"The whole way in which a storm evolves once it makes landfall is not as well-known as the behavior of storms on the open ocean," said Joannes Westerink, a University of Notre Dame engineer working on the AdCirc storm-surge model for the corps. "Yet there is no region in the country where that is more critical than Louisiana. You have Lake Pontchartrain that is able to nail New Orleans (from the north). Surge can propagate up the river, and surge can come in from southeast. It's a complex problem."

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Forecasting on the Web

So it's a big challenge to create software that mimics this landscape and shows how an enormous, hurricane-driven swell moves across it. Programs gauge the complex forces acting on the water column, such as wind and air pressure using basic equations that describe fluid dynamics.

Programmers must try to model the winds of an artificial hurricane so they match a real one. They must decide how wide an area to model. If the area is too small, the model won't depict the slow buildup of a surge on the open sea and will end up with inaccurate results on what occurs when the wave hits land.

Once a model is complete, scientists use "hindcasting" to make it conform to reality. They plug the parameters of a real storm into a model and compare the results with recorded storm-surge heights. If the numbers don't line up, then the program needs adjusting.

If a model works, many scenarios can be explored. The National Weather Service uses the SLOSH model to run parallel tracks of storms at various strengths across an entire area. It then puts them together in a map showing the high points for flooding from each category and speed of storm. Emergency planners can then see the worst case for flooding in, say, a Category 3 storm moving at a given speed. The areas deepest underwater get highest priority in evacuations.

The increasing power of personal computers means that models can be run in much shorter times than before -- enough time to collect data, input it into a model and get a useful result as a storm approaches. The LSU engineers have been doing this since the mid-1990s, offering flood forecasts to local officials on the World Wide Web after every six-hour weather service track prediction.

Such information can be used to plan road closures, sandbagging efforts and evacuation management. "If there has been a major change in the way we deal with these things, it's in the short term. Hour by hour, we are able to factor in minor nuances and changes in direction of a storm,"

Jefferson Parish Office of Emergency Preparedness director Walter Maestri said. "And the way we use that information for short-term planning is if there's an area where for whatever reason people have not responded, we use it to move those folks out quickly."

Modelers can also take a real storm from the past and rerun it in today's landscape. Since the landscape is sinking and eroding and levees have been built or raised, storms from the past would produce different flooding patterns today. Designers can judge weak points in today's landscape and levee designs and plan for the future.

Though they may be looking at the same phenomenon, no two models are alike in the way they interpret the various forces at work in a storm surge. The differences depend on how the model was developed, how it depicts the intricacies of winds and water currents and its real-world purpose.

A recent SLOSH simulation shows Hurricane Betsy moving over a present-day New Orleans. As the storm hits, the model shows water rising along the levees on the south side of St. Bernard Parish and along the Intracoastal Waterway as it heads into New Orleans. Soon the water is pouring over the top of the levees at those two junctures and is spreading through Chalmette and eastern New Orleans. By the time the flood ends, water has reached depths of 5 feet in Chalmette and 8 feet in some parts of New Orleans.

But the corps says the levees would hold off another Betsy. They cite AdCirc model simulations that show Betsy hitting New Orleans today with no flooding inside the levees. AdCirc is considered the state of the art in storm-surge modeling in part because it can re-create the winds of historical hurricanes with some accuracy.

The SLOSH model is used to alert the public to flood threats and plan for worst-case situations. Typical SLOSH maps show the highest possible flooding over wide areas. But several modelers using other programs say SLOSH may overestimate flood levels.

"For Louisiana, SLOSH tends to give higher elevations than the FEMA model," Suhayda said. SLOSH maps, he said, "would tend to overestimate the flood threat. For purposes of evacuation, where you are trying to portray what could be the worst case, that's not that bad. But if you apply that reasoning to flood elevations for the FEMA model, it's totally different. If you build your house, and (the model shows) flooding is higher, you'll have higher rates and people are going to complain much more."

National Weather Service SLOSH modeler Wilson Shaffer defends the general accuracy of the program. But, he said, "given the choice of over- or underestimating, I would rather err on the side of overestimating what it is. The results of underestimating could be disastrous."

Such differences aren't unexpected. "The models are all trying to do the same thing," Suhayda said. "It's just different approaches. In that sense no model is perfect; each one has to make those compromises."

Improving the grid

One of the biggest problems in storm-surge modeling is that the grid used to represent a given landscape is often crude, with points sometimes a

mile or more apart. Flooding critical to the New Orleans area, such as levee overtopping or water in the streets, takes place on a much smaller scale.

AdCirc uses a mathematical technique common in computerized engineering, crash testing and 3-D animation. It creates a "mesh" of triangular cells that represents the landscape and a more precise mathematical technique to calculate surge dynamics. Recent advances have let programmers create a very fine mesh, with points only a few hundred feet apart, in areas such as New Orleans, while leaving a looser mesh on the open water. That way the computer focuses on the areas that count.

"It's providing lots of detail," Westerink said. "About 90 percent of the computational time is spent on south Louisiana, but the grid spreads out to the entire Gulf."

As computer power grows, the models get better and also deal with new challenges. "The models are evolving," Westerink said. "Any model that stagnates, it's not good. In the 1970s we were doing computational models that had several hundred points. Now we're in the millions." But as the scale gets finer, new questions come up. For example, AdCirc modelers are studying in detail how to represent water flowing over a weir or a levee, a fine detail not seen before.

Current surge models also don't account for the smaller waves that run on top of the large surge wave. Doing so would involve complex calculations, because waves depend not only on winds but on currents and water depth. But waves do plenty of the damage in a flood, so generating a model that accounts for waves may be the next big advance in storm-surge modeling.

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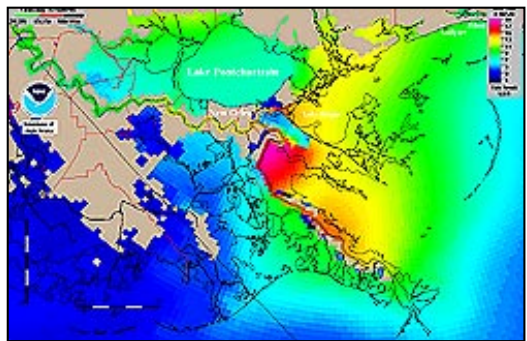


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Hurricane Betsy - Animated SLOSH Model

This animation, produced by National Weather Service scientists using the SLOSH (Sea, Lake and Overland Surges from Hurricanes) Model, shows what might happen if Hurricane Betsy hit the present-day southeastern Louisiana landscape, which has higher levees than in the past. It shows flooding in eastern New Orleans and St. Bernard Parish inside hurricane levees. Experts caution that the model is somewhat speculative, and at least one other model shows that Betsy would not flood inside the levees if it hit today.

Click for 480-324pixel animation

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Another huge structure will be built on top of sensitive marshes. Its big innovation -- a design to let water flow back and forth through gates to preserve wetlands -- is untested. And no one is yet sure how to integrate it with planned coastal restoration projects.

Hurricane risks are on the rise here because natural storm protections such as wetlands and barrier islands are disappearing. And for 200 years the corps -- with its propensity to build large projects that hurt marshlands -- has unintentionally contributed more to the deterioration of those protections than any other agency, public or private.

Now the corps is in charge of fixing many of the problems it created, and officials plan to use many of the same techniques they always have.

If current plans to restore the coast get a green light, the corps will have a central role in building levees, locks and floodgates and in maintaining and rebuilding wide areas of marshlands and barrier islands all at the same time. Its record raises a central question: Can the corps learn from mistakes and protect the region from hurricanes, or might it end up making a bad situation worse

Protections foster erosion

Since the early 1800s, the corps has designed, built and maintained the massive public works projects that make modern New Orleans and south Louisiana possible.

The corps created the deep-draft Mississippi River channel that helps the Port of New Orleans serve as the nation's largest handler of bulk cargo. The corps raised key levees that protect the city and development along the river from spring flooding, tropical storms and hurricanes. The corps also built and permitted the navigation channels for an expanding oil and gas industry that has underwritten the state's economy for decades.

But depending on what scientist you talk to, these projects also are responsible for a third to more than half of the erosion that has occurred along Louisiana's coast in the past 100 years, when more than 1 million acres of Louisiana's coast, mostly wetlands, have eroded -- an area the size of Rhode Island. The rate of loss grew slowly to about 14 square miles a year in the early 1940s, then increased rapidly to a high of 42 square miles in the late 1960s before slowing to between 25 and 35 square miles a year today.

As a result, the corps' own hurricane protection levees have become more vulnerable. They were built with the understanding that they would be buffered from winds and storm surge by 40 to 50 miles of protective swamp and marsh, corps and state officials say. But today the Gulf has moved north, threatening the levees and the communities they protect with higher storm surges and stronger wind-driven waves.

"The leveeing and controlling of the Mississippi River for flood protection and navigation improvements for the last 125 years is an example of the things (the corps) can do," said Clifford Smith, chief executive officer of T. Baker Smith & Co., a coastal engineering firm in Houma. "But it's also an example of how some of the problems developed in south Louisiana."



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Progress exacts costs

The projects that make living here viable have backfired in a variety of ways:

- The Mississippi River channel carries millions of tons a year of sediment off into the deep waters of the Gulf instead of into the natural channels that would build up and expand the bird's-foot delta and barrier islands at the river's mouth. Without sediment to replenish them, the wetlands that serve as a buffer against the winds and waves pushed ashore by storms and hurricanes disappear.
- The Old River Control Structure in Simmesport stops the river from changing its course to follow the path of the Atchafalaya River, and a dam built at the turn of the 20th century blocks Mississippi River water and sediment from traveling down Bayou Lafourche. Both stop the river's natural tendency to move like a hose back and forth along the coastline, building new wetlands and restoring the coast.
- Navigation channels such as the Mississippi River-Gulf Outlet, the Gulf Intracoastal Waterway and oil-field canals let wetlands-destroying saltwater from the Gulf reach farther and farther inland. Ships using the channels have eroded their banks and surrounding wetlands, and the channels provide faster pathways for hurricane storm surges.

Combined with the natural sinking of sediments underlying the remaining wetlands, managing the Mississippi River delta for humans has turned vast expanses of marsh and swamp into open water, and the damage is continuing.

"Even the corps (engineers) will acknowledge that were they to design and build the Mississippi River and Tributaries Project today, it would be done in a manner that recognized the importance of the unintended effects of these projects," said Randy Hanchey, a former corps engineer who now directs Louisiana's coastal restoration program as deputy secretary of the state Department of Natural Resources.

But, he said, blaming the corps is simplistic. "One needs to keep in mind that all these projects, including the MR-GO, and certainly including all the

levees, were projects that the state of Louisiana and local communities lobbied for, fought for and supported for years," Hanchey said. "The corps doesn't build projects that people don't want. If it's been a mistake, it's a mistake we all made."

Now, after decades of manhandling nature, corps officials say they have learned a lesson and are changing their attitude. They want to fix some of the damage by restoring part of the Mississippi River's natural functions and rebuilding the coast.

"Our mission set has changed in response to what the American people wanted us to do," said Lt. Gen. Robert Flowers, chief engineer of the corps. "In the 1930s and 1940s, when large public works projects were deemed necessary to stimulate the economy, stimulate development, recover from war, provide jobs, that's what the corps executed. In the past the corps' thrust was to view projects in isolation. Today we see environmental restoration as a growing part of our mission set."

With concern rising among scientists and political leaders over the plight of south Louisiana, the corps is pursuing two goals simultaneously: It is expanding hurricane levee protection southward toward the Gulf and in New Orleans-area suburbs with projects that would cost at least \$2.5 billion if all are eventually built. It also is examining whether the levees surrounding the east bank of New Orleans and Jefferson Parish should be raised.

At the same time, the corps would play a leading role in ambitious state plans to restore the coast that are still awaiting congressional approval. The \$14 billion, 30-year blueprint includes construction of new barrier islands and refurbishment of old ones, as well as massive structures built into levees to reroute as much as a third of the Mississippi River's water and sediment to restore coastal wetlands.

Forging a new vision

The corps' mission in Louisiana is evolving at a time when the agency is under fire from an array of environmental groups, scientists and some members of Congress. Environmentalists say the corps has paid inadequate attention to the ecological effects of some of its large projects. Budget hawks say the corps spends too much for questionable results. Some critics are calling for wholesale changes in how the agency operates, massive budget cutbacks or both, which corps officials have resisted.

Flowers said the corps must weigh many different interests, some of which will inevitably conflict, and do so fairly. "I hate to hear comments describing the corps as an agency that's insensitive to the environment. That's not true," he said. "We're an agency whose rules require us to look at all aspects of the project: economic, environment, social effects, property rights, you name it. We have to take all facets into consideration in making our recommendations."

Though they still harbor complaints about some corps projects, most environmental groups say the agency has been moving in the right direction in Louisiana.

"The corps has slowly come around to looking at projects holistically, but they're not there yet," said Kate Costenbader, coordinator of the National Wildlife Federation's Greening the Corps campaign. "With flooding in

particular, they've taken one community and built a flood-protection levee or a dam, and when it was done, found that they've decreased the space for water to go, so they increased flooding downstream."

Critics say the corps must do more than build walls and structures. It must take into account how those big construction projects alter the complex life of the coast: ecological relationships, the seasonal dynamics of erosion, the aftereffects of storms. The corps has not traditionally cultivated such expertise in its engineers.

"The question that has been asked in the past has been how to manage the river for navigation and flood control, what to do to facilitate oil and gas production on- and offshore, and how to bring natural gas onshore," said Jim Tripp, chief counsel for Environmental Defense, a national environmental organization, and a member of the Governor's Committee on the Future of Coastal Louisiana. "But now there's a new variable: How do we do all these things in a manner compatible with comprehensive deltaic restoration"

Other agencies that can act as a counterweight to the corps should participate in new projects to ensure that past mistakes aren't repeated, critics say.

"You have to have checks and balances built in," said Fred Weinmann, a former Environmental Protection Agency biologist who sits on a national corps' environmental advisory committee.

"I don't think the corps is the wrong agency to do the work, but it may not always be the right agency to make decisions," he said. "You've got to have people from outside the agency who know what they're doing involved in the design of these projects, and then you have to have them stay involved during construction."

EPA eyes Morganza levee

The Morganza-to-the-Gulf levee reflects many of those tensions. The corps usually builds hurricane levees at the edges of settled areas. But the Morganza levee would enclose a half-dozen scattered small towns along bayous, and some of it would be built across marshes. That's a potential problem because marshes depend on the daily flux of tides to sustain their web of life. Cut that off, and wetlands inside the levee may die.

To compensate, the corps created designs for a "leaky levee." The project will have nine 56-foot-wide gates, three larger floodgates and a dozen 6-foot-by-6-foot culverts that will be closed only during floods. They will let water -- and fish -- flow through the levee into the marshes behind it and flow out again. Corps scientists think the structures will protect marshes from storm damage and coastal erosion.

Scientists who have reviewed the design are cautiously optimistic about the project. "The folks down there need hurricane protection, and the corps has made a legitimate effort to provide it, one that recognizes the need to protect wetlands," said John Ettinger, a scientist in the Environmental Protection Agency's water quality protection division who drafted EPA comments on the proposal.

But the EPA cited several potential problems it says must be closely watched, especially how the altered water flow through the levees will

affect wetlands behind them.

For example, ponds could be created on the inside of the levee. Without adequate pumps in place, that could hurt wetlands and accelerate their demise. "EPA's position is whenever you alter the hydrologic regime of a wetland, more likely than not it will not recover," Ettinger said.

The biggest imponderable is how engineers will simultaneously coordinate coastal restoration with levee building over decades.

Coastal restoration projects will depend in part on building structures that divert water and silt from the Mississippi River and direct them across marshes. The diversions will deposit silt and push the saltwater south, rebuilding the land and reversing some of the damage done by saltwater intrusion. But building levees across marshes may interfere with that process.

Corps watchers also worry about the uncertainties of timing and money. It often takes decades from the time corps projects are proposed until their completion. Budgeting problems could delay or halt some projects even after they are begun.

Bush administration officials have said they want to restrain corps spending, and agency administrator Mike Parker was forced to resign this year after he criticized the idea of cutting back. Budget shortfalls this year have left the corps scrambling to find money to continue building unfinished flood control projects in New Orleans and Jefferson Parish.

"Time is our enemy," said Smith, the Houma engineer who sits on the Mississippi River Commission and also is a member of the governor's coastal task force. "The more time that's spent studying and getting projects approved and funded, the bigger the problems we have."

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SPECIAL EDITION *Washing away* THE TIMES-PICAYUNE

Cost of Survival

Part 5 of a Special Report



The 1900 Galveston hurricane was the deadliest in U.S. history, killing up to 8,000 residents as the violent ocean surge swept across the Texas island city with no warning.
(HISTORIC NATIONAL WEATHER SERVICE COLLECTION)

Improvements in forecasting have greatly reduced storm casualties. Now, scientists are developing techniques that could save more lives by improving hurricane warnings and evacuation

INSIDE PART 5

COST OF SURVIVAL
New Orleans and south Louisiana will always be vulnerable to a catastrophic hurricane, yet there are ways to make the area safer. But implementing the proposals may be prohibitively expensive.

ADVANCE WARNING
The deadly Galveston hurricane of 1900 was a horrifying demonstration of the importance of better storm

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times critical for New Orleans.

Meanwhile, efforts to rebuild the area's natural coastal protections are showing promise.

predictions.

FUTURE OF COAST

An ambitious 30-year plan would pump new life into south Louisiana's beleaguered coast and wetlands. It may be the region's best hope for weathering major storms.

AHEAD OF THE STORM

Planning is the key to surviving a hurricane. Have a destination in mind and make arrangements for your loved ones, pets and home. Then when a storm threatens, leave.



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COST OF SURVIVAL

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New Orleans and south Louisiana will always be vulnerable to a catastrophic hurricane, yet there are ways to make the area safer. But implementing the proposals may be prohibitively expensive.

By Mark Schleifstein and John McQuaid

Staff writers

If hurricanes haven't seriously scarred coastal Louisiana or swept it out to sea in the next 50 to 100 years, the very process of protecting the region may still end up altering it almost beyond recognition.

Based on current plans and proposals, here are some changes that coming generations may see:

- A giant wall, more than 30 feet high in places, cuts through New Orleans and across Jefferson Parish to create a "safe haven" should a storm surge from Lake Pontchartrain top the levees. The levees themselves are 10 feet or more higher than today, and some are crowned with a sea wall, blocking views of the lake. A large collapsible wall sits atop some levees, ready to be raised during hurricanes.
- At the Rigolets and Chef Menteur passes to the lake, huge floodgates stand ready to be closed if waters rise. All across the Mississippi River delta, hurricane levees crisscross marshes, surrounding dozens of towns. At key junctures on the river, large gated sluices direct fresh river water across stretches of marshland, rebuilding it with silt. Dredges have hauled sand from miles offshore to sculpt and maintain new barrier islands where only slivers exist today.
- From New Orleans to Morgan City, thousands of homes have roofs fortified to resist high winds and are equipped with steel storm shutters. Outside the levees, most homes have been raised on pilings 15 feet high or more. Main roads and highways are at similar heights.
- Some communities have built elevated shelters capable of withstanding 175-mph winds, similar to those being constructed in Bangladesh today.

- But big storms still threaten even this highly engineered landscape. In some places the Gulf of Mexico has maintained its steady progress inland and the region is starting to resemble Venice, Italy, the city of canals. Water routinely laps at the foot of levees, eroding them. In other areas, levees and walls deflect surging floodwaters into new places and to surprising heights. Engineers watch as the sea rises and the land sinks and wonder whether their ambitious fixes will ultimately amount to nothing.

It's impossible to make a large city or a broad area like the Mississippi River delta completely disasterproof. Nature is too fierce, human structures and activities too exposed. But most emergency managers agree that south Louisiana could be much safer than it is. That will take creative engineering design and new thinking about how to disasterproof communities. It also will take plenty of money.

These innovations are collectively more ambitious than any similar engineering project anywhere in the world and will change not only the shape of the Mississippi River delta but the way people live here. Some will end up behind walls. Some on stilts. If programs don't work, many people may ultimately move away.

"We have to think big. It's the only thing that will get us anywhere," said Len Bahr, the governor's executive assistant for coastal activities.

If erosion, subsidence and sea-level rise continue on their present course, scientists say cities and towns will become man-made islands surrounded by rising Gulf waters and vulnerable to all manner of storms. That scenario strikes fear into the hearts of engineers and public officials. If water laps against levees and floodwalls, flooding becomes an almost daily threat. Transportation and other normal activities can be easily disrupted by rising water. Just maintaining the levees becomes a complex task.

"We don't want to be in a situation where there are just levees and the Gulf," said Al Naomi, an Army Corps of Engineers project manager who is leading a preliminary study on whether to significantly increase levee protection across the area. "We want something between us and the Gulf."

Several large-scale efforts to avert this "waterworld" scenario and fortify the landscape are already under way, and more are proposed, some in the realm of the fanciful and others merely ambitious.

The \$14 billion, 30-year Coast 2050 plan being pushed by a governor's committee and Louisiana members of Congress seeks to rebuild the coast, primarily by diverting water and silt from the Mississippi River across marshes and rebuilding barrier islands. Its promoters say it would begin to reverse some of the losses of the past 100 years and restore natural hurricane protections.

But at best, that would provide only partial protection from hurricanes. Even if the entire coast could be restored to the way it was a century ago, large storms could still devastate the area with flooding, rain, wind and tornadoes far inland. Scientists and engineers say additional fixes are needed.

"We are not going to stop marsh loss. Subsidence is too dominant," said James Coleman, a professor of coastal studies at Louisiana State University. Coastal restoration "is a temporary fix in terms of geological

time. You will see results of massive coastal restorations in our lifetime, but in the long run they are also going to go."

Naomi is looking at whether to upgrade levee protection from Morgan City to the Mississippi border to withstand Category 4 and 5 hurricanes, which can have storm surges 30 feet high. Corps officials say most current federal hurricane levees protect up to the level of a fast-moving Category 3 storm.

Though building levees and floodwalls to any height is theoretically possible -- "if we can build a 50-story building, we can build any kind of wall," Naomi said -- any realistic proposal will involve complex trade-offs. Levees can be built only so high before they either take up too much space or begin to collapse, for example. The alternative is to build more walls, but they are much more expensive and also heavier, meaning they would sink faster in relation to sea level.

High walls also are not especially attractive. "You talk about the levees in Jefferson Parish, they're 17 to 18 feet high," Naomi said. "If you put a wall on top of that, it could be something unsightly. Do people really want that" A more aesthetically appealing alternative -- building a collapsible wall on some sections of the lakefront -- would be still more expensive, he said.

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Giant wall against water

A storm surge that tops the levees could flood the east bank to depths of more than 20 feet and take weeks to drain. Louisiana State University engineering professor Joseph Suhayda proposes building a wall that would cut across Orleans and Jefferson to create a refuge of last resort for residents. With its top reaching 30 feet above sea level, the wall would run from the foot of Esplanade Avenue to the Interstate 610 corridor, then west across parts of Jefferson Parish.

That would stop a flood coming in from the lake and create a "community haven" between the wall and the river levees where people left behind in a hurricane could retreat. It also would protect the Central Business District, the French Quarter and other areas from flood damage.

Corps engineers are looking at other approaches, too. "If we can find a way to keep storm surge away from those levees by attacking a surge farther out (in the Gulf) and making the levees a rear line of defense, we might not have to build them so high," Naomi said. "If you can slow the surge down, then you've accomplished something."

For Orleans and Jefferson parishes, other east bank communities and parts of St. Tammany, the task would be to block storm-surge water from entering Lake Pontchartrain. One way to do that is to install gates along the Rigolets and Chef Menteur passes, something engineers have rejected in the past as too expensive and impractical. But the idea is worth examining, Naomi said.

Given the high stakes -- tens of thousands of people dead in a flood that tops the levees -- Naomi said he would look for ways to account for the risk in the corps' cost-benefit analyses, which typically do not incorporate loss-of-life estimates.

If the past is any guide, not all of these experimental ideas will fly, and some of those that are tried may not work. Large-scale plans have many unforeseen small-scale effects that communities will have to wrestle with and seek more money to fix.

Grand Isle, for example, has at least a dozen separate programs designed to fortify it against erosion and flooding. But results have been mixed, and upgrading projects that have proved only partially effective is difficult.

In the 1970s the corps rebuilt beaches, installed rock breakwaters at intervals and built a levee to protect against beach erosion. But erosion has taken 300 to 400 feet of beach in the past decade, Mayor David Camardelle said. "Building the levee out of sand and putting it there is like putting sugar in coffee," he said. "It's gone."

Louisiana's plans to sculpt the Mississippi River delta to better withstand hurricanes may set new standards for coastal engineering. But on a smaller scale -- the community and neighborhood level -- the state lags behind others in updating important policies, such as improved building standards, better evacuation routes and controlling development in floodprone areas.

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Gambling big on FEMA aid

The megadisasters of the past decade have caused emergency managers across the country to reassess their programs, which traditionally stress postdisaster response. In the wake of recent megadisasters -- Hurricane Andrew in 1992, the 1994 Northridge, Calif., earthquake and the Sept. 11 terrorist attacks -- many officials are now focused more on preventive measures to reduce damage and save lives.

"There is a huge shift among local and community leaders, and I think among average citizens," Federal Emergency Management Agency director Joe Allbaugh said. "The American public is paying more attention to the possibility of disasters happening, especially since 9/11. But we've got to do more."

Even in high-risk areas, home and business owners, local officials and those who run key facilities such as hospitals often do little to fortify their property against floods, winds or wildfires -- perhaps with the expectation that federal programs will put everything back together should disaster strike. But government aid is at best a patchwork, and FEMA and other agencies have been making the rules more restrictive and monitoring their money more closely.

"It's wrong; it's just not true. The greatest fallacy perpetrated by media and politicians is that FEMA will make you whole," said Mary Comerio, a professor of architecture at the University of California, Berkeley, and author of a book on disaster recovery. Though the government provides substantial financial aid and other assistance, many homes are never rebuilt and many businesses never recover from a catastrophic event, she said.

North Carolina is one state that has pioneered "disaster-resistant" policies. After Hurricane Floyd devastated thousands of square miles of the state with flooding in 1999, Gov. Jim Hunt and state officials decided to make disaster issues a top priority. They added \$836 million in state money to \$1.3 billion in federal money for a comprehensive program that includes disasterproofing for communities and homes, up-to-date flood

plain mapping and other programs.

"You can reduce the risk from almost any natural hazard," said Gavin Smith, director of North Carolina's new hazard-mitigation program. "You can move structures away from the hazard or you can protect them in place. For example, there's armoring a structure against high winds. For us, it's not just about hurricanes and flooding. We have an earthquake threat in western North Carolina, so we are spending funds to retrofit schools."

North Carolina's Tar River overflowed during Floyd, putting entire neighborhoods under water. Officials there have used the state programs to launch an aggressive buyout program to move people out of the 100-year flood plain where the worst flooding occurred. Once they are bought out and cleared, some areas will be turned into a waterfront park.

Because most of south Louisiana is a flood plain, emergency managers say massive buyouts are impractical but that targeted buyouts in areas that flood frequently might work. FEMA already offers these on a limited basis.

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Castles made of sand

Some observers say the recent explosion of vacation homes and fishing camps in coastal areas including Grand Isle, Cocodrie and parts of St. Bernard and Plaquemines parishes is foolhardy. Though new structures are elevated, they still can be destroyed by winds, waves and moving debris in a hurricane.

"It's crazy to build in some of these areas," said University of New Orleans coastal geologist Shea Penland. "Many of those structures just won't survive."

Some North Carolina community leaders found buyouts unthinkable. Belhaven, N.C., which sits in low-lying swamp three feet above sea level, had six storm-surge floods in three years, culminating with Floyd. The local elementary and junior high schools had to be torn down and rebuilt on higher ground.

"You can either have Belhaven in the 100-year flood plain or not have Belhaven at all," Town Manager Tim Johnson said. "So the alternative was to elevate."

The town pooled \$16 million in FEMA and state grants to raise more than 300 of the town's 962 homes either 8 or 9 feet above the ground, the biggest single elevation project in the nation. On any given day, several homes in town are being raised or moved. On one street, workers gently position four steel girders under a home as they prepare to lift it. In a local community center, contractors walk new participants through the process.

Like most places, Louisiana has no proactive program to raise vulnerable homes. To qualify for favorable federal flood insurance rates, new homes must be built above the 100-year flood level, which approaches 10 feet in some places. Some new homes are 15 feet off the ground. If a flood damages a home and the owner wants to rebuild, money is available to raise the structure. But owners of existing homes usually must bear the cost of raising the structure above the flood level.

In Bangladesh, where catastrophic hurricanes accompanied by 20-foot storm surges in 1970 and 1991 took 300,000 and 138,000 lives, respectively, a consortium of world charities began building triangular-shape concrete shelters on stilts in more than 1,000 locations. The shelters have been hugely successful in saving thousands of lives during recent hurricanes, officials say.

Louisiana emergency preparedness officials hope to persuade the Legislature to adopt a similar plan: requiring all new public buildings in the coastal zone to be built to withstand catastrophic storms so they can be used as shelters.

On an even smaller scale, individuals can invest more in disaster-proofing their homes. A few thousand dollars will buy clips to keep a roof from flying off a home and steel shutters that will prevent hurricane-force winds from blasting through the house.

Some disaster specialists say the same philosophy holds not just for homes but for all buildings in risky areas, and that developers and local officials should start thinking about disaster every time they draw a blueprint.

"Say New Orleans needs a new hospital," said Dennis Mileti, a sociologist who directs the University of Colorado's Natural Hazards Research and Applications Information Center. "Say the worst possible flooding is five stories high. So you put the garage on the lower floors and put everything above the fifth floor. Why build an essential facility like a hospital on the ground when you know it might flood. It might be wise to do it for schools, hospitals, and other essential facilities. Maybe it's not prudent to tear them down today and rebuild them. But in America we tear stuff down and rebuild it all the time."

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WARNED TOO LATE: At least 8,000 people died in the Galveston hurricane in 1900 because weather officials failed to recognize the danger of the storm.
(HISTORIC NATIONAL WEATHER SERVICE COLLECTION)

ADVANCE WARNING

Improvements in forecasting have greatly reduced storm casualties. Now, scientists are developing techniques that could save more lives by improving hurricane warnings and evacuation times critical for New Orleans.

By Mark Schleifstein and John McQuaid
Staff writers

VIRGINIA KEY, FLA. --
The best example of the importance of accurate hurricane forecasting may be found in the wreckage

of its worst failure.

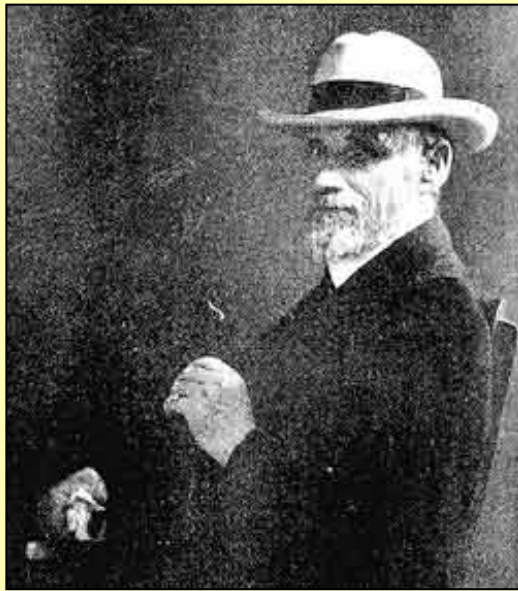
At least 8,000 people died in Galveston, Texas, in September 1900, primarily because weather officials didn't recognize the powerful dynamics of the storm and failed to warn residents until it was too late.

The thriving Gulf Coast seaport was devastated. Homes and businesses were flattened. Bodies floated in Galveston Bay for days. Scientists were forced to re-examine their theories about the storms and the way that warnings were issued.

Fifteen years later, U.S. Weather Bureau forecaster Isaac Cline, the man who had failed to alert Galveston, was able to warn the Louisiana coast a day before an equally strong hurricane hit New Orleans, likely saving thousands of lives.

The period after the Galveston disaster marked the beginning of a century of scientific and technological advancements in hurricane forecasting that first and foremost saved lives. During the first 30 years of the 20th century, the average annual loss of life in U.S. hurricanes was 329. During the next 40 years, the average number of deaths dropped to 70 a year, and since 1969 the average has fallen to fewer than 20.

"Hurricane research is one of the successes of the 20th century," said Hugh Willoughby, director of the Hurricane Research Division, the nation's hurricane research think tank on Virginia Key, a small island sandwiched between Miami Beach and the Miami-Dade County mainland.



Fifteen years after failing to alert Galveston, U. S. Weather Bureau forecaster Isaac Cline was able to warn Louisiana a day before an equally strong hurricane hit New Orleans, likely saving thousands of lives.

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'People here can't move'

Pinpointing storm's swath

But scientists admit they still don't understand many things about hurricanes. The giant storms are steered by complicated weather patterns that not even the most powerful computers can predict with certainty. The storms also can weaken or strengthen suddenly in ways that scientists have not yet been able to anticipate.

Perhaps most crucial, the advances in better and earlier warnings have been offset by the explosion in coastal population and the increase in the amount of time it takes to get these new coastal residents out of harm's way. The New Orleans area, for example, needs at least 72 hours to evacuate all its residents. Hurricane forecasting has not been refined enough to meet that kind of time frame.

Three days before a hurricane hits, the official forecast can be off by as much as 250 miles in either direction. That is a dramatic improvement from the 520-mile error rate of 30 years ago, but still a wide area for making the expensive decision to shut down a city. Even 24 hours in advance, the average forecast error is about 85 miles, meaning 170 miles of coastline or more may get hurricane warnings, according to Max Mayfield, director of the National Hurricane Center.

Until more progress is made, warnings will continue to be a two-edged sword: They save lives and reduce property damage in the part of the warning area where the hurricane hits, but they also can result in expensive false alarms that may hinder the credibility of future warnings.

When Hurricane Floyd approached the U.S. coast in September 1999, forecasters were forced to put almost the entire eastern coastline under an escalating series of watches and warnings. About 2 million people from Florida to Delaware evacuated their homes. The evacuation may have cost as much as \$2 billion in direct expenses and lost business revenue.

Forecasters are optimistic about their ability to reduce forecasting errors and predict more accurate tracks and intensities days in advance. Improvements in computer models and in the data going into them can continue to reduce error rates over the next 30 years, Willoughby said.

But intrinsic limits can defeat even the most sophisticated models. Chaotic behavior in the atmosphere will eventually limit the ability of forecasters to improve that accuracy beyond a certain level, Willoughby said.

"Chaos" is a mathematical term referring to dramatic shifts and cycles that can appear random. Chaotic behavior can be almost impossible to predict, like figuring out the effect of a butterfly's wings on prevailing winds. In the case of the atmosphere, fluctuations in temperature, pressure or wind speed that start out small can unexpectedly grow, confounding forecasters.

"Chaos theory has a big effect on error," Willoughby said. "The atmosphere is an unevenly heated, rotating flow of gas. Changes happen on a scale too small to observe. That's why we will eventually get to that point where we're making a forecast that doesn't get any better."

At the point that limit is reached, he said, scientists hope the forecasts will be in the range of a 30-mile error at 24 hours, 60 miles at 48 hours and 90 miles at 72 hours.

Scientists have a promising technique that can help them sort out both chaotic effects and inaccuracies in computer models. By running an "ensemble" of different forecast models and comparing the results against weather data, they can see how errors in each model diverge from reality and adjust them accordingly the next time out.

A "superensemble" of 12 models devised by Florida State University scientists correctly predicted the landfall of Hurricane Floyd four days in advance in 1999. Florida State atmospheric scientist Tiruvalam Krishnamurti said that the technique doesn't always produce such accurate results, but said it could cut current errors by close to half.

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Levees choke delta growth

Finite pool of research cash

The errors might be shrinking faster if it weren't for budget woes at the National Weather Service, forecasters say. Annual financing for Willoughby's research division was stuck at \$2.6 million from 1982 to 1999 and has received only minor increases since, officials said, affecting basic research into hurricane movements and intensity that would help reduce forecast error.

Officials say hurricane research is forced to compete for scarce dollars with basic research into global climate change, tornadoes, forecasting of weather systems that affect commercial aircraft, volcanoes and earthquakes. Nevertheless, the Hurricane Research Division has made progress in many areas and is focusing much of its research on the most dangerous of hurricanes, Willoughby said.

"It turns out that the storms we need to worry about are Category 4 hurricanes," he said, which have winds of 131 mph to 155 mph and can create a storm surge of up to 18 feet above high tide.

Between 1925 and 1995, 10 Category 4 storms accounted for 45 percent of the total damage done by hurricanes in the United States, although they represented only 10 percent of tropical-storm landfalls. The 30 Category 3 hurricanes, with winds between 111 mph and 130 mph, accounted for 35 percent of all damage.

The Atlantic and Gulf of Mexico coastlines have mostly escaped the major storms in the past few decades. That means residents, emergency managers and political leaders might not know what to expect when such an event eventually occurs.

"There's been no experience with a Category 4 hurricane running over a late-20th century city," Willoughby said. Even Hurricane Hugo in 1989, a Category 4 storm, did not hit Charleston, S.C., directly.

And while Hurricane Andrew caused \$30 billion in damage in Homestead, Fla., and south Miami-Dade County in 1992, its worst winds were 20 miles south of the heavily populated Miami Beach and downtown Miami. If it had hit 20 miles farther north as a Category 5, the damage could have totaled \$52.5 billion, according to a study by researchers Roger Pielke Jr. at the National Center for Atmospheric Research and Christopher Landsea at the Hurricane Research Division.

In human terms, the differences of the two paths are staggering, according to a study conducted by the Miami Herald after the storm. Instead of the 350,000 left homeless in south Miami-Dade County, a Category 5 storm cutting across Miami Beach and downtown Miami could have damaged or destroyed the homes of as many as 1.6 million people.

That's why Willoughby's scientists are trying hard to understand how a hurricane strengthens and weakens, and especially the phenomenon called "rapid deepening," the process by which a relatively weak storm can become a killer in as little as 12 hours.

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Models predict dire floods, erosion

Models have a problem recognizing intensity changes because they don't do a good job of depicting how a hurricane interacts with the ocean's surface, where temperatures can vary dramatically. A hurricane can weaken when it churns cooler ocean water to the surface. It can strengthen when it runs over a patch of much warmer water, such as the "loop current," a loop of warm water that often breaks off from the Gulf Stream and drifts in the Gulf of Mexico.

Studies in recent years have linked the loop current to the rapid intensification of several storms, including Hurricane Opal, whose winds jumped from 100 mph to 150 mph in just 18 hours, and then dropped back to 110 mph just before it went ashore in the Florida panhandle in October 1995.

Models were inaccurate because they relied on surface-water temperature measurements made by satellites. "If you look at the satellite pictures, you can't see the eddies. You can't see the deeper, warm water," Willoughby said.

To solve the problem, Willoughby is making use of military castoffs. For years the Navy has used instruments called bathythermographs, which measure water temperature at different depths, to correct sonar readings used to hunt for enemy submarines. Now they're also being used to determine the location and size of the loop current near the Louisiana coast.

National Hurricane Center director Mayfield said he's concerned that the focus on the warm eddies may be too simplistic to explain the rapid deepening. "We've had a lot of hurricanes going over the loop current that didn't develop rapidly," Mayfield said. "It's just not that easy."

The answer may be to improve instruments to allow the sampling of the atmosphere in three dimensions by aircraft flying through hurricane cores, he said.

Researchers also are fine-tuning models to give more information about

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the amount of rainfall accompanying hurricanes and tropical storms. Knowing how much rain will fall could be a major help for communities such as New Orleans and Jefferson Parish, where neighborhoods quickly fill with rainwater and drainage pumps have a limited capacity to pump it away.

"Most of the people that die in hurricanes drown in fresh water," Willoughby said, the result of inland flooding caused by a hurricane's torrential rains. "So we need to predict rainfall."

"The average hurricane dumps 100 inches of rain in its lifetime, all in one spot if it stood still," said Frank Marks Jr., a 23-year veteran of the Hurricane Research Division. "But if it moves, its motion and wind speed affect how the rain falls. The important thing is to figure out where the rain is going to go."

To find out, Marks and other scientists are using a new satellite that can measure rainfall rates of hurricanes as they traverse the globe. In its first four years, the satellite collected data on 245 tropical cyclones.

In the next year, Marks said, he hopes to produce a computer model that marries the rainfall history of past hurricanes gathered by the satellite to the forecast tracks being produced by existing models. That should help forecasters better predict how much rainfall a hurricane will generate, and where.

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Coastal Resuscitation

An ambitious 30-year plan would pump new life into south Louisiana's beleaguered coast and wetlands. It may be the region's best hope for weathering major storms.

By Mark Schleifstein
Staff writer

After decades of division over who and what are most responsible for Louisiana's dissolving coastline, state officials, environmentalists, business leaders and scientists have found common ground on what they think it will take to fix the problem.

The often-combative factions are rallying around something called Coast 2050, a \$14 billion, 30-year wish list of flood-control, water-diversion and coastal-restoration programs that would be the largest construction project ever undertaken. The plan is aimed at re-creating a historic mix of swamp, marshland and barrier islands by unleashing some of the natural forces that had been bottled up by levees and other flood-control projects in the past century.

That should restore some of the region's natural storm protections, scientists say, reducing inland flooding and wind damage from tropical storms and weaker hurricanes that have become common events in south Louisiana in recent years.

"In the New Orleans area, if all the Coast 2050 strategies are implemented, you stand a pretty good chance of returning to a level of protection similar to 40 years ago," said Denise Reed, a professor of coastal geomorphology at the University of New Orleans.

But even with united local support, the scope of the proposal means the next phase of the battle will be fought over federal dollars in Congress, where the outcome is anything but assured.

The state would like to tap into the process Florida established in 2000 when it got congressional approval for an \$8 billion plan to restore fresh-

water flow in the Everglades.

But Florida had several key advantages in the political arena, including 12 million more people and 16 more electoral votes in presidential elections than Louisiana. With a \$50 billion annual operating budget, Florida also expects to be able to contribute half the costs of the program. Louisiana, with a state budget of \$16 billion, would have a much harder time kicking in a substantial share.

Florida also sold its plan during times of budget surpluses and a soaring stock market, while Louisiana is lobbying in an era of deficits and during an expensive war on terrorism.

It's a struggle, but Louisiana leaders hope they can make a case for Coast 2050 based on the straightforward argument that the sinking landscape is a direct threat to people, commercial interests, the environment and the economy -- including key fisheries and oil and gas production with national significance.

The battered coast and disappearing wetlands expose about 2 million south Louisiana residents, billions of dollars in property and key industries to increased flooding and damage from hurricanes, storms and even high tides. Officials fear the nation's energy flow could be disrupted if a hurricane takes out major pipelines or transfer facilities.

U.S. Rep. Billy Tauzin, R-Chackbay, says that should be reason enough for federal help.

"When you consider our contribution to national energy security, when we're finding out how risky it is to trust foreign sources of oil and gas, I'm not sure this is a bad time to make that argument," Tauzin said.

"If the nation continues to rely on Louisiana as the place for so much of the nation's energy requirements, the nation can't forsake our coastline at the same time," he said.

Tauzin, chairman of the House Energy and Commerce Committee, recently asked a subcommittee to create a task force comprising high-ranking officials of a variety of federal departments to oversee the wetlands-restoration plan.

But Congress already has rejected legislation that would have provided the state with money to use as its share of the construction projects.

When Sen. Mary Landrieu, D-La., proposed her Conservation and Reinvestment Act in 1998 to divvy up offshore oil revenue among states directly affected by offshore production, Louisiana would have gotten the lion's share of the money. State officials made it clear they would use most of Louisiana's share as its match for coastal-restoration projects.

The House approved a version of the bill in 2001, but it died in the Senate. Instead, Congress approved a one-year, diluted version aimed largely at financing parks and recreation.

Meanwhile, Tauzin and other members of the congressional delegation have been focusing on reshaping Coast 2050 within the confines of the federal Water Resources Development Act, the vehicle used by Florida to authorize its Everglades-restoration efforts.

Projects included in the water bill are guaranteed a line in the president's budget each year, but not the actual dollars necessary to build them.

In 2004, after a broad-based environmental impact statement is complete, the delegation will return to request authorization for the entire plan. With the authorization in hand, members of the Louisiana delegation say, the fight over money for the federal share of individual projects will begin in earnest.

"If we're successful in obtaining federal authorization in 2004 and if the state can succeed in trying to find the additional revenue necessary to be an effective cost-sharing partner, we can stay ahead of some of the wetland losses and have a pretty good chance of eventually developing a sustainable coastal system," said Randy Hanchey, assistant secretary of the Louisiana Department of Natural Resources.

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Breaux Act a precursor

Just getting to this point has been an arduous journey.

Scientists began focusing on the state's wetland-erosion problem in the 1970s, but disagreement over the extent of the damage, the causes and possible remedies delayed a meaningful response. The first concerted restoration efforts didn't take shape until 1990, when Congress passed the Coastal Wetlands Planning, Protection and Restoration Act, better known as the Breaux Act. Under the act, named for its sponsor, Sen. John Breaux, D-La., the federal government dedicated \$35 million a year and the state added \$15 million a year to pay for variety of small restoration projects and experiments.

The act has had some successes but is spread among several small projects rather than the large programs most experts now say are needed to reverse the damage. The scientists, environmentalists and government officials brought together under the Breaux Act eventually recommended taking steps toward creating a self-sustaining coastline, a wide swath of wetlands and barrier islands that would be continually replenished with water and sediment from the Mississippi River while protecting existing human settlements and the fish and wildlife on which a big chunk of the state's economy depends.

Seeking to bridge the traditional disagreements between environmentalists, developers and regulators, the Coalition to Restore Coastal Louisiana recruited an unusual partner to advise it on developing support for the self-sustaining approach. The group turned to R. King Milling, president of Whitney National Bank and Whitney Holding Corp., who stressed the links between wetlands loss and the state's economy.

A prominent New Orleans business and civic leader and former king of Carnival, Milling was not the typical environmentalist. But he said he had been concerned for years about what was happening to the coastline.

"I used to do a lot of hunting and saw the destruction, disappearance of the land," Milling said. "When I practiced law, I represented individuals and corporations that were impacted by the changes in the wetlands. Add that to the fact that I've been president of a bank for 17 years, and we've got a significant interest in this area."

When the coalition, an unusual alliance of business leaders, environmental activists and scientists, approached him about its report, Milling was concerned about its direction.

"The issues were presented to me as being related primarily to the environment, and I saw them -- continue to see them -- as issues that relate to the economy and commerce and the overall financial infrastructure of southeastern Louisiana," Milling said.

Milling had identified a missing element that would add urgency to a plan that had to win support in the Legislature and Congress, where economic issues can be an easier sell than environmental protection. During the next two years, Milling crisscrossed the state, giving speeches promoting the state's restoration plans and urging state officials to take action.

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Price tag on restoration

One of those targeted by Milling was Gov. Foster.

"I felt we finally had a governor that would intuitively understand the issues if we presented them to him properly, and would take them on," Milling said.

With urging from Milling, coalition officials and representatives of the Army Corps of Engineers, state Department of Natural Resources and his own Office of Coastal Activities, Foster convened a "coastal summit" in August 2001 at which he declared war on coastal erosion.

Foster tapped Milling to lead a task force to outline necessary changes in state law and the state's bureaucracy to better attack the problem. In February the task force adopted a report recommending that the state commit to spending between \$150 million and \$200 million a year on the restoration plan. Officials say they are probably a year from taking the spending request to the Legislature.

For a state with a questionable record of dealing with its environmental problems and a reputation for looking to the federal government to bail it out of financial jams, just the suggestion of that kind of commitment was seen as a seismic shift.

Officials are not yet able to quantify how much hurricane damage might be avoided by adopting the plan, but UNO's Reed is hopeful.

"Most marshes close to the Mississippi River stand the best chance of regaining their integrity from the Coast 2050 strategies," Reed said, because it will be easiest to funnel river water and sediment to them. "But it's going to be a decade or so before any are on the ground."

And there are some hurricane-protection issues that remain unresolved, such as the effects of erosion along the Mississippi River-Gulf Outlet, she said.

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"It acts like a conduit for water movement straight to the city," Reed said. "The Coast 2050 strategy is to encourage re-evaluation of the waterway aimed at its closure. But closure wouldn't mean filling in the channel, only constricting its depth and width."

Houma and eastern Terrebonne Parish would not be so lucky, Reed said.

"The area between Bayou Lafourche and Houma is really suffering a lot of loss," she said. "These are marshes that are a long way from the Atchafalaya and Mississippi rivers" and will be difficult to rebuild.

"We have ideas and plans on how to get the land-building started again in that area, but the farther you are from rivers, the more difficult it is to make that happen," she said.

That's why construction of the proposed Morganza-to-the-Gulf hurricane-protection levee is important for communities in that area, she said.

'A national problem'

To help sell the rest of the nation on the importance of the coastal-restoration efforts, the state is embarking on a national education campaign aimed at convincing the public of the state's need for help.

Val Marmillion, a former aide to Breaux who is developing the campaign for the state Department of Natural Resources, already has gotten some encouraging news from small focus groups in Louisiana and Philadelphia aimed at narrowing the state's message.

The 15-person Louisiana focus group recognized the need for wetlands restoration but thought people outside the state would never support the dollars necessary to do the job.

But the Philadelphia group "seemed to think this is a national problem, without a doubt," Marmillion said. "And both groups shared the view that the federal government should assume the primary role in implementing the plan."

The focus groups also have helped Marmillion develop a brand name for the effort: "America's Wetland."

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AHEAD OF THE STORM

Planning is the key to surviving a hurricane. Have a destination in mind and make arrangements for your loved ones, pets and home. Then when a storm threatens, leave.

By Mark Schleifstein
Staff writer

New Orleans-area emergency officials have some simple advice for how to survive a catastrophic hurricane: Get out.

"At some point you have to accept some responsibility for helping yourself," said Deputy Fire Chief Terry Tullier, acting director of the New Orleans Office of Emergency Preparedness. "You have to understand that this could happen, and whether it's the second or third time you've been asked to evacuate this year . . . you have to get up and go.

"The alternative is unacceptable," he said.

For Col. Jesse St. Amant, director of the Plaquemines Parish Office of Emergency Preparedness, that means: "Every person who fails to leave is going to be a search-and-rescue mission, either a casualty, injury or death."

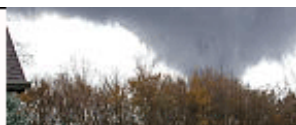
That's because few buildings in the area are capable of withstanding the winds from even a relatively moderate storm. The New Orleans building code only requires houses to withstand winds of 100 mph, meaning that a strong Category 2 storm, with winds between 100 and 110 mph, would heavily damage or destroy most homes.

The Red Cross has decided that operating shelters south of the Interstate 10-Interstate 12 corridor is too dangerous. Recent studies by Louisiana State University engineering experts indicate that public refuges of last resort cannot be guaranteed to withstand winds from a major hurricane.

Heavy rains or storm surge can cause sudden flooding that cuts off escape routes and could leave people stranded on rooftops or in trees for days -- if they survive the storm.



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The time to map out your evacuation is now, not when a hurricane is threatening the city, said Kay Wilkins, executive director of the southeast Louisiana chapter of the American Red Cross.

"You want to plan now, because you need to be able to think out in advance where you're going to evacuate to without the pressure of a hurricane coming at you," Wilkins said.

Wilkins and others say these factors need to be considered in an evacuation plan:

- Make sure your evacuation vehicle will survive what could be a slow trip to higher ground. Officials estimate that at the height of an evacuation, reaching a safe location could take four times as long as normal. That means it could take eight hours to reach Baton Rouge, 16 hours to get to Alexandria and 20 hours to reach Shreveport. Because of the additional congestion from a Mississippi Gulf Coast evacuation, reaching Jackson, Miss., could take as long as 24 hours.
- Have an out-of-state contact for family members to call in the event you are separated during the evacuation. Being outside the area affected by a hurricane, the contact will be more likely to be able to receive calls.
- Families with elderly, ill or disabled relatives should leave sooner to avoid extended travel time and consult with doctors and caregivers to make sure medications and other special needs are addressed.
- Prepare a disaster supply kit that includes water, food, sleeping bags, a first-aid kit, flashlight, battery-powered radio and extra batteries.
- Important papers should be in the disaster kit, kept separately in a waterproof container. Documents to take during an evacuation include insurance policies, a property inventory of your home, birth certificates and passports, and an up-to-date list of medications family members are taking.

- Pet owners should make sure a place for their pets will be available. Red Cross-operated shelters in Louisiana don't allow pets, but most will have contacts with local veterinarians or kennels for evacuees to call when they arrive.
- Keep trees and shrubbery trimmed during hurricane season; make sure lawn furniture, trash cans, toys and other objects can be easily stored within a secure building; ensure that storm shutters are in good working order or that 5/8-inch plywood window coverings are cut before the first storm warnings are issued.

Now also is the time for people to make sure their homeowner's insurance coverage is in order, said Frank Pagano, a National Flood Insurance Program official.

Homes damaged by hurricanes can be covered by two separate insurance policies. One, a traditional homeowner's policy, pays for damage caused by wind or falling trees, and for water that leaks into a house from the roof. Most of those policies now require a deductible equivalent to 2 percent of the value of the home, unless a higher premium is paid.

A separate policy issued under the National Flood Insurance Program pays only for damage from floodwaters. That policy includes a \$500 deductible on damage to the building and a separate \$500 deductible on damage to a building's contents.

In the New Orleans area, officials say some homeowners have decided against buying flood insurance because their home isn't located in a mandatory flood insurance area.

That's not a good idea, said Ron Castleman, regional director of the Federal Emergency Management Agency. In the event of a catastrophic hurricane, which could put 20 feet of water even in areas protected by hurricane levees, homes without flood insurance will not be covered for water-related damage.

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Water is never far from New Orleanians. Just outside the city, saltwater intrusion is destroying marshes, including this one near the Bayou Bienvenue-Florida Avenue Canal between New Orleans and St. Bernard Parish. Now that cypress trees and other vegetation have died, erosion will accelerate, further stripping the region of its natural protections against hurricanes.

(PHOTO BY ELLIS LUCIA / The Times-Picayune)

It's only a matter of time before south Louisiana takes a direct hit from a major hurricane. Billions have been spent to protect us, but we grow more vulnerable every day.

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IN HARM'S WAY

With the land around us constantly sinking, our natural storm protection is disappearing. Levees protect us, but they're not enough.

GOING UNDER

GRAPHIC SPECIAL: What would have happened if Hurricane Georges hadn't turned aside at the last moment?

LAST LINE OF DEFENSE

GRAPHIC SPECIAL: Computer models show that even storms weaker than Category 3 could break through the levees.

NUMBERS GAME

GRAPHIC SPECIAL: Each year the world's tropical waters spawn more than 50 cyclonic storms. History says we're due.

NATURE'S ULTIMATE WEAPON

GRAPHIC SPECIAL: A look inside the formation and power engine of the hurricane.

LAST ISLAND'S WALTZ

A few years before the Civil War, wealthy vacationers waltzed the night away as a hellish storm churned toward them.

WRITTEN OFF

A hurricane levee is intended to protect much of southeast Louisiana, but will leave a number of communities to face the flood outside the walls.

STORM REMINDERS

A mass grave marks the small island overcome by a hurricane.

EVOLVING DANGER

The risk is growing greater, and no one can say how much greater

THREATENING SKIES

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