The Atlantic

How Humans Sank New Orleans

Engineering put the Crescent City below sea level. Now, its future is at risk.

Downtown New Orleans and the Mississippi River, with the French Quarter in the foreground and the West Bank in the distance

Lorenzo Serafini Boni / Emily Jan / The Atlantic

RICHARD CAMPANELLA | FEB 6, 2018 | TECHNOLOGY

BELOW SEA LEVEL. It's a universally known topographical factoid about the otherwise flat city of New Orleans, and one that got invoked ad nauseam during worldwide media coverage of Hurricane Katrina and its catastrophic aftermath in 2005. Locally, the phrase is intoned with a mix of civic rue and dark humor.

It's also off by half. Depending on where exactly one frames the area measured, roughly 50 percent of greater New Orleans lies above sea level. That's the good news. The bad news: It used to be 100 percent, before engineers accidentally sank half the city below the level of the sea. Their intentions were good, and they thought they were solving an old problem. Instead, they created a new and bigger one.

Three hundred years ago this spring, French colonials first began clearing vegetation to establish *La Nouvelle-Orléans* on the meager natural levee of the Mississippi River. At most 10 to 15 feet above sea level, this feature accounts for nearly all the region's upraised terrain; the rest is swamp or marsh. One Frenchman called it "Nothing more than two narrow strips of land, about a musket shot in width," surrounded by "canebrake [and] impenetrable marsh."

For two centuries after the establishment of New Orleans in 1718, urban expansion had no choice but to exploit this slender ridge—so much so that many patterns of local history, from urbanization and residential settlement geographies to architecture and infrastructure, spatially echoed the underlying topography.

New Orleans and its vicinity in 1863. The developing city tightly hugs the ridge nearest the Mississippi River. (Wells, Ridgway, Virtue, and Co. / Library of Congress)

This might seem paradoxical to anyone who's visited the Crescent City. What topography? In one of the flattest regions on the continent, how can elevation matter so much? But that's exactly the point: The lower the supply of a highly demanded resource, the more valuable it becomes. Unlike most other cities, which may have elevational ranges in the hundreds of feet, just a yard of vertical distance in New Orleans can make the difference between a neighborhood developed in the Napoleonic Age, the Jazz Age, or the Space Age.

Understanding how these features rose, and why they later sank, entails going back to the end of the Ice Age, when melting glaciers sent sediment-laden runoff down the Mississippi to the Gulf of Mexico. Starting around 7,200 years ago, the river's mouth began pressing seaward, dumping sediments faster than currents and tides could sweep them away. The mud accumulated, and lower Louisiana gradually emerged from the Gulf shore.

Areas closest to the river and its branches rose the highest in elevation, because they got the most doses of the coarsest sediment. Areas farther from the river got just enough silt and clay particles to rise only slightly above the sea, becoming swamps. Areas farthest out received scanty deposition of the finest particles amid brackish tides, becoming grassy wetlands or saline marsh. The entire delta, under natural conditions, lay above sea level, ranging from a few inches along the coastal fringe to over a dozen feet high at the crest of the Mississippi River's natural levee. Nature built lower Louisiana above sea level, albeit barely—and mutably.

Native peoples generally adapted to this fluidity, shoring up the land or moving to higher ground as floodwaters rose. But then European imperialists came to colonize. Colonization meant permanency, and permanency meant imposing engineering rigidity on this soft, wet landscape: levees to keep water out, canals to dry soil, and in time, pumps to push and lift water out of canals lined with floodwalls.

ALL THIS WOULD take decades to erect and centuries to perfect. In the meantime, throughout the French and Spanish colonial eras, and under American dominion after the Louisiana Purchase in 1803, New Orleanians had no choice but to squeeze their booming metropolis onto those "two narrow strips of land" while eschewing the low-lying "canebrake [and] impenetrable marsh." Folks hated every inch of that backswamp, viewing it as a source of miasmas, the cause of disease, and a constraint on growth and prosperity. One observer in 1850 unloaded on the wetlands: "This boiling fountain of death is one of the most dismal, low, and horrid places, on which the light of the sun ever shone. And yet there it lies under the influence of a tropical heat, belching up its poison and malaria ... the dregs of the seven vials of wrath ... covered with a yellow greenish scum."

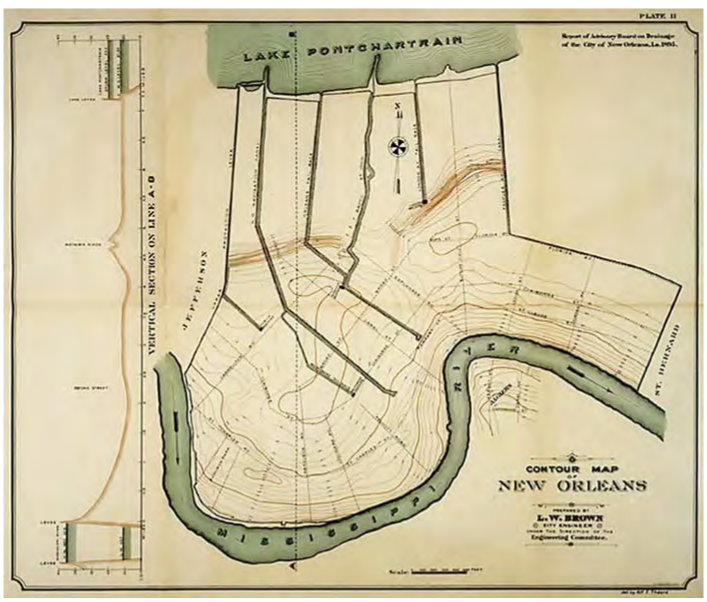
Only later people would learn that it was not miasmas but the invasive *Aedes aegypti* mosquito, brought in by transatlantic shipping, that caused diseases like yellow fever; that it was urban cisterns and poor sanitation that enabled mosquitoes to breed and feed on human blood; and that the "dismal, low" terrain actually aided the city by storing excess water, be it from the sky, the Mississippi River, the bay known as Lake Pontchartrain, or the Gulf of Mexico. It was not "horrid" but propitious that nobody lived in the backswamp, and that the technology to drain it was not available. And most importantly, that the "yellow greenish scum" lay above sea level.

Understandably, given the incompatibility of natural deltaic processes with urbanization, New Orleanians began erecting embankments along the river and digging drainage ditches within a year of the city's foundation. One colonist described how settlers in 1722 were "ordained [to] leave all around [their city parcel] a strip at least three feet wide, at the foot of which a ditch was to be dug, to serve as a drain." Outflow canals were excavated to speed drainage back toward the swamp, and in nearby plantations, ditches were dug to control soil water or divert river water to power sawmills.

Gravity was the main source of energy for these initial water projects, but in the early 1800s, steam power came into the picture. In 1835, the New Orleans Drainage Company began digging a network of urban ditches, using a steam-driven pump to push the runoff back out of Bayou St. John—with limited success. A similar pumping system was attempted in the late 1850s, only to be disrupted by the Civil War. In 1871, the Mississippi and Mexican Gulf Ship Canal Company dug 36 miles of ditches, including three major outfall canals, before it too went bankrupt.

It was becoming clear that draining New Orleans would best be stewarded by the public sector instead. Municipal engineers in the late 1800s cobbled together the extant network of gutters and ditches and, with the propulsion of some steam-driven pumps, were able to expel up to one-and-a-half inches of rainfall per day into surrounding water bodies.

That wasn't nearly enough to drain the swamp, but it was enough to begin permanently altering the New Orleans's land surface. We know this because in 1893, when the city finally got serious and funded expert engineers to figure out how to solve this problem, surveyors set out to map local elevations as had never been done before. The resulting topographical map of New Orleans (1895) would inform the engineering of what would become a world-class system.



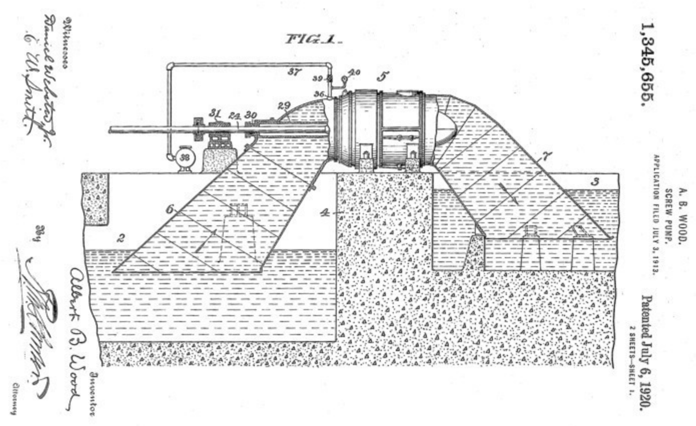
Contour map of New Orleans, produced as part of the city's 1895 effort to finally solve the drainage problem
(Courtesy of the New Orleans Public Library)

The 1895 map also revealed something curious: The rear precincts of one downtown *faubourg* had, for the first time, dipped slightly below sea level. The sinkage would not bode well for things to come.

WHAT WAS beginning to happen was anthropogenic soil subsidence—the sinking of the land by human action. When runoff is removed and artificial levees prevent the river from overtopping, the groundwater lowers, the soils dry out, and the organic matter decays. All this creates air pockets in the soil body, into which those sand, silt, and clay particles settle, consolidate—and *drop below sea level*.

Construction of the new drainage system began in 1896 and accelerated in 1899, when voters overwhelmingly approved a two-mill property tax to create the New Orleans Sewerage and Water Board. By 1905, 40 miles of canal had been excavated, hundreds of miles of pipelines and drains had been laid, and six pumping stations were draining up to 5,000 cubic feet of water per second. System efficacy improved dramatically after 1913, when a young engineer named Albert Baldwin Wood designed an enormous impeller pump that could discharge water even faster. Eleven "Wood screw pumps" were installed by 1915, and many are still in use today. By 1926, over 30,000 acres of land had been "reclaimed" via 560 miles of pipes and canals with a capacity of 13,000 cubic feet of water per second. New Orleans had finally conquered its backswamp.

The change in urban geography was dramatic. Within a decade or so, swampland became suburbs. Property values soared, tax coffers swelled, and urbanization sprawled onto lower ground toward Lake Pontchartrain. "The entire institutional structure of the city" reveled in the victory over nature, wrote John Magill, a local historian. "Developers promoted expansion, newspapers heralded it, the City Planning Commission encouraged it, the city built streetcars to service it, [and] the banks and insurance companies underwrote the financing." The white middle class, eager to flee crumbling old *faubourgs*, moved into the new "lakefront" neighborhoods en masse, to the point of excluding black families through racist deed covenants. And in a rebuke of two centuries of local architectural tradition, new tract housing was built not raised on piers above the grade, but on concrete slabs poured at grade level. Why design against floods if technology has already solved that problem?



Design plans for a Wood screw pump (U.S. Patent 1,345,655)

The change in topographic elevation was more subtle, but equally consequential. A city that had been entirely above sea level into the late 1800s, and over 95 percent in 1895, had by 1935 fallen to about 70 percent above sea level.

Subsidence continued even as more and more people moved into subsiding areas. While the vast majority of New Orleans's 300,000 residents lived above sea level in the early 1900s, only 48 percent remained above the water in 1960, when the city's population peaked at 627,525. That year, 321,000 residents lived on former swamp, over which time they dropped into a series of topographical bowls four to seven feet below sea level.

The average New Orleanian of this era perceived being below sea level as something of a local curiosity. Then as now, most folks did not understand that this was a recent man-made accident, or that it could become hazardous. But streets increasingly buckled and buildings cracked. When Hurricane Betsy ruptured levees and flooded the bottoms of four sunken urban basins in 1965, the curiosity became more of a crisis.

Soil subsidence made frightful headlines in the 1970s, when at least eight well-maintained houses in a suburban subdivision exploded without warning. "Scores of Metairie residents," *The New Orleans Times-Picayune* reported, "wondered whether they are living in what amounts to time bombs." The affected subdivision, low-lying to begin with and positioned on an especially thick layer of peat, had been drained just over a decade earlier. With so much "wet sponge" to dry out, the soils compacted rapidly and subsided substantially, cracking slab foundations. In some cases, gas lines broke and vapors leaked into the house, after which all it took was a flicked light switch or a lit cigarette to explode.

The emergency was abated through ordinances requiring foundational pilings and flexible utility connections. But the larger problem only worsened, as gardens, streets, and parks continued to subside, and those neighborhoods that abutted surrounding water bodies had to be lined with new lateral levees and floodwalls. Many of those and other federal structures proved to be under-engineered, underfunded, and under-inspected, and all too many failed in the face of Hurricane Katrina's storm surge on August 29, 2005. The rest is topographic history, as seawater poured through the breaches and filled bowl-shaped neighborhoods with up to 12 feet of saltwater. Large-scale death and catastrophic destruction resulted, in part, from New Orleans having dropped below sea level.

A LIDAR elevation model of New Orleans shows areas above sea level in red tones (up to 10 or 15 feet, except for the artificial levees) and areas below sea level in yellow to blueish tones (mostly ranging from -1 down to -10 feet). (Richard Campanella / FEMA)

What to do? Urban subsidence cannot be reversed. Engineers and planners cannot "reinflate" compacted soils if city dwellers have built lives upon them. But they can reduce and possibly eliminate future sinkage by slowing the movement of runoff across the cityscape and storing as much water as possible on the surface, thus recharging the groundwater and filling those air cavities. The Greater New Orleans Urban Water Plan, conceived by a local architect, David Waggonner, in dialogues with Dutch and Louisiana colleagues, lays out a vision of how such a system would work. But even if executed fully, the plan would not reverse past subsidence. This means that greater New Orleans and the rest of the nation must be committed to maintaining and improving structural barriers to prevent outside water from pouring into "the bowl."

To a degree, those resources arrived after Katrina, when the Army Corps of Engineers fast-tracked the design and construction of a unique-in-the-nation Hurricane and Storm Damage Risk-Reduction System. Costing over $14.5 billion and completed in 2011, "The Wall," as folks call the sprawling complex, aims to keep those living inside secure from flooding from storms computed to have a 1 percent chance of occurring—not the level of security needed, but an improvement nonetheless.

YET, HISTORY SHOWS that “walls” (that is, levees, embankments, floodwalls, and other rigid barriers) have gotten New Orleans into topographical trouble, even if they have also been essential to the viability of this 300-year-old experiment in delta urbanism. The city cannot rely on them alone. The biggest and most important part of assuring a future for this region is to supplement structural solutions with nonstructural approaches.

Louisiana’s coast has eroded by over 2,000 square miles since the 1930s, mostly on account of the leveeing of the Mississippi River and the excavation of oil, gas, and navigation canals—not to mention rising sea levels and intruding saltwater. Slowing that loss requires tapping into the very feature that built this landscape, the Mississippi River, by diverting its freshwater and siphoning its sediment load onto the coastal plain, pushing back intruding saltwater and shoring up wetlands at a pace faster than the sea is rising.

Restored wetlands would serve to impede hurricane storm surges, reducing their height and power before reaching “The Wall,” and thus lessening the chances that they break through and inundate “the bowl.” A federally backed state plan by the Coastal Protection and Restoration Authority is now complete and approved, and some projects are underway. But the larger effort is a moonshot, costing at least $50 billion and possibly double that. Only a fraction of the needed revenue is in hand.

Meanwhile, inhabitants will have to raise their residences above base-flood elevation (a requirement to qualify for federal flood insurance). If finances allow, they might opt to live in the half of the metropolis that remains above sea level. Collectively, they might consider advocating for the Urban Water Plan, supporting coastal restoration efforts, and understanding the larger global drivers of sea-level rise.

They can also forswear draining any further wetlands for urban development. Let swamps and marshes instead be green with grass, blue with water, absorptive in the face of heavy rainfall, buffering in their effect on storm surges—and above sea level in their topographic elevation. When it comes to living being below sea level, New Orleanians have little choice but to adapt.

ABOUT THE AUTHOR

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