The 1927 Great Mississippi Flood: 80-Year Retrospective

RMS Special Report

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INTRODUCTION

In the spring of 1927, the most catastrophic river flood to impact the United States occurred along the Mississippi River. The flooding, which inundated parts of Arkansas, Illinois, Kentucky, Louisiana, Mississippi, Missouri, and Tennessee, was notable both for its extent as well as its profound impact on future flood risk management. In all, approximately 27,000 square miles (70,000 square kilometers) were left underwater, ruining crops, damaging or destroying 137,000 buildings, causing 700,000 people to be displaced from their homes, and killing 250 individuals across the seven impacted states.

The flooding was a result of persistent heavy rains that fell across the central U.S. starting in August 1926 and continuing through the spring of 1927. As unprecedented amounts of run-off from the different tributaries combined, extreme water levels churned by the wind overwhelmed the levees protecting the Mississippi Valley floodplains, breaching the flood defenses as the water traveled southward. It was not until August 1927 that the last of the floodwaters had flowed into the Gulf of Mexico. In the aftermath, direct economic losses along the lower Mississippi River were estimated by the Red Cross and the U.S. Weather Bureau to be between $250 and $350 million. This loss included damages from the land flooded by the failure of levees (Figure 1), as well as the damages to St. Bernard and Plaquemines parishes due to the dynamiting of the levee at Caernarvon, Louisiana, downriver from New Orleans.

The 1927 flood was a disaster on such a scale that it changed the political climate of the U.S., both in the passage of the Flood Control Act in 1928 and the election of Herbert Hoover as the thirty-first president of the United States after he ran successful flood relief operations during the 1927 event. Eighty years later, this retrospective reviews the 1927 Great Mississippi Flood, assesses the long-term impact of the event on flood risk management in the U.S., considers the potential for levee failures during future Mississippi floods, and estimates the economic costs that would be associated with a repeat of the same event in 2007.

Figure 1: The Great Mississippi Flood of 1927 in Natchez, Mississippi, showing a submerged train with boats brought in for rescue (Courtesy of NOAA's National Weather Service Collection from the family of Captain Jack Sammons, Coast and Geodetic Survey)

THE 1927 GREAT MISSISSIPPI FLOOD

The flooding that occurred in the spring of 1927 along the lower Mississippi River was initiated by rainfall that began the previous summer. Moreover, the cascade of levee breaches along the miles of river meant that flooding of the Mississippi Valley evolved over a period of months.[1]

AUGUST TO DECEMBER 1926

Around the middle of August 1926, the rains began to fall over the upper midwestern U.S. The first storm system lasted for many days, starting in South Dakota, Nebraska, Kansas, and Oklahoma and moving eastward into Iowa, Missouri, Illinois, Indiana, Kentucky, and Ohio. This system was followed within two days by a second and third storm, which moved across the Mississippi Valley, causing rain to pour for two weeks. By September 1, 1926, dozens of streams and rivers began to overflow their banks and inundate towns from "Carroll, Iowa to Peoria, Illinois, 350 miles apart" (Barry, 1997). The deluge of rain continued through September into early October and caused the Mississippi River to rise rapidly, washing out bridges and railroads. For example, 15 inches (38 centimeters) of rain fell over the course of three days in Iowa, flooding Sioux City. By the end of October 1926, when the rains stopped, flooding was observed across all of the upper midwestern states, with the Neosho River in Kansas and the Illinois River in Illinois causing the worst known flooding in U.S. recorded history.

In mid-December 1926, the storms began anew across the Mississippi Valley, with snow falling across the north and rain to the south and east. To the north, Helena, Montana was hit with close to 30 inches (76 centimeters) of snow. To the south in Little Rock, Arkansas, close to 6 inches (15 centimeters) of rain fell in one day. By Christmas, thousands were left homeless due to the flooding and railroad traffic was suspended across the Mississippi River. Many rivers rose to their highest levels ever recorded and the gauge readings across the Ohio, Missouri, and Mississippi rivers from October to December 1926 were at the highest ever known. For example, the gauge at Vicksburg, Mississippi along the Mississippi River in October 1926, which usually was around zero at that time of year, was over 40 feet (12 meters). This gauge reading foreshadowed the events to come, as high waters in the spring were expected to follow.

JANUARY TO MARCH 1927

From Cairo, Illinois to the Gulf of Mexico, the Mississippi River Commission had built levees along the 1,100 miles (1,770 kilometers) of the lower Mississippi River. This commission, established in 1879, was made up of army and civilian engineers and was charged with the task of protecting the surrounding lands from the floodwaters of the Mississippi River. On January 1, 1927, the river reached flood stage at Cairo, Illinois, the earliest date this had ever happened. Gauges along the Mississippi River from Cairo to New Orleans were to remain at flood stage for over 150 consecutive days. The levees were already saturated and the occurrence of more rain might cause them to fail.

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[1] The synopsis of events is taken primarily from Barry, 1997.

In early January, no storms brewed over the region, but beginning in mid-January, the rains began to fall again. The Ohio River flooded Cincinnati on January 28, 1927. In early February, the White and Little Red rivers flooded over 100,000 acres in Arkansas. Rains continued through the end of the month. In early March, a blanket of snow fell from the Rockies to the Ozarks in the north and rain deluged areas to the south in the lower Mississippi Valley. For example, in Mississippi, four inches (10 centimeters) of rain fell on March 16. Then, from March 17 to March 20, three tornadoes touched down in the lower Mississippi Valley, killing 45 people and damaging the levees protecting the surrounding region. By the end of March 1927, every levee board south of Cairo was operating 24 hours a day, patrolling the levees for breaches and sandbagging the levees to prevent overtopping.

Figure 2: Flooding in March 1927 on U.S. Route 51 between Mounds, Illinois, and Cairo, Illinois (Courtesy of the U.S. National Oceanic and Atmospheric Administration)

The month of April brought no respite from the rain, and the rivers of the upper and lower Mississippi Valley continued to rise. By the second week of April, over 1 million acres of land were underwater and more than 50,000 people were driven from their homes and living in temporary shelters in Arkansas, Illinois, Kentucky, Mississippi, Missouri, Oklahoma, and Tennessee. The upper and lower Mississippi River — from Iowa to Louisiana — was in flood stage. On April 13, tornadoes once again touched down in the region. But the worst was yet to come for Louisiana.

On April 15 (Good Friday), New Orleans received 15 inches (38 centimeters) of rain over the course of 18 hours, totaling over one-quarter of the city's annual average. Farther north, Greenville, Mississippi received over 8 inches (20 centimeters) of rain; between 6 and 15 inches (15 and 38 centimeters) fell in other counties along the Mississippi River. On the same day, the *New York Times* reported that "From Cairo to the sea, the most menacing flood in years was sweeping down the Mississippi River and its tributaries tonight." A follow-up article showed pictures of downtown New Orleans with 4 feet (1.2 meters) of standing water, mistakenly stating that the flooding was due to Mississippi River overflow rather than heavy rainfall. Some of the political leaders of the Delta states raised serious doubts about the levees holding back the waters of the river.

Then, on April 16, approximately 1,200 feet (366 meters) of levee at Dorena, Missouri, which lay only 30 miles (48 kilometers) south of Cairo, Illinois, collapsed. This breach flooded 175,000 acres of land. The volume of water flowing down the Mississippi River was unprecedented; in 1927, the Mississippi River south of Cairo carried a volume of water measuring at least 1.7 million cubic feet per second (cusecs) and possibly 2 million cusecs. In 1844, the record flow of the river near St. Louis was 1.3 million cusecs; in 1993, the volume was 1.03 million cusecs.

It was inevitable that another breach would happen, but there was uncertainty as to where it would occur. As a result, thousands of men struggled to reinforce the levee along the lower Mississippi River with sandbags. Then, on Thursday, April 21 at 8:00 am, the levee broke at Mounds Landing, which lay below the junction with the Arkansas River and approximately 12 miles (19 kilometers) north of Greenville, Mississippi. Greenville was flooded the next day. The breach measured over 3,960 feet (1,207 meters) wide and 100 feet (30 meters) deep, flooding the Mississippi Delta with a volume of water measuring 468,000 cusecs. In only ten days, 1 million acres of land across the delta were immersed under water at least 10 feet (3 meters) deep. In 2007, a deep still lake remains at the point where the former levee was breached, eroding the underlying delta sediments.

More breaches along the levee occurred farther to the south through the months of April and May, as the floodwater was channeled back once again through the levees and into the Mississippi River at Vicksburg, Mississippi. On May 24, the final breach of the 1927 flood occurred at McCrea, Louisiana on the east bank of the Atchafalaya levee (Figure 3 shows the full extent of the flood).
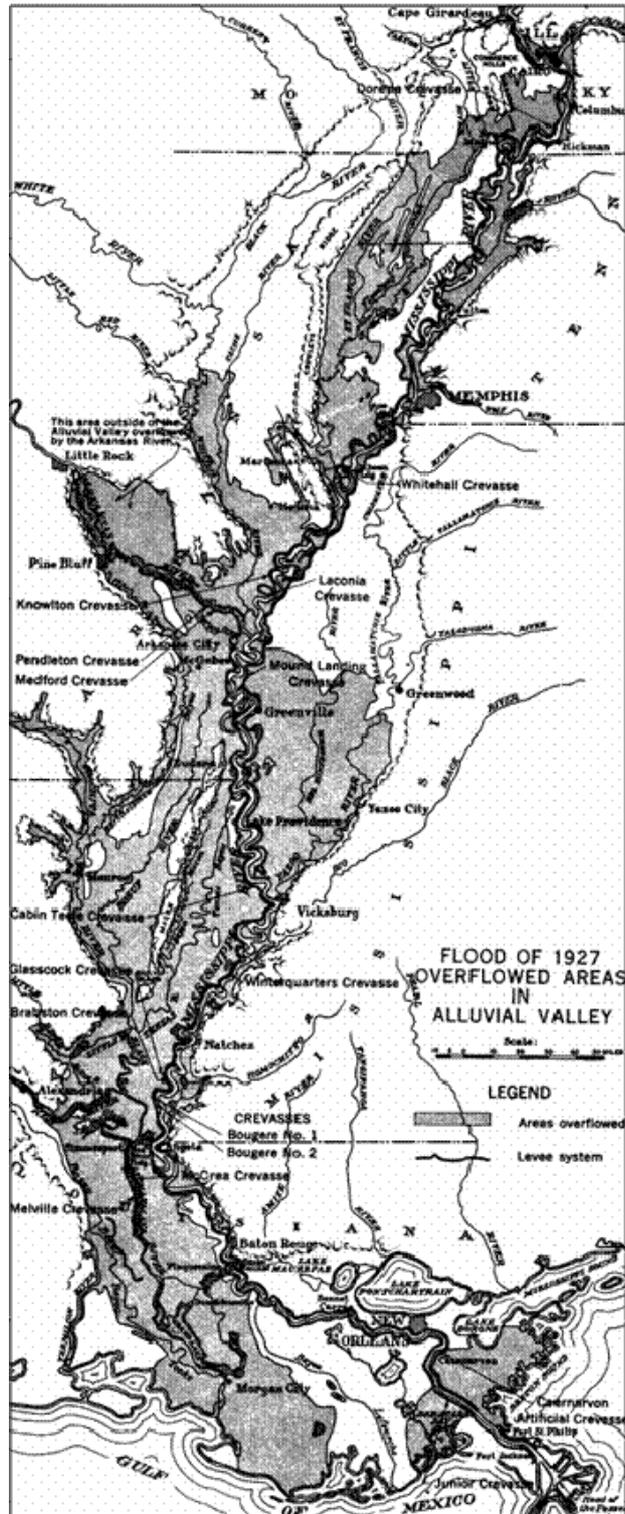
Figure 3: Detailed map of the areas flooded during the 1927 event
(Courtesy of the U. S. Army Corps of Engineers
http://www.mvd.usace.army.mil/mrc/Upon_There_Shoulders/index.html)

The 1927 Greet Mississippi Flood
80-Year Retrospective

With concern that the waters could overflow the city of New Orleans, on Friday, April 29, the levee at Caernarvon, Louisiana was dynamited downstream of the city, with the intention of increasing the speed of the river as it passed New Orleans and hence reducing the height of the anticipated flood wave (Figure 4). The Caernarvon breach flooded most of St. Bernard and Plaquemines parishes, with the houses and fields of the poor living to the east and south sacrificed for what was considered (at least by the city fathers) a greater good. And while reparations were promised by the governor of Louisiana, the mayor of New Orleans, and other men of industry in the city, little was ever actually given in compensation for those flooded out of the area. Moreover, the dynamiting proved to have been unnecessary, as breaches upstream of the city had allowed the excess flow to pass directly to the sea along the Atchafalaya Channel. However, memories of the dynamiting of the levees run deep and there were many conspiracists living in the Lower Ninth Ward in New Orleans on August 29, 2005, who claimed vociferously that the levees had once again been dynamited with the intention of saving the wealthier and whiter sections of the city.
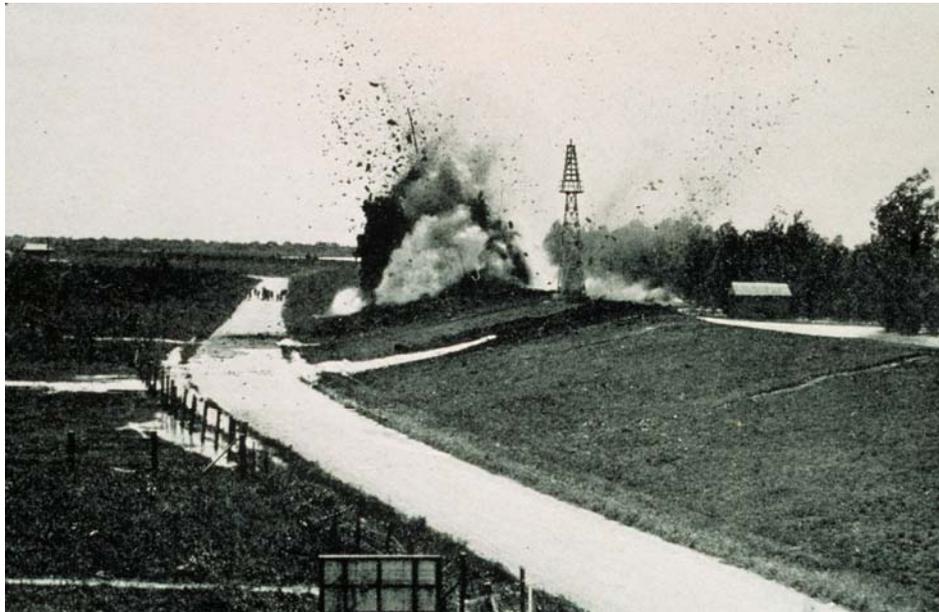
Figure 4: Dynamiting of the levee at Caernarvon, Louisiana to take pressure off levees further upstream at New Orleans (Courtesy of NOAA's National Weather Service Collection)

THE LEGACY OF THE 1927 FLOOD

The 1927 Great Mississippi Flood inundated 27,000 square miles (70,000 square kilometers) of land with as much as 30 feet (9 meters) of water. It took until mid-August for all of the water to recede, leaving a mud-covered, barren landscape. The 1927 flood triggered a whole new approach to catastrophe management. In April 1927, Herbert Hoover, the commerce secretary under President Coolidge, was appointed by the president to lead the rescue and relief efforts (Figure 5). He coordinated the federal response with those of the local governments, as well as the Red Cross. It was estimated that 330,000 people were rescued from rooftops and other high ground as the water levels rose. However large numbers of African Americans were left stranded on top of the intact sections of the levees because the white planters in the area were concerned that if they left "there will be no labor to work the crops" (Barry, 1997). Many did indeed take the opportunity to escape north to cities like Chicago, bringing stories of the miseries of the flood and the breaking levees to enrich the traditions of blues music.

Tent cities run by the Red Cross sprang up across the impacted states and housed over half of the 700,000 estimated refugees left homeless by the flooding. The majority of people in these camps were African American. In May, reports began to circulate about abuse by guardsmen to those living in the camps, and in response, Herbert Hoover created the Colored Advisory Commission and appointed Robert Moton as its chairman to investigate. The commission found that many of the allegations could be substantiated; however, the overall findings were suppressed. And in 1928, Herbert Hoover — known as the "Great Humanitarian" due to his managing of the relief efforts — was elected to the presidency of the United States.

Figure 5: Herbert Hoover (left) in Natchez, Mississippi during the 1927 flood (Courtesy of the U. S. Army Corps of Engineers http://www.mvd.usace.army.mil/mrc/Upon_There_Shoulders/index.html)

The most important legacy of the 1927 flood was the change in the role of the federal government in managing flood risk in the U.S. Out of the catastrophe grew the Flood Control Act of 1928, which gave the federal government authority over the containment of the lower Mississippi River. On May 15, 1928, President Coolidge signed the act into law, committing the federal government — not the state or local authorities — to a definite program of flood control from Cape Girardeau, Missouri to the Head of Passes (i.e., where the Mississippi River branches off in three directions as water flows into the Gulf of Mexico).

The act authorized "under the direction of the Secretary of War and the supervision of the Chief of Engineers" a system of flood control achieved through floodways, levee channel improvements and stabilization, and tributary basin improvements. A total of $325 million was appropriated for the construction of "floodways, spillways or diversion channels" to divert flow from the Mississippi River (e.g., in the Atchafalaya basin). In the wake of the 1927 disaster, the original scope of the flood control plan was even more comprehensive, encompassing areas along the upper Mississippi River with federal expenditures of around $100 million a year, but was scaled back due to the projected costs.

In 2007, the plan to control the waters of the lower Mississippi River is known as the Mississippi River and Tributaries (MR&T) Project. According to the U.S. Army Corp of Engineers (USACE), the design flood used for control structures is known as the "project flood" and is greater than the 1927 Great Mississippi Flood, being estimated at 2.36 million cusecs at Cairo, Illinois; this is approximately 10% larger than the volume of water recorded at the junction with the Arkansas River during the 1927 flood (just north of the breach at Mounds Landing). Unofficially, however, the maximum flow along the Mississippi River during the 1927 flood may have been over 3 million cusecs.

THE GREAT MISSISSIPPI FLOOD IN 2007

For the 80th anniversary of the Great Mississippi Flood, RMS evaluated the potential impacts if the event (i.e., the combination of levee failures and areas of inundation) were to occur today. Due to the economic and social changes that have occurred along the lower Mississippi River since 1927, the estimated $250 − $350 million loss in 1927 would no longer be a regional economic catastrophe, but a national disaster. In addition, as seen in the aftermath of Hurricane Katrina in 2005, shutting down the Port of New Orleans for a period of time could impact the global economy.

The analysis presented here was first undertaken by RMS in 2003. It has been updated to reflect the economic and exposure conditions in 2007. The first stage of the event reconstruction was to ascertain the extent and depth of flooding in 1927 based on the original detailed mapping of the flooded area. Then, the value and construction type of all properties at risk within this flood extent was modeled, and the loss at each location was calculated based on the expected flood vulnerability of the buildings and their contents. The total loss is then the sum of all the losses in the affected communities. At flood depths of more than 5 feet (1.5 meters), a large majority of properties are a total loss.

FLOOD EXTENT AND DEPTH

In order to determine the boundaries of the 1927 flooding, the most reliable contemporary maps of the flood extent were digitized and geographically referenced using available landmarks, such as river channels and administrative boundaries. RMS used a high-resolution digital terrain model (DTM)[2], which produces a digital topographic map with no landscape features, to refine and ensure mapping accuracy with regard to flooding extent, flooding depth, and the slope of the land. Refinements on the flood extent and depth were additionally tested against satellite imagery and a 330-foot (100-meter) resolution digital elevation model (DEM), which produces a topographic map with landscape features. For example, in some areas where the DEM failed to explain why an area was not flooded, satellite imagery (Figure 6) clearly showed that flood defenses in the form of levees along the river must have breached only on one side during the 1927 event.

[2] Developed by the U.S. Geological Survey (USGS)
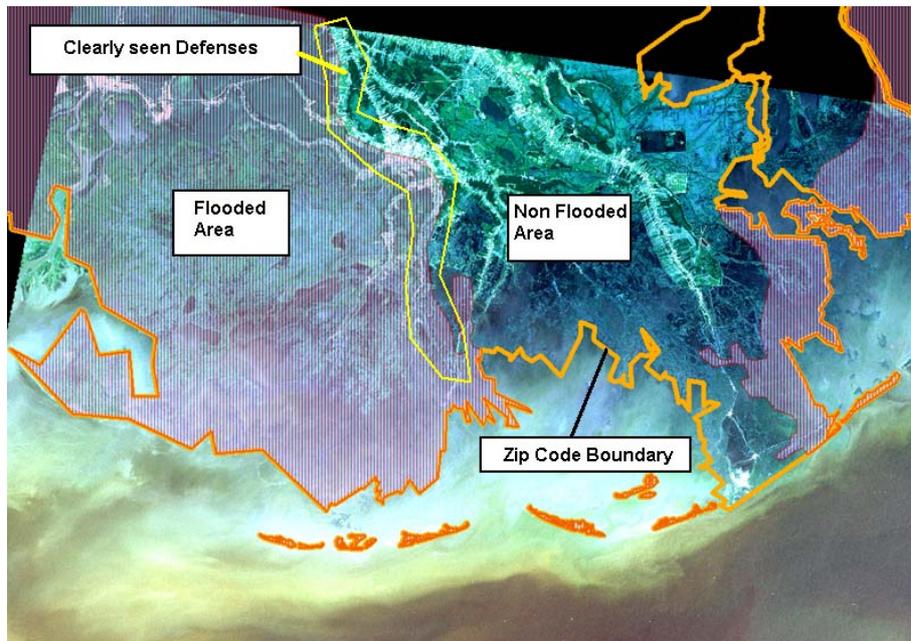
Figure 6: Flood defenses shown on satellite imagery, accounting for flooding on the western side of the levee but not the eastern side

Once the flood extent was determined [Figure 7(a)], flood depths across the impacted area were derived. At the boundary of the flood extent with the landscape, the flood depth was zero. Then, in a series of transects across the river at intervals approximately 3,280 feet (1,000 meters) apart, elevation levels as provided on the DEM were noted. Ideally, such 'crosscut' lines drawn perpendicular to the river and trimmed at the flood extent lines will have the same elevation levels at either end. These elevation levels are assumed to represent the upper water level at that point along the river. The separate profiles were tested to show that the water levels were falling consistently downriver. Ground elevations were deducted from these upper water levels to calculate the flood depth at each point along the traverse. From the point data, a continuous flood depth grid was created using smoothing methods to eliminate abrupt changes in depth across the flood extent [Figure 7(b)]. Using this technique with a 3.3-foot (1-meter) vertical resolution, flood depths across the 100 impacted counties range from 3.3 feet (1 meter) to over 50 feet (15 meters) with an average depth of 12.5 feet (3.8 meters).
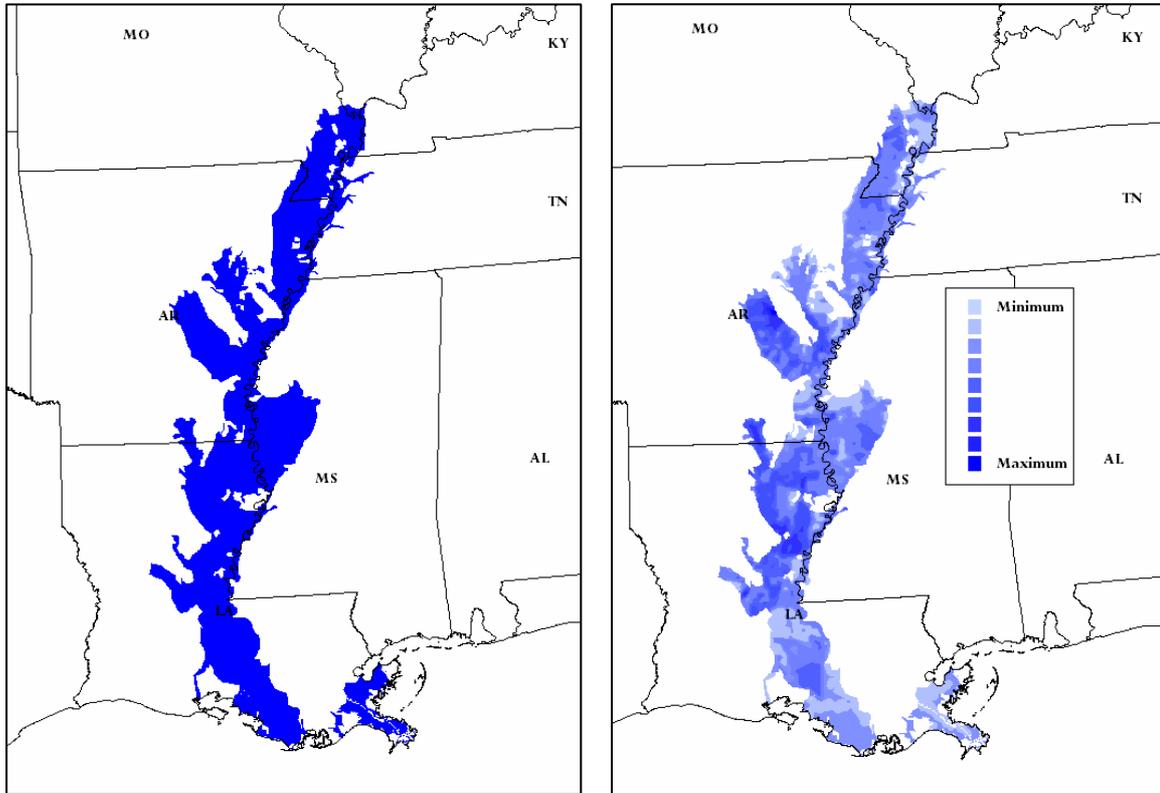
Figure 7: Digitized (a) extent of inundation and (b) flood depth during
the 1927 Great Mississippi Flood

EXPOSURE

In all, there are 100 counties (or portions of counties) across seven states (AR, IL, KY, LA, MS, MO, and TN) within the 1927 flood extent. For example, 100% of Mississippi County in Missouri, but only 1% of Jackson County in Arkansas, lies within the flood extent. According to the latest estimates from the U.S. Census Bureau, approximately 1.9 million individuals live within this area today, roughly 50% more than the estimated 930,000 who resided in the impacted area in 1927.

RMS estimates the value of the building inventory within the flood extent, including structures and their contents, at about $240 billion, with $150 billion for residential properties (single-family and multi-family dwellings), and $90 billion for commercial and industrial properties. Of these estimates, approximately 60% of the value is attributed to property exposure and 40% to contents exposure. These inventory estimates are based on the 2007 RMS® U.S. Industry Exposure Database (IED). The residential line of business in the U.S. IED is developed using aggregate, sanitized insurance data and publicly available data such as U.S. Census population, per capita income, and replacement cost per square foot. For commercial and industrial lines, exposures are based on fixed reproducible tangible asset data from the U.S. Bureau of Economic Analysis, business pattern data from the U.S. Bureau of Economic Analysis, business square footage, and employee data from Dun & Bradstreet.

Building and Contents Vulnerability

The vulnerability of the building and contents exposures is a function of the flood depth. The methodology used in this reconstruction takes a distribution of flood depth in each county and uses it to estimate the mean damage of the exposures within the flood extent of the county. Separate vulnerability functions are used for building damage and contents damage for each line of business, with the most important determinant being the building height. Taller buildings tend to have more restricted contents damage than shorter buildings, since part of the contents will be located on the higher floors that are not flooded.

Economic Loss Estimates

Based on the RMS analysis, total economic damages are estimated between approximately $130 billion and $160 billion, 65% of which is due to residential damage and the remaining loss to commercial structures (Table 1). This range in estimated loss arises principally from uncertainties in recreating the flood extent and flood depths from the available flood extent maps. Additionally, there is inherent uncertainty in the vulnerability of the building stock and contents to the severity of the flooding, and in particular those situations in which the flooding could be considered to cause a total loss. While some damage would occur in all of the affected states, the state of Louisiana sustains close to 40% of the total loss.

Table 1: Estimated economic losses from a repeat of the 1927 Great Mississippi Flood in 2007

State	Line of Business	
	Residential Losses ($Billions)	Commercial Losses ($Billions)
Louisiana	$37.0 - $42.0	$15.0 - $21.0
Arkansas	$30.0 - $33.5	$14.5 - $18.5
Tennessee	$9.5 - $11.5	$6.0 - $7.5
Mississippi	$8.0 - $9.0	$3.0 - $4.0
Missouri	$6.5 - $8.0	$3.5 - $5.0
Kentucky	$0.3	$0.5 - $1.0
Illinois	$0.2	$0.1
TOTAL	**$91.5- $104.5 Billion**	**$42.6 – $57.1 Billion**

This Event in Perspective

It should be noted that any future flood event is unlikely to replicate the flood extent of 1927. Levees have been built stronger and higher since 1927, but the bed of the river has also risen in many places. With stronger levees one could expect fewer failures, although as the experience of levee failures in New Orleans after Hurricane Katrina revealed, relatively short sections of levee failure can have truly catastrophic consequences — the taller the levee, the greater the speed and force of the flooding.

In contrast to the 1927 flood, where no compensation was available for those who lost homes and businesses within the flood extent, the National Flood Insurance Program (NFIP) would cover a percentage of the loss if it were to recur today. For approved communities that institute floodplain management strategies (approximately 75% of all communities in the U.S.), homeowners and business owners could purchase coverage for water damage under the NFIP. Based on the most recent information from the flood program (NFIP, 2007), there are close to 220,000 policies covering $37 billion in exposure across the 100 counties affected by the 1927 flood, representing about 16% of the total exposure value. Therefore, in the event of a repeat of this catastrophe, around 84% of the loss would be outside the terms of insurance. This is a higher dollar amount of uninsured loss than in Hurricane Katrina.

Faced with this level of loss, one could anticipate a series of consequences. Significant pressure could be placed on insurers to pay some part of the loss under the terms of fire insurance coverage. Lawsuits could be filed, claiming that the damage was a consequence of levee failure, debris damage, or contamination rather than simply flood inundation. There could also be significant political fallout from a disaster of this magnitude and its economic consequences in the lower midwestern states — as was the case in 1927. The large majority of the people in the affected area would not be able to live in their homes and would be forced to relocate or to live in temporary accommodations. One could expect large levels of permanent migration out of the region and the relocation of businesses. Traffic down the Mississippi River would likely be disrupted for several months, during and following the flood.

In setting premium rates in the Mississippi River floodplain, there is inevitably some inherent risk that the levees could fail. To encourage communities to participate in the NFIP program, those residing in an area prior to the issuance of a Flood Insurance Rate Map (FIRM) have their premiums subsidized. Moreover, when there is evidence that risk was previously underestimated, it can be difficult to get the appropriate adjustments to the FIRM approved. Around $108 million in premium is collected annually for the 220,000 policies issued across the 100 counties in this analysis, corresponding to an average rate of 0.29%. This implies a 340-year return period of catastrophic flooding causing total loss to a property and a longer return period if there are contributions to losses from more frequent, rainfall-related flooding.

In a recent study of great floods on major river systems with catchments greater than 77,220 square miles (200,000 square kilometers) and with return periods of 100 years or more (Milly et al., 2002), events such as those of 1927 on the Mississippi River and 1993 on the Mississippi and Missouri rivers show a statistically significant increase in occurrence over the past 30 years. This is consistent with climate model outputs, implying a connection with climate change and global warming, and also implying that the return periods of extreme flows employed in designing the Mississippi levees may need to be assessed. It suggests that the risk to properties within these areas is currently higher than is generally appreciated, because the probability of failure of these levees could be higher. This is the same situation that prevailed in New Orleans before Hurricane Katrina.

As this report shows, the potential for a large flood loss far greater than has been seen in U.S. history exists. The spotlight of world attention today is on how New Orleans resolves to sustain itself in a situation of rising risk. U.S. and local governments have the opportunity to pioneer solutions that ensure that risk is managed and mitigated appropriately. As the leading independent provider of global risk information, RMS will be working to ensure that risk analytics continue to remain at the heart of decisions about development, flood protection, and insurability.

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