# Community Resilience: Lessons from New Orleans and Hurricane Katrina

## CARRI Research Report 3

Community & Regional RESILIENCE Initiative

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# COMMUNITY RESILIENCE: LESSONS FROM NEW ORLEANS AND HURRICANE KATRINA

C. E. Colten,* R. W. Kates,† and S. B. Laska‡

*Carl O. Sauer Professor, Department of Geography and Anthropology, Louisiana State University, Baton Rouge, Louisiana

†Independent Scholar, Trenton, Maine

‡Professor of Sociology and Director of the Center for Hazards, Assessment, and Response and Technology, University of New Orleans, New Orleans, Louisiana

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## RESEARCH FINDINGS ABOUT COMMUNITY AND REGIONAL RESILIENCE

One of the commitments of the Community and Regional Resilience Initiative (CARRI) is to understand what resilience is and how to get there, based on research evidence.

As one resource for this effort, CARRI has commissioned a number of summaries of existing knowledge about resilience, arising from a number of different research traditions. This paper is one in a series of such summaries, which will be integrated with new resilience explorations in several CARRI partner cities and with further discussions with the research community and other stakeholders to serve as the knowledge base for the initiative.

For further information about CARRI's research component, contact Thomas J. Wilbanks, wilbankstj@ornl.gov, or Sherry B. Wright, wrightsb@ornl.gov.

## COMMUNITY AND REGIONAL RESILIENCE INITIATIVE

Oak Ridge National Laboratory's (ORNL) Community and Regional Resilience Initiative (CARRI) is a program of the Congressionally funded Southeast Region Research Initiative. CARRI is a regional program with national implications for how communities and regions prepare for, respond to, and recover from catastrophic events. CARRI will develop the processes and tools with which communities and regions can better prepare to withstand the effects of natural and human-made disasters by collaboratively developing an understanding of community resilience that is accurate, defensible, welcomed, and applicable to communities across the region and the nation.

CARRI is presently working with three partner communities in the Southeast: Gulfport, Mississippi; Charleston/Low Country, South Carolina; and the Memphis, Tennessee, urban area. These partner communities will help CARRI define community resilience and test it at the community level. Using input from the partner communities, lessons learned from around the nation, and the guidance of ORNL-convened researchers who are experts in the diverse disciplines that comprise resilience, CARRI will develop a community resilience framework that outlines processes and tools that communities can use to become more resilient. Of critical importance, CARRI will demonstrate that resilient communities gain economically from resilience investments.

From its beginning, CARRI was designed to combine community engagement activities with research activities. Resilient communities are the objective, but research is critical to ensure that CARRI's understanding is based on knowledge-based evidence and not just ad hoc ideas—we want to get it right. To help with this, CARRI has commissioned a series of summaries on the current state of resilience knowledge by leading experts in the field. This kind of interactive linkage between research and practice is very rare.

In addition to its partner communities and national and local research teams, CARRI has established a robust social network of private businesses, government agencies, and non-governmental associations. This network is critical to the CARRI research and engagement process and provides CARRI the valuable information necessary to ensure that we remain on the right path. Frequent conversation with business leaders, government officials, and volunteer organizations provide a bottom-up knowledge from practitioners and stakeholders with real-world, on-the-ground, experience. We accept that this program cannot truly understand community resilience based only on studies in a laboratory or university. CARRI seeks to expand this social network at every opportunity and gains from each new contact.

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## LIST OF RESEARCH PAPERS BY NUMBER

CARRI Report 1: Susan L. Cutter, Lindsey Barnes, Melissa Berry, Christopher Burton, Elijah Evans, Eric Tate, and Jennifer Webb, *Community and Regional Resilience: Perspectives from Hazards, Disasters, and Emergency Management*, September 2008.

CARRI Report 2: Susanne C. Moser, *Resilience in the Face of Global Environmental Change*, September 2008.

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# 1. VULNERABILITY AND RESILIENCE IN NEW ORLEANS

New Orleans occupies a perilous place on the subsiding delta of the lower Mississippi River (Figure 1) where flooding from the river and hurricanes have been commonplace since the city's inception. In addition to 27 major floods over the past 290 years (Kates et al. 2006), the city has had to contend with other hazards, including nineteenth-century invasions, yellow fever epidemics, and twentieth-century drinking water pollution (Colten 2005). Of these hazards events, yellow fever produced the highest number of fatalities, but advances in medical science have largely eliminated most devastating diseases from the city and improvements in water quality and treatment have likewise reduced toxic and bacterial threats. Flooding remains the most pressing concern and is the focus of this report.

New Orleans and its surrounding suburban communities have demonstrated an ability to rebound from repeated encounters with riverine and hurricane floods, many of which produced limited impacts. Over the course of nearly three centuries, local and federal organizations collaborated to erect extensive flood protective structural systems, establish hurricane and river flood forecasting, and formulate evacuation plans. Before Hurricane Betsy in 1965, a relatively small population lived in the most vulnerable locations. Following that landmark storm, a combination of new hurricane protection levees and modest-sized storms kept damages to a minimum until Hurricane Katrina arrived. This storm overwhelmed the hurricane protection levees in August 2005 and flooded approximately 80 percent of the city, forced a complete and extended evacuation, caused an extensive relocation of population (150,000 fewer residents 2.3 years later), disrupted basic municipal services for months, left over

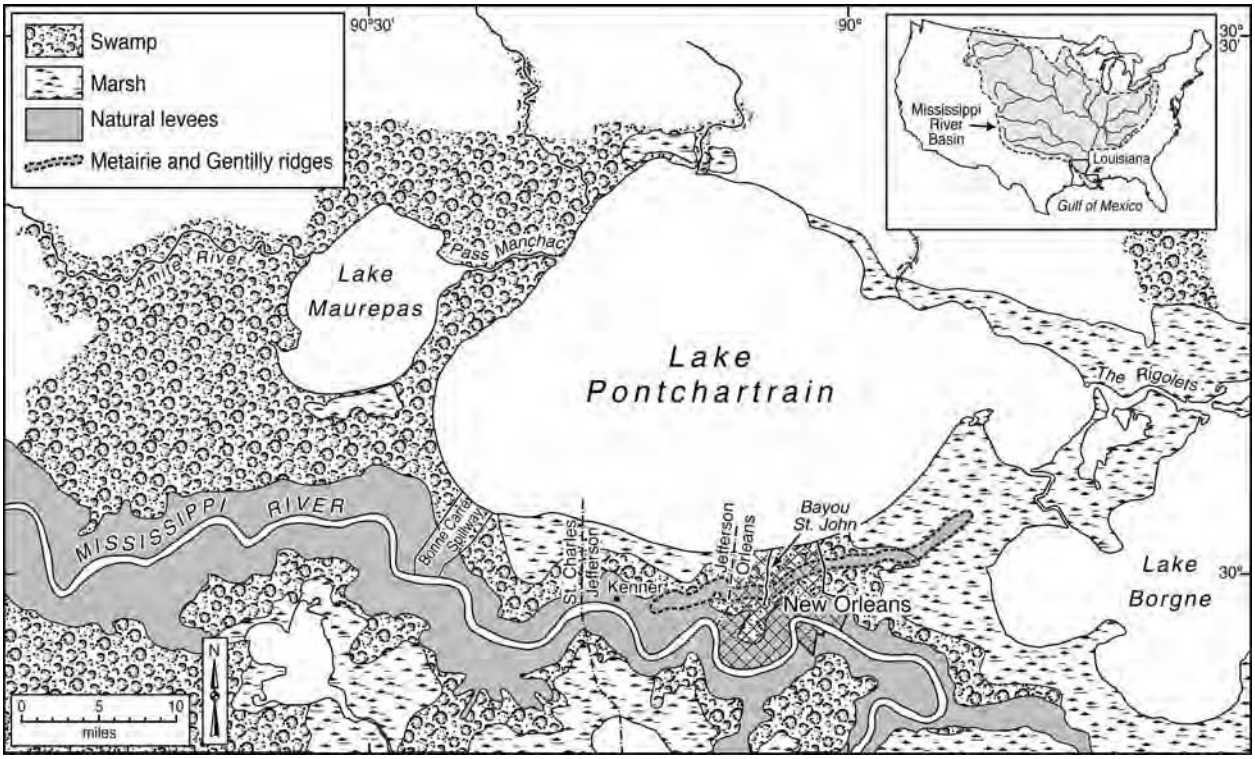


**Figure 1. New Orleans Environmental Setting.** *After*: Colten, Craig E. 2005. *An Unnatural Metropolis: Wresting New Orleans from Nature*. Baton Rouge, Louisiana State University Press.

half the city's residences seriously damaged, derailed economic activity, disentangled social networks, and exposed the ineffectiveness of institutional and governmental capabilities to react promptly to such an event. The ensuing response has been determined but fitful in its progress. One would hardly characterize the region's reaction as resilient, although some elements of resilience were in place before the storm and there has been a determined effort to bring about a full-fledged recovery that reflects a resilient spirit, if not a resilient social and physical infrastructure.

## 2. ELEMENTS OF RESILIENCE

The Community and Regional Research Initiative on Resilient Communities (CARRI) defines resilience as "a community or region's capability to prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to public safety and health, the economy, and national security" (Wilbanks 2007). Thus enhancing a community's resilience is to improve its capacity to *anticipate* significant multi-hazard threats, to *reduce* overall the community's vulnerability to hazard events, and to *respond* to and *recover* from specific hazard events when they occur. Sixty years of hazard and disaster research has offered extensive findings regarding this capacity, and we draw on a recent report summarizing this research (Figure 2) (National Research Council 2006a), as well as our own hazard and disaster research (Burton, Kates, and White 1993; Colten 2005; Laska forthcoming), studies of Katrina (Colten 2007, Kates et al. 2006, Laska and Morrow 2006), and knowledge of the New Orleans community and region (Colten 2005, Laska 2004).[1] While most communities have some emergency management framework for hazard response, other elements of community

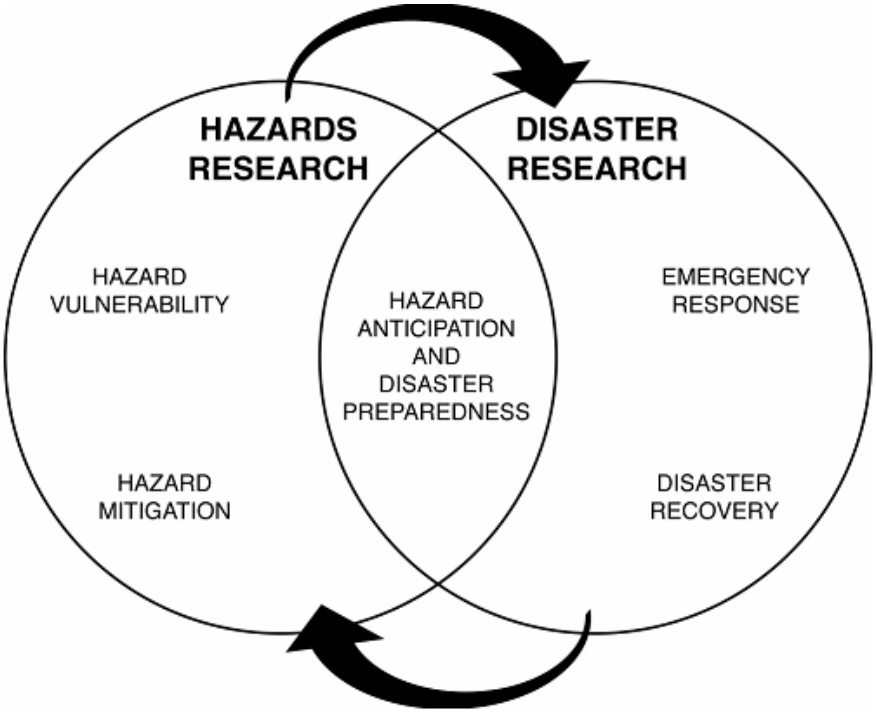


**Figure 2. Hazards and Disaster Research.** *Source:* National Research Council. 2006a. *Facing Hazards and Disasters: Under Human Dimensions.* Washington, D.C.: National Academy Press.

resilience—hazard anticipation, vulnerability reduction, and disaster recovery—commonly are fragmented (Birkman 2006).

## 2.1 Anticipating Multi-Hazard Threats

Hazards are threats to people and what they value. They are expressed during the occurrence of non-routine episodic events such as earthquakes, floods, flu pandemics, hurricanes, tank car derailments, terrorist attacks, and wildfires or as cumulative events emerging over time such as coastal erosion, drought, economic depression, and HIV-AIDS. Disasters result from the conjunction of hazard events with households, communities, and regions and result in excessive physical damage, human harm, economic loss, and social disruption. Enhancing community resilience reduces the disaster impacts of hazard events.

Anticipation of multi-hazard threats begins with hazard identification, takes form with specific event monitoring, forecasting, and warning, and includes recognition of the need to prepare for, respond to, and recover from such events. Hazards to be identified should include natural or environmental hazards (geophysical and biological), technological, and socio-economic, and significant hazards need to be addressed. There is value in thinking broadly but realistically about the hazards that a community should anticipate, such as which ones could prove disastrous for extensive parts of the community as evident either by experience or by risk assessment.

The impacts of hazard events are made more severe by preconditions of social vulnerability and other concurrent stresses or events. For example the impacts of floods can be made worse by floodplain development, low-income populations in inferior housing in vulnerable locations, land subsidence, stream channel alteration associated with transportation or levee building, and precipitation and tropical cyclone intensity from climate change. The impacts of wildfires are intensified by expanding wildlife habitats, $CO_2$ enhanced growth, fire protection, and cumulative drought. Identifying multiple and different types of hazards also enables resilient communities to draw upon and integrate different communities of planners and responders and to increase their capacity to respond to and recover from unanticipated and surprising events. For example, resilient communities planning for and responding to both geophysical and biological hazard events bring together the joint capabilities and extensive experience of the emergency management and public health communities.

Having identified the relevant set of multiple hazards, a resilient community seeks to assess their exposure (magnitude, frequency) and their sensitivity (expected consequences) to them, then to create integrated systems of monitoring, forecasting, and warning, and to make these assessments widely and publicly available. Special attention needs to be paid to often-ignored cumulative events, stresses, and community trends. Based on these assessments, preparations to prepare for, respond to, and recover from such events should follow, creating integrated emergency institutions and communications, developing formal disaster plans, training first responders, engaging in multi-hazard event response exercises, maintaining standby people, material, and financial resources, undertaking public education and information, and continuing long-term planning for recovery and vulnerability reduction (National Research Council 2006a).

## 2.2 Responding to Hazard Events

When a hazard event or multiple events are about to impact a community, a set of emergency responses ensues. Resilient communities will issue and widely disseminate

unambiguous forecasts and warnings, undertake evacuations or provide alternative shelter, and mobilize emergency personnel, volunteers, and standby material and financial resources. Following the event, emergency responders undertake search and rescue; care for and treat casualties, evacuees, and the sheltered; find, remove, and identify the dead; conduct damage and needs assessments; and restore order. The *emergency* period overlaps with a *restoration* period, when the repairable essentials of urban life are restored, which in turn overlaps with a *reconstruction* period, when the infrastructure, housing, and jobs for the destroyed city and pre-disaster population are re-established, as well as commemorative or betterment reconstruction.

In every hazard event and resulting disaster, creativity and improvisation are required as hazard events occur that have not been anticipated or the magnitude of such events is greater than anticipated and overwhelms planned-for responses, such as when people and resources are themselves casualties or are not accessible, communication links prove inadequate or fail, or responsibility and leadership are divided and public information is inadequate, confusing, or false. Vulnerable populations, groups, or locations that have not been identified or are ignored in planning receive inadequate responses. Surprising impacts occur (e.g., collapse of the New Orleans levees and failure of government to evacuate stranded residents for 5 days) and surprising needs arise (e.g., pet care). To respond to unplanned for or poorly dealt with impacts and needs, new groups of people or organizations emerge to help. To assist in this process, resilient communities will have assessed supplementary sources of response and assistance in advance (e.g., alternative shelters and feeding institutions, volunteer responders and skills, material stocks and logistic assistance from private business), but they will also have created a response climate capable of successfully using emergent groups and leadership.

## 2.3 Recovering from Disasters

Disaster recovery addressing the long-term needs of disaster victims and their community is both physical and social. This includes efforts to heal the injured and traumatized and their disrupted communities, to bring together separated families, to identify the dead, to restore the pre-disaster social and economic activities (familial and friendship support networks, income-producing, education, culture) and necessary services (financial, medical), to facilitate the permanent return of residents, and to repair and reconstruct the built environment (housing, business, utilities, transportation, civic) sufficient to support these essentials of urban life.

Recovery takes an extended time that is measured in years for most large disasters. Using a sequence of four identifiable post-disaster periods—emergency, restoration, reconstruction, and commemorative or betterment reconstruction—the time needed for disaster recovery appears to be a multiple of roughly 100 times the extent of the emergency period (Kates et al. 2006). Resilient communities can improve on that performance (Tierney and Burneau 2007).

Cities and regions seeking to recover after a disaster seem to simultaneously pursue goals to *rapidly recover* the familiar built environment and social-economic activities and to aspire to reconstruct in *safer*, *better*, and sometimes in more *equitable* ways. Conflict arises among groups or institutions and even individuals pursuing these different goals because they cannot be given equal attention in time, resources, and values. In addition, in accomplishing one goal, another may be less achievable. For example, rapid recovery, safer reconstruction, or a better community can be achieved for some segments of the population and community locations but not for others. Resilient communities recognize these conflicts as conflicts in values and try to plan for them and resolve differences beforehand, and then balance them during reconstruction. Political and economic power most often determines the outcome.

## 2.4 Reducing Vulnerability to Hazard Threats

The key to increasing community resilience is to reduce its overall vulnerability—the potential for harm and social disruption from multi-hazard threats—before hazard events occur. Thus hazard anticipation includes a vulnerability assessment identifying both the physical and social and economic vulnerability of the community and region. Physical vulnerability describes the potential for harm to both the built environment (buildings, utilities, transportation lines, recreational facilities, and other infrastructure) and the natural environment (shores, wetlands, rivers, forests, hill sides, agricultural land) and their related economic losses. Social and economic vulnerability describes the potential for harm to the well-being of human populations (deaths, injuries, pain and suffering, disruptions of activities, family life, community functioning, and loss of economic activities and services). Social and economic vulnerability has also come to mean the analysis of the relative disproportional potential of harm to sub-groups in a population, that is, groups often characterized by income, age, gender, family relationships, ethnicity, race, and hazard exposure (Laska and Morrow 2006; National Research Council 2006a; Buckle 2004; Cutter and Finch 2008).

A variety of measures are available to mitigate hazard threats by reducing the potential for physical harm and social disruption in advance of hazard events. There are three major modes of actions: limiting exposure to the hazard, diminishing the direct impacts of hazard events, and sharing the losses from such events. Hazard exposure can be limited by restricting or selecting development within hazard zones (land acquisition, regulation, use, and density restrictions, community relocation), by enacting and enforcing hazard-resistant construction codes, and by evacuating populations and property in advance of hazard events. The impacts of hazard events can be reduced by community-wide protection (sea walls, levees, dams, fire breaks, quarantine), by strengthening the built environment to resist the physical forces of hazards (e.g., building codes and standards, elevation requirements, redundancy in essential services), and by protecting populations (shelters, drills, vaccinations). Provisions can be made for sharing losses in advance of hazard events (insurance, relief funds, personal savings). Finally, very important to post-disaster resilience is an ongoing community-wide commitment to respect all segments of the community and to be inclusionary in the decision-making process and resource allocation so that trust is established in advance of the next disaster.

We use these elements of community resilience (anticipate, respond, recover, reduce) to assess the resiliency of New Orleans before, during, and after Hurricane Katrina. We divide the first time period, "Before Hurricane Katrina," beginning with early history and continuing up to the point in which the storm was being tracked in the Gulf of Mexico. The "during" period includes the onset of the storm up to the 1-year anniversary, and the "after" period from 1 year after the storm into the foreseeable future.

# 3. BEFORE HURRICANE KATRINA

## 3.1 Anticipation before Katrina

From back-to-back hurricanes in 1722 and 1723 to a pair of nineteenth-century calamities, New Orleans and Gulf Coast residents had come to identify powerful tropical storms as a primary hazard during the late summer and early fall seasons (USACE 1972). Monitoring and forecasting hurricanes had improved over the twentieth century. From vague newspaper notices and warning flags in the early 1900s to more accurate predictions broadcast on radio

and television by the early 1960s, storm tracking enhanced anticipation tremendously. By the 1940s, the weather service would issue standardized warnings and local plans advised people to evacuate low areas and for those who were in secure structures to board up windows and stockpile food and water (Tannehill 1938; Dunn and Miller 1960).

In the 90 years since the 1915 hurricane, preparations spread across several areas: storm forecasting, coordinated evacuations, and mobilization of government and civic organizations. The burden of the Weather Bureau in the early twentieth century was to provide warnings to businesses and to minimize the commercial disruption. Private-sector preparations, such as the railroad company staging track repair crews and shipping companies taking safe anchorage to avoid storms, were the primary anticipatory steps, other than efforts at the private business and household level.

Very general guidance for coordination of disaster response efforts was available in New Orleans by 1949 in a local plan required by the State Office of Civil Defense (Louisiana Military Department 1950). Among the disasters anticipated were floods, fires, epidemics, and hurricanes. By the time of the 1964 hurricane, preparations were more extensive and more organizations were involved (U.S. Department of Commerce 1959a). By the 1990s, Federal Emergency Management Agency (FEMA) and the State Department of Emergency Preparedness had assumed responsibilities formerly delegated to civil defense organizations, while the National Guard, the Coast Guard, the Red Cross, local law enforcement, and other government entities continued roles performed under the previous administrative apparatus.

At the local level, activating civil defense plans, such as canceling classes and transforming schools and other public buildings into shelters, reflected a collective social planning effort. Improved communication and other technologies enabled anticipation to filter from large businesses and the military, which had effective internal communications systems early in the century, to an increasing number of local government and social organizations. Most significantly, anticipation broadened its reach beyond providing advance notice to commercial and national defense organizations to evacuating and sheltering those who lived in the most vulnerable areas.

Reflecting heightened anticipation, there were repeated official warnings that New Orleans remained vulnerable to a major hurricane strike (Sands 2006 ; NOTP 1990) from the 1970s on. In the 5 years prior to Katrina, major warnings, some of them eerily foretelling what would occur in Katrina, appeared in a popular science magazine, in a series of local newspaper articles, in scientific papers, and in a disaster simulation exercise (Fischetti 2001; McQuaid and Schelefstein 2002; Laska 2004; FEMA 2004).

## 3.2 Response before Katrina

Responding to floods in the nineteenth century was largely the responsibility of the individual and the municipality. During the early twentieth-century hurricanes, large corporations were the most capable of responding. Railroads and public utility companies pre-positioned crews and equipment and went to work quickly to repair infrastructure following hurricanes. Voluntary efforts, aided by the National Guard and city crews, constituted the principal means of supplying relief efforts in the early twentieth century (NOTP 1915a; NOTP 1915b; NOTP 1915c).

Newspaper accounts of the 1947 hurricane indicate a coordinated response by city government, the Red Cross, and National Guard. This reflects the post–World War II expansion of federal involvement and the lingering presence of war-time preparedness that carried over into the Cold War era. Federal involvement continued to expand following the 1947 hurricane.

City and military personnel jointly responded by participating in rescue and public safety actions after Hurricane Flossy in 1956 (NOTP 1956a; NOTP 1956b). Hurricane Betsy in 1965 had the most extensive impact on New Orleans up to that point in time and generated the most elaborate response. It flooded 43 percent of the city and seriously damaged over 14,000 homes (USACE 1965). Local, state, and federal officials coordinated a massive evacuation and a swift emergency response. Together with private companies and the Red Cross, the joint response had infrastructure, schools, and businesses functioning a near-normal levels 1 month after Betsy roared through the city.

The response did not end with clean up and repairs. Congress almost immediately appropriated funds to expand and strengthen the region's levee system (Colten 2006) and considered flood insurance legislation with "a new sense of urgency" (NOTP 1965a). These two responses constitute the most extensive re-calibration of preparations for future storms. Appropriations for the previously planned hurricane protection system set in motion the protracted construction of levees and other protective structures around the settled areas of southeast Louisiana—a system that was still incomplete when Katrina made landfall. While Congress did not immediately enact a flood insurance program, it eventually created the National Flood Insurance Program (NFIP) in 1967. New Orleans qualified to participate and revamped its building codes to call for higher floor elevations. Eventually flood insurance subscriber rates in the area were the highest in the country (Colten 2005).

## 3.3 Recovery before Katrina

In general, New Orleans and its vicinity rebounded following previous hurricanes and river floods, often aided by prevailing positive demographic and economic trends. The consistent element of recovery efforts centered on prompt restoration of the city's economy and its urban infrastructure—a return to the familiar. During past yellow fever and flood events, the city's leadership went to great lengths to represent commercial activity as unaffected by these calamities (Duffy 1966; Barry 1997), which indeed remained strong owing to the regional economy. Following the tradition of publicly downplaying disaster, the mayor called for a publicity campaign to tout the city's prompt recovery after Betsy in 1965 (NOTP 1965b).

Prior to Hurricane Betsy, population growth trends resumed promptly after calamities. Neither epidemic disease nor floods stymied population growth. Of course, national and regional immigration patterns factored into nineteenth-century demographic trends as well. Waves of Irish and later Italian immigrants continued to arrive in the city despite nineteenth-century yellow fever epidemics. Following the 1965 hurricane, however, a different set of interrelated factors conspired to prompt a major population adjustment. Interstate highways and a general out-migration of affluent whites from urban centers propelled depopulation of the city. While the Corps of Engineers began improving levees around the urban core, they also built improved protection for adjacent suburban areas—Jefferson Parish, St. Bernard Parish, and eastern New Orleans. Between 1960 and 2000, the city experienced a general population loss and a shift from a white (62 percent in 1960) to black majority (67 percent in 2000). The combined influence of transportation changes, white-flight, and expanded hurricane protection area, plus the "oil bust" of the 1980s, produced a more socially segregated city, with a spatially concentrated poor population, while at the same time the New Orleans area had become a more dispersed urban region by 2005 (Lewis 2003; Colten 2005; Burby 2006). Recovery following Betsy has not produced a more resilient population within the city; instead, the population was heavily dependent on rigid structural protection systems that encircled a sizable poor population (19 percent below poverty in 2004) with inadequate means to respond to hazards.

## 3.4 Reduction before Katrina

Following a series of river floods during the Colonial Period, the government mandated that all landowners build and maintain levees for riparian properties. This protected both the region's rural agricultural and urban commercial territories and enabled them to recover jointly. A post-flood rule of thumb emerged to build levees 1 foot higher than their previous height. In time, protective works design became more sophisticated and the Weather Bureau and the Corps of Engineers developed a method to calculate a hypothetical "standard project hurricane" for coastal locations (U.S. Dept. of Commerce 1959b). For New Orleans, the standard project hurricane had a projected probability of recurring "of only once in about 200 years" (USACE 1962; USACE 1966b, 28) with winds of 100 miles per hour and a forward speed of 11 knots per hour (USACE 1966b, 28). This guided initial hurricane protection levee design and construction following Hurricane Betsy (Figure 3). Construction proceeded in fits and starts and costs spiraled, making it ever more difficult for local partners and the Corps to secure adequate

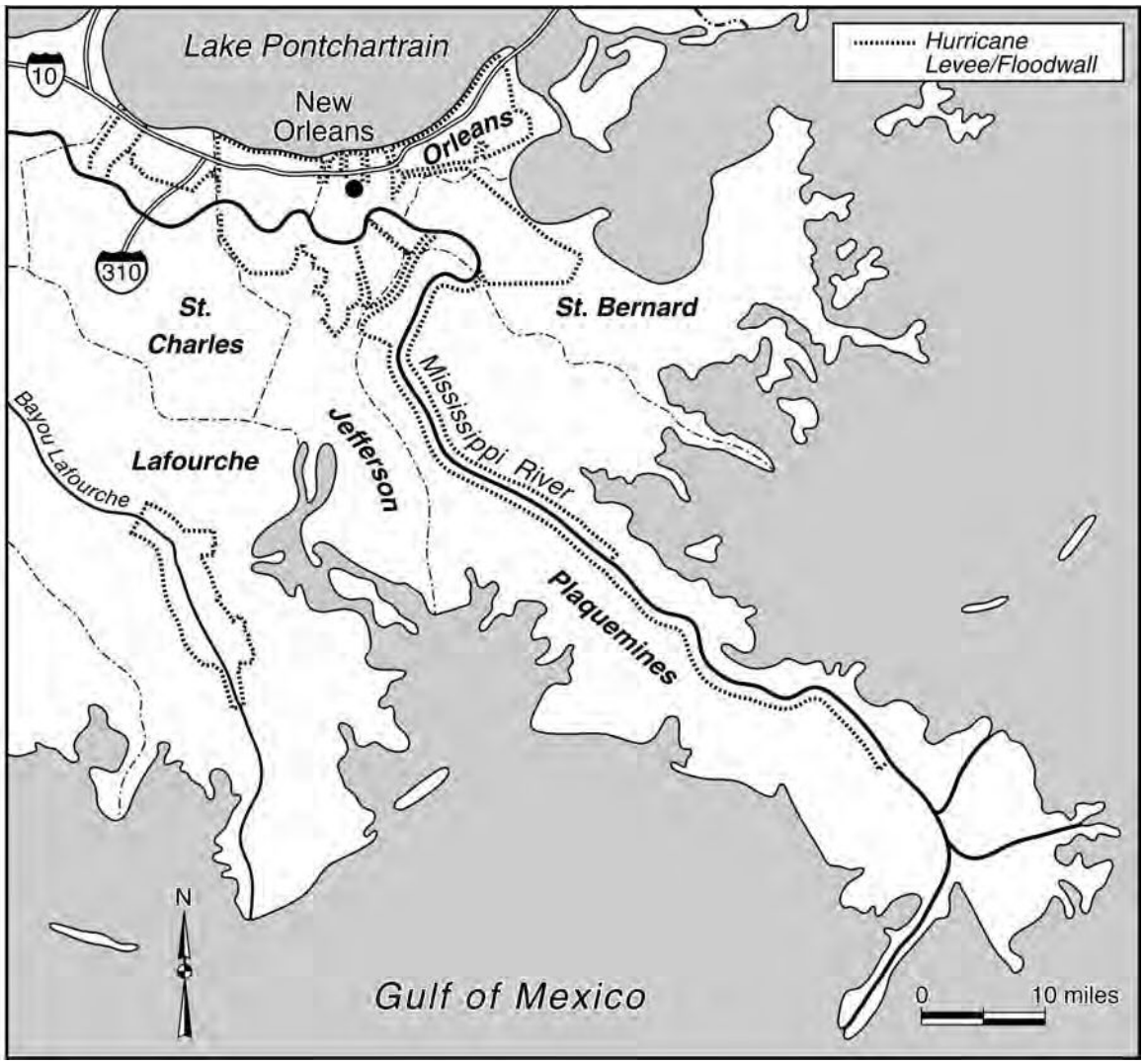


**Figure 3. Lake Pontchartrain and Vicinity, Louisiana Hurricane Protection System.** *After:* Yodis, E., and C. E. Colten. 2007. *Geography of Louisiana*. New York: McGraw-Hill.

funding. Competition among Louisiana interests, economic cycles, and national spending priorities all disrupted steady funding. Those responsible for the levees gave little consideration to the fact that each component was part of a comprehensive protection system. At the time of Katrina in August 2005, some portions of the hurricane protection system were nearly complete, while others were about one-third complete. Protection remained uneven, and the reduction of risk was incomplete (Colten 2006).

There were no restrictions on development within the expanding levee system. Between 1965 and 2005, developers built 22,000 new homes in previously uninhabitable sections of eastern New Orleans (Burby 2006). The number of households in Jefferson and St. Bernard parishes swelled between 1960 and 2000 from 55,351 to 176,234 and from 8,104 to 25,123, respectively. With new housing, the population in both Jefferson and St. Bernard more than doubled between 1960 and 2000, while New Orleans lost population to its suburban territory. At the same time, new housing in the city increased in the most flood-prone areas.

Another element of flood risk increased as the levee system crept toward completion. With a ring of levees around the urban area, subsidence within that circle, and increased land cover, New Orleans and its neighbors faced increasing problems from rain-induced flooding. In the 1990s, the Corps of Engineers embarked on a massive program to improve the region's internal drainage and thereby reduce flood risk from precipitation (Southeast Louisiana Drainage Project). It enlarged the capacity of the drainage system and the pumps that lift the water into the river and lake. This system was largely in place by 2005 (Colten 2005) and had demonstrated its benefits (Ergen 2006; Stack 2007).

Evacuation offered a second key element to efforts to reduce hurricane impacts. Hurricane prediction had improved considerably during the span between Betsy in 1965 and the early twenty-first century. Satellite tracking and weather models provided much greater forecast precision and television and the Internet afforded much more effective dissemination of that critical information, but planning for evacuation omitted significant numbers of residents. The Corps' and FEMA's evacuation report from 1994 revealed that a sizable population would be hesitant to evacuate (FEMA and USACE 1994), yet warnings before Georges in 1998 and Ivan in 2004 prompted unprecedented levels of evacuation (USACE et al. 1999; Howell 2005). Additional research produced the effective "contra-flow" evacuation option (Theodoulou and Wolshon 2004). Yet despite the widely publicized Hurricane Pam drill, the state's emergency plan remained incomplete when the 2005 hurricane season arrived (IEM 2004). In anticipation of a storm even more powerful than Katrina, effective steps to reduce impacts were not finalized and concern about "evacuation fatigue" plagued those involved in evacuation planning (Howell 2005; Jenkins, Laska, and Williamson 2008).

A third element began in 1967 when Congress passed the National Flood Insurance Program (NFIP) to reduce the burden of disaster relief and share the costs among all rate payers. Subscribership in the NFIP in New Orleans stood at 57 percent before Katrina, although this varied across the city based on income (Brinkman and Ragas 2006) , largely due the frequent localized floods within the ring of levees and not the risk of catastrophic loss associated with hurricanes. However, of course, the risk coverage applies to both. Delayed, uneven, and inconsistent enforcement of building codes enacted at the local level and extensive urbanization in flood-prone areas minimized the benefits intended by the program (Colten 2005).

# 4. DURING AND AFTER KATRINA

## 4.1 Anticipation during and after Katrina

As Hurricane Katrina moved toward Louisiana in August 2005 the National Hurricane Center offered precise warnings 32 hours in advance of landfall and tightened the accuracy of its projected landfall zone (Knabb et al. 2005). During the storm's acceleration across the Gulf, Louisiana Governor Blanco requested that President Bush declare an emergency on August 27 (effective August 26). This activated National Guard and state agencies (U.S. Congress 2006; Brookings Institution n.d.). Hurricane models had predicted the type surge that occurred in the structural bottleneck between the Chalmette and the New Orleans east levees (Mashriqui 2006), but most plans did not adequately anticipate widespread and massive levee failure. Pre-Katrina doomsday scenarios projected the levees holding and capturing water that overtopped the barriers.

While planners anticipated that some residents and visitors would not evacuate, they overlooked other consequences. Emergency plans foresaw cell phone communication as one layer in a redundant communication system. Emergency responders, including police, would oversee public safety with available emergency vehicles, while households would stockpile food and water, and the Red Cross would supply back-up source emergency rations. These plans failed as there was no anticipation of disrupted landlines and emergency communications that prompted an overwhelming demand on the undamaged cell-phone relay towers. With power off, emergency vehicles could not be refueled, and some emergency responders redirected their efforts to evacuating and caring for their own families. The possibility that the Red Cross would not be able to enter the city was not anticipated, nor the desperation and looting that followed the exhaustion of meager food and water stockpiles while the officials blockaded entry of additional emergency supplies.

## 4.2 Response during and after Katrina

While downstream parishes began declaring evacuations on Saturday the 27th, New Orleans Mayor Nagin delayed ordering a mandatory evacuation until the 28th. The same day, he opened the Superdome as the refuge of last resort (U.S. Congress 2006; Brookings Institution n.d.). Transportation officials enacted the contra-flow plan, which routed all interstate highway lanes in an outbound direction to speed evacuee movement. Amtrak, the federal train system, was not taken advantage of (NYT 2006a), although planners had discussed its use before Katrina.

Municipal, state, and federal officials staffed emergency facilities and put existing plans into operation. By the 29th, some 1.2 million evacuees had found shelter with friends and families, in commercial lodging facilities, or in locally operated arenas, schools, and other large facilities across the state. The Red Cross and the military dispatched teams and supplies to staging centers across the region to serve the swelling number of evacuees (U.S. Congress 2006b). Due to the sizable deployment of National Guard troops and their most modern equipment to Iraq, only inferior resources were available locally. Evacuees reported that they anticipated no more than a 3-day departure. Despite evacuation orders, some 130,000 residents and visitors to the city did not flee and rode out the storm—a number in accord with pre-storm predictions (Laska 2004).

When Katrina passed over the area, levees proved inadequate (Figure 4). Overtopping and failure in several locations allowed floodwaters to rush through the low-lying neighborhoods.

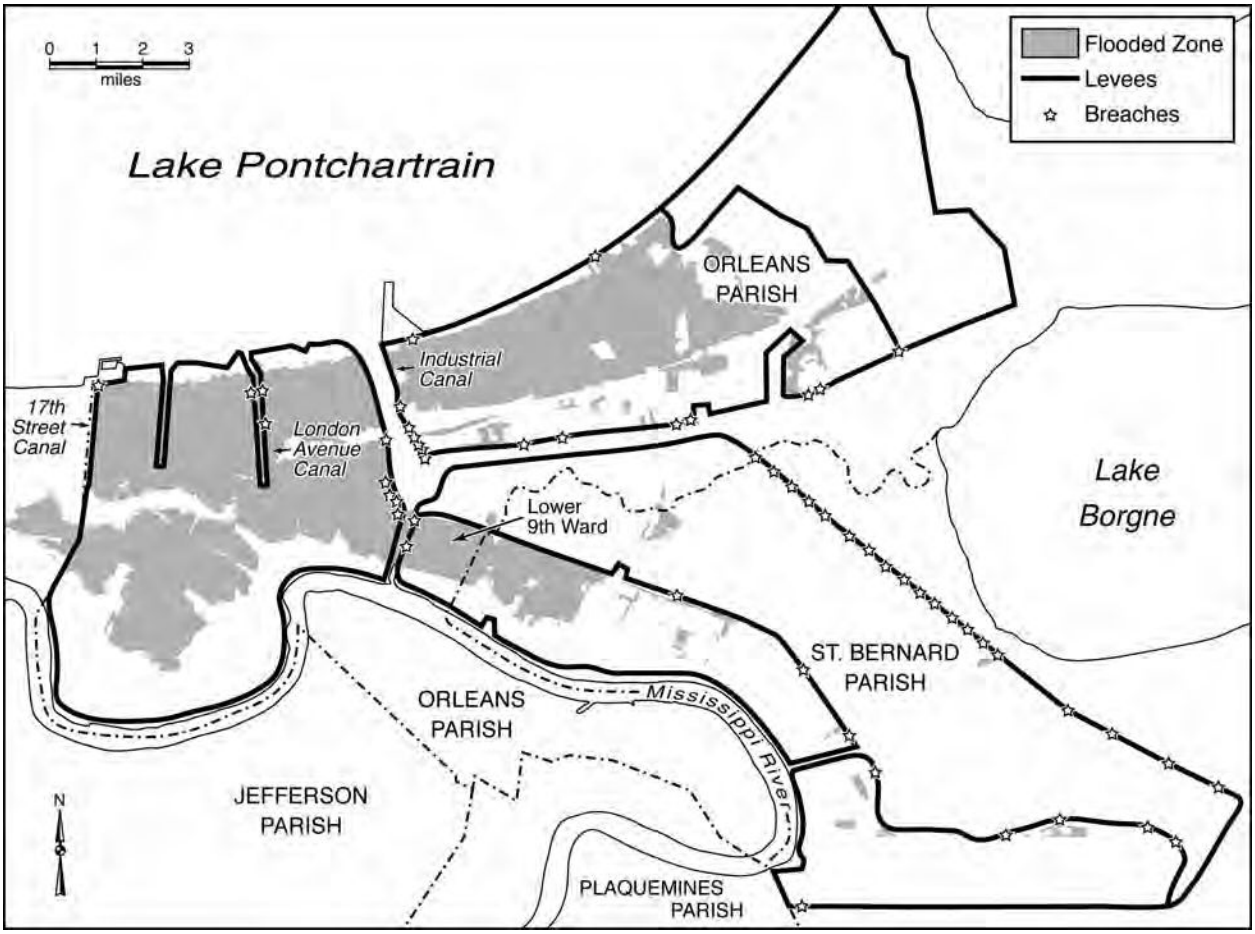


**Figure 4. Levee Breaches and Flooding after Hurricane Katrina.** *After:* Yodis, E., and C. E. Colten. 2007. *Geography of Louisiana*. New York: McGraw-Hill.

At the peak of flooding, some 80 percent of the city was under water. Depths ranged from a few inches up to over 15 feet. Ad hoc voluntary efforts in the affected neighborhoods were critical to the survival of many in the early post-storm hours. As soon as the winds subsided to safe levels, the Coast Guard began helicopter evacuations and plucked thousands of people from rooftops in the flooded zones. Louisiana wildlife and fisheries crews launched an armada of small watercraft through the streets of New Orleans to assist with rescue. In addition, volunteer boat owners from the region converged to assist with rescue, although law enforcement turned some back in the early hours as part of the disorganized use of volunteers.

Despite plans and exercises to prepare for events of this sort, the extreme conditions overwhelmed institutional responses at all levels (U.S. Congress 2006). Confusion ensued as communication among emergency responders became erratic. Efforts to evacuate the considerable number of displaced residents and hospital patients who had remained in the city took several days. With evacuees scattered over much of the Gulf south and unable to return to their homes, relief supply delivery became inconsequential (LGN 2005; Brookings Institution n.d).

Despite confusion among some government organizations, many private sector and public organizations responded quickly. Retail giant Wal-Mart displayed the private sector's ability to respond. According to one source, Wal-Mart trucks were distributing aid to Katrina's victims days before federal relief agencies (ST 2005; CIO 2005). The railroads opened their lines within a

month and a half. Port facilities and the airport were operational within a month as well, although the volume of traffic, particularly the airport, has been slow to rebound to pre-storm levels. Likewise public transportation agencies quickly opened one bridge of the interstate highway east of the city. Compared to previous storms, such as Betsy, key transport infrastructure was functional swiftly.

Within a week after the storm's arrival, New Orleans was a severely damaged shell without power or other basic services, it had virtually no residential population, and no revenue for the city's coffers. Over 134,000 residential units (of a pre-storm 188,000) suffered damage, and of that number over 105,000 had major or severe damage (FEMA 2006a). Fatalities never reached the number some had forecast, but some 1,500 perished in Louisiana—most in New Orleans. Following a second inundation due to Hurricane Rita in late September, it took 53 days from Katrina's landfall to pump the city dry. From October 12 on, emergency operations yielded to recovery efforts. Levee and infrastructure repairs took longer than anticipated and delayed related responses (New Orleans 2005–2006; USACE 2006a and 2006b).

Despite extensive emergency apparatus in the city's hospitals, the floodwaters disabled several low-floor generators or their electronic controls and left patients and staff in sweltering conditions. Medical personnel soon discovered that emergency medical supplies were inadequate for the extended emergency period. Further, evacuation plans for hospitals offered little hope for immediately alleviating conditions. Congress concluded that evacuation plans for those with special needs were inadequate (U.S. Congress 2006c). When flooding occurred, medical staff remained on hand without outside assistance until hastily arranged evacuations could move the patients to triage centers at the airport and beyond the city (U.S. Congress 2006; Batcher and Devlin 2005). Nursing homes proved to be even more inadequate than the hospitals in terms of providing care for their charges. Most hospitals closed for weeks or months after the storm, leaving the city with inadequate medical care for the returning population. Two principal hospitals, including the major public facility relied on by lower-income residents, have failed to reopen.

The magnitude of the event, the long-term displacement of residents, the disruptions to economic activity, and the inadequate labor force for rebuilding have presented complex obstacles to an efficient response. Nonetheless, at the 8-month mark, New Orleans was more or less on track in term of the pace of recovery experienced by other cities that had experienced comparable disasters (Kates et al. 2006). At the 1-year mark, the Brookings Institution reported that housing shortages were causing higher prices, the labor force was a mere 30 percent of pre-storm levels, and gas and electricity were reaching only 41 and 60 percent of the pre-storm customer base, respectively (mostly due to slow return of customers). Business and tourism travel to the region were at about 80 percent of the pre-storm levels after a year (Brookings Institution 2006). The city's population stood at 49 percent (Brookings Institution 2007), and only 29 percent of schools were open 12 months after the storm (Brookings Institution 2006).

## 4.3 Recovery during and after Katrina

Mayor Nagin followed the basic pattern of his predecessors by focusing on restoring basic infrastructure and the economy first. The long-term recovery of the hospitality industry has been good and, buoyed by major sports and entertainment events, hotel and motel tax revenue for early 2008 climbed to near or above pre-Katrina levels (Brookings Institution 2008). With the infusion of federal dollars for rebuilding, large engineering firms have secured federal contracts. Over $16 billion in construction funds are destined to keep the economy going for at least 2 years, but only 35 percent of FEMA infrastructure funds released to the state have

reached New Orleans. The city's economy remained below pre-storm levels in late 2007 but was above previous estimates, suggesting a stronger than anticipated recovery (Scott et al. 2007). By early 2008, unemployment in the region was very low, reflecting a shortage of workers, returnees, and affordable housing. While cash is flowing into the city, many small locally owned professional businesses are struggling to maintain their staffs as large outside firms out-compete local companies for contracts and resident professional staff. Tourists avoiding the hurricane season could impose staffing burdens on restaurants and hotels. By mid-2007, some 9,300 employers closed or moved out and 6,000 started up or moved in since Katrina (Brookings Institution 2008).

Higher education and medicine, mainstays of the economy, suffered long-term blows from the storm. Reduced staffs and below-normal enrollment have stymied the recovery of universities. Displaced medical schools have largely returned, but with reduced capacity. The loss of jobs and opportunities in higher education has serious long-term implications (Brookings Institution 2008). Hospital closures have left a major gap in health care, especially for mental illness. The city has only about three-quarters the pre-storm hospital capacity (Brookings Institution 2008) and still faces a major loss in skilled medical jobs, and consequently physicians continue to leave the area (NYT 2007).

Given the housing and other public service shortages, the population return has been better than expected. Using mail delivery as a measure of population return, New Orleans had 141,825 households receiving mail as of February 2008, compared to the pre-storm total of 198,232—or 71 percent (Brookings Institution 2008b). A pre-storm population of 437,186 (2005) fell to an estimated 210,198 in July 2006. That estimate climbed to 239,124 the following year, only 50 percent of the pre-Katrina estimated population (Brookings Institution 2007). New Orleans has challenged the Census estimates given the disparities between the Post Office and Census tabulations.

The population is undergoing a regional redistribution that is supplanting the formerly centralized New Orleans (Yodis and Colten 2007). Neighboring Jefferson Parish has 98 percent of its pre-storm population, while hard-hit St. Bernard Parish remains at 43 percent of its 2005 total. Upriver and northshore parishes have grown by about 5 percent. Not all migrants have remained in the region however. An August 2007 report indicated over 11,000 individuals remained in the three principal Texas cities, with another 1,200 in Atlanta (Louisiana Recovery Corps 2007). Other estimates place the number of evacuee households in north Texas at over 30,000 (Dallas Morning News 2007).

Housing has been a key factor in recovery. With over 105,000 houses needing substantial work, sheltering both residents and workers has been a challenge. While most homeowners had some form of insurance, they endured delays in receiving payment, and when payments arrived there was typically a gap between the cost of repairs and the funds issued by the insurer. The sheer volume of work to be done and finding adequate labor to complete repairs has slowed the process of restoring housing.

Temporary housing in the form of trailers was slow to arrive, partly because of FEMA ineptitude and partly because of resistance from local council members who sought to restrict the opening of trailer courts in their districts. The population living in trailers remains high, although it is steadily declining, and there has been concern about toxic emissions from the materials used to manufacture the shelters. Only recently did FEMA begin testing to gauge the safety of the trailers and only at the command of Congress (NOTP 2008). Trailer courts will close during 2008, a process that will exacerbate the housing shortage (FEMA 2006c and 2007). Despite the unveiling of plans for flood-resistant house plans, known as Katrina Cottages, soon

after the storm, funding for these only began arriving in early 2008 and there has been little use of modular housing.

To provide an incentive for people to either return to or remain in Louisiana, the state created the Road Home program. It offers residents funds that can build a financial bridge between insurance payouts and the actual cost of repair, or enable families to salvage a portion of their equity if they opt to relocate within the state. The program endured a painfully slow start. By January 2008, it had received over 60,000 applications from Orleans Parish residents. Despite the many hurdles to resuming a pre-storm existence, 75 percent of Orleans Parish residents who applied for Road Home funds indicated they intended to return to their pre-storm homes (Brookings Institution 2008c). The lure of the familiar is powerful.

The Federal Housing Administration is moving forward with demolition of the sprawling public housing projects and thus will eliminate that component of affordable housing for renters. Current plans call for the removal of 4,500 units and their eventual replacement with 1,841 apartments (BRA 2007a). Many of the public housing units were in bad condition prior to the storm, but critics of the destruction plan noted the 2–3 story units, with sturdy mid-century brick construction surrounded by open space and pleasant shade trees, were far more humane shelters than high-rise public housing units built elsewhere (NYT 2006b).

Another measure of the recovery has been the restoration of community organizations. There has been a healthy return or growth of community organizations (Nelson et al. 2007; Polk City Directory 2005 and 2007). Neighborhood organizations in places like the Holy Cross and the Vietnamese community in Versailles have also provided powerful social networks to overcome the storm's disruptions (Leong et al. 2007; Breunlin and Regis 2006). Likewise voluntary and not-for-profits have played a significant role in restoring housing and providing essential services (PRC 2007; New Orleans Area HFH 2007). Official plans did not include a role for these community groups, which proved central to initial recovery. Their success is contributing to the rewriting of the role of such groups in future community resiliency.

Developing a viable and acceptable recovery plan proved to be a tortuous process. Community members rejected the poorly presented Urban Land Institute Plan (ULI 2005), and several other subsequent efforts floundered (Nelson et al. 2007). Eventually, community involvement in a neighborhood-based planning process led to a summer 2007 adoption of the Unified New Orleans Plan (New Orleans 2007a). It projects a 10-year time frame for recovery and a "neighborhood stabilization program." This component will help people in the most severely damaged areas to relocate to planned "cluster developments" in areas that experienced less flood damage and where the city will be investing in improved infrastructure and more complete social and commercials services. In addition, the UNOP plan will include programs designed to help residents raise their houses to the FEMA Base Flood Elevations (New Orleans 2007b). While not a major overhaul in terms of land use, the plan offers modest encouragement to relocate to safer ground and considerable support for making houses more flood resistant. The attempt to encourage "clustering" on high ground never evolved because residents felt threatened that it would deny resources to hard hit neighborhoods. Tension continues between the "right to return" and risk reduction.

Within the city's Office of Recovery Management is the hazard mitigation unit that concentrates the city's efforts to revise the required mitigation plan and to work toward serious implementation of it. Such an emphasis is a new one for the city post-storm. The city has released a hazard mitigation plan that seeks to create an ongoing process to complement the emergency response plan (NOOHSP 2005). It provides a process for assessing risk, coordinating local mitigation efforts, and involving diverse stakeholders in a perpetual process.

Sustained recovery still relies on a secure levee system and other appropriate measures of risk reduction. The Corps of Engineers have projected 2011 as the date when the levee system will be certified at the 100-year level. The city's evolving risk-reduction planning relies on adequate levees completed on schedule. The Corps' post-Katrina risk assessment, its Risk and Reliability Analysis, has prompted criticism and confusion and little consensus (USACE 2007, V. 8; USACE 2007b; BRA 2007b). Part of the concern about future safety arises from the configuration of the city, the levees, and coastal waters. Areas of eastern New Orleans suffered inundation from overtopping of both canal walls and levees. These areas are predominately African American. The Corps Risk and Reliability Analysis does not explicitly address environmental justice. Furthermore, residents of eastern New Orleans have voiced strong concern about adequate protection for their neighborhoods in the future. Their fears are based on both their most recent floods experiences and a more deep-seated distrust that stems from long-standing grievances with the Corps and other government organizations (Landphair 2007; Colten 2007).

In the immediate aftermath of the storms, the Working Group for Post-Hurricane Planning for the Louisiana Coast encouraged planners to include not just levees but a "sustainable coastal landscape." It explicitly recognized both coastal subsidence and sea-level rise as key concerns. To offset both these processes that increase vulnerability, the planning group strongly encourages coastal restoration and expansion efforts (WGPHP 2006). This plan strongly influenced the Louisiana Recovery Plan, which calls for multiple lines of defense that include restoring barrier islands and coastal wetland, backed by levees along with other non-structural defenses and effective evacuation plans (Lopez et al. 2007; LRA 2007a).

## 4.4 Reduction during and after Katrina

Preparations for the arrival of Katrina included substantial evacuations along with positioning supplies both in the city and at more secure inland locations (U.S. Congress 2006). While much attention has been focused on the evacuation's failures, over two-thirds of the population evacuated themselves, mostly by private auto. These efforts significantly reduced their vulnerability. Within the first year after the storm, the Corps of Engineers made repairs to over 200 miles of its hurricane protection system of levees and pumps and thereby restored reduction capacity. It has also built flood gates and pumps at the mouths of the outfall canals to reduce the risk of levee failure along those waterways. As was the case before the storm, rigid structures continue to limit future exposure.

There is, however, significant cynicism shared by local residents and officials about the safety of the levees and the degree to which large bureaucracies, namely, the Corps and FEMA, are able to achieve their designated missions. Since Katrina two themes—redundancy of safety efforts and locals taking care of themselves—have emerged as resiliency actions not recognized before but as important to residents of a twenty-first-century society (Beck 1992). Risk studies to date have noted that individuals lose control when facing an extreme hazard and necessarily relinquish management to large bureaucracies. Katrina is causing this conclusion to be re-thought.

City and state planning and popular opinion call for improved levee protection, resistant to a category 5 hurricane, coastal restoration, and effective evacuation plans (LRA 2007a). The Working Group for Post-Hurricane Planning for the Louisiana Coast plan, with its redundant systems, strongly influenced the Louisiana Recovery Plan, which calls for multiple lines of defense (Lopez et al. 2007; LRA 2007a).

To diminish future wind damage, the state passed new building codes before the end of 2005. These acts seek to ensure that new and rebuilt structures are more hurricane resistant (Louisiana Act 12 2005). New Orleans, however, already had adopted the International Building Codes put into effect for the rest of the state after the storm, and consequently there were no significant changes to the city's design standards imposed by the state action (ICC 2003; New Orleans 2006a). Although an exact count is not possible, few of the more than 100,000 homes severely damaged by Katrina were built to these new codes (most predated their adoption).

In addition to wind-resistant construction, contractors had to build in accord with the 1995 city code that required both slab and raised houses to be at least 18 inches above the highest point of the curb in front of the house even before the storm (New Orleans 1995). Since the storm, the city adopted the revised FEMA Advisory Base Flood Elevation Level maps (New Orleans 2006a) which designated most areas of the city as requiring National Flood Insurance, and thus structures must adhere to this advisory (New Orleans 2007c; FEMA 2006b). Substantially rebuilt houses (including those officially designated as damaged more than 50 percent) must have their bottom inhabited floors at least 3 feet above the highest existing adjacent grade or the local Base Flood Elevation (implementing whichever of the two is higher). FEMA insurance serves to share the losses among all policy holders. In contrast to FEMA flood insurance practices since Katrina, private insurers have been reluctant to issue new homeowners' policies, the major source of insurance against wind and storm damage, and have raised premiums on existing policies (Louisiana Department of Insurance 2005 and 2007). This has presented obstacles to those wishing to rebuild and discourages return to vulnerable locations.

The state revamped its all-hazards *emergency* response plan, which was incomplete before Katrina. In August 2006 it released a major update which was followed by a second in July 2007 (Louisiana 2007). The current state plan is an "all-hazards" plan and outlines steps to contend with a range of natural and technological events. Key adjustments include canceling use of the Superdome as a shelter of last resort and use of city busses to shuttle evacuees to a staging area where the elderly and disabled will be transported to safe locations by Amtrak trains while buses evacuate the younger and healthier (New Orleans 2006a). The city plan relies heavily on evacuation, both self-evacuation and assisted evacuation, for those with special needs.

Several organizational adjustments also followed the storm. Under considerable national pressure to streamline levee district management and coordination, the state legislature consolidated the numerous parish levee districts in southeast Louisiana into two districts—one on either side of the Mississippi River. The state also created the Louisiana Recovery Authority to oversee regional recovery planning, while the city created its Office of Recovery Management with local oversight authority.

# 5. IN THE FUTURE

## 5.1 Anticipation in the Future

After the storm, the Corps of Engineers and numerous forensic teams sought to determine the cause of the levee failures in an attempt to correct any design flaws (USACE 2006; Seed et al. 2006; National Research Council 2006; Team Louisiana 2006; ASCE 2007). At the core of the planning for future events has been a determination that the levees will be rebuilt to withstand to a "100-year storm" or a storm with a 1 percent probability of occurring any give year. This aligns the levees with the FEMA flood insurance program, which uses the same level of risk to

delimit the 100-year floodplain and is defined based on rainfall and drainage (river levees are built to a higher standard). In its post-Katrina risk assessment, the Corps moved away from using wind speed as the primary measure of hurricane magnitude and included elements such as size of the storm which can contribute to surge (USACE 2007a). Yet this system makes no mention of wind speed, the one measure that the general population has come to rely on during the past half century and thereby diminishes public comprehension of risk. The Corps has received authorization to study the feasibility of building levees to withstand a category 5 hurricane and in May 2008 was behind schedule on releasing its final report. Yet, funding for additional levees is not assured, and because construction would take so much additional time, advocating category 5 protection may diminish focus on the other risk reduction methods that would provide safety more expeditiously. These include marsh rebuilding and systematic building elevation.

FEMA issued preliminary flood maps in April 2006. The federal agency required that individuals restoring substantially damaged homes or building new homes within the ring of levees must have their floors at the Base Flood Elevation (BFE) or 3 feet above grade—whichever is higher (FEMA 2006a, 1). If compliance to these requirements does not occur, a community stands to lose access to the National Flood Insurance Program. The FEMA floodplain designation sets in motion a host of building codes and construction requirements (FEMA 2006a) that prompt individual property owners to anticipate future floods and to take personal responsibility for their safety. High flood-proofing costs, particularly to raise concrete slab houses, and limited access to programs to assist with these costs in the wake of Katrina has prompted public "push back" from embracing personal responsibility.

The state has undertaken a massive planning process for the entire coastal zone. The Louisiana Recovery Authority issued a report that anticipates future hurricanes and includes a blend of coastal restoration and improved levee protection to fend off future storms (LRA 2007a). Despite its call for sustainable development, it recommends creating economic development in some of the coast's most vulnerable locations such as Grand Isle and Cameron Parish. Some of the funding for coastal restoration was in the Water Resources Development Act that Congress passed over a presidential veto in fall 2007. The challenge for the state has been to mount a rapid, robust restoration program; by mid-2008 such a program had not yet begun in any comprehensive way.

## 5.2 Response in the Future

By mid-2007, Louisiana had thoroughly revised its Emergency Operations Plan (Louisiana 2007). It is an "all-hazards" plan that includes components that deal with evacuation, sheltering evacuees, and the role that each state agency is to play in the event of an emergency. The state operates an Emergency Operations Center from which it can coordinate local, state, and federal efforts (Louisiana 2007). The plan contains components to deal with medical evacuations and hazardous material spills during an emergency. One key improvement in the revised response has been improved communications systems (although anticipated in the post–9/11 period, communications remain a national challenge). The state plan has several layers of redundancy built into it. In the event of a disaster, the operational plan calls for the deployment of local resources until they are depleted; then it makes state and federal resources available. The concept is that a layered response will prevent total collapse by positioning resources from the next level of government when lower level resources are exhausted.

In early 2008, Louisiana updated its State Hazard Mitigation Plan, and it incorporates potential hazard profiles, risk assessment, and mitigation planning details. The 2008 update

contains several additional topics not covered in the previous plan. These topics include prioritizing potential hazards, integrating parish and municipal hazard mitigation plans with the state plan, assessing future development scenarios into the Risk Assessment section, and a comprehensive Mitigation Action Plan (Louisiana 2008).

The city of New Orleans prepared a new Emergency Preparedness Plan before the 2006 hurricane season. It terminated its reliance on a shelter of last resort and shifted efforts to its "City Assisted Evacuation Plan" for those with special needs or without personal transportation (New Orleans 2006b). To work successfully the city's plan requires an 84 hour advance warning. Improved communications are a central component to the city's plan as well (New Orleans 2006c and 2006d). Dissemination of the plan to all relevant non-governmental stakeholders and systematic drilling by the city had not been fully implemented by the city at the end of the 2007 hurricane season. As with many of the resiliency efforts, volunteer and non-governmental stakeholders' participation represents a key to successful government programs. Such a partnering requires a paradigm shift that is only beginning to emerge from the Katrina experience.

Initial responsibility for mobilizing a response rests on the shoulders of local officials who must monitor storm conditions reported by the National Hurricane Center. Highly trained and experienced professional staffs must be recognized as the means to implement the will of a community for successful evacuations, a key to resilient activity. Also, continuing efforts to update and drill response plans are essential.

## 5.3 Recovery in the Future

A number of major projects are in various stages of development or construction that should support future recovery. These include a major veterans/teaching hospital to replace the antiquated Charity Hospital destroyed by the storm, mixed-income and charity-supported housing projects, and long-term repairs and improvement to streets and public utilities.

A positive development is to integrate hazard mitigation and recovery into the ongoing planning process. The city, through its Office of Recovery Management, intends to incorporate constant reassessment of hazard mitigation plans and recovery into the city's long-term plan (Blakeley 2007). The state, through its Emergency Operations Plan, includes recovery as a basic part of its response to future hazard events, with recovery coordinators and state Department of Economic Development officials playing a key role (NOOHSPS 2005; Louisiana 2007, ESF 14). Yet there are no specific plans, only a broad-brush agenda for officials to keep recovery as a fundamental component of planning. The state plan makes no provision for community input or addressing environmental justice issues. The Louisiana Recovery Authority (LRA) state-wide plan did, however, involve substantial stakeholder input into the long-term recovery process, but the agency is not a permanent addition to state government (LRA 2007a).

## 5.4 Reduction in the Future

Government bodies have installed various short-term structural changes to reduce the threat of future storms. These include stronger levee supports at the site of breaches along with gates and temporary pumps at the mouths of outfall canals. Surge dampening structures east of the city are part of the ongoing projects, but they could displace the threat to adjacent communities. Coastal restoration plans also factor into reducing impacts in the more distant future (USACE 2007b; WGPHG 2006).

The Corps of Engineers' Risk and Reliability study shows how flooding will be reduced from future Katrina-like storms when their levee repairs are complete in 2011. While the Corps promises no added protection from more powerful storms, its risk maps indicate that floodwaters will not cover as much territory, nor will flood levels be as high if the levees do not breach. Improvements to levees will be coupled with houses raised above the FEMA Base Flood Elevation. Already individuals are raising houses and funds (and up to $90,000 per house from three separate programs) are available to all Road Home recipients to raise their houses if they so choose (NOTP 2008a). Unfortunately, these funds became available 2½ years after the storm. This delay discouraged most from initiating repairs, or making secondary repairs, to achieve the desired safety levels. New houses also will have to be built using more flood-resistant designs. FEMA announced in May 2008 that it will provide $750 million in grants to assist families in raising their houses (BRA 2008). These steps will reduce direct damages in the future.

Hurricane evacuation improvements focus on increasing the sensitivity of public officials to the needs of the economically, physically, and age-vulnerable populations and to improve coordination at all levels. The non-governmental stakeholder groups for these vulnerable groups have been at the forefront of advocating and providing resources to work toward these goals.

One of the initial recovery plans (ULI 2005) called for a reduction of the city's footprint and the creation of flood retention basins in the lowest areas of the city—the so-called "green dots" plan. Vigorous opposition led to the abandonment of this plan. Regardless of the plan's merits and its ill-planned presentation, land-use restrictions in high-hazard zones within the city are not a major part of future reduction procedures.

Insurance is intended to give property owners access to reserve funds to reduce the impacts of a calamity. In Louisiana, insurance has become less accessible—some allege insurance "red lining"—particularly in the southern portion of the state. State programs to encourage insurance companies to write policies and a state-operated last-resort insurer are in place (Louisiana Property and Casualty Insurance Commission 2003; NOCB 2006). No significant improvement in the cost and willingness of the companies to write insurance is expected in the near term.

# 6. LESSONS LEARNED FROM KATRINA

## 6.1 The Greatest Overall Disaster in U.S. History Occurred at a Time of Unprecedented U.S. Wealth and Power

New Orleans was a catastrophe waiting to happen with extensive and repeated warnings from both scientists and the media that the "big one" would eventually hit the city. The pre-Katrina estimated population of 437,186 lived in a bowl, half below sea level, between the natural levees of the Mississippi River and the built levees (pierced by canals) along Lake Pontchartrain. Katrina brought severe but not catastrophic winds, record rainfalls and storm water damage, followed by the collapse of major canal floodwalls, allowing water to fill the bowl in about 80 percent of the city.

While upwards of a million residents in the metropolitan area evacuated, an estimated quarter of New Orleans residents were unable or unwilling to leave. Many died; most took refuge for as long as a week in the Superdome, the Convention Center, in hospitals and nursing homes, in upper stories of their homes, or on elevated highways. Within a month, evacuees from New Orleans could be found in every state of the union. The full costs of Katrina in the

New Orleans will never be known. The initial death toll was about 1300 (excluding several hundred additional fatalities attributed to the evacuation experience), and we estimated an aggregate monetary loss of around $40–50 billion in Orleans Parish including direct property losses ($20–22 billion), still ongoing economic losses ($4–8 billion), and emergency assistance ($16–20 billion). The human and social disruption from the experienced trauma, the out-migration, and the breakup of community has also been extraordinary.

Through extensive media coverage, the world saw remarkably inadequate rescue operations, the failure of complete evacuation, the collapse of the levees, the subsequent out-migration, and the plight of those remaining in the city, with the burden falling heaviest on the African-American, poor, aged, and infirm members of the population. What amazed many worldwide was that these extensive failures, often attributed to conditions in developing countries, occurred in the most powerful and wealthiest country in the world.

## 6.2 Creating Community Resilience Takes Time and Longer Than Anticipated

As described below, improving the elements of community resilience (anticipation, vulnerability reduction, response, recovery) takes many years. Thus to improve anticipation by creating an effective tracking and warning system took 40 years and to inform the community about the catastrophic threat took 37 years. To reduce vulnerability with levees and drainage (only partly completed before Katrina) took 40 years, and following Katrina, it will take at least 6 years to rebuild a reliable levee system to protect against a modest 100 year storm (1/100 chances per year). Emergency response plans were remarkably deficient, and their improvement was chronically behind schedule and incomplete at the time of Katrina. The actual emergency response period following Katrina took at least 6 weeks, and that was longer than any similar disaster in U.S. history. The restoration period to rehabilitate repairable infrastructure took about a year, a lengthy period for those awaiting services but somewhat faster than would be predicted by the exceptional length of the emergency period. However, to develop a community-acceptable reconstruction plan took 21 months and to reconstruct after Katrina will take at least a decade more.

## 6.3 Surprises Should Be Expected

Every hazard event brings surprises and every disaster even more. The surprises come from unanticipated events, anticipated events but failed responses, or anticipated events that are proved wrong by experience. A central task for resilient communities is to consider the surprise experiences from other disasters, to try and anticipate unexpected problems, and to plan for redundancy in emergency response and recovery.

The central unanticipated event during Katrina was the failures of levees along the major canals and the subsequent deep flooding of the city. Levee overtopping was anticipated, but the four massive breaches, and several other seldom-discussed breaches, that flooded 80 percent of the city with upwards of 20 feet of water were not anticipated. These failures led to emergency response failures for events that had been anticipated. For example, emergency planning for the hospitals and the Superdome anticipated a maximum of 3 days rather than the full week experienced before final evacuation. School buses that were to be used for evacuating households without autos were themselves flooded and their drivers, as were many first responders, unwilling or unable to report for duty. Unanticipated was the widespread concern for pets that led many to delay evacuation. Several major expectations were proved wrong by the experience. There was widespread expectation that the floodwaters would prove to be a

"toxic gumbo" reflecting the extensive flooding of oil and chemical plants and the "cancer alley" of Louisiana. Extensive testing found no additional levels of toxic materials in the environment other than were there prior to Katrina. The expectation that deaths would be higher among blacks both because of their absolute majority in New Orleans and their increased vulnerability were not borne out. Deaths were equally divided by race although not by age, with the elderly by far the most dramatic group of victims. Race, however, was found to divide those in the more flooded and less flooded areas.

## 6.4 Anticipation

### 6.4.1 Long-Term Anticipation and Short-Term Warning Systems Took Time to Develop, Were Effective, and Yet Were Insufficient to Induce Sufficient Community Resilience

An extraordinary event such as Katrina had been partly experienced in Hurricane Betsy (1965), had been anticipated by the expert community for many years, had been reported on publicly 2 years before Katrina in a widely disseminated account in the newspaper, and was simulated in an emergency exercise a year before Katrina. The Weather Bureau had begun monitoring and offering predictions on hurricanes in the nineteenth century and had initiated a formal coordinated effort to track and offer warnings by the mid-1960s. By the time of Katrina, the actual warning of the event was excellent, having been tracked publicly for 4 days, with the time and location of the storm track forecast accurately to within 24 miles, a full day before it came onshore (Knabb et al. 2005).

Yet despite such anticipation, the protective works were both incomplete and failed, and the State's emergency plan had not been updated. The plan for evacuation did not accommodate the estimated 130,000 people who lacked autos, stayed to tend to family members or pets, or were in hospitals and nursing homes that opted not to evacuate. Planning assumed that evacuation would be short term (no more than 3 days), and many, including the hospitals, made decisions not to evacuate based on that notion and possibly the cost of such a delicate process. There were inadequate provisions for first responders and their families and for post-storm secondary evacuation. Public emergency plans did not provide guidance for recovery, although the city had hurricane-resistant building codes in place (that post-dated most residential construction). Utility and transportation companies did have their own recovery plans. There were no plans, public or private, for reconstruction.

### 6.4.2 Best Available Scientific and Technological Knowledge Does Not Get Used or Widely Disseminated

Following Hurricane Betsy in 1965, engineering designs for new and improved protective works took into account the estimated frequency and magnitude of a standard project hurricane and the effects of storm surge, land subsidence, and rising sea level as measured at that time. However, 19 years later, these estimates were still being used when subsidence within the levees had lowered the land surface by 10 feet and sea level had risen by approximately 7 inches and storm waves and surges by proportional amounts (USGS 2004). The multi-decadal rhythm of frequent hurricanes and the frequency of more intense hurricanes enhanced by global warming may have increased as well. In addition, publicly available risk assessments in the form of FEMA maps of the 100 year floodplain have never included sea-level rise or land subsidence effects.

## 6.5 Response

### 6.5.1 The Emergency Response Period to Katrina Took Longer Than Any Similar Disaster in U.S. History

The emergency response period is characterized by search and rescue, emergency shelter and feeding, the establishment of order, the clearing of major arteries, and for floods the draining of water. Before Katrina, the most comparable disaster on record, the San Francisco earthquake of 1906, had an emergency period of 4 weeks. Using as an indicator for Katrina, the "dewatering" of New Orleans when the floodwaters were pumped and drained from the city, provides a response period of 6 weeks or an alternative length of the emergency response period could be as much as 14 weeks, using for its conclusion the end of emergency shelter. The extended period was partly due to secondary flooding from Hurricane Rita, but in retrospect the major causes of the extended response were the failures of anticipation, of planning, of responsibility, and of execution.

### 6.5.2 Major Response Capability and Resources Were Invisible, Refused, or Poorly Used by the Emergency Response Structure

"Emergent" individuals or organizations that respond to unaddressed needs are characteristic of all disaster responses. In responding to Katrina, they were sometimes refused or poorly used by government officials. These "shadow responders" often emerge from households, friends and family, neighborhoods, non-governmental and voluntary organizations, businesses, and industry. In New Orleans, we estimate that they provided most of the initial evacuation capacity, sheltering, feeding, health care, and rebuilding, and much of the search and rescue, cleanup, and post-Katrina funding. These individuals and organizations would have been able to do more if the tri-level system (city, state, federal) of emergency response was able to effectively use, collaborate with, and coordinate the combined public and private efforts. How to do so, in advance of hazard events, is a central task of enhancing community resilience.

### 6.5.3 Elements of Multi-hazard Response Capabilities May Be in Place, but Shifting Priorities Disrupted the Ability to Transfer Capabilities from One Hazard Response to Another

The New Orleans medical community grew in response to nineteenth-century epidemic diseases and had endured numerous hurricanes. The medical community provided some of the most active members of the local emergency preparedness committee, but over the years their preparation was inadequate to respond to the crises created by Hurricane Katrina. Medical training and care provided less preparation for geophysical events than biological threats. From civil defense preparations during the 1950s and 1960s to recent homeland defense preparations, national military priorities sometimes overshadowed the more commonplace and repetitive events such as hurricanes. Diversion of resources within FEMA and the National Guard to a homeland defense agenda left both organizations below full strength for responding to an event like Katrina. Additionally, while the numerous organizations involved in emergency response and recovery have distinct and often effective responders, they seldom work together.

## 6.6 Recovery

### 6.6.1 Recovery Takes Longer Than Anticipated

It is standard after disasters that local boosters, officials, and residents promise to rebuild and in a short time, but their rhetoric is seldom realized. Unappreciated is the long period of time that actual recovery requires, especially after a catastrophe such as Katrina. Recovery can be divided into three periods. Before the emergency response period is over, a restoration period ensues where the essentials of urban life that are repairable are restored, and before it is over, a period of reconstruction begins to replace the infrastructure, housing, and jobs destroyed sufficiently for the pre-disaster population. This is often followed or overlaps with a period devoted to commemorative or betterment reconstruction, usually characterized by major projects of memorial and/or civic improvement.

In New Orleans, we estimate that the restoration period lasted for a year. While some sections of the city had power within 3 to 4 months, delivery of dependable services to the city and restoration of traffic control equipment took a full year. During that year, the breaches in the levees were repaired and partly improved and close to 40,000 home owners received building permits (a measure of their immediate intent to rebuild but not an accurate gauge of actual home restoration). Based on our expectation that the period would be ten times the length of the emergency period (at least 60 weeks), the period was somewhat shorter than expected. This shorter restoration period can be explained either by the major commitment of funding, resources, and leadership or that the shorter year-long restoration period better reflects the historic scale of experience in other recovery efforts (Haas et al. 1977).

But the reconstruction period seems destined to take longer than expected. Plans for reconstruction began to circulate even within the emergency period, and serious planning began in 10 weeks. However, torn between a top-down and a bottom-up process and conflicting goals for reconstruction, New Orleans engaged in five separate planning processes, and it took 21 months to develop a community-acceptable reconstruction plan (Nelson et al. 2007). Thus reconstruction is clearly on track to last 10 or more years (ten times the restoration period). The city's Office of Recovery Management is using a 10-year reconstruction period, but it is also likely that reconstruction in the classic sense of sufficient for the pre-disaster population may never occur as current estimates project a long-term population substantially smaller than the pre-disaster population.

### 6.6.2 Recovery is Slowed by Unanticipated Conflict between Processes and Goals of Reconstruction

New Orleans underwent an extremely long planning period for reconstruction, consisting of five different planning processes, extending over 21 months. Major reasons for the multiple plans and delays were differences in processes and in goals. Top-down versus bottom-up process differences emerged as the poles of contention with a mayoral top-down outside expert initiative evoking a strong neighborhood-inspired, city-council-authorized counter effort. This was replaced by an externally funded, expert supported, unifying process but was only resolved by the appointment of an internationally recognized, highly accomplished urban planner and disaster recovery expert as director of a newly created Office of Recovery Management.

However, underlying the differences in approach are the all important differences in goals. Cities and regions seeking to reconstruct after a disaster seem to simultaneously pursue goals to *rapidly recover* the familiar and to reconstruct in *safer*, *better*, and sometimes in more *equitable*

ways. Conflict arises between groups or institutions and even individuals pursuing these different goals because they cannot be given equal attention in time, resources, and values. In addition, in accomplishing one goal, another one may become less achievable. Thus, efforts in New Orleans to slow rebuilding in order to allow time for assessment, planning, and reconciliation were resisted or circumvented. Efforts to accept a New Orleans with a smaller footprint and use reclaimed areas for green space and rainwater storage (safer, better) were seen as efforts to destroy existing neighborhoods, especially those with large poor and black populations.

### 6.6.3 Disasters Accelerate Existing Pre-disaster Trends

Recovery following disaster generally follows the pre-disaster trajectory, with the disaster even accelerating previous trends. Thus New Orleans, whose population had declined by 31 percent from a peak 1960 Census estimate of 627,525 to an estimated July 2005 pre-Katrina population of 437,186, lost two-thirds of that population. The estimated population 2½ years later is about two-thirds of the pre-Katrina level with refugee population still scattered to all 50 states. The economy was also declining pre-Katrina, and despite the inflow of recovery monies, after peaking in 2006, the number of building permits declined during the last quarter of 2007. To escape this gloomy trajectory, current New Orleans recovery planning seeks explicitly to utilize topographic variation within the city (designation of targets areas also likely sought to include neighborhoods that were active in the planning process) and have identified some 17 target recovery areas with more encouraging population and economic potential to concentrate recovery resources and to serve as reconstruction clusters. Some business clusters in heavily flooded areas have made strides towards restoration in early 2008.

## 6.7 Reduce Vulnerability

### 6.7.1 Despite 290 Years of Effort, Overall Vulnerability to Hurricanes Has Grown

Geophysical vulnerability in New Orleans is marked by its below-sea level, bowl-shaped location, its accelerating subsidence, rising sea level, storm surges, and possible increased frequency of larger hurricanes. All of these are only partly natural phenomena and have been made worse by human location decisions, extraction of groundwater, oil, and natural gas, canal development, loss of barrier wetlands, internal rainfall storage, global warming, and the design, construction, and failure of protective structures. Reducing vulnerability from riverine flooding has been successful to date due to building protective works to a high protection standard and employing diversion outlets for floodwaters. Hurricane protection has used a lower protective standard, and protection projects both before and after Katrina were not completed. Begun after Hurricane Betsy in 1965, the Corps of Engineers' Lake Pontchartrain and Vicinity hurricane protection project failed to meet its initial completion date of 1978 but was nearing completion in some sections by the time of Katrina. Following Katrina, the Corps of Engineers had patched the breaches within 1 year but projected it would take at least 6 years to restore the levees to their pre-storm design configuration and were just beginning to study the costs and benefits of a higher protection standard (category 4 and 5 hurricane protection). In fact, drainage canals have actually enhanced inflows to the city.

Equal to or greater than the increase in geophysical vulnerability has been the increase in social vulnerability. Following Hurricane Betsy in 1965, new levees and internal drainage encouraged new development in low-lying areas, placing an additional 170,000 households

across the metropolitan area in harm's way. Subsequent loss of population within the city diminished this trend somewhat, but selective population loss (white flight) may have enhanced the social vulnerability and subsequent failure to respond to distinctive needs of the elderly, the poor, and households without autos. A poorer, older city was clearly more vulnerable to Katrina, and no planning to date has addressed poverty reduction or youthful in-migration to reduce future vulnerability. Indeed cynics point out that policies adopted to discourage poor people from returning (e.g., reduced public housing) is one immoral way to reduce such vulnerability.

### 6.7.2 Efforts to Provide Protection Reduced Vulnerability to Frequent Small Events but Increased Vulnerability to Rare Catastrophic Events

In the 40 year span between Hurricane Betsy and Katrina, protective works—new and improved levees, drainage pumps, and canals—successfully protected New Orleans and surrounding parishes against three hurricanes in 1985, 1997, and 1998. However, these works were the basis for the catastrophe of Katrina, having enabled massive development of previously unprotected areas and the flooding of these areas that resulted when the works themselves were inadequate.

## 6.8 Closing Comments

New Orleans and its citizens have undoubtedly coped with hazard events on a regular basis for nearly 300 years. In the absence of a specific resilience framework, elements of resilience have ebbed and flowed through the area's efforts to deal with events such as hurricanes. Certain elements have weakened, while others have grown stronger. What sets resilience in human communities apart from biotic communities is the capacity to learn from past experiences and employ strategies to contend with future events. We hope this assessment of resilience before, during, and after Katrina and into the future will offer guidance for implementing a more comprehensive, effective, and equitable approach to dealing with hurricanes and other hazard events and that Katrina will become a lesson that remains deeply ingrained in the social memory of the city's citizens.

## ENDNOTE

[1] The sociologist author is ground truthing the case data and adding specific detail to enhance the utility of the study and requested this extended footnote to present the more sociological framing and to permit the reader to benefit in this manuscript from exposure to both.

From a sociological perspective, a disaster is seen as coming from risk to a hazard, the same as it is seen by geographers. Most of the risk, however, for most victims is believed to be due to vulnerability incurred by them due to the way in which the society organizes access to its resources. The categories used to frame vulnerability include social class, gender, race, age, and disabilities, to name five important ones (Laska and Morrow 2006), and all too frequently there is an intersection of these categories such that a person, a family, is in multiple disadvantaged groups. For example, in Katrina lower-income African-American women and their children were likely the most vulnerable.

To appreciate this framing, consider the opposite: A community where everyone has a meaningful job, adequate income, substantial housing, good education, access to health care,

safe neighborhoods, and, therefore, equal opportunities for their children. We call this essential resiliency (Laska forthcoming). Thus a combination of essential resiliency and specific hazard resiliency results in a hurricane, for example, being a mere storm event, not a catastrophe, or mere glancing blow. Individuals, families, neighborhoods, and the city and region as a whole would not be badly affected and would get back to normal very quickly. This latter comprehensive invulnerability to hazards is the goal from the sociological perspective. For it to occur, sociologists argue both types of resiliency—essential and hazard focused—must exist.

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Community and Regional Resilience Initiative
National Security Directorate
P.O. Box 2008
Oak Ridge National Laboratory
Oak Ridge, TN 37831-6252

www.ResilientUS.net