# Amphibious Architectures:

The Buoyant Foundation Project
in Post-Katrina New Orleans

by
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# Author’s Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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# Abstract

This is a research-based thesis building upon the study conducted over the past two years with Dr. Elizabeth English on the Buoyant Foundation Project (BFP). The BFP is currently developing an amphibious foundation system to retrofit vernacular wooden 'shotgun' houses in the Lower Ninth Ward in New Orleans. This neighbourhood was chosen because of its unique cultural heritage and the severe, but recoverable, damage incurred in the aftermath of Hurricane Katrina. The BFP system will allow homes to float when flooding occurs, rising and descending vertically to avoid flood damage. It provides an alternative solution to permanent static elevation, the mitigation strategy currently recommended by the United States federal government.

The thesis will demonstrate how the Buoyant Foundation Project is a culturally supportive, technically feasible, economical, sustainable and resilient form of flood mitigation for post-Katrina New Orleans.

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## List of Acronyms

| | |
|---|---|
| ABFE | Advisory Base Flood Elevation |
| ASCE | American Society of Civil Engineers |
| BF | Base Flood |
| BFE | Base Flood Elevation |
| BFP | Buoyant Foundation Project |
| DFE | Design Flood Elevation |
| DHS | Department of Homeland Security |
| EPS | Expanded Polystyrene (Styrofoam) |
| FEMA | Federal Emergency Management Agency |
| FIRM | Flood Insurance Rate Map |
| FIS | Flood Insurance Study |
| FHBM | Flood Hazard Boundary Map |
| FMA | Flood Mitigation Assistance |
| GNOCDC | Greater New Orleans Community Data Center |
| HEAG | Highest Existing Adjacent Grade |
| HMGP | Hazard Mitigation Grant Program |
| HPS | Hurricane Protection System |
| IA | Individual Assistance |
| ICC | International Code Council |
| IGS | Innovative Green Solutions |
| L9W | Lower Ninth Ward |
| LAGIC | Louisiana Geographies Information Center |
| LCA | Life Cycle Assessment |
| LIDAR | LIght Detection And Ranging |
| LSU | Louisiana State University |
| MIR | Make It Right |
| NFIP | National Flood Insurance Program |
| NOAA | National Oceanic and Atmospheric Administration |
| NOLA | New Orleans, Louisiana |
| NGS | National Geodetic Survey |
| NTHP | National Trust for Historic Preservation |
| PAGP | Public Assistance Grant Program |
| PDM | Pre-Disaster Mitigation |
| PRC | Preservation Resource Center |
| SFHA | Special Flood Hazard Area |
| SHPO | State Historic Preservation Office |
| UNESCO-IHE | United National Educational, Scientific, and Cultural Organization - Institute of Higher Education |
| UNO | University of New Orleans |
| USGS | United States Geological Survey |
| USCGS | United States Coast and Geodetic Survey |
| USACE | United States Army Corps of Engineering |
| VGP | Vertical Guidance Post |

*I feel I am slowly forgetting the city I love and was [sic] home to me… homes are in ruins, neighbors are eerily quiet, and there is no life. There are no birds. The homes are scarred with the paint from the writing of rescue workers showing whether bodies were recovered or not. As hard as you try, the paint does not completely come off. Paint does not disguise the painful memory.* [1]

- Bridget Dugan, *Loss of Identity in Disaster: How to Say Goodbye to Home.*


*fig. 1: Post-Katrina, New Orleans, 2005*

# 01

# introduction

Global climate change is predicted to spark catastrophic flooding, posing a serious threat to coastal regions worldwide. Faced with an uncertain future, human beings must re-evaluate their relationship to nature, and particularly water. People in the Netherlands have adapted to these uncertain forces of nature and developed unique methods of living with water.

According to Dutch architect Hans Venhuizen, “amphibious living” is a concept that abandons the need to control water, and is accepting of climatic influence, tides, and seasonal changes in the natural environment.[2] Venhuizen states that “controlling natural conditions does not begin with imposing one’s own will on the landscape, but through taking full advantage of the qualities of a dynamic relationship between land and water. . . . It is not a question of living beside water, or living on water; it is not about the illustrative use of water, but rather living with water.”[3]

Flexible and multi-layered systems are required to accommodate the changing forces of nature. Amphibious foundations are dynamic systems that operate passively, adapting to changing conditions. Specifically, amphibious foundations allow a house to remain on land during normal, non-flood conditions, but enable the house to rise and float on the water’s surface during a flood.

In August of 2005, New Orleans experienced catastrophic flooding as a result of multiple levee failures during and after the passage of Hurricane Katrina (fig. 1). Eighty percent of the city became inundated with water, damaging over half the homes in New Orleans.[4]

Residents were displaced to other parts of Louisiana and the United States, leaving many neighbourhoods abandoned. The slow return of former residents has diminished the unique culture and identity of New Orleans. Elements of the city’s character are now at risk of being lost.[5]

Elizabeth English founded the Buoyant Foundation Project (BFP) in 2006 in an effort not only to provide a safe and reliable form of flood protection, but also to encourage the authentic restoration of traditional New Orleans neighbourhoods, especially in the Lower Ninth Ward. The project is specifically designed to preserve traditional, wooden "shotgun" style housing that is prevalent throughout New Orleans, including the Lower Ninth Ward. The BFP serves as a catalyst for the restoration of shotgun housing through retrofitting remaining structures with the buoyant foundation system.[6]

The BFP addresses the need for an alternative form of flood protection in the wake of Hurricane Katrina. The Federal Emergency Management Agency (FEMA) is recommending to homeowners, including those in low-lying areas of South Louisiana, to permanently elevate their homes to comply with the new Base Flood Elevation (BFE) requirements.[7]

The BFP is a flood protection system that provides an alternative to permanent static elevation. It allows a house to remain close to street level while minimizing both property damage and the destruction of neighbourhood character in the event of a flood. The BFP is a flood mitigation strategy that adapts to flood conditions when necessary, and does not inconvenience residents since the home remains close to street level under normal conditions.[8]

It has been more than five years since the storm, and many residents have not returned to their former homes for fear that they will have to face another catastrophic flood or live with the inconvenience of a home permanently raised to a high elevation. The BFP aims to provide a viable alternative in the hope that residents who have remained away for these reasons will return to their former homes, helping to restore the vitality and vibrancy of this unique city.[9]

The following document will address how the BFP can provide a culturally sensitive, technically feasible, economical, sustainable, and resilient form of flood mitigation for the Lower Ninth Ward in post-Katrina New Orleans. The significant challenges causing flooding in New Orleans will be outlined, focusing on three areas: ecology, unnatural disaster, and infrastructure. Each of these critical challenges has resulted in land loss and increased New Orleans' vulnerability to future flooding. The events of Katrina have proven the United States federal hurricane protection system to be an ineffective and unreliable form of flood mitigation for New Orleans. Artificial levee failure caused severe flooding that damaged or destroyed much of the housing in New Orleans.[10] The BFP can provide a consistent form of flood mitigation for residents in the Lower Ninth Ward, one of the most severely damaged — but recoverable — neighbourhoods of the city.[11] The BFP is culturally supportive through aiding in the restoration of a traditional housing typology, the shotgun house. Local and international examples of amphibious architecture outline the project's technical feasibility and design parameters. The BFP will demonstrate how its design is a more cost-effective, sustainable, and resilient solution when compared to permanent static elevation for residents in the Lower Ninth Ward. Lastly, future ambitions for the project will be discussed. Through implementation of the BFP, it is hoped that New Orleans will re-emerge safer, stronger, and more flood resilient.

01

i

# endnotes


1. Bridget Dugan, "Loss of Identity in Disaster: How to Say Goodbye to Home?" *Perspectives in Psychiatric Care 43* (2007): 45 as quoted in De-Mond Shondell Miller and Jason David Rivera, *Hurricane Katrina and the Redefinition of Landscape* (Lanham: Lexington Books, 2008), 6.

2. Bureau Hans Venhuizen, "Amphibious Living," http://www.amfibischwonen.nl/index2-e.html (accessed July 1, 2010).

3. ibid.

4. United States Department of Commerce NOAA/NESDIS, "Hurricane Katrina: A Climatological Perspective, http://www.ncdc.noaa.gov/oa/climate/research/2005/katrina.html, (accessed September 1, 2009) and Christine F Andersen *et al.*, *New Orleans Hurricane Protection System : What Went Wrong and Why : A Report* (Virginia: ASCE, 2007), 1.

5. United States Department of Commerce NOAA/NESDIS. 2005, 1.

6. Elizabeth English, "Amphibious Foundations and the Buoyant Foundation Project: Innovative Strategies for Flood-Resilient Housing," (paper presented at the International Conference on Urban Flood Management, Paris, France, November 25-27, 2009), 1-2 (appendices, 412).

7. Elizabeth English, "The Buoyant Foundation Project,"http://www.buoyantfoundation.org (accessed September 1, 2010).

8. ibid.

9. Allison Plyer, “Neighborhood Recovery Rates Resiliency of New Orleanians Shown in Neighborhood Repopulation Numbers,” http://www.gnocdc.org/RecoveryByNeighborhood/index.html (accessed July 1, 2010).

10. Andersen *et al*. 2007, 1.

11. Associated Press, “New Orleans’ Katrina-Ravaged 9th Ward Can Be Rebuilt, Planners Say,” http://www.foxnews.com/story/0,2933,242316,00.html (accessed October 23, 2009).

# 02

# the buoyant foundation project:

# challenges

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# 02 i challenges

Chapter two outlines the significant challenges the BFP will address. This chapter is divided into three subsections: ecology, unnatural disaster and infrastructure. Each appears in chronological order, outlining the challenges that have plagued New Orleans for centuries to the more recent challenges which occurred as a result of Hurricane Katrina and its aftermath.

The deterioration of natural resilience, subsidence, rising sea levels and land loss are critical ecological challenges that will contribute to future flooding in New Orleans if left unaddressed. Additionally, these challenges must be resolved in a sound and sensitive way, as human intervention itself has accelerated land loss and made New Orleans more vulnerable to flooding. Traditional infrastructure implemented to control flooding has weakened New Orleans' natural resilience and destabilized soil resulting in significant land loss. Rising sea levels due to global warming will also result in future land loss.

Chapter 2 then explores the impact of Hurricane Katrina by examining the timeline, duration of the storm and damages. The impact includes not only ecological and residential damage, but also encompasses lack of essential services, flawed emergency shelter strategies, and, ultimately, loss of human life. For survivors, Katrina resulted in vast displacement that continues to this day. It is also discussed why Katrina can be classified as an "unnatural disaster." The majority of the flood damage was caused by levee failure and could have been prevented if the levees had been properly designed and maintained.

The chapter concludes with a review of the United States Army Corps of Engineers' (USACE) artificial levee system, discussing its design, the failures that occurred during and after Hurricane Katrina, and the severe flooding which resulted, particularly in the Lower Ninth Ward.

# 02

# ii

# challenges: ecology

DETERIORATION OF NATURAL RESILIENCE

The Greater New Orleans Area is surrounded by levees. After the Great Mississippi Flood of 1927, the United States Army Corps of Engineers (USACE) "integrated the management of flood control and navigation on the Mississippi River."[12] According to Craig E. Colten, Professor of Geography and Anthropology at Louisiana State University, "[H]uman effort to manage the environment has been an important dimension in shaping the New Orleans landscape, that serves as a visible record of human interaction with the environment. The mighty levees encircling the city serve one fundamental purpose: flood protection, both from high river stages of the Mississippi and hurricane-driven storm surges from Lake Pontchartrain."[13]

However, the infrastructure that was implemented to control flooding has weakened New Orleans' natural resilience and destabilized its soil. This has resulted in significant land loss, exacerbated by rising sea levels due to global warming. Human interventions, and the lack thereof, have created conditions for an "unnatural disaster." Much of the damage that accompanied Katrina could have been prevented by restoration of the shoreline and better design and maintenance of the levees.

The artificial levee system creates a barrier that inhibits the replenishment of land beyond its boundary, creating a static wall of protection. This human intervention actually prevents the functioning of a natural, ecological system of protection that had long existed. Before the Mississippi River was contained by the artificial levee system, fluctuations in water level throughout the year would naturally cause the river to overflow, deposit silt onto the banks, and create a natural levee through soil replenishment (fig. 2).[14]

Roger T. Saucier, in a report by Richard P. McCulloh, Paul V. Heinrich, and Bill Good, Research Associates of Geology at Louisiana State University, further elaborates:

> Prior to the construction of artificial levees, the Mississippi River and its distributaries constructed natural levees via overbank deposition in repeated episodes of flooding. During major floods, waters overflowed channel banks and poured out into the adjacent inter-distributary basins. As the floodwaters left the channels of either the Mississippi River or its distributaries, the expansion of flow from unconfined channels and the baffling effect of the marsh or swamp vegetation caused an abrupt drop in the floodwater velocity. As a result of this decrease in velocity, the sand and silt being carried by the floodwaters settled out adjacent to the channel margins, causing the construction of natural levees along them. These floodwaters carried finer grained sediments, mainly clay particles, beyond the natural levees and out into the inter-distributary basins where they preferentially accumulated.[15]

John McQuaid and Mark Schleifstein, in the report by McCulloh, Heinrich and Good, explain how artificial levees and floodwalls were implemented along the Mississippi:

> Levees and flood walls that protect against flooding from both the Mississippi River and hurricanes are built by the USACE and are maintained by local levee districts [fig. 3]. The USACE and the local districts share the construction cost of hurricane levees, [along] the Mississippi River. . . Local levee districts [will] also build and maintain non-federal, lower-elevation levees with construction money from each district's share of property taxes and state financing. . . . Different factors permit Lake Pontchartrain levees of varying elevations to withstand an 11-1/2 foot storm surge plus several feet of waves.[16]

Figure 4 is a geological map of New Orleans. It was mapped using soil surveys, 1:24 000-scale topographic maps, and Light Detection And Ranging (LIDAR) digital elevation models (DEMs).[17]

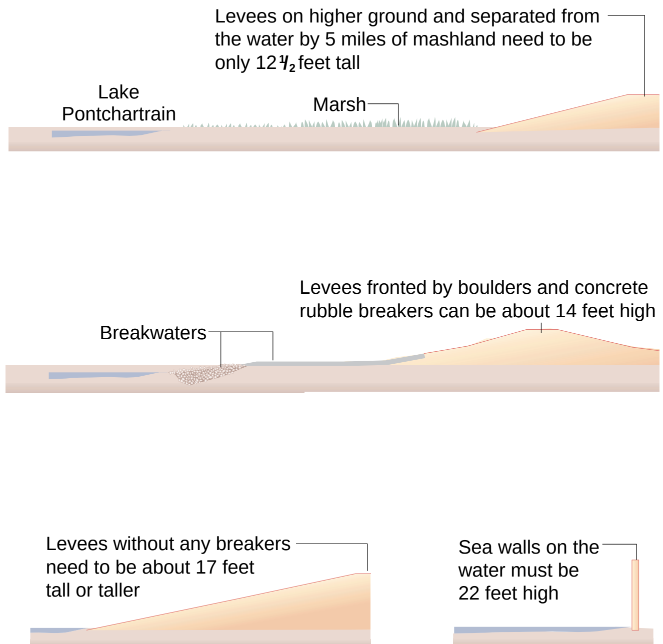



*fig. 2: Artificial Levee System, Sections*

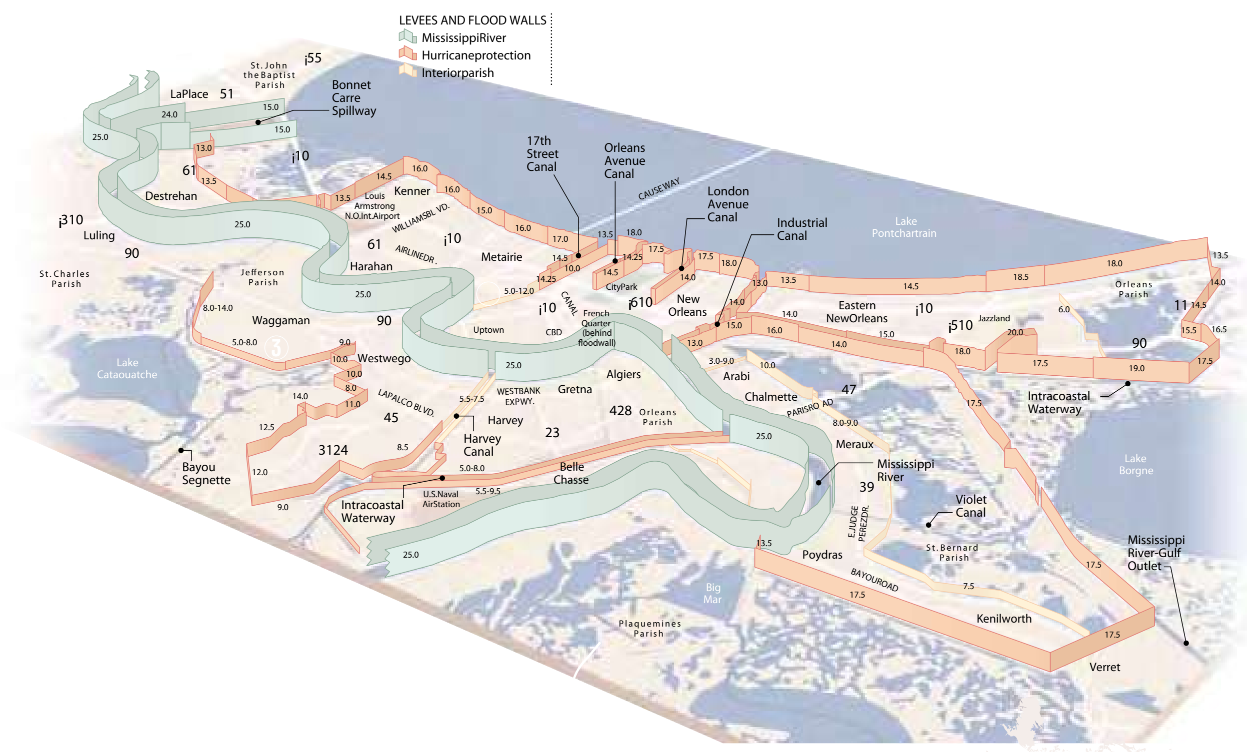



*fig. 3: Artificial Levee System*

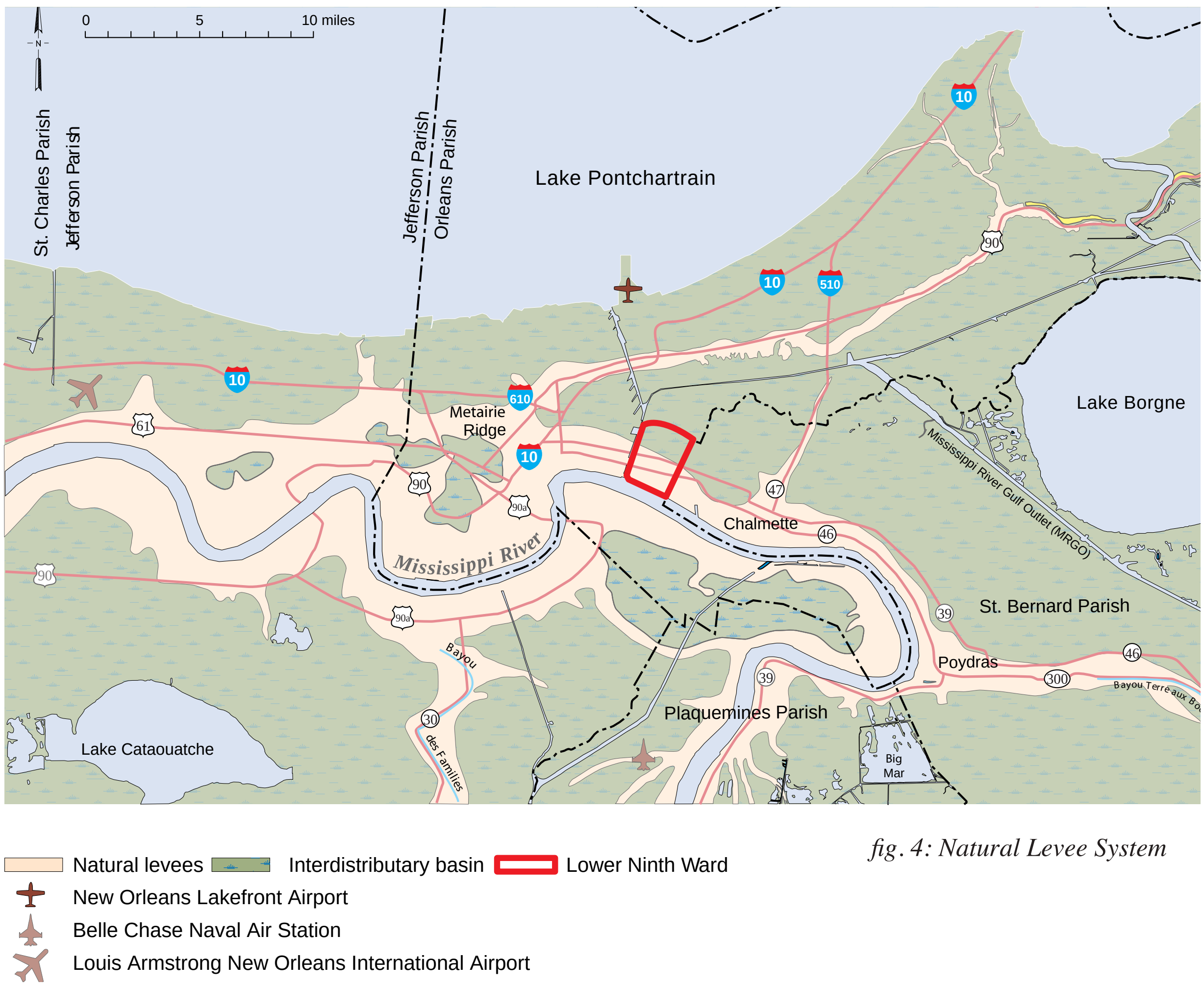



*fig. 4: Natural Levee System*

D. E. Frazier and A. Osanik *et al.* explain the distinct geography of New Orleans:

> Jefferson, Orleans, St. Bernard, and Plaquemines parishes all lie within the delta plain of the Mississippi River. One of the major characteristics of river deltas is their network of distributaries. These are streams that fork from the main river channel and distribute the water through a larger and larger area of the delta plain as the river approaches its mouth. Branching off from the modern and abandoned channels of the Mississippi are numerous distributaries, for example, Bayou La Loutre–Bayou Terre aux Boeuf. During a flood, the active deltaic distributaries carry sediment-bearing floodwaters away from the river and out onto the surrounding delta plain. Thus the distributaries, when unencumbered by artificial levees, play a significant role in maintaining the wetlands. These channels radiate outward, in a fan-like network, from the main channel of the Mississippi River.[18]

Frasier and Osanik *et al.* outline how the artificial levee system inhibits the deltaic distributaries from carrying sediment to maintain the wetlands. This lack of sediment is destroying New Orleans' natural defense against hurricanes and flooding (fig. 5). Richard Campanella, Assistant Research Professor of Earth and Environmental Science at Tulane University, also comments on human intervention and its impact on the natural ecosystem. Campanella was a panelist at the Building Resilience Workshop, a conference held in New Orleans in February 2010. He began his talk by showing the correlation between New Orleans' topography and the movement of population after the municipal drainage system was implemented to control flooding. He points out that in the 1700s, the original population centroid (the center of balance on which the population is evenly distributed) was around the St. Peter Street and Royal Street intersection. When the municipal drainage system was installed in the early 1900s, it slowly started to remove water from the sand, silt and clay which began to dry out the land (also known as dessication). As the land dried out, population began to move away from the river and closer to the lake, onto land that was previously uninhabitable. Campanella points out that major parts of New Orleans are now below sea level due to human intervention, not natural occurrences. The pumping infrastructure intended to help manage flooding has resulted in greater problems, destabilizing soil and causing New Orleans to sink — this is also known as subsidence. By the year 2000, modern-day LIDAR and GPS topography assessments show that after 100 years, many areas of the City have dropped 2 to 3 meters below sea level. Campanella continues his talk by posing a question in relation to Dr. Elizabeth English's initial topic question, "What innovations have occurred in response to catastrophic events?" He inverts the question and poses a rhetorical question, "What catastrophic events came off what we thought were innovations? – Innovative solutions have too often spawned disasters." He concludes by offering a lesson that can be learnt from the post-Katrina era; "the more radical the plan the more likely it is to fail."[19]

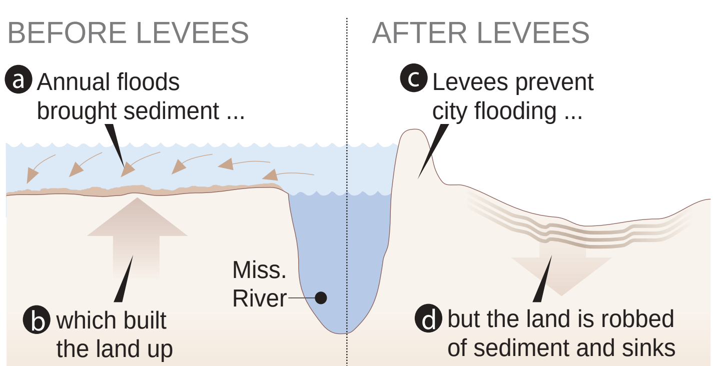



*fig. 5: Before and After Artificial Levees*

SUBSIDENCE

According to Christine Anderson *et al.*, in a report by the American Society of Civil Engineers (ASCE):

> Large portions of Orleans, St. Bernard and Jefferson parishes are currently below sea level — and they continue to sink. New Orleans is built on thousands of feet of soft sand, silt, and clay. Subsidence, or settling of the ground surface, occurs naturally because of the consolidation and oxidation of organic soil and also the intervention of pumping out local groundwater. In the past, flooding and deposition of sediments from the Mississippi River counterbalanced the natural subsidence, leaving southeast Louisiana at or above sea level. However, because of the major flood control structures built upstream on the Mississippi River and levees built around New Orleans, fresh layers of sediment are not replenishing the ground lost by subsidence.[20]

Figure 6 is a three-dimensional representation that illustrates the natural process of subsidence. It shows how soft sediment beneath Louisiana's coast is sinking, due to water and gases being squeezed out by the soil's own weight.[21]

McCulloh, Heinrich, and Good further explain the soil mechanics processes:

> [Figure 7 shows] schematic cross-sectional diagrams depicting subsidence at subregional and superficial scales in the New Orleans area. As shown in the cross section at the bottom, thick clay-rich layers in the subsurface compact more than sand layers and discrete sand bodies; the clay-rich layers expel water into the more permeable sands over time and further compact by concurrent mechanical rearrangement of the clay particles. In the New Orleans area, the resulting subsidence from this natural process has been accelerated by groundwater pumping that removes water from the sands, which are replenished with water expelled from the clayrich layers. At and near the surface [as show in the magnified portion of figure 7], human-induced alterations of the land greatly accelerate drainage of the upper part of the soil column. When the soil is drained, it and its contained organic matter (peat and organic-rich clay, depicted as black lenses in the [magnified portion of figure 7]) lose a substantial percentage of their original volume and are exposed to atmospheric oxygen. This process may result in a dramatic volume reduction of the organic matter in a short time, which at the surface appears as sinking of the ground. (In the main cross section [of figure 7], black arrows represent a decrease in the thickness of the sedimentary section over time, preferentially in the clay-rich layers. In the [magnified portion of figure 7], blue arrows represent the seepage and flow of water into a man-made excavation—in this case, a drainage canal—and black, dashed arrows represent the downward movement of the ground surface over time from volume loss caused by drainage and oxidation of organic-rich wetland soils).[22]

Anderson, Campanella, McCulloh, Heinrich, and Good highlight how human intervention has accelerated the deterioration of New Orleans' natural resilience. Artificial levees have inhibited fresh layers of sediment from replenishing the ground lost by subsidence. Pumping infrastructure has destabilized soil and also increased the rate of subsidence. The state of Louisiana is currently trying to figure out a way to deposit silt in a controlled fashion to replenish the soil and natural levee system.[23]

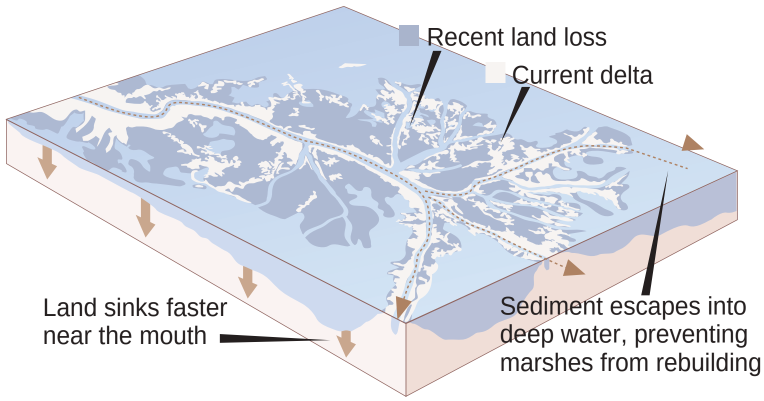



*fig. 6: Three-Dimensional Subsidence Diagram*

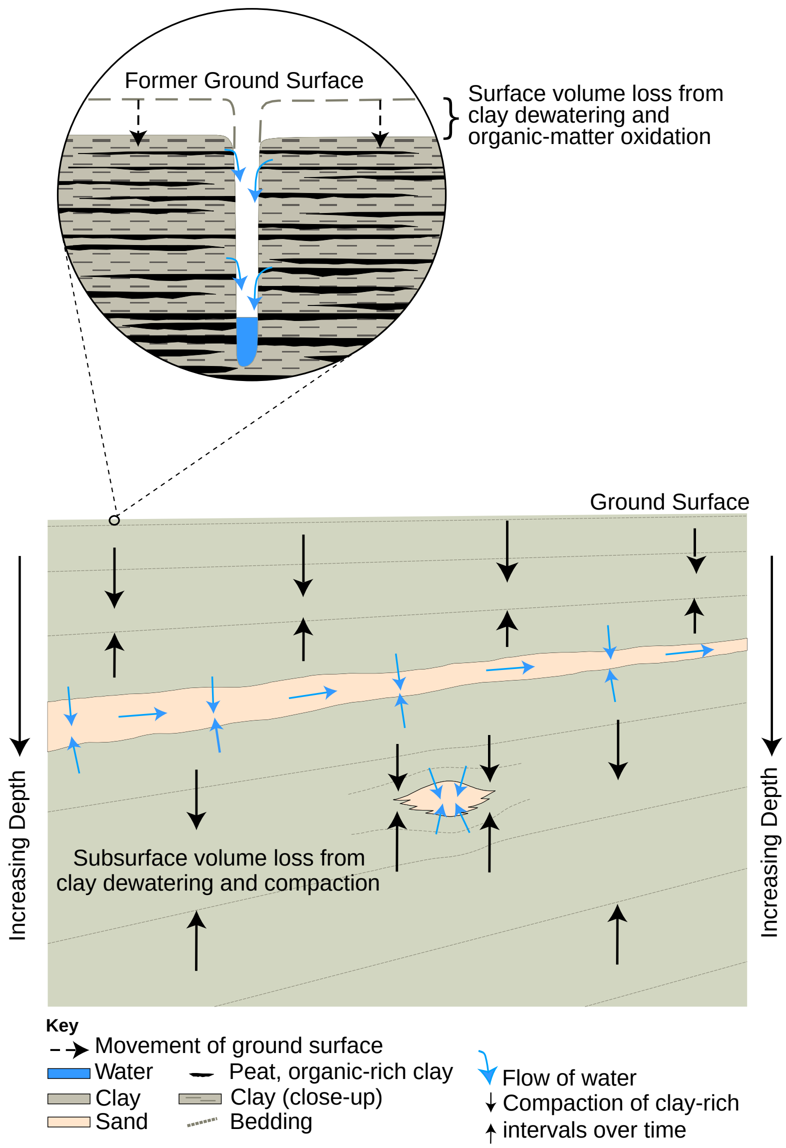



*fig. 7: Schematic Cross-Section Diagrams Depicting Subsidence At Submerged and Superficial Scales*

## RISING SEA LEVELS

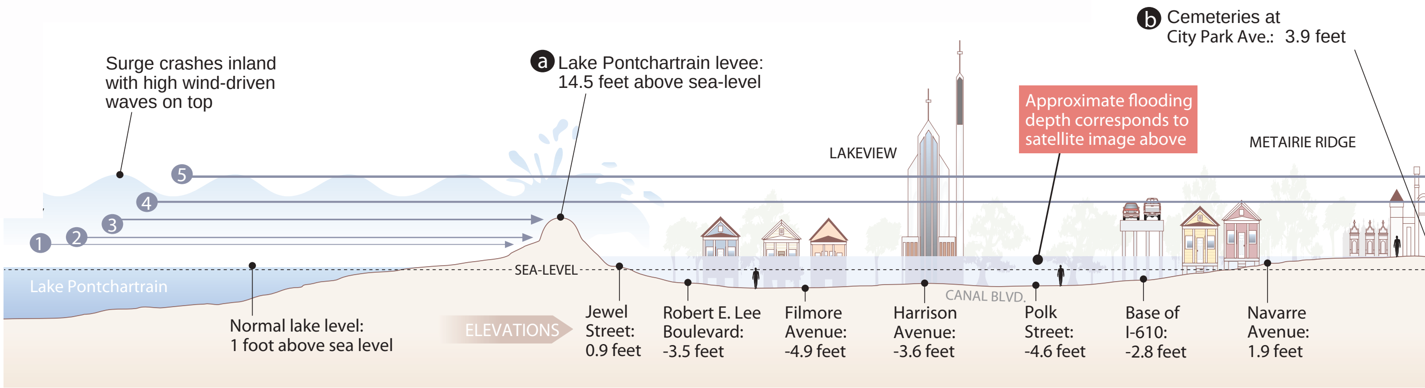
Rising global surface temperatures mean coastal regions will continue to be affected by flooding. Robert Giegengack, Professor of Earth and Environmental Science, and Kenneth R. Foster, Professor of Bioengineering, both from the University of Pennsylvania, assert "the mean surface temperature of the North Atlantic has risen by approximately 0.8 degrees Celsius since the 1930s, with the major part of this increase occurring since 1990. There is thus empirical support for the prediction of an increase in the number and destructiveness of hurricanes as a result of global warming."[24]

New Orleans is a coastal region that is particularly vulnerable to flooding and hurricanes. Craig Colten states that "although described in some cases as the antithesis of nature, cities are not, nor can they be, insulated from interaction with their environment. . . . Reconstructing the responses to these challenges is fundamental to understanding the urbanization and the territory the city now occupies."[25]

As mentioned earlier, global warming has created a twofold issue for Louisiana that stems from rising ocean surface temperatures. First, an increase in ocean surface temperature creates the necessary conditions for hurricanes to form. Second, an increase in ocean surface temperature causes the ice caps to melt, which causes sea levels to rise. This means that the 40% of New Orleans that is below sea level is even more susceptible to flooding.[26]

Figure 8 illustrates "the bowl," displaying the various topographic levels of the city above and below sea-level. Storm surge simply follows the law of gravity and moves to the lowest points.[27] Prior to Hurricane Katrina, after Hurricane Georges, Louisiana State University's (LSU) Water Resources Research Institute, and the Army Corps of Engineers predicted that "when a hurricane even stronger than Georges hits New Orleans, Lake Pontchartrain — a foot higher than sea level — will be the city's biggest threat. Surge water from the Gulf of Mexico, topped by towering waves, will swell the lake above levees and cause widespread flooding."[28]

Figure 9 compares average surge levels by category, overlaid on a cross-section of the city. Figures correspond to maximum surge heights, plus Lake Pontchartrain's +1 sea level. High tides could add as much as two feet, and the surge level could rise even higher in some spots on the shore.[29] (Note: elevations are approximate).



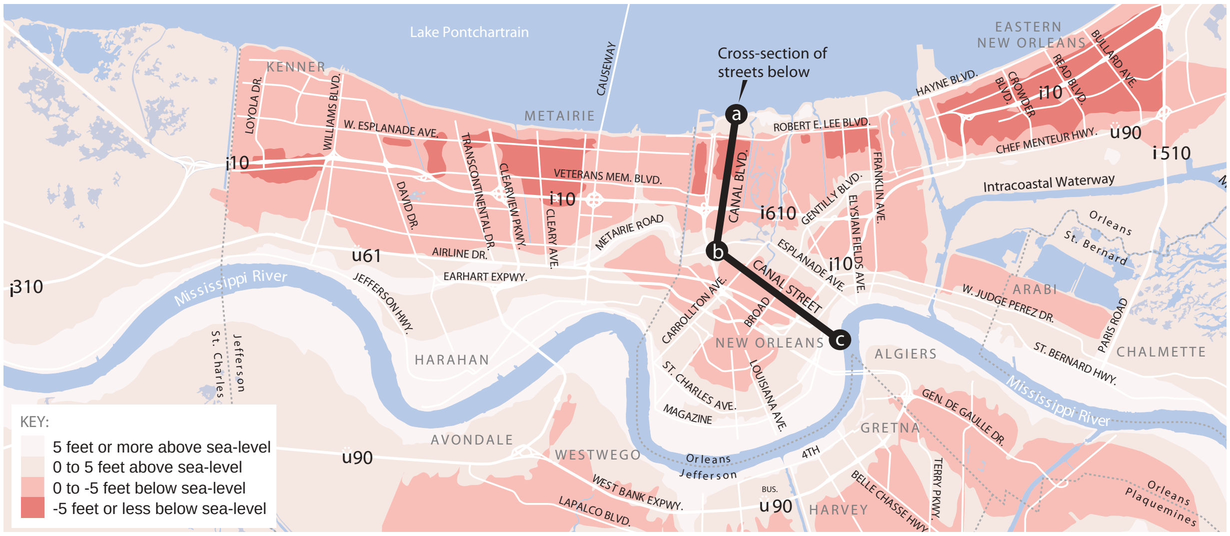



*fig. 8: Defining the 'Bowl'*

| Hurricane Category | Surge and waves at low tide* | Effect on New Orleans |
|---|---|---|
| 1 | 7 feet | Lake Pontchartrain's levees stop the low-level surge |
| 2 | 9 feet | Levees stop the surge, but some waves could find their way over |
| 3 | 14 feet | Levees stop bulk of surge, but waves could cause considerable flooding |
| 4 | 19 feet | Levees topped, causing catastrophic flooding |
| 5 | 24 feet | Entire city submerged including Mississippi River levees |

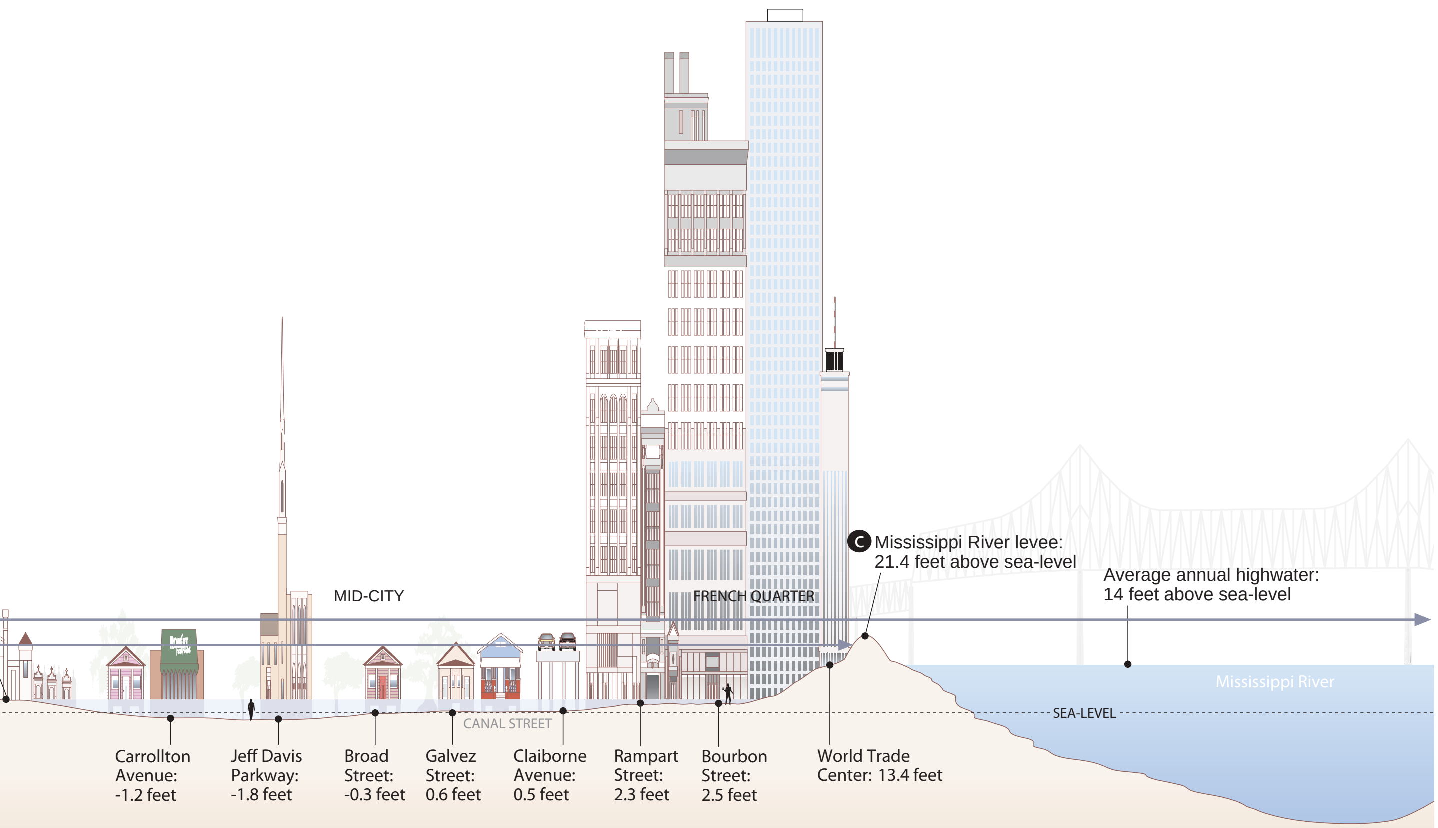



*fig. 9: Possible Storm Surge and Inundation*

LAND LOSS

A change in coastline resulting from a combination of lost natural resilience, subsidence, and rising sea levels could have dramatic effect in New Orleans. Figures 10 to 13 are hypothetical depictions that compare a change in coastline using 1, 2 and 3.3 foot rises in sea level.

Figure 14 is a graph showing the relative sea level rise, a combination of sea level rise plus the rate of subsidence for Grand Isle from 2002-2007.

Figure 15 displays a larger view of the Louisiana coast, and provides a comparison of the areas of land loss and gain for 1932-2000 and the projected losses from 2000-2050. According to the United States Geological Survey (USGS):

> Coastal Louisiana has lost an average of 34 square miles of land, primarily marsh, per year for the last 50 years. From 1932 to 2000, coastal Louisiana has lost 1,900 square miles of land, an area roughly the size of the state of Delaware. If nothing is done to stop this land loss, Louisiana could potentially lose approximately 700 square miles of land, or about equal to the size of the greater Washington D.C.-Baltimore area, in the next 50 years. Further, Louisiana accounted for an estimated 90% of the coastal marsh land loss in the lower 48 states during the 1990s.[30]

The deterioration of natural resilience, subsidence, rising sea levels, and land loss are critical ecological challenges affecting New Orleans. If left unaddressed, these challenges will result in more damage. An alternative flood-mitigation strategy is required — one that does not disrupt the New Orleans' ecosystem or deteriorate its natural resilience. Innovative flood protection methods are critical for the survival of New Orleans.


*fig. 10: 2-Foot Sea-Level Rise, Context*

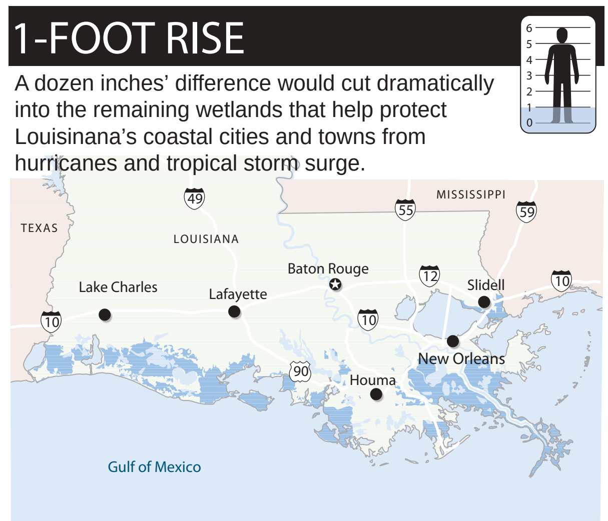



*fig. 11: 1-Foot Sea-Level Rise*

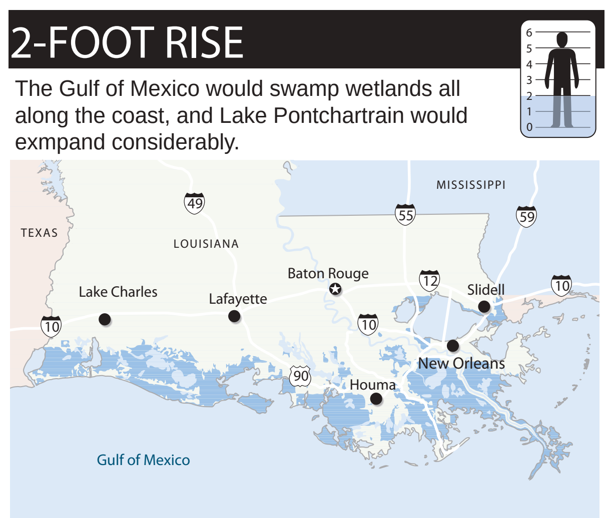



*fig. 12: 2-Foot Sea-Level Rise*

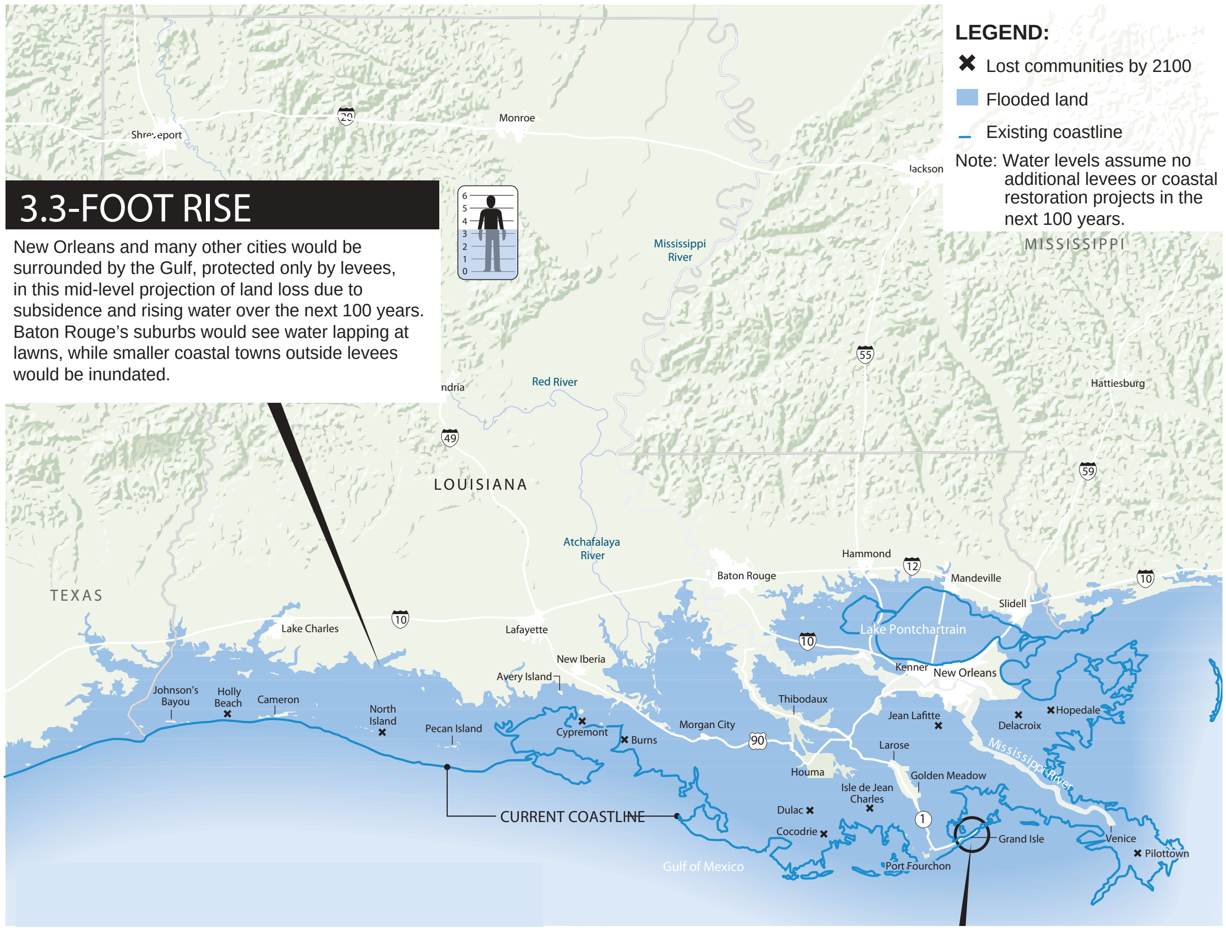
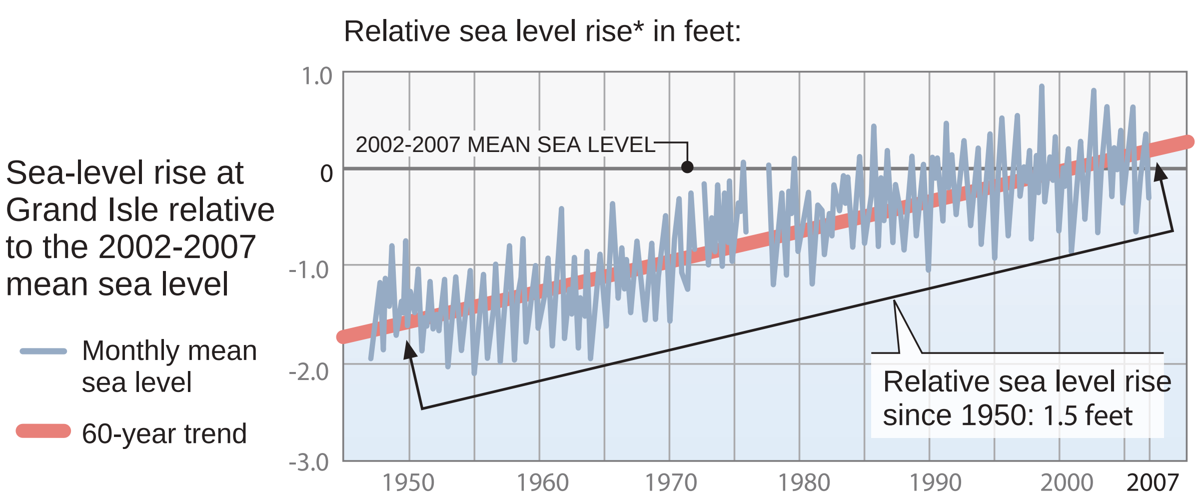



*fig. 13: 3.3-Foot Sea-Level Rise*




*Sea level rise + subsidence rate = relative sea level rise     Source: NOAA

*fig. 14: Sea-Level Rise at Grand Isle Relative to the 2002-2007 mean Sea-Level*

# 02

# iii

# challenges: unnatural disaster

Saturday August 27, 2005.

*By Saturday morning, (the National Hurricane Center was) locked onto southern Louisiana. It was a pretty darned good two-day forecast, and nobody trusts four-to-five-day forecasts anyway, whether it's a hurricane or not. [Barry] Keim gives the first of his many weather briefings to state homeland security and Office of Emergency Preparedness officials late that morning. He was officially 'activated' to duty at the Emergency Operations Center in Baton Rouge at 2 p.m.*

*In the briefings, a duty that Keim shares with LSU scientist Kevin Robbins and others, 'we take the forecast and localize it with local information, like wave buoy data, local wind speeds, and so on, and tell the elected and appointed officials so they can make decisions.' In this first briefing, 'the forecast was calling for a Category 4 hurricane, and that's enough to get anyone's attention. Nobody dreamed at that time that it would be as bad as it was, but they were very concerned.'*[31]

— Thomas Hayden, quoting Barry Keim and Kevin Robbins, in *Storm Experts Feared the Worst: A Diary of a Mad Hurricane*

*fig. 16: Hurricane Katrina Approaching the Gulf Coast on August 28, 2005, Aerial View*

HURRICANE KATRINA

As Hurricane Katrina inundated New Orleans, storm surge from the Gulf of Mexico catastrophically damaged the City's hurricane protection system. Multiple levee failures resulted in the greatest post-hurricane destruction in the history of the United States.[32] According to the Department of Homeland Security (DHS), "[Hurricane Katrina] devastated 90,000 square miles of the Gulf Coast [fig. 16,17]."[33] The National Hurricane Center (NHC) and the National Oceanic and Atmospheric Administration (NOAA) announced that it was "the costliest and one of the five deadliest hurricanes to ever strike the United States."[34]

According to Richard D. Knabb, Jamie R. Rhome, and Daniel P. Brown from the National Hurricane Center:

> [H]urricane [Katrina] then made landfall, at the upper end of Category 3 intensity with estimated maximum sustained winds of 110 kt [127 mph], near Buras, Louisiana at 1110 UTC 29 August. Katrina continued northward and made its final landfall near the mouth of the Pearl River at the Louisiana/Mississippi border, still as a Category 3 hurricane with an estimated intensity of 105 kt. . . . Katrina weakened rapidly after moving inland over southern and central Mississippi, becoming a Category 1 hurricane by 1800 UTC 29 August.[35]

The American Society of Civil Engineers (ASCE) reported "the storm overtopped levees and floodwalls throughout southeast Louisiana and also caused the levees and floodwalls in New Orleans to fail or breech in more than 50 locations. Water rushed into New Orleans and flooded over 80% of the city — more than 10 feet deep in some neighborhoods."[36]

The table in figure 18, compiled after the storm in 2005, displays Hurricane Katrina among the most severe hurricanes to hit the United States in recent history. Estimates of death toll and damage continue to rise, even five years later.[37]

| | TROPICAL DEPRESSION | TROPICAL STORM | SAFFIR-SIMPSON HURRICANE INTENSITY SCALE 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|
| Wind speeds (in mph) | Less than 39 | 39-73 | 74-95 | 96-110 | 111-130 | 131-155 | More than 155 |
| Damage level | None | Minimal | Minimal | Moderate | Extensive | Extreme | Catastrophic |
| Storm surge | None | Less than 4 feet | 4-5 feet | 6-8 feet | 9-12 feet | 13-18 feet | More than 18 feet |
| Coastal evacuation (depends upon sea level) | -- | -- | None | None | Several blocks | Up to six miles | 5-10 miles |
| Barometric pressure (in inches) | 29.73 (est.) | Less than 29.53 | 28.94-29.53 | 28.50-28.91 | 27.91-28.47 | 27.17-27.88 | Less than 27.17 |

*fig. 17: Saffir-Simpson Hurricane Scale*

| 1900-present | DEADLIEST Storm | U.S. Deaths | STRONGEST (at U.S. landfall) Storm | Category | Minimum air pressure (inches) | COSTLIEST Storm | Cost (billions) |
|---|---|---|---|---|---|---|---|
| 1 | Galveston, Texas (1900) | 8,000-12,000 | Florida Keys (1935) | 5 | 26.35 | Katrina (2005) | $40 |
| 2 | Lake Okeechobee, Fla. (1928) | 2,500 | Camille (1969) | 5 | 26.84 | Andrew (1992) | $21.6 |
| 3 | Katrina (2005) | 1,570 | Katrina (2005) | 3 | 27.11 | Wilma (2005) | $8.4 |
| 4 | Florida Keys (1935) | 408 | Andrew (1992) | 5 | 27.23 | Charley (2004) | $7.7 |
| 5 | Audrey in La., Texas (1957) | 390 | Florida Keys, Texas (1919) | 4 | 27.37 | Ivan (2004) | $7.4 |
| 6 | Miami, Pensacola, Fla.; Miss., Ala. (1926) | 372 | Lake Okeechobee, Fla. (1928) | 4 | 27.43 | Hugo (1989) | $6.8 |
| 7 | Grand Isle, La. (1909) | 350 | Donna (1960) | 4 | 27.46 | Rita (2005) | $5 |
| 8 | Florida Keys, Texas (1919) | 287 | New Orleans (1915) | 4 | 27.49 | Frances (2004) | $4.8 |
| 9 | New Orleans (1915) | 275 | Carla (1961) | 4 | 27.49 | Jeanne (2004) | $3.8 |
| 10 | Northeastern Texas (1915) | 275 | Hugo (1989) | 4 | 27.58 | Georges (1998) | $3.5 |

*fig. 18: Comparison of the Deadliest, Strongest and Costliest Hurricanes in the United States*

TIMELINE

The following images are screenshots taken from NOLA.com (the website of the *New Orleans Times Picayune*), documenting the significant events and times of the storm (fig. 19). They begin on August 28, 2005, the day before Katrina struck the city, and end September 1, 2005, after the storm had subsided.[38]


*fig. 19: Hurricane Katrina Timeline*


New Orleans, August 29, 2005
Lake Pontchartrain
Lake Borgne
**4:30 a.m.:** Rising water in the Industrial Canal leaks through damaged gates into neighborhoods on both sides of the I-10 High Rise. The flow is minor compared to what is in store for these areas.
TIME
AM
PM
4:30
LEGEND
Breach
Flooded land
Levees
Compromised levee
CONTROL PANEL
Back
Next
SCENE
2

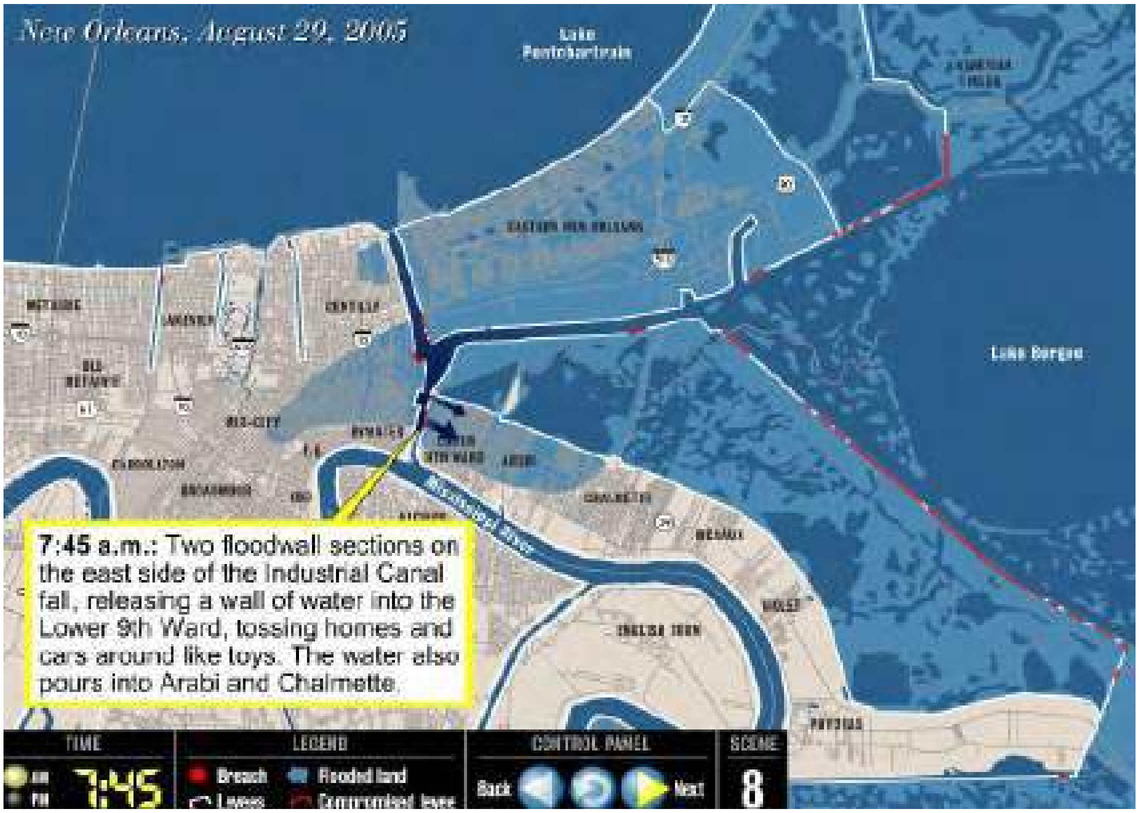

New Orleans, August 29, 2005
Lake Pontchartrain
Lake Borgne
TIME
AM
PM
5:00
LEGEND
Breach
Flooded land
Levees
Compromised levee
CONTROL PANEL
Back
Next
SCENE
3


New Orleans, August 29, 2005
Lake Pontchartrain
6:10 a.m.: Katrina makes landfall at Buras. A wall of water 21 feet high crosses the Mississippi River and its levees, inundating most of Plaquemines Parish.
Breton Sound
Miss. River
Gulf of Mexico
TIME
6:10
LEGEND
Breach
Flooded land
Levees
Compromised levee
CONTROL PANEL
Back
Next
SCENE
4


New Orleans, August 29, 2005
Lake Pontchartrain
Lake Borgne
6:30 a.m.: Surge builds in the Intracoastal Waterway's "funnel," and levees protecting eastern New Orleans are overtopped and breached. Soon, the area is under water.
TIME
6:30
LEGEND
Breach
Flooded land
Levees
Compromised levee
CONTROL PANEL
Back
Next
SCENE
5


New Orleans, August 29, 2005
Lake Pontchartrain
6:50 a.m.: Storm surge from the "funnel" reaches the Industrial Canal. Water overtops floodwalls and levees on both sides, but the worst is still ahead.
Lake Borgne
TIME
AM
PM
6:50
LEGEND
Breach
Flooded land
Levees
Compromised levee
CONTROL PANEL
Back
Next
SCENE
6


New Orleans, August 29, 2005
Lake Pontchartrain
7:30 a.m.: Levee wall panels on the west side of the Industrial Canal breach, flooding the Upper 9th Ward, Bywater and Treme.
Lake Borgne
TIME
AM
PM
7:30
LEGEND
Breach
Flooded land
Levees
Compromised levee
CONTROL PANEL
Back
Next
SCENE
7


New Orleans, August 29, 2005
Lake Pontchartrain
Lake Borgne
7:45 a.m.: Two floodwall sections on the east side of the Industrial Canal fall, releasing a wall of water into the Lower 9th Ward, tossing homes and cars around like toys. The water also pours into Arabi and Chalmette.
TIME
AM
PM
7:45
LEGEND
Breach
Flooded land
Levees
Compromised levee
CONTROL PANEL
Back
Next
SCENE
8


New Orleans, August 29, 2005
Lake Pontchartrain
Lake Borgne
8:30 a.m.: Lake Borgne advances to St. Bernard Parish's second line of defense, easily topping the 7-foot to 9-foot 40-Arpent Canal levee and filling neighborhoods from Poydras to Chalmette.
TIME
AM
PM
8:30
LEGEND
Breach
Flooded land
Levees
Compromised levee
CONTROL PANEL
Back
Next
SCENE
9


New Orleans, August 29, 2005
Lake Pontchartrain
About two miles west, surge reaches an embankment at the foot of the Orleans Avenue Canal that is 6 feet lower than the floodwalls. Water tops the embankment and pours into City Park.
Lake Borgne
9 a.m.: Surge rises to 10 feet in the London Avenue Canal and levee wall panels on both sides start bending. Water leaks into yards, but the flow is still minor.
TIME
AM
PM
9:00
LEGEND
Breach
Flooded land
Levees
Compromised levee
CONTROL PANEL
Back
Next
SCENE
10


New Orleans, August 29, 2005
Lake Pontchartrain
Lake Borgne
9:30 a.m.: I-wall panels on the east side of the London Avenue Canal fail, releasing a wall of water and sand into homes and expanding the flooding of Gentilly.
TIME
AM
PM
9:30
LEGEND
Breach
Flooded land
Levees
Compromised levee
CONTROL PANEL
Back
Next
SCENE
11


New Orleans, August 29, 2005
9:45 a.m.: Several 17th Street Canal levee wall panels fall, releasing a roaring torrent of water into Lakeview. Water from this breach eventually fills much of midtown New Orleans and parts of Metairie.
On the north shore, Katrina makes landfall near Slidell. Storm surge is 15 feet at the Lake Pontchartrain shoreline and reaches more than five miles inland at some points. St. Tammany Parish neighborhoods from the Rigolets all the way to Madisonville are flooded.
Lake Pontchartrain
St. Tammany Parish
TIME
9:45
LEGEND
Breach
Flooded land
Levees
Compromised levee
CONTROL PANEL
Back
Next
SCENE
12


New Orleans, August 29, 2005
Lake Pontchartrain
10:30 a.m.: I-wall panels on the west side of the London Avenue Canal are pushed over, adding 8 feet of water to flooded Gentilly and contributing to rising water across the city.
Lake Borgne
Parts of Jefferson Parish also flood as rainwater leaks through an unstaffed pumping system.
TIME
10:30
LEGEND
Breach
Flooded land
Levees
Compromised levee
CONTROL PANEL
Back
Next
SCENE
13

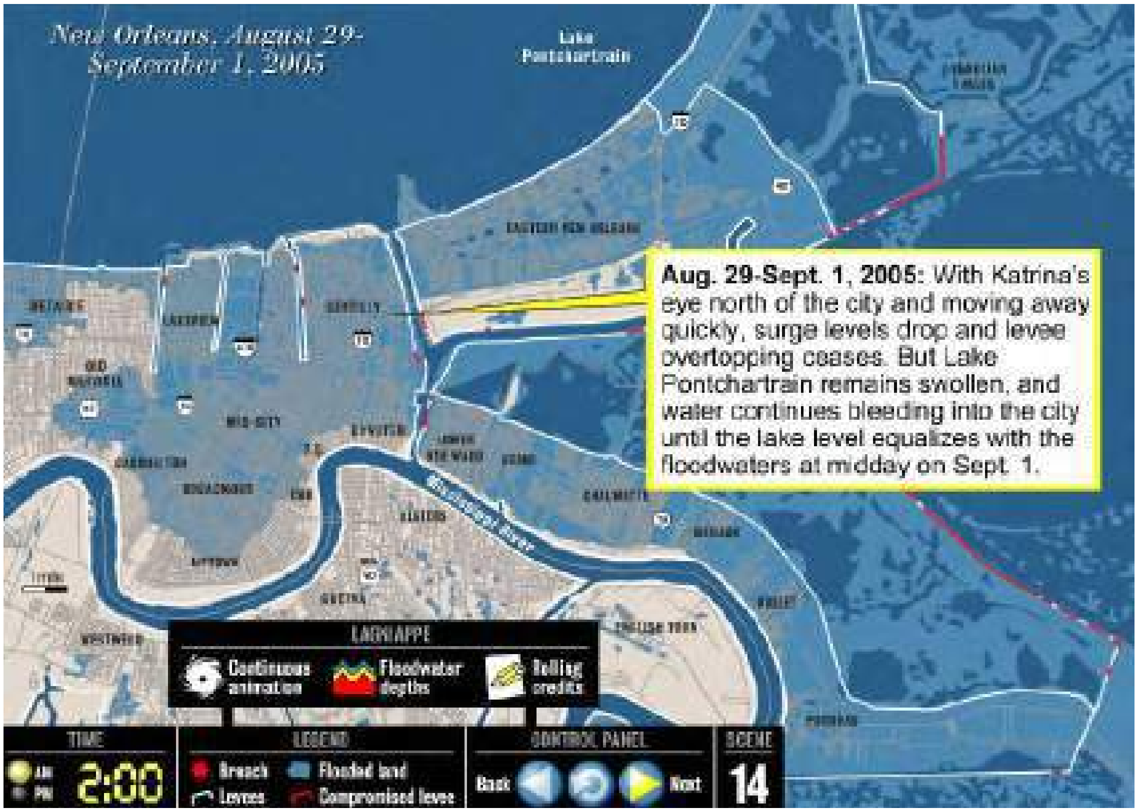

New Orleans, August 29-
September 1, 2005
Lake
Pontchartrain
Aug. 29-Sept. 1, 2005: With Katrina's eye north of the city and moving away quickly, surge levels drop and levee overtopping ceases. But Lake Pontchartrain remains swollen, and water continues bleeding into the city until the lake level equalizes with the floodwaters at midday on Sept. 1.
LAGNIAPPE
Continuous animation
Floodwater depths
Rolling credits
TIME
AM
PM
2:00
LEGEND
Breach
Flooded land
Levees
Compromised levee
CONTROL PANEL
Back
Next
SCENE
14

*fig. 20: Destroyed Neighbouhood, Post-Katrina New Orleans, 2005*

*fig. 21: Flooded Street, Post-Katrina New Orleans, 2005*

AFTERMATH

In New Orleans, the Lower Ninth Ward was one of the neighbourhoods most impacted by Hurricane Katrina. Make It Right (MIR), a non-profit organization founded by actor Brad Pitt, has been active in rebuilding part of New Orleans' Lower Ninth Ward. MIR remarked on the impact of Hurricane Katrina and its aftermath:

> Levee failure created floodwaters that tore houses from their foundations, threw houses on top of cars, and erased blocks upon blocks, leaving many residents homeless [fig. 20, 21]. . . . Neighbors tell stories of devastating heat, desperate attempts to save family members by hacking holes through roofs to provide air and escape from the rising floodwaters, and hours upon hours and days upon days spent on rooftops without drinking water in the relentless sun waiting for help. The wait went on for more than two years later after the storm.[39]

The following pages will discuss some of the major factors that contributed to the devastation caused by Hurricane Katrina, including lack of preparedness, insufficient temporary shelter, and the delayed return of utilities. Figures 22 to 25 depict exterior and interior scenes of the aftermath of Hurricane Katrina in New Orleans.

*fig. 22: Rescue Boat, Post-Katrina New Orleans, 2005*


*fig. 23: US Coast Guard Rescue Boat, Post-Katrina New Orleans, 2005*

# new orleans post-katrina exterior images


*fig. 24: Exterior Photo Montage of Post Katrina, New Orleans*

# new orleans post-katrina interior images

*fig. 25: Interior Photo Montage of Post Katrina, New Orleans*

*fig. 26: The Superdome, Post-Katrina*

*fig. 27: People Waiting Outside the Superdome*

*fig. 28: Inside the Superdome, Post-Katrina*

*fig. 29: Vacant FEMA Trailers, Post-Katrina*

INSUFFICIENT TEMPORARY SHELTER

As a part of the New Orleans' disaster plan, the Louisiana Superdome and the Ernest N. Morial Convention Center were the primary designated shelters for residents in New Orleans who were unable to evacuate from Hurricane Katrina. Ezra Boyd, Brian Wolshon, and Ivor Van Heerden have provided post-Katrina population estimates for these designated emergency shelters: the Superdome had a population of 35,000 and the Convention Center, 19,000 (fig. 26-28).[40] The overcrowded conditions and lack of utilities and basic amenities exacerbated the situation greatly. Plans to provide alternate short-term shelter were equally botched. According to a report by the President's Council on Integrity and Efficiency:

> FEMA purchased 24,967 manufactured homes at a cost of $862.7 million and 1,755 modular homes at a cost of $52.4 million in response to the need for transitional housing to assist displaced evacuees from Hurricanes Katrina and Rita. . . . Most importantly, FEMA had no plans for how the homes would be used before they were purchased. Subsequently, there are currently 17,055 mobile homes and 5,707 travel trailers staged at eight emergency housing sites waiting to be used [fig. 29].[41]

This poor planning and misallocation of resources had significant ramifications for residents of New Orleans. Trailers, and other shelter devices such as tarps, were distributed in strict adherence to overly bureaucratic guidelines and in a manner that was inconsistent with the need. According to Rebekah Green, Lisa K. Bates, and Andrew Smyth, "as of October 2006, only 1.6% of flooded units in the Lower Ninth Ward had received FEMA trailers, far below the 6.3% citywide average."[42] In addition to trailers, FEMA provided heavy-duty blue plastic tarps to protect residential and commercial pitched roofs after Hurricane Katrina.[43] According to FEMA, to qualify for a tarp "the home must have at least 50% of the structural roof remaining (rafters and decking), and it must be an asphalt-shingled pitched roof."[44] This strict requirement about the type of material and pitch of roof disqualified homes that could have continued to function as temporary shelter. Additionally, homes with roofs that were more than 50% damaged, and in greatest need of protection, were disqualified from this minimal service by virtue of being essentially overly destroyed.

LACK OF UTILITIES

As of May 2006, electricity and gas were restored to all neighbourhoods in New Orleans except the Lower Ninth Ward. These utilities were only partially restored in this neighbourhood and the schedule for full restoration had not been determined. The slow return of utilities prolonged the recovery of the Lower Ninth Ward after Hurricane Katrina. In fact, without utilities, residents could not access the FEMA trailer program nor were they permitted to return to their homes. According to the New Orleans Mayor's Office, in a press release issued in June of 2006, "more than one year after Katrina, many Lower Ninth Ward residents still lacked the municipal services necessary for trailer placement. . . . Without these basic utilities [electricity, sewage, and water], homeowners in the Lower Ninth Ward were unable to place FEMA trailers on their properties or reoccupy their homes."[45] Figure 30 is a table of services by Entergy, one of the primary providers for electricity and gas in New Orleans.[46] This table shows that utilities in many parts of the Lower Ninth Ward had not been fully restored for almost a year after the storm. This greatly compromised the recovery of this neighbourhood and inhibited residents from rehabilitating their homes, resulting in further property damage that could have been prevented.

**Hurricane Katrina**
**Entergy Restoration Assessment Summary**
***May 10, 2006***

| Zip Code | Electric | | | Gas | | | Change Since last report | |
|---|---|---|---|---|---|---|---|---|
| | % Power Available | Status | ETA for Green | % Gas Available | Status | ETA for Green | Electric | Gas |
| 70114 | 100 | Green | on | 100 | Green | on | | |
| 70131 | 100 | Green | on | 100 | Green | on | | |
| 70115 | 98 | Green | on | 100 | Green | on | | |
| 70118 | 98 | Green | on | 98 | Green | on | | |
| 70116 | 98 | Green | on | 100 | Green | on | | |
| 70112 | 100 | Green | on | 100 | Green | on | | |
| 70113 | 100 | Green | on | 100 | Green | on | | |
| 70130 | 99 | Green | on | 100 | Green | on | | |
| 70125 | 95 | Green | on | 100 | Green | on | | |
| 70119 | 98 | Green | on | 100 | Green | on | | |
| 70124 | 96 | Green | on | 100 | Green | on | | +9% |
| 70122 | 97 | Green | on | 100 | Green | on | | |
| 70126 | 95 | Green | on | 100 | Green | on | | |
| 70127 | 95 | Green | on | 100 | Green | on | | |
| 70128 | 96 | Green | on | 100 | Green | on | | |
| 70129 | 92 | Green | on | 81 | Green | on | | |
| 70117 (Upper) | 95 | Green | on | 100 | Green | on | | +6% |
| 70117 (Lower) | 82 | Green | tbd | 50 | Amber | tbd | +2% | +50% |
| Total | 96% | Green | | 97% | Green | | | +2% |

**Status Criteria**
Green: 75% - 100% Functional
Amber: 25% - 74%
Red: 0% - 24%

***Indicates repopulated zip codes.***
***Indicates partially repopulated zip codes.***

**Updated:** 5/10/2006
**70129: Completed work on Feeder backbone in Lake Catherine area. Restoring laterals and transformers upon customer request**
**70124: (Lake View): Most work completed in Lakeview area near breach except for 2 block area adjacent to breach.**
**70117 (Lower): Restored gas service to area bounded by Claiborne to River, Industrial Canal to Parish Line also restored electric service to entire area except for several blocks nearest breach.**

**Devastated areas WITHOUT ETAs include sections:**
70117: (Lower 9th Ward): Electric Service - Several block area nearest breach.
70117: (Lower 9th Ward): Gas Service - Claiborne to Florida, Industrial Canal to Parish Line

*fig. 30: Hurricane Katrina Entergy Restoration Assessment Summary*

*fig. 31: Homes Inspected by National Guard*

VESTIGES OF KATRINA

The eerie markings depicted in figures 31, 32, and 33 were made by the National Guard and special military units from Louisiana and other states while inspecting homes for survivors. The crews spray painted each house, leaving a permanent record to communicate their findings. They painted an "X" on the front of each home: the upper quadrant indicated the date; the left quadrant recorded the agency ("FL-1" for the first Florida team), or simply the searcher's initials; the right quadrant was used for houses that were not entered ("NE" for No Entry) or other comments about the conditions found; and in the lower quadrant, the number of dead bodies found inside.[47]

DEATH TOLL

In spite of search and rescue efforts, the precise death toll from Hurricane Katrina is still not known. Jed Horne, in his book *Breach of Faith: Hurricane Katrina and the Near Death of a Great American City*, comments on the accepted death toll in May 2006:

> It would never be known exactly how many people died. The best estimate placed the toll at about 1,100, with another 231 lost in Mississippi. Nor was it clear what proportion of the casualties died immediately, leaving the rest to a lingering demise — by drowning, from exposure, from medical conditions that worsened lethally as men, women, and children attempted to wade or swim to dry ground, perched on rooftops awaiting help that never came, or succumbed to infernal temperatures and dehydration in attics where the floods had chased them.[48]

According to Allison Plyer, Chief Demographer at the Greater New Orleans Community Data Center (GNOCDC), as of April 15, 2010, "Hurricane Katrina and the levee failures resulted in the deaths of at least 1,464 Louisiana residents. The major causes of death include: drowning (40%), injury and trauma (25%), and heart conditions (11%). Nearly half of all victims were over the age of 74."[49] Ezra Boyd, PhD candidate at the Louisiana State University (LSU) Department of Geography and Graduate Research Assistant at the LSU Hurricane Public Health Center, confirms approximately 1,500 Louisiana residents died due to Hurricane Katrina and levee failures.[50]


*fig. 32: Diagram of markings made by National Guard*


*fig. 33: Markings made by National Guard on Homes*

# 02
# iv
# challenges: infrastructure

## HURRICANE PROTECTION SYSTEM

The failure of New Orleans' hurricane protection system caused the majority of damage during and after Hurricane Katrina. The American Society of Civil Engineers (ASCE) report explains the New Orleans hurricane protection system: "The USACE is responsible for the design and construction of most of the flood and hurricane protection levees along the Mississippi River and in the New Orleans area. . . . The USACE Hurricane Protection Projects in the New Orleans area are generally grouped into three main units: i) Lake Pontchartrain and Vicinity, ii) West Bank and Vicinity; and iii) New Orleans to Venice."[51]

The USACE designed and built three types of structures in the New Orleans hurricane protection system: the I-Wall, T-Wall and earthen levee (fig. 34, 35). The earthen levee comprises the majority of the USACE hurricane protection system.[52]

The ASCE report explains:

> When an earthen levee is raised with additional earth fill, it can typically only be heightened by increasing the width at the base. In most urban areas of New Orleans, the land has been developed right up to the base of the levee. To raise and widen the levee would require private property to be purchased and buildings to be removed. . . . Where an existing levee was located adjacent to buildings, canals or other structures, the USACE often resorted to using I-walls to avoid impacting adjacent development.[53]

To adequately protect New Orleans from flooding, earthen levees need to be raised to accommodate changes in flood protection criteria, based on updates in meteorological data.[54] However, due to their close proximity to adjacent buildings, there is often insufficient space for lateral expansion. An additional layer of flood protection is required to accommodate floodwaters in the event earthen levees overtop, as observed during Hurricane Katrina. Figure 36 illustrates how earthen levees can be heightened.

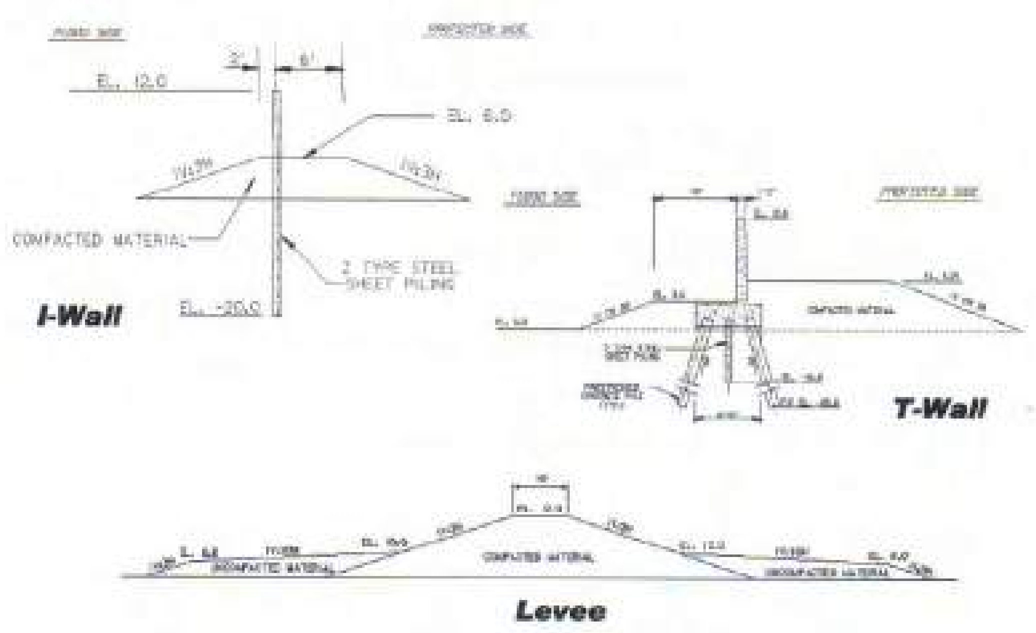



*fig. 34: Typical USACE Flood Protection Structures*

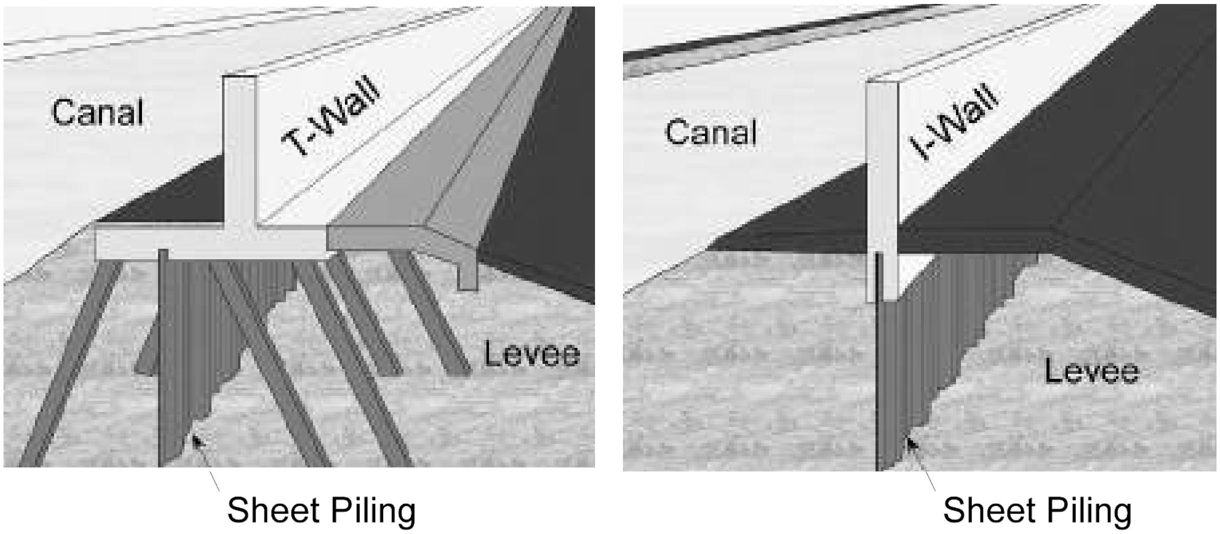



*fig. 35: T-Wall and I-Wall, Three-Dimensional Sections*

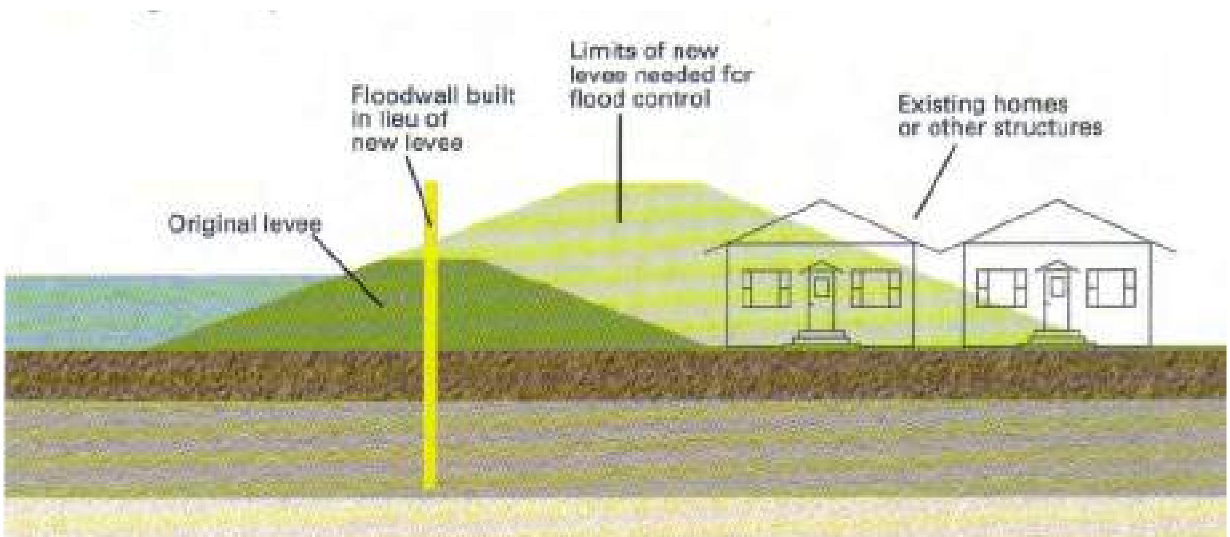



*fig. 36: Increasing the Top Elevation of an Earthen Levee*

ARTIFICIAL LEVEE FAILURE

Katrina's damage to New Orleans was mainly a consequence of artificial levee failure. Failures at approximately fifty locations in the city's hurricane protection system resulted in the massive, destructive flooding of New Orleans (fig. 37, 38).[55] According to the ASCE report:

> Levees and floodwalls were built around the city and adjacent parishes to protect against flooding. During and after Hurricane Katrina many of those levees and floodwalls were overtopped and several were breached allowing billions of gallons of water from the Gulf of Mexico, Lake Borgne, and Lake Pontchartrain to flow into New Orleans and flood major portions of the city. . . . There were two direct causes of the levee breaches: collapse of several levees with concrete floodwalls (called-I walls) because of the way they were designed, and overtopping, where water poured over the tops of the levees and floodwalls and eroded the structures away. . . . Furthermore, the many existing pump stations that could have helped remove floodwaters were inoperable during and after the storm.[56]

Risk had been increased by the practices of the USACE where the hurricane protection system was poorly designed and constructed. It was also under-maintained because of insufficient government funding. Government funding was allocated but never appropriated to make the necessary improvements to the hurricane protection system.[57]

The ASCE report states: "The Lake Pontchartrain, Louisiana and Vicinity Hurricane Protection Project was intended to protect St. Bernard, Orleans, Jefferson and St. Charles parishes between Mississippi River and Lake Pontchartrain. The project generally included earthen levees with floodwalls along Lake Pontchartrain, the 17th Street Canal, the Orleans Canal, the London Avenue Canal and the Industrial Canal."[58] The ASCE report further states: "The Lake Pontchartrain and Vicinity Hurricane Protection Project system experienced the worst damage during and after Hurricane Katrina and resulted in the most serious consequences to the city and people of New Orleans. Of the 284 miles of federal levees and floodwalls — there are approximately 350 miles in total — 169 miles were damaged. Levees in USACE's New Orleans to Venice Hurricane Protection Project sustained significant damage caused by powerful floodwaters overtopping and breaching the levees. The levees in the USACE's West Bank and Vicinity Hurricane Protection Project experienced the least amount of damage."[59]

Anuradha Mathur and Dilip da Cunha surmised "the tragedy that struck New Orleans in the wake of Katrina was only immediately caused by a failure to keep Lake Pontchartrain out of the city; its deeper cause lies in a success at keeping the Mississippi within levees. It is a success that has come at the cost of a natural land-building process that the Mississippi once conducted through the agency of its meanders and overflows."[60]

Figure 39 depicts a breached levee in the 17th Street Canal wall in New Orleans, Louisiana. NOAA's National Geodetic Survey (NGS) explains:

> A part of the West End neighbourhood of New Orleans is to the right on the east side of the canal, severely flooded; to the left, west of the canal, is part of Metairie, Louisiana, not flooded…Metal girders and/or plates were later hung along the north side of the Hammond Highway bridge ([see fig. 39] gray bridge at top, with debris in canal on the north/Lake Pontchartrain side) to block the entrance to the canal. The breach in the canal berm and canal wall (lower right) were closed with helicopter-dropped sandbags and trucks dumping fill southward from Hammond Highway. . . . The breach was closed [at the 17th Street Canal wall] Monday, September 5, 2005. An opening was then made in the metal wall to allow city drainage through the canal.[61]

Although failure at the 17th Street Canal caused significant flooding in New Orleans, levee failure at the Industrial Canal was responsible for the much of the flooding in the Lower Ninth Ward neighbourhood. According to the ASCE report, "the failure of the Industrial Canal East Bank north I-wall was likely the source of the earliest flooding (observed at 5:00 am) in the Lower Ninth Ward."[62] Figure 40 is a photo taken at the Industrial Canal, where the levee overtopped and also breached.


*fig. 37: Areas of Levee Failure, Plan View*

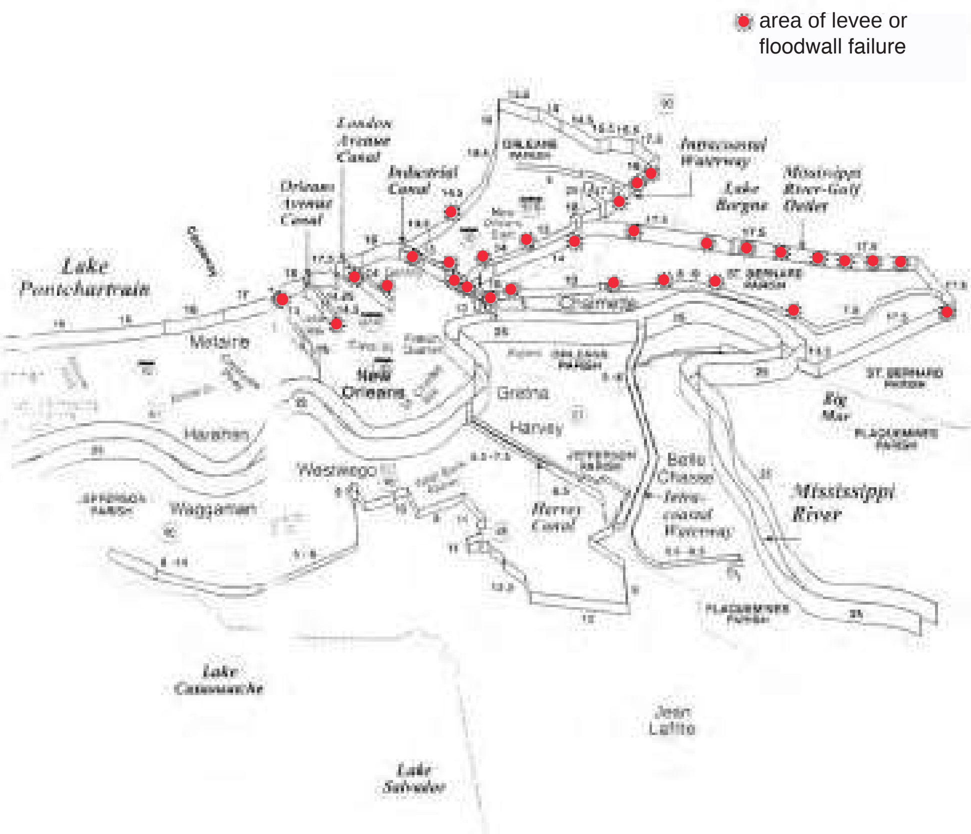



*fig. 38: Areas of Levee Failure, Three-Dimensional View*

*fig. 39: NOLA 17th Street Breach, August 31, 2005.*

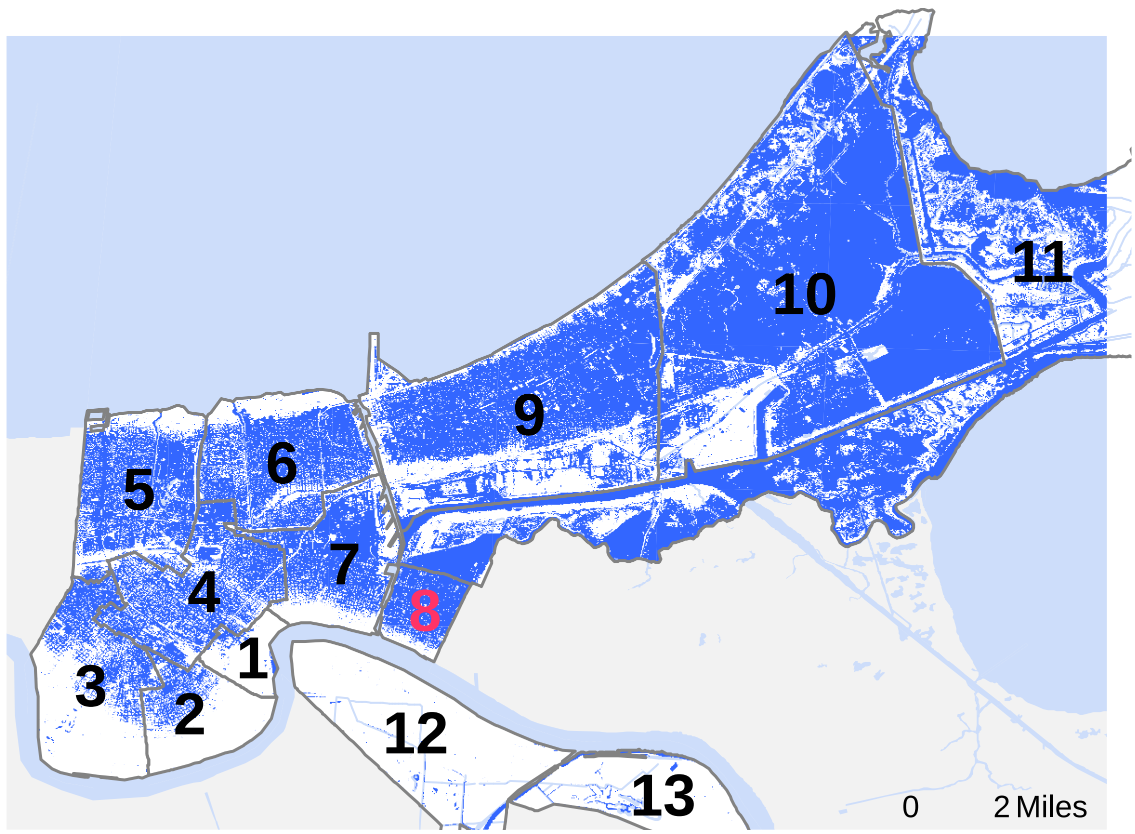

*fig. 40: Levee Overtopping at the Industrial Canal*

## FLOOD DEPTH AND DURATION

As mentioned earlier, New Orleans suffered severe flooding due to multiple levee failures during and after the passage of Hurricane Katrina. Figure 41 illustrates the extent of flooding by district on August 31, 2005, two days after the storm. Figures 42 and 43 are two aerial photographs of New Orleans flooded after Hurricane Katrina. Figure 44 is a diagram comparing New Orleans before the storm and after the storm, outlining the boundary of the highest flood levels. Figure 45 is a photo taken in New Orleans on September 8, 2005, ten days after the storm. According to the ASCE report, "by September 1, 2005, portions of Lakeview, Gentilly, New Orleans East and the Lower Ninth Ward were submerged in more than 10 feet of water (orange and red colored areas). Significant portions of the city stood in water more than 6 feet deep (green and aqua-colored areas) [fig. 46]."[63]

This information is further illustrated in figure 47, where a significant portion of the Lower Ninth Ward stood in more than four feet of water. Figure 48 provides greater detail, displaying the number of days each block remained flooded after Hurricane Katrina. In the Lower Ninth Ward, the area shaded in red remained wet for 23-29 days after the storm, which devastated property. Conversely, the area shaded in light green of the Lower Ninth Ward (the area of focus for the BFP) remained wet for 7-11 days, which resulted in significantly less damage and a greater percentage of salvageable properties.[64]

# Extent of Flooding from Katrina Levee Failures




**1** Central Business District, French Quarter
**2** Central City, East Riverside, Garden District, Irish Channel, Lower Garden District, Milan, St. Thomas, Touro
**3** Audubon, Black Pearl, Broadmoor, Dixon, East Carrollton, Fontainebleau, Freret, Hollygrove, Leonidas, Uptown, West Riverside
**4** Bayou St. John, BW Cooper, Fairgrounds, Gert Town, Iberville, Mid-City, St. Bernard Area, Seventh Ward, Treme/Lafitte Tulane/Gravier
**5** City Park, Lakeshore/Lake Vista, Lakeview, Lakewood, Navarre, West End
**6** Dillard, Filmore, Gentilly Terrace, Gentilly Woods, Lake Terrace & Lake Oaks, Milneburg, Pontchartrain Park, St. Anthony Gentilly, UNO
**7** Bywater, Desire Area, Desire Development, Florida Area, Florida Development, Marigny, St. Claude, St. Roch
**8** Holy Cross, Lower 9th Ward
**9** Little Woods, Pines Village, Plum Orchard, Read Boulevard East, Read Boulevard West, West Lake Forest
**10** Village de L'Est
**11** Lake Catherine, Viavant/Venetian Isles
**12** Algiers Point, Behrman, Fischer, McDonogh, Old Aurora, US Naval Support Area, Tall Timbers/ Brechtel, Whitney
**13** English Turn

*fig. 41: Extent of Flooding from Katrina Levee Failures by District*

*fig. 42: Post Katrina Aerial Photograph, New Orleans, Louisiana, 2005*

*fig. 43: Post Katrina Aerial Photograph, New Orleans, Louisiana, 2005*

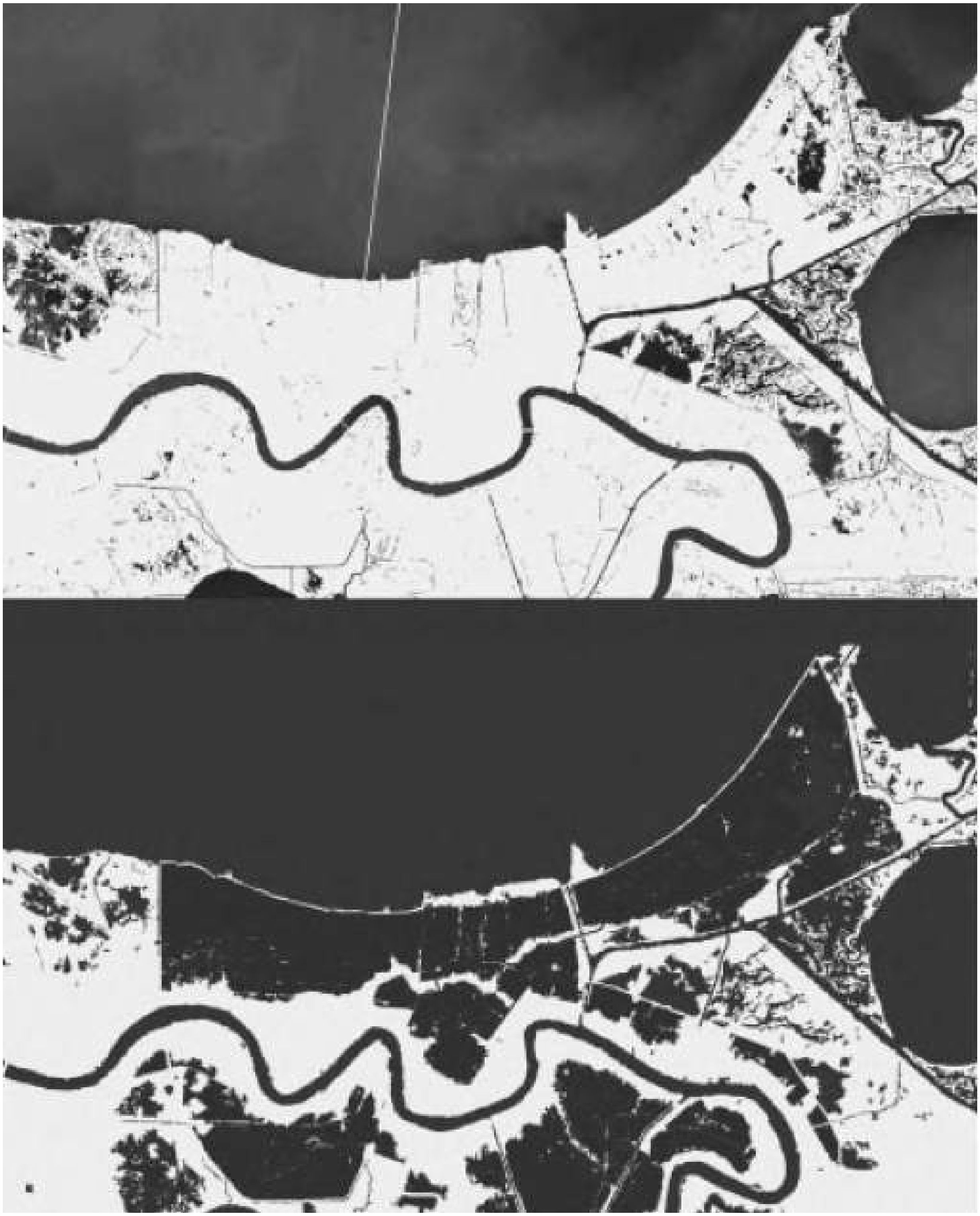


*fig. 44: Diagram Showing the Extent of Flooding After Hurricane Katrina*

*fig. 45: New Orleans House Flooded in the Aftermath of Katrina*

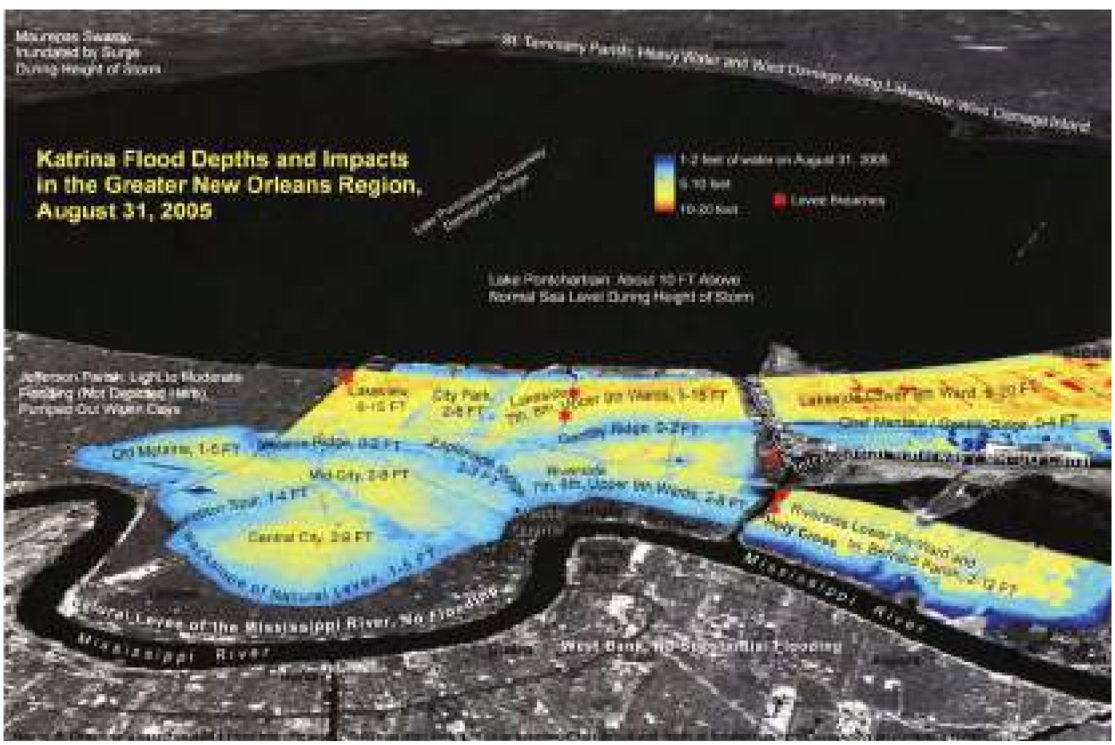
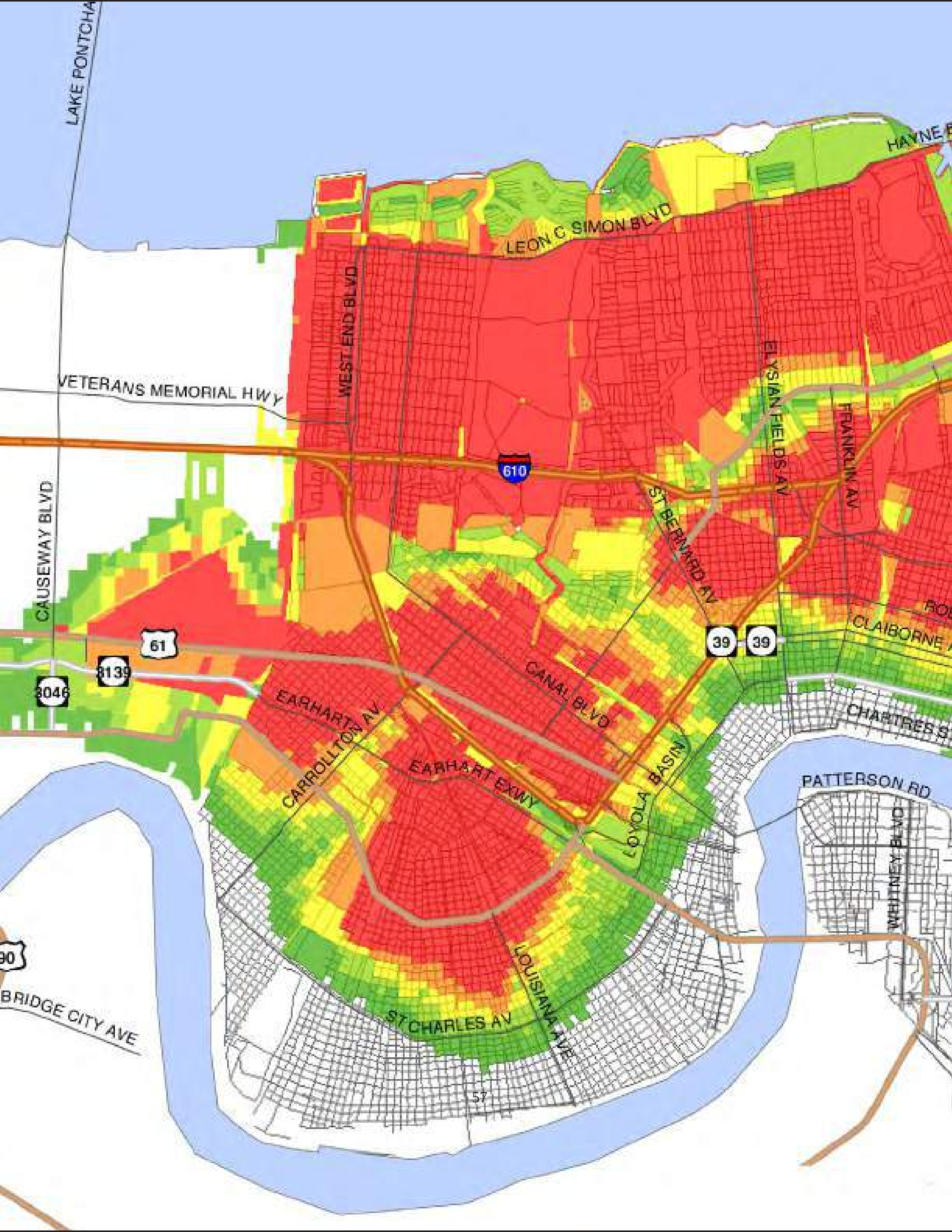



*fig. 46: Katrina Flood Depths and Impacts in the Greater New Orleans Region*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HAYNE
LEON C SIMON BLVD
WEST END BLVD
VETERANS MEMORIAL HWY
ELYSIAN FIELDS AV
FRANKLIN AV
610
CAUSEWAY BLVD
ST BERNARD AV
ROI
CLAIBORNE A
39
39
61
3139
3046
CANAL BLVD
EARHART
CARROLLTON AV
CHARTRES S
EARHART EXWY
LOYOLA
BASIN
PATTERSON RD
WHITNEY BLVD
90
BRIDGE CITY AVE
ST CHARLES AV
LOUISIANA AVE

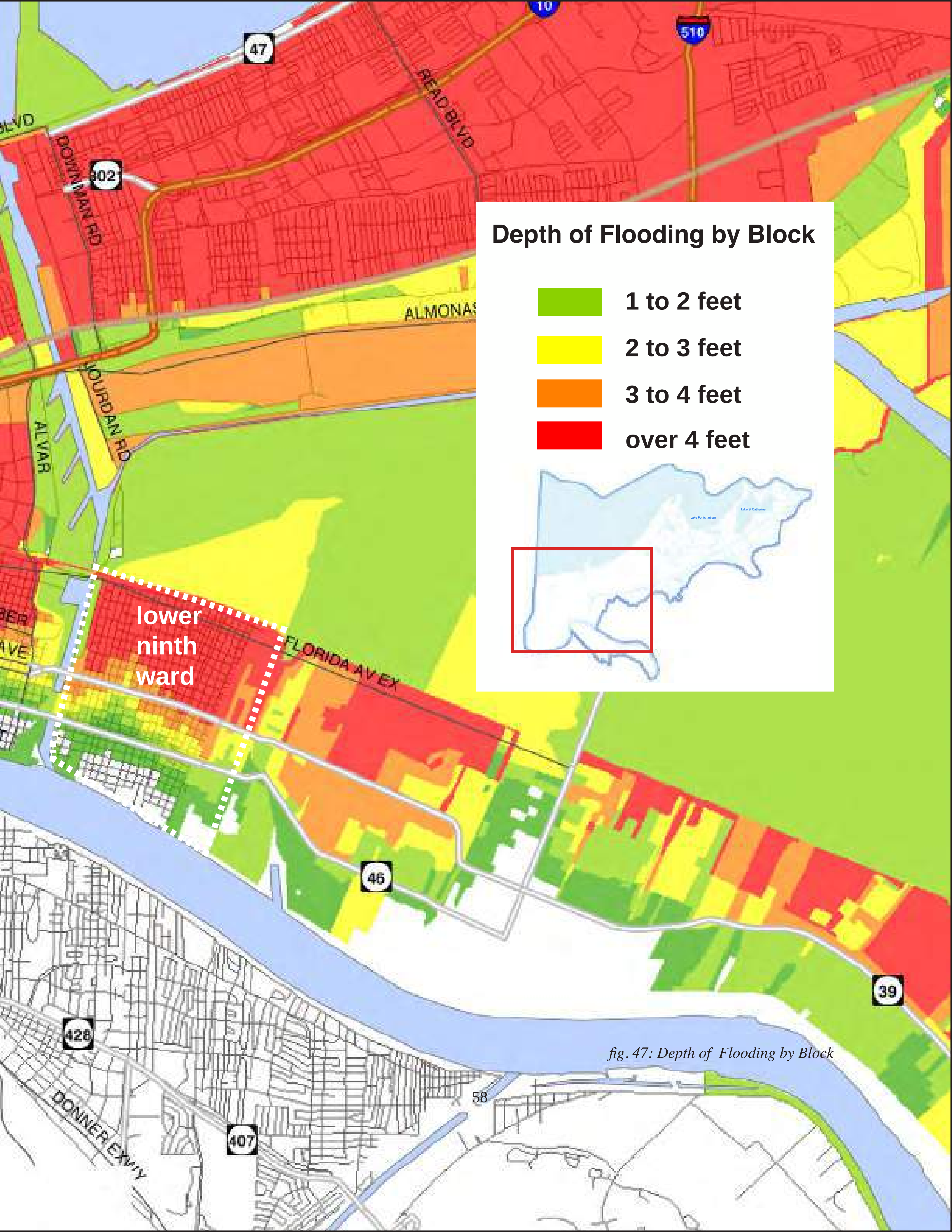
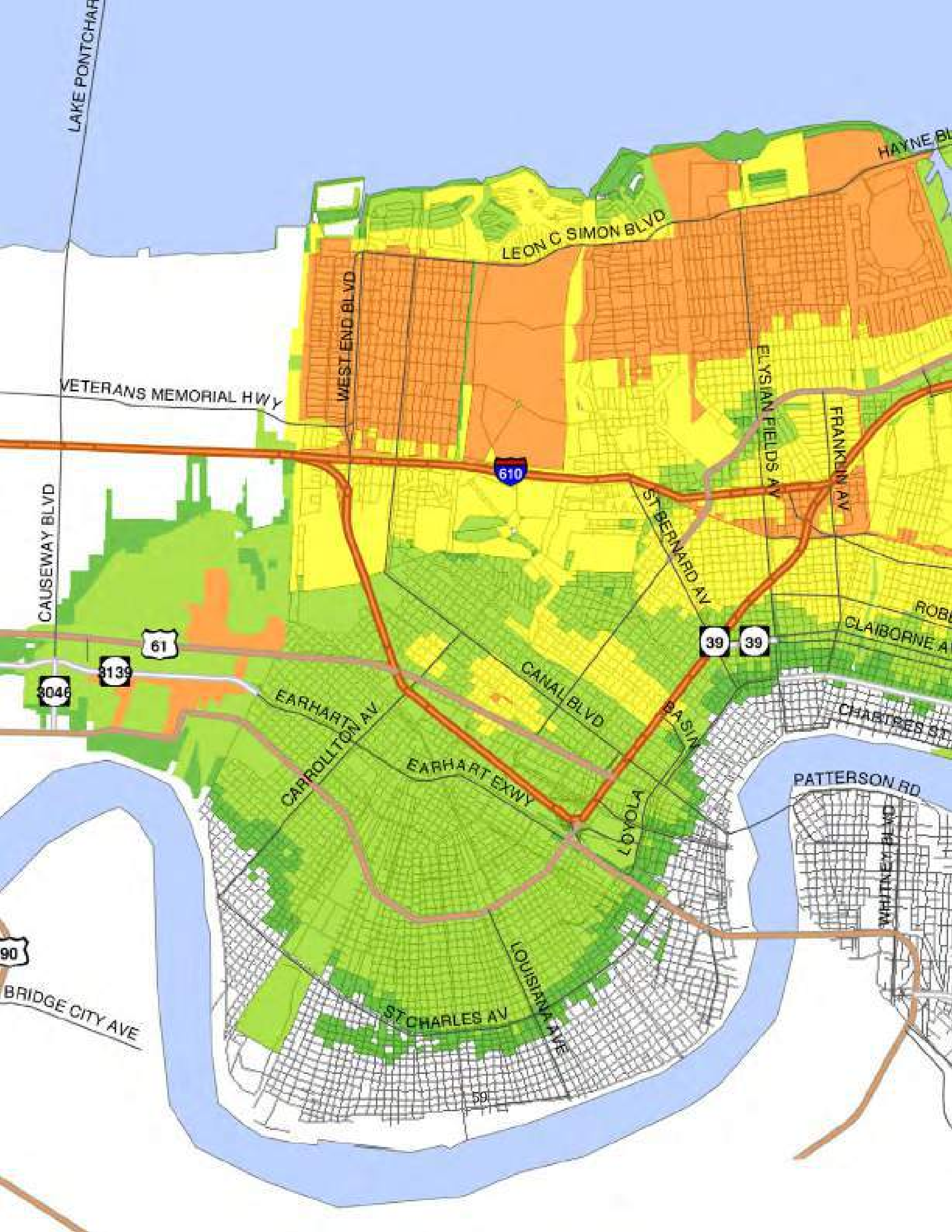



*fig. 47: Depth of Flooding by Block*



LAKE PONTCHAR
HAYNE BL
LEON C SIMON BLVD
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VETERANS MEMORIAL HWY
610
ELYSIAN FIELDS AV
FRANKLIN AV
ST BERNARD AV
CAUSEWAY BLVD
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3139
3046
ROBE
CLAIBORNE A
39
39
CANAL BLVD
EARHART
CARROLLTON AV
BASIN
CHARTRES ST
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PATTERSON RD
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WHITNEY BLVD
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BRIDGE CITY AVE
ST CHARLES AV
LOUISIANA AVE

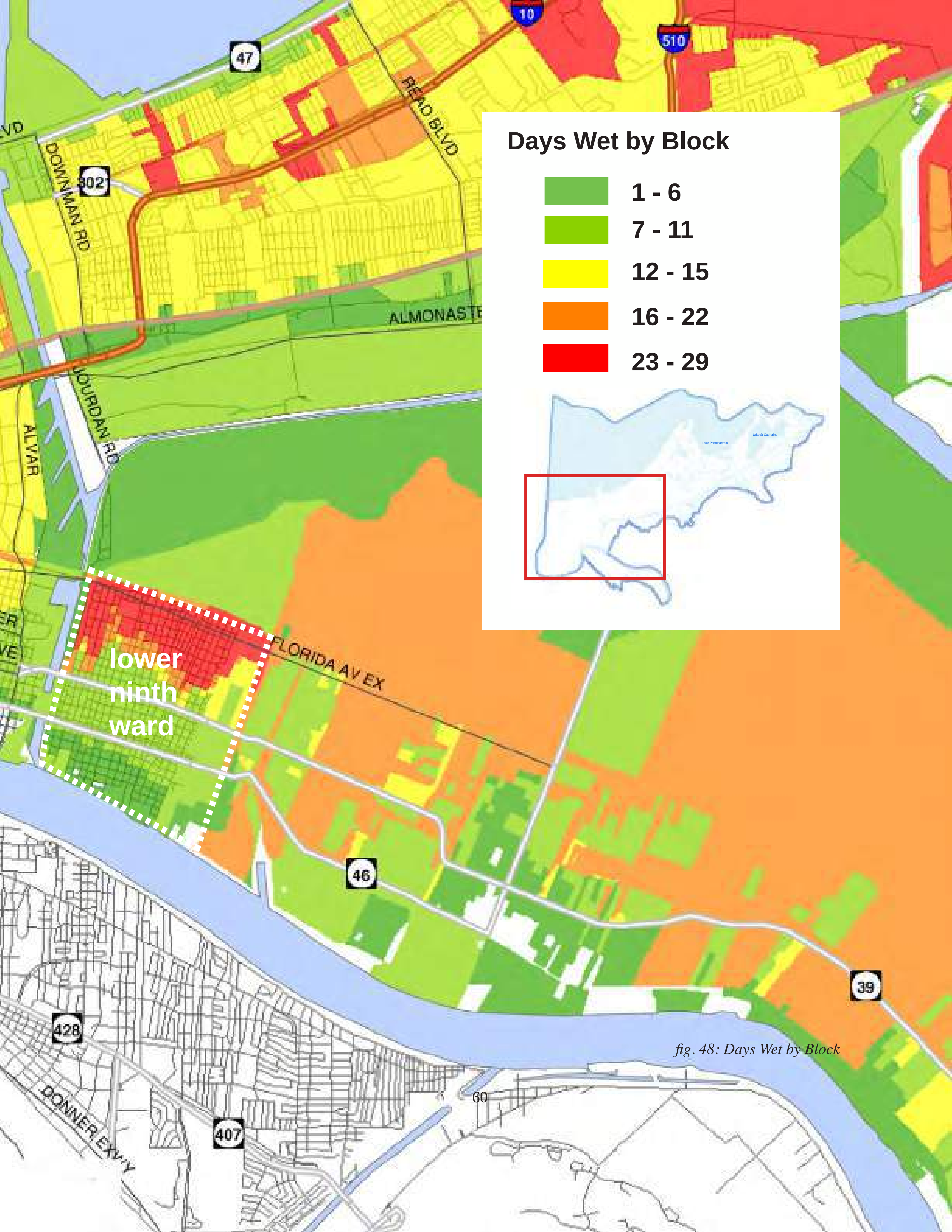


*fig. 48: Days Wet by Block*

# 02 V summary

Chapter two has outlined the significant challenges contributing to the need for an alternative flood-mitigation strategy in New Orleans. Infrastructure alone cannot protect the city from future flooding.

The major ecological challenges such as the deterioration of natural resilience caused by the implementation of the artificial levee system, subsidence, rising sea levels, and land loss suggest that future flooding cannot be avoided. This chapter has also explored ways in which human interventions, before and after Katrina, have been unsuccessful. Man-made containment of the Mississippi River has disturbed New Orleans' ecosystem and natural defense. Prior to the implementation of artificial levees, annual floods brought sediments that fortified land and created natural barriers. Artificial levees have inhibited this natural process; land has been robbed of its sediment and is sinking. When combined with all other ecological factors, Louisiana's coastline is particularly vulnerable and sinking at a much faster rate than other parts of the gulf coast.

The tragic event of Hurricane Katrina, and the major infrastructural failure and inundation that resulted, revealed how conventional flood-mitigation strategies, in the form of static barriers and pumping systems, are not sufficient to protect New Orleans from future flooding. An alternative system is required to adequately protect New Orleans from future flooding.

The next chapter will discuss physical and cultural aspects of the Lower Ninth Ward to demonstrate why it is an ideal site for the implementation of the Buoyant Foundation Project.

02

vi

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# 03

# the buoyant foundation project: context

context:

# 03

# i

# context

The previous chapter outlined the major ecological challenges affecting New Orleans: the deterioration of natural resilience, subsidence, rising sea levels, and land loss. The chapter also explored ways in which human interventions, before and after Katrina, were unsuccessful: the design of levees, disaster management, emergency shelter strategies, rescue efforts, and rebuilding. Chapter three will focus on how the Buoyant Foundation Project (BFP) provides a culturally sensitive flood mitigation strategy for the Lower Ninth Ward in post-Katrina New Orleans.

This chapter builds upon one of the most critical challenges: the diaspora, its cultural implications, and resettlement. In the aftermath of Hurricane Katrina, New Orleans' residents have been displaced to other parts of Louisiana and the United States, leaving many neighbourhoods under populated and some abandoned. Their slow return has compromised the unique culture and identity of New Orleans.

This chapter then explores the Lower Ninth Ward and its former sense of "place" — examining physical and cultural aspects of the neighbourhood, and discussing the pre-Katrina conditions that contributed to New Orleans' culture. Of particular importance is the shotgun house and its influence on the tight-knit communities created by the spatial arrangement of this housing typology. The BFP serves as a catalyst for the restoration of this housing type, as it provides a retrofit for the foundation, enabling the house to float when there is a flood. A brief history of shotgun housing is provided, discussing the origins and characteristics of the shotgun house, and the four common variations are explained. The variations are then linked to particular parishes in south Louisiana and Henry Glassie suggests a theory about the design process.

Chapter three connects the ongoing ecological and infrastructural risks (discussed in chapter two), the diaspora and stalled process of restoring the Lower Ninth Ward, and the distinct history and culture of the area. The evidence makes it clear that the Lower Ninth Ward is an ideal site for implementation of the BFP.

The chapter concludes with a brief discussion of permanent static elevation, and its negative impact on neighbourhood character by distancing homes from street level and impeding the close relationships made possible by congregating on the front porch. The BFP offers a culturally supportive solution by permitting houses to remain close to street level.

# 03

# ii

# context: diaspora

DIASPORA

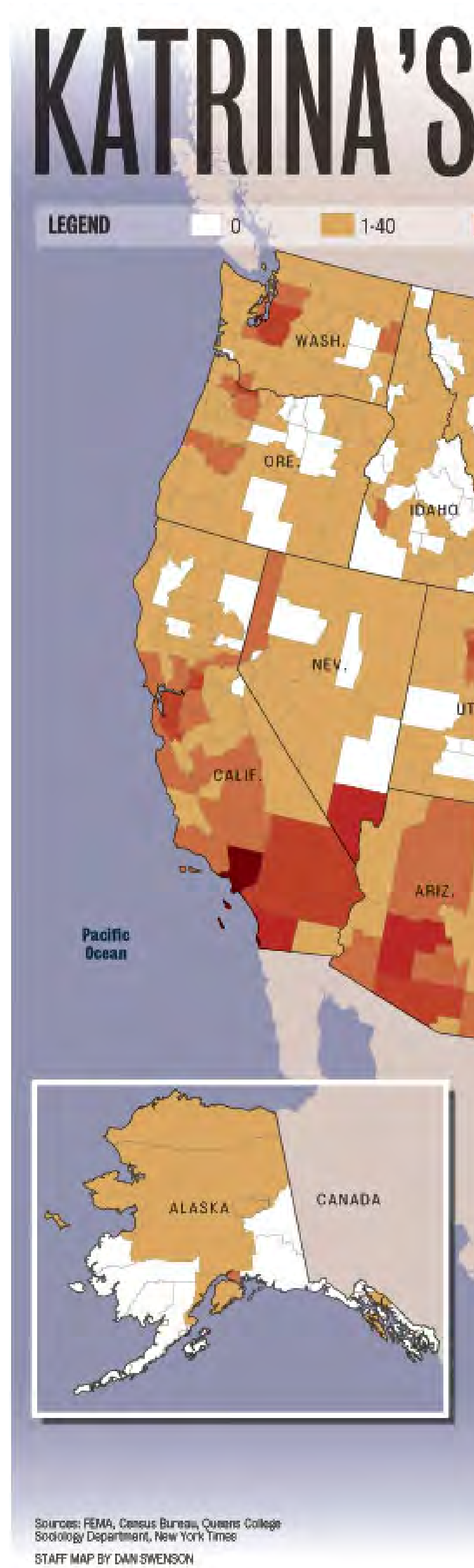
The flooding that accompanied Hurricane Katrina, obliterated neighbourhoods in New Orleans and caused significant damage to housing, rendering numerous dwellings uninhabitable. Residents from New Orleans were scattered all over Louisiana and the United States (fig. 49). According to NOAA, "the flooding of New Orleans, LA following the passage of Katrina was catastrophic, resulting in the displacement of more than 250,000 people, a higher number than during the Dust Bowl years of the 1930s."[65]

SPATIAL REDISTRIBUTION

Figure 50 illustrates the local diaspora in the Louisiana region according to FEMA in 2005. This map illustrates the location of victims by ZIP code at the time they registered with FEMA for Individual Assistance (IA). Both displaced and non-displaced applicants are depicted. Approximately 58 percent of all registered requests for IA originated within Louisiana. Orleans Parish is highlighted and is one of the largest areas for IA applicants, in the range of 8,001-16,000.[66]

POPULATION DENSITY

Figure 51 compares the pre-Katrina (2004), and post-Katrina (2006) populations of Orleans, St. Bernard, Plaquemines and Jefferson parish in Louisiana. According to the ASCE report, "the combined populations of Jefferson, Orleans, St. Bernard and Plaquemines parishes dropped by 44 percent after Hurricane Katrina."[67] Figure 52 is a table showing a comparison of population by parish in 2000 to 2009. Figure 53 shows the specific population density in May 2008. The most devastated parts of the Lower Ninth Ward had a population density of 0-4 persons per acre.[68]



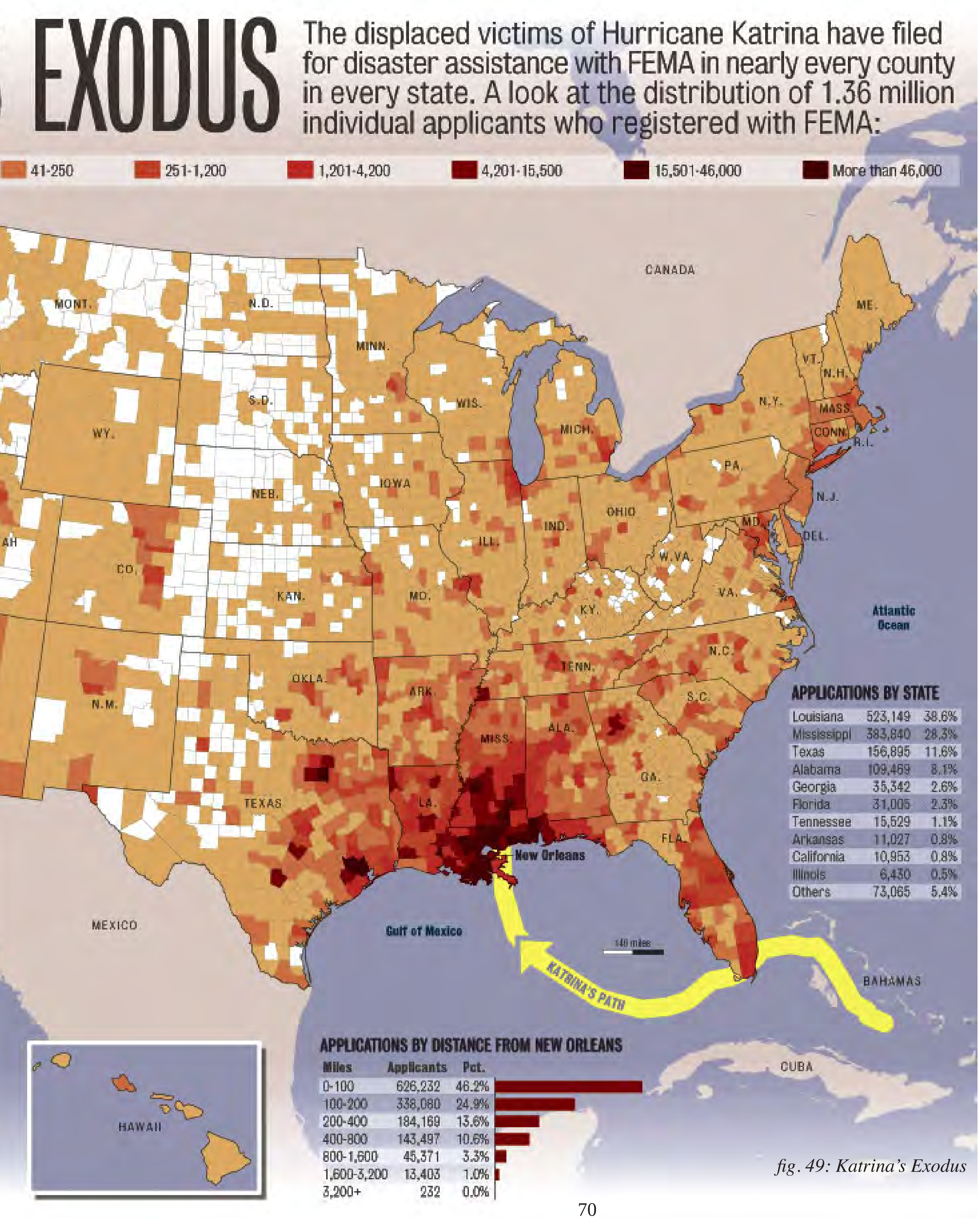



*fig. 49: Katrina's Exodus*

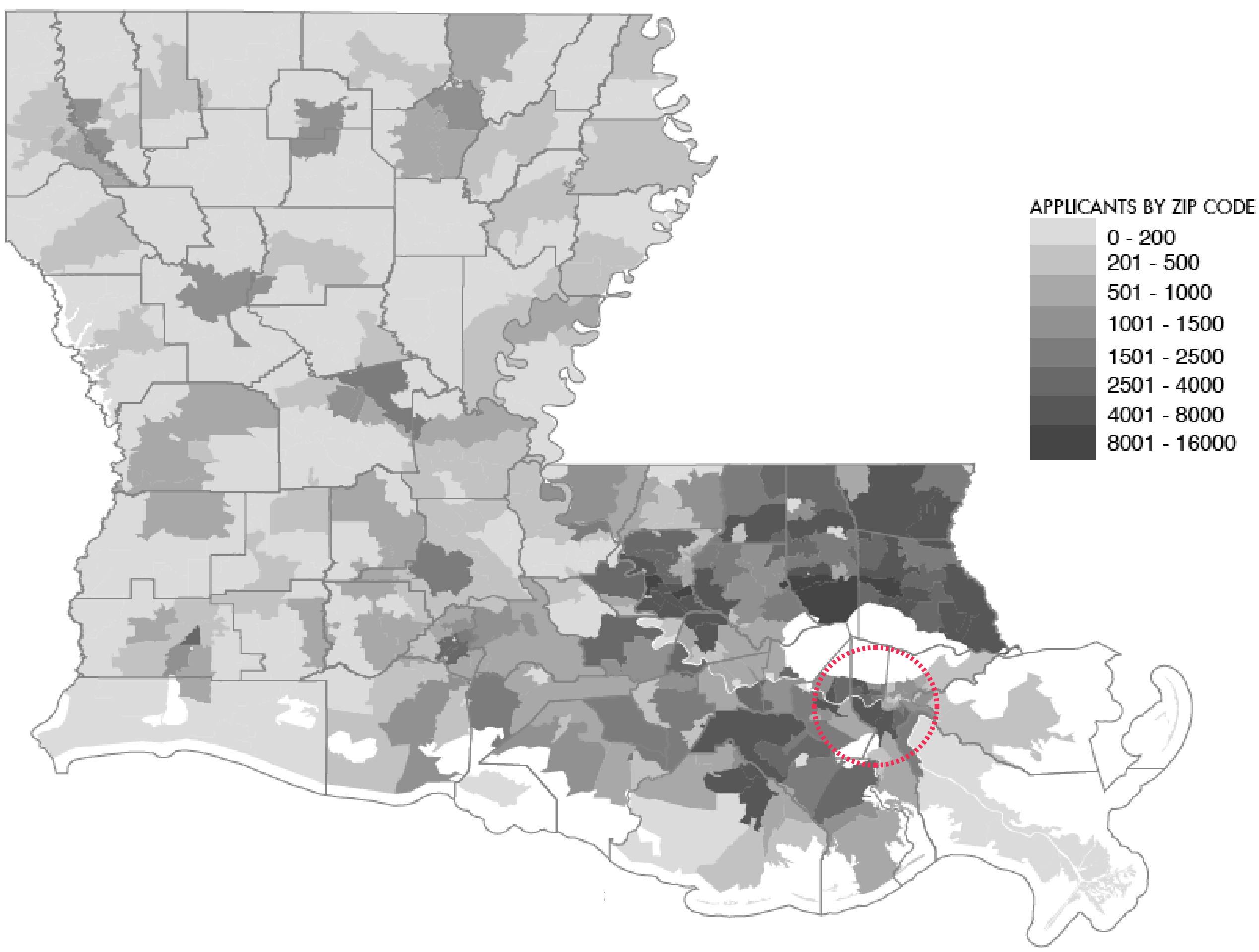
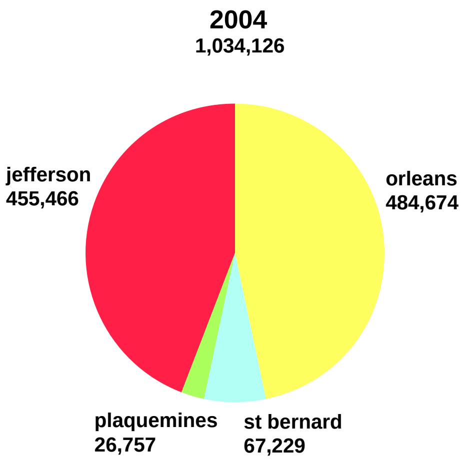



*fig. 50: Population Redistribution in Louisiana, September 20, 2005*

**population**



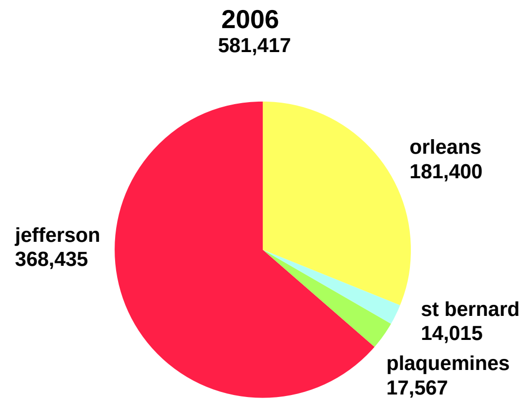
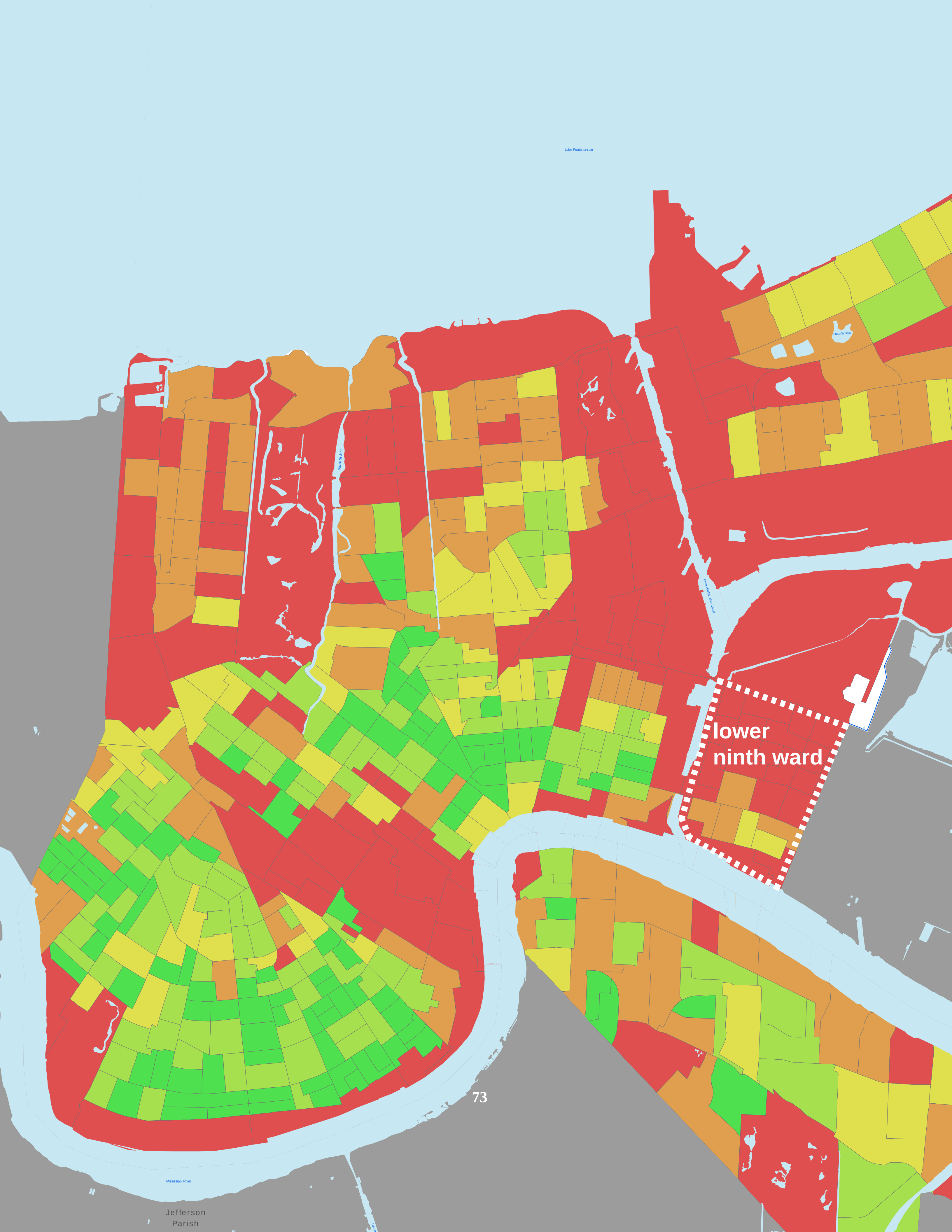




*fig. 51: Population Decline Comparison*

**Total population estimates by parish (2000-2009)**

| Year | Jefferson | Orleans | Plaque-mines | St. Bernard | St. Charles | St. John | St. Tammany |
|---|---|---|---|---|---|---|---|
| Census 2000 | 455,466 | 484,674 | 26,757 | 67,229 | 48,072 | 43,044 | 191,268 |
| July 1, 2001 | 452,088 | 477,932 | 26,852 | 66,554 | 48,412 | 43,575 | 195,718 |
| July 1, 2002 | 451,453 | 472,744 | 27,119 | 66,286 | 48,960 | 43,955 | 200,873 |
| July 1, 2003 | 451,533 | 467,761 | 27,644 | 65,727 | 49,039 | 44,452 | 205,883 |
| July 1, 2004 | 452,678 | 461,915 | 28,602 | 65,427 | 49,524 | 45,046 | 211,529 |
| July 1, 2005 | 451,652 | 455,188 | 28,549 | 64,951 | 50,116 | 45,597 | 217,407 |
| July 1, 2006 | 420,683 | 208,548 | 21,293 | 14,493 | 51,759 | 47,697 | 223,062 |
| July 1, 2007 | 440,339 | 288,113 | 21,353 | 33,439 | 51,946 | 47,910 | 226,315 |
| July 1, 2008 | 444,655 | 336,644 | 21,138 | 37,669 | 51,619 | 47,438 | 229,384 |
| July 1, 2009 | 443,342 | 354,850 | 20,942 | 40,655 | 51,611 | 47,086 | 231,495 |

*fig. 52: Total Population Estimates by Parish 2000-2009*


lower
ninth ward
Jefferson
Parish

# population density map

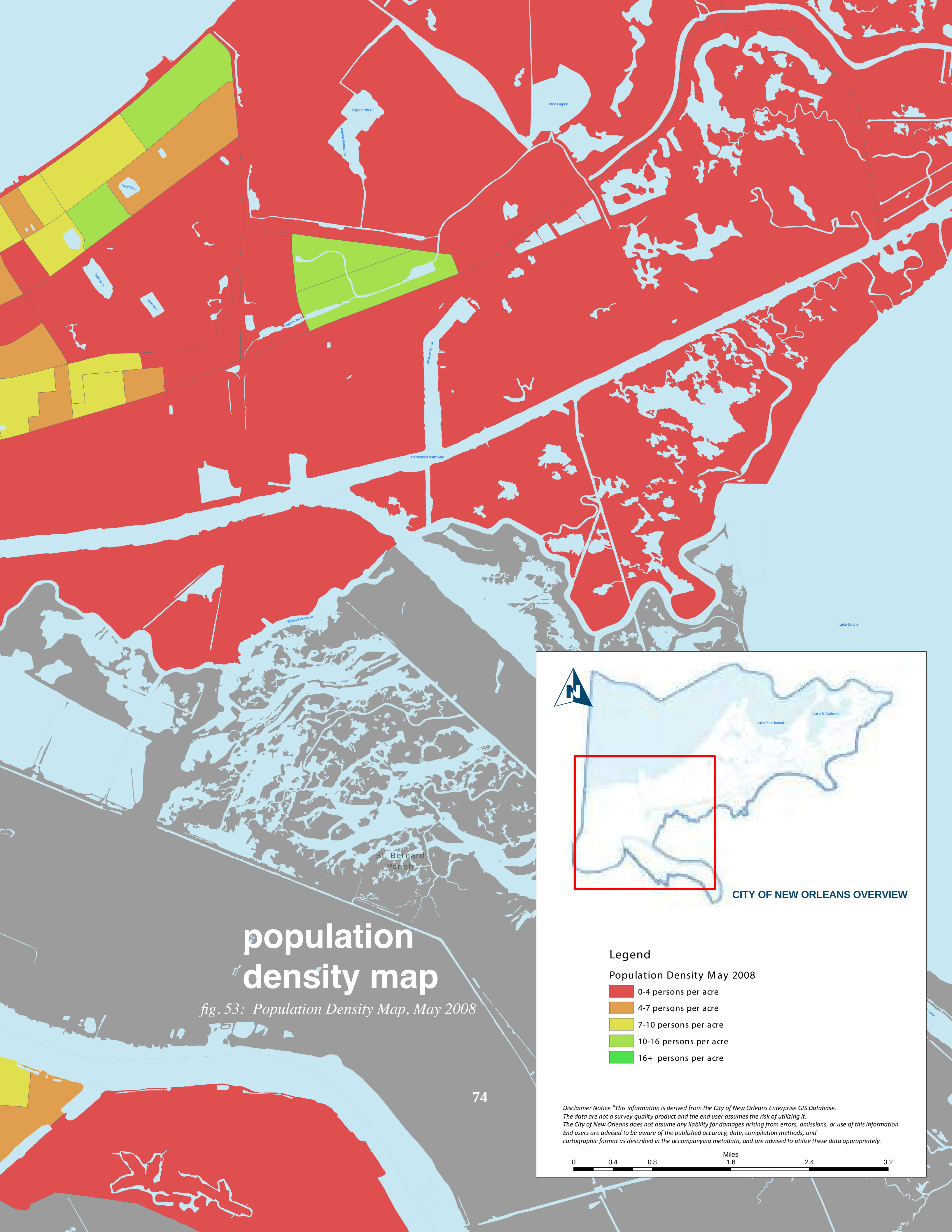



*fig. 53: Population Density Map, May 2008*

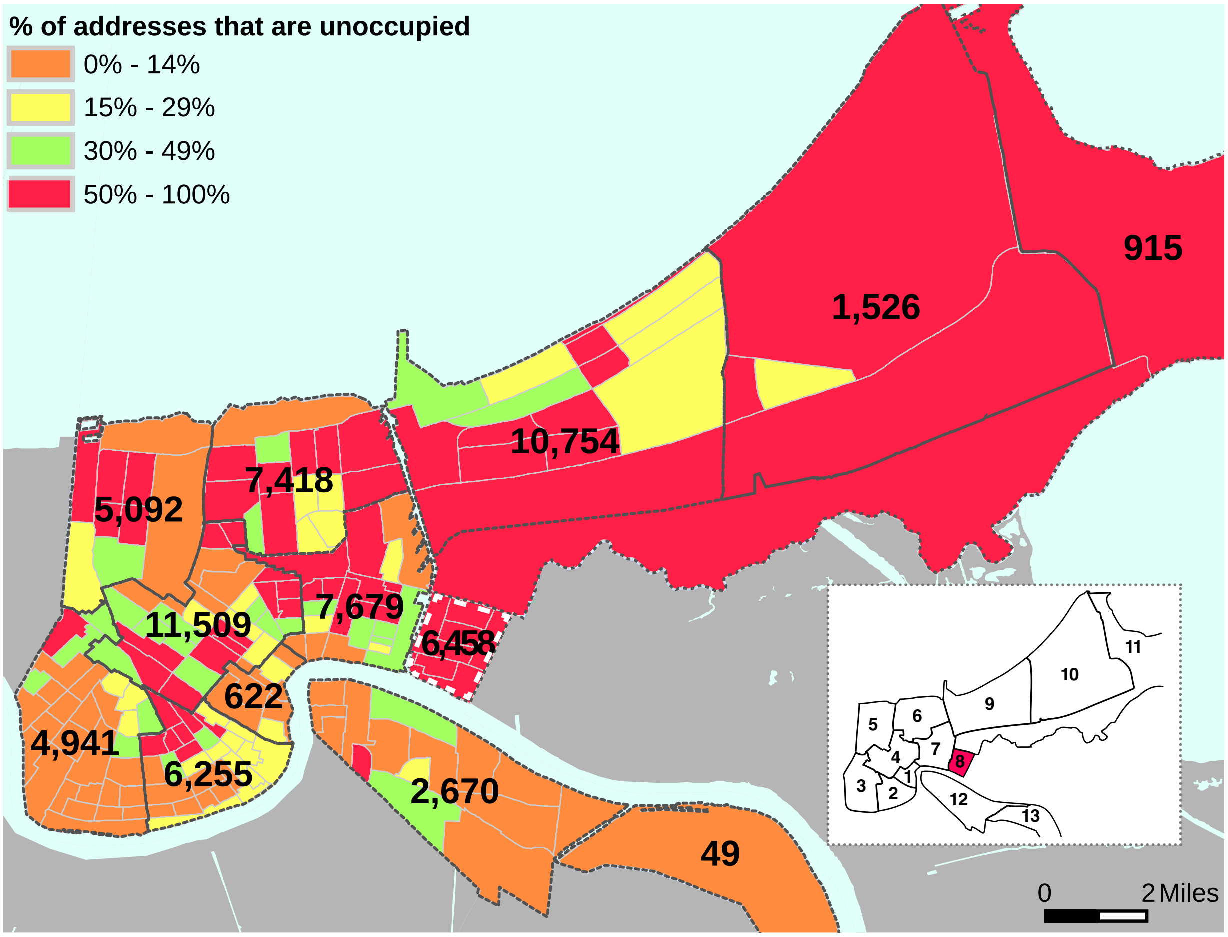



*fig. 54: Number of Unoccupied Residential Addresses by Planning District and Percent by Census Tract, March 2009*

RE-POPULATION

Tens of thousands of residents from New Orleans were scattered all over Louisiana and the United States. Repopulating the area has met with myriad challenges. The Brookings Institution Metropolitan Policy Program and the Greater New Orleans Community Data Center (GNOCDC) discusses the number of unoccupied residential addresses in New Orleans post-Katrina:

> [S]ince September 2008, the number of unoccupied residential addresses in New Orleans declined from 69,727 to 65,888 by March 2009 [fig. 54]. . . . Planning District 4 has the largest number of unoccupied addresses with 11,509 [see inset diagram in figure 54 for district locations and figure 41 for district legend]. . . . Planning Districts 6, 7, 8 and 9 experienced extensive flooding and each had more than 6,000 unoccupied residential addresses. . . . 'Addresses' are distinguished from 'properties' in that multiple addresses can be located on a single property (e.g. shotgun double). Unoccupied addresses include vacant and no-stat addresses. Vacant addresses have not had mail collected for 90 days or longer. No-Stat addresses include addresses identified by the letter carrier as not likely to receive mail for some time, buildings under construction and not yet occupied, and rural route addresses vacant for 90 days or longer. . . .

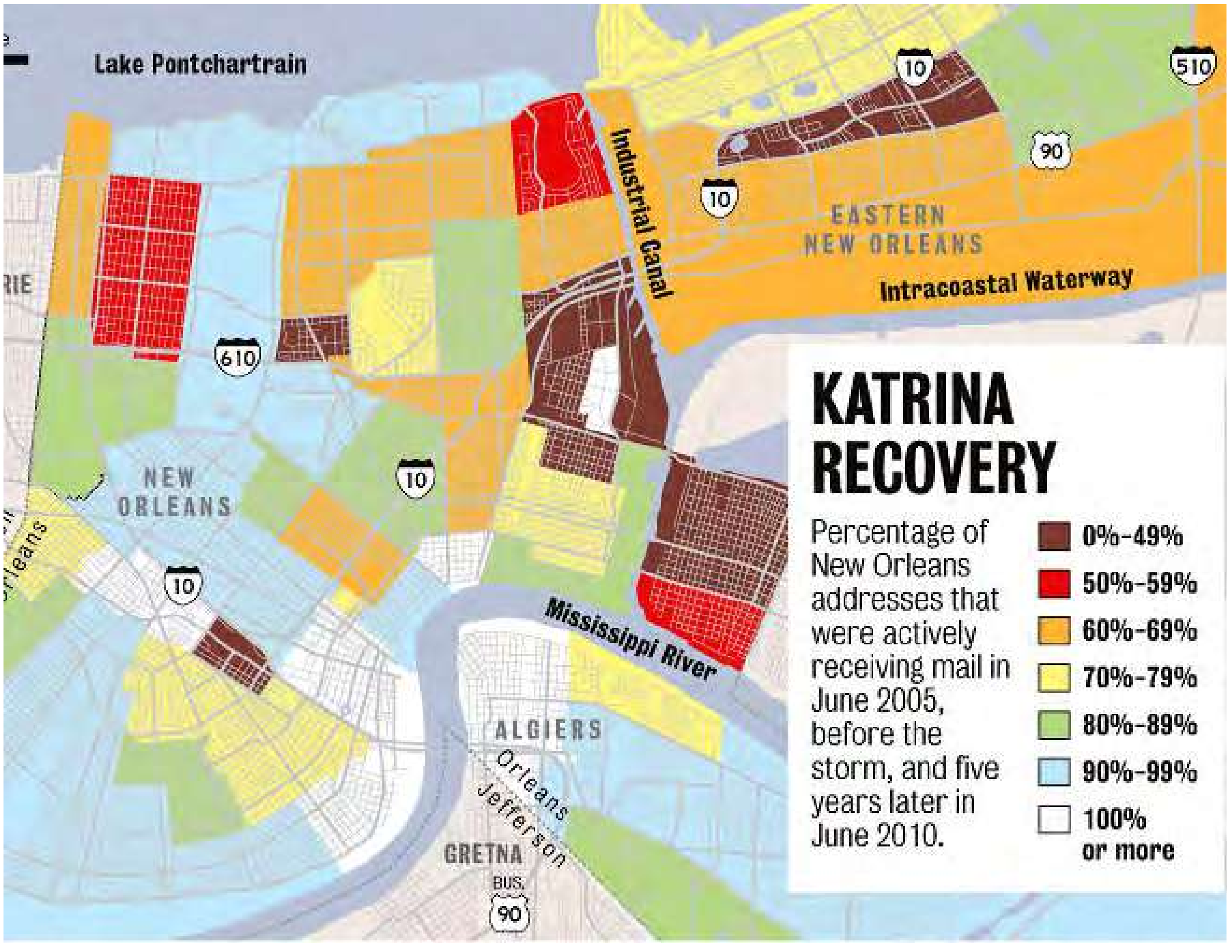
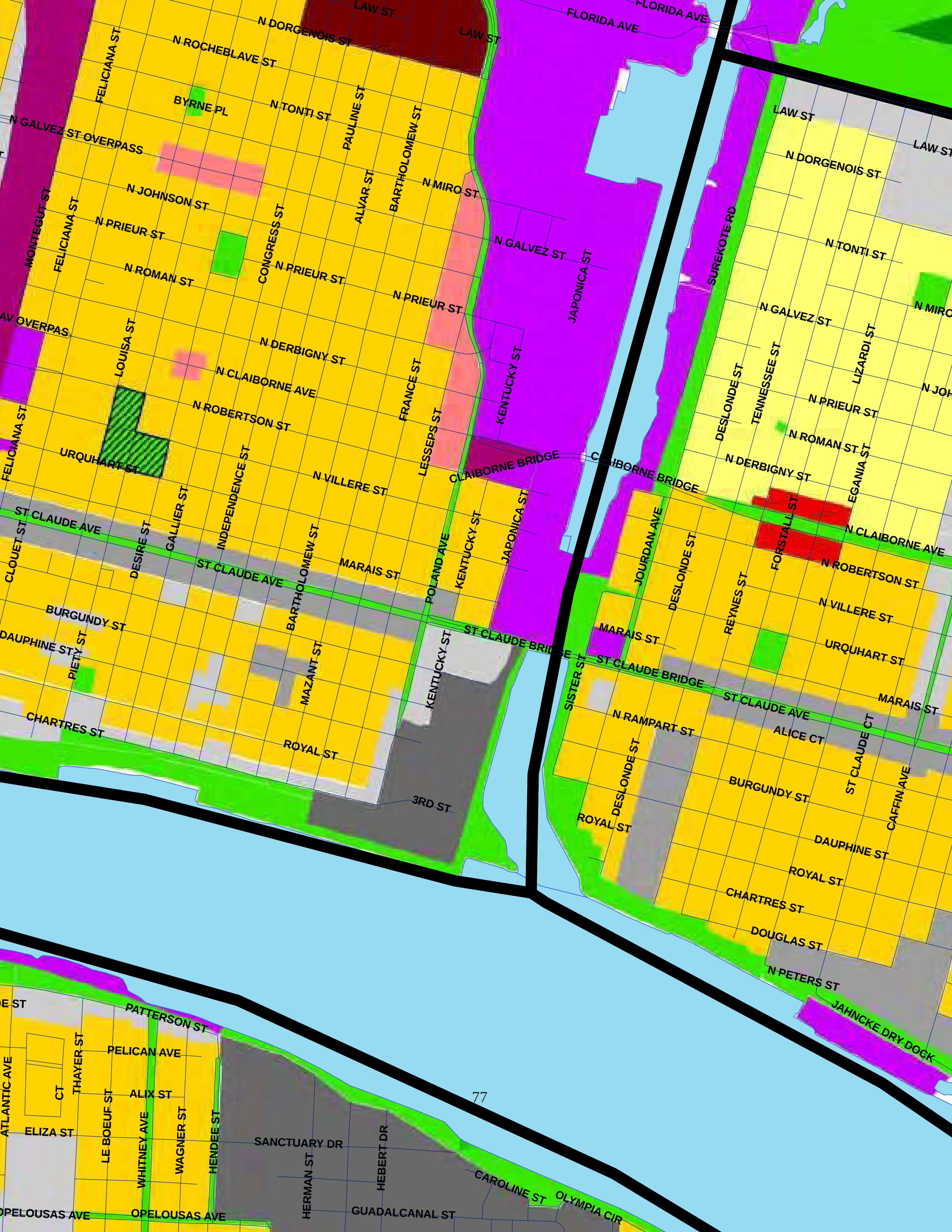



*fig. 55: Percentage of New Orleans Addresses Actively Receiving Mail in June 2005 and June 2010*

> In the parishes affected by Hurricanes Katrina and Rita, no-stat addresses include heavily damaged homes that have not been re-occupied.[69]

Figure 55 is a current map, showing the percentage change from 2005 to 2010 of active mailing addresses. It that displays that 0-49% of addresses were actively receiving mail in the majority of the Lower Ninth Ward in June 2005, before the Hurricane Katrina, and five years later in June 2010.[70] Figure 56 is a map of the District 8 Working Plan for Future Land Use, issued in January 26, 2010. The majority of the Lower Ninth Ward is expected to remain low density residential.[71]


LAW ST
FLORIDA AVE
N DORGENOIS ST
N ROCHEBLAVE ST
FELICIANA ST
BYRNE PL
N TONTI ST
PAULINE ST
BARTHOLOMEW ST
N GALVEZ ST OVERPASS
N MIRO ST
N JOHNSON ST
ALVAR ST
MONTEGUT ST
N PRIEUR ST
CONGRESS ST
N GALVEZ ST
JAPONICA ST
N ROMAN ST
SUREKOTE RD
LOUISA ST
N DERBIGNY ST
N CLAIBORNE AVE
FRANCE ST
KENTUCKY ST
N ROBERTSON ST
LESSEPS ST
URQUHART ST
CLAIBORNE BRIDGE
N VILLERE ST
ST CLAUDE AVE
DESIRE ST
GALLIER ST
INDEPENDENCE ST
CLOUET ST
MARAIS ST
POLAND AVE
BURGUNDY ST
DAUPHINE ST
PIETY ST
MAZANT ST
ST CLAUDE BRIDGE
CHARTRES ST
ROYAL ST
3RD ST
DESLONDE ST
TENNESSEE ST
LIZARDI ST
EGANIA ST
FORSTALL ST
JOURDAN AVE
REYNES ST
SISTER ST
N RAMPART ST
ALICE CT
ST CLAUDE CT
CAFFIN AVE
DOUGLAS ST
N PETERS ST
JAHNCKE DRY DOCK
PATTERSON ST
PELICAN AVE
THAYER ST
ALIX ST
ATLANTIC AVE
ELIZA ST
LE BOEUF ST
WHITNEY AVE
WAGNER ST
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GUADALCANAL ST

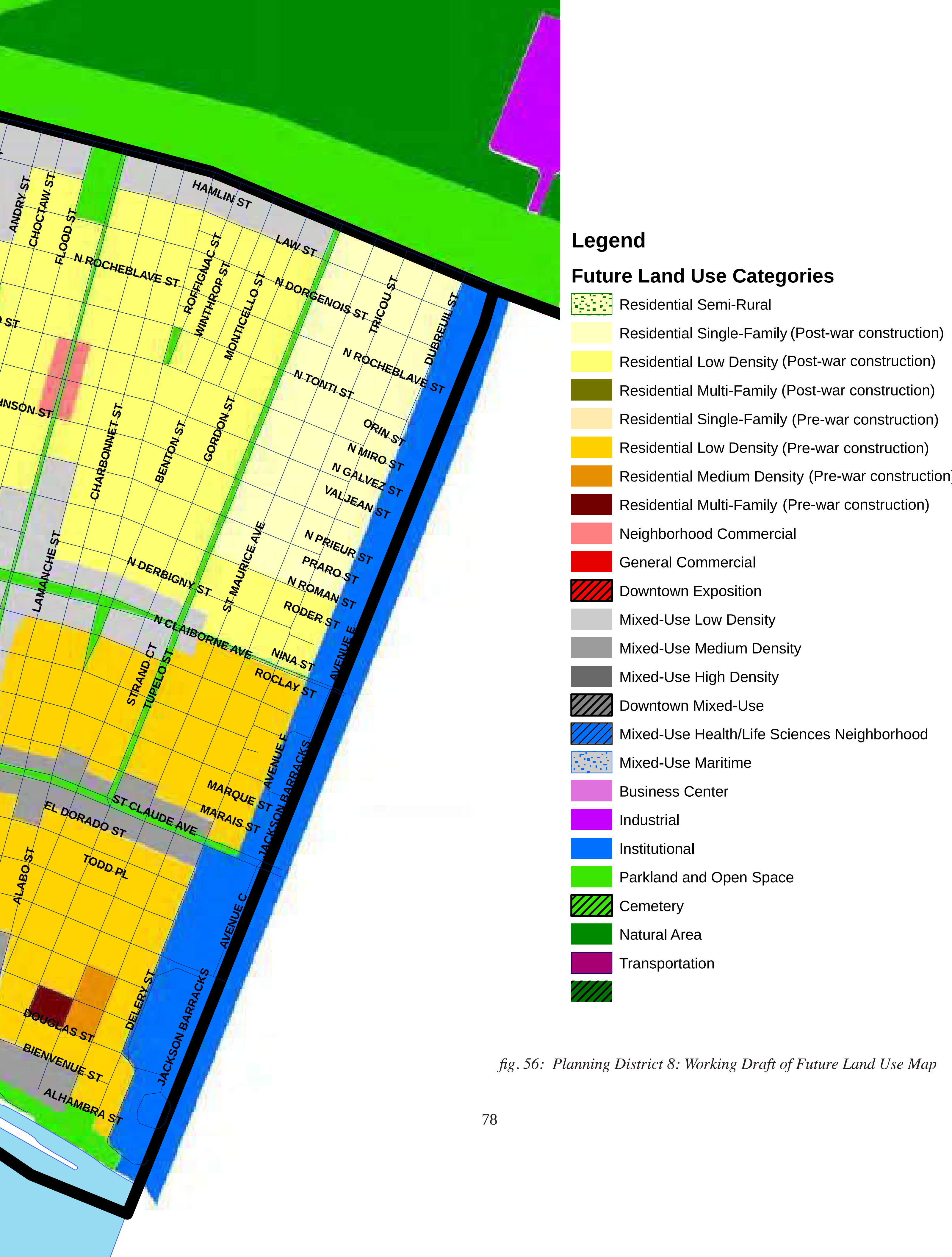



*fig. 56: Planning District 8: Working Draft of Future Land Use Map*

NEIGHBOURHOOD RECOVERY

The Association of Community Organizations for Reform Now (ACORN) is committed to the authentic recovery of the devastated Lower Ninth Ward (fig. 57). Through conducting surveys of its former residents, they have compiled significant data to assist in restoring these neighbourhoods in a manner that residents want. *The People's Plan,* a study by ACORN in conjunction with Cornell and Columbia Universities and the University of Illinois, is a strategic plan of action for the recovery of neighbourhoods in the Lower Ninth Ward. It presents a thorough assessment of the area and its former residents' desires to restore their damaged communities.[72]

Figure 58 charts the type of property damage. According to *The People's Plan*, property damage relates to "collapsed walls, caved roofs or houses that have moved off their foundation. . . . Fifteen teams of university students conducted a survey of the residential housing on 165 blocks in Planning Districts 7 and 8. The survey covered 12% of the building stock in these districts. The teams captured information on the types of residential structures and the recovery activity evident at the time of the survey. . . . [They confirmed that] over 80% of the remaining homes had no structural damage when surveyed in October 2006."[73]

Figure 59 displays the amount of flood damage to homes in the Lower Ninth Ward. When *The People's Plan* report was released in 2006, "flooding was extensive throughout Planning Districts 7 and 8. Homes with some flood damage will typically cost $35,000-$50,000 to repair. . . . [H]eavily flooded homes will likely need to be raised to FEMA guidelines. This procedure will add an additional $20,000-$30,000 in repair cost to the 75% of homes on pier foundations and will be too costly to perform on the 25% of homes on slab foundations."[74]

Figure 60 charts the recovery activity in the Lower Ninth Ward as of October 2006 for Planning Districts 7 and 8. According to the report, "approximately 70% of the homes had been gutted or debris had been removed. . . . Recovery activity was more limited in the heavily damaged northern section of the Lower Ninth Ward, where 40% of the homes surveyed showed some sign of recovery, typically gutting."[75]

Figure 61 displays the results of a survey conducted with former residents of the Lower Ninth Ward inquiring about their desire to return to their former residences. Residents from four neighbourhoods in Districts 7 and 8 (St. Claude, Bywater, the Lower Ninth Ward and Holy Cross) were surveyed. Of the 165 blocks surveyed in Planning Districts 7 and 8, residents expressed an "overwhelming desire to move back to New Orleans (94% Lower Ninth, 100% Holy Cross, 88% St. Claude, and 85% Bywater), but also in their commitment to rebuilding and returning to their pre-Katrina homes."[76]

Many of the residents surveyed were already in the process of reoccupancy. Resident recovery and rebuilding efforts in the District 8 were much slower than District 7.

According to *The People's Plan*, "only 8% and 12% of residents surveyed in the Lower Ninth and Holy Cross, respectively, reported reoccupation in their homes. Close to 80% were in the process of rehabilitating or gutting their former residences. . . . [As one resident of the Lower Ninth Ward said,] 'This neighbourhood isn't known for its schools or education, but the residents of the Lower Ninth are hard working people. We have always worked hard and we will always work hard. We aren't going anywhere.'"[77]

The statement affirms that the Lower Ninth Ward continues to possess a strong sense of community. Former residents have a strong desire to return to their former neighbourhood, ensuring the way of life is not lost. (See page 423 in the appendices for *The People's Plan* full report).

*fig. 57: Northern Portion of the Lower Ninth Ward - Post-Katrina New Orleans, 2006*

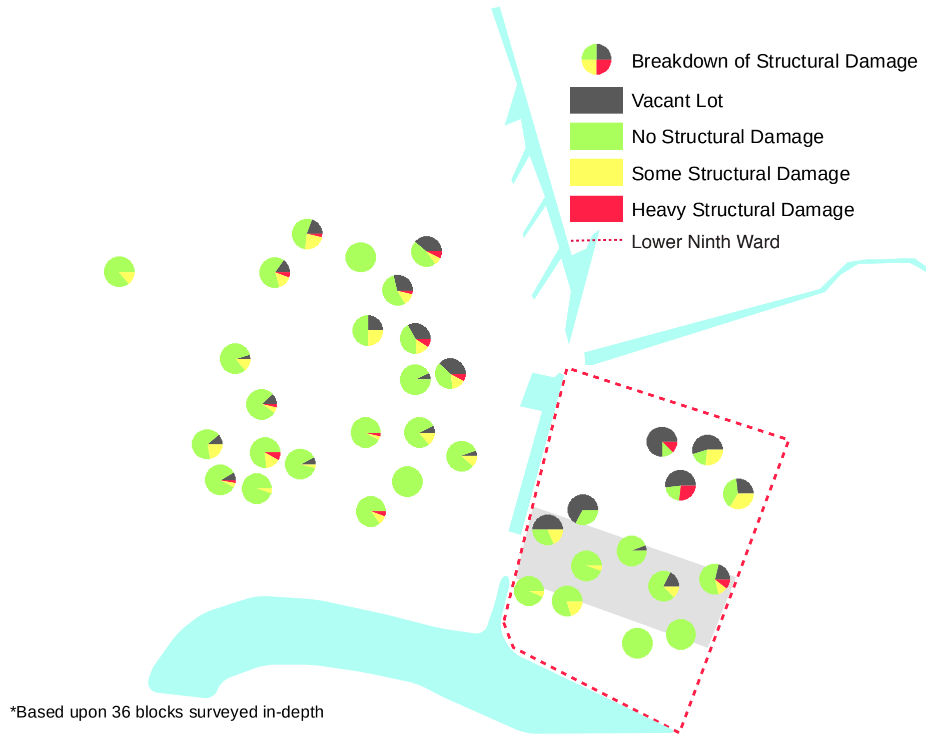



*fig. 58: Structural Damage in the Lower Ninth Ward*

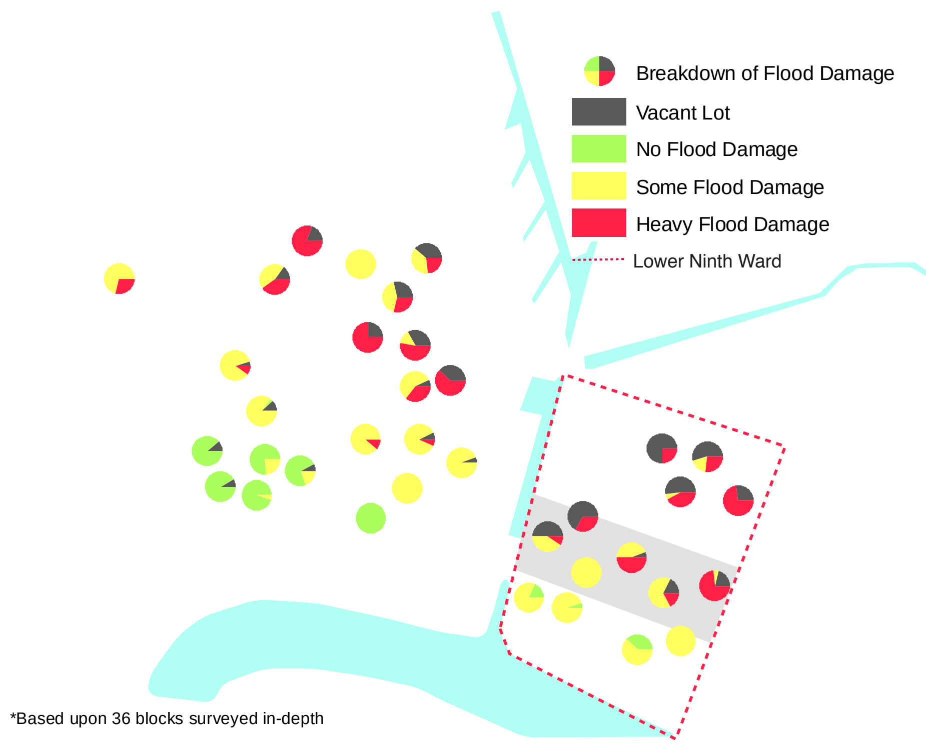



*fig. 59: Damage due to Flooding in the Lower Ninth Ward*

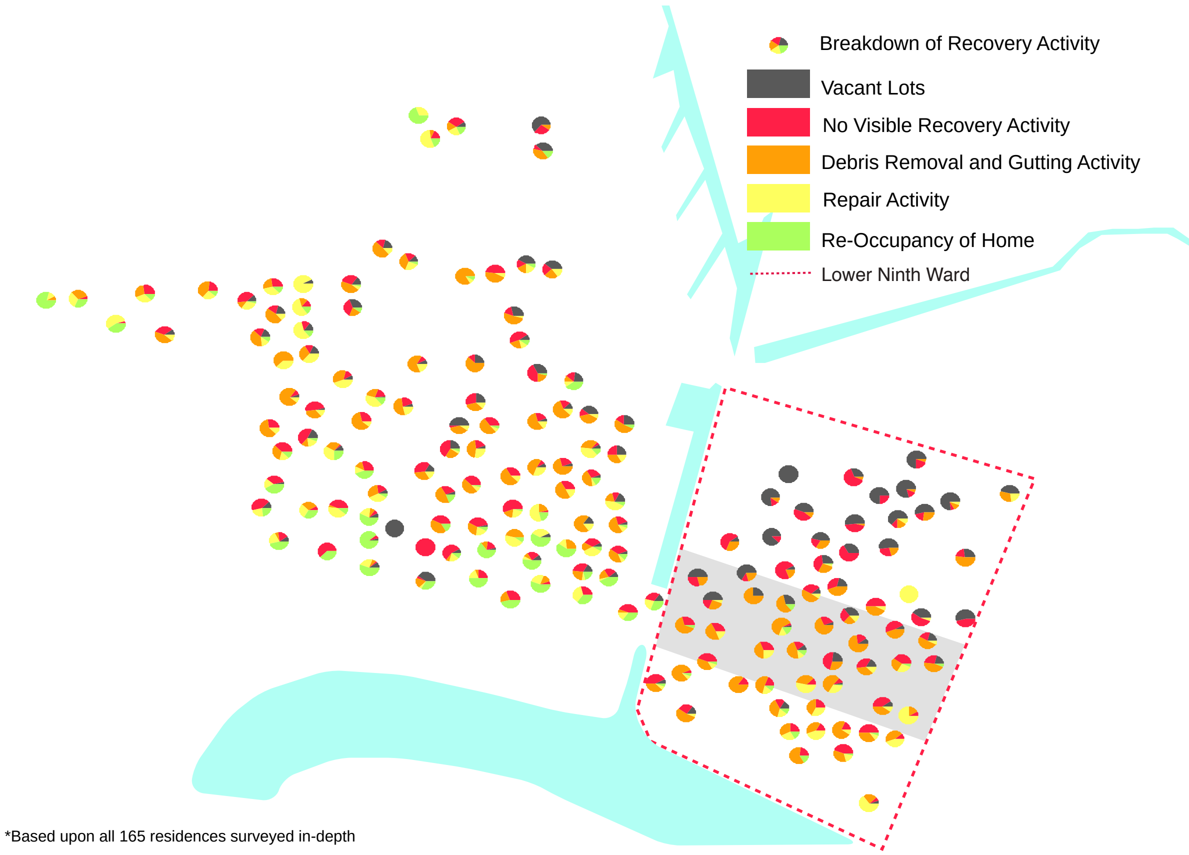



*fig. 60: Residential Recovery in the Lower Ninth Ward*

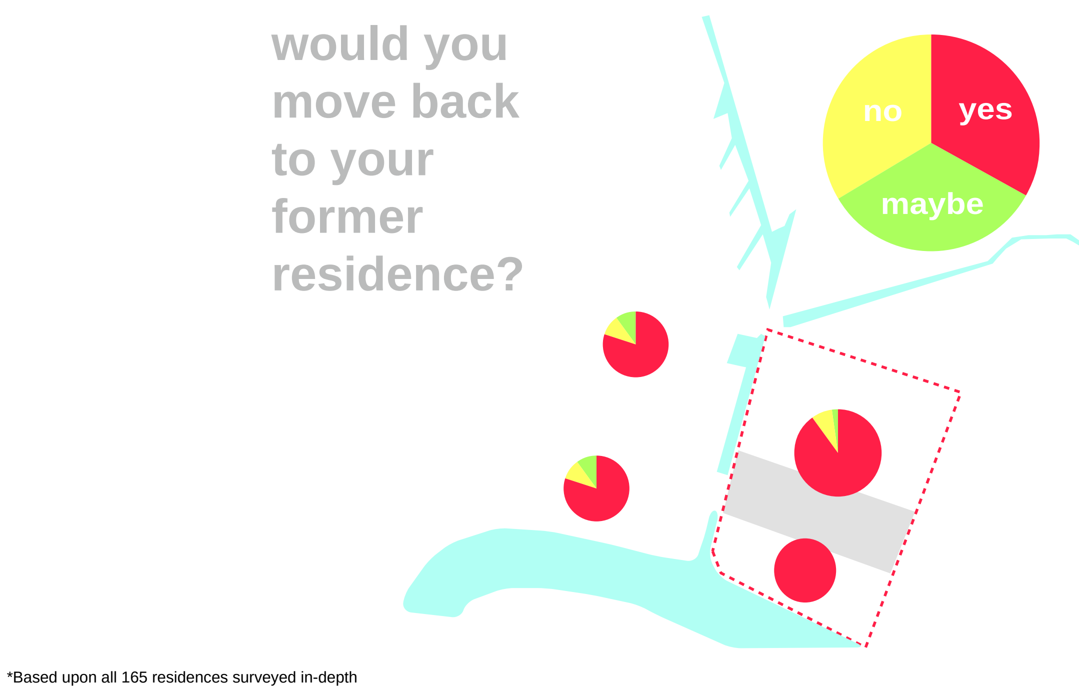



*fig. 61: Desire to move back to the Lower Ninth Ward*

# 03

# iii

# context: site

## SITE: THE LOWER NINTH WARD

The Ninth Ward is geographically the largest of the 17 Wards that comprise New Orleans (fig. 62). The Ninth Ward is divided into three sections: the Upper Ninth Ward, Lower Ninth Ward, and New Orleans East. The Upper and Lower Ninth Wards are separated by the Industrial Canal. The Lower Ninth Ward contains the neighbourhood of Holy Cross as shown in figure 63. The extent of the Lower Ninth Ward is also the boundary for Planning District 8 (fig. 64, 65).[78]

Prior to Hurricane Katrina, the Lower Ninth Ward was a rich cultural community with tight-knit, family-oriented neighbourhoods. According to Douglas Brinkley, Professor of History at Rice University:

> As one community leader aptly described it, the Lower Ninth Ward had an 'atmosphere of engagement that featured time spent with one another in dialog, in celebration of the music, words and history that make the Lower Ninth Ward so special'. . . . The modern day [pre-storm] Lower Ninth Ward was distinguished in many ways, not least the fact that more residents owned their homes than in any other part of the city. The population is predominantly African American, and their homes were built on land that was, in the Colonial Louisiana of the 19th Century, plantation land. These homes were built and paid for in modern times, thanks to an industrious nature and commitment to independence. . . . Porches and stoops were important places to catch up with one another and talk about everyday life.[79]

Douglas Brinkley highlights some important historical and cultural aspects of the Lower Ninth Ward prior to Hurricane Katrina. A high percentage of owner-occupied homes, among other factors, has strengthened stewardship within this community.

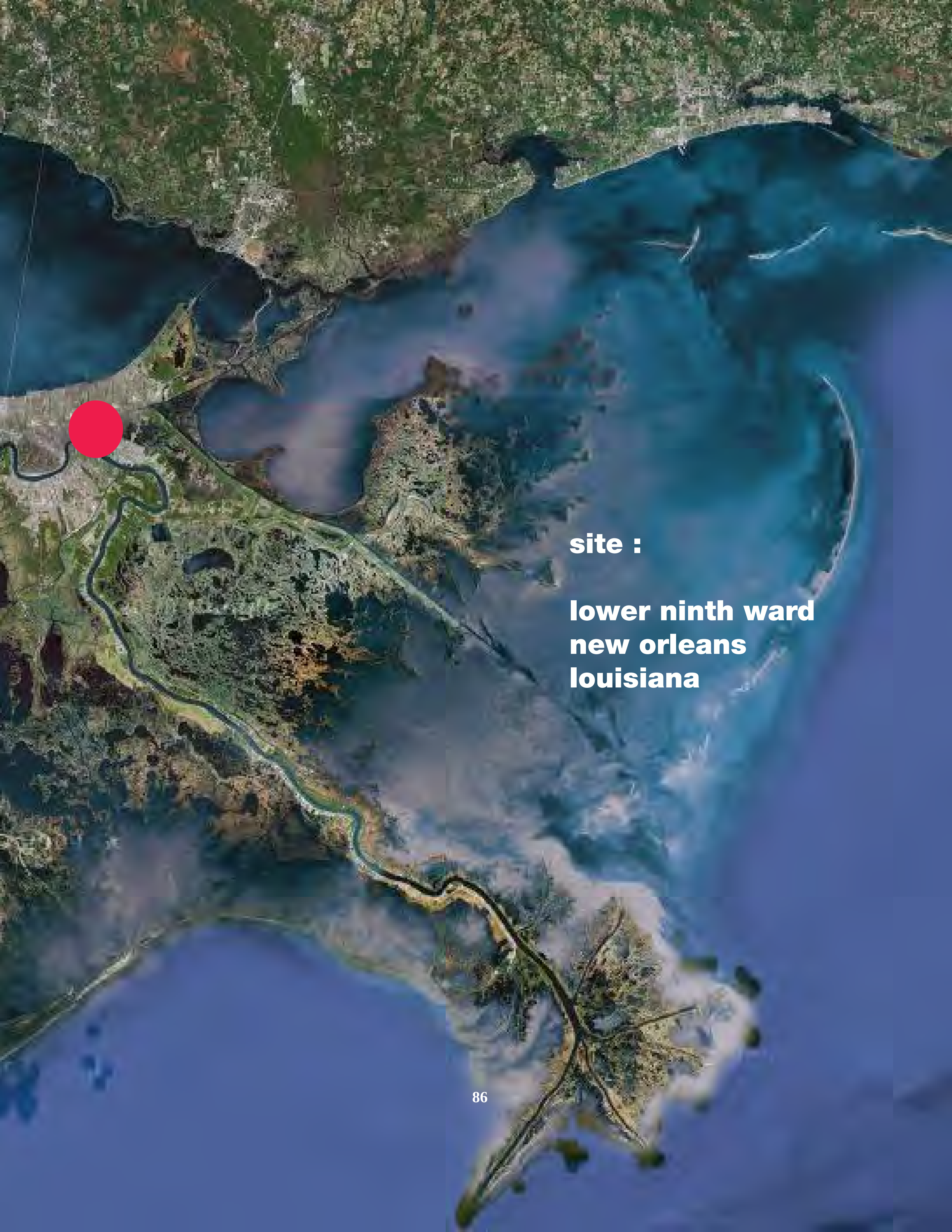
## WHY THIS SITE?

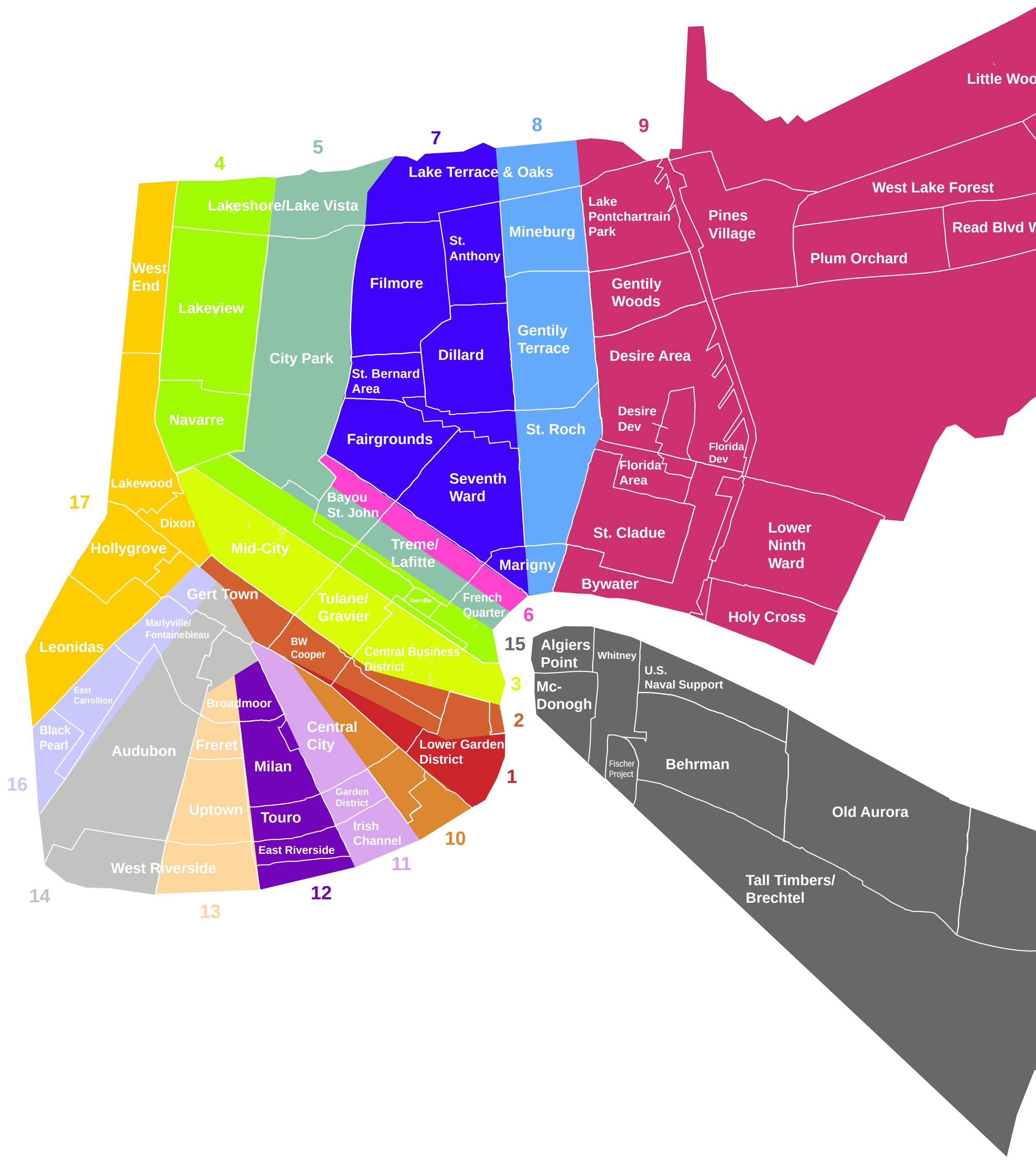
As explained in the following paragraphs, the Lower Ninth Ward is an appropriate site for the BFP for three main reasons: i) it requires an alternative flood-mitigation solution that respects its unique social culture; ii) many homes are salvageable and suitable for retrofit with buoyant foundations; and iii) the Lower Ninth Ward is one of the better locations along the river that should be safe from long-term ecological problems.[80]

The Lower Ninth Ward requires a flood mitigation solution that is respectful of the neighbourhood's social culture. Due to the severe flooding after Hurricane Katrina, FEMA is recommending that homeowners in South Louisiana permanently raise their homes to protect against future flooding. Raising homes high above street level will destroy neighbourhood character by removing the connection of the front porch to the street. (This concept is discussed in greater detail later in the chapter). The BFP supports the local culture because it facilitates the restoration of shotgun housing, a housing type that fostered the tight-knit culture that characterized this neighbourhood before Katrina. The BFP also preserves the relationship of porch to street, allowing residents to continue to live close to street level.[81]

According to *Mission 2010: New Orleans,* a study conducted by MIT students, the Lower Ninth Ward experienced significant damage after Katrina; "82% of the homes had more than $5,200 damage."[82] However, according to New Orleans planners, many of the remaining homes were in better condition than initially reported, and "more than 80% of Ninth Ward structures suffered no terminal structural damage."[83] This information was published in an Associated Press article in 2007 (two years after Hurricane Katrina). The article affirms that many houses in the Lower Ninth Ward are structurally viable. This means that rehabilitating these structures for retrofitting with buoyant foundations is indeed possible for this area (fig. 66).

*fig. 62: Aerial View of Southeast Louisiana*


site :
lower ninth ward
new orleans
louisiana



Little Woo
West Lake Forest
Read Blvd W
Plum Orchard
Pines Village
Lake Pontchartrain Park
Gentily Woods
Desire Area
Desire Dev
Florida Dev
Florida Area
Lower Ninth Ward
St. Cladue
Bywater
Holy Cross
9
8
7
5
4
Lake Terrace & Oaks
Mineburg
Gentily Terrace
St. Roch
Marigny
St. Anthony
Filmore
Dillard
St. Bernard Area
Fairgrounds
Seventh Ward
Lakeshore/Lake Vista
City Park
Lakeview
Navarre
West End
Lakewood
Dixon
Hollygrove
Leonidas
17
Mid-City
Bayou St. John
Treme/ Lafitte
French Quarter
6
Tulane/ Gravier
Central Business District
BW Cooper
Gert Town
Marlyville/ Fontainebleau
East Carrollton
Black Pearl
16
Audubon
Broadmoor
Freret
Uptown
West Riverside
14
13
Milan
Touro
East Riverside
12
Central City
Garden District
Irish Channel
11
Lower Garden District
10
1
2
3
15
Algiers Point
Whitney
U.S. Naval Support
Mc-Donogh
Fischer Project
Behrman
Old Aurora
Tall Timbers/ Brechtel

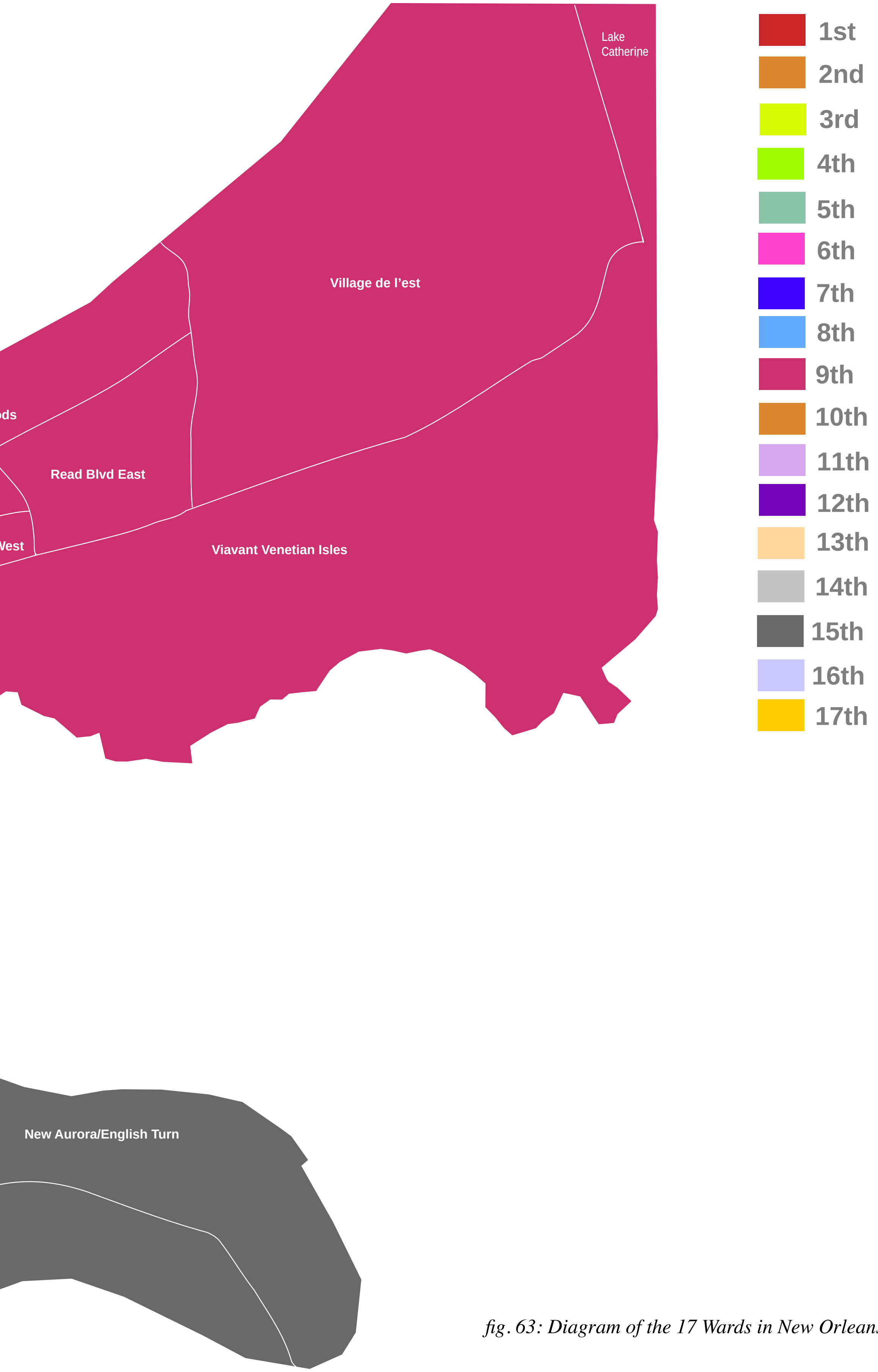
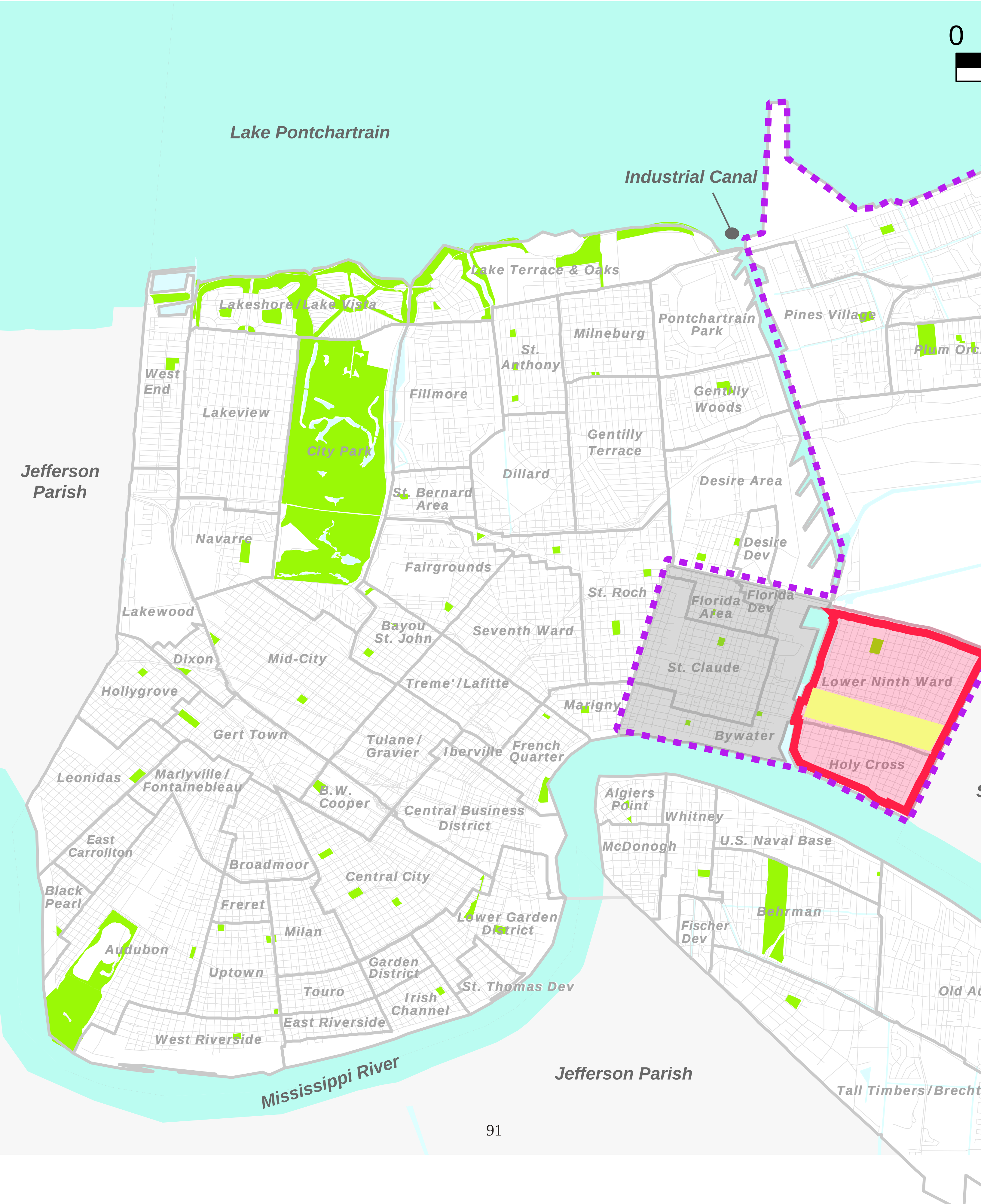



*fig. 63: Diagram of the 17 Wards in New Orleans*


*fig. 64: Partial Aerial View of New Orleans*


0
Lake Pontchartrain
Industrial Canal
Lake Terrace & Oaks
Lakeshore/Lake Vista
Pontchartrain Park
Pines Village
Plum Orc
Milneburg
St. Anthony
West End
Lakeview
Fillmore
Gentilly Woods
Gentilly Terrace
City Park
Jefferson Parish
Dillard
Desire Area
St. Bernard Area
Navarre
Desire Dev
Fairgrounds
St. Roch
Florida Area
Florida Dev
Lakewood
Bayou St. John
Seventh Ward
Dixon
Mid-City
St. Claude
Lower Ninth Ward
Hollygrove
Treme'/Lafitte
Marigny
Gert Town
Tulane/Gravier
Iberville
French Quarter
Bywater
Holy Cross
Leonidas
Marlyville/Fontainebleau
B.W. Cooper
Algiers Point
Central Business District
Whitney
East Carrollton
McDonogh
U.S. Naval Base
Broadmoor
Black Pearl
Central City
Freret
Behrman
Lower Garden District
Fischer Dev
Milan
Audubon
Garden District
Uptown
St. Thomas Dev
Old Au
Touro
Irish Channel
East Riverside
West Riverside
Jefferson Parish
Mississippi River
Tall Timbers/Brecht

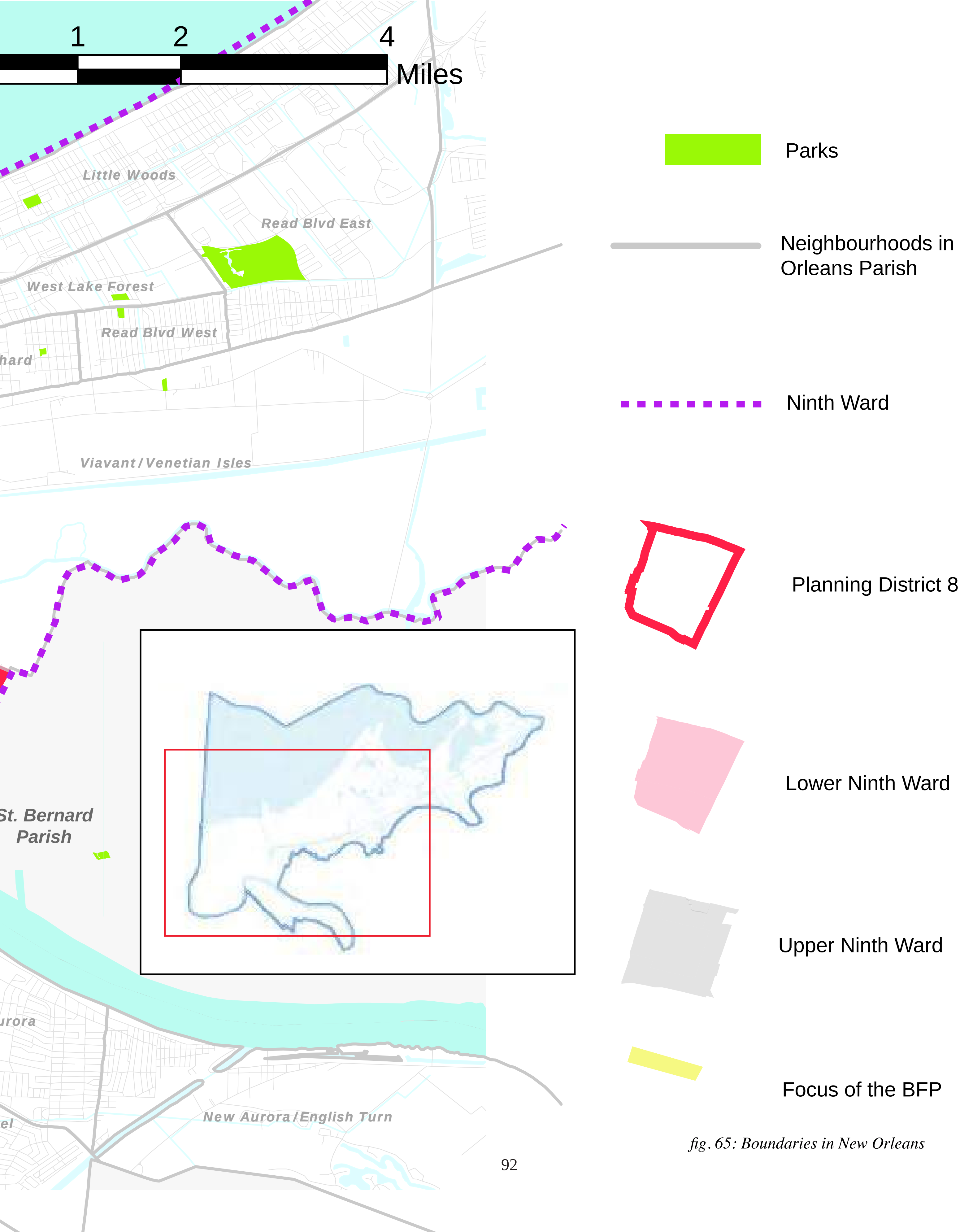



*fig. 65: Boundaries in New Orleans*

As reported in *Mission 2010: New Orleans*, the Lower Ninth Ward "is one of the better location – that is, more likely to be safe from long-term ecological problems such as sea level rise and subsidence"[84] (as discussed in Chapter Two), which makes it one of the safer locations along the river for displaced residents to return.

According to Bonnie Krenz, a student at MIT and co-author of *Mission 2010: New Orleans,* "[the Lower Ninth Ward has a] subsidence rate, 5 millimeters per year, which is slightly less than those of many of the areas along Lake Pontchartrain, and its average elevation, 0.9 meters above sea level, is much higher than many areas of New Orleans, even higher than the average elevation of New Orleans as a whole, that is exactly sea level."[85]

As discussed in Chapter Two, ecological challenges such as sea level rise and subsidence make coastal Louisiana particularly vulnerable to flooding. As identified by Krenz, the Lower Ninth Ward is a location that will not be as severely affected by these ecological challenges. If effective flood mitigation strategies are implemented, the Lower Ninth Ward can become a more flood resilient neighhourhood.

The following excerpt is from a Fox News broadcast from Monday, January 8, 2007 by Associated Press.

*NEW ORLEANS — The predominantly black neighborhoods known as the Ninth Ward can be brought back largely as they existed before Hurricane Katrina flooded them, a survey contends.*

*The finding contradicts the common perception that the neighborhoods are so damaged that they need to be rebuilt from scratch, said urban planners who conducted the survey.*

*'The structural integrity of the buildings, even in the most devastated areas,* ***are in much better condition than has been reported,****' said Kenneth Reardon, chair of Cornell University's city and regional planning department.*

*The survey found that* ***more than 80 percent of the Ninth Ward structures "suffered no terminal structural damage"*** *and that the majority of those structures were built atop piers, making it easier to raise them to meet new flood zone requirements.*

*Researchers and structural engineers based their assessment on the inspection of about 3,000 buildings.*

*Yet, the neighborhoods are being repopulated very slowly because of the bureaucratic and financial hurdles residents face, the survey concluded after interviewing hundreds of residents. Only about 20 percent of the residents have returned home, the survey found.*[86]

*(emphasis added)*


*fig. 66: Lower Ninth Ward, Pre and Post Katrina Housing*


*fig. 67: Mardi Gras, New Orleans*

*fig. 68: Jazz Festival, New Orleans*

## SENSE OF PLACE

The BFP supports the recovery of "place" through encouraging the restoration of a physical habitat. By facilitating the rehabilitation of shotgun housing and enabling houses to remain close to street level, the BFP can preserve the former streetscape and neighbourhood character of the Lower Ninth Ward, thus supporting significant cultural drivers that contribute to the unique social culture of New Orleans.

Timothy Cochrane, as quoted in Barbara B. Brown and Douglas D. Perkins, writes, "'Place'. . . means permanence, security, nourishment, a center or organizing principle."[87] John D. Eyles, as quoted in Brown and Perkins, further defines "place" as "a center of felt value, incarnating the experience and aspirations of people. Thus it is not only an arena for everyday life. . . [it also] provides meaning to that life. To be attached to a place is seen as a fundamental human need and, particularly as a home, as the foundation of our identities and ourselves. Places are thus conceived as profound centers of human existence."[88] Keith H. Basso as quoted in Miller and Rivera adds, "senses of place also partake of cultures, of shared bodies of 'local knowledge' with which persons and whole communities render their places meaningful and endow them with social importance."[89]

Before Hurricane Katrina, New Orleans was a city with a strong sense of "place." Roger Abrahams *et al.* outline significant aspects that contribute to New Orleans' cultural identity. According to Abrahams *et al.*, prior to Katrina:

> The cultural values of New Orleans include celebrated cuisine, music, architecture, literature and events (Mardi Gras and Jazz Fest) [fig. 67, 68] that fuse Old and New Worlds, North and South Americas, Latin and Protestant worlds and gregariously mix races and identities. In American culture and memory, it is the nation's most interracial and international city; it is a place of tolerance and creativity. New Orleans's cultural values bridge historic and contemporary periods; they relate to the built environment as well as the more immaterial, ephemeral expression of culture.[90]

While living in New Orleans to research his book *Nine Lives*, Daniel Baum wrote a daily online column for *The New Yorker*. He comments that what New Orleanians love about their city is "neither the food nor the music but the intimacy of the neighbourhoods — knowing everybody on the block where you were born, and never leaving."[91]

Elizabeth English lived in New Orleans from 1999 to 2004 while teaching at Tulane University. In her assessment, "New Orleans is famous for its food and its music, but the food and music that you consume in the French Quarter was not generated in the French Quarter, they come from the neighborhoods like the Lower Ninth Ward, or Mid City or New Orleans East — the neighborhoods that are largely lower income, largely black and that have evolved a unique culture. . ."[92]

Famous Lower Ninth Ward resident Fats Domino has made a significant musical contribution that has added vibrancy to New Orleans. Douglas Brinkley discuses Fats Domino's significance to the Lower Ninth Ward in *The Great Deluge: Hurricane Katrina, New Orleans, and the Mississippi Gulf Coast*:

> The most famous Lower Ninth Ward resident at the time of Katrina was undoubtedly the seventy-seven-year old Fats Domino. . . . As his legend grew, the self-reliant Domino stayed wedded to the Lower Ninth Ward. With his colorful neckties, bright pink Cadillac, and brood of children, Fats was the unofficial mayor of the Lower Ninth Ward. . . . He appeared at the yearly New Orleans Jazz and Heritage Festival and occasionally at Mississippi Gulf Coast casinos, but stayed largely out of the limelight. . . . Fats didn't like traveling. He was a homebody.[93]

Figure 69 depicts the Second Line Parade in the Lower Ninth Ward at the 4th Anniversary of Hurricane Katrina on August 29, 2009.

*fig. 69: Second Line Parade in the Lower Ninth Ward, Post-Katrina New Orleans*

As discussed earlier, residents of New Orleans were forced to vacate their homes during and after Hurricane Katrina and relocate to other parts of the United States. Immediately after the storm, many neighbourhoods were no longer recognizable. Miller and Rivera state, "since the storm, the loss of culture indicative to New Orleans is one of the primary concerns of the city's residents. Culture is significant to the survivors because it has shaped a sense of place."[94]

Many homes, the centers of "felt value," have been destroyed or become uninhabitable. Former residents have left their neighbourhoods in search of refuge. The faith of residents must first be restored before they will return to their homes. The BFP aims not only to provide effective flood protection but also the sense of security that make a community and "place" possible. Through retrofitting and restoring as many homes as possible with the implementation of buoyant foundations, it is hoped that citizens will feel a renewed sense of place. The community's morphology will remain intact, but individual residences will emerge safer and more flood resilient.

# 03
# iv
# context: the shotgun house

## THE SHOTGUN HOUSE + THE BFP

A goal of the BFP is to encourage the restoration of flood-damaged shotgun houses in the Lower Ninth Ward. Arguably, the area's unique culture can be linked to the Louisiana shotgun house (fig. 70). This housing type plays a major role in the culture of the south.

Elizabeth English believes the Louisiana shotgun house has influenced the tight-knit communities and unique culture of the Lower Ninth Ward. She states:

> Might not restoration of the physical habitat encourage restoration of the culture? Demolition and rebuilding would not reestablish the pre-Katrina neighborhoods, community culture, and culture of community that had flourished there; we would do better if we could 'save the shotgun'. In fact, the shotgun houses themselves are critical players in this project, because the uniqueness of New Orleans culture is, I believe, in no small part due to shotgun house typology. The strong sense of community at the heart of New Orleans cultural life is a direct response to an absence of privacy in a shotgun house that serves to foster social interaction, both within the house and among the houses in a neighborhood of shotguns.[95]

John Michael Vlach is a Professor of American Studies and Anthropology at The George Washington University and Director of the university's Folklife Program. He began his pioneering work in the 1970s, dedicated to the study of shotgun housing and the culture that emanates from it. Vlach would agree with English's view. He states, "since a house as a spatial phenomenon is an important expression of the individual and his group, and because the values upon which culture depends are in many ways derived from house form, the shotgun may represent the continuation of an African life-way, an African culture."[96]

Vlach describes the shotgun housing typology as a "spatial phenomenon." With the absence of separated circulation space, this seemingly dysfunctional "spatial phenomenon" plays a significant role in the unique, tight-knit culture of the Lower Ninth Ward.

The following portion of this chapter outlines the history, origins, defining characteristics and design process of this housing type, which is important to fully understand its influence on the culture Lower Ninth Ward neighbourhood.

## BRIEF HISTORY

According to Dell Upton, "[shotgun houses were originally] widely distributed throughout the Caribbean basin. They were brought to the Gulf Coast in the late eighteenth and nineteenth centuries in the course of continual migrations among the French- and Spanish-speaking Caribbean islands and the North American mainland.[97] In Upton's essay, he combines theories from Vlach and Jay Edwards, Professor of Anthropology and Geography at Louisiana State University, about where and when shotgun housing was brought to the Gulf Coast.

Vlach states, "New Orleans should be considered the specific center of shotgun development. This city is the cultural focus of southeastern Louisiana, the region definable by the presence of the shotgun house. The house probably radiated out across the countryside from New Orleans rather than climbing the folk-urban continuum that is assumed to exist in folk architecture."[98]

The shotgun house has been associated with the African-American population since its first appearance in the United States. Vlach remarks, "the American shotgun house is connected directly to Haiti and consequently represents the final product of a set of developments that are ultimately derived from African architecture."[99]

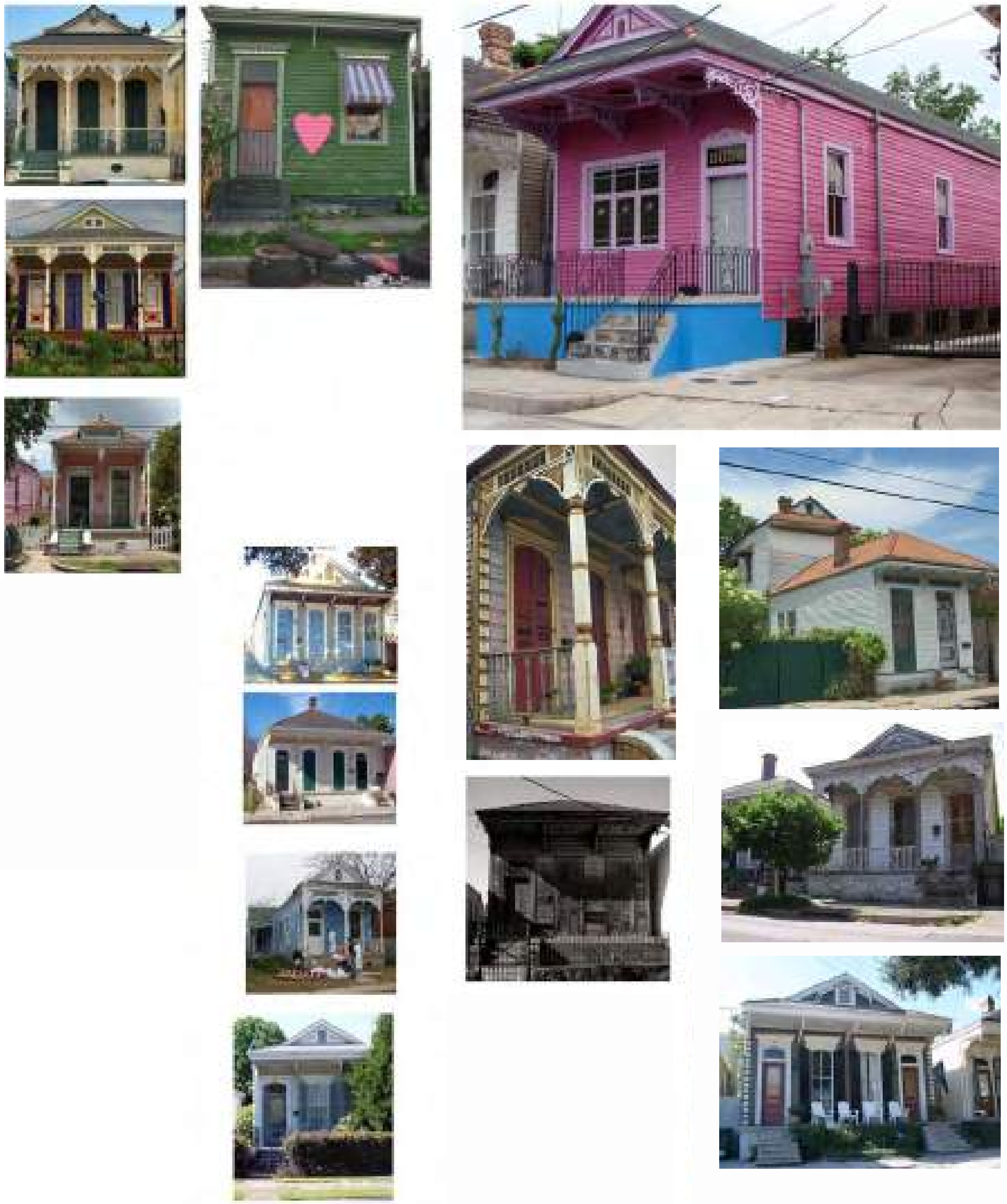


*fig. 70: The Louisiana Shotgun House, Montage*

*fig. 71: Single Shotgun House,*
*3913 St. Claude Avenue, Upper Ninth Ward*

*fig. 72: Brightly Painted Shotgun Houses*

ORIGINS OF THE SHOTGUN HOUSE

According to Jay Edwards of LSU, "theories of the origins of the shotgun lie deeply enmeshed in larger cultural debates on race and authority in the city. Some see the shotgun as a response to constrained urban lots while others see the building type inextricably linked to the city's substantial nineteenth-century African American population."[100]

Edwards describes how the origins of the shotgun houses are not apparent architecturally, and to fully understand their design one must understand the culture from which they originated. Dell Upton supports Edward's view: "The significance of shotgun houses in New Orleans and on the Gulf Coast lies in the specifics of where, when, and for whom they were built. Their simple presence means little — it is their place in the larger mix of local, regional, national and international practices that is significant. To reproduce shotgun houses in great numbers seventy years after they lost their place in the local repertoire would create a picture-post card New Orleans, not a living landscape."[101]

Dell Upton explains that shotgun houses cannot be merely reproduced, despite the efforts to rebuild in post-Katrina New Orleans – their significance lies within their cultural legacy.

DEFINING CHARACTERISTICS

Figure 71 is a photo of a single shotgun house located at 3913 St. Claude Avenue, between Alvar and Bartholomew streets in the Upper Ninth Ward. The photo was taken by Michael Eastman in spring of 2005, a few months before Hurricane Katrina.[102] Figure 72 displays the various types of ornamentation on shotgun façades.

There are many definitions of a basic shotgun house. According to Virginia McAlester *et al.*, Adviser Emeritus of the National Trust for Historic Preservation, "the [basic] shotgun house is a narrow rectangular domestic residence, usually no more than 12 feet (3.5 m) wide, with doors at each end [fig. 73]. It was the most popular style of house in the Southern United States from the end of the American Civil War (1861–65), through to the 1920s."[103]

According to Vlach, "The shotgun house is a one-room-wide, one-storey-high building with two or more rooms, oriented perpendicularly to the road with its front door in the gable end. These are the essential features of the house; they are found in all examples. Other aspects such as size, proportion, roofing, porches, appendages, foundations, trim and decoration have been so variable that the shotgun form is difficult to identify."[104]

The basic single shotgun house typically consists of three to five rooms that are lined up one behind the other, with no hallways.[105] According to the Preservation Alliance of Louisville and Jefferson Co., the common spatial arrangement of a basic single shotgun house is "typically a living room first, then one or two bedrooms, and finally a kitchen in the back [fig. 74, 75]."[106] McAlester *et al.* state: "The rooms are well-sized, and have relatively high ceilings for cooling purposes, as when warm air can rise higher, the lower part of a room tends to be cooler. The lack of hallways allows for efficient cross-ventilation in every room."[107] According to Vlach, the term "shotgun house" originated because one could fire "a shotgun through the house — in the front door and out the back — without doing any damage because the doorways are all in a line. Hence the house is called a shotgun and a straight alignment of doors is assumed. While it does happen that doors sometimes fall into a line, a zig-zag pattern is more common [fig.74]."[108]

*fig. 73: Shotgun Interior*

According to Wikipedia, shotgun houses "typically have a wooden frame structure and wood siding, although some examples exist in brick."[109] In New Orleans, the house is usually raised two to three feet off the ground on masonry piers.[110] The Bywater Neighbourhood Association, states: "[Rooms] usually have some decoration such as moldings, ceiling medallions or elaborate woodwork."[111]

The front porch is another common and significant element of shotgun house typology, particularly in New Orleans. According to Vlach, "front porches are particularly common on shotgun houses. Most often the roof is extended by projecting the gable some distance beyond the front wall, but there are a number of ways that the porch may be attached."[112]

Another important feature of shotgun typology is the placement of the front door. "The most notable and distinguishing characteristics of the shotgun," according to Vlach, "are the placement of its front door and its orientation, for these features overtly violate the standard canon for American folk building. The usual folk house has its door on the long side and the building runs parallel to the road. The perpendicular orientation of the shotgun with its frontward-facing gable and gable door signals an abrupt departure from the common pattern."[113]

All shotgun houses have one door in the front (two doors for double shotguns) and almost all have a door in the back. A modified version of the shotgun house, the "camelback," is a shotgun in which the rear section is two stories high. What is essential to this form is that the front portion of the house is one storey high. A double shotgun also emerged that fuses two single shotgun houses together side by side. The double shotgun can also have a "camelback," thus becoming a "double camelback."[114]

Figures 76 and 77 are two block plans of neighbourhoods in New Orleans. The New Orleans city layout's narrow lot divisions fashioned the development of a house with one room aligned behind another to conserve space.[115]

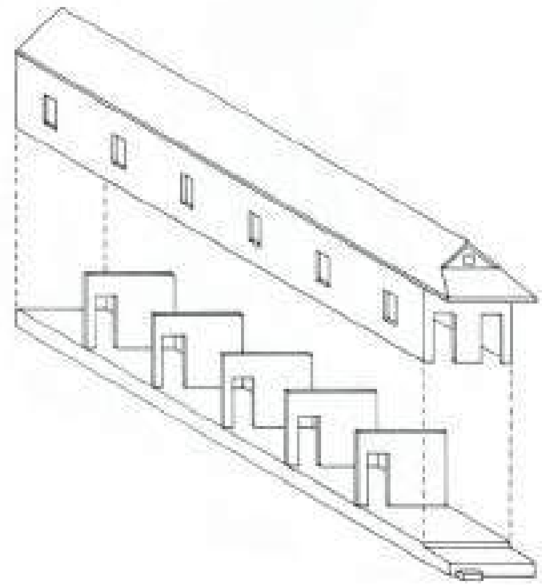


*fig. 74: Shotgun House, Room Assembly*


*fig. 75: Shotgun House - Typical Plan*

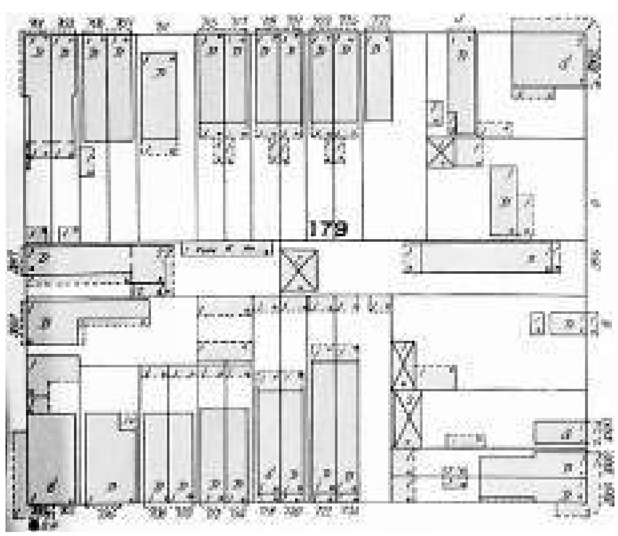


*fig. 76: New Orleans Block Plan with Shotgun and Double Shotguns in 1908*

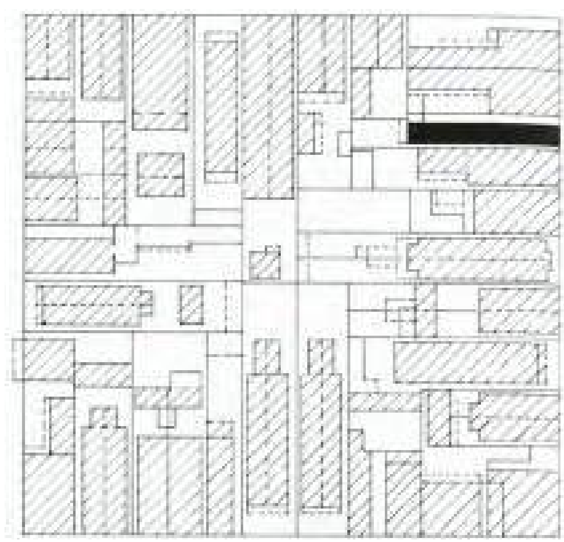


*fig. 77: New Orleans Block Plan with Shotgun and Double Shotguns - (Date Unknown, Post 1908)*

## single shotgun

Figures 78 to 81 illustrate the differences between the four most common typologies of shotgun housing. Figure 82 illustrates some of the various floor plan layouts that can be found in Louisiana, transcribed from Vlach's fieldwork as documented in the second volume of his doctoral dissertation. A single shotgun's plan is normally one room wide with a door and a window or just a door in the front façade (fig. 78).[116]

## double shotgun

The double shotgun house is essentially two single shotguns joined together. It typically has four openings in the front facade, two doors and two windows. On a block of typical 30-foot lots, a range of three to 14 feet can be found between shotgun houses, be they single or double. The close spacing of this type creates a strong street front definition in a block of shotguns. The double shotgun forms a two-family house with a common party-wall separating the units that run the length of the house.[117] According to Vlach, this type "requires less land per household than the traditional shotgun, and was used extensively in poorer areas because it could be built with fewer materials and use less land per occupant. It was first seen in New Orleans in 1854 [fig. 79]."[118]

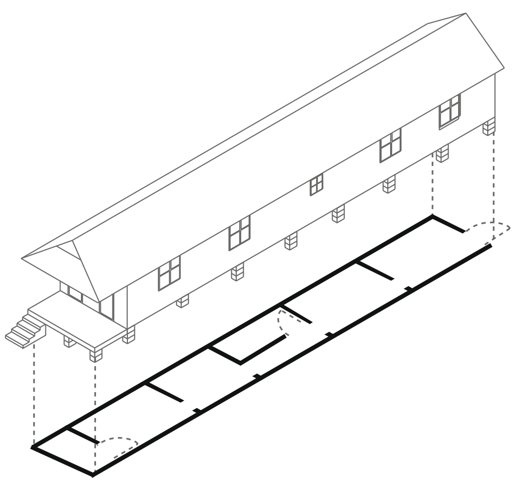


*fig. 78: Single Shotgun House, 3D View and Plan*

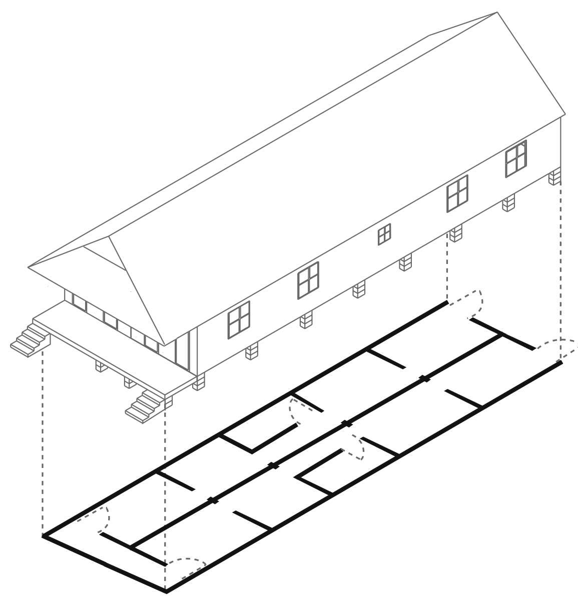


*fig. 79: Double Shotgun House, 3D View and Plan*

# shotgun typologies in south louisiana

## camelback shotgun

The camelback shotgun house is essentially a single shotgun house with a partial second story containing additional rooms, usually sitting at the rear portion of the house. Similar to the traditional single shotgun house, the only difference in the floor plan is the presence of a stair leading up to a second floor that may contain one to four rooms. This type was created to avoid additional taxes based on the area of the front facade. The city placed a higher tax value on two-storey houses, but the camelback, because its façade at street front is a single storey was regarded and taxed as a one-storey building (fig. 80).[119]

## double camelback shotgun

The double camelback shotgun house, similar to the single camelback, has additional rooms added vertically at the rear of the house and, like the double shotgun, merges two single shotguns laterally. This typology is the least common in New Orleans, however it is the most economic choice and can accommodate larger families on a modest lot (fig. 81).[120]

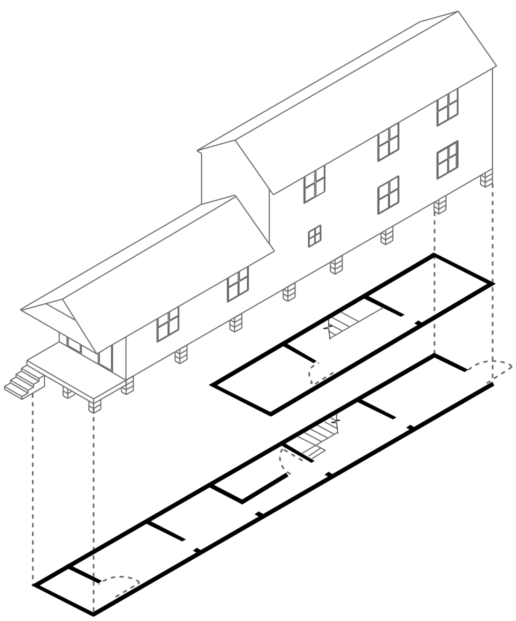


*fig. 80: Camelback Shotgun House, 3D View and Plan*

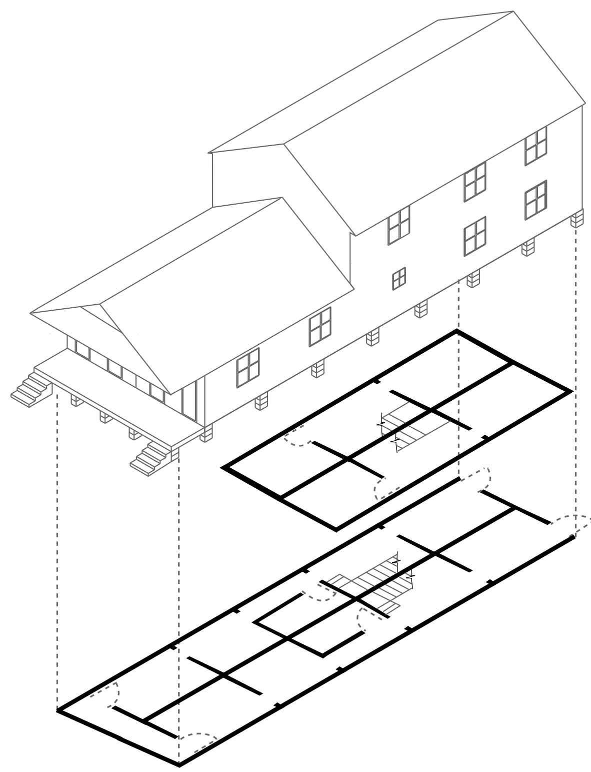


*fig. 81: Double Camelback Shotgun House, 3D View and Plan*


KITCHEN
12'X 9'
LIVING ROOM
12'X 12'
PORCH
13' X 6-1/2'
13' x 30
POINT COUPEE PARISH
KITCHEN
14' x 13'
LIVING ROOM
14' x 13'
PORCH
14' x 5.5'
14' x 34'
IBERVILLE PARISH
BEDROOM
7' x 6'
BEDROOM
6' x 6'
KITCHEN
13-1/2" x 12"
LIVING ROOM
13-1/2" x 13"
PORCH
14-1/2' x 6'
14-1/2' x 38'
ASSUMPTION PARISH
KITCHEN
15-1/2' X 9-1/2'
BEDROOM
15-1/2' X 13-1/2'
LIVING ROOM
15-1/2' X 13-1/2'
PORCH
16-1/2' X 6'
16-1/2' X 45'
MADISON PARISH
KITCHEN
12' X 14-1/2'
BEDROOM
12' X 14-1/2'
BEDROOM
12' X 14-1/2'
LIVING ROOM
12' X 14-1/2'
PORCH
6' X 4'
13' X 64'
ORLEANS PARISH
BATH
6-1/2' x 8'
BATH
6-1/2' x 8'
KITCHEN
12-1/2' X 12-12'
KITCHEN
12-1/2' X 12-12'
BEDROOM
12-1/2' X 14'
BEDROOM
12-1/2' X 14'
LIVING ROOM
12-1/2' X 13'
LIVING ROOM
12-1/2' X 13'
24' X 43
ORLEANS PARISH
KITCHEN
12-1/2' X 8
BEDROOM
8' X 10-1/2'
LIVING ROOM
12-1/2' X 10-1/2'
PORCH
13-1/2' X 6'
13-1/2' X 37'
WEST BATON ROUGE PARISH
BATHROOM
6'X 6-1/2'
KITCHEN
16' X 9-1/2'
BEDROOM
16' X 9-1/2'
LIVING ROOM
16' X 9-1/2'
PORCH
17' X 6'
17' X 44''
TERREBONNE PARISH
BOSSIER
WEBSTER
CADDO
BIENVILLE
DE SOTO
RED RIVER
NATCHITOCHES
SABINE
VERNON
BEAUREGARD
CALCASIEU
CAMERON

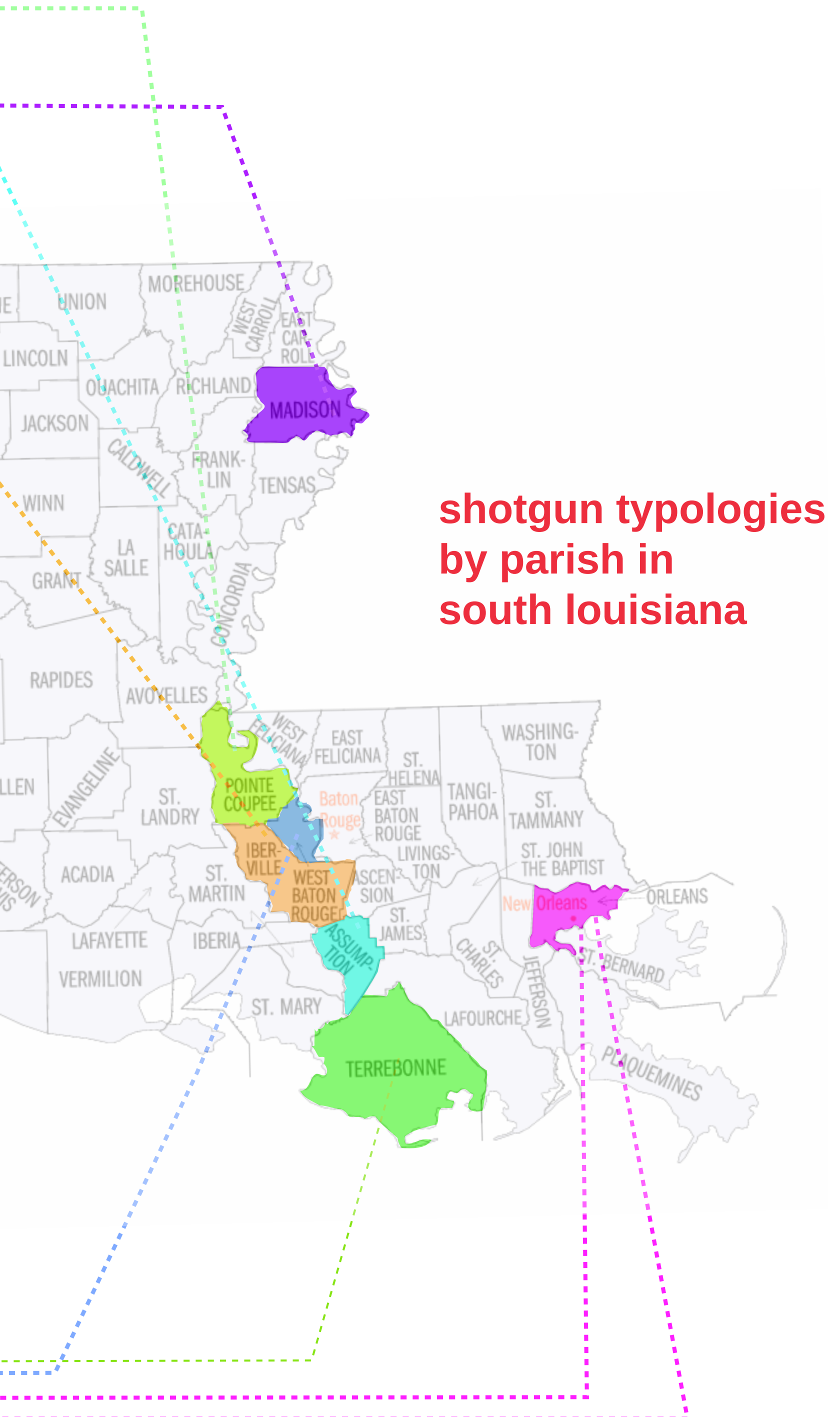



*fig. 82: Shotgun Typologies by Parish in Southern Louisiana*

SHOTGUN TYPOLOGIES BY PARISH

Figure 82 is a comparison of various shotgun house plans from different parishes across Louisiana. The original plans were transcribed from hand drawings in the second volume of Vlach's doctoral dissertation, entitled *Sources of The Shotgun House: African and Caribbean Antecedents for Afro-American Architecture*. Volume Two comprises measured plans of various types of shotgun housing based on his field work. His study was conducted in 1973 in Louisiana, Port-Au-Prince, Haiti and Ile Ife, Nigeria, highlighting the African and Caribbean contribution to this traditional American housing type.[121]

In an article entitled *Reinnovating the African-American Shotgun House*, Sheryl Tucker states, "the shotgun form grew out of traditional values African society placed on the continuity of the extended family and reverence for one's ancestors. The lives of family and clan members were so interwoven with each other that the boundaries between self, family and community were ambiguous."[122] This particular housing type expresses social values and cultural traditions of generations of African-Americans, where its restoration plays a vital role in preserving the culture of New Orleans.

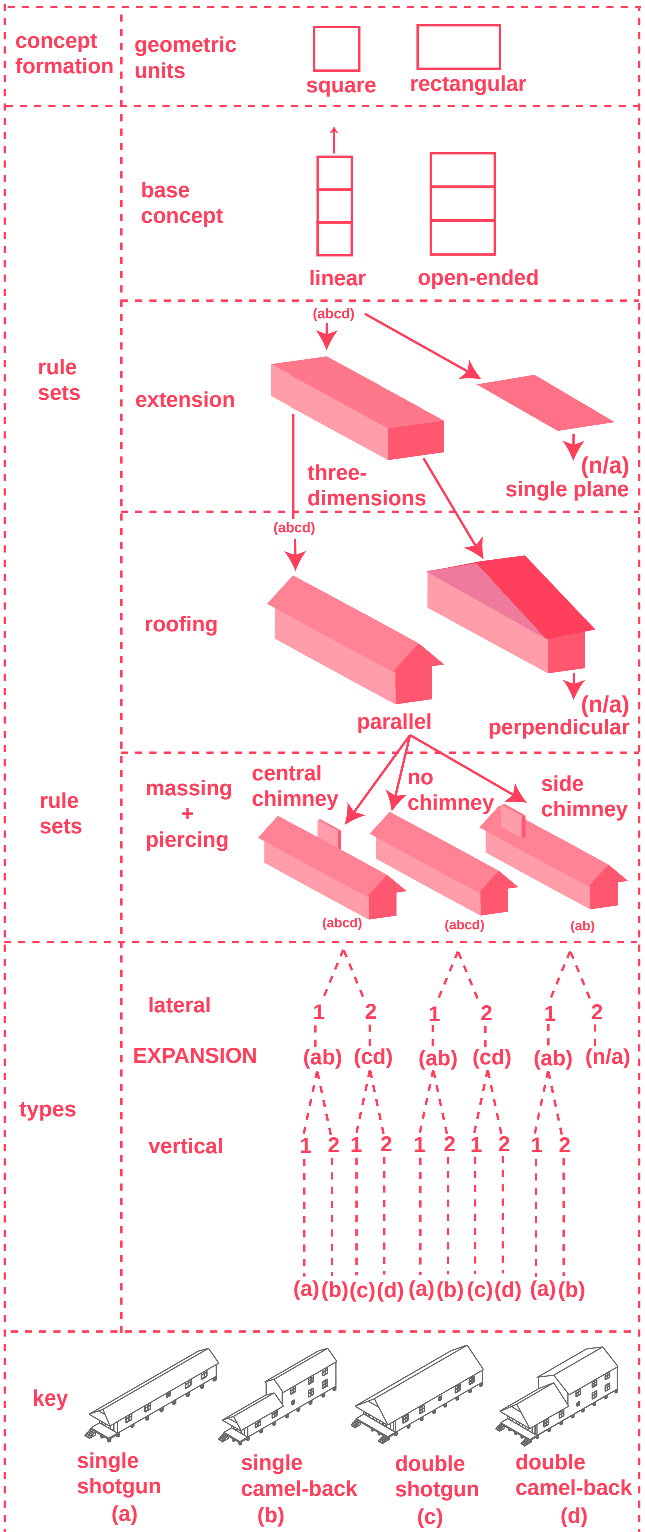
## DESIGN PROCESS

The design process for shotgun houses, illustrated in figure 83, was adapted from a diagram originally published in the first volume of Vlach's doctoral dissertation. Vlach quotes Henry Glassie, a world-renowned folklorist and emeritus College Professor of Folklore at Indiana University Bloomington with specializations in vernacular architecture. Glassie presents an analysis of the shotgun building process in which four sets of rules are used to transform architectural concepts from ideas to tangible artifacts. The base design concept is a linear arrangement of volumes that instead of being a complete whole, incorporates the immediate option to add extra units. The linear string of volumes is "then extended three dimensionally and given a roof axis," explains Glassie, but the building axis is not determined by the rules for roofing. The ridge line of a shotgun house is always parallel to the building's length which is already determined by the base concept (fig. 83). Glassie further elaborates:

> Next rules for massing and piercing are used to locate chimneys, doors and windows. The building is then complete but may be expanded further by either lateral or vertical doubling of structure. Chimneys may be massed centrally or to the side, but do not affect avenues of movement through the house because the base units are large enough not to be blocked off by a fireplace. . . . Rules for piercing are highly variable because the house façade has only a single element as its base. . . . The front of a shotgun may be pierced in many ways. It may have one or two doors, a door and window, or a door and two windows. The arrangement of openings can be balanced or asymmetrical. The vertical or lateral doubling rules can both be used in shotgun houses, although when the vertical option is followed, it is only used for [the rear] portion of the house.[123]

This theory summarizes a potential process for shotgun house design, however as stated earlier, its design is primarily driven by historical and cultural evolution.

# shotgun house design process




the 4 shotgun types have units that are both square and rectangular

the 4 shotgun types are both linear and open ended

the 4 shotgun types are ONLY 3 dimensional

the 4 shotgun types ONLY have a roof axis that runs parallel to the house

the 4 shotgun types may have a central chimney or no chimney

ONLY the single and single camel-back shotgun styles may have side chimneys

doubling a single shotgun creates a double shotgun, where two side chimneys would merge centrally

doubling a single camel-back creates a double camel-back, where two side chimneys would merge centrally

*fig. 83: Shotgun House Design Process*

*fig. 84: An Elevated Double Shotgun House*

PERMANENT STATIC ELEVATION +
LOSS OF NEIGHBOURHOOD CULTURE:

The current flood mitigation strategy recommended by the United States federal government agency FEMA for residential neighbourhoods is permanent, raised static elevation. The BFP provides a form of flood mitigation that is an alternative to that by offering a culturally supportive solution that promotes the authentic restoration of shotgun residences in New Orleans Through retrofitting existing shotgun residences with the proposed buoyant foundation system, houses will remain close to street level, preserving the original neighbourhood character. Permanent static elevation destroys neighbourhood character by elevating houses off street level, thus removing the close relationship between the front porch and the street (fig. 84). The ability for residents to sit on the front porch and talk to their neighbours as they pass by on the street is compromised. The porch is no longer a place of social encounter, which is a major cultural driver in traditional New Orleans neighbourhoods. The BFP is a solution that preserves the original neighbourhood character by allowing houses to remain close to street level.[124]

English recounts the neighbourhood character of the Lower Ninth Ward before Katrina. She states:

> [W]hat developed in these neighborhoods was a very, very, very strong sense of community. The neighbors on the block became like a little village, raised each other's children, and went to each other's house for food all the time. I hear about the kids growing up, and whosever house they were, wherever they were at dinner time, that's where they ate dinner, because it was all like one big family. When these neighborhoods were first settled, the people who built the houses usually gave the houses to their children and then if they had more than one child who wanted to live nearby, then they would buy a house that became available on the block. There would be whole families that lived very close to one another. So, there is a very, very strong sense of community that developed that I think is related to the form of the shotgun house, and that that's why the vernacular architecture and the culture that evolved there is unique.[125]

The goal of the BFP is to aid in the restoration of the Lower Ninth Ward, in a way that will allow for these tight-knit communities to form once again. "The strong sense of community at the heart of New Orleans cultural life is a direct response to an absence of privacy in a shotgun house that serves to foster social interaction, both within the house and among the houses in a neighborhood of shotguns,"[126] English suggests. She believes that one of the fundamental aspects about New Orleans, particularly the Lower Ninth Ward, is the shotgun house and the culture that developed in these neighbourhoods.

# 03 V summary

This chapter has focused on physical and cultural aspects of the context in which the Buoyant Foundation Project (BFP) will be implemented.

The chapter began with the post-Katrina situation and discussed the slow recovery in the Lower Ninth Ward neighbourhood in comparison to other neighborhoods in New Orleans, due in part to diaspora, due in part to abnormally slow restoration of services.

The cultural vibrancy and significance of this particular neighbourhood prior to Katrina was then discussed, highlighting its strong sense of community and "place." Homeownership was high, and residents have expressed a strong desire to return to their former neighbourhood and resume their lives. Additionally, research demonstrated that after Katrina the homes of the Lower Ninth Ward were in large part repairable. The BFP is a flood-mitigation solution that could best fulfill residents' wishes and facilitate the restoration of shotgun housing.

The Lower Ninth Ward is an extremely tight-knit neighbourhood, which was cultivated by a particular housing typology: the New Orleans shotgun house. The general lack of interior privacy created by the absence of separated circulation space, coupled with the utilization of the front porch as a social realm, has fostered a culture of social interaction. In addition, the modest spatial configuration forces utilization of all available space, including the exterior spaces. The porch serves as an extension of the living room, where it becomes a space for neighbourhood encounters and social interaction.

The BFP enables the authentic restoration of the Lower Ninth Ward, where houses sit close to the ground, retaining the relationship of resident to street thus reinforcing the unique social culture of this neighbourhood and ultimately restoring its sense of place.

The following chapter will give a thorough overview of a "solution" to the challenges discussed in the previous chapters. The BFP will be explained in detail, giving a chronology of the project's evolution to date and highlighting the major milestones in the project's development.

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# 04

# the buoyant foundation project: a solution

# 04 i

# a solution: the buoyant foundation project

Chapter four discusses the Buoyant Foundation Project (BFP) as a solution to the challenges outlined in Chapters Two and Three. The BFP was conceived as an alternate flood mitigation strategy for shotgun homes, which are a common housing typology in the Lower Ninth Ward of New Orleans. The BFP is currently the only strategy that simultaneously resolves the technical, safety, and socio-cultural aspects of flood protection. It is the goal of the BFP to provide the Lower Ninth Ward with safer and more flood-resilient homes while protecting the culture and way of life.

This chapter begins by introducing the mission of the BFP and then discusses why it is a more effective flood-protection solution than permanent static elevation. A diagrammatic streetscape is provided, comparing non-elevated homes, permanently elevated homes, and homes on buoyant foundations during a flood. This illustrates the BFP's efficacy. A thorough review of the BFP's components is then given, and it is explained how the system operates during dry and flooded conditions. This is followed by a brief discussion of a shotgun house at 1315 Lamanche Street in the Lower Ninth Ward, New Orleans, that maybe available to the BFP to retrofit with a buoyant foundation. The role of FEMA and the NFIP is then discussed. A summary of FEMA's interaction with the BFP throughout the evolution of the project from 2007 to the present is provided.

The chapter concludes with a brief review of government policy, which further explains the involvement of FEMA and the NFIP with the BFP.

# 04

# ii

## a solution: project

DEFINITION OF BUOYANT FOUNDATIONS

Elizabeth English founded the Buoyant Foundation Project (BFP) in 2006 as a non-profit research initiative. According to English:

> The mission of the BFP, founded in 2006, is to support the recovery of New Orleans' unique and endangered traditional cultures by providing a strategy for the safe and sustainable restoration of traditional housing. Flood-proofing the city's traditional elevated wooden shotgun houses by retrofitting them with buoyant (amphibious) foundations avoids the destruction of neighborhood character that results from permanent static elevation high off the ground. Buoyant foundations provide increased safety and resilience in cases of extreme flooding and support the restoration of both the physical and the social structures of pre-Katrina New Orleans neighborhoods.[127]

The BFP is the first modern engineered initiative for retrofitting existing shotgun houses in order to preserve a culturally significant housing type in New Orleans. The flooding caused by failure of the hurricane protection system proved government measures to be inadequate. Homeowners in low-lying areas in South Louisiana are required to elevate their homes to comply with the new Advisory Base Flood Elevations (ABFEs). This concept is discussed in greater detail later in this chapter. The United States federal government is recommending that homeowners in particular areas permanently raise their homes, in some cases 12-15 feet above street level, to protect their homes from flooding.[128]

English comments:

> Permanently elevating houses . . . may be FEMA's solution to the problem of flooding but it creates new problems, such as difficult access to living areas, loss of neighborhood character and increased vulnerability of the structure to wind damage. With permanent static elevation, even if a house is raised to the BFE or higher, it can still flood in an extreme event. In the meantime, residents must live with daily inconvenience and a reduced quality of life in the hope of avoiding flooding in a future event that is statistically very rare indeed.[129]

In response to the catastrophic flooding in New Orleans and the new BFE legislation, English sought an alternative solution. She conceived of the BFP as a solution that would enable homes to rise during flooded conditions but remain at street level under normal conditions, allowing residents to maintain their former way of life and preserving the character of their neighbourhoods. English founded the BFP as an initiative to aid in the authentic recovery of New Orleans and to support the restoration of the traditional ways of life in New Orleans that were disrupted by Katrina.[130]

English defines a buoyant foundation as:

> [A] buoyant foundation is a type of amphibious foundation that is specially designed to be retrofitted to an existing south Louisiana shotgun house. It allows the house to sit just above the ground like a normal elevated house under normal conditions, but to rise up and float safely on the water when there is a flood. It has a structural subframe that attaches to the underside of the house and supports the flotation elements, or buoyancy blocks. Extensions of the structural subframe attach to the tops of vertical guidance poles near the corners of the house that telescope out of the ground to provide resistance to lateral forces from wind and flowing water. When flooding occurs, the flotation blocks lift the house, with the structural subframe transferring the forces between the house, blocks and poles. The vertical guidance poles keep the house from going anywhere except straight up and down on top of the water.[131]

Figures 85 and 86 depict a house on a buoyant foundation under normal conditions and during flooded conditions. During normal conditions the house sits at a height only slightly above its pre-katrina elevation, and during a flood it simply floats up to whatever height is necessary, up to a maximum of perhaps 25 feet.[132]

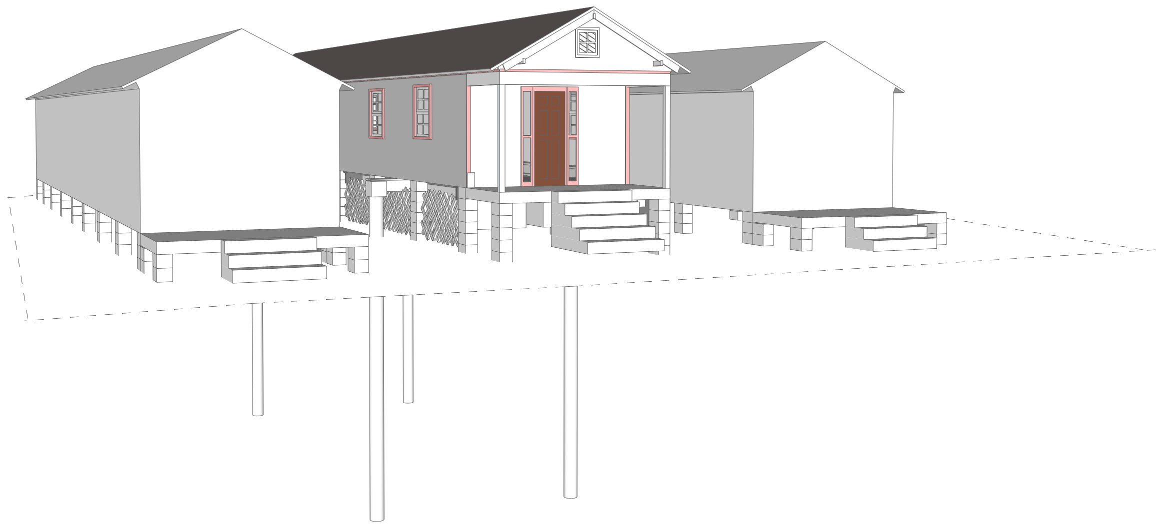


*fig. 85: Shotgun House on Buoyant Foundations - Normal Position*

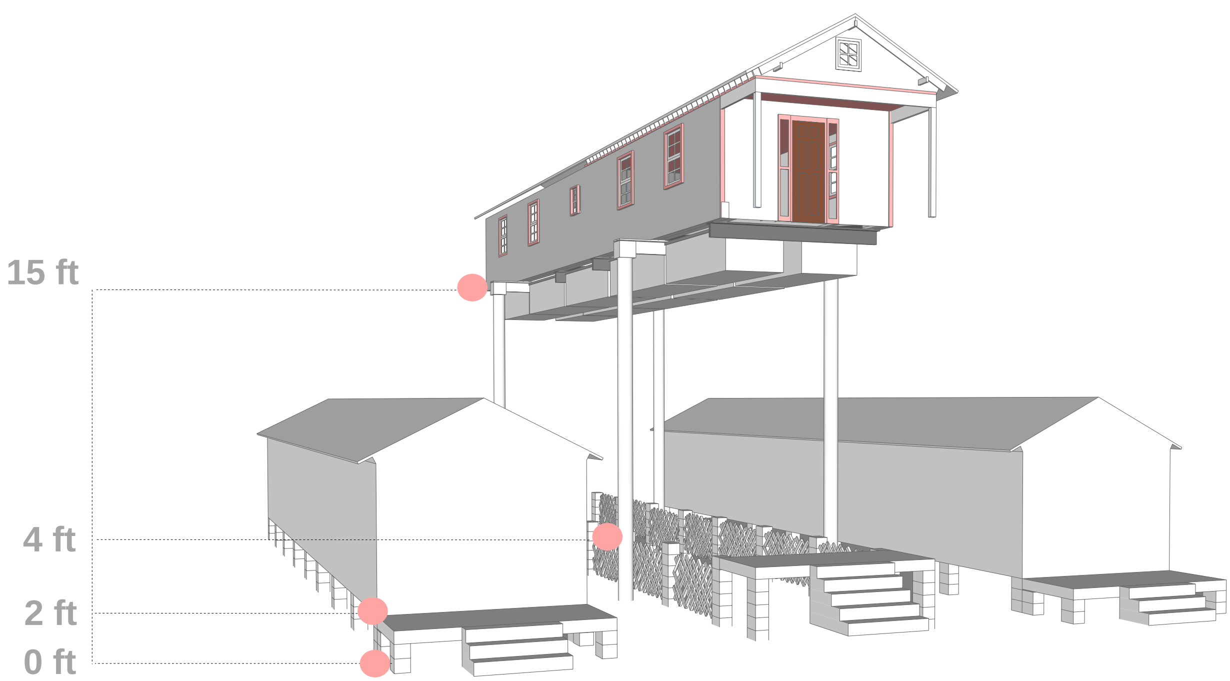



*fig. 86: Shotgun House on Buoyant Foundations - Extended Position*

WHY USE BUOYANT FOUNDATIONS

The BFP is the only flood mitigation strategy that simultaneously resolves technical, safety and socio-cultural issues. Currently, the flood-protection method recommended by FEMA and the NFIP is permanent static elevation. This strategy disrupts neighbourhood character and way of life by removing the front porch from its close relationship to the street. Permanent static elevation is insufficient protection in extreme flooding.[133] Other significant problems with permanent static elevation include:

- *Permanent static elevation is much more expensive than installing a buoyant foundation.*

- *Access is difficult due to the increased number of stairs needed to reach the elevated home. This is inconvenient for daily use and is problematic for elderly & disabled.*

- *There is greater risk of wind damage in a future hurricane.*

- *It creates a "gap-toothed" effect in the neighborhood streetscape where houses are raised to varying elevations depending on the owner's choice of height.*

- *Homes lose relationship to the street by being raised high above street level.*

- *There is loss of neighborhood character due to the varying elevations of each house and separation of porches from street level.*[134]

Figures 87 is a diagram that displays three identical single shotgun houses during flooded conditions: before static elevation, with static elevation, and using a buoyant foundation. The house on the buoyant foundation is the only house that is protected from extreme flooding. Figure 88 is a diagram that draws a comparison of three possible streetscapes, where the streetscapes illustrate flood conditions i) before static elevation; ii) with static elevation; and iii) using buoyant foundations. The houses in the pre-Katrina scenario, close to street level with little flood protection, are inundated. Some of the houses that are permanently elevated are flooded, illustrating that this solution is not always effective since flood levels may exceed elevation height. Aesthetically, the statically elevated streetscape is visually undesirable because of its "gap-toothed" effect of mismatched building heights.[135] Conversely, the BFP offers an alternative solution that adapts to changing water levels, ultimately providing the homeowner with a safer, more reliable form of flood protection. The major advantages of using a buoyant foundation compared to permanent static elevation are that:

- *It facilitates restoration instead of demolition and new construction, which promotes energy conservation, economic growth, and socio-cultural sustainability.*

- *The house remains close to the ground under ordinary non-flood circumstances.*

- *It elevates a house to exactly what is required to stay above water, even if the flood level is high above BFE.*

- *In a high wind event, with no flooding, it remains close to the ground and is therefore less susceptible to hurricane wind damage.*

- *It alleviates loss of elevation due to soil subsidence and elevated sea level.*

- *The house looks essentially the same as before Katrina.*

- *The original traditional architecture is preserved .*

- *The neighbourhood retains its original character.*[136]

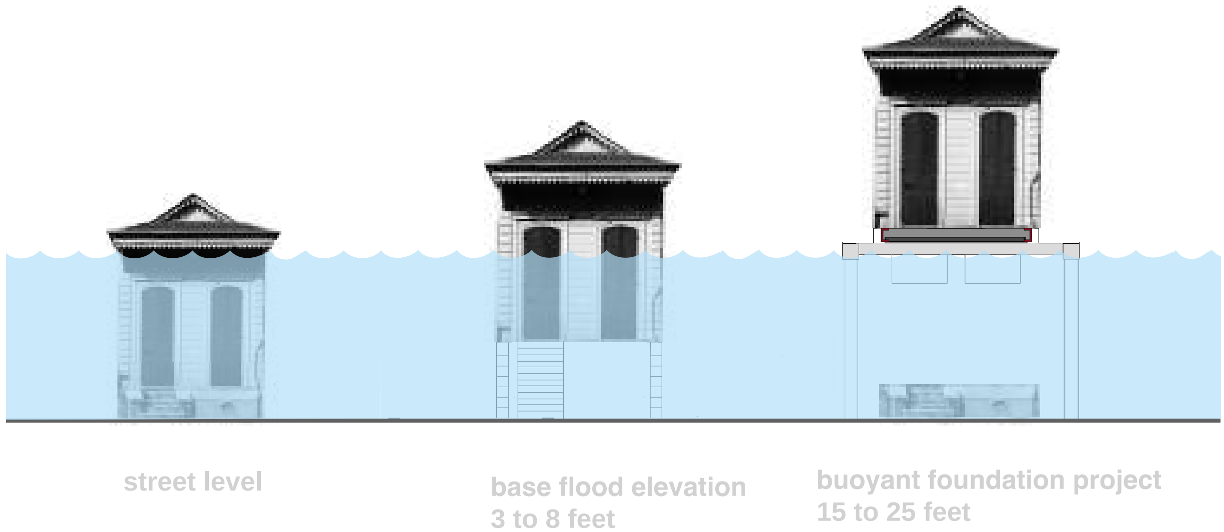



*fig. 87: Static Elevation versus Amphibious Foundations During a Flood*

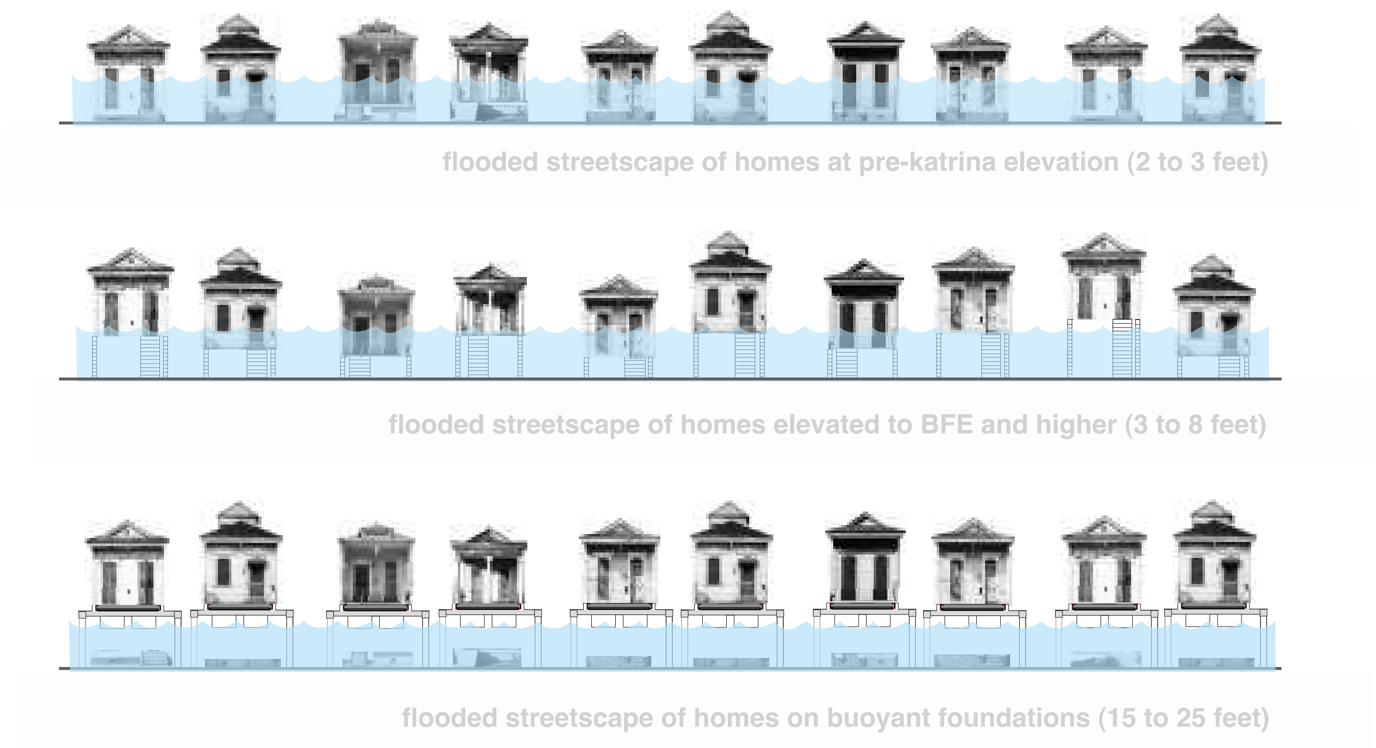



*fig. 88: Streetscape Comparison Diagram During a Flood*

HOW IT WORKS

Elizabeth English discusses how a floating dock can inform the BFP when designing a passive floating structure. She states:

> A look at floating docks [fig. 89] and houseboats suggests that there may be an alternative approach [to permanent static elevation], one that would allow a house to remain close to the ground under normal conditions but rise as much as necessary, even if far above the BFE, when flooding occurs.[137]

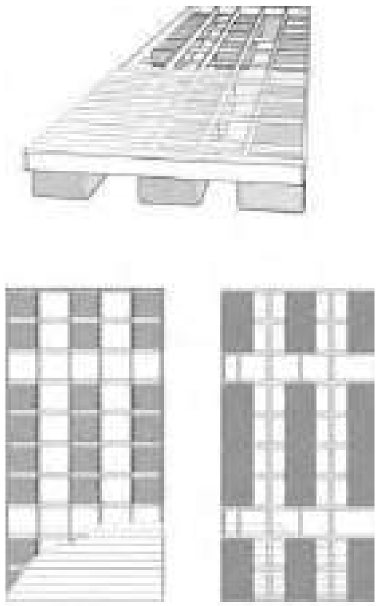


*fig. 89: A Floating Dock System*

English further explains how buoyant foundations work:

> It basically works like a floating dock. A steel frame that holds the flotation blocks is attached to the underside of the house. There are four 'vertical guidance' posts not far from the corners of the house. The tops of the posts are attached to the steel frame. The posts telescope out of the ground, allowing the house to move up and down. Utility lines have either self-sealing 'breakaway' connections or long, coiled 'umbilical' lines. When flooding occurs, the flotation blocks lift the house, with the steel frame transferring the forces between the house and the blocks. The vertical guidance posts keep the house from going anywhere except straight up and down on top of the water. The entire system works completely passively. After the buoyant foundation system has been installed, the house remains supported on its original piers except when flooding occurs.[138]

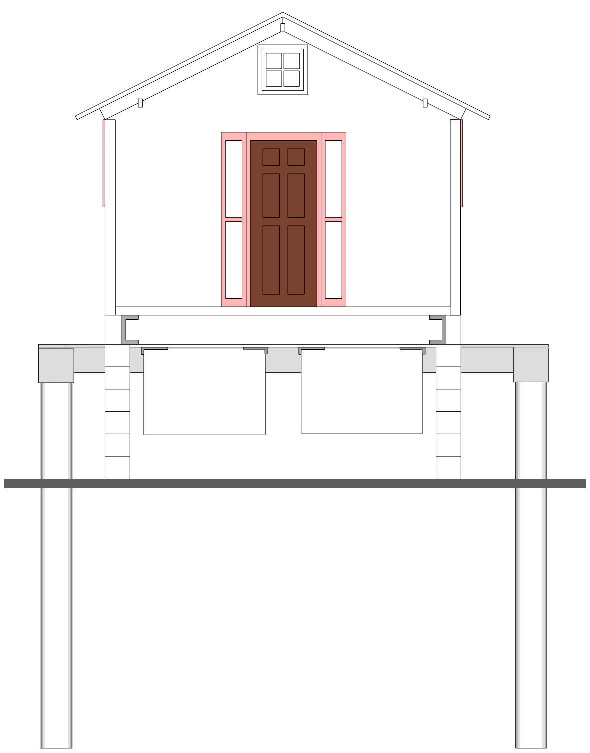


*fig. 90: BFP Section*

Buoyant foundations work passively by adapting to changing water levels during a flood. The major components that make up this system are flotation blocks, telescoping vertical guidance posts, structural subframe and self-sealing or umbilical connections for utilities. Figure 90 is a sectional drawing of a shotgun house with a buoyant foundation installed, showing the buoyancy blocks under the house and the vertical guidance posts that telescope out of the ground. Figure 91 is an exploded axonometric drawing of a shotgun house with buoyant foundations installed, exposing and identifying the major components of the system.

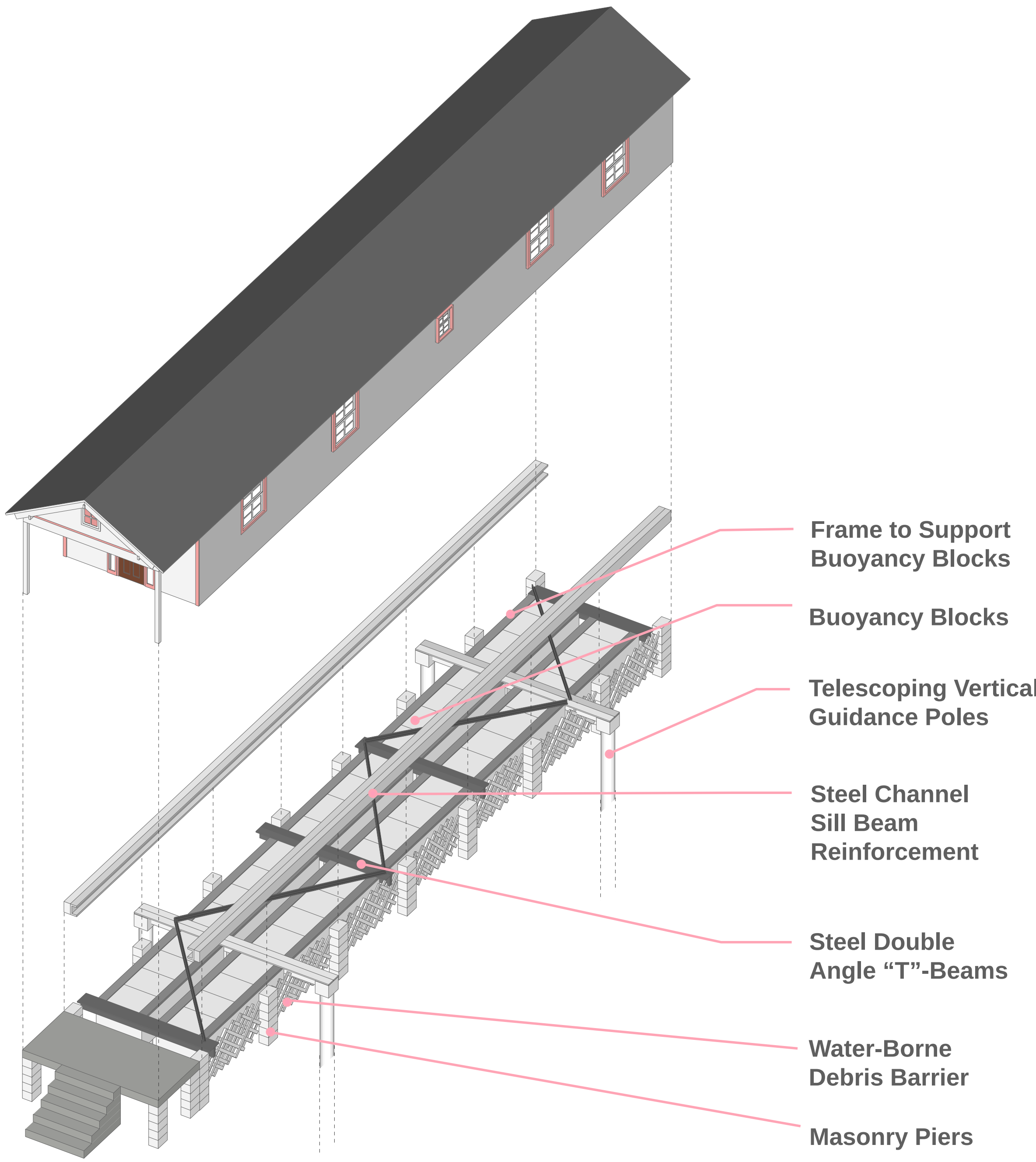



*fig. 91: Buoyant Foundation System, Exploded Axonometric*

# prototype house for possible retrofit with BFP

## site: 1315 lamanche street
## lower ninth ward
## new orleans

*fig. 92: 1315 Lamanche Street, Shotgun House*


*fig. 93: Aerial View of 1315 Lamanche Street*


north villere
north villere
lamanche street
1315
lamanche street
lamanche street
urquhart street
charbonnet street

## 1315 LAMANCHE STREET

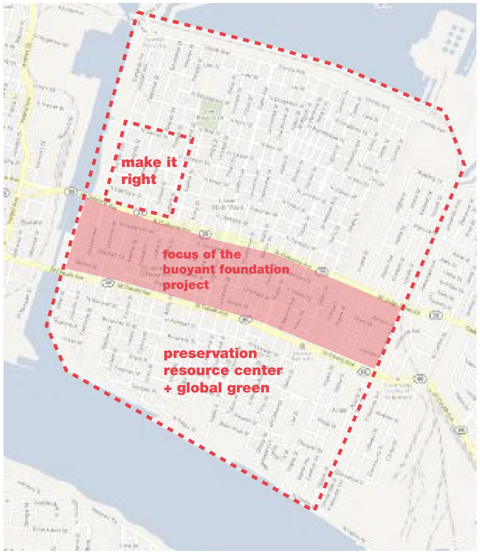



*fig. 94: Three Areas of Focus of Aid Organizations in the Lower Ninth Ward*

Three areas have been identified in the Lower Ninth Ward (fig. 94) where aid organizations are concentrating their efforts. Make It Right (MIR) has concentrated its efforts on rebuilding in the northern portion of the Lower Ninth Ward, north of North Claiborne Avenue.[139] In the southern portion, south of St. Claude Avenue, the Preservation Resource Center (PRC) and Global Green are providing assistance to help residents rebuild housing authentically and to preserve the neighbourhood's cultural heritage.[140] Neighbourhoods to the north and south are being helped, but the "middle zone" south of North Claiborne Avenue and north of St. Claude Avenue has been neglected. This area has been selected by the BFP because there is an abundance of recoverable shotgun houses that could be suitable for retrofit with buoyant foundations. In 2007, planners found that "more than 80% of the Ninth Ward structures suffered no terminal structural damage."[141]

*fig. 95: Conceptual Rendering of 1315 Lamanche Street, Existing Condition, Three-Quarter View*

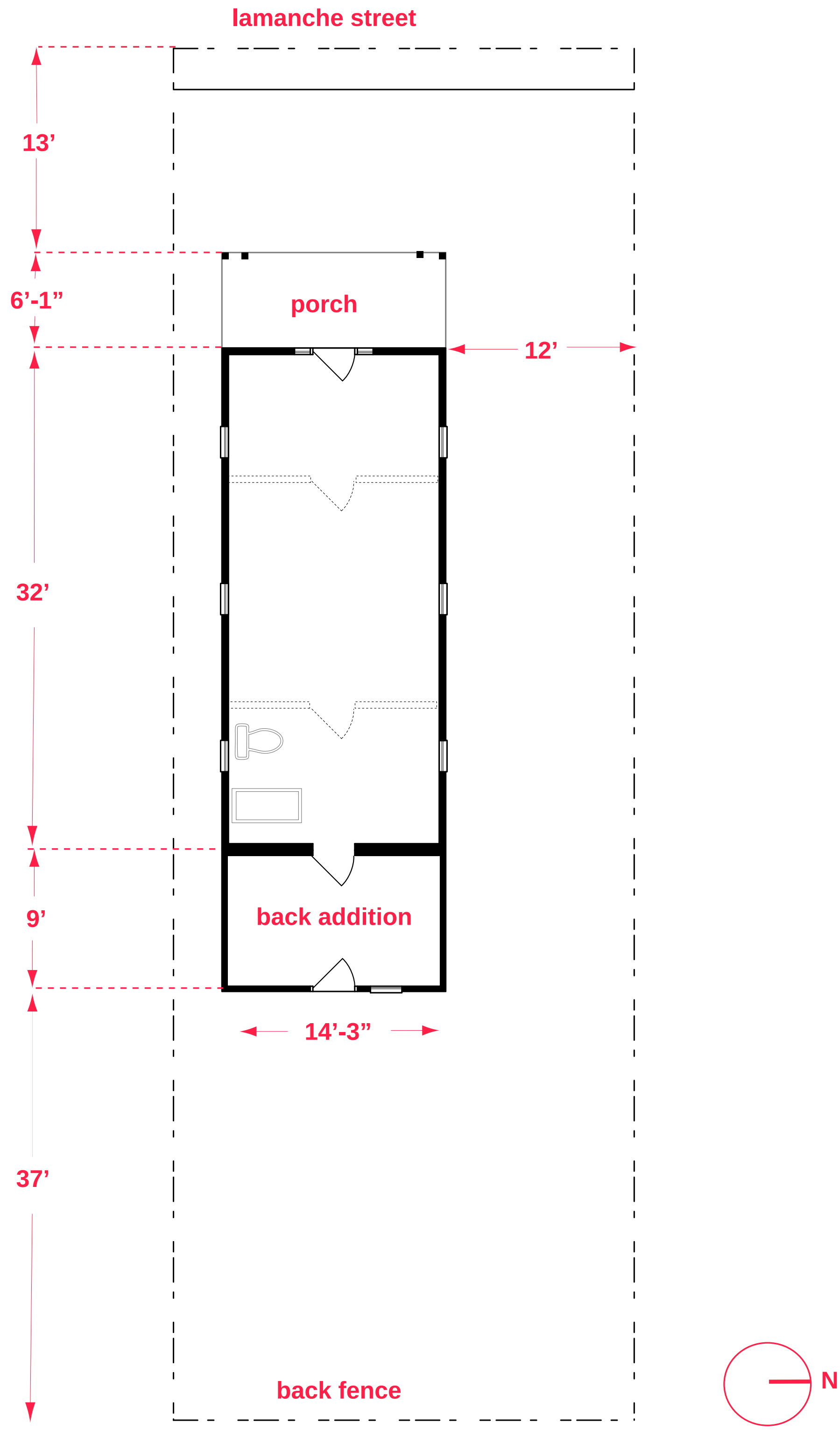
The BFP has access to a shotgun house at 1315 Lamanche Street (fig. 92, 93) and may use it to retrofit with a buoyant foundation. 1315 Lamanche Street is situated south of North Claiborne Avenue and north of St. Claude Avenue in the "neglected" portion of the Lower Ninth Ward. Figures 95-98 are renderings of the existing house at 1315 Lamanche Street. They were created by graduate student Andre Arseneault at the University of Waterloo, School of Architecture, for the course ARCH 684-016, entitled "Amphibious Architectures: The Buoyant Foundation Project and Alternative Flood Mitigation Strategies in Post-Katrina New Orleans," held at the University of Waterloo School of Architecture in the spring term of 2009. Figures 99 and 100 were transcribed from sketches and photos provided by Elizabeth English and Ezra Boyd. They show a plan and elevation drawing with approximate dimensions of the shotgun house at 1315 Lamanche Street.

*fig. 96: Conceptual Rendering of 1315 Lamanche Street, Existing Condition, Back View with Addition (to be removed)*

As mentioned in previous sections, the Lower Ninth Ward, because of its proximity to the Industrial Canal levee breach, was one of the most severely damaged neighbourhoods in New Orleans.[142] The slow restoration of utilities inhibited FEMA trailer placement, causing a lag in rebuilding and restoration in the Lower Ninth Ward behind other neighbourhoods. Poverty, the scale of the devastation, government policies, and inaction were also contributing factors.[143] The BFP aims to help the Lower Ninth Ward recover by providing a reliable flood mitigation strategy to homeowners so that they may feel safe to return to their former residences.

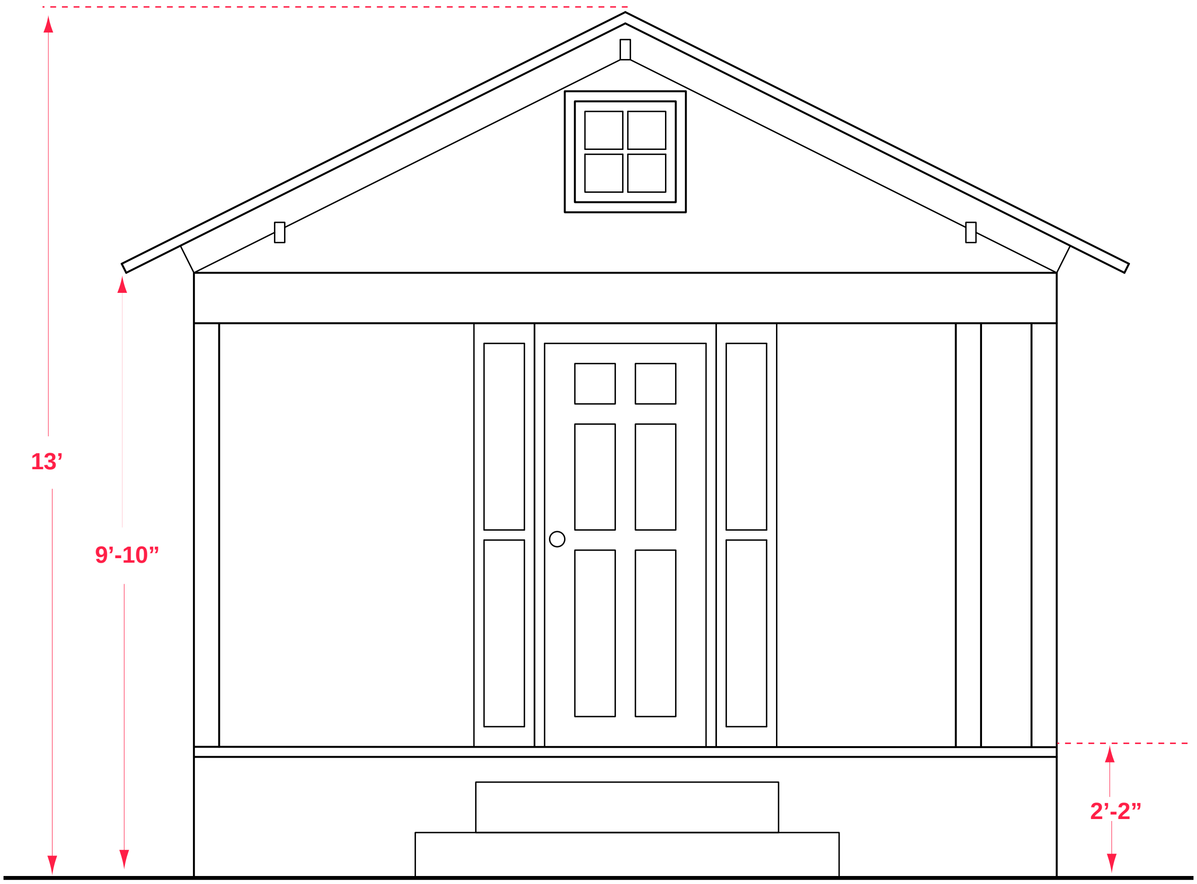
*fig. 97: Conceptual Rendering of 1315 Lamanche Street Retrofit with the Buoyant Foundation System*

*fig. 98: Conceptual Rendering of 1315 Lamanche Street Retrofit with the Buoyant Foundation System, Fully Extended*




# 1315 lamanche street - plan

*fig. 99: 1315 Lamanche Street, Plan*




# 1315 lamanche street - elevation

*fig. 100: 1315 Lamanche Street, Elevation*

# 04

# iii

# a solution: policy

ROLE OF FEMA + THE NFIP

In 2007, Elizabeth English received a letter from Ross Richardson, Branch Chief of DHS/FEMA (fig. 101) expressing his concerns that the Buoyant Foundation Project was not in compliance with NFIP regulations. Richardson states, ". . . the local floodplain management regulations must be met in order for the entity to continue to participate in the NFIP. Communities/parishes must issue permits with the proper requirements whether it is NFIP related or other building code requirements. . . . We have concerns about a concept being promoted and publicized that would jeopardize a community's good standing in the NFIP."[144]

In 2008, other negative reaction by the Louisiana Home Builders Association was voiced on a televised interview with Jon Luther, executive vice president of the local home builders association, as part of a Fox News broadcast about the BFP (see page 455 in appendices for the full broadcast entitled, "The Buoyant Foundation Project Movie"). Jon Luther stated that strict new codes were established for rebuilding homes demolished or damaged after Katrina. Homes must be elevated off the ground, and he said that floating homes would not fit that criterion. He observes, "I would venture to say that FEMA and the NFIP would have a very hard time evaluating a house that's floating on water to know whether or not it would be a good risk to insure for flood insurance" (appendices, 455). English responds that since there has been no precedent for this in the United States, it is no surprise that FEMA, the NFIP and the ICC are reluctant to accept this new method.[145]

In spring 2009, the BFP proposed a two-phase installation sequence to satisfy the objectives of FEMA and NFIP. Phase 1 complies with NFIP regulations that call for buildings to be "properly elevated and meet specific foundation and anchoring requirements." Phase 2, conversion to a Buoyant Foundation by adding buoyancy and vertical guidance, could be installed at a later time, after completing a thorough testing program leading to the granting of compliance. The separation of installation into these phases resolved issues with FEMA, whereby phase 1's 'Non-Permanent Static Elevation to BFE' adequately addressed Ross Richardson's concerns.[146]

Bhola Dhume, deputy director of the Department of Safety and Permits for the City of New Orleans, encouraged English to go ahead with the project's two-phase installation strategy. He also encouraged marketing the project as a more economical approach than permanent static elevation. Nelson Savoie, acting chairperson of the City of New Orleans Department of Safety and Permits, also agreed that if the project met BFE requirements, and was adequately supported on a code-compliant foundation, then it could be permitted by the City of New Orleans.[147]

In fall 2009 MIR's FLOAT House was completed in the Lower Ninth Ward. The completion of an amphibious house in the Lower Ninth Ward would suggest that FEMA made the choice not to discourage MIR from constructing the project. MIR's FLOAT House employs an amphibious foundation and is the first such house in the United States to receive an occupancy permit. The FLOAT House complies with the building code in the two areas of concern to FEMA: the house meets BFE requirements under static conditions; and it is supported structurally under static conditions in a way that meets all local codes.[148]

In December 2009, Brett Schweinberg, a writer for the Tri-Parish Times Newspaper, conducted an interview with Earl Armstrong, a public information officer for FEMA, regarding his views on buoyant foundations after the FLOAT House had been built and occupied (appendices, 340), (fig. 102, 103). Schweinberg reports on his contact with Armstrong regarding NFIP approval of buoyant foundations. Armstrong states, "Depending on the type of structure, different National Flood Insurance Program (NFIP) regulations may apply as to the eligibility for flood insurance coverage for floating structures. There may be circumstances where a structure that is primarily land-based, but was built on platforms to allow for sporadic flotation, could be ruled eligible for flood insurance. In such cases, however, several entities may share a role

*LETTER FROM FEMA, Friday, September 28, 2007*

*Dr. English:*

*Thanks for your time this morning discussing this concept and LSU's involvement in promoting it per the website, www.buoyantfoundation.org. As discussed, we have major concerns that this type of development does not meet minimum National Flood Insurance Program (NFIP) criteria (44 CFR Part 60.3) in which local governments must adopt in order to participate in the program and make flood insurance available.*

*You stated that you were aware that "the concept is not approved by FEMA" and that flood insurance would not be available. As we discussed, the local floodplain management regulations must be met in order for the entity to continue to participate in the NFIP. Communities/parishes must issue permits with the proper requirements whether it is NFIP related or other building code requirements.*

*Structures, as defined in the local floodplain management ordinance, must be properly elevated and meet specific foundation and anchoring requirements. Requirements will vary depending on the specific site situation. These requirements and NFIP supporting information can be found on our website, www.fema.gov.*

*We have concerns about a concept being promoted and publicized that would jeopardize a community's good standing in the NFIP. With that in mind, I would highly recommend that LSU withholds any information to the public until the recommended concept meets all local regulatory requirements.*

*Sincerely,*
*Ross Richardson*

*Ross K Richardson CFM*
*Branch Chief*
*DHS/FEMA RVI-IM-CM*
*800 N. Loop 288*
*Denton TX 76209*
*(940) 898-5210 office*
*(940) 368-6972 cell*
*(940) 898-5195 fax*
*ross.richardson@dhs.gov*
*Be FloodSmart, go to www.floodsmart.gov or www.fema.gov*

*fig. 101: Letter from FEMA, Friday September 28, 2007*

in deciding whether such a structure can [be] covered by flood insurance."[149]

Armstrong points out that although FEMA and the NFIP may chose to allow houses on amphibious foundations if they meet the BFE of three feet under static elevation, it is also up to the community to decide if the structures meet building code and floodplain management requirements to issue a building permit. Armstrong adds that there may be additional costs for structures on floatable foundations, and the insurance premium may be exceptionally high. These factors may be deterrents, but are not impossible to overcome. MIR was able to obtain a building permit for the FLOAT House which is in a community adjacent to the area of focus for the BFP.[150]

The Association of State Floodplain Managers (ASFPM) 34th Annual National Conference was held on May 16-21, 2010, in Oklahoma City. During the conference, English met with several FEMA representatives, who cautiously agreed that the implementation of amphibious foundations could be allowed as long as they met all BFE and local code regulations and had the support of the local department of permits and safety. This was not only a significant advancement since the BFP's first conversation with FEMA in 2007; it was, in fact, a major breakthrough in the future acceptability of amphibious architecture in the United States. The need for the BFP's two-phase testing program is obviated in light FEMA's acknowledgement of the acceptability of amphibious foundations within a specified set of limits.[151]

*LETTER FROM TRI-PARISH TIMES, Monday, December 14, 2009.*

*Dear Ms. English:*

*We met last week at the make it right house for an interview for the Tri-Parish Times. I'm mailing you from home to let you know what FEMA told me last week. I've attached their email below.*

*From what I gather from their e-mail, you should be a go in the 9th ward to build floating houses as long as they meet the BFE of 3 feet. Any additional flood protection after that is considered gravy, and it sounds like you shouldn't have too many problems. My article explains some of the skepticism and legal issues in my area. The piece will be in print next week and should be online shortly. I'll be sure to send you the link to that once it's up.*

*Thanks again for your time,*

*Brett D Schweinberg*
*b.schweinberg@gmail.com*

*fig. 102: Letter from Tri-Parish Times, Monday December 14, 2009.*

*LETTER FROM FEMA, Friday, December 11, 2009*

*Brett,*

*You had asked about NFIP coverage for floating structures. I hope this information helps.*

*Depending on the type of structure, different National Flood Insurance Program (NFIP) regulations may apply as to the eligibility for flood insurance coverage for floating structures.*

*NFIP regulations specifically exclude buildings located entirely in, on, or over water from flood insurance coverage eligibility, if such structures were constructed or substantially improved after September, 1982.*

*There may be circumstances where a structure that is primarily land-based, but was built on platforms to allow for sporadic flotation, could be ruled eligible for flood insurance. In such cases, however, several entities may share a role in deciding whether such a structure can covered by flood insurance.*

*These include the local community, which may decide that these structures do not meet required building codes or floodplain management requirements to issue a building permit. It can also be the case that, although the structure is eligible to be insured, the actual cost of an insurance premium could be extraordinarily high. This might be the case, for example, with floating structures where the lowest floor elevation of the structure would actually be several feet below the Base Flood Elevation (BFE) that flood insurance rates are partly determined by. In both scenarios, a floating structure, while eligible for flood insurance, may not be able to obtain it for reasons having nothing to do with NFIP regulations.*

*FEMA and the NFIP continue to actively work with our state, local and private sector partners to help protect against the threat of our nation's leading disaster threat, flooding.*

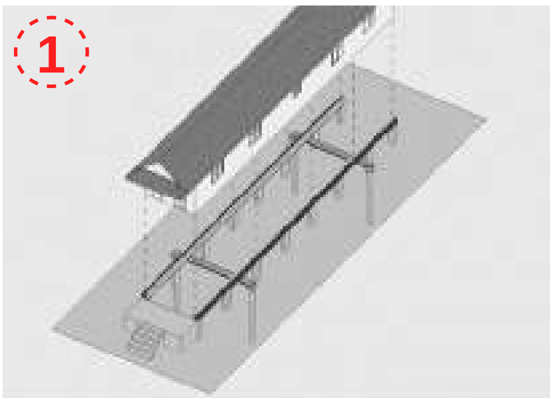
*Earl Armstrong*
*Public Information Officer*
*Federal Emergency Management Agency Region VI*
*800 N. Loop 288*
*Denton, Texas 76209*
*940-898-5275*
*earl.armstrong@dhs.gov*

*fig. 103: Letter from FEMA, Friday December 11, 2009.*

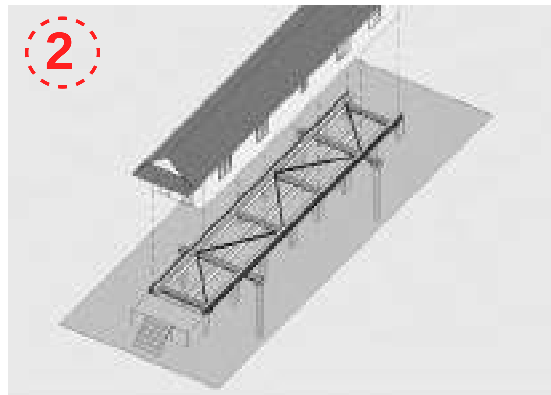
ASSEMBLY STEPS:

Figure 104 illustrates the assembly process for homeowners. As mentioned previously, in spring of 2009, a two-phase testing program was developed to comply with FEMA and NFIP legislation. The first phase included the required components to provide static elevation to the BFE in compliance with FEMA and the NFIP regulations. It did not include components beyond what were required for static elevation to BFE (fig. 105).[152]

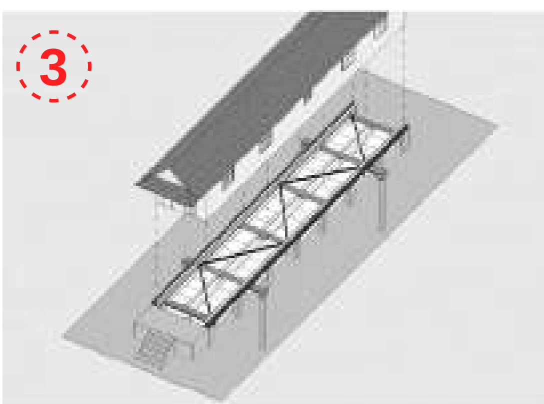
The second phase added the 'amphibious' components, including the addition of the buoyancy blocks, the telescopic guidance posts and modification of utility connections to accommodate the rising and falling of the structure. These are elements that are not necessary for static elevation but allow the house to behave amphibiously (fig. 106). Because of the recent change in FEMA's interpretation, which is that occasional flotation may now be deemed compliant with the NFIP, separation into the two phases will no longer be required.[153]



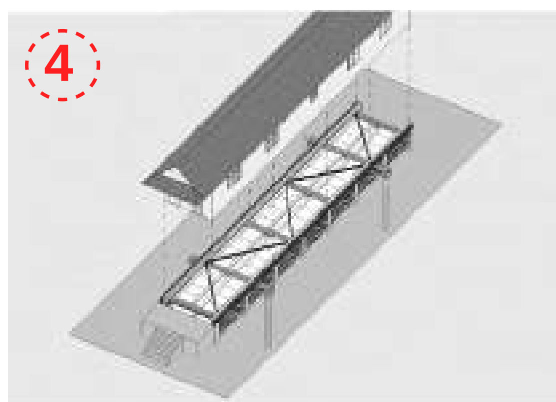

**Put in vertical guidance posts and attach channels to inside surfaces of sill beams**




**Add T-beams and secondary angles to support buoyancy blocks**




**Add buoyancy blocks**




**Add protective screen to keep waterborne debris from settling underneath house**

*fig. 104: Assembly Process*

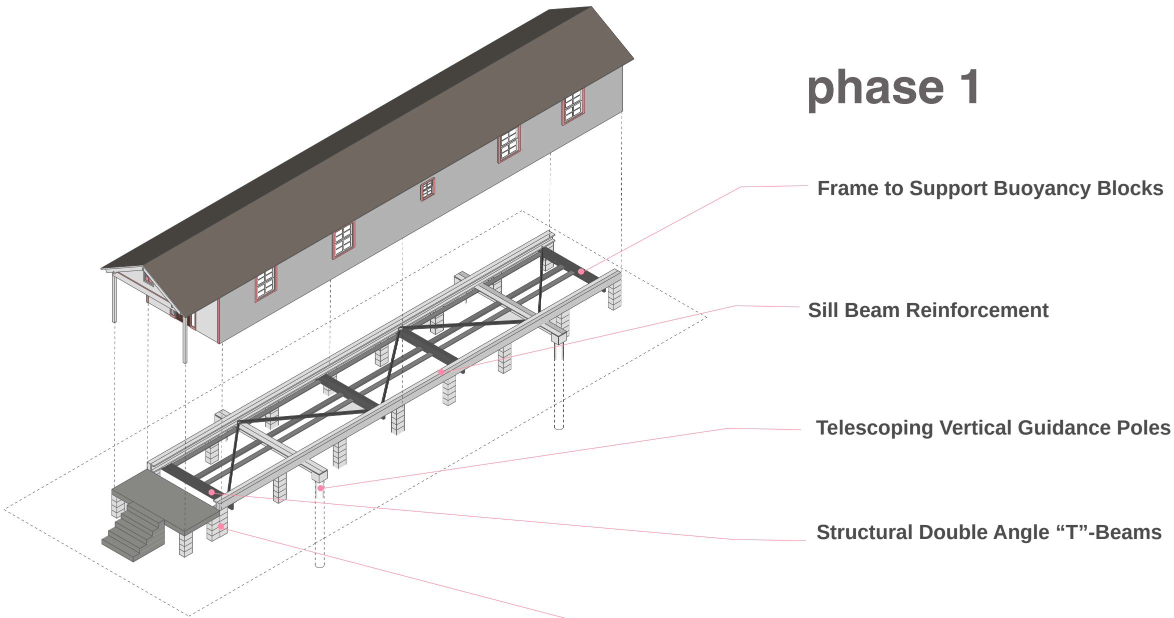



*fig. 105: Components for Static Elevation to BFE, Diagram (Previously Phase 1)*

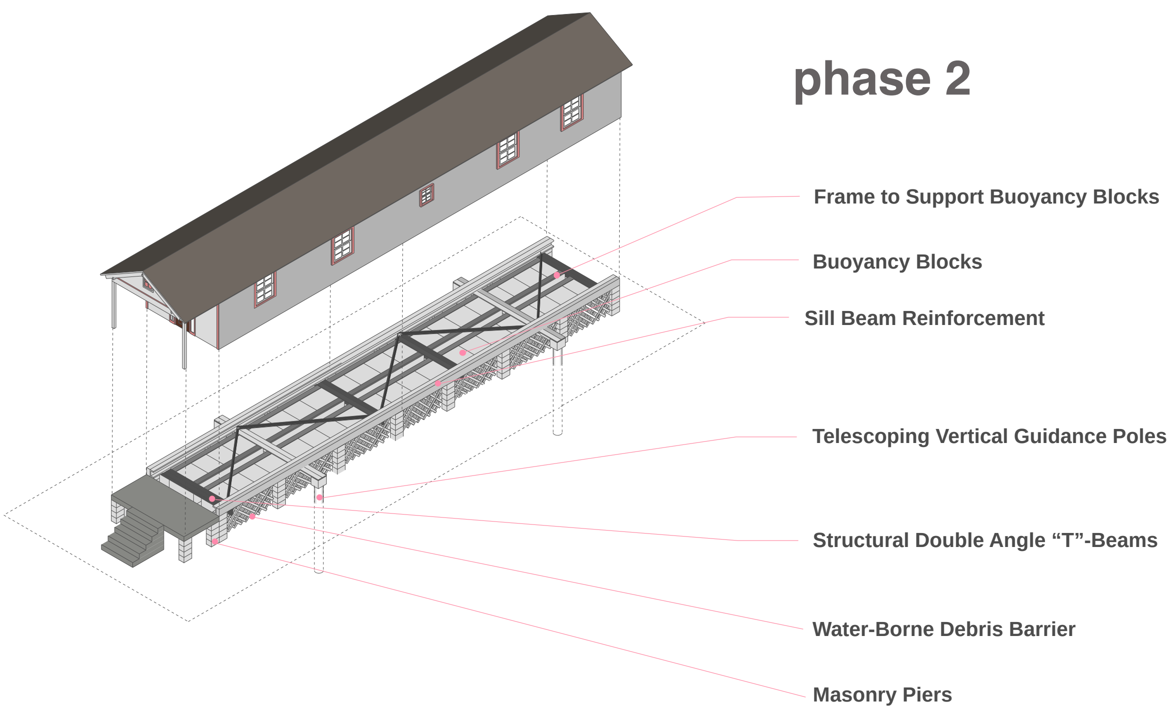



*fig. 106: Addition of Buoyancy Components and Vertical Guidance, Diagram (Previously Phase 2)*

# 04
# iv
# a solution: legislation

*fig. 107: An Elevated House in New Orleans*


*fig. 108: Flood Level Exceeded BFE*


*fig. 109: ABFE Guidance and Levee Sub-Basin Locations for Orleans Parish*

BASE FLOOD ELEVATION

In the aftermath of Hurricane Katrina, new base flood elevations have been recommended for buildings in low-lying areas of South Louisiana. The United States federal government recommends that residents in these areas permanently elevate their homes to comply with these new regulations (fig. 107).[154]

FEMA defines Base Flood Elevation (BFE) as "the computed elevation to which floodwater is anticipated to rise during the base flood. Base Flood Elevations (BFEs) are shown on Flood Insurance Rate Maps (FIRMs) and on the flood profiles. The BFE is the regulatory requirement for the elevation or flood proofing of structures. The relationship between the BFE and a structure's elevation determines the flood insurance premium."[155]

Figure 108 is a photograph of a house in New Orleans after Hurricane Katrina, displaying the flood level and how it far exceeded what was thought to be a sufficient BFE for that neighbourhood.

BFEs are derived from the Base Flood (BF), which is defined by FEMA as "the flood having a one percent chance of being equaled or exceeded in any given year. This is the regulatory standard also referred to as the '100-year flood.' The base flood is the national standard used by the NFIP and all federal agencies for the purposes of requiring the purchase of flood insurance and regulating new development."[156] BF was the original standard used by the NFIP prior to the implementation of BFEs.

ADVISORY BASE FLOOD ELEVATION

Areas that had BFEs prior to Hurricane Katrina now being assigned Advisory Base Flood Elevations (ABFEs).[157] FEMA explains ABFEs as "[a]n interim product (in place of pre-Katrina BFEs) to assist communities in their rebuilding efforts while new Flood Insurance Rate Maps (FIRMs) are being completed. In many areas, the flood elevations caused by hurricanes Katrina and Rita exceeded the BFEs on the current effective FIRMs for the Gulf Coast Parishes of Louisiana."[158] FIRMs were last issued in 1984. Since Katrina, new figures incorporating the last 35 years are being used to calculate new BFEs. Prior to Hurricane Katrina, no base flood elevations or depths were required for the Lower Ninth Ward since it was in a zone protected by levees. However, as Katrina displayed, levees may not always withstand severe inundation.[159] According to FEMA:

> After Hurricanes Katrina and Rita struck the Gulf Coast, FEMA conducted a new flood frequency analysis and determined that the current base flood elevations, or BFEs, for many communities impacted by the hurricane are too low. The analysis took into account data from Hurricane Katrina, as well as additional tide and storm data from other events that have occurred over the past 25 years. . . . ABFEs [fig. 109] are significantly higher than the Base Flood Elevations (BFEs) shown on pre-Katrina flood maps, and extend farther inland than the Special Flood Hazard Areas [SFHAs] on the existing maps.[160]

Figure 110 is an example of map provided by the National Oceanic and Atmospheric Administration (NOAA) in 2006, illustrating an example of storm surge inundation by Hurricane Katrina in Mississippi. Flooding in this area, as with many other areas along the Gulf coast, "extended beyond the limits of the mapped 100-year floodplain [SFHAs]."[161]

Currently, as shown in figure 111, the ABFE for the Lower Ninth Ward is "three feet above the Highest Existing Adjacent Grade (HEAG) at the building site."[162] FEMA defines the HEAG is as "the highest natural elevation of the ground surface prior to construction next to the proposed walls of a structure."[163]


*fig. 110: Flooding Beyond the Special Flood Hazard Area*

According to FEMA, "in order to be eligible for FEMA funding for certain mitigation and recovery projects, communities are required to adhere to the elevation requirements established by ABFEs."[164] The following FEMA programs now require using ABFEs (in addition to NFIP):

1. Public Assistance Grant Program — Provides funds for the repair, replacement and restoration of public facilities.

2. Hazard Mitigation Grant Program (HMGP) — Provides grants to fund mitigation projects after a disaster strikes to enable mitigation measures to be implemented during the recovery process.

3. Flood Mitigation Assistance (FMA) program — Provides grants to mitigate future flood damages for structures insured under the NFIP.

4. Pre-Disaster Mitigation (PDM) program — Awards nationally competitive grants to fund hazard mitigation projects.

5. Executive Order 11988 Floodplain Management — Requires Federal agencies to consider floodplain implications for all Federal construction projects.[165]

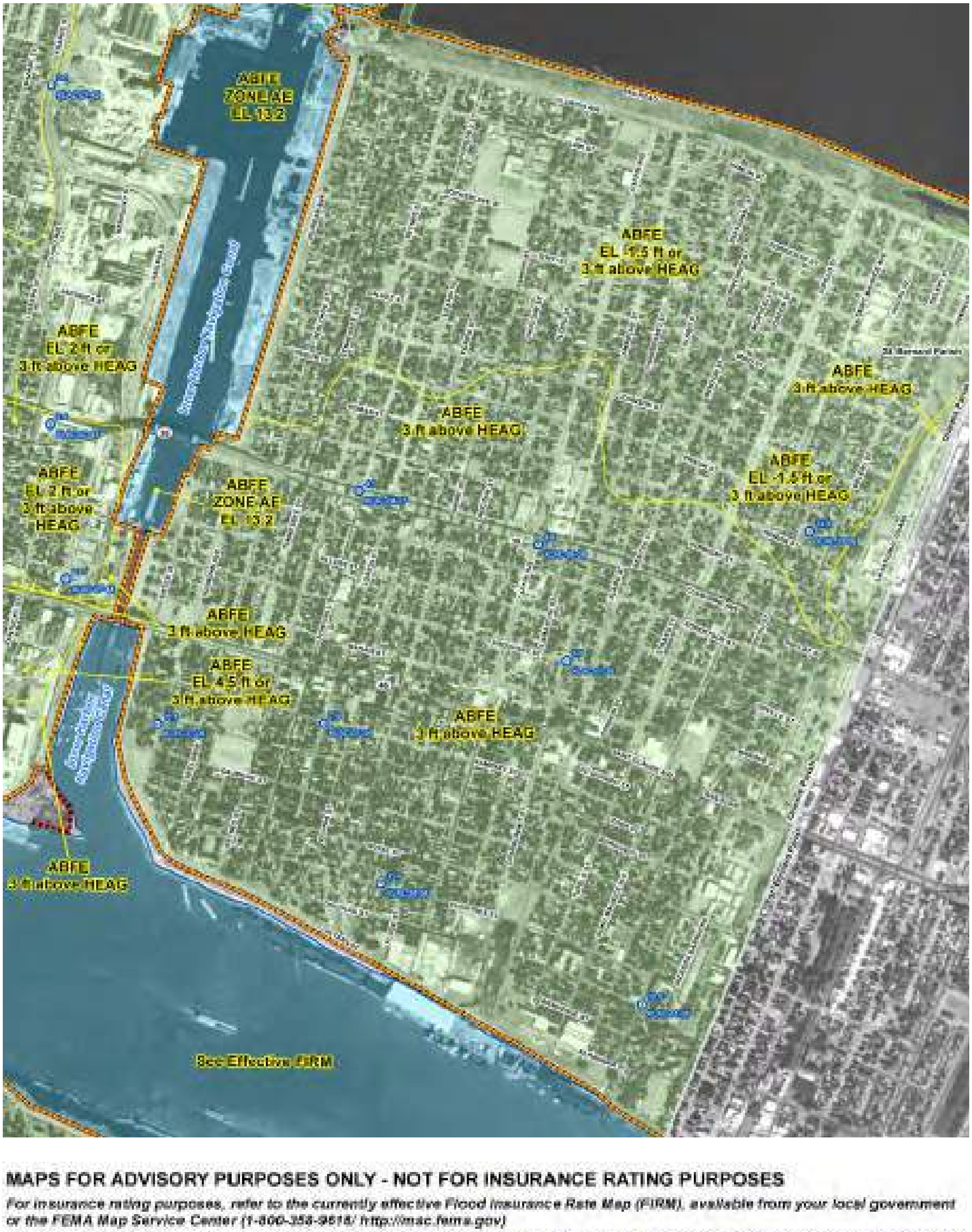
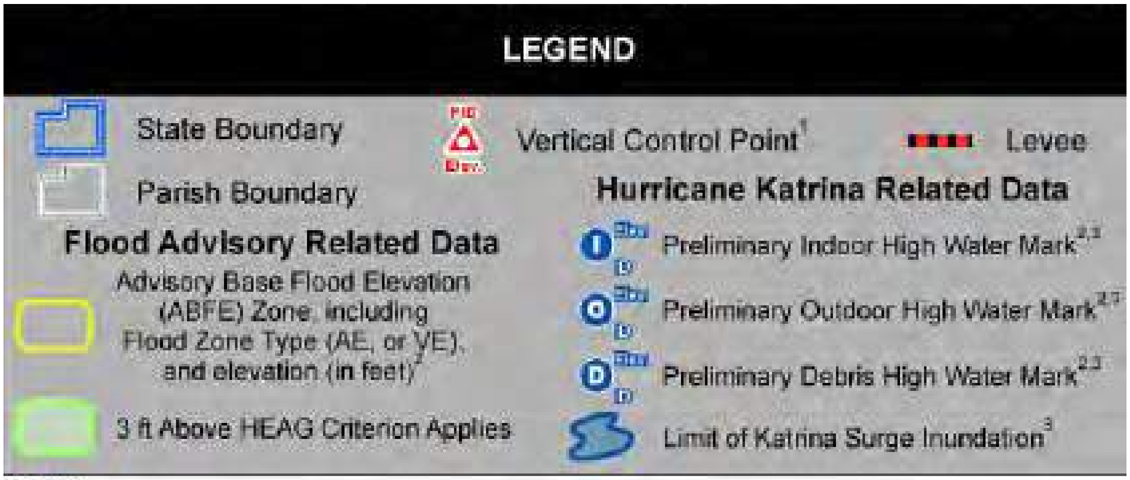



*fig. 111: Hurricane Katrina Surge Inundation and Advisory Base Flood Elevation Map for Orleans Parish, Louisiana*




**Notes:**

[1] Measured in feet relative to the North American Vertical Datum of 1988.

[2] Measured in feet relative to the National Geodetic Vertical Datum of 1929 (NGVD29). To conver of 1988 in Orleans Parish, subtract 0.2 feet.

[3] Inundation limits estimated from surveyed, surge-only High Water Marks. Local wave effects (w these elevations.

## HOW TO READ THIS MAP

In levee-protected areas, **the Advisory Base Flood Elevation (ABFE) to be used for rebuilding at a particular property is the higher of these two options:**

(1) Current, effective Base Flood Elevation (BFE) shown on the community's Flood Insurance Rate Map (FIRM), or

(2) 3 feet above Highest Existing Adjacent Grade (HEAG) at the building site. The HEAG is defined as the highest natural elevation of the ground surface prior to construction next to the proposed walls of a structure.

Using the best-available data, FEMA has mapped the areas of the Parish where each of these two options should be applied:

– **In green-shaded areas**, FEMA recommends that the first floor of the building (including basement) be elevated 3 feet above HEAG at the building site.

– **Outside of green-shaded areas**, FEMA recommends that the first floor of the building (including basement) be elevated at or above the BFE shown on the community's FIRM. FEMA has provided the current BFEs on the map above in yellow and black text (for example, "**EL 1.5 ft**"). The zone or area where each BFE applies is outlined in yellow; these zone boundaries are the same as those shown on the FIRM. If the FIRM does not have a BFE for a particular area, no elevation will be listed on the map above. In those cases, buildings should be elevated to 3 feet above HEAG.

Anywhere in the Parish, the Community Floodplain Administrator may determine a site-specific ABFE rather than rely on the information mapped above. Using detailed topographic data for the site, the Floodplain Administrator can determine what elevation corresponds with 3 feet above HEAG and compare it to the FIRM BFE. Again, FEMA's guidance is that buildings should be elevated to **whichever of those two elevations is higher at the site.**

For more information on how the ABFE guidance was determined for this Parish, please see: ***http://www.fema.gov/pdf/hazard/flood/recoverydata/orleans_parish04-12-06.pdf.***

## FLOOD ZONES

According to FEMA, flood zones are, "geographic areas that the FEMA has defined according to varying levels of flood risk. These zones are depicted on a community's Flood Insurance Rate Map (FIRM) or Flood Hazard Boundary Map [FHBM]. Each zone reflects the severity or type of flooding in the area."[166] FEMA has identified these particular zones for use in the National Flood Insurance Program (NFIP). Each flood zone indicates the degree of flood-risk for that particular land area.[167] Figure 112 shows a FIRM for the Lower Ninth Ward. It indicates that Lamanche Street (the proposed site for a full-scale BFP retrofit in the Lower Ninth Ward) falls under zone B.

## ZONES A and V

FEMA defines flood zones A and V as: "Areas subject to inundation by the 1-percent-annual-chance flood event generally determined using approximate methodologies. Because detailed hydraulic analyses have not been performed, no Base Flood Elevations (BFEs) or flood depths are shown. Mandatory flood insurance purchase requirements and floodplain management standards apply."[168] Zones A and V differ in that Zone V is a coastal area subject to wave action, which is displayed in figure 113.

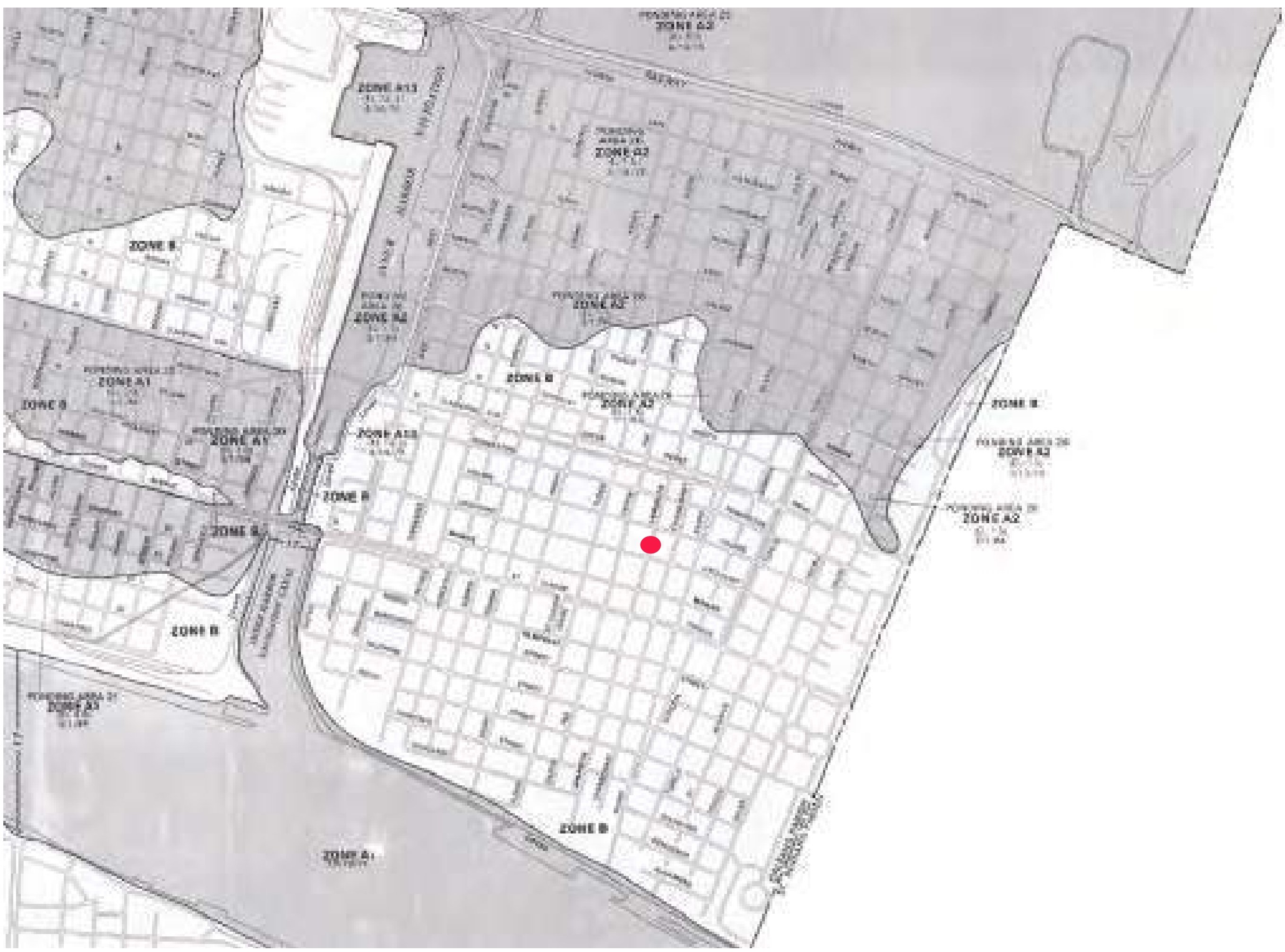



*fig. 112: FEMA Flood Zone Plan, Lower Ninth Ward*

ZONES B, C, and X

According to FEMA, flood zones B, C, and X are "areas identified in the community FIS [Flood Insurance Study] as areas of moderate or minimal hazard from the principal source of flood in the area. However, buildings in these zones could be flooded by severe, concentrated rainfall coupled with inadequate local drainage systems. . . . Flood insurance is available in participating communities but is not required by regulation in these zones. (Zone X is used on new and revised maps in place of Zones B and C)."[169] Zones B and X are areas between the limits of 100 to 500 year flood and Zones C and X are above the 500 year flood level (fig. 113).

| | |
|---|---|
| **Zone A** | The 100-year or base floodplain. There are six types of A Zones:<br>**A** The base floodplain mapped by approximate methods, *i.e.,* BFEs are not determined. This is often called an unnumbered A Zone or an approximate A Zone.<br>**A1-30** These are known as numbered A Zones (*e.g.,* A7 or A14). This is the base floodplain where the FIRM shows a BFE (old format).<br>**AE** The base floodplain where base flood elevations are provided. AE Zones are now used on new format FIRMs instead of A1-A30 Zones.<br>**AO** The base floodplain with sheet flow, ponding, or shallow flooding. Base flood depths (feet above ground) are provided.<br>**AH** Shallow flooding base floodplain. BFEs are provided.<br>**A99** Area to be protected from base flood by levees or Federal Flood Protection Systems under construction. BFEs are not determined.<br>**AR** The base floodplain that results from the decertification of a previously accredited flood protection system that is in the process of being restored to provide a 100-year or greater level of flood protection. |
| **Zone V and VE** | **V** The coastal area subject to a velocity hazard (wave action) where BFEs are not determined on the FIRM.<br>**VE** The coastal area subject to a velocity hazard (wave action) where BFEs are provided on the FIRM. |
| **Zone B and Zone X (shaded)** | Area of moderate flood hazard, usually the area between the limits of the 100-year and 500-year floods. B Zones are also used to designate base floodplains of lesser hazards, such as areas protected by levees from the 100-year flood, or shallow flooding areas with average depths of less than one foot or drainage areas less than 1 square mile. |
| **Zone C and Zone X (unshaded)** | Area of minimal flood hazard, usually depicted on FIRMs as above the 500-year flood level. Zone C may have ponding and local drainage problems that don't warrant a detailed study or designation as base floodplain. Zone X is the area determined to be outside the 500-year flood and protected by levee from 100-year flood. |
| **Zone D** | Area of undetermined but possible flood hazards. |

*fig. 113: Flood Insurance Rate Map Zones Defined by the NFIP*

FLOOD ZONES + BASE FLOOD ELEVATIONS

FEMA recommends:

> In all areas where flooding is a concern, inside and outside the Special Flood Hazard Area (SFHA), FEMA requires the lowest floor must be elevated so that the bottom of the lowest horizontal structural member is at or above the Design Flood Elevation (DFE).
>
> In flood zones V and A, use a DFE that results in freeboard (elevate the lowest floor above the BFE) [fig. 114].
>
> In flood zones V and A, calculate design loads and conditions (hydrostatic loads, hydrodynamic loads, wave loads, floating debris loads, and erosion and scour) under the assumption that the flood level will exceed the BFE [fig. 114].
>
> In an A zone subject to waves and erosion (i.e., Coastal A zone), use a pile or column foundation [fig. 114].
>
> Outside the SFHA (in flood zones B, C, and X), adopt flood-resistant design and construction practices if historical evidence or a review of the available flood data shows the building could be damaged by a flood more severe than the base flood [fig. 115].[170]

Freeboard is defined as, "[A]n added safety factor expressed in feet that many communities add to their BFEs to account for uncertainty or provide an increased level of protection. . . . For example if the current BFE at a location is 14 feet above sea level and the community adopts a 3 foot freeboard, new and substantially improved and damaged buildings would have to have their lowest floors elevated to 17 feet above sea level."[171] Freeboard is illustrated in figure 114 and is particularly important for areas vulnerable to flooding (zones A and V).

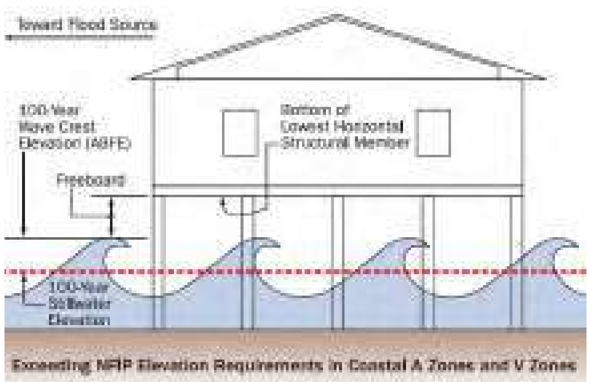



*fig. 114: Recommended Construction in Zones A and V*

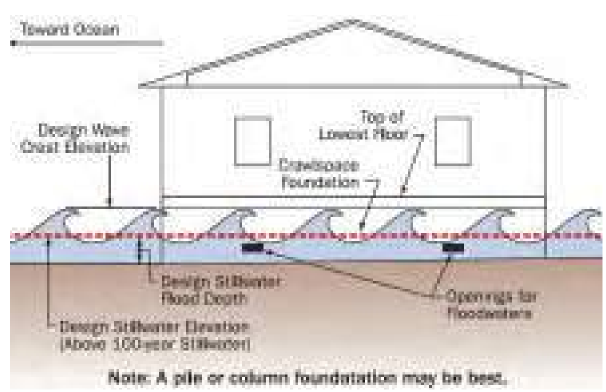



*fig. 115: Recommended Construction in Zones B, C and X*

FLOOD INSURANCE COVERAGE

Figure 116 is a table that compares 2006 housing damage estimates in the Lower Ninth Ward based on homes that were, according to FEMA, fully insured, partially insured and not insured prior to Hurricane Katrina. Within the FEMA 100 year floodplain (zone A), 52% of damaged homes were uninsured compared to 48% fully insured. Outside the FEMA 100 year floodplain (zone B), 70% of damaged homes were uninsured compared to 30% fully insured.[172] Insuring a home, regardless of where it is situated, does not guarantee that the coverage will be sufficient, especially during such unforeseeable circumstances as Hurricane Katrina. The only true "insurance" is a reliable flood-protection system, such as could be provided by the BFP.

**Housing Unit Damage Estimates as of February 12, 2006**
Lower 9th Ward Planning District Total Housing Damage

| | Owner-Occupied Housing Units | | | |
|---|---|---|---|---|
| | Insurance Status | | | |
| | Hazard & Flood | Hazard Only | No Insurance | Owner Subtotal |
| **Homes with flood damage** | | | | |
| *Homes in FEMA 100 yr. fl plain* | | | | |
| Minor Damage | 3 | 2 | 1 | 6 |
| Major Damage | 12 | 4 | 13 | 29 |
| Severe/Destroyed | 567 | 216 | 396 | 1,179 |
| *Subtotal* | *582* | *222* | *410* | *1,214* |
| Homes outside 100 yr. fl plain | | | | |
| Minor Damage | 5 | 19 | 14 | 38 |
| Major Damage | 95 | 125 | 82 | 302 |
| Severe/Destroyed | 422 | 493 | 501 | 1,416 |
| *Subtotal* | *522* | *637* | *597* | *1,756* |
| **Homes with no flood damage (generally wind damage)** | | | | |
| Minor Damage | - | - | 1 | 1 |
| Major Damage | 2 | 1 | 1 | 4 |
| Severe/Destroyed | - | - | - | - |
| *Subtotal* | *2* | *1* | *2* | *5* |
| **TOTAL** | **1,106** | **860** | **1,009** | **2,975** |
| Census 2000: | | | | 3,671 |
| Percent: | | | | 81% |

| | SBA Median Verified Loss: | |
|---|---|---|
| FEMA Damage Level: | | N |
| Major: | $ 95,857 | 72 |
| Severe: | $ 114,915 | 573 |

*fig. 116: Damage to Owner-Occupied Housing Units in the Lower Ninth Ward, Post-Katrina*

# 04

# V

# summary

This chapter has discussed the Buoyant Foundation Project (BFP) as an alternative solution for flood mitigation in New Orleans.

Prior to Katrina, residents in the Lower Ninth Ward were not required to purchase flood insurance because they were in a "levee protected" area. This was misleading to homeowners, and provided a false sense of security to those who decided not to insure their properties in accord with government legislation. Fifty-two percent of the damaged homes in the Lower Ninth Ward situated within the designated floodplain area did not carry flood insurance, nor did 70% of the damaged homes outside of the designated floodplain area in the Lower Ninth Ward. These homes may have survived undamaged had they been fitted with buoyant foundations. In reality, even if base flood elevations (BFE's) are raised, and insurance is purchased, the current flood mitigation strategy in New Orleans is inadequate and will not provide sufficient protection in an extreme flood.

As discussed at the beginning of the chapter, the BFP provides an alternative solution to permanent static elevation, while addressing the technical feasibility, safety and socio-cultural aspects of flood protection simultaneously. The BFP aims to retrofit existing shotgun houses in New Orleans with buoyant foundation systems comprised of the core elements: buoyancy elements, vertical guidance posts, a steel substructure that attaches these elements to the house, and accommodation of the utility connections. The system works passively, enabling the house to remain close to street level during normal conditions and to float whenever there is a flood. Prior to June 2010, a two-phase installation schedule was designed to comply with FEMA and NFIP regulations; however, it is no longer needed in light of the recent completion of an amphibious home in the Lower Ninth Ward and subsequent meetings with FEMA officials that indicate a changing perspective towards amphibious construction in New Orleans.

The BFP is a small-scale intervention that could provide another layer of flood protection to supplement traditional infrastructural methods currently in place in New Orleans. The BFP can improve flood protection for individual properties in low-lying areas of New Orleans. The BFP could supplement insurance programs to give more adequate protection to houses during unforeseeable extreme floods.

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# 05

# the buoyant foundation project : technical feasibility

technical feasibility:

# 05 | technical feasibility

Chapter 5 discusses the technical feasibility of the Buoyant Foundation Project (BFP) in relation to local and international examples of amphibious housing.

Six pertinent and completed projects have been selected: Amphibious Fishing Camps in Point Coupee Parish, Louisiana; Amphibious Housing in Maasbommel, Netherlands; LSU Prototype in Baton Rouge, Louisiana; Noah's Ark Project in Lakeview, New Orleans; FLOAT House in the Lower Ninth Ward, New Orleans; and LIFT House in Dhaka, Bangladesh. The amphibious houses in Maasbommel inspired the initial concept of using amphibious foundations to provide flood protection in New Orleans. The amphibious fishing camps in Point Coupee Parish provide an example of a technically feasible system using similar components, particularly buoyancy blocks and vertical guidance posts. This precedent confirmed that BFP's proposed system could work and be cost effective. The LSU prototype was a full-scale, built demonstration of the buoyant foundation system. The Noah's Ark Project in Lakeview, FLOAT House, and LIFT House were recently completed. They may help with regulatory and political hurdles, and are useful examples of amphibious systems for new construction. The Noah's Ark Project in Lakeview is believed to be the first modern fully-engineered home built with an amphibious foundation in the United States and second in the world only to the houses in Maasbommel. The FLOAT House was the first fully permitted amphibious house in the United States. The LIFT House is believed to be the first modern fully engineered amphibious house constructed outside of the United States and the Netherlands. It is student designed and constructed and implements sustainable materials. In this discussion, each project is fully documented, and will appear chronologically based on the date of construction.

A summary and analysis conclude the chapter, highlighting the projects' significant contributions or future influence on the BFP. A tabular summary compares particular factors of each project's technical feasibility. Factors such as date of completion, architect, challenges, maximum elevation during flooding, buoyancy system, major building materials and cost can be visually compared and cross referenced among the six examples and the BFP.

# 05 ii

# technical feasibility: pointe coupee parish


raccourci
old river

# pointe coupee parish, louisiana

*fig. 117: Partial Aerial View of Pointe Coupee Parish*

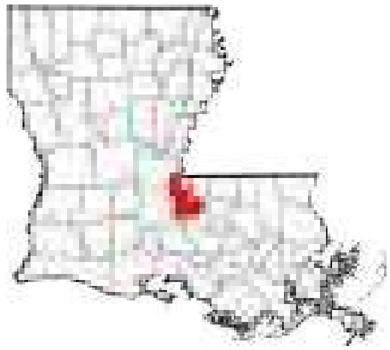

*fig. 118: Pointe Coupee Parish Key Map*


*fig. 119: Old River, Key Map*

*fig. 120: Permanent Static Elevated Fishing Camp in Raccourci Old River*

*fig. 121: Fishing Camp on Amphibious Foundation in Raccourci Old River*

POINT COUPEE PARISH,
AMPHIBIOUS FISHING CAMPS

Parish administrator, Owen J. Bello, Pointe Coupee Parish, Louisiana (fig. 117, 118) comments on Raccourci Old River as follows:

> [Raccourci Old River is] One of the oldest settlements in the entire Mississippi Valley, a community steeped in history and tradition. . . . Situated at the apex of Louisiana's 'French Triangle', Pointe Coupee Parish, with a recorded history dating from the time of the Iberville exploration in 1699, has a fascinating Creole culture embodying elements of the French, African and other nationalities who having called this place 'home' for nearly three centuries. . . . Pointe Coupee has a resident population of nearly 25,000, . . . Surrounded by the Mississippi, Atchafalaya and Lower Old Rivers and blessed with the oxbow lakes called False River and Raccourci-Old River, Pointe Coupee Parish is a paradise for sportsmen, including hunters, anglers, boaters and [water] skiers.[173]

According to the Louisiana Sportsman Magazine, "Old River is a 12 mile long, 4,000 acre oxbow lake near the town of Morganza Louisiana [fig.119]. Flooding from the nearby Mississippi River affects the water levels on Old River and in turn affect the fishing conditions. In the spring of 1997 many camps were flooded when the Mississippi River levels were extremely high."[174] It is important to note that flooding is common to this area where annual fluctuations in the Mississippi River often flood the fishing camps in spring.[175] To mitigate future flooding, residents designed and built permanently raised camps (fig. 120), camps on amphibious foundations (fig. 121) and hybrids, combining both strategies (fig. 122).

Elizabeth English describes the local phenomena of these amphibious fishing camps:

> In rural areas of south Louisiana, there have been clusters of amphibious housing functioning reliably for over thirty years. Raccourci Old River in Point Coupee Parish is one such location. The lake that is called Old River was once a part of the Mississippi River, and remains connected to the Mississippi at one end; thus the water level in Old River rises and falls with the Mississippi's spring floods. Unhampered by building codes in these rural areas, local residents and vacationing fishermen devised an amphibious foundation system that has been keeping their homes and fishing camps dry for over three decades. Large blocks of EPS (expanded polystyrene, or styrofoam) are secured underneath the home which has been raised to an elevation 3 - 4 ft above the ground. . . .

Long poles or pipes are sunk into the ground near the corners of the house. When flooding occurs, the EPS blocks raise the house [fig. 123]. Sleeves that have been placed around the poles and attached to the structural frame of the home are able to slide up and down, allowing the home to rise and fall with the level of flooding [fig. 124].[176]

*fig. 122: Dry in September*

*fig. 123: Floating in February*

*fig. 124: Detail of Amphibious Foundation*

*fig. 125: Fishing Camp on Amphibious Foundation in Raccourci Old River*

DRY IN SEPTEMBER, FLOODED IN FEBRUARY

Adaptations of the fishing camps with amphibious foundations have been made entirely at the initiative of the individual homeowners (fig. 125). The NFIP does not provide insurance to homes on amphibious foundations, however, this strategy has been effective and homeowners have not needed to make claims. Repetitive claims from this area, made by homeowners with non-elevated, non-amphibious homes, are common.[177]

The amphibious fishing camps at Pointe Coupee Parish were among some of the first examples upon which English and her Louisiana State University (LSU) undergraduate mechanical engineering students based their early research. These systems typically cost approximately $5,000 or less to implement on an existing structure.[178]

The reliable performance of these amphibious structures in a highly flood-prone area suggests that amphibious foundations could be appropriate for implementation in the Lower Ninth Ward, where the threat of flooding is rare but the consequences are severe. The goal of the BFP is to engineer an amphibious foundation system, similar to those implemented by residents of Pointe Coupee Parish, making it code compliant and visually appropriate for an urban context. The the possibility of integrating more sustainable materials such as thermoplastic timber and recycled water bottles is also being researched. The photos on the following pages (fig. 126, 127) document amphibious fishing camps in Old River, Pointe Coupee Parish, in September and February. Each spring, when the Mississippi River floods, the amphibious fishing camps rise up and float safely above the floodwaters, and descend when the floodwaters recede.