

Syracuse University

**SURFACE**

---

Syracuse University Honors Program Capstone  
Projects

Syracuse University Honors Program Capstone  
Projects

---

Spring 5-2016

## Preparing for and Responding to Flood Disasters: A Tale of Two Floods

Rachel Correll

Follow this and additional works at: [https://surface.syr.edu/honors\\_capstone](https://surface.syr.edu/honors_capstone)



Part of the [Geography Commons](#)

---

### Recommended Citation

Correll, Rachel, "Preparing for and Responding to Flood Disasters: A Tale of Two Floods" (2016). *Syracuse University Honors Program Capstone Projects*. 971.

[https://surface.syr.edu/honors\\_capstone/971](https://surface.syr.edu/honors_capstone/971)

This Honors Capstone Project is brought to you for free and open access by the Syracuse University Honors Program Capstone Projects at SURFACE. It has been accepted for inclusion in Syracuse University Honors Program Capstone Projects by an authorized administrator of SURFACE. For more information, please contact [surface@syr.edu](mailto:surface@syr.edu).

© (Rachel Correll, May 2016)

## **Abstract**

There have been major floods throughout geologic history and there will continue to be major floods for centuries and milleniums to come. Preparation and response strategies have always been in place, however, with more frequent and sever floods expected to come in the future, these strategies certainly have room for improvement. In this thesis I outline the strangths and weaknesses of these strategies in two case studies, Hurricane Katrina in New Orleans and The Great Mississippi Flood of 1993 in St. Louis. My research compares disaster preparedness and response in two case studies of recent major flooding in the U.S. My objective is to learn from these cases, searching for ways to improve future methods and strategies to protect from flood disasters. The most outstanding problems lie within the trust in levees, the reluctance to evacuate, and the resources available post-disaster. The problems may be addressed through stronger levees, a participation of the community in federal insurance programs, and a better understanding of the demographics that are most often adversely affected.

## **Executive Summary**

Natural disasters are inevitable. They occur all over the world, with some regions being more prone to natural disasters. Natural disasters include tornadoes, hurricanes, flooding, wild fires, and tsunamis and are defined for this purpose as a natural occurrence that has a strong, negative impact on a human community. For example, a portion of the Midwest is known as Tornado Alley for the numerous tornadoes that occur there on an annual basis. Other disasters are more dispersed. Floods can occur anywhere in the country at any time of the year. Since 1925, there have been 4,000 human lives taken by floods (Cigler and Burby 1990). A large part of these deaths is the lack of proper preparation and response to the flood.

Flooding as a natural disaster can be highly damaging, as in the case of Hurricane Katrina in New Orleans. This area is highly prone to hurricanes and flooding due to its location on the Gulf of Mexico. It comes as a surprise then that the city was so unprepared for the hurricane when it hit. Even areas that are not highly prone to flooding need to have improved flood emergency management preparation and response methods. According to the Federal Emergency Management Agency's website, even living near a small creek will put you at risk of flooding (fema.gov, 2014). Things will only be continuing to get worse as well. According to a study about the climate change and flooding relationship by Wilby and Keenan, "Anthropogenic climate change is expected to increase flood risk through more frequent heavy precipitation, increased catchment, and sea level rise," (Wilby and Keenan, 2012). Preparation and response strategies can be developed for communities to reduce risk presented to residents in flood prone regions.



## Table of Contents

<b>Abstract.....</b>	<b>iii</b>
<b>Executive Summary.....</b>	<b>iv</b>
<b>Acknowledgements .....</b>	<b>v</b>
<b>Chapter 1: Theoretical Background .....</b>	<b>1</b>
Prologue .....	1
Defining and Measuring Flood Events.....	4
Defining a Flood Disaster .....	6
Protection Against Flood Disaster.....	8
Recovering From a Flood Disaster.....	10
Uneven Geography.....	11
<b>Chapter 2: The Great Mississippi Flood of 1993- St. Louis, Missouri... 13</b>	
St. Louis, Missouri.....	14
The Rain.....	14
Mitigation and Preparation.....	16
The Impact.....	17
<b>Chapter 3: Hurricane Katrina-New Orleans, Louisiana..... 19</b>	
The Storm.....	20
Disparities and Impact.....	21
Analyzing the Data.....	24
<b>Chapter 4: Discussion and Analysis..... 27</b>	
Pre-storm Preparation.....	27
Looking to the Future.....	33
<b>References.....</b>	<b>37</b>

## **Acknowledgements**

This thesis would not have been possible without the years long help of Dr. Susan Millar. Thank you for your never-ending patience, your encouraging attitude, and ceaseless belief in me. I want to thank Dr. Millar for sharing her expertise with me and guiding the way to the success I have found. Thank you also to Dr. Cathryn Newton and Dr. John Western for supporting me through this process and being a great pick-me-up whenever I was discouraged.



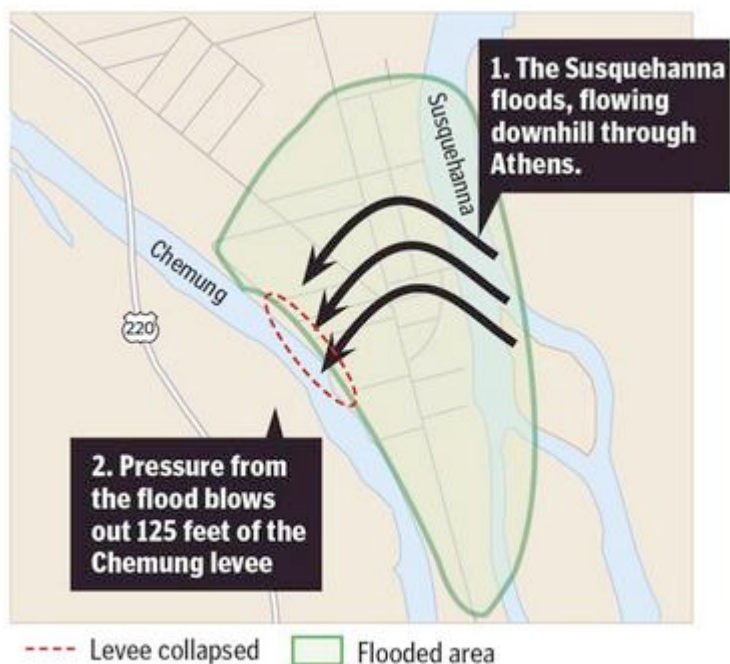


## Chapter 1

### Introduction

#### Prologue

The interest I developed in flooding began with a major flood in my home valley in 2011. On the very first day of high school in my senior year school was cancelled due to flooding throughout the valley. One town in particular was hit hard. Athens is located in a small area of land located between two rivers, the Susquehanna and the Chemung Rivers. At three in the morning on September 8, 2011, the fire and police departments woke the residents of homes located between the two rivers. My grandparents were one of several evacuated families. In their groggy state of mind, they moved all the expensive belongings to the second level of the house, grabbed what clothes and valuables they could before moving to my uncle's home to wait. Two hours later, homes were inundated.



There was a slightly larger flood in 1972 that damaged or destroyed many of the same houses affected by the 2011 flooding. After the 2011 flood, my grandparents lived with us for three months as my father and family friends worked day in and out to put their home back together. Luckily my dad is a self-employed contractor who was able to dedicate his time to making their home inhabitable again (while still working for other families in order to fund the rebuild and support my family). Many other families had to wait a year or more to move back home due to lack of labor and materials (Frantz, 2012). Still others were never able go back home: FEMA condemned many properties deemed uninhabitable, forcing many to move or rebuild with minimal funds.

The levee was a source of security for the Athens' residents even though it had failed for a second time. These levees were built to sustain a 500-year flood but were not able to hold back the two floods separated by only 39 years (Frantz 2012). Athens has higher ground located near the Susquehanna River but slopes downhill towards the Chemung River. The side of town located near the Chemung River is on the floodplain, and is prone to inundation depending on the river level. This is the location of a levee built 26 feet above the average bankful height of the river. On the Susquehanna River side of town there is not a levee and here the homes are located just above the height of the water. In both floods, the Susquehanna River flooded the region, flowing from one side of town to the other where the Chemung River is located. Ironically, the Chemung River levee had a hole the size of a two-story house, which enabled the floodwaters to recede more quickly than expected. Of course, this caused problems in and of itself, but that is a story for another time.

The psychological stress experienced by residents manifested itself in many ways before, during, and after the flood. My grandparents' reactions were similar to those that were expressed

by neighbors, friends, and other community members, therefore I will use them as an example. Prior to the flood, the general feeling was of invincibility; there was no reasonable way that a flood could hit the town so soon after the 1972 event. During the flood, my grandparents felt a sense of numbness, disbelief, and defeat. They stood at the top of a hill, watching as water settled into their beloved home. In the years since the flood, heavy, persistent rains make my grandmother anxious. She no longer feels safe in her home behind the levee, and talks frequently of moving if she could afford it.

Immediately after the flood, there was a lot of opportunistic looting that kept the already busy police force even busier. People were eagerly awaiting the arrival of the National Guard and FEMA in the hopes that everything would begin to get better. Presumably, experienced officials would be there to help the valley recover. Unfortunately, the help was not what was hoped. FEMA's financial aid fell short on several occasions and the National Guard made it difficult to access homes during the initial cleanup stages. The valley was able slowly to recover from the damages done to the region, but there has been little progress in improving the policies in place to help residents prepare for a major flood such as this again.

My experience has spurred me to further do research on flooding in the United States and on the policies in place for preparing communities for flooding, and to rapidly respond when a disastrous event occurs. I chose two case studies in order to conduct this research. The first case study is of St. Louis, Missouri, in the Great Mississippi River Flood of 1993. The second case study is of New Orleans, Louisiana, in Hurricane Katrina of 2005.

Flooding threatens many livelihoods in the United States. It affects people that live anywhere near water whether that is a small creek, large river, or along the coastline. There are many causes of major flooding. Dam breaks, ice and snowmelt, heavy precipitation, tsunamis, storm surges all

exacerbated by saturated soil, impervious surfaces, and a frozen ground, pose a potential to flood the land (Anderson et al 2013). These possibilities are the controlling factors to when and how bad a flood is for a region. In this chapter I will discuss how we define and measure flooding from an environmental perspective, why disasters are inherently a human problem influenced by geography, and what the typical mitigation and response strategies are in the United States.

### **Defining and Measuring Flood Events**

Each river is unique and dynamic. Each one has its own flood stage. The United States Geological Service (USGS) defines flood stage as being “the stage at which overflow of the natural stream banks begins to cause damage in the reach in which the elevation is measured” (USGS 2016). Another way to think about flood stage is gage height. Gage height refers to the height of the water relative to a measuring point. The USGS has many stream gaging stations across the country that are used to measure river height and discharge. When the water rises above the flood stage and so the river over flows its banks, there is a threat to people, property, and infrastructure (USGS 2016). The higher the river is above the flood stage, the more likely it is to be a bigger flood when it crests the river banks. What is defined as flood stage is determined though examining the magnitude of past events and applying scientific calculations of the river channel’s capacity.

Each region has different frequencies of flooding depending, in part, on its general height above sea level. Locations close to sea level are thus more likely to experience flooding compared to those at higher elevations. However, even places located well above sea level are affected by flooding if they are close to river floodplains. The impact of a significant precipitation event, then can have immediate impact on river communities, an effect that is



magnified downstream as floodwaters converge into river channels. One region may flood rarely except during significant precipitation events but fifteen miles downstream, there might be regular flooding every fifty years. The frequency of flooding is known as the recurrence interval. For example, a 500-year flood recurrence interval means that every year there is a 0.2% chance of a major flood; whereas a 100-year flood recurrence interval means that there is a 1% chance in any year that a major flood will occur. Holmes and Dinicola (2010) define the 100-year flood on the basis of an estimate of the average likelihood over an extended period of time. However, the USGS realizes that the phrase “100-year flood” can be misleading; therefore recently they have been referring to the annual exceedance probability (AEP) which represents the likelihood that a flood of a particular magnitude will occur in any one year (Holmes and Dinicola 2010).

Determining if a flood will occur takes more than just understanding recurrence intervals though.

The conditions and events that happen upstream can play a vital role in downstream river response. A watershed is an area in which all precipitation that lands within its boundary will eventually flow into one outlet channel. Therefore, all the water from the small tributaries and creeks end up in one river. That means that heavy rainfall falling in smaller watersheds upstream will converge and increase the magnitude of the flooding downstream.

The extent to which flooding might affect residential or commercial property is usually determined by using flood zone maps. Floodplains, as the term indicates, are regions where there is likely to be flooding at least once every two years. The extent of the floodplains can vary depending on the river’s size and the general topography of the area. Due to their frequent inundation they normally contain very fertile land, one of the reasons that they have become prime locations for human settlement (National Geographic). FEMA uses several data sets to construct their flood frequency maps. “River flow, storm tides, hydrologic/hydraulic analyses



People inherently think of floods as being disastrous events, but this is entirely a human construct. Humans consider them negatively because they are associated with destroyed homes, damaged croplands, and expensive reparations. The disruption they cause to everyday activities causes strain on a society; floods are no exception. However, flooding is a natural process that occurred long before human settlement. Floods help keep land fertile. Many farms are located on floodplains for this reason. The fertile soil encourages the growth and stability of crops because the floodwaters carry nutrients that nourish the soil. The fertile soils made it possible for people to live in one location and grow plentiful crops (Day 2004).

Humans have gravitated to the fertile soil along waterways since prehistoric times. For example, Mesopotamian civilizations (literally people from “the land between two rivers”) began a permanent style of living because of the fertility of the land between the Tigris and Euphrates Rivers. This land periodically flooded making it an ideal place to farm. Once people were able to farm, there was no longer a need to consistently be moving, following the food source.

In more recent times, in addition to the availability of fertile land, rivers and coasts provide ideal routes for transporting agricultural produce and other commodities, and they provide a source of fish. Many of the world’s largest cities developed along the coast because of the opportunities such a location presented for trading. Very recently however, reasons for living along the water are becoming less of a matter of convenience as they are for aesthetic reasons. Owning a home overlooking the Gulf of Mexico with spectacular sunset views, is a dream to which many aspire. However, living this close to the water has its costs, especially when there is heavy rain upstream or if a hurricane hits.

Hurricanes and flooding are part of the natural cycle of earth systems. These events only become disasters when people get in the way, or a densely populated area receives a direct hit. A

hurricane making landfall in Florida is going to have the same force on the coast whether the coast is inhabited or not. Homeowners can prepare for an incoming storm by boarding windows, moving all the valuable belongings to a higher elevation, and installing storm windows and doors. These and other preventive actions can help significantly to protect the individuals and their home and property. However, if they are in the direct path of the disaster, they are likely to sustain damage no matter how many preventative measures are in place.

### **Protection Against Flood Disasters**

Home protection must go beyond that of just boarding up a house during a hurricane. Federal aid, insurance policies, and nonprofit organizations all help homeowners when a natural disaster occurs. The federal government offers aid in the form of the National Insurance Flood Plan (NFIP). However, this is only available to local communities that opt to participate in the scheme. To be a part of the NFIP, first a community must elect to participate. Thereafter, the community must conform to a series of standards and rules that have been set by FEMA. Although individuals do not get to choose to be part of the plan themselves, if the community as a whole has decided to participate, then in the event of a disaster, every person in the community gets reimbursed for damage. Participation in CRS is lower when the communities have a higher population of senior citizens as well as higher education levels, mostly because they have a greater influence on the local government to control its actions through elections and meetings (Li 2012).

The CRS is not an easy system to be a part of. Every community that wants to be a part of the system, must decide to what degree they are going to put in the effort to change policies and implement better strategies for flood mitigation and preparation. A ladder system is used

whereby the more policies implemented and protective structures built by the community, the higher the rating it receives. The higher the CRS rating then entitles them to more federal support in the event of a disaster (FEMA).

For individual homeowners and for business owners, private insurance is an alternative for those in communities that opt to not participate in the CRS. This allows more individual choice, including whether or not to have insurance and how much the insurance to buy. Normally, these policies have choices of coverage, including simply the cost of the dwelling, or personal belongings, or for liability claims in the case of rental properties. Individual insurance policies however, provide some problematic clauses when loss and damage are a result of flooding. Therefore, they can often be an impediment for residents receiving any post-storm reparation.

Both the NFIP and homeowner's insurance protect against flood damage to homes. Homeowner's can have both private insurance and insurance covered by the NFIP if their community is part of the CRS. However, in many instances, one of the biggest problems that homeowner's run into when a hurricane hits and destroys the home is which insurance covers what. In the case of a hurricane, the NFIP will cover any damage caused to the home from floodwater, but not the damage that was caused by wind from the hurricane. On the other hand, homeowner's insurance often only covers the damaged property from the wind, not the floodwater. One might assume that if a person has both insurances, they have coverage for all types of hurricane damage. Unfortunately, in practice, this is rarely the case. After Hurricane Katrina in New Orleans, Louisiana, commercial insurance companies and FEMA battled over who would pay what, delaying the provision of timely help to the devastated homeowners (Freudenburg et al 2009). NFIP officials claimed that there was more wind than water damage

therefore the homeowner's insurance should cover repair costs, but the homeowner's insurance companies claimed that the damage was from floodwaters. Many homeowners were left in despair and without aid until the government and insurance companies negotiated. This is just one case where money mattered more than helping the victims.

To reduce damage from flooding events, both federal and state governments construct physical protective infrastructure. Structures may include levees, sea walls, and designated paths for floodwaters outside of communities. The key factor is to make sure that all parties are on the same page about the risk factors involved as well as convey to the community that no structure is fool proof.

### **Recovering from a Flood Disaster**

Post flooding, there are many tasks to complete. A community has to clean up and rebuild. The speed at which these two tasks are completed is extremely important because they determine if and when residents move back home and resume their old lifestyles or if they have to relocate to an entirely new place. The immediate and long-term responses to a flood therefore have a great impact on a victim's future.

Ideally, those who can collect on insurance policies (either from the NFIP, homeowner's insurance, or both) do, and will voluntarily relocate to a new, safer location outside of the flood zone. If moving to a new location is not a financially viable option, there are others. This might include some type of structural reinforcement to the house to prevent it from being as badly damaged by a future flood. Raising a home onto stilts is one popular option. However, reinforcement is not often done. It seems that the natural response of many victims is to take the insurance payout, and stay where they are. Typically, the compensation is rarely enough to

cover the cost of moving or reinforcing the home. Many homeowners are devastated to learn that in order to keep their flood insurance plan, they must either pay a significant amount more per year or raise their homes (Linskey 2013).

By acknowledging that uprooting and relocating are difficult both financially and emotionally, there needs to be better provision by insurance companies and federal agencies to commit funding support to victims of flooding, specifically to alleviate the stress of relocation. This might be possible if funding could be better rationalized by limiting the number of times an individual can collect flood insurance when a disaster is declared. Currently there is no limit to the number of times they can do so despite their location within flood zones and therefore guaranteed to experience regular minor flooding and possibly disastrous flooding. It is perhaps gratifying to note that more recently after Superstorm Sandy, the federal government bought out many of the property owners in Sayreville, South River, Woodbridge, East Brunswick, Newark, Old Bridge, Linden, Manville, Pompton Lakes, and Lawrence in New Jersey to remove them from harms way. Such a strategy ultimately reduces the federal costs of future events (NJDEP 2015).

### **Uneven Geography of Disaster**

The ability to recover rapidly from a natural disaster is essential. The faster that the people of a community is able to recover, the sooner society can return to its previous natural state, or ideally a better state more prepared for a disaster of that magnitude. Rapid recovery reduces the time that the people are suffering and lacking resources. However, a community can only recover as fast as its slowest group. If the recovery rate is spread out with varying rates in different groups, then there are severe social effects. These effects can be mitigated though by

ensuring that all participants of a society is prepared and cared for (Adger et al. 2005). In order to help mitigate certain groups suffering more than others, trends should be mapped. By analyzing these trends, preparation strategies can be put in place to help mitigate the magnitude of suffering due to flooding for those areas (Parker and Mitchell 1995).



## Chapter 2

### The Great Mississippi Flood of 1993-St. Louis, Missouri

The Great Mississippi River Flood of 1993 is an event that lives on in the stories passed down to grandchildren about its widespread destruction and its unprecedented scale. Flooding impacted nearly thirty percent of the Mississippi River watershed and affected nine midwestern states along the Colorado, Missouri, and Mississippi Rivers (Figure 1), including North Dakota, South Dakota, Nebraska, Kansas, Minnesota, Iowa, Missouri, Wisconsin, and Illinois (NOAA and Salter 1997). Flooding in this region occurred anywhere from sixty-two to two hundred days. Much of it was in large part due to the failure of nearly one thousand recently built levees, costing approximately \$25 billion for the entire storm. Ultimately, the disaster cost fifty people their lives (NOAA and Salter 1997).

**Figure 1**



Figure 1- Map outlining the Mississippi River Watershed (nps.gov).

### **St. Louis, Missouri**

For the purpose of this research project, I chose to examine just one city, St. Louis, MO, of the many that were inundated by the 1993 flood. St. Louis was one of the largest cities affected by the massive extent of the flooding. It also recorded the highest-ever flood stage for the Mississippi River of the 1993 flooding. The river crested its banks in St. Louis on August 1, 1993, at 49.58 feet. As a result, more than 25% of the levee system failed (NOAA).

### **The Rain**

This disaster in the Midwest was of particular interest because of the unique events leading up to its occurrence. A pattern bringing persistent rain began in the summer of 1992 and settled in over the region culminating in the flooding in 1993. The same regions were bombarded time and again by heavy and persistent rainfall. July, September, and November received higher than average rainfall (See Figure 2) as did the following spring of 1993, when more rain fell across the Mississippi River Basin than during any season over the previous century (Lovelace). In total, this region received 3.5 inches more precipitation than the yearly average (USGS). Much of this rain went directly into stream systems and ultimately into the Mississippi, but a critical factor in the magnitude of the flooding was the fact that by Spring 1993 the soils were saturated and therefore any subsequent rain simply ran straight into streams (Pitlick 1997).

### **Figure 2**

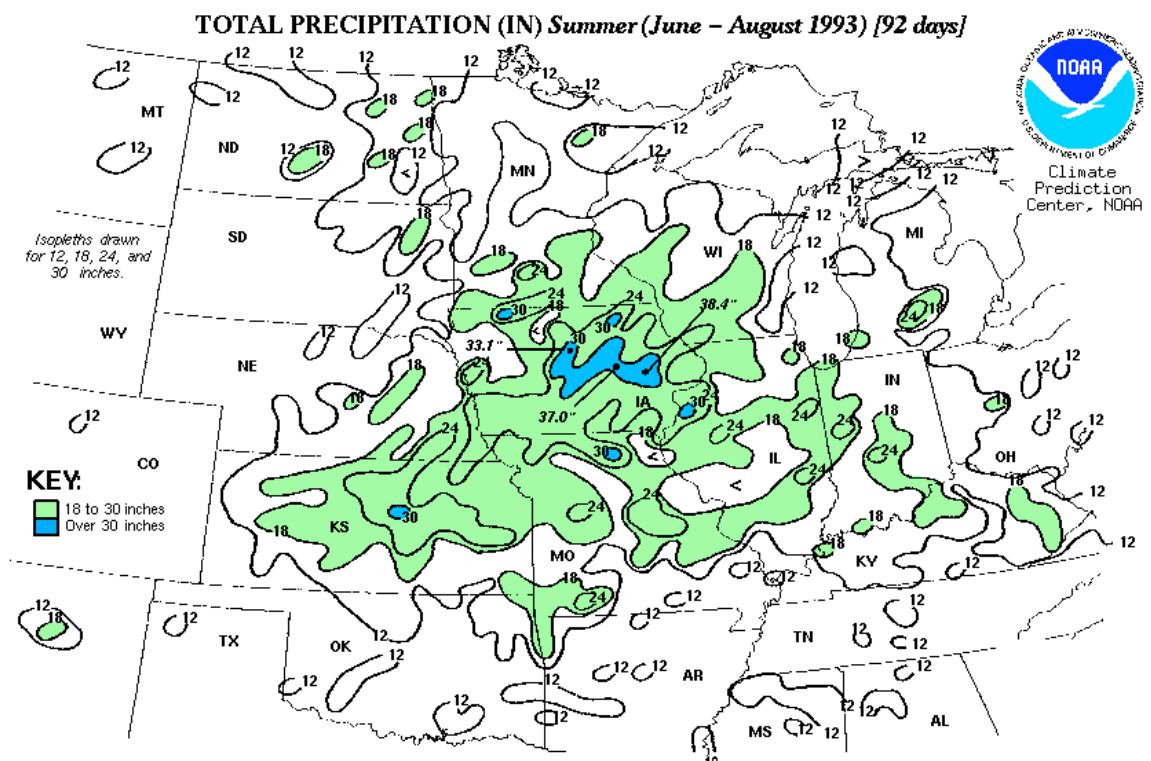


FIGURE 2.2 Total precipitation, based on reports from the River Forecast Centers during Summer (June - August), 1993. Over 18 inches of rain drenched large sections of the central Great Plains, central Gulf Coast, and the lower reaches of the Missouri and Ohio River Valleys during the 64-day period ending June 11, 1995 (Figure 2.1). Between 2 and 3 feet of precipitation inundated some areas near the intersections of Missouri, Kansas, Oklahoma, and Arkansas as well as portions of the Mississippi Delta (most of which fell within a few days in the latter region). During Summer 1993, the heaviest precipitation was observed primarily north and west of the currently-affected region, but portions of eastern Kansas and northern Missouri received exceptionally heavy precipitation and endured severe, prolonged river flooding during both episodes.

(NOAA)

In addition to water in the flood discharge, tons of soil and sediment are transported by the power of the moving water. So when the river tops its banks and floods surrounding areas it is carrying much of that sediment with it. According to Ayres (1993), in the case of the Mississippi flood there was enough sediment in the river water to cover a 1,000-acre farm with a foot of topsoil every twenty-four hours.

By the time the flood hit St. Louis, it was the largest recorded discharge in over 150 years (Lovell, USGS). St. Louis experienced seventy-seven days of flooding and one hundred and forty-four days of the Mississippi river being above flood level, meaning it had the potential to flood at any point during that time. Ultimately, flooding exceeded the 100-year event (USGS).



Aerial view of the Missouri River flooding on July 30, 1993, in the vicinity of Cedar City and Jefferson City Memorial Airport immediately north of Jefferson City, Missouri, looking south (photograph from the Missouri Highway and Transportation Department).

(USGS)

## Mitigation and Preparation

Flood control structures and evacuation plans were in place in St. Louis. As a river town, St. Louis had experienced large-magnitude flooding in the past, so officials had invested in mitigation efforts. Some of these structures did their jobs whereas the river overcame others. One structure that was able to withstand the flow was the St. Louis Flood Wall. This wall was built following the 1844 flood (the last massive flood) and was designed to keep a large flood like the one at that time from occurring again. The flow rate of the 1844 flood was about 880,000 cubic feet per second whereas the 1993 flood was about 1.032 million cubic feet per second (Porter 1993). Fortuitously, it was able to hold back the 1993 waters with just two feet to spare (NOAA) and was not one of the structures that failed.

In St. Louis, as in many flood-prone urban areas, the United States Army Corps of Engineers (USACE) are primarily responsible for designing and constructing flood defenses. A critical part of the defense system are the levees. These are generally constructed in order to prevent the river from overtopping its banks during a flood, and most commonly constructed of concrete and steel pilings, but can in some instances be earthen. Levees can have real benefits by minimizing water inundation into areas of valuable real estate, but they can also create a false sense of security to people living in proximity to the levee thus reducing their motivation to follow evacuation orders.

### **The Impact**

The flood was devastating to everyone in its path. Because of the number of people affected and the fact that the country's major agricultural areas were impacted, this flood had implications all across the nation. The event reached the lives of millions through newspaper articles, television, and the radio. There were several articles in the New York Times that described the heartache, suffering, and challenges that people in the Midwest were facing. People were faced with damaged homes, lost belongings, endless work to try to clean up and repair their property, and had to seek any monetary assistance that the federal government could provide. The president at the time, Bill Clinton, visited St. Louis where he announced that he was awarding more aid beyond the funds released when the region was declared a national disaster area. After signing in legislation to award a further \$6.2 billion for cleanup efforts, he encouraged the victims to stay positive because the hardest work has yet to come (Jehl 1993). The extra funding support was desperately needed. Much of the affected area was farmland,

public housing, and public works. Millions of crops were ruined after being submerged under dirty floodwater for such a long length of time.

During his visit, President Clinton also showcased 19 people by paying tribute to their bravery and selfless effort during the worst of the disaster. Although we typically consider first responders to a disastrous flood is not what we would typically think of as first responders in cases of emergency to be firefighters, EMTs, and police officers, in the case of St. Louis and in many situations, first responders are themselves victims of the disaster, but risk life and limb to help others in even worse predicaments than themselves. This humanitarianism behavior seems universal (Jehl 1993).

## Chapter 3

### Hurricane Katrina-New Orleans, Louisiana

Hurricane Katrina caused a disaster that was national in its impact. Before even striking New Orleans, it had claimed the lives of many in Florida as it made its way from the Atlantic into the Gulf of Mexico and began to take aim at Louisiana. In New Orleans, the city was well fortified by levees that had been built by the US Army Corps of Engineers over the period of land reclamation and river control for shipping, from 1930 on. However, the presence of levees in New Orleans had created a false sense of security for many residents, reducing their impulse to leave the city. Mr. Mullet is but one example of the dangers of residents having this false sense of security (Schwartz 2007).

Mr. Mullet had long worked jobs on the water to earn money for his mother who was raising him and his three siblings. When Mr. Mullet married the young couple moved to a house 50 yards behind the St. Bernard Parish levee, just outside New Orleans. In addition to his job, he took the time to visit and care for his mother and two elderly aunts who lived nearby. When Hurricane Katrina struck, he evacuated his wife, sending her to stay with family well north of the city. He refused to leave the city himself, however, because his mother and aunts were not able to get out and he did not want them to be stranded alone. The three elderly women decided to remain in one of the aunt's homes, assuming they could ride out the hurricane, something they had managed during many others. Mr. Mullet thought the women would be safer in his home because of its location behind the levee, so that is where he took them. During the peak of the storm, water topped over the levee in a giant wave and headed straight for the Mullet home. Everyone hurriedly put on life jackets as the water swept them out of the home. The frail, old

ladies had difficulties, but he could only hold onto his mother and one of his aunts. The other aunt got caught on a fence and sadly drowned. The others clung to a tree for hours waiting to be rescued. Finally, a neighbor spotted them and rescued them. Mr. Mullet's surviving aunt later died from diseases she caught from being in the dirty floodwater for so long.

Nearly a decade later, Mr. Mullet is still haunted by the events of that day. He still feels responsible and guilty for the death of his two aunts. His guilt, a form of post-traumatic stress, still haunts him to the extent that he is yet to tell his family details of the events, nor the daughter of one of the aunt's the full, true story of her death. He fears that they will blame him as he blames himself, or tell him how he should have acted differently in order to have rescued her. In either case, these are emotions that his fragile mental state is not capable of rationalizing (Perez 2006).

Mr Mullet is only one example of the thousands of people suffering from the emotional damage of losing their family, friends, and neighbors as well as their homes and belongings. In one USA Today article, a survivor recounts leaving her elderly mother behind to drown because the woman refused to leave her beloved home (O'Driscoll, 2005). Not only did the mother drown, but the daughter has to live with the loss and the mental anguish over not being more insistent about making her mother leave.

## **The Storm**

Hurricane Katrina began as a small tropical depression and meteorologists did not expect it to grow much larger (Revkin 2005). A convergence of unusual factors in 2005 paved the way for Hurricane Katrina's power (NOAA 2005). First, a very low vertical wind shear existed that allowed convection to develop through the entire troposphere, providing a vent for the storm and



allowing it to draw moisture from the warm ocean to constantly fuel it. Second, higher than normal sea level temperatures were recorded in the Gulf of Mexico, and a weak atmospheric ridge trapped warm water just offshore coastal Louisiana. This trap lasted long enough that not only was the surface water warm but it was also warm at depth, too. This helped fuel the hurricane and allowed it to strengthen shortly before striking New Orleans. Hurricane Katrina was not only strong, but it was also large in size allowing it to affect a significant portion of the southern United States (NOAA). Unfortunately, the scientific evidence suggests that storms like Hurricane Katrina may be more frequent in the future. This in addition to the threat of rising sea level means that there will be more intense storms, storms with unpredictable paths, and they will cause overwhelming loss of life, property, and mental security (Wilby and Keenan 2012).

### **Disparities and Impact**

In New Orleans, many citizens felt that the hurricane officials were exaggerating the size and intensity of the storm in order to scare them into evacuating the region. In the first few hours and days after the storm, however, shock and realization set in. People despaired as they realized missing family members and friends were gone forever, that their homes were completely destroyed, the costs were going to be greater than they could ever manage, and that the pets they had had to leave behind were lost to the raging floodwaters (O'Driscoll 2005, Perez 2006). There were several personal accounts of the devastation and obstacles faced during and post-disaster.

As retold by Dave Eggers (2009) in his careful analysis of the immediate aftermath of Katrina, the story of Zeitoun is especially harrowing. Zeitoun decided to stay in the city to protect his rental properties and construction business interests. He made sure that his wife and four kids evacuated north to stay with relatives in Baton Rouge for safety. Zeitoun was somewhat blasé about the potential for the magnitude of the storm and impact that officials were

predicting. He felt no need to worry because he had survived hurricane threats dozens of times. Flooding began slowly, inundating only the lowest points of the city. At first, it seemed as if the water damage would not be devastating. But, the storm and flooding was severe enough to cause multiple levee failures, and this factor was the key to the magnitude of the disaster in the city by allowing inundation of much larger regions than ever before. During Hurricane Katrina it was the first time that he was stuck for days, when eight feet of water flooded his home causing him to move to the roof, and when his main tools of survival were a tent that he pitched on his roof and an aluminum canoe to allow him to help others and to see what was going on (Eggers 2009).

The disaster was devastating to many who were left with virtually nothing to go back to; yet at the same time these same people praised the response from official post-storm. The Coast Guard received high approval, in part because they were given top-billing in the media by highlighting their rescue of people trapped in attics or on roofs. On the other hand, the Federal Emergency Management Agency (FEMA) was criticized quite heavily for their lack of involvement and provision of timely aid to those affected (O'Driscoll 2005). There was also evidence of corruption especially in the case of construction companies brought in by government officials to help rebuild the city after the floodwaters receded. Cray (2005) points out that FEMA knowingly hired companies that were not up to par with the requirements of disaster reconstruction. Some companies participated in illegal activities including hiring illegal immigrant workers. Many companies hired people formerly employed by FEMA to increase their chances to get the bid to be the company to do the clean up and rebuild in the disaster-affected region (Cray 2005). To add to this, the companies that FEMA were hiring were widely known to provide inadequate work and to be overpaid for the jobs (Cray 2005). FEMA came

under scrutiny with regards to their ability to hire legitimate companies for natural disaster response; however, these claims could not be held up in court.

FEMA's involvement with dubious companies during Hurricane Katrina is only part of the case that many have built against the federal government during crisis. Recently, the Army Corps of Engineers were investigated for building subpar levees. The levees were supposed to be built to withstand a Category 4 Hurricane, but they were barely able to withstand a mild Category 3 hurricane. As of this time, there is no hard evidence to support the claims. The fatal flooding that occurred in New Orleans may have had much to do with discrepancies in the levee structure orchestrated by the Army Corps of Engineers. To what degree should officials of this corporation be held responsible? There is a belief that higher-ranking city officials had the Corps build substandard levees in New Orleans (Robertson and Schwartz 2015). The discrepancies are believed to have stemmed from local government and community officials trying to reduce the cost of building. This opened the path for the engineers to build the structures that could only withstand up to a category three hurricane (Robertson and Schwartz, 2015).

FEMA is more than just an emergency response organization. After the 9/11 attacks in New York City, FEMA and the Department of Homeland Security merged to become one department fighting the war on terrorism and natural disasters. Under its new mandate, what is less well-known is that FEMA set up a temporary prison just outside of New Orleans to handle anyone believed to have been responsible for looting in the aftermath of the storm. In some cases heavily armed criminals allegedly were seen to travel from house to house in boats and ransack empty properties taking valuables from evacuated homes. According to Eggers (2009), gunshots could be heard at night. FEMA arrested anyone who was caught in the act of looting or even acted suspiciously. This over-criminalization of individuals during the flooding resulted in

almost anyone who was left in the city getting thrown into the makeshift FEMA prisons before being shipped off to a high security prison (Eggers 2009).

Those unlucky enough to not escape the dragnet and who ended up in FEMA's prison were often not treated fairly nor given access to the due process of the justice system. Guards and policeman acted as if the arrested were highly dangerous and needed maximum security. They were strip searched, not allowed to touch the fence, and were never given anything to sleep on. They were placed with five or more people into a small cage with no protection to the elements or medical attention. Some of the people in the prison were arrested for "stealing" items from their own homes or siphoning gas from neighboring cars in an emergency situation. Zeitoun in particular, was taken to the FEMA prison for behaving suspiciously in his home and then interrogated about terrorism (Eggers 2009). FEMA decided to work both the disaster angle and try to prevent any potential terrorist acts in the city, despite admitting that it was unlikely that there would be any major terrorist activity during an unexpected and severe natural disaster.

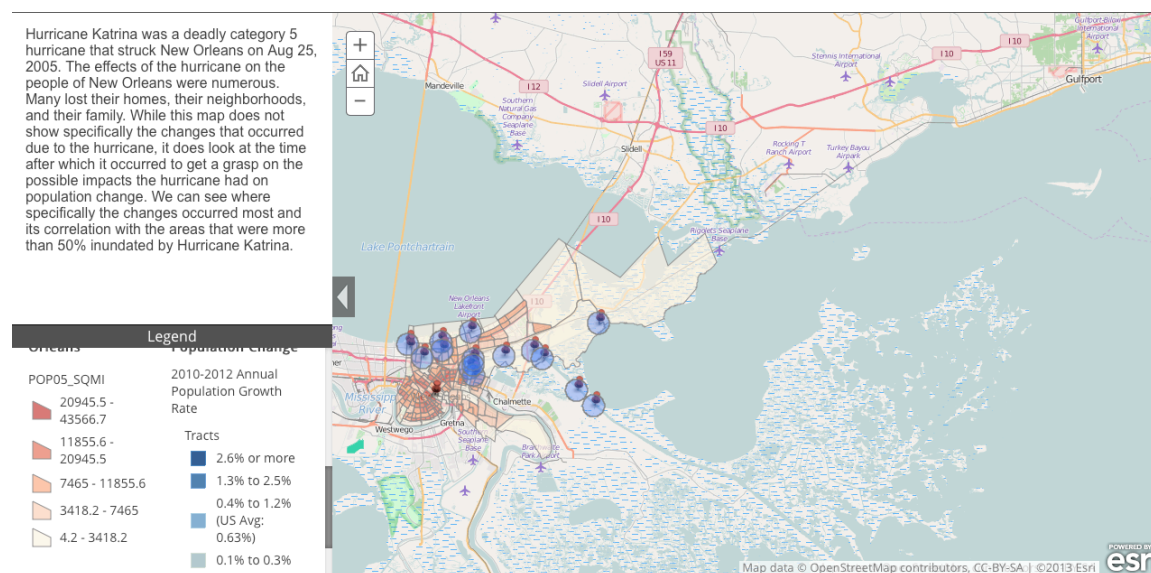
### **Analyzing the Data**

Understanding what happened in New Orleans is the first step in making changes to the system. To comprehend the risk and the damage to regions that have been affected by disaster, there are ample Geographic Information Science (GIS) tools to work with. Below is one graph that I have put together to show where population density was the highest and how that relates to the location of levee breaks. I have also included a one-mile radius buffer around each of the breached levees to illustrate the likely areal extent of the impact of the breaches. Several of the levees that broke were close to each other. Figure 5 illustrates where buffers overlap, and thus

highlights the extent to which it was densely populated areas that were affected by multiple levee breaks.

In 2005, Louisiana had the 4<sup>th</sup> lowest median income in the United States at an earnings amount of \$36,729 (Gutierrez, Sampson, and Kincannon, 2006). In New Orleans, there was a 23.3% poverty rate; one of the highest in the United States (Katz 2006).

**Figure 5**



During a disaster it is often the poorest areas that are at greatest risk because they have limited resources to prepare, to evacuate and to recover (Lower socioeconomic classes do not always have access to the internet, television, or reliable transportation. Without reliable information about the progress of the disaster, specific evacuation routes or shelter locations are unknown. As long as power was still available, many residents relied on the television, radios, and internet updates to follow the path and severity of the hurricane. During the inundation of the city, it was often only infrequent phone calls via cellular networks from evacuated family members that allowed those stranded to get any information at all (Eggers 2009).

Once a decision to evacuate is made, either mandated by the government or voluntarily by the individual, access to reliable transportation becomes important. For those that do not have personal vehicles or vehicles that can support people with disabilities, evacuation becomes a challenge. When New Orleans officials implemented a voluntary evacuation, all the major highways were designated as one-way traffic out of the city. The traffic was already slow moving, so when the mandatory evacuation was enforced the highways were gridlocked. It could take a hours for a single car to move 20 miles (Eggers 2009).

Lack of financial resources makes people especially vulnerable to disasters. Homeless people have no shelters or means to get out of the city making them completely reliant on officials to provide sheltering and transportation services. A lack of disposable income makes it more difficult to assemble an emergency kit of supplies in anticipation of a disaster. Additionally, post-disaster, there is a lack of fund for them to re-establish their home if it was destroyed or even damaged. Living paycheck to paycheck is difficult to begin with, but when a disaster wipes out a home and in some cases their job, then fully recovering from the disaster becomes almost impossible. The final straw for many, was FEMA's reliance on third party contractors that took away business from the locals who desperately needed the work (The H. John Heinz III Center for Science, Economics, and the Environment 2000).

## **Chapter 4**

### **Discussion and Analysis**

In this research, I have examined two major flood events that have affected large population centers and caused major damage to people and property. Despite flooding caused by severe and prolonged precipitation in the case of the Mississippi, or a category 3 hurricane in the case of New Orleans, some similarities between the events can be observed. One of the main questions I want to address in my research is how communities prepare for, and respond to disasters, so that we can determine better ways for communities to be ready for similar events in the future. In this chapter, I will compare and contrast the cases of St. Louis and New Orleans. By understanding the similarities and differences in their degree of preparation, their immediate post-storm response, and what they have done in the intervening years to mitigate future events, I hope to be able to pinpoint some common themes that apply to all flood disasters.

#### **Pre-storm Preparation**

Flooding is a powerful natural force. According to the IPCC AR4 report, sea level is expected to rise anywhere from 0.18 meters to 0.59 meters from 2090-2099 further exacerbating flooding in low-lying areas (IPCC 2007 p. 750). If these predictions hold true, then federal, state and local agencies will need to be prepared. It is important then, for vulnerable communities to learn from previous events. In this analysis, I will examine to what extent New Orleans and St. Louis have re-thought their preparation protocol due to past events in order to see how likely each is to make changes to improve their chances of withstanding the potential increased

magnitude of future events. Prior to the flood events in New Orleans and St. Louis, several common factors are apparent. In particular, both relied heavily on the presence of levees to protect them from flooding. In both cases, the levees systematically broke, allowing water to inundate much of the urban area. St. Louis suffered from the failure, not just of publicly funded levee systems, but also those built by private entities primarily to protect individual property or farmland. It is possible for private citizens who own land to protect their property by building their own levees. Levee owners must still comply with federal regulations as outlined by the NFIP (FEMA 2008). However, they are privately funded and so may be limited by the financial resources of the business or individual interests who are building them. In the case of New Orleans, it was the federally funded Army Corps of Engineers that failed. After a long inquiry, the Army Corps of Engineers acknowledged that the catastrophic flooding that occurred in New Orleans was due to a fatal flaw in engineering of the levees designed to protect the city. Local officials who participated in the design of the project also are under fire for their alleged role in cutting the design standards, refusing to comply with the USACE design of gates at the mouths of canals, which would have been the more effective option. Though there is no clear reason why the design was not accepted, the local officials opted for the extensive levee system that ultimately catastrophically failed (Robertson and Schwartz 2015). Despite, these inadequacies, the extent of the failure was unexpected. In most instances, there is always going to be some seepage underneath the levees, but their total collapse through undermining by the force of the river is very unusual (Carrns and McKay 2005).

In both St. Louis and New Orleans, levees were the main defense. As property values along rivers and coasts increase, their presence increasing will become important and therefore they will require higher construction standards. In New Orleans, the levees were designed to



withstand a Category 3 hurricane, yet as Hurricane Katrina blew through as a Category 3, there was still major, detrimental flooding due to the 10-20 foot storm surge (National Hurricane Center). This meant that some of the levees were overtopped by as much as 5 feet (Heerden 2007). Building levees to withstand larger floods is costly, and depending on the convergence of causal factors and future climate and sea level changes, there is no guarantee that even those will work.

A common theme I found across both case studies and the personal stories retold in books and newspaper articles, was that many residents were simply in a state of denial that a disaster like this could really happen to them. Many people had lived their whole lives without ever witnessing a flood of this magnitude. This mentality provides people the courage to attempt to wait out the storm in their homes. People living on higher ground or outside of floodplains are more justified to hold this sense of invulnerability, since these areas are typically not as likely to be flooded. Even though, in both New Orleans and St Louis, city officials declared a mandatory evacuation, they could not ensure that everyone left. In both cases, officials went from door to door to encourage people to leave, but they do not have the authority to forcibly move them.

In New Orleans, neighborhoods at the lowest elevations were the most densely populated, and in particular those at lower socioeconomic brackets, thus exposing the most vulnerable people to the greatest risk of flooding (Felsenstein and Lichter 2014). The fixed infrastructure of an urban area tends to lock in further development in potentially high-risk flood zones. New Orleans and St. Louis still focus activity on their flood-prone land despite the recent disasters. One of the negative impacts of enhanced fortification as new preventative structures are built, is that they reduce the perceived risk of flooding. This often continues over time as the memory of

previous disasters fade. The net result is that a community can become even more vulnerable (Baldassarre et al 2015).

In the case of New Orleans and St Louis, communication to the public was done through media outlets, in particular radio and television. During Hurricane Katrina, the widespread use of the internet and cellular technology enhanced their use as a means of providing emergency information. However, for poorer communities the lack of reliable access to information led to higher proportions of the population remaining in the city, although as we have seen, even if they did want to evacuate they often could not afford to, or like Mr. Mullett, they wanted to stay to protect their property and family (Eggers 2009). People who had remained in the city were cut off from information due to power failures and the general lack of any attempt on the part of city officials to access the worst-hit areas and give up-to-date information to those stranded. What is crucial is that authorities maintain clear communication channels so that individuals have the agency to make informed decision for themselves to protect their lives and property.

When people remain in their homes during disasters as happened in both St Louis and New Orleans, they become a direct threat not only to themselves but also the first responders who have to try to help. By choosing to stay in the path of the storm, people are putting their lives at risk and possibly in need of rescue. Trained first responders must then carefully work to extract them from floodwaters, hopefully without putting themselves at too much risk (Bills et al 2011). First responders are often traumatized by the witnessing so much human suffering, severe injuries, and death. Further, as in the case of St Louis, many of these first responders are not trained specialist who have undergone some psychological training to help deal with the emotional stress such work can create. Approximately 25% of the first responders in Hurricane Katrina suffered from depression post-storm (Osofsky et al 2011).

A further difficulty observed in both cases, is that when inundated, the expected geography of the city changes. It becomes disorienting and difficult to navigate. People and animals must move up to second and third stories of homes, and are often trapped there waiting for the waters to recede. During this time, water, food, and transportation access are restricted to what might have been a sealed freezer or still-dry pantry in the house. Those that have boats can move about the flooded region with greater ease, but then they risk of being arrested and accused of looting, even if they are within their own home (Eggers 2009).

Both St. Louis and New Orleans relied heavily on first responders during and immediately after the disaster. Community officials set up shelter locations for both regions for any residents that needed to evacuate their homes but had nowhere to stay outside of the city. The shelters provided somewhere to stay, food, water, and medicines for all those in need. Agencies such as the American Red Cross also set up temporary shelters to house people and provided many of the same necessary items for survival as the community shelters did. ARC also provided a simple missing persons database as an additional resource. This allowed volunteers to check with other shelters and rescue teams in an attempt to locate missing family and friends that had not been heard from since the disaster (Eggers 2009).

The shelters were not without problems, though. Many of them were overcrowded and lacked adequate essential supplies. In New Orleans, even people sheltering in the Superdome were not safe from looting and other criminal activity. Following the event, two women reported being raped in the shelter, victim to predators in a situation that lacked proper security services or helplines. One of the victims recounted that she had to wash herself with bleach because there was nowhere for her to receive help in the midst of a disaster-stricken city (Burnett 2005). People were sleeping in cramped positions whenever they were lucky enough to find a free

space. Outside of the shelter there were crowds of people. Many were sick, injured, or disabled and seeking medical help from the few emergency medical personnel that were available.

Corpses of those who had fallen victim were simply lined up around the Superdome, only some of them covered by sheets. There was no real separation for those who were healthy and those in desperate need of help.

During a disaster, the normal system of emergency teams such as the police force and the emergency medical services are not operating at the same capacity they can under normal circumstances. There was limited access to the flooded areas and communication systems were unavailable. That meant that all patrolling had to be undertaken by boat and aircraft. The lack of electrical power meant that phone lines were down and cell phones could not be charged, so victims could not report crimes or emergencies. Petty criminals taking advantage of the opportunity of a near empty city were able to get away with looting homes, siphoning gas, and in some cases where fighting over meager resources occurred a number of murders were committed. The difficulties of ensuring normal policing, the air-based enforcement, and the reconfiguration of FEMA into the Department of Homeland Security by the time of Katrina, meant that many innocent people were made vulnerable when caught in the disaster zone.

Flooding affects many coastal and river cities, and very often these cities have experienced many serious floods. Some of these cities have been awarded governmental support to relocate outside the flood zone. This was the case for landowners who were hit by the 1993 Mississippi River Flood. The government bought the land from them and allowed that land to return to its natural floodplain state. In total, the government obtained 7700 properties costing approximately \$56.3 million (Pinter 2005). The compensation to the landowners was used to build or buy homes in a new location. Many residents of Valmeyer, Illinois, a town also affected

by the 1993 floods relocated to a hilltop a mile and a half away from the former town site. However, residents of Valmeyer had suffered more from the emotional costs of relocating rather than the financial costs. During interviews after the relocation several expressed their initial reluctance to move in the beginning and their later wish that they could return to their old homes. The process of rebuilding a community on the new hilltop location had not been easy (Bosman 2016).

### **Looking to the Future**

Many coastal and river settlements will continue to be under threat of flooding as sea level rises and storms intensify. If they are to withstand these changes, there is an imperative need to better prepare for future flood events, as well as develop a set of protocols for effectively and efficiently responding to the possibility of a disaster following a major flood. Examining and comparing the degree of preparation between the disasters in St. Louis and New Orleans, it is possible to draw some general common threads that help shed a light on how the threat of disaster was dealt with in the past, and how it might be possible to adapt these strategies for the future. In this section, I outline some important parallels between the two events, offer some critiques of how the disaster preparation and response unfolded, and finally some recommendations for adapting these disaster protocols in the event of future catastrophes.

Levees are not a one-stop solution, but they are one of many important defense structures that enable better preparation for flooding. Levees are designed to hold back the river or storm surge waters. The design, including the height of levees, is usually determined on a cost-benefit basis, and therefore, by definition they will not ever be able to hold back the most unlikely events. This means that it is necessary for local officials to carefully assess the likelihood of a

flood disaster based on future predictions rather than past (The Economist, 2016). By using historic data, local and federal governments are only able to make predictions for an unchanging environment. Therefore, levees to withstand future events need to be built with more frequent, severe hurricanes and greater intensity precipitation events in mind.

City, state, and federal officials will never be able to force all flood –threatened residents to evacuate their homes. People will always believe they know what is best for them. Their own belief and value system, and their sense of belonging, will often be what they base their evacuation decision on. Eggers (2009) highlights one family’s struggle to determine when and how to evacuate their homes. Ultimately they decided that the father should stay to take care of their home and rental properties because they believed, like many others, that the flood would not affect them.

Acknowledging that some residents will refuse to evacuate, government officials need to devise different mechanisms in order to protect the citizens. Relocating entire towns, as was done in Valmeyer, is a difficult and long process. Despite the challenges presented, governmental buyouts are probably one of the best options to enable people to relocate away from flood prone areas, especially those who may not have the financial resources to do it themselves. Although initial relocation costs might be very high an outlay for the Governments, over time the reduced cost of future damage and lives lost will far outweigh the relocation expense. At the time of Valmeyer’s relocation, there were few examples to follow, but many lessons can be learned from it. A more formal process, clear guidelines and resources to support those being relocated might make it a smoother and less harrowing transition.

Providing resources for community residents to better prepare for flooding will reduce the feelings of uncertainty if a disaster is imminent. Widespread and frequent evacuation drills

might reduce panic because the procedures will be routine and familiar with practice. Having specific and familiar locations for shelters for them to stay whether that be a community center or American Red Cross shelter or a relative's home outside of the flood zone makes the process of leaving much easier. Addressing socioeconomic differences within a community can also help with emergency plans. Building an emergency kit can be a financial burden for those in poverty so Government help to provide these kits would reduce the amount of immediate supplies needed during a storm.

Education and resources are key for the survival of residents in areas prone to flooding. Encouraging people to think about their personal safety before their belongings and human may help reduce the number of people choosing to stay in the city. Reminding residents that floods will occur could prompt someone to consider the dangers (crime, death, disease, etc.) threatening their lives. Early warning systems can provide residents with time to prepare their homes and then get themselves out of harm's way. Even with all these protocols in place, it is still not certain whether the disaster might strike. Local and State officials are those in charge of making the decision to evacuate but that decision is based on the probability of the event occurring. Evacuate, and the storm misses, then it reduces the citizens' confidence in what the government is telling them to do. For the officials, however, it is better to err on the side of caution rather than face the possibility of thousands of people stranded in a disaster zone.

There are no guarantees when and how disasters will strike a community, but it is vital that people are educated about the risks presented during them and provided the resources to help them not only survive, but also to function normally post-disaster. As we move forward into climate change history, anywhere from 50 to 200 million people across the world will be displaced by 2050 from the risks they face from flooding. Luckily, the United States is has

approved a plan to provide \$1 billion to 13 states to help relocate citizens in high-risk zones (Davenport and Roberston 2016).



## References

- "Floods in the Midwest: Disaster Foretold." *The Economist* (January 9, 2016): 25.
- Adger, W N., Terry P. Hughes, Carl Folke, Stephen R. Carpenter, and Johan Rockstrom. "Social-Ecological Resilience to Coastal Disasters." *Science* 309, no. 5737 (August 2005): 1036-39.
- Anderson, Theresa K., and J M. Sheperd. "Floods in a Changing Climate." *Geography Compass* 7, no. 2 (2013): 95-115.
- Ayres Jr., B. Drummond. "What's Left From the Great Flood of '93." *The New York Times*, August 1993.
- Baldassarre, Giuliano D., Alberto Viglione, Gemma Carr, Linda Kuil, and Kun Yan. "Debates-Perspectives on socio-hydrology: Capturing feedbacks between physical and social processes." *Water Resources Research* 51 (2015): 4770-81.
- Bills, Martin, Barry Edwards, Keith Gillespie, Jon Gorman, and Daniel Graham. "Management of Water and Flood Incidents." edited by Vicky Barlow, 11-13. N.p.: Rescue 3 International, 2011.
- Bosman, Julie. "A Town Drowned and Resurrected on a Bluff Misses Its Old Home." *The New York Times*, January 6, 2016.
- Burnett, John. "More Stories Emerge of Rapes in Post-Katrina Chaos." National Public Radio. <http://www.npr.org/templates/story/story.php?storyId=5063796>.
- Carrns, Ann, and Betsy McKay. "When Floodgates Fail; As Levee is Breached, New Orleans is Inundates; Rooftops, Attics for Refuge." *Wall Street Journal Eastern Edition*, August 31, 2005.
- Cigler, Beverly A., and Raymond J. Burby. "Local Flood Hazard Management: Lessons from National Research." In *Cities and Disasters: North American Studies in Emergency Management*, edited by Richard T. Sylves and William L. Waugh Jr, 59-74. Springfield: Charles C Thomas Publisher, 1990.
- Cray, Charlie. "Disaster Profiteering: The Flood of Crony Contracting Following Hurricane Katrina." *Multinational Monitor*, September 2005.
- Davenport, Coral, and Campbell Robertson. "Resettling the First American "Climate Refugees"." *The New York Times*, May 2016, sec. A, p. 1.
- Day, Cindy. "Devastating flooding brings fertile land." *The Halifax Daily News*, September 2004, p. 30.
- Eggers, Dave. *Zeitoun*. Boston: McSweeney's, 2009.
- Eisenman, MD, MSHS, David P., Kristina M. Cordasco, MD, MPH, Steve Asch, MD, MSHS, Joya F. Golden, BA, and Deborah Glik, ScD. "Disaster Planning and Risk Communication with Vulnerable Communities: Lessons From Hurricane Katrina." *American Journal of Public Health, Supplement 1* 97, no. S1 (2007): 109-15.
- Federal Emergency Management Agency (FEMA). "What's New in Flood Hazard Mapping." <http://www.fema.gov/whats-new-flood-hazard-mapping>.
- Felenstein, Daniel, and Michal Lichter. "Social and economic vulnerability of coastal communities to sea-level rise and extreme flooding." *Natural Hazards* 71, no. 1 (March 2014): 463-91.
- FEMA. "Community Rating System."
- FEMA. "Provisionally Accredited Levees." <http://www.fema.gov/media-library-data/9848948edd7359c0dd8847b87dda10b2/Procedure+Memorandum+No.+43+->

- +PAL+FAQ+(Answers+to+Questions+about+PM+43)+-+Chapter-Section+Number+-+1.0.pdf.
- Frantz, Jeff. "Tropical Storm Lee's lasting impact: Tiny Pennsylvania town recovers faster than its residents." PennLive. Accessed February 22, 2016.  
[http://www.pennlive.com/midstate/index.ssf/2012/09/tropical\\_storm\\_lees\\_lasting\\_im\\_5.html](http://www.pennlive.com/midstate/index.ssf/2012/09/tropical_storm_lees_lasting_im_5.html).
- Fruedenberg, William R., Robert Grambling, Shirley Laska, and Kai Erikson. *Catastrophe in the Making: The Engineering of Katrina and the Disasters of Tomorrow*. Washington, D.C.: Island Press, 2009.
- Gutierrez, Carlos M., David A. Sampson, and Charles L. Kincannon. "Income, Earnings, and Poverty Data From the 2005 American Community Survey." US Census Bureau.  
<https://www.census.gov/prod/2006pubs/acs-02.pdf>.
- Heerden, Ivor L. "The Failure of the New Orleans Levee System Following Hurricane Katrina and the Pathway Forward." *Public Administration Review* 67, no. S1 (December 2007): 24-35.
- Holmes, Jr., Robert R., and Karen Dinicola. "100-Year Flood-It's All About Chance: Haven't we already had one this century?" edited by United States Geological Survey (USGS), 2010.
- Intergovernmental Panel on Climate Change. *Contribution of Working Groups I, II, and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Geneva, Switzerland: IPCC, 2007.
- Jehl, Douglas. "Clinton Hails Midwest Courage Against the Flood." *The New York Times*, August 12, 1993.
- Katz, Bruce. "Concentrated Poverty in New Orleans and Other American Cities." Brookings.  
<http://www.brookings.edu/research/opinions/2006/08/04cities-katz>.
- Li, Jingyuan. "Community Flood Hazard Mitigation and the Community Rating System of National Flood Insurance Program" PhD dissertation, East Carolina University, 2012.
- Linskey, Annie. "FEMA's New Flood Maps Pressure Homeowners to Raise Their Houses." *Bloomberg Businessweek*, August 22, 2013  
<http://www.bloomberg.com/news/articles/2013-08-22/femas-new-flood-maps-pressure-homeowners-to-raise-their-houses>.
- Lovelace, James T., and Claude N. Strauser. "Perception and Reality Concerning the 1993 Mississippi River Flood: An Engineers' Perspective." .
- Meehl, G.A., T.F. Stocker, W.D. Collins, P. Friedlingstein, A.T. Gaye, J.M. Gregory, A. Kitoh, R. Knutti, J.M. Murphy, A. Noda, S.C.B. Raper, I.G. Watterson, A.J. Weaver and Z.-C. Zhao, 2007: Global Climate Projections. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- National Geographic. "Flood plain."  
<http://education.nationalgeographic.com/encyclopedia/flood-plain/>.
- National Hurricane Center. "Hurricanes in History."  
<http://www.nhc.noaa.gov/outreach/history/#katrina>.

- National Oceanic and Atmospheric Administration (NOAA). "CPC: Flooding in the Central US: Special Climate Summary-95/2."  
[http://www.cpc.ncep.noaa.gov/products/special\\_summaries/95\\_2/](http://www.cpc.ncep.noaa.gov/products/special_summaries/95_2/).
- National Oceanic and Atmospheric Administration (NOAA). "Regional climate highlights: North America."  
[http://www.cpc.ncep.noaa.gov/products/assessments/assess\\_95/name.html](http://www.cpc.ncep.noaa.gov/products/assessments/assess_95/name.html).
- National Weather Service, . "High Water Level Terminology." National Oceanic and Atmospheric Administration (NOAA).
- New Jersey Department of Environmental Protection (NJDEP), . "Superstorm Sandy Blue Acres Buyout Program: Frequently Asked Questions." (September 15, 2015).
- O'Driscoll, Patrick. "Survivors tell stories of relief and heartbreak." *USA Today*, August 31, 2005.
- Osofsky, H J., J D. Osofsky, J Arey, M E. Kronenberg, and T Hansel. "Hurricane Katrina's first responders: the struggle to protect and serve in the aftermath of the disaster." *Disaster Med Public Health Prep* (September 2011): 214-19.
- Paranjothy, Shantini, John Gallacher, Richard Amlot, James G. Rubin, and Lisa Page. "Psychological impact of the summer 2007 floods in England." *BMC Public Health* 11 (2011).
- Parker, Dennis, and James K. Mitchell. "Disaster Vulnerability of Megacities: An Expanding Problem that Requires Rethinking and Innovative Responses." *GeoJournal* 37, no. 3 (November 1995): 295-301.
- Perez, Evan. "Louis's Choice: As Katrina Fades, One Man Struggles With His Memories; Mr. Mullet's Kin Don't Know How Aunt Pee Wee Dies; He Does and Is in Torment; 'I Keep Seeing Her Face'." *The Wall Street Journal*, April 3, 2006, p. A1.
- Pinter, Nicholas. "One Step Forward, Two Steps Back on U.S. Floodplains." *Science* 308, no. 5719 (April 8, 2005): 207-08.
- Pitlick, John. "A Regional Perspective of the Hydrology of the 1993 Mississippi River Basin." *Annals of the Association of American Geographers* 87, no. 1 (1997): 135-51.
- Porter, E F. "An Overflow of Numbers the Flood of '93 May Now be the Leading Cause of Statistics." *St. Louis Post*, August 23, 1993, sec. 01D.
- Revkin, Andrew C. "With Few Warning Signs, an Unpredictable Behemoth Grew." *The New York Times*, August 29, 2005, sec. A, p. 13.
- Robertson, Campbell, and John Schwartz. "Decade After Katrina, Pointing Finger Firmly at Army Corps." *The New York Times*, May 23, 2015.
- Salter, Christopher L. "The Great Flood of 1993: Causes, Impacts, and Responses." *American Geographical Society* 87, no. 3 (July 1997): 434-36.
- Schwartz, John. "Army corps details flood risks facing New Orleans." *The New York Times* (2007).
- The H. John Heinz III Center for Science, Economics, and the Environment. *The Hidden Costs of Coastal Hazards: Implications for Risk Assessment and Mitigation*. Washington, D.C.: Island Press, 2000.
- United States Geological Survey (USGS). "How do I interpret gage height and streamflow values?." Accessed February 21, 2016. <http://help.waterdata.usgs.gov/tutorials/surface-water-data/how-do-i-interpret-gage-height-and-streamflow-values>.
- Wilby, Robert L., and Rod Keenan. "Adapting to flood risk under climate change." *Progress in Physical Geography* 36, no. 3 (2012): 348-78.