AN EVALUATION OF THE CAUSES, CONSEQUENCES, AND POTENTIAL SOLUTIONS TO INCREASED RED RIVER FLOODING IN THE CADDO PARISH REGIONS OF NORTHWEST LOUISIANA

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PREPARED BY: JORDAN CHRISTMAN, KATHRYNANN FIELDS, STEVEN HEBERT, BRANDON KALLENBACH, MARIO MARTINEZ, SHELBY PONCIK, AMANDA SUMNER, & ELIZABETH THOMAS

FACULTY ADVISOR: DR. ARNOLD VEDLITZ

2018 MASTER OF PUBLIC SERVICE & ADMINISTRATION CANDIDATES AT THE BUSH SCHOOL OF GOVERNMENT AND PUBLIC SERVICE AT TEXAS A&M UNIVERSITY

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EXECUTIVE SUMMARY

Urban flooding is a challenge for many parts of the world, and Caddo Parish, Louisiana, is no exception. Caddo Parish, located in Northwestern Louisiana on the banks of the Red River, has been the subject of intense flooding for decades, issuing widespread devastation to many areas of the parish. As waters from rain events and upstream reservoirs deluged the Red River, countless individuals and communities were affected. In addition to damage and destruction of homes and personal belongings, sectors of the economy were also impacted, notably agriculture and industry. Rising waters jeopardized public infrastructure, affecting commerce throughout the parish, particularly waterway systems. This report, prepared by graduate students of the Bush School of Government and Public Service at Texas A&M University, per request of the Caddo Parish Sheriff's Office, outlines policy solutions to protect the individuals and communities of Caddo Parish from future flooding.

In order to provide comprehensive solutions and recommendations to increase community resiliency and mitigate flood risks, this research is comprised of an extensive literature review, case study evaluation, technical review, survey data analysis, and approximately 40 stakeholder interviews. The literature review revealed that the causes of increased flooding can be attributed to rainfall events, urbanization, and diminished infrastructure impacting economic, social, and environmental segments of the community. Two case studies are also evaluated, focusing on floods that occurred in Grand Forks, North Dakota, and Napa County, California. From these case studies, similarities that existed between these communities and Caddo Parish are identified and policy options implemented in both sites when formulating customized recommendations. Furthermore, the geography, demographics, cultural context, and economy of Caddo Parish are also factors considered within the research. Understanding these elements of the region are paramount to developing long-term, sustainable solutions.

One of the most extensive portions of the research is the technical review. First, flood management as well as the general causes of flooding were investigated in order to identify human activity that potentially could be modified to mitigate damage. Within the research, it was recognized that the Federal Emergency Management Agency maps used to indicate flood-prone areas in Caddo Parish were outdated, and upstream United States Army Corps of Engineers reservoir projects potentially increased the magnitude of flooding. In order to mitigate flooding along the Red River, the team studied both engineering and ecosystem management approaches. Dam construction, floodplain zoning, an improved levee system, and dredging of the Red River were all carefully considered when developing a series of policy recommendation for the Parish to implement. Improved ecosystem management practices such as riverside forests, vegetation management and reclamation in riparian zones, and avoidance of building in impervious zones are also viable options to mitigate flood damage, as well as improve ecosystem services and natural aesthetics.

The empirical field work is comprised of approximately 40 stakeholder interviews as well as data analysis from the Louisiana State University Public Opinion Survey to gauge attitudes towards flooding. A variety of stakeholders were interviewed throughout the research process, ranging from individuals with engineering to non-profit management positions within the community. These stakeholder interviews were an important component of the work undertaken, as they

allowed the team to identify similarities in how the community viewed the causes of the flooding, the agencies responsible, as well as possible recommendations. Additionally, the team analyzed a series of questions from the public opinion survey and conducted statistical hypotheses testing to better gauge attitudes towards flooding as well as assess characteristics affecting these attitudes.

Upon conclusion of the research process, the team presents policy recommendations. In order to increase protection and mitigate risks of urban flooding, the following should be considered for implementation: flood education outreach, increased training and exercises, upstream partnerships, green infrastructure, stormwater utility fees, updated floodplain maps, improved land use planning/building codes, and dredging. Implementation of these recommendations will strengthen resiliency and facilitate sustainability in Caddo Parish.

Introduction

In 2015 and 2016 the Red River in Northwest Louisiana experienced significant flooding. Heavy rainstorms in Oklahoma and Texas broke the 120-year-old record of total monthly rain for the area in May of 2015 (Caddo Levee District, 2015). Consequently, the Red River swelled, forcing water downstream and flooding Northwestern Louisiana. The second wave of flooding from Tropical Storm Bill led to additional heavy rainfall and cost the community an estimated $8.2 million in property damages in Caddo Parish. Agricultural loss was estimated to be $7 million in Northwestern Louisiana which greatly affected commerce. The city flooded again in March 2016. Following the 2015 and 2016 Red River floods, there was considerable concern about preventing future flooding in Caddo Parish and Northwestern Louisiana.

The Caddo Parish Sheriff's Office, Flood Technical Committee, and other local agencies requested the assistance of a team of Bush School of Government and Public Service graduate students in examining the various causal factors affecting the increased flooding of the Red River and presenting a set of possible alternative solutions for consideration by governmental and nongovernmental stakeholders and citizens. The following report discusses scientific and technical issues and the diverse human factors that led to increased flooding of the Red River.

The report outline is as follows – a comprehensive literature review of urban flooding throughout the United States that includes published materials, government reports, and newspaper articles; two detailed case studies, representing flooding incidents with issues similar to Caddo Parish; a technical examination of flood characteristics available by the U.S. Army Corp of Engineers; in depth stakeholder interviews aimed at drawing out the expertise of local and regional experts and decision makers; and in depth, statewide public opinion survey of residents from Louisiana conducted by the Center for Public Policy at the Manship School at Louisiana State University that focused on statewide attitudes about flooding. Using these various approaches, the team examined the context of flooding both nationally and statewide and applied that to the case of flooding in Caddo Parish, Louisiana.

Based on the results, the team identified and suggested a set of possible policy options based on the research from the literature review, case studies, technical review, and empirical research of both the survey data and stakeholder interviews. The report begins with a comprehensive review of urban flooding in the United States, outlining causes, impacts, and solutions.

Statement of the Problem

Caddo Parish faces reoccurring issues and problems due to the repeated flooding of the Red River. This report seeks to integrate detailed information on these problems gathered from in-depth stakeholder interviews, public opinion survey data, case studies, technical review, and the literature provided in scholarly publications, government reports, and media stories. The purpose of this study is to help identify key problems and evaluate possible recommendations.

Urban Flooding: What We Know from Other Contexts & Studies

Introduction

Throughout the United States, urban flooding appears to be a common problem. It has been seen as a greater issue in the Midwest and the South. Urban flooding is different than a flash flood because an urban flood occurs when there is heavy rain, high snow melt, or any sort of increase in water amount at a steady rate unlike a flash flood where rain comes down rapidly (Rainready, 2016). Additionally, urban flooding is characterized "by repetitive, costly and systematic impacts on communities, regardless of whether or not these communities are located within a formally designated floodplain or near any body of water" (Illinois Department of Natural Resources, 2015). There are three main categories that help to explain the increase in urban flooding. The first category is excessive rainfall due to changes in weather patterns particularly the increase in intense storms. The second category is the increase in urbanization specifically increase in impervious spaces and decreasing amounts of green space. The last category is the outdated, decaying or inadequate infrastructure.

Intense floods economically affect communities as the population and businesses grow in vulnerable areas (Svetlana, 2015). Flood damage exacerbates in urban areas, i.e., high population, high assets and vulnerable infrastructures. De Moel et al. (2009) found that flood-prone areas remain attractive for socioeconomic activities, which encourages citizens and businesses to remain, thereby ensuring high damage potential. Growing communities seek structural and environmental defenses they can implement to avoid future flood damage.

Why It's Occurring

The team examine the changes in weather patterns with the increase in short and long-term rainfall and the increase in both the number and intensity of storms. The 2014 National Climate Assessment Report stated, "over the last 54 years, there has been major increase in precipitation across most of the country and projects more and intense future rain storms" (National Climate Assessment Report, 2014). The same report also states that "heavy downpours are increasing nationally especially over the last three to five decades; the largest increases are in the Midwest and Northeast" (National Climate Assessment Report, 2014). It is apparent that increase in rainfall will occur based on these past trends and future predictions.

We next look at the role played by the increase in urbanization, the reduction of greenspace, and the concomitant increase in concrete surfaces. The overall population of the United States, specifically our urban population, is growing. With the increase in population, urban and suburban areas that were previously left as natural green areas are now turning into developed areas to meet the new population demands for both housing and business concerns (Wheater, 2009). Urbanization leads to higher amounts of paved surfaces. These paved surfaces do not allow for water to be absorbed into the ground leading it to concentrate in areas therefore causing flooding (National Institute of Disaster Management). The building of impervious surfaces disrupts the natural process of the water cycle. The increase in urbanization has also led to development in floodplain areas because of increasing need of development.

The third area of focus is on problematic infrastructure assets. Generally, across the United States, the infrastructure was built over 50 years ago. It is simply outdated and unable to handle

the increase precipitation. Levees, dams, catchment basins and stormwater removal systems are prime examples of infrastructure elements that need repair, updating and replacement. These systems were not built to withstand the increasing amounts of rain we are seeing and now lead to significant flooding in areas where houses, businesses, governmental agencies and health facilities are located (Rainready, 2016).

Impacts

Economic

The economic impacts from flooding have been monumental. From 1970-1980, "the total federal costs of flooding estimated to exceed $4 billion" (Burby, 2017). The same article led to a prediction of over $50 billion throughout the 1980s (Burby, 2017). There is a high correlation between the increase in flooding and increase the dollar amount of damages payments made from state and federal sources. More recent numbers from 2014 show that direct flood damage added up to $2.86 billion in payouts from the federal government alone (National Weather Service, 2014). That cost was in 2014 alone, and the 2017 events with Harvey, Maria, and other large storm events will significantly exceed those numbers. Looking at some more recent numbers from National Oceanic and Atmospheric Administration (NOAA) from 2007-2017, there is an estimated $39 billion in damage across the United States (NOAA, 2018). It is evident that the costs of flooding will only continue to increase. Increased incidents of flooding leads to an increase in the amount of damage, which becomes a burden for citizens, businesses, and all levels of government.

Social

Social costs come in the form of loss of life and injuries, health impacts, and economic dislocations for both individuals and firms. Many of the floods occurring in the United States have seen both a loss of life and a high number of injuries. The great flood of 1972 in Mississippi led to the displacement of 700,000 people (Tollan, 2002). This high displacement of people leads to direct impacts on the economy of the area in the form of loss of tax base and loss of business. In 2014 alone, the United States had 55 deaths because of the flooding and many more occurred with the storms in 2017. Looking at the same range from 2007-2017 from NOAA, there were an estimated 191 deaths from flooding incidents across the United States (NOAA, 2018). Health impacts are also a major factor that come after a flood has occurred. Studies have shown there are psychological impacts including psychological distress from floods, having to leave one's home, and the disruption of normalcy(Paranjothy et al., 2011) . There are also issues with the potential for contaminated drinking water, waterborne illnesses, and mold and mildew in the impacted areas. Clean drinking water is a necessary item for communities to function. If the following issues occur, then there will be greater increases in loss of life or injuries. Floods may also cause damage to infrastructure including the following sectors: communication, transportation, healthcare, utilities, and waste water.

Environmental

Flooding not only brings in the issue of increased amounts of water into an area but the potential for other issues such as an increase in debris, mudslides, and sediment. These potential problems only increase the number of financial damages. The other environmental impacts include wildlife impacts such as water contamination, habitat loss, and a decrease in access to food sources (Natural & Beneficial Functions Committee, 2015).Livestock also becomes impacted because

there is a higher focus on preserving human life over the lives of animals (Bawden, 2014). The ecosystems of the area becomes disrupted when a flood occurs.

Solutions

The solution to flooding is to work to build more resilient cities in areas that are flood-prone. Solutions range from reducing impervious surfaces, managing rainfall, improving infrastructure, improving flood water removal systems, and designing more green space to better absorb excess water (Association of State Floodplain Managers, 2015). Cities across the United States have also worked to implement flood management practices. Detroit, Michigan, has focused on utilizing vacant space, urban gardening, and tree canopies as well as involving grassroots efforts to promote education on urban flooding (Association of State Floodplain Managers, 2015). Chicago, Illinois, has also used citizen partnerships, NGO partnerships, and green roof programs. Green roofs is the concept of adding layers of vegetation on top of buildings all across the city. The purpose is to help manage stormwater runoff in a controlled environment (City of Chicago). Chicago has also implemented the Green Alley Program which involves increasing the use of permeable pavement that "allows stormwater to filter through the pavement and drain into the ground instead of collecting on hard surface" (City of Chicago). This program helps to reduce the amount of standing water that leads to potential flooding. Milwaukee, Wisconsin, created a sustainability office, increases in urban gardening, protection of wildlife and habitat, and innovative basement feasibility study. These programs are initiatives that various cities across the United States have taken in order to lessen the damages of flooding. Also, several next step strategies exist, such as preventing land development in floodplain areas, managing watersheds, increasing in green space, increasing in education of flood damage, and promoting public private partnerships (Natural & Beneficial Functions Committee, 2015). Additionally, physical solutions for flood management include levees, reservoirs, and pumps have been implemented to keep the floodwaters away from the area. Land use planning is another tool that local governments may use to prevent development in flood plains. These are several of the possible solutions to help mitigate the damage of urban flooding.

Case Study: Red River of the North in Grand Forks, North Dakota

The Red River of the North, which originates in the United States and flows northward to Canada, flooded in 1997, causing extensive damages in Grand Forks, North Dakota, and East Grand Forks, Minnesota (Xuefeng and Gajan, 2011). More than 75,000 residents were evacuated as a result of this major disaster (James and Korom, 2001). The 1997 flood was the second major disaster faced by Grand Forks in a short period. When the flood came, the city was still recovering from a major blizzard that affected the region a few weeks earlier. The flood caused significant damages to public and private structures in the city, estimated to be $2 billion, and most of these damages were not in the traditional 100-year floodplain. As is often the case with floods, some families were separated for an extended period of time, and the economic life of the communities was significantly disrupted (James and Korom, 2001). The 1997 flood changed Grand Forks forever, forcing some people to leave everything they owned to move out of flood-prone areas.

Floods are a reoccurring phenomenon in Grand Forks. The Red River floods are frequent due to its inherent characteristics of a flat river gradient and a northward flow. While the causes behind the floods on the Red River of the North are not related to those of the other Red River in Louisiana,

this case provides a good insight on potential policy solutions to address major floods like the ones that occurred in Caddo Parish recently. The Grand Forks flood has been cited as a case study by American Rivers to understand how natural flood protection can work and how communities can respond to flood hazards, while also protecting the environment (American Society of Civil Engineers, 2015).

Comparing Grand Forks, North Dakota and Caddo Parish, Louisiana

Grand Forks, the third largest city in North Dakota, is home to the University of North Dakota and the Grand Forks Air Force Base (City of Grand Forks, 2018). Similar to Caddo Parish, Grand Forks is located on a state line that divides multiple jurisdictions. The location near other jurisdictions is highly relevant as it means collaboration with partners in other jurisdictions, which is essential to planning flood protection strategies and allocating resources. However, this collaboration may be difficult to accomplish. For both Grand Forks and Caddo Parish, any decisions made in a neighboring jurisdiction could have important implications for neighboring communities. Collaboration and partnerships are therefore key to long-term flood planning.

Impacts of the 1997 Flood on Housing, the Economy, and Public Health

The 1997 flood severely devastated Grand Forks and has had significant impacts on housing, the economy, and public health in the region. As a result of this flood, more than 75,000 residents were evacuated, and the damages to properties are estimated to exceed $2 billion (James and Korom, 2001). Businesses have also been severely affected by the flood. As explained by James and Korom, 86% of the businesses in Grand Forks shut down during the flood, causing significant economic damages, especially when considered that at the time businesses in Grand Forks represented 20% of the economic activities in North Dakota (2001). Furthermore, the flood caused a significant labor shortage due to residents leaving the town (James and Korom, 2001). Public health was also affected by the 1997 flood. While some believe that the impact was mostly physical, the majority of the consequences of the flood were related to mental health. As residents tried to repair their properties before the upcoming winter, many lacked sufficient sleep and rest and were not able to spend as much time as they were accustomed to with their families and friends leading to many reported cases of depression (O'Neil et al., 1999).

What Caused the 1997 Flood?

Floods in the Grand Forks area are relatively frequent. The 1997 flood is attributed directly to the Red River's natural characteristics and the late blizzard. The river's flat terrain keeps the water in place until it overflows. When the river reaches flood level, the waters encounter frozen streams and tributaries as it flows north towards Canada, leaving the water to accumulate rather than run off (Paulus, Greenleaf, and Behling, 2008).

The Actors Involved: The Importance of Early Stakeholder Involvement

Federal, state, and local government along private sectors were involved in the 1997 flood including the cities of Grand Forks, ND, and East Grand Forks, MN, the state of North Dakota, the state of Minnesota, FEMA, the United States Army Corps of Engineers (USACE), and local law enforcement agencies. The early involvement of some stakeholders, including the Greenway Alliance, made it possible to move forward with bold policy solutions. For example, early stakeholder engagement helped create a greenway along the river where neighborhoods used to

be. The Greenway Alliance's purpose is to garner political support for the Greenway needed to promote some challenging solutions (American Rivers, 2006).

Policy Options: The East Grand Forks–Grand Forks Flood Damage Reduction and Recreation Project

As a result of the 1997 flood, the cities of Grand Forks and East Grand Forks formed a partnership with USACE to develop a flood protection system that would make the region more flood resilient (Paulus, Greenleaf, and Behling, 2008). Interestingly, the region has been affected by the sixth highest ever recorded flood in the area in 2006, and no significant damages have been reported, which demonstrates that the system has been effective (American Rivers, 2006).

It is important to note that the cities benefited from a fast-tracked process under Section 137 of the Omnibus Consolidated and Emergency Supplemental Appropriations Act (P.L. 105-277) for the fiscal year 1999 in order to get the project approved quicker (Paulus, Greenleaf, and Behling, 2008). It is critical to understand that the approval process would have taken much longer had the two cities and states presented different and separate projects to the federal government. As part of this project, between 2000 and 2007, $409 million have been invested to build flood protection infrastructure, including floodwalls and levees. In addition, construction has been restricted on the floodplains, a greenway has been created along the river, the sewer systems in both cities have been modified, and new pumping stations have been installed (Kaiser, 2009). Furthermore, the state of North Dakota has implemented many policy measures to help people recover from the 1997 flood.

Restricting Construction on the Floodplains

Following the 1997 flood, decision-makers in North Dakota and Minnesota restricted commercial and residential construction on the floodplains. Furthermore, a decision has also been made by the two cities in collaboration with FEMA to repurchase some properties on the floodplains in order to remove several low-lying neighborhoods in both North Dakota and Minnesota on both sides of the Red River of the North, moving the flood line higher up, farther from the river (Paulus, Greenleaf, and Behling, 2008). These decisions resulted in the creation of two new parks.

Building Dykes and Walls on Both Sides of the River

As a measure to mitigate potential future floods, dykes have been built on both sides of the Red River of the North. The decisions related to the locations of the new dykes were based on geotechnical indicators instead of political factors. The cities bought many properties to build the new structures, making the process more difficult. It is important to understand that given the soil composition, making any decisions based on something other than geotechnical conditions would have created adverse effects such as a landslide (Paulus, Greenleaf, and Behling, 2008).

Creation of a Greenway along the River

A greenway of more than twenty miles was created along the river, and as a result, residents received significant flood insurance savings and new green spaces were created (American Rivers, 2006). The greenway includes recreational facilities such as bike paths, parks, and even golf courses; however, none of this would have been possible without collaboration between the different agencies, states, and early stakeholder engagement. "Collaboration on the Greenway successfully overcame many initial challenges, including different funding capabilities between

North Dakota and Minnesota, competing for political interests, and concerns over future management. Because of the early involvement of local stakeholders, the project has long enjoyed support from the entire community" (American Rivers, 2006).

Modifications to Stormwater Infrastructure in Both Cities

A common problem with storm sewers is that water can back up into the sewer system, which exacerbates flooding. To address this problem, the East Grand Forks–Grand Forks Flood Damage Reduction and Recreation Project redesigned all stormwater piping in both cities so stormwater would discharge into the river through gated outlets that could be closed during periods of flood. The post-flood recovery project also included the installation of a series of pumps across the two cities. From a resilience standpoint, it is important to note that all the pumps across the city are equipped with generators that start automatically when a power outage occurs. This point is critical as Grand Forks lost power for a week during the 1997 flood (Paulus, Greenleaf, and Behling, 2008).

Policy Measures Implemented by the State of North Dakota

The state of North Dakota has also implemented some recovery measures through its various agencies and departments. Here is a breakdown of the key policy measures implemented by the state:

- Justice: The Office of the Attorney General implemented various measures to protect residents against fraudulent activities and better support law enforcement agencies and fire departments.
- Finance: The Bank of North Dakota created special credit services specially tailored for those affected by the 1997 flood, including the City of Grand Forks and the University of North Dakota.
- Economic Development and Finance: The North Dakota Department of Economic Development and Finance worked with the various Grand Forks stakeholders, including lenders and developers, to determine what the financial needs of the community were.
- Employment: Job Service North Dakota created a "one-stop shop" to ensure that reputable contractors were properly licensed and that residents were not taken advantage during the recovery of the 1997 flood.
- Education: The North Dakota Department of Public Instruction took various measures with its partners, including the states of South Dakota and Minnesota to ensure that children displaced by the flood would be able to continue their education (North Dakota Emergency Services).

Lessons Learned from the Red River of the North Flood

The 1997 flood of the Red River of the North is a case that illustrates elements required for cities and organizations to succeed in their post-flood recovery efforts. As explained in this case study, early stakeholder involvement and cooperation between the states of Minnesota and North Dakota have been instrumental in getting all the projects bundled as one larger project and quickly approved by Congress through omnibus legislation. The case of Grand Forks offers important lessons about planning, potential land use regulations, infrastructure asset repair, upgrading and expansion, inter-jurisdictional cooperation, and federal grant making that may provide some relevant insights for the flooding problems in Caddo Parish.

Case Study: Napa River in Napa County, California

Summary

Since 1862, over twenty-seven significant floods have been recorded in the Napa County area, resulting in substantial loss of life and property damage (Napa County Ordinance No.1, 1997). The residents of Napa County are accustomed to the danger and damage of frequent flooding. Since the 1970s, floods have caused an excess of over $542 million in property damage in Napa County, indicative of the region's extensive flooding history (Napa County Conservation District, 2017). The most significant and damaging flood occurred in 1986. The flood of 1986 caused three deaths, 14-20 inches of rainfall, $140 million in damage, and forced 7,000 residents to evacuate their homes (Napa County Ordinance No.1, 1997). The 1986 flood was a turning point for the local government, realizing its own failure to implement mitigation and flood protection measures. The government's failure to implement a flood protection strategy was the evident outcome of the ongoing tension between the USACE and Napa County government. Unable to reach consensus on a flood proposal project, Napa County residents were left vulnerable in the following years. The 1995 flood damaged over 220 properties and cost over $100 million in damages (Napa County Ordinance No.1, 1997). The damages from common annual floods cost an average of $6 million annually in repairs and cleaning (Napa County Ordinance No.1, 1997). The high costs and frequency of these floods places a large burden on the residents of Napa, often leaving them vulnerable to future natural disasters.

Napa River

Napa River, the source of the flooding, is fifty miles long; its watershed extends over 426 square miles. The river, along with its forty-seven tributaries, starting from Mount St. Helena and ending at the San Pablo Bay. Environmental factors have impacted the health of the river. Pollution caused by the runoff of fertilizers and the decreased oxygen for aquatic life caused by algae bloom has put the river's health in jeopardy. In addition, water diversion has decreased the flow of fresh water, severely impacting the habitat of several aquatic species. The river is experiencing increased sedimentation with roughly seventy to two-hundred thousand tons of sediments entering the watershed annually. The causes of sedimentation are related to bank erosion and removal of native flora. However, the consequences of sedimentation are significant as it reduces food supply for fish and effects the diversity of the habitat. In response to this, government officials and community representatives developed a set of "living river" objectives designed to revitalize the river's health and alleviate flooding (FONR, 2017).

Policy Options: Napa River – Napa Creek Flood Protection Project

After several failed attempts to address the flood problem, a set of diverse interest groups and stakeholders gathered to form a coalition called the Community Coalition for Napa Flood Management. The coalition conducted a series of meetings from 1996 to 1997 with the goal of developing a living river design for the Napa River. The ideas and concepts developed by the coalition laid the foundation the county's flood protection system. In 1998, Napa County voters supported Measure A which led to the creation of the Napa River – Napa Creek Flood Protection Project in 1998 (Napa County Ordinance No.1, 1997). The primary components of Measure A included a half-cent sales tax increase, a technical advisory panel, a financial oversight committee, and the Napa Flood Protection and Watershed Improvement Expenditure Plan. The

Flood Protection Project was designed to defend against 100-year floods while providing environmental restoration and economic development to the region (Napa County Ordinance No.1, 1997). The Flood Protection Project provided new mitigation and protection measures to be utilized for future floods. In addition, the plan restores the Napa River, Napa Creek, and other tributaries, enhances riparian environments, accounts for the Napa River's overall watershed and its natural processes, envisions wetlands and establish floodplains terracing by river-widening, and avoids environmentally damaging techniques (Napa County Ordinance No.1, 1997).

In addition to the flood protection project, Napa County improved several critical areas that led to a more resilient and prepared community. Improvements in early warning information, vulnerabilities reductions, resiliency, protective measures, and risk management were essential in providing adequate flood mitigation and protective measures in Napa County.

Public Information & Warning

Public information and early warning is essential in informing residents of impending danger and other life-saving information. The Napa County Office of Emergency Services (OES) provides accessible information about emergency preparedness, response, and recovery (Napa County OES, 2017). Furthermore, OES updates county emergency plans as needed while providing disaster training for the community. To further illustrate the importance of public information and warning, OES provides several venues for accessing information. One of these platforms in use is the NIXLE system, which provides residents with mobile alerts and notifications in the event of an emergency in the area (Napa County OES, 2017). Through a simple registration on NIXLE, individuals will receive emergency notifications directly to mobile devices. In addition to NIXLE, Napa County has embraced social media as a viable platform for distributing information regarding weather and storm alerts. Through the Napa County's Facebook and Twitter accounts, information on social media can be readily available to residents. This approach reflects the County's commitment to public information and warning. Another platform of information deliverance is the County's geographic information system (GIS) maps that display road conditions, road closures, or restricted access due to construction, floods, fires, and other issues (Napa County OES, 2017). Through several information platforms, Napa County residents can quickly access information regarding storm preparedness, road conditions, and weather notifications.

Community Resilience

Through education and skill building, OES provides readily available information on how to prepare an emergency supply list. Under the OES' guidelines, the basic emergency supply kit contains the following recommended items – water, food, battery-powered radio, flashlight, whistle, first aid kit, and local maps (Napa County OES, 2017). In addition to an emergency supply kit, OES provides information on how to construct a family emergency plan. Within the family emergency plan, OES states that the plan should include identifying out of town contacts, ensuring family members know phone numbers to contact, subscribing to NIXLE, reading FEMA's "ready.gov" plans, and contacting animal shelters on how to prepare pets for disasters. The Napa County government has provided the necessary educational and skill building methods for its residents to utilize, the effects are simple a more resilient community. A culture of resilience will allow residents to be more adaptable and provide them with the ability to withstand and rapidly recover from flood incidents.

Long-term Vulnerability Reduction

Reducing vulnerabilities requires long-term planning, commitment, and investment to ensure community resilience after a disaster. The benefits of a safer community translates to less dependency on external aid. As a result, the Napa County government, through the implementation of the flood project, has successfully addressed flood vulnerabilities in the region. Within Napa City's Citizens' Guide to Flooding and Flood Recovery, information is presented regarding risk reduction, flood insurance, and flood proofing. The Citizens' Guide recommends residents to purchase flood insurance as homeowner's insurances polices do not cover for flood damage (Citizens' Guide to Flooding and Flood Recovery, 2007). As a participant of National Flood Insurance Program (NFIP), the city of Napa had 1,400 flood insurance policies in effect in 2007 (Citizens' Guide to Flooding and Flood Recovery, 2007). The city of Napa informs that flood insurance may be a requirement from banks as part of a mortgage or home improvement loan; however, these policies may only cover structural damage. As a result, city of Napa recommends homeowners to be well informed on insurance due to the frequency of floods.

In addition to flood insurance, the city of Napa provides several ways to flood proof a home or other structure. Re-grading the lot or building a small floodwall can be useful in keeping water away, but this approach is only appropriate if the flooding is minor and the property is located away from the floodway. Waterproofing the walls and placing watertight closures on doors and other openings is another approach but should not be recommended for homes with basements or if flood water reach over two feet. Elevating homes above flood levels is another approach; the cost elevating a small house can be approximately $50,000. If these approaches are not feasible, the city of Napa provides information on how to purchase and locate sandbags during the start of the rainy season and during the activation of the flood watch. The city of Napa's sandbag program also facilitates resident's access to sandbags. At the start of the rainy season, residents can fill their own sandbags at no cost during the first Saturday of every month of the rainy season (November – March). Plus, the city crews will haul away the sandbags at no charge. The guidelines presented under the long-term vulnerability reductions have been followed and implemented within Napa County. The city of Napa has taken the proactive approach of addressing flooding issues through risk transfers (via flood insurance) and recommending mitigation measures into homes and buildings (Citizens' Guide to Flooding and Flood Recovery, 2007). This approach has enabled residents to be more resilient and reduce vulnerabilities in the future.

Physical Protective Measures

The Napa Flood Project incorporates several of these protective elements by introducing various environmentally beneficial methods to combat floods. These methods rely exclusively on updating and replacing the post-1986 flood control infrastructure. The methods include bypass channels, set-back levees, floodwalls, widening the river, and bridge replacements (Napa County Ordinance No.1, 1997). Through this, Napa County has the necessary protective measures to combat floods and mitigate its effects. Additional flood management measures were created post-1986 flood, such as the construction of new bridges in Napa City and urban stormwater run-off facilities in the city of St. Helena, elevation and relocation of structures in various areas in the county, stabilization and enhancement of the Kimball Reservoir in Calistoga City, and

replacement of the existing wastewater treatment facility in American Canyon city (Napa County Ordinance No.1, 1997). As a result, Napa County has provided its cities with necessary physical protective measures to address frequent floods and provide residents with necessary physical safeguards.

Lessons Learned from Napa River Floods in Napa County

The extensive flood history in Napa County illustrates a community willing to take a proactive stance on flood management. As a result, this case study represents a model of success, where a community made the necessary policy decisions to create a system that protects its residents. The role of the stakeholder coalition proved to be instrumental in guiding the creation of the Napa River – Napa Creek Flood Protection Project and the support of the community was necessary for its success. Furthermore, the case study of Napa County can be beneficial to the Caddo Parish community. The Napa floods relate significantly to the floods in Caddo Parish as both communities are experiencing regular flooding events. Caddo Parish can observe and learn from the failures and successes of the flood management in Napa County. From this information, Caddo Parish can derive ideas and solutions that are applicable to the Red River. Nonetheless, this case study should be viewed, not as a blueprint, but as an example of how a community responded to frequent flood threats.

Key Takeaways: Grand Forks and Napa County Case Studies

The Grand Forks and Napa County case studies provide important lessons that could also be applied to Caddo Parish. As demonstrated by these case studies, stakeholder engagement and collaboration are of critical importance. In the case of the Napa River, several stakeholders united and formed a coalition, which then successfully addressed the flood problem in the area. Significant stakeholder involvement has also been instrumental in addressing the flood issues in Grand Forks. For example, the greenway along the Red River of the North has been created in large part due to the early involvement of key stakeholders in the project. These cases therefore make it clear that stakeholder engagement and collaboration is part of the solution for Caddo Parish.

These two case studies also demonstrate the importance of collaboration between different government agencies and levels of government to properly address flood issues. Furthermore, as made clear in the Grand Forks case study, it is also important to collaborate with neighboring jurisdictions to obtain the best possible results. The success of the flood protection measures adopted in Grand Forks are in large part due to the significant collaboration of the states of North Dakota and Minnesota. For example, the two states presented a joint project to the federal government which greatly accelerated the approval process. As one can see, collaboration with neighboring jurisdictions is critical, and there is no doubt that any successful solutions to the flood problems in Caddo Parish will also involve actors in neighboring states and parishes. The main takeaway of these two case studies is therefore that proper stakeholder engagement and collaboration between the various government agencies and levels of government, including in neighboring jurisdictions are of critical importance for the success of any flood protection measures in Caddo Parish.

History and Background of the Red River Region

Demographics & Cultural Context

Caddo Parish is the fourth most populous parish in Louisiana with Shreveport as the parish seat. In 2016, reports estimated Shreveport's population at 194,920 in 2015 and Caddo Parish's population at 248,851. Between 2010 and 2016, the population of Shreveport and Caddo Parish declined by 2.7% and 2.4%, respectively. Within Caddo Parish, 7% of the population was under five years of age, 24.2 % was under 18 years of age, and 15.8 % was 65 years of age or older. For Caddo Parish, 52.6% of the population was females. Population reports show African Americans at 49.2%, exceeding the number of whites which stands at 47.4% (United States Census Bureau, 2016). Shreveport's populations closely resemble that of Caddo Parish with African Americans as its most populous group.

Shreveport has a diverse economy with most employees in trade, transportation, and utilities followed by education, health services, and government sectors. Caddo Parish's median property value in 2015 was $144,600 with a median household income of $41,040. Shreveport's median household income was $38,585. Reports cite the Red River as a significant source of income and affluence (Data USA). Estimates show 26.4% of Caddo Parish's population live in poverty, while Shreveport's poverty level was 23.6%. The Census Bureau reported 58.7% of Caddo Parish's population aged 16 or older was in the workforce (United States Census Bureau, 2016). Education data cite 85.9% of the population of Caddo Parish held a high school graduate degree or higher, and 23.8% held a bachelor's degree or higher. These figures were not significantly different for Shreveport, Louisiana. Approximately 85.5% of the population held a high school graduate degree or higher, and 25.5% held a bachelor's degree or higher (United States Census Bureau, 2016).

Caddo Parish and the City of Shreveport are poorer and less educated areas when compared to national data. The population of Shreveport damaged over the past few decades, as did the parish and state. Since 1980, the total population of Shreveport declined from 205,820 to 194,920 (US Census Bureau). This population decline is noteworthy considering the overall state population increased during the same period, from 4.2 million to 4.6 million. Caddo Parish exhibited a similar trend; the population during this period dropped from 252,358 in 1980 to 248,851 in 2016 (US Census Bureau – Table 1).

History of the Red River

Over the past two centuries, the Red River experienced multiple significant floods in the Caddo Parish region. The Great Flood in 1800 created a natural dam that resulted in high water conditions and flooding in several tributaries. These conditions contributed to the formation of Caddo Lake. The highest mark that the river has reached was 45.9 feet in May of 1849 when Fulton, Arkansas, flooded which overwhelmed the lower streets of Shreveport. Captain Henry Miller Shreve (namesake of Shreveport), from the 1830s to the 1850s, worked to clear the logs from the Red River and adjoining lakes and bayous. In August of 1849, a hurricane altered the streambed of the Red River to its current state. Formerly, the river flowed through Natchitoches, Louisiana, but the flood impacts of 1849 reversed its course to its state prior to the flood of 1825 (Brown, 1999).

Severe weather resulting from El Niño caused the Red River Flood of 1990. A two to three week period of rain in northeast Texas, southeast Oklahoma, and southwestern Arkansas caused flooding in the Red River watershed, which caused downstream flooding. The Denison Dam, Millwood Lake, Wright Patman, and Lake O'Pines reservoirs released excess water into surrounding tributaries which then overflowed into the Red River. The normal crest was at 15 feet in Caddo and Bossier Parishes, however, the flooding exceeded the crest at 34.5 feet. Backwater from Cross Lake and 12-mile Bayou filled up (Haynes, 2015).

Recent Floods

In 2015, heavy rainstorms in Oklahoma and Texas broke the 120-year-old record of total monthly rain for Caddo Parish and the surrounding area (Caddo Levee District, 2015). May of 2015 became the wettest month on record for these two states (Davies, 2015). Consequently, the Red River swelled, forcing water downstream and flooding northwestern Louisiana. The Red River in Shreveport rose to its highest peak at 37.14 feet on June 9th which was the highest crest record in seventy years. The moderate flooding stage was listed at 31.50 feet, with the highest flooding stage recorded at 45.90 feet in 1849 (Davies, 2015). The Red River had a secondary crest at 31.05 feet on June 30th, 2015. The second wave of flooding was from Tropical Storm Bill caused by additional heavy rainfall (Nuttall, Palmer, & Parker) The 2015 flood crest was higher than the flood crest in 1990 (Red River Valley Association, 2016).

The 2015 flood endangered wastewater treatment plants and threatened to breach levees, impacted over 190 homes with the Martin Luther King, Jr. and Allendale areas being the most impacted. Reports estimated $8.2 million in property damages in Caddo Parish. Additionally, traffic roadways in the area were partially or entirely submerged by floodwater (Nuttall, Palmer, & Parker). Due to the flooding, railway cars and tracks, portable buildings in docks, and roadways were damaged. The floods harmed farmland and livestock as well (Beiard, 2015). Estimates indicated agricultural loss to be $7 million in northwestern Louisiana. The storm affected approximately 90,000 acres of agricultural land, 38,000 acres of cropland, and 52,000 acres of pasture and hay meadow. Of the 38,000 acres of cropland, the storm affected 18,000 acres of soybeans and 7,000 acres of corn and cotton (Orlando, Guidry, & Levy, 2015).

The flood impeded the waterway systems, which greatly affected commerce. The flooding led to the closure of four locks to navigation in 2015, and all five locks to navigation in March 2016. This was the first time since the construction of the waterway that more than two locks closed to commerce at the same time (Red River Valley Association, 2016). After the flooding, the Caddo Levee District, which was responsible for operating and maintaining the integrity of approximately 119 miles of levee systems in the Parish and providing flood protection for 30,000 residents and 200,000 acres of land, inspected the five main levees. The examination found that the levee system performed well and provided necessary flood protection (Caddo Levee District, 2015). The Red River is one of the highest silt carrying rivers in the U.S. The flood caused silt deposits at approaches to five locks and closed them to commerce due to siltation and lack of channel depth of nine feet required for navigation. The Caddo-Bossier Port did not have navigation for forty-eight days due to the siltation of the waterway system in this area. The tows could not reach the Caddo-Bossier Port for 127 days (Red River Valley Association, 2016). Based on location, floodwaters rose to or above the toe of the levee and remained against the levee for ten days or more (Caddo Levee District, 2015).

After the flood, former Louisiana Governor Bobby Jindal requested a major disaster declaration on July 6, 2015, due to severe storms and flooding that prior month (FEMA, 2015). Shortly after, on July 13th, former President Obama declared a major disaster in Louisiana (FEMA, 2015). The President announced disaster relief for Red River flooding and issued a disaster declaration for five parishes along the Red River, including Caddo Parish. This made the Hazard Mitigation Grant Program assistance requested by former Governor Jindal available statewide (FEMA, 2015). Reports estimated $17 million in damages to farms, businesses, and homes in this area (LMFA, 2015). Caddo Parish reported a $31 per capita impact with only Bossier Parish having a higher parish-wide per capita impact of $44.45 (FEMA, 2015).

Shreveport flooded again in March 2016, which meant that Shreveport surpassed the flood stage four times in a one-year period. Since 1849, fifteen flood control reservoirs were built above Shreveport-Bossier City. If reservoirs had not been in operation, the Shreveport gage would have reached 41.9 feet (Red River Valley Association, 2016).

Geography of Red River

The Red River is named for its reddish-brown waters, caused by the red clay that runs through this region. The Red River is the fourth longest river in the United States based on the length of navigation. Its watershed covers 89,970 square miles, beginning in Llano Estacado in Texas and flowing east between Texas and Oklahoma through Arkansas, cutting off the southwestern corner of the state, and then flowing into Louisiana until it enters the Atchafalaya River. The river covers 1,600 miles total. The river has nearly 1,000 navigable miles and is elevated 2,400 feet above sea level at its starting point (Brown, 1999). In Shreveport, the river gage zero elevation is 131 National Geodetic Vertical Datum (NGVD) with a flood stage occurring at a river height of 30 feet (Hanson G.M.). The width of the river in this city is 1,360 feet when full, with 183 miles of riverfront in Shreveport.

The Red River transports large amounts of sediment downstream. The Red River Sediment Transportation Study found that about 1.6 million cubic yards of wet sediment is deposited in the navigation channel at Pool 5 near Shreveport annually. The sediment flow stops at Caddo Parish leading to constant maintenance of the surrounding river-ways in order to manage barge traffic. Without this maintenance, the flood stage elevation for Caddo parish would continue to rise past its current levels (Flood Technical Committee).

Economic Consideration in Flood Mitigation and Recovery

Following the 2015 and 2016 Red River floods, the city experienced loss of economic activity, property damages and damage to government infrastructure. The Red River generated $9.9 billion in revenue and created 120,000 jobs since the inception of the Red River Waterway project in 1968 (Watson, 2016).

The White House's proposed budget for 2018 made cuts to numerous FEMA programs. President Donald Trump rescinded former President Barack Obama's Executive Order 13960, which required recipients of federal funds to consider risk-management standards when building in flood zone areas (Kousky, 2017). Due to policy changes, increasing investments in risk reduction

continues to be a challenge for communities such as those in Caddo Parish, as risk reduction measures can be costly.

According to the Director of the Policy Research and Engagement at Wharton Risk Center, there are several challenges for flood risk reduction. Social, political, and economic structures create different exposures to risk by factors such as class, age, race, and gender (Dyson, 2006). The costs and benefits of a natural disaster, such as flooding, affect different stakeholders, or, in economic terms pose an "externality problem"(Kousky, 2017). For the rebuilding process to be cost-effective, the integration of risk reduction measures is essential and provides an opportunity to improve flood risk management. Construction can be inexpensive in floodplain areas thus leading to lower costs for developers and builders. Yet the homeowner and taxpayer often incur the losses when the home is flooded, consequently leaving no financial motive to alter building practices without risk reduction and mitigation policies to interfere. Returns to investment in flood risk reduction vary according to its respective geographical situation. Research suggests that best practices would be to conduct a thorough analysis of the proposed flood risk strategy and tailor it to meet the needs of the local conditions. (Hawley et al., 2012).

Technical Review

Caddo Parish has a flooding problem originating from the Red River. The leading organization responsible for managing the river, USACE, does not have adequate funding to maintain the current dredging standards. USACE manages the river to the best of their ability using locks, dams, and reservoirs, yet extended periods of rain can overwhelm these mechanisms for managing river flow. In addition, loose sediment flows through the river regularly, reshaping the structure of the river over time. These deposits lead to rising riverbed levels over the years that exacerbate flooding. Finally, FEMA flood maps and their federal flood insurance program have failed to create negative incentives to locate development along the river (Board, T.E., 2017). These issues have led to Caddo Parish and Shreveport suffering increased flood damages and increased risk of future flooding damages.

Flood Management and Causes

Urban environments create additional issues for flooding. The removal of vegetation, dispersion of soil, grading of land surface, and construction drainage networks increases runoff to streams that are a result of rainfall and snowmelt. Runoffs contribute to the increase of hydrological factors such as peak discharge, volume, and frequency of floods in nearby streams, which then results in changes to the land. Changes to stream channels during urbanization can limit the capacity of the channels to carry floodwaters.

Land usage and other human activities influence peak discharge of floods by modifying how rainfall and snowmelt are stored and how water runs off of the surface of land into nearby streams in urban areas. Roads and buildings cover most of the land surface in urban areas, which means less storage capacity to harness rainfall and snowmelt in the region. The construction of infrastructure typically removes vegetation and soil from the land. Impermeable surfaces that reduce the ability for water to infiltrate into the ground replaces permeable soil that allows for penetration of water. This, in turn, accelerates runoff into streams and ditches. A dense network of ditches and culverts in the city reduces the distance that runoff has to travel over land and

through subsurface flow paths to reach streams and rivers. Once water enters into a drainage network, it begins to flow even faster. With less storage capacity for water in urban basins accompanied by additional runoff that is moving at a higher speed, urban streams rise quickly during storms and have higher peak discharge rates than would a rural stream. The total volume of water discharged during a flood tends to be much larger for urban areas than rural streams.

Development along streams, river channels, and floodplains can alter the capacity of a channel to retain and carry water. Thus, this development increases the height of the surface of the water. Manmade structures that infringe on floodplain territory can increase flooding upstream by narrowing the width of the channel water. This increases the water's resistance to flow. When the water reaches a higher level as it flows past the obstruction, it creates backwater flow. Sediment and debris can cause constriction of a channel and increase the chances of flooding. Erosion of urban streams represents another consequence of urbanization. Frequent flooding raises the channel and increases bank erosion. Furthermore, where channels straighten and banks of the stream or river are bare of vegetation, streamflow velocities increase. A common consequence of urbanization is increased peak discharge and frequency of floods (Konrad).

Reports confirm increased accumulation from silt as a result of high-water events for more than two decades changed the characteristics of the channel. Construction of jetties to keep the main river channel from silting, along with a series of locks and dams may have caused secondary constriction of the river that could be causing silting (Nuttall, Palmer, & Parker).

Post-Flood Actions

U.S. Army Corps of Engineers Study and Update to FEMA Maps

The Flood Technical Committee found that FEMA last published flood insurance maps thirty-five to forty years ago for Caddo Parish, determining flood-prone areas and their insurance coverage, yet the maps have not changed since. These maps, usually updated every ten years, ensure that the current Base Flood Elevation is available. The maps assisted the regulation of development of infrastructure and housing (Flood Technical Committee, 2015). USACE has initiated a study on sedimentation and hydrology to update the predicted flood stage elevations. USACE was appropriated $1.5 million from Fiscal Year 2016 to conduct a Hydraulic and Sedimentation Study to identify changes in the floodplain and flood storage capacity, but the President's Fiscal Year 2017 Budget reduced the USACE budget by $1.3 billion, reducing funding to this project. The budget also cut funds for the J. Bennet Johnston Waterway, leaving it unable to perform necessary annual operations and maintenance. The majority of the funding shortfall affected dredging the channel (Red River Valley Association, 2016). Funding was critical to move forward with updating the maps, so Congressman Mike Johnson of Louisiana District 4 testified to the Appropriations Subcommittee on Energy and Water Development. He stated that the budget allocated only $250,000 of the Hydraulic and Sedimentation Survey in 2016 and that FEMA could not update their maps without the completion of the USACE study. He also testified that the area needed to maintain its 9 feet x 200 feet channel and deepen the river to 12 feet from its preexisting 9 feet. He asked the Subcommittee to appropriate funding for dredging (Subcommittee on Energy Testimony, 2017). In the meantime, the city is currently applying for $2.346 million in Hazard Mitigation Grant funds from FEMA to purchase and

demolish homes that have a history of repeated flood losses. The city could also potentially design and construct a flood reduction infrastructure project (Shreveport).

The USACE study came to a halt. In 2017, President Trump revoked the establishment of a federal flood risk management standard through executive order. Trump's budget called for $667 million in cuts from FEMA, including the Pre-Disaster Mitigation Grant Program while also eliminating the NFIP $190 million discretionary appropriations for its flood hazard mapping program (Gonzalez, 2017).

However, the city and surrounding parishes have taken action into their own hands. Local leaders in Caddo and Bossier Parish formed the Flood Technical Committee after the 2015 flooding (KSLA Staff, 2016). The Committee consists of the following people and organizations: Red River Valley Association, Caddo Sheriff's Office and Office of Homeland Security and Emergency Preparedness, Caddo Parish, Bossier Parish, Shreveport, Bossier City, Caddo & Bossier Levee Districts, Caddo-Bossier Port, Red River Watershed Management Institute, and the Red River Waterway Commission. The team coordinates with federal agencies, investigates the causes of flooding, considers plans for mitigation, and analyzes data to provide to community leaders. After their inception, the Committee examined the possible origins of the 2015 Red River Flooding which could include record rainfall, sand and sediment accumulation, development near the river, and inaccurate flood insurance maps (Flood Technical Committee, 2015).

The Committee reported that 1.6 million cubic yards of silt accumulate in the Red River near Shreveport each year but determined that it is not economically feasible to remove this silt through dredging. The Committee also decided that the Base Flood Elevation is no longer accurate after the 2015 flooding. The Committee recommended that local public agencies use the High-Water Mark (HWM) from the study conducted to regulate development and establish legislation that would allow for the preservation of open space for flood storage protection (KSLA, 2016). The Caddo Commissioners voted on January 5th, 2017 to raise construction elevations along the Red River due to the flooding. The Commission adopted maps showing new high-water levels based on the summer 2015 floods and changed building code by requiring the heights of buildings to be constructed 1.5 feet above the HWM (Waxel, 2017).

USACE constructed multiple projects along the Red River to assist with managing water flow. Over fifteen flood control reservoirs and their coinciding locks and dams affect the Red River. Some of the main reservoirs include the Tulsa District, which has control of Lake Texoma/Denison Dam and Hugo Lake; the Little Rock District, which has the authority of Millwood Lake; and the Fort Worth District, which controls the Wright Patman and Lake O'Pines Reservoirs. These districts coordinate to manage the water flow of the river through storing water in the reservoirs and strategically allowing a specific amount of water to flow down the river at a time. This system works well for day-to-day water management, but the problem occurs during a massive storm or multiple smaller storms across the states that contain the Red River. The Red River then floods downriver when too much water flows through the river for the reservoirs to contain, and water releases to prevent the reservoirs from flooding the surrounding areas. Water continues to flow downriver until the river can no longer contain the flow (Little Rock Flood Control Reservoir).

Engineering Mitigation Approaches

Engineers approach flood management in two ways, through hard or soft engineering practices. While hard engineering impacts are favorable and have a significant effect on a river, they can disrupt ecological systems in the drainage basin and are very expensive. Soft engineering focuses on the reduction of flooding impacts.

One example of a hard engineering technique is building a dam. A dam impedes the flow of water, keeps discharge downstream low, and can generate hydroelectric power. However, there are some disadvantages to building dams, such as high costs and require large quantities of natural resource inputs. Dams have a considerable impact on the local environment and pose a chance of structural failure – the results can be catastrophic for the surrounding community. A second hard engineering technique is artificial levees, which are embankments that extend the height of the channel. Levees potentially encourage development in the floodplain. Construction in floodplains increases the risk of flooding and causes extreme danger if the levees fail. Wing dykes are a third type of hard engineering. Wing dykes are slats placed at 90 degrees to the banks of the river channel and are typically set in pairs on either side of the channel with a gap between them that allows boats to navigate freely. The sediment builds up behind the dykes, and narrows the channels, causing water to flow faster. This reduces the risk of flooding by getting water away from the flood area as quickly as possible. While there is the advantage of increasing navigation of boats in the area, this method can also increase flooding downstream. Channel straightening is an additional example of a hard engineering alternative, which involves blocking meanders and constructing straighter routes to make the river flow faster. Nevertheless, flooding can become more likely downstream along with erosion. Lastly, diversion spillways are artificial channels constructed to accommodate overflow. This hard engineering alternative moves water around a flood risk area and sends it into another river or back into the same river downstream. This can potentially threaten to flood the overflow areas.

Floodplain zoning that places land use restrictions in areas surrounding the river is a form of soft engineering. It reduces the regions impacted by a flood and decreases the risk of flooding caused by urbanization. Afforestation is another method of soft engineering which involves planting trees in a drainage basin to increase the interception and storage of water while reducing surface runoff making it less likely to flood. It also prevents "mass wasting" which reduces the amount of soil entering the river and keeps water-holding capacity high. However, this method of soft engineering requires a large land mass. An alternative is a riparian buffer, which is thin strips of land with vegetation running adjacent to the channel. Wetland restoration is another technique that creates conditions favorable to the development of wetlands and allows storage of large amounts of water, thereby reducing river discharge and downstream flooding. Farmers usually oppose this method in agrarian areas because it reduces the area of available farming. The last example is river restoration. This technique restores the river to what it was before the implementation of engineering alterations. Techniques include re-straightening a channel or removing artificial levees. This technique is desirable where land is no longer economically valuable and reduces the flooding risk downstream without maintenance costs (Jackson, 2014).

Ecosystem Management

Over the last several decades, efforts increased to focus on ecosystem science and management as ways to prevent and mitigate flood damage. Many of these efforts have been a result of a

heightened sense of awareness of environmental issues at large, such as rising sea level, deforestation, and reductions in biodiversity. Scientists now realize that modification of human activity helps to protect the natural world around us. Management of the ecosystem provides long-term resiliency and mitigates damages. Riparian areas are perhaps some of the most threatened components of many ecosystems; yet, when properly managed their benefits are invaluable. A well-managed riparian zone can provide channel stability, plant and sediment trapping, habitat provision, recreational value, economic benefits, and most importantly, flood control. (Waters and Rivers Commission, 2000).

While engineering structures such as dykes, levees, dams, and reservoirs have certainly proved beneficial in protecting communities from the power of water, the importance of employing ecosystem management practices that compliment these measures should not be overlooked (Marijnissen, 2017). The United States Department of Agriculture's Natural Resource Conservation Service (NRCS) is a proponent of natural channel and floodplain restoration. To accomplish this, they suggest grouping fluvial geomorphology, hydraulics, hydrology, and aquatic biologic attributes (Southerland, 2017).

In western Montana, the Bitter Root River had been subject to a 2008 flood that left the river's bank highly eroded and stripped of the riprap initially installed to protect the river (Southerland, 2017). Following the flood, a toe wood revetment was installed to protect the river from future flooding. A toe wood revetment is the transplant and establishment of woody species to provide stream bank stabilization in comparison to uncovered banks, subject to further erosion and collapse, especially during future flood events (Southerland, 2017). Toe wood revetments also have a dual purpose in their use of timber and woody species both below and above the river's surface, provide additional habitat for aquatic species that thrive in these environments, such as bass and catfish, two species commonly found in portions of the Red River in Louisiana as well.

In the Bitter Root River, the ecosystem management practices employed were highly effective. After high rainfall and runoff events, the implementation of geomorphic restructuring plans, proved successful as the stream banks remained stable against the threat of flooding. Not only were these methods preventative of flooding, but they were cost effective. In the case of the Bitter Root River, the re-establishment of rock riprap cost an estimated $250,000; however, the toe revetment installed cost just $79,000 (Southerland, 2017).

Ecosystem management practices are efficient far more cost-effective than traditional engineering methods. When comparing the cost of engineering structures to ecosystem-based adaptions, the latter is often far more cost-efficient (Marijnissen, 2017). Not only do green approaches provide a financially feasible option to mitigate and prevent flooding, but they offer a host of other benefits to the community including climate and disease regulation, water purification, recreation, ecotourism, and aesthetic value (European Commission Directorate-General Environment, 2011). Nature and ecosystems are essential to Louisianans for a variety of reasons, both culturally and economically. The potential to introduce these benefits, in addition to measures to prevent flooding, is indeed something we should consider when working on solutions for the community of Shreveport, Louisiana.

When applying ecosystem management options, it is essential to assess the area you are working in, to choose the best method. In the case of Shreveport, several options have the potential to assist in flood mitigation in the Red River. Considering the relatively flat nature of the landscape in the surrounding area, some options include stream bank stabilization, channel re-profiling, wetland restoration, and the planting of riparian buffer zones and stream margins (European Commission Directorate-General Environment, 2011). In the case of Caddo Parish, an ecological restoration of Red River riparian areas could be very beneficial in order to mitigate future flood risks. There are several ecological restoration practices recommended by the Conservation Reserve Enhancement Program in order to control flooding through natural practices. Some of these include preservation and enhancement of riverside forests and avoidance of building on impervious surfaces. Vegetation improvement in riparian areas also increase water-holding capacity of floodplain soils, further mitigating flooding risks in high rainfall events (Conservation Reserve Enhancement Program). In addition to restoration practices, the reclamation of some riparian areas could also be a useful preventative measure to enhance protection from flooding while retaining economic benefits (The National Academies of Science, Engineering, and Medicine, 2002).

Levee System in Caddo Parish

The construction of levees along the Red River assist with flood prevention. According to USACE, there are thirteen levees located within 50 miles of Shreveport, and four of the levees are maintained by the Caddo Parish Levee District (Caddo Levee Board). USACE classified all of these surrounding levees as minimally acceptable or unacceptable[1]. Specifically, USACE states that the Caddo Levee District managed Black Bayou-Pine Island levees are minimally acceptable, the Twelve Mile Bayou levee is unacceptable, and the Red River levee has minimally acceptable and unacceptable sections. A minimally acceptable levee, as defined by USACE, contains one or more unacceptable inspection items that would not prevent the segment or system from performing as intended during the next flood event. USACE reclassifies the minimally acceptable levees as unacceptable after a two-year deadline. An unacceptable levee contains one or more deficiencies that would prevent the segment or system from performing as intended, or one with a serious deficiency noted in past inspections but not corrected within two years of inspection. These neglected levees will not properly prevent flood damages to the surrounding area as they are intended to do during a large flood event (USACE National Levee Database).

Dredging

Currently, USACE dredges the Red River to assist with maintaining navigation. The current standard calls for the Red River to maintain a depth of nine feet and width of two hundred feet to support barge traffic between Shreveport and the Atchafalaya River. This is taken care of by spot dredging areas where there is too much sediment buildup, costing USACE roughly $3.2 million annually. However, the level of dredging currently undertaken is not enough to support navigation efforts. To fully comply with current standards, it is estimated that an additional $2.7 million be spent on dredging annually (Dredging Today, 2016). In addition, the dredging south of Shreveport allows barges to travel up the river. However, the sediment deposits settle in Shreveport and just north of the city. To adjust the high-water level for the river, USACE will

[1] It is known that there are discrepancies between USACE and the Caddo Levee District when it comes to defining how levee standards are classified. For this report, USACE standards are used.

have to dredge these new areas to assist with navigation to allow for large barge traffic. The National Weather Service (NWS) recommends dredging the river depth from nine feet to twelve feet. Estimates indicate dredging costs over $2000 an hour to undertake, so this preventative measure will be expensive and need to be done on a regular basis (KSLA, 2015). Another factor to consider is the deposition of the sediment dredged from the river. USACE disposes most of the dredged sediment into the channel outside the navigation segment, but there are additional uses for the sediments. The Environmental Protection Agency recognizes both commercial and environmental advantages of dredged sediment, such as using the sediment to restore coastal or wetland regions, aquaculture, forestry, agriculture, mine reclamation, industrial, and commercial development (EPA, USACE). Louisiana could find potential environmentally friendly solution for the dredged material within the state.

Empirical Field Work

Stakeholder Interview Summaries

In order to better understand attitudes of the community towards flooding in Caddo Parrish, the team understood the importance of stakeholder interviews. Many of the proposed recommendations take into account the information and analysis from the stakeholder interviews. The team conducted thirty-six in-depth stakeholder phone interviews from January – March 2018. The team prepared an IRB-approved discussion guide (Appendix D). The stakeholders came from a variety of backgrounds and areas of expertise, ranging from engineering, business, governments, communication, and nonprofit professionals. Majority of stakeholders were not directly impacted by the floods; however, they actively participated in the recovery process. After analyzing the input from stakeholders, similar patterns and themes emerged.

Events Leading Up to the Flood and During Flood

When conducting the interviews, the majority of stakeholders identified heavy rains in the state of Oklahoma, Arkansas, and Texas as the cause of extreme downstream flooding in Caddo Parish during June 9th – 10th, 2015. Many interviewees cited Lake Texoma as the biggest source of floodwaters when Texoma's Dennison Dam water was released into the Red River. Prior to the flood, engineering employees from different branches of government and organizations stated they received updates on when the river would crest and at what height from USACE and the NWS. Unfortunately, many of the predictions received from the NWS were not accurate. In order to prepare for the flood, city officials distributed hundreds of thousands of sandbags. Individuals from the City Engineering Department, along with other businesses, sandbagged key areas such as a veterans' home, a major sewage plant, the Caddo-Bossier Port, and businesses on the Boardwalk. In addition, the city issued directives to evacuate areas that they believed would flood. However, this became a challenge as NWS predications could not adequately gauge the river crest, making it difficult to evacuate residents. The inaccuracy of the predictions could be the result of forecasts failing to consider the chronic silting and shallowing of the river. The NWS' initial prediction for the Red River crest was at thirty-two to thirty-three feet, but crested at thirty-seven feet. Furthermore, evacuations were based on outdated FEMA flood maps. While the flood was occurring, an engineering firm north of Lock and Dam #5 conducted studies with sonar systems and GPS to gauge elevation and measure HWMs. After analyzing data, the city engineering department realized that the 2015 flood did not follow historical patterns. Although the river did not reach 1990 elevation, the cubic feet per second (CFS) flow was higher than the

1990 flood. It was concluded that the flood data curves were out of date and that increased silting and the shallowing of the river needed to be better modeled.

Post-Flood

Overall, the interviewees mostly agreed that communication by the city during the flood was executed properly. Only a small minority viewed that flood communications could have been improved through consolidation and expediency in dispersion. Many of the interviewees believe that efficient communication was a result of lessons learned since Hurricane Katrina. The interviewees witnessed the presence of several organizations working together in the recovery efforts, including the Red Cross, Salvation Army, Samaritan's Purse, Goodwill, and first responders. Interviewees indicated a strong source of community resiliency aiding in the overall recovery process.

Groups Affected

Many of the respondents stated that those most impacted by the floods were homes built inside of the levee system, with the most frequently cited neighborhood being River Bluff. When questioning the interviewees on which groups they believe were most impacted by the floods, the responses varied. Some individuals indicated that flooding was widespread, with no particular income group or demographic disproportionally impacted. Others stated that a majority of homes affected were higher-income residential areas. However, other stakeholders disagreed on which areas were impacted by the floods. Additional stakeholders perceived rural areas of Caddo Parish as being the most impacted, due to their isolated nature. This made it difficult for resources and first responders to assist these isolated areas.

Causes of Flooding

The overwhelming response from the stakeholders identified urban development as the major cause of flooding. The majority of the interviewees pointed out that new homes are being built inside of the levee system, putting themselves at more risk for flooding. One stakeholder stated that people will move into the area believing that flooding will not happen to them. Another stakeholder could not comprehend why banks are approving loans for homes in flood-prone areas. Stakeholders believed that developers should be accountable for building within flood zones inside of the levee system. Interviewees even went as far to say that they do not feel sympathy for individuals who knowingly build inside of the levee.

Another issue regarding urbanization that was mentioned in the interviews is that urbanization is removing storage capacity from the river and wetlands. The construction of Clyde Fant Parkway increased the removal of storage capacity of the river, causing stormwater drainage systems to silt up. Another issue that was cited within the interviews that contributed to the loss of storage capacity was the rock dykes built in the river by USACE. After Lock and Dam #5 was completed, the training dykes were built perpendicular to water flow, causing deposition to accumulate on the downstream side of the dykes. Additionally, this restricted water flow to the floodplain. These river dykes caused a hydraulic jump behind this point in the river. Additionally, stakeholders noted that ever since Lock and Dam #5 was constructed, the river gauge at the Railroad Bridge in Downtown Shreveport has increased by two or more feet.

One additional item that was cited as being a cause for flooding of the Red River was siltation. The Red River is one of the most highly silted rivers in the United States. Over time, deposition has accumulated upstream and moved downstream, building up in Shreveport.

Recovery

After the flooding, many expressed that initial recovery was well coordinated and efficient. There was excellent communication and many non-profit organizations were critical in ensuring that individuals affected by the flooding had essential provisions – food, clothing, and shelter. Most individuals agreed that initial response and recovery were excellent, asserting that they had a great amount of pride and appreciation for their community in how they strategized to ensure that basic necessities were delivered to those in need. There was widespread collaboration in these efforts ranging from FEMA to local food banks and churches. An issue that arose was the inability of some affected by the flooding to receive assistance due to the fact they no longer had an address. In addition, it was also mentioned that the process to receive assistance was confusing in regards to eligibility requirements and the application process.

Possible Solutions

Lastly, there was a wide array of possible solutions proposed by the stakeholders. Two widely cited solutions were for FEMA to update its flood maps to improve the accuracy of potential flood zones and for USACE to take more responsibility for preventing future floods. Others suggested studying the lock and dam system, the levee system, and BFE.

Other more detailed suggestions included the state applying pressure on the federal government to buy land from property owners living in flood zones in order to prevent future development. Also, stakeholders suggested that the local government prevent developers from developing in this area. In addition, it was suggested that a lock and dam be constructed upstream of Shreveport to manage the uncontrolled portion of the river. One stakeholder recommended moving the dredge spoil from Shreveport to the Atchafalaya Basin. Another proposition from stakeholders was to create an ordinance to establish a mandatory BFE. Several stakeholders proposed that more intense dredging was perhaps the most immediate solution to the flooding. There were others that believed improving green spaces was a necessary step in moving forward to prevent flooding. One last suggestion was for USACE to finish their Hydrological and Sediment Survey in order to gather the data necessary for FEMA to update its flood maps.

Moving Forward

Most stakeholders remain concerned with future flooding and agreed that coordinated efforts need to be made across different levels of government to reach consensus that results in action. The majority of stakeholders did not view the flooding as a "one-time event" but simply a matter of time until the next devastating flood occurs. Many of the stakeholders were hesitant to place the government as the party responsible for action to prevent future flooding; however, the majority expressed that state and local government involvement would be the best as opposed to federal government intervention. Some linked flooding solutions to economic development issues that could lead to higher revenues for government solutions, as well as greater community resiliency. This led many stakeholders to assert that the overall focus should be improving the economy of Caddo Parish in general and building resiliency in communities with job creation and higher standards of living. An overall concern was expressed about the economic future of

Caddo Parish, as its gaming industry is on the decline and the area would need to seek other opportunities to diversify its economy apart from this. Several stakeholders believed there should be a focus on improving communities through better transportation systems, reduction in unemployment, and education on flooding and the risks associated with living in areas subject to flooding.

Public Opinion Survey

What do Citizens of Louisiana Think about Flooding?

The Louisiana State University Manship School of Mass Communications – Reilly Center of Media & Public Affairs generously provided the survey data necessary to further the research into the recent floods in Louisiana. The Community Resilience Study survey[2] collected data from a randomly selected sample of adult residents in Louisiana through telephone interviews conducted from Jan. 8th – Feb. 6th, 2017, covering only the 2016 floods (Community Res. Study, 2017). A copy of the survey is in Appendix A.

What is Public Opinion?

The Community Resilience Study survey is an example of public opinion. Public opinion can be instrumental in guiding policy and set the guidelines where policymakers can operate (Bardes & Oldendick, 2016). This suggests that public opinion can be useful in various ways – identifying problems, evaluating solutions, or approving resource allocation. Public opinion is defined as the "aggregate of the views of individual adults on matters of public interest" (Bardes & Oldendick, pg. 5, 2016). This definition allows for better understanding of what public opinion is and its role in the policymaking process. Without the support of the public, policymakers may hesitate on making policy on various public interests. Conversely, public support can correspond into action. This suggests a link between public opinion and policy (Bardes & Oldendick, 2016). Nevertheless, the linkage between public opinion and public policy should continue to be used by policymakers, as it can guide and facilitate the policymaking process.

Regional Disparities

Upon analyzing the survey data, patterns arose from various regions in Louisiana, further indicative of how flood impacts varied throughout the state. We divided the state into two regions – a northern and southern region. A third region, the northwestern region, was formed as a subset of the northern region. Through this process, the state's sixty-four parishes were divided into sections. The northern region is comprised of twenty-nine parishes, the southern region – thirty-five parishes, and the northwestern region – nine parishes (Appendix B). Through simple descriptive statistics, responses were categorized based on the respondent's regions, allowing for observation and analysis. From the survey, specific questions were instrumental in gauging the residents' experiences during the 2016 flood in Louisiana. The following tables reflect patterns

[2] From a total sample of 1,079 respondents, 418 respondents originated from landline telephone and 661 from cell phone interviews. The response rate for the survey is 19.1%, it reflects the percentage of eligible residential households or cell phones in the sample that completed an interview. Furthermore, the statewide sample had an overall margin of error of +/- 3.1%. It should be noted that apart from sampling error, other forms of errors and bias can occur, primarily due to practical difficulties in conducting telephone surveys and the wording of the questions.

among the various regions according to specific survey questions regarding the respondent's experience and opinions during the flood.

When respondents were asked if their residence was flooded during 2016, 19.2% confirmed that their residence was flooded (Table 1). Upon separating respondents according to regions, a 7% gap is revealed between the northern and the southern parishes. This is indicative that residences were more affected by the floods in the southern parishes. When asked if respondents hosted other flood victims in their homes because of the flood, 18.2% of total respondents stated "yes" to that survey question (Table 1). Similar to the previous survey question, a disparity exists between the northern and southern parishes – southern parish residents were 10% more likely to state "yes."

When respondents were asked if their work was disrupted due to the 2016 flood, 30.9% of total respondents stated "yes" (Table 1). This result is particularly alarming, further revealing the statewide economic impacts of the floods. Upon examining the regions, one-third of respondents from southern parishes and one-fifth of respondents from northern parishes had their work disrupted due to flooding. These results further indicate that the 2016 flood prevented many residents from working.

Respondents were also asked if the flooding affected their income; this question only applied to respondents that previously stated that their work was disrupted by the flooding. This is a critical question is it further illustrates the economic impacts of the 2016 flood. Overall, 57.7% respondents confirmed that floods affected their income (Table 1). This pattern is similar throughout the other regions – 52.3% for northern parishes, 58.4% for southern parishes, and 66.7% for northwestern parishes. Once again, these results are alarming as over half of the respondents stated their income was negatively impacted by the flood.

Furthermore, respondents were asked if their homes lost power or other utilities during the flood, approximately 28% did experience such circumstances (Table 1). Due to the flood, over a quarter of residents from the state had utilities lost or experienced power failure. This pattern was similar throughout the other regions, suggesting that the accessibility of utilities and power were greatly impacted by the flood.

Survey respondents were asked if they had applied for any form of financial or monetary assistance from the federal government. From total responses, approximately 20% applied for such assistance from the federal government (Table 1). The results reflect several regional disparities – 10% in the north, 21% in the south, and 5% in the northwest. Several factors can explain the gaps between regions. First, southern parishes have larger populations than northern parishes, suggesting more residents were impacted in that region, resulting in a greater number of applications for financial assistance. Another possible explanation is that residents from these regions may not have the necessary information or governmental assistance to guide them through the application process. Nevertheless, the regional differences should be further examined in order to provide residents with the opportunity to apply for and receive federal assistance.

Additionally, respondents were asked if the news remained a credible source of information during the 2016 flood. Throughout the state, 64% of total respondents classified the news as credible (Table 1). This pattern was similar throughout the other regions – 64% in the north, 64% in the south, and 67% in the northwest, signaling the residents' dependence and confidence on news for information during natural disasters. These results indicate that there is no disparity between regions within Louisiana regarding news as a trusted source of information.

Table 1. Percent of "Yes" Response by Region

Survey Questions	**Louisiana**	**South**	**North**	**Northwest**
"Was your residence flooded during any of these severe storms during 2016?"	19.2%	20.5%	13.7%	11.2%
"Did anyone stay with you who had to leave their homes because of flooding in 2016?"	18.2%	20.19%	10.6%	8.1%
"Was your work disrupted due to any flooding in 2016?"	30.9%	33.3%	20.1%	15%
"Did this affect your income?"	57.7%	58.4%	52.3%	66.7%
"Did your home lose power or any other utilities during the flooding in Louisiana last year?"	27.9%	27.2%	29.7%	25.5%
"Did you or anyone in your household apply for any financial or monetary assistance from the federal government, including FEMA, following the Louisiana floods of 2016?"	19.5%	21.5%	10%	5.1%
"Do you think news was a credible source of information regarding recovery resources during and after the Louisiana floods of 2016?"	64.9%	64.3%	66.7%	67.2%
Source: Community Resilience Study (2017)				

When asked if residents could successfully deal with the threats posed by flooding, over three-quarters of respondents from all regions agreed that they could successfully deal with the threats posed (Table 2). While the percentages reflect positive results, the concern should be focused on the respondents that did not agree with this statement. Those that disagreed accounted for roughly 10% of total responses. This result was consistent throughout all regions, signifying the importance of flood preparedness across the state.

Impacted residents were asked if they received support from family and friends after the floods. Over 60% of total respondents stated that they received support (Table 2). The results from the different regions vary, ranging from as low as 43% in the northwest region to as high 63% in the southern region. Furthermore, the disparity occurs as well for respondents that disagreed with the statement – 24% in the northwest region and 13% in the southern region. The significant gaps between the northwestern and southern responses are problematic, as it is indicative that the northwestern region lacked the social support system during natural disasters.
Respondents were asked about receiving early warning information prior to the flood. According to the survey, 57.3% of total respondents agreed with the statement; however, 42.7% did not agree (Table 2). This proves to be problematic, as over a third of the total respondents did not receive the necessary information regarding the flood and other preparation measures. Unfortunately, this is not an isolated event; it is, however, consistent throughout the other regions. Roughly 35% in northern parishes and 44% in southern parishes experienced similar issues. With significant portions of the population lacking the necessary early warning information, this could become a priority for the state and parishes to improve upon.

Table 2. Percent of Agreeing Respondent by Region

Survey Questions	**Louisiana**	**South**	**North**	**Northwest**
"I was able to successfully deal with the threats posed by the flooding?"	82.4%	81.8%	87.2%	83.7%
"I was able to draw on the support of family and friends to help me get back on my feet after the flooding"	61.5%	63.5%	47.6%	43.2%
"I was able to get early warning information needed to prepare for the flooding"	57.3%	55.8%	64.3%	62.1%
Source: Community Resilience Study (2017)				

Respondents were asked how prepared do you feel if your community were to flood in the next twelve months. Overall, 28% of the total respondents within Louisiana stated that they felt their community would be "unprepared" for future flooding (Table 3). However, the residents from the northwest region reported the highest levels of unpreparedness – 34.7%. This is problematic for residents in the northwest, as the statistic indicates that communities feel as if they are inadequately prepared to confront future floods. Preparedness measures could be proposed and implemented to reassure residents that their community remains resilient and safe.

Table 3. "How prepared do you feel if your community were to flood in the next 12 months?"					
Region	**Not Prepared**	**Somewhat Unprepared**	**Neither**	**Somewhat Prepared**	**Very Prepared**
Louisiana	15.8%	12.5%	5.1%	40%	24.8%
North Region	16%	12.8%	5%	39.7%	25.1%
South Region	15.7%	12.4%	5.1%	40%	24.7%
Northwest Region	21.4%	13.3%	6%	37.7%	21.4%
Source: Community Resilience Study (2017)					

Implications from Regional Analysis

The results from the Community Resilience survey present opportunities to improve in various areas of concerns when it comes to flooding in Louisiana. Regional disparities should be taken into account by policymakers. The main areas that should be addressed are the vast economic impacts of the floods and both preparation and communication failures. The northwest region of Louisiana suffers from higher disturbances to income, lower federal aid applications, lower reported levels of social support, and reported lower levels of preparedness within communities. This signifies additional negative economic impacts for residents within the northwest. Early warning communication presented itself as a uniform issue throughout all regions, indicating a lack of early warning information necessary for flood preparation. Nonetheless, results from the Community Resilience survey highlight serious issues that are found throughout Louisiana. It would be beneficial for policy to be guided by data, as it will enable for a more comprehensive decision-making process and action towards floods.

Investigating other possible statistical differences in Louisiana

In order to obtain a better statistical understanding of public opinion about flooding in Louisiana, three questions from the survey were selected to use for hypothesis testing. The following three questions were selected to be used as the dependent variables for testing:

- "I was able to successfully deal with the threats posed by the flooding."
- "How prepared do you feel if your community were to flood in the next twelve months?"
- "I was able to get early warning information needed to prepare for the flooding."

Responses indicating less preparedness or access to information will be treated as the respondent being more at risk to a flood event. All three questions asked for responses on a linear five-point scale, making them ideal for analysis. The independent variables tested for significance were education and income. Education and income will serve as the independent variables for the hypothesis testing, as they are two relevant, ordinal variables provided in the survey. Race, sex,

party identification, and home ownership will also be analyzed, however, because these variables are not ordinal they will only serve as descriptive variables.

The hypotheses tested were:

1. **H_0:** If the respondent is more educated, then there is an equal or greater chance that the respondent will be negatively impacted by a flood event.
   H_1: If the respondent is more educated, then there is a lesser chance that the respondent will be negatively impacted by a flood event.

2. **H_0:** If the respondent has greater income, then there is an equal or greater chance that the respondent will be negatively impacted by a flood event.
   H_1: If the respondent has greater income, then there is a lesser chance that the respondent will be negatively impacted by a flood event.

In order to analyze the questions, some basic descriptive statistics were gathered to describe relationships between variables. Chi-squared distributions and P values were calculated to test for statistical significance between variables. The P value is most important for the variable analysis. A value of .05 or less indicates that there is a strong relationship between the two variables, a value from .05 to .1 indicates a weaker relationship, and a value larger than .1 indicates an insignificant relationship.

Results

When measuring education as a predictor for flood vulnerability, there was not a significant relationship with how respondents dealt with flooding (Table 4) or how prepared the respondents perceives their community (Table 5). The relationship between education and obtaining early warning information had weak significance, with a P value of 0.095 (Table 6). However, it becomes clear when looking at the data that the relationship is not that greater education leads to more access to communication. Instead, respondents across educational backgrounds stated that they either had access to communications or did not, creating a dataset with bimodal distribution toward either end of the responses. The data does not provide sufficient evidence to reject null hypothesis number one, therefore, the hypothesis that there is a lesser chance that better educated respondents will be negatively impacted by flood events must be rejected.

Table 4. "I was able to successfully deal with the threats posed by the flooding."

	X^2	P value
Education Level	30.3678	0.173
Income Level	37.9710	0.38

Source: Community Resilience Study (2017)

Table 5. "How prepared do you feel if your community were to flood in the next 12 months?"		
	X^2	**P value**
Education Level	25.9592	0.355
Income Level	36.2624	0.456
Source: Community Resilience Study (2017)		

Table 6. "I was able to get early warning information needed to prepare for the flooding."		
	X^2	**P value**
Education Level	33.4235	0.095
Income Level	52.1668	0.04
Source: Community Resilience Study (2017)		

The data measuring income also shows very similar results to the education data. There is not a significant relationship between income and how respondents dealt with flooding (Table 4) or how prepared the respondent's community is (Table 5). What's more, the relationship between income and access to early warning information was bimodal as well. This bimodal relationship was significant, with a P value of 0.04 (Table 6). However, this data does not provide the necessary information to reject the second null hypothesis. Therefore, the second hypothesis that respondents with greater income will have a lesser chance of being negatively impacted by a flood event must be rejected as well.

When analyzing the non-ordinal variables, race stood out as a relevant variable in need for more studying. Comparing the difference between white and black respondents, it became clear that black respondents were more affected by the flood than white respondents. When asked if respondents' homes flooded, black respondents were 8% more likely to say "yes" than white respondents. Black respondents were also more likely to have their work disrupted by 3%, more likely to have income disrupted by 12% if their work was disrupted, and had a 12% greater chance of losing utilities. This racial disparity should be investigated further. The final interesting non-ordinal variable was that individuals who responded that they owned a home were less likely than renters to have their house flood, have their income or work disrupted, or have issues with utilities (Table 7 & 8).

Table 7. Percent of Respondents Who Indicated Negative Flood Impacts by Race		
	Race	
Survey Questions	**White**	**Black**
"Was your residence flooded during any of these severe storms during 2016?"	17%	25%
"Was your work disrupted due to any flooding in 2016?"	30%	33%
"Did this affect your income?"	54%	66%
"Did your home lose power or any other utilities during the flooding in Louisiana last year?"	25%	37%
Source: Community Resilience Study (2017)		

Table 8. Percent of Respondents Who Indicated Negative Flood Impacts by Housing Status			
	Housing Status		
Survey Questions	**Own**	**Rent**	**Other**
"Was your residence flooded during any of these severe storms during 2016?"	16%	24%	29%
"Was your work disrupted due to any flooding in 2016?"	29%	37%	34%
"Did this affect your income?"	55%	64%	63%
"Did your home lose power or any other utilities during the flooding in Louisiana last year?"	26%	37%	35%
Source: Community Resilience Study (2017)			

Recommendations

Based on the examination of the literature review, case studies, empirical research of both the survey data and stakeholder interviews, these are the broad recommendations that we present for consideration to Caddo Parish.

Strengthening Resiliency

Resiliency refers to "the ability of systems, infrastructures, government, business, and citizenry to absorb and/or quickly recover from an adverse event or series of events caused by attack or natural disaster which may cause harm, destruction, or loss of national significance and to restore minimum essential operations and reduce the consequences of its degradation or failure regardless of its cause" (DHS, 2007). Some actions to consider include:

Flood Education Outreach
Flooding is a natural phenomenon that will most likely continue to increase in the area. To help mitigate the problems of property and economic loss, and injuries/ loss of lives, there should be a flood education outreach program to help increase the knowledge for government, business, and citizens of what to do and what not to do before, during, and after a flood. One example of an education outreach program is the "Turn Around Don't Drown" flood campaign by the National Weather Service. A more locally focused campaign that centers around more specific area issues might be useful and something the parish might consider and implement. This campaign could be pushed in the parish in order to decrease the amount of driving during a flooding incident. Some other examples include mailing flyers or brochures, creating media commercials for both radio and television, placing signs and posters around the town, and creating campaigns that target preparations, emergency response, and recovery. As noted in the public opinion survey, flooding is a problem that affects all groups of people. Educational programs can help to provide a common understanding of flooding and provide equal chance to take preventive actions before a flood as well as understand post flood recovery.

Training and Exercises
Floods plans are an important tool in order to reduce the damage that may occur; however, plans need to be tested. Training and exercises are tools for emergency managers to use to test emergency plans in a simulated event with little to no risk. It provides opportunities to show vulnerabilities as well as strengths of any flood specific plans. The best way to start the testing of plans is to start with seminars and progress to full-scale exercises. Full-scale exercises bring together all the stakeholders in a realistic environment. All participants can learn various things such as potential roles and functions during a flood situation, communication, and coordination throughout the different organizations, and test their capabilities. This work to train first responders on the emergency plans of the community. Training and exercises help to provide the best practices for floods and leads to the growth in best practices in a flooding emergency incident.

Partnerships and Collaboration
Based on a majority of the interviews, the Red River flooding comes from the increase of rain in Texas and Oklahoma and the shrinking size of the channel caused by sedimentation. The Grand

Forks and Napa County case studies demonstrated how multi-jurisdictional collaborations and partnerships can lead to positive outcomes. From the case studies and the causes of the previous floods, Caddo Parish should consider collaborations and partnerships with neighboring parishes, counties and organizations such as the Red River Valley Association. Through these collaborations and partnerships, it would be possible to work on solutions that have to be completed up river in order to prevent the excessive rainfall from flowing down. These relationships could also help to increase the situational awareness for the risk of a flood and may also help combat the problem with the inaccurate reports by the National Weather Service that were mentioned. Open communication across all levels of government from local to state to federal to build the relationship and trust can help to improve mitigation efforts of flooding.

Facilitating Sustainability

The University of California at Los Angeles (UCLA) has focused attention on the problems of recovery from natural disasters. Their UCLA Sustainability Committee has argued that "the physical development and institutional operating practices that meet the needs of present users without compromising the ability of future generations to meet their own needs" is the way to proceed. "Sustainability presumes that resources are finite and should be used conservatively and wisely with a view to long-term priorities and consequences of the ways in which resources are used." (From UCLA Committee Website)

Green Infrastructure

Green infrastructure is a cost-effective approach to reduce flood effects. With the increase in urbanization throughout the United States and especially in coastal areas, the amount of concrete increases. The increase in non-porous concrete leads to disturbances in the natural stormwater runoff process. Green infrastructure such as parks, farms, greenways, buffers along waterways, residential landscaping, and urban gardens create storage areas to prevent flooding from runoff water. Green infrastructure "uses vegetation, soils, and other elements and practices to restore some of the natural processes required to manage water and create healthier urban environments" (EPA, 2017). The Green Roofs and the Green Alleys Programs used in Chicago are possible program ideas that Caddo Parish could look into in order to mitigate flooding effects. The Parish could also consider expanding and improving riparian zones which would involve adding green vegetation along the Red River to help water runoff management.

Stormwater Utility Fees

Around the country, local communities are starting to implement a fee in order to collect revenue for needed stormwater services and projects. A stormwater utility fee is similar to a water, sewer, or garbage utility fee. For example, in Fort Worth, Texas, all owners of developed property within the city are charged a user fee for stormwater services. Since this fee is not a tax, nonprofits, state government, and federal government properties may be responsible for paying this fee as well. The fee applies to impervious areas meaning areas where surface water does not run freely. This could also help to decrease the usage of impervious materials for development work. They have set prices based on square feet. Perhaps Caddo Parish should consider implementing such a stormwater utility fee.

Technical Recommendations

Updating Floodplain Maps

FEMA produces flood maps for substantial flooding issues, but they have gone on record to state that "the flood insurance rate map may not adequately identify all of a community's at-risk areas" (2005). The responsibility falls on communities to create their flood maps and assess potential flooding threats. The team recognizes that the Corp of Engineers are currently waiting for more funding to improve these maps; however, Caddo Parish should consider producing its own maps. Caddo Parish will have a better understanding of the area, which will produce more accurate maps for the community. These maps can also help to update mortgages as well as insurance rates.

Land Use Planning and Building Codes

Land use planning has to do with making decisions about where people and businesses can legally build. Such planning would include looking at the floodplain areas and marking them off. Zoning and regulations for land use mitigate potential flooding situations by not allowing business to build on floodplains. If business continues to grow on these plains, they are accepting the risk of flooding. Caddo Parish should ensure that the development in these areas continue to allow the natural run-off process to occur. If this process does not occur, Caddo Parish could work to implement a policy to fine the business developers. Having building standards focused on flooding will decrease the amount of damages on houses and businesses.

Dredging

Caddo Parish does not have the decision-making authority when it comes to how dredging is conducted within its boundaries, but that does not mean Caddo Parish should do nothing. The goal should be for Caddo Parish to work collaboratively to seek creative partnerships where new ideas can be developed with the state and other organizations looking to improve the areas around the Red River. Efforts should be made to inform the Corp of Engineers of the specific concerns within the Parish, and how increased dredging could benefit the region. Caddo Parish could push for both increasing the standard depth of the Red River from nine feet to twelve feet in order to assist with increased water flow, as well as push for the same dredging standards to be applied north of Shreveport that are established for the Red River south of the city. Also, Caddo Parish could investigate public-private partnership options to increase dredging activity north of Shreveport. It is possible to use the dredged material as sand for fracking. Performance Proppants is a firm present in Bossier Parish already selling dredged material to fracking wells that they collect from the Red River (Performance Proppants, 2018). Investigating possible options to sell dredged material could recoup part of the costs it takes to dredge the Red River.

Conclusion

Globally, flooding has become a more prominent problem causing upheaval in small and large communities alike. Due to more severe weather patterns, increased urbanization, and aging infrastructure, millions of people are put at risk each year. As rivers come out of their banks and coastal waters encroach on cities located on shoreline, infrastructure is destroyed, economies suffer the repercussions, and most importantly, hundreds of thousands of lives are claimed.

Caddo Parish is no stranger to flooding, with flood events associated with the Red River dating back to over a century ago. Repeated flooding has damaged agriculture, industry, homeowners, and local businesses. However, the recent flooding has signaled that change is necessary in order to avoid further damages. As the flooding devastated the community, local government did its part by stepping in to warn citizens living in the area to evacuate areas deemed at-risk of flooding and responded to the post-flood recovery in a way that was lauded by its citizens. However, nothing could have prepared local government or individuals living in the area for the magnitude of the damage that would occur due to historic flooding. The flood did not follow historical patterns for a number of reasons: increased development along the river put more individuals and structures at risk. Urbanization also took away storage capacity of the river, and increased deposition in the Red River over the years induced more severe flooding. Due to this, FEMA flood maps were out of date, signaling that the parish was fundamentally different from the last time that these maps were drawn. Local residents also weighed in on the matter, stating that there were issues with individuals and developers building within the levee within recent years and adjustments not being made to include the high-water mark. If things do not change, these residents will remain at risk as well as the surrounding businesses and industry.

In response to the flood, local officials and experts formed the Flood Technical Committee to tackle these issues. They have also assisted USACE to conduct a hydraulic and sediment study of the river's channel to establish flood stage elevation for use by FEMA to update the Flood Insurance Rate Maps for Caddo Parish. However, additional actions can be taken into consideration when thinking of ways to mitigate the effects of future flooding. Educational outreach, emergency training, and exercises to prepare for future floods can be implemented on a local government level. From an infrastructure perspective, green infrastructure can be built, and revenue could be raised through a stormwater fee in order to help pay for these new technologically-forward developments. In addition, FEMA flood maps could be updated, land use zoning policies could be enacted to prevent building in flood-prone areas, and additional dredging could be considered to remove accumulated sedimentation in the river.

Caddo Parish has done an excellent job in recovering from the recent flooding and has shown its resiliency as a community in the face of disaster. However, as the Public Opinion Survey noted, one-third of northwestern respondents feel that their communities are unprepared for the next flood. As a way to ensure that the cities of Shreveport and Bossier City remain thriving urban areas and to protect them from future potential floods. Local officials, experts, and employees must collaborate in order to implement creative ideas to guarantee the future vitality of their community.

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Appendix A

Community Resilience Survey Questions

Have I reached you on a landline or cell phone?
1. Landline
2. Cell phone

What parish is your current home located in?

We would like to ask you about your experiences during the floods in Louisiana last spring and summer. Was your residence flooded during any of these severe storms during 2016?
1. Yes
2. No

Are you back living in your home?
1. Yes
2. No

Did anyone stay with you who had to leave their homes because of flooding in 2016?
1. Yes
2. No

Was your work disrupted due to any flooding in 2016?
1. Yes
2. No

Did this affect your income?
1. Yes
2. No

Did your home lose power or any other utilities during the flooding in Louisiana last year?
1. Yes
2. No

I will read you a few statements, please tell me whether you strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, or strongly disagree with each. First 'I was able to successfully deal with the threats posed by the flooding.'
1. Strongly agree
2. Somewhat agree
3. Neither agree nor disagree
4. Somewhat disagree
5. Strongly disagree

Next, 'I was able to draw on the support of family and friends to help me get back on my feet after the flooding.'

1. Strongly agree
2. Somewhat agree
3. Neither agree nor disagree
4. Somewhat disagree
5. Strongly disagree

'I was able to get early warning information needed to prepare for the flooding.'
1. Strongly agree
2. Somewhat agree
3. Neither agree nor disagree
4. Somewhat disagree
5. Strongly disagree

How prepared do you feel if your community were to flood in the next 12 months?
1. Not prepared at all
2. Somewhat unprepared
3. Neither unprepared nor prepared
4. Somewhat prepared
5. Very prepared

Following the Louisiana floods in 2016, how would you rate the performance of FEMA, the Federal Emergency Management Agency, on a scale from 0 to 100 - zero being a poor job and 100 being an excellent job?
[Numeric response 0 to 100]

Using the same scale, how would you rate the performance of the Louisiana state government following the Louisiana floods in 2016?
[Numeric response 0 to 100]
888. Don't know [Not read]
999. Refused [Not read] 5

Did you or anyone in your household apply for any financial or monetary assistance from the federal government, including FEMA, following the Louisiana floods of 2016?
1. Yes
2. No

What about after previous natural disasters, such as Hurricane Katrina in 2005? Did you or anyone in your household apply for any financial or monetary assistance from the federal government then?
1. Yes
2. No
Do you think the news was a credible source of information regarding recovery resources during and after the Louisiana floods of 2016?
1.Definitely yes
2. Probably yes
3. Maybe or maybe not

4. Probably not
5. Definitely not

Officials who monitor the weather name hurricanes and some other storms but did not name the storms that caused major flooding in Louisiana in 2016. Do you think it mattered that these storms were not named?
1. Yes
2. No

Why do you think it mattered that these storms were not named?
[Response recorded verbatim]

We would like to ask you about race relations in the state. Do you think race relations in Louisiana are getting better, getting worse or staying about the same?
1. Better
2. Worse
3. Same

Which of these three statements comes closer to your own views -- even if none is exactly right. One: "Our country has made the changes needed to give blacks equal rights with whites," or two: "Our country needs to continue making changes to give blacks equal rights with whites," or three "Our country has gone too far in making changes on rights for blacks"?
1. Our country has made the changes needed to give blacks equal rights with whites
2. Our country needs to continue making changes to give blacks equal rights with whites
3. Our country has gone too far in making changes on rights for blacks

Do you think our country will eventually make the changes needed to give blacks equal rights, or do you think the country will never make those changes?
1. Will eventually make them
2. Will never make them

Thinking about your own experience, have you ever personally experienced discrimination or been treated unfairly because of your race or ethnicity, or not?
1. Yes
2. No

And how often would you say you experienced discrimination because of your race or ethnicity?
1. Never
2. Rarely
3. From time to time
4. Regularly

Should government make more effort, less effort, or the same amount of effort to reduce racial segregation in Louisiana's public schools?

1. More
2. Less
3. Same

In Louisiana today nearly three quarters of black students attend majority black schools. Should government make more effort, less effort, or the same amount of effort to reduce racial segregation in Louisiana's public schools?
1. More
2. Less
3. Same

Should government make more effort, less effort, or the same amount of effort to reduce racial differences in punishment for people convicted of similar crimes?
1. More
2. Less
3. Same

Should government make more effort, less effort, or the same amount of effort to reduce the gap in wages and income between white and black workers doing similar jobs?
1. More
2. Less
3. Same

Now we would like to ask you a few questions about police. How much confidence do you have in police to not use excessive force?
1. Great deal
2. Fair amount
3. Just some
4. Very little

How much confidence do you have in police to treat blacks and whites equally?
1. Great deal
2. Fair amount
3. Just some
4. Very little

How often, if ever, do you worry about violence by police against people in your community?
1. Never
2. Rarely
3. Sometimes
4. Most of the time
5. All of the time

Thinking about events in Baton Rouge last summer, in your opinion, were the protests in Baton Rouge following the Alton Sterling shooting justified or were they unjustified?
1. Justified

2. Unjustified

During the Baton Rouge protests, do you think police used the right amount of physical force when interacting with protesters, should they have used more force, or should they have used less force?
1. Used right amount of force
2. Should have used more force
3. Should have used less force

In your opinion, do Louisiana citizens need to pick a side between police and protesters, or is it possible to support the need for police and the concerns of protesters at the same time?
1. Need to pick a side
2. Can do both

Listen to the following two statements, and tell me if you agree strongly, somewhat agree, somewhat disagree, or strongly disagree: First, 'Generations of slavery and discrimination have created conditions that make it difficult for blacks to work their way out of the lower class.'
1. Strongly agree
2. Somewhat agree
3. Neither agree nor disagree
4. Somewhat disagree
5. Strongly disagree

Next, 'It's really a matter of some people not trying hard enough; if blacks would only try harder they could be just as well off as whites.'
1. Strongly agree
2. Somewhat agree
3. Neither agree nor disagree
4. Somewhat disagree
5. Strongly disagree

How important is your race to your identity?
1. Very important
2. Somewhat important
3. Not at all important

Do you think the news was a credible source of information about the Alton Sterling shooting in the days after it occurred?
1. Definitely yes
2. Probably yes
3. Maybe or maybe not
4. Probably not
5. Definitely not

Now, thinking about the ambush that killed three police officers in Baton Rouge last summer, please tell me if you strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, or strongly disagree with each of the following statements. First, "Local and state authorities did a good job communicating with the community during and after the Baton Rouge police officer ambush this summer."
1. Strongly agree
2. Somewhat agree
3. Neither agree nor disagree
4. Somewhat disagree
5. Strongly disagree

Next, "Local media did a good job communicating with the community during and after the Baton Rouge police officer ambush this summer."
1. Strongly agree
2. Somewhat agree
3. Neither agree nor disagree
4. Somewhat disagree
5. Strongly disagree

Do you think the news was a credible source of information about the shooting deaths of Baton Rouge police officers in the days after it occurred?
1. Definitely yes
2. Probably yes
3. Maybe or maybe not
4. Probably not
5. Definitely not

When a crisis hits your local community, where is the first place you go to find information on the crisis?
1. Facebook
2. Twitter
3. Local news online
4. Local printed newspaper
5. Local television
6. Radio
7. Call or text a friend
8. Something else

Please indicate how much you agree or disagree with each of the following statements: "When there is a CRISIS in the local community, the local media should help protect local citizens through information."
1. Strongly agree
2. Somewhat agree
3. Neither agree nor disagree
4. Somewhat disagree
5. Strongly disagree

"When there is a CRISIS in the local community, the local media should advocate for the community."
1. Strongly agree
2. Somewhat agree
3. Neither agree nor disagree
4. Somewhat disagree
5. Strongly disagree

"When there is a CRISIS in the local community, the local media should get involved in social justice."
1. Strongly agree
2. Somewhat agree
3. Neither agree nor disagree
4. Somewhat disagree
5. Strongly disagree

"When there is a CRISIS in the local community, the local media should aid the community in recovery."
1. Strongly agree
2. Somewhat agree
3. Neither agree nor disagree
4. Somewhat disagree
5. Strongly disagree

How often do you check for news on social media, such as Facebook or Twitter?
1. Many times a day
2. Once a day
3. Four or five times a week
4. Two or three times a week
5. Once a week
6. Never

How often do you read news online?
1. Many times a day
2. Once a day
3. Four or five times a week
4. Two or three times a week
5. Once a week
6. Never

How often do you read printed news, such as newspapers and magazines?
1. Many times a day
2. Once a day
3. Four or five times a week
4. Two or three times a week

5. Once a week
6. Never

How often do you watch news on television?
1. Many times a day
2. Once a day
3. Four or five times a week
4. Two or three times a week
5. Once a week
6. Never

Generally speaking do you consider yourself a Democrat, Republican, independent, or what?
1. Democrat
2. Republican
3. Independent
4. Something else

Would you consider yourself a strong or a not so strong [INSERT RESPONSE TO PREVIOUS QUESTION]
1. Strong
2. Not so strong

Would you say, you lean to the Democratic Party or Republican Party, or would you say you don't lean to either party?
1. Democratic Party
2. Republican Party
3. Does not lean

What year were you born?
[Numeric response]

Do you own your own home, pay rent, or something else?
1. Own home
2. Pay rent
3. Something else

Do you own a cell phone?
1. Yes
2. No

Do you have a landline telephone in your home?
1. Yes
2. No

[CALLER RECORDS GENDER, ASKED ONLY IF NECESSARY]

1. Male
2. Female

What is your race?
1. White
2. African American or black
3. Something else

What is the highest degree or level of school that you have completed? Please stop me when I get to the category that includes your highest level of education.
1. Less than 9th grade
2. 9th through 12th grade (no diploma)
3. High school graduate (includes equivalency)
4. Some college, but no degree
5. Associate's degree
6. Bachelor's degree
7. Graduate or professional degree

We would like to know what your household income was last year before taxes. Please stop me when I get to the category that includes your household income.
1. Under $10,000
2. $10,000 - $14,999
3. $15,000 - $24,999
4. $25,000 - $34,999
5. $35,000 - $49,999
6. $50,000 - $74,999
7. $75,000 - $99,999
8. $100,000 - $149,999
9. $150,000 - $199,999
10. $200,000 or more

And what is your zip code?
[Numeric response]

Appendix B

List of Regions in Louisiana

Northern Region Parishes:

- Caddo
- Bossier
- Webster
- Claiborne
- Union
- Morehouse
- West Carroll
- East Carroll
- Madison
- Richland
- Ouachita
- Lincoln
- Bienville
- Red River
- De Soto
- Sabine
- Natchitoches
- Winn
- Jackson
- Caldwell
- Franklin
- Tensas
- Concordia
- Catahoula
- La Salle
- Grant
- Vernon
- Rapides
- Avoyelles

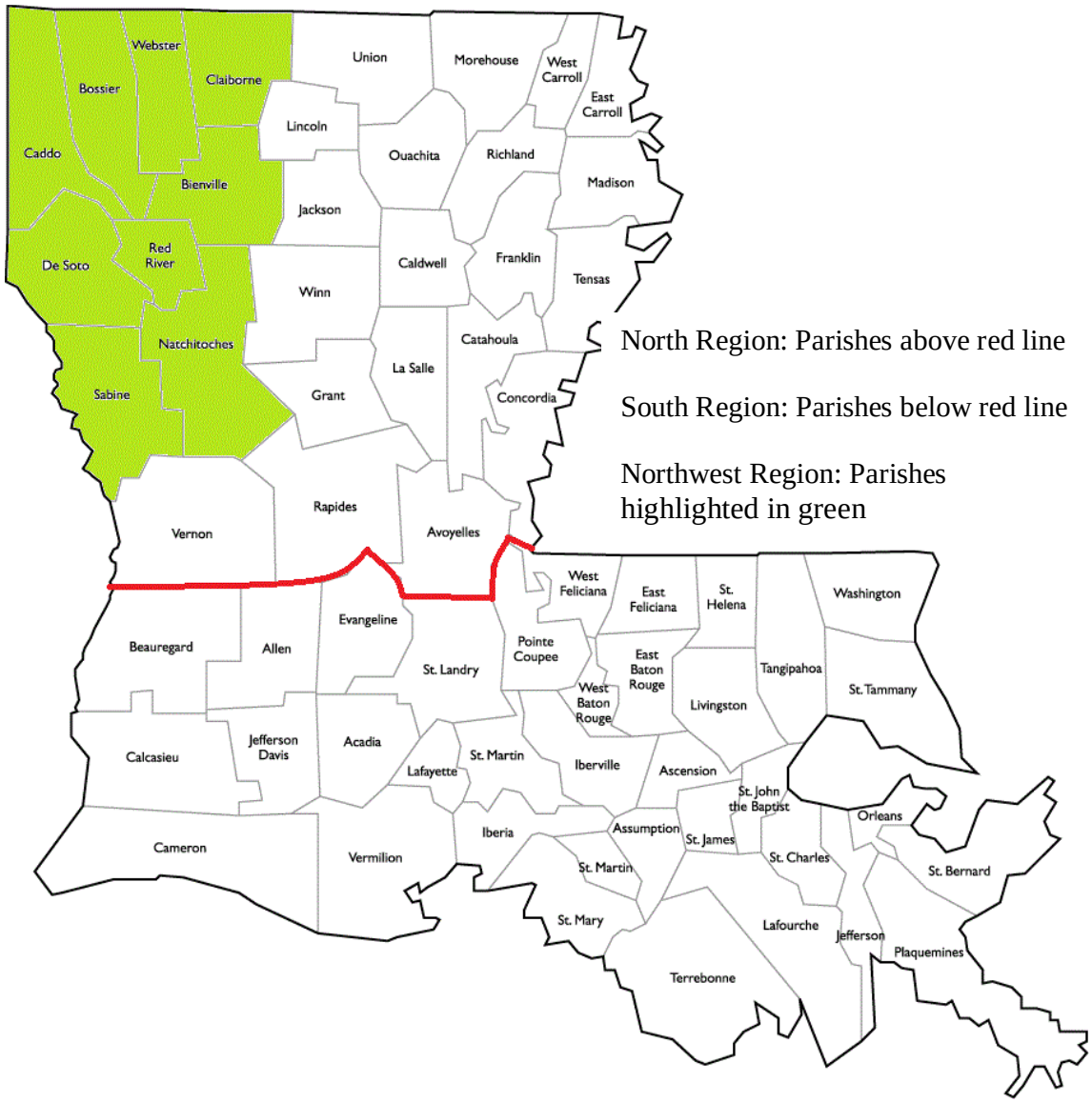
Southern Region Parishes:

- Beauregard
- Allen
- Evangeline
- St. Landry
- Pointe Coupee
- West Feliciana
- East Feliciana
- St. Helena
- Tangipahoa
- Washington
- Calcasieu
- Jefferson Davis
- Acadia
- Lafayette
- St. Martin
- Iberville
- West Baton Rouge
- East Baton Rouge
- Livingston
- St. Tammany
- Cameron
- Vermilion
- Iberia
- Ascension
- St. Mary
- Assumption
- St. James
- St. John the Baptist
- Terrebonne
- Lafourche
- St. Charles
- Jefferson
- Orleans
- St. Bernard
- Plaquemines

Northwest Region Parishes:

- Caddo
- Bossier
- Webster
- Claiborne
- De Soto
- Red River
- Bienville
- Sabine
- Natchitoches

Map of Regions in Louisiana



North Region: Parishes above red line

South Region: Parishes below red line

Northwest Region: Parishes highlighted in green

Appendix C

Survey Statistics by Region

Table 1. "Was your residence flooded during any of these severe storms during 2016?"			
Region:	**Yes**	**No**	**N**
Louisiana	19.2%	80.6%	1079
North Region	13.7%	85.8%	219
South Region	20.5%	79.5%	844
Northwest Region	11.2%	87.8%	98
Source: Community Resilience Study (2017)			

Table 2. "Did anyone stay with you who had to leave their homes because of flooding in 2016?"			
Region	**Yes**	**No**	**N**
Louisiana	18.2%	81.7%	870
North Region	10.6%	89.4%	188
South Region	20.19%	79.79%	671
Northwest Region	8.1%	91.9%	86
Source: Community Resilience Study (2017)			

Table 3. "Was your work disrupted due to any flooding in 2016?"			
Region	**Yes**	**No**	**N**
Louisiana	30.9%	69%	1079
North Region	20.1%	79.4%	219
South Region	33.3%	66.7%	844
Northwest Region	15%	84.7%	98
Source: Community Resilience Study (2017)			

Table 4. "Did this affect your income?"			
Region	**Yes**	**No**	**N**
Louisiana	57.7%	42%	333
North Region	52.3%	45.5%	44
South Region	58.4%	41.6%	281
Northwest Region	66.7%	33.3%	15
Source: Community Resilience Study (2017)			

Table 5. "Did your home lose power or any other utilities during the flooding in Louisiana last year?"			
Region	**Yes**	**No**	**N**
Louisiana	27.9%	68.4%	1079
North Region	29.7%	66.7%	219
South Region	27.2%	69.1%	844
Northwest Region	25.5%	69.4%	98
Source: Community Resilience Study (2017)			

Table 6. "I was able to successfully deal with the threats posed by the flooding."						
Region	**Strongly Agree**	**Somewhat Agree**	**Neither**	**Somewhat Disagree**	**Strongly Disagree**	**N**
Louisiana	56%	26.4%	3%	5.6%	6.4%	593
North Region	64.4%	22.8%	3%	4%	4%	101
South Region	54.6%	27.2%	3.1%	5.9%	6.9%	478
Northwest Region	56.7%	27%	0%	5.4%	5.4%	37
Source: Community Resilience Study (2017)						

Table 7. "I was able to draw on the support of family and friends to help me get back on my feet after the flooding."						
Region	**Strongly Agree**	**Somewhat Agree**	**Neither**	**Somewhat Disagree**	**Strongly Disagree**	**N**
Louisiana	50%	11.5%	16.3%	5.2%	9.4%	593
North Region	38.6%	9%	22.8%	6%	14.8%	101
South Region	51.4%	12.1%	15.5%	5.2%	8.1%	478
Northwest Region	37.8%	5.4%	21.6%	10.8%	13.5%	37
Source: Community Resilience Study (2017)						

Table 8. "I was able to get early warning information needed to prepare for the flooding"						
Region	**Strongly Agree**	**Somewhat Agree**	**Neither**	**Somewhat Disagree**	**Strongly Disagree**	**N**
Louisiana	39.8%	17.5%	5.5%	12.8%	22.9%	593
North Region	47.5%	16.8%	6%	14.8%	14.8%	101
South Region	37.6%	18.2%	5.4%	12.3%	24.7%	478
Northwest Region	37.8%	24.3%	10.8%	13.5%	13.5%	37
Source: Community Resilience Study (2017)						

Table 9. "How prepared do you feel if your community were to flood in the next 12 months?"						
Region	**Not Prepared**	**Somewhat Unprepared**	**Neither**	**Somewhat Prepared**	**Very Prepared**	**N**
Louisiana	15.8%	12.5%	5.1%	40%	24.8%	1079
North Region	16%	12.8%	5%	39.7%	25.1%	219
South Region	15.7%	12.4%	5.1%	40%	24.7%	844
Northwest Region	21.4%	13.3%	6%	37.7%	21.4%	98
Source: Community Resilience Study (2017)						

Table 10. "Did you or anyone in your household apply for any financial or monetary assistance from the federal government, including FEMA, following the Louisiana floods of 2016?"			
Region	**Yes**	**No**	**N**
Louisiana	19.5%	80%	1079
North Region	10%	89.5%	219
South Region	21.5%	77.7%	844
Northwest Region	5.1%	94.9%	98
Source: Community Resilience Study (2017)			

Table 11. "Do you think news was a credible source of information regarding recovery resources during and after the Louisiana floods of 2016?"						
Region	**Definitely Yes**	**Probably Yes**	**Maybe or Maybe Not**	**Probably Not**	**Definitely Not**	**N**
Louisiana	33.4%	31.5%	12.3%	8.8%	9.6%	1079
North Region	34.7%	32%	12.3%	6.8%	10.5%	219
South Region	32.9%	31.4%	12.4%	9.3%	9.3%	844
Northwest Region	33.6%	33.6%	15.3%	5.1%	9.2%	98
Source: Community Resilience Study (2017)						

Survey Statistics by Demographics

Table 12. "I was able to successfully deal with the threats posed by the flooding."						
Education level	**Strongly Agree**	**Agree**	**Neither**	**Somewhat Disagree**	**Strongly Disagree**	**N**
Less than 9th Grade	50%	17%	0%	0%	33%	6
9th through 12th grade (no diploma)	42%	34%	0%	11%	13%	38
High school Graduate or equivalent	56%	25%	3%	9%	7%	122
Some College	55%	28%	4%	6%	7%	162
Associate's degree	57%	27%	4%	5%	7%	56
Bachelor's degree	69%	23%	1%	4%	4%	109
Graduate or Professional degree	60%	30%	5%	1%	4%	82
$\underline{X^2 = 30.3678}$			$\underline{\text{P-Value} = 0.173}$			
Source: Community Resilience Study (2017)						

Table 13. "How prepared do you feel if your community were to flood in the next 12 months?"

Education level	Not Prepared	Somewhat Unprepared	Neither	Somewhat Prepared	Very Prepared	N
Less than 9th Grade	35%	6%	12%	18%	29%	17
9th- 12th grade (no diploma)	16%	11%	5%	43%	25%	61
H.S. Graduate or equivalent	17%	14%	4%	36%	29%	235
Some College	18%	12%	5%	42%	23%	264
Associate's degree	17%	10%	9%	38%	25%	106
Bachelor's degree	11%	15%	4%	44%	27%	213
Graduate or Professional degree	14%	13%	6%	46%	21%	155
$X^2 = 25.9592$			P-Value = 0.355			

Source: Community Resilience Study (2017)

Table 14. "I was able to get early warning information needed to prepare for the flooding."

Education level	Strongly Agree	Agree	Neither	Somewhat Disagree	Strongly Disagree	N
Less than 9th Grade	57%	14%	0%	0%	29%	7
9th - 12th grade (no diploma)	49%	21%	0%	10%	21%	39
H.S. Graduate or equivalent	44%	13%	5%	10%	28%	125
Some College	36%	17%	7%	14%	25%	162
Associate's degree	40%	11%	5%	18%	26%	57
Bachelor's degree	49%	20%	5%	15%	12%	109
Graduate or Professional degree	27%	29%	7%	12%	24%	82
X^2 =33.4235			P-Value = 0.095			

Source: Community Resilience Study (2017)

Table 15. "I was able to successfully deal with the threats posed by the flooding."

Income level	Strongly Agree	Agree	Neither	Somewhat Disagree	Strongly Disagree	N
Under $10,000	41%	32%	8%	5%	14%	37
$10,000-$14,999	48%	36%	4%	8%	4%	25
$15,000-$24,999	46%	29%	2%	12%	12%	59
$25,000-$34,999	65%	26%	4%	6%	0%	54
$35,000-$49,999	51%	25%	4%	6%	15%	53
$50,000-$74,999	59%	26%	4%	5%	7%	82
$75,000-$99,999	61%	28%	3%	3%	5%	64
$100,000-$149,999	66%	25%	2%	5%	3%	64
$150,000-$199,999	58%	31%	4%	0%	8%	26
$200,000 or more	81%	14%	0%	0%	5%	21
$X^2 = 37.9710$				P-Value= 0.380		

Source: Community Resilience Study (2017)

Table 16. "How prepared do you feel if your community were to flood in the next 12 months?"						
Income level	**Not Prepared**	**Somewhat Unprepared**	**Neither**	**Somewhat Prepared**	**Very prepared**	**N**
Under $10,000	21%	16%	6%	33%	24%	63
$10,000-$14,999	25%	15%	2%	44%	15%	48
$15,000-$24,999	18%	13%	4%	44%	22%	101
$25,000-$34,999	8%	16%	9%	47%	20%	91
$35,000-$49,999	20%	16%	10%	32%	22%	106
$50,000-$74,999	15%	12%	4%	43%	26%	154
$75,000-$99,999	16%	9%	7%	38%	30%	113
$100,000-$149,999	14%	14%	3%	45%	24%	112
$150,000-$199,999	13%	11%	2%	46%	28%	46
$200,000 or more	11%	19%	5%	38%	27%	37
$X^2 = 36.2624$			P-Value = 0.456			
Source: Community Resilience Study (2017)						

Table 17. "I was able to get early warning information needed to prepare for the flooding."

Income level	Strongly Agree	Agree	Neither	Somewhat Disagree	Strongly Disagree	N
Under $10,000	32%	29%	5%	16%	18%	38
$10,000-$14,999	58%	8%	8%	8%	19%	26
$15,000-$24,999	44%	15%	2%	14%	25%	59
$25,000-$34,999	35%	17%	9%	19%	20%	54
$35,000-$49,999	42%	9%	5%	18%	25%	55
$50,000-$74,999	45%	17%	0%	17%	22%	83
$75,000-$99,999	42%	30%	5%	8%	16%	64
$100,000- $149,999	32%	18%	12%	8%	29%	65
$150,000- $199,999	22%	30%	0%	11%	37%	27
$200,000 or more	58%	16%	0%	11%	16%	19
$X^2 = 52.1668$				P-Value = 0.040		

Source: Community Resilience Study (2017)

Table 18-A. Percent of Respondents Who Indicated Negative Flood Impacts by Race

Survey Questions	Race	
	White	Black
"Was your residence flooded during any of these severe storms during 2016?"	17%	25%
"Was your work disrupted due to any flooding in 2016?"	30%	33%
"Did this affect your income?"	54%	66%
"Did your home lose power or any other utilities during the flooding in Louisiana last year?"	25%	37%

Source: Community Resilience Study (2017)

Table 18-B. Percent of Respondents Who Indicated Negative Flood Impacts by Education			
	Education		
Survey Questions	**Low**	**Medium**	**High**
"Was your residence flooded during any of these severe storms during 2016?"	32%	21%	13%
"Was your work disrupted due to any flooding in 2016?"	29%	32%	30%
"Did this affect your income?"	74%	66%	40%
"Did your home lose power or any other utilities during the flooding in Louisiana last year?"	32%	30%	27%
Source: Community Resilience Study (2017)			

Table 18-C. Percent of Respondents Who Indicated Negative Flood Impacts by Income			
	Income		
Survey Questions	**Low**	**Medium**	**High**
"Was your residence flooded during any of these severe storms during 2016?"	26%	16%	17%
"Was your work disrupted due to any flooding in 2016?"	27%	34%	33%
"Did this affect your income?"	76%	54%	46%
"Did your home lose power or any other utilities during the flooding in Louisiana last year?"	35%	28%	28%
Source: Community Resilience Study (2017)			

Table 18-D. Percent Of Respondents Who Indicated Negative Flood Impacts By Housing Status			
	Housing Status		
Survey Questions	**Own**	**Rent**	**Other**
"Was your residence flooded during any of these severe storms during 2016?"	16%	24%	29%
"Was your work disrupted due to any flooding in 2016?"	29%	37%	34%
"Did this affect your income?"	55%	64%	63%
"Did your home lose power or any other utilities during the flooding in Louisiana last year?"	26%	37%	35%
Source: Community Resilience Study (2017)			

Appendix D

Stakeholder Discussion Guide

General Section

1. Tell me a little about your organization; what is its major mission; how long have you been operating?
2. Now tell me a little about yourself; how long have you lived in this area; how long have you been working at this organization; what is your principal role; what is your educational background?
3. Tell me what you remember about the 2015 and 2016 Red River floods; did your organization play a role in response or recovery (if so what)?
4. Did your organization work with any others to help in flooding response or recovery efforts; which ones; how would you describe those interactions?
5. What leaders, organizations or agencies did you observe working to help with response and recovery; how would you describe their role and their level of success?
6. What about you personally; were you and your family affected by the flooding; did you deal with government or private agencies to get help; how would you describe that process? Are you concerned about future flooding?
7. Have you ever had flood insurance? Why did you (or not) get flood insurance? What was your experience with the process? Did you receive any assistance to get through the process? If so, with who?
8. What sort of funding/financial aid has been provided to assist with flooding efforts, if any? What was the sources of these funds? What was the purpose of the funding? Describe the process for receiving and accessing the fund?
9. What do you see as the major factors responsible for the flooding?
10. Who do you think has the primary responsibility for flood prevention, response and recovery?
11. Do you think there are specific actions or policies that might have been taken before the flooding to reduce the floods' negative impacts; who do you think should be responsible for those actions or policies?
12. Do you think these actions or policies are likely to be implemented in the future; if not, what barriers to implementation do you see?
13. How would you describe the state of Louisiana's role in flood prevention, response and recovery for this area; how would you describe their performance in this role; is there anything else you think the state of Louisiana might do to help with this regional flooding problem?
14. Who was most affected by the recent floods? Who remains most at risk for future floods?

15. What about the Federal role and responsibilities? How would you describe their performance; is there anything else you think they could do to be more helpful with this area's flooding problems?
16. Could you describe communication between public officials and the community before, during, and after the flood; Do you have any suggestions for improving those communications?
17. Is there any information that I have not asked about, that you think I should know?
18. Do you have any documents, meeting notes, or materials we could use to further our research?
19. Is there anyone else that you think we should get in contact with that can assist us in furthering our research?

Scientist & Engineers

1. How many times has dredging been conducted before? To what magnitude? What were the results? After dredging, what was done with the dredging spoil? Costs?
2. What infrastructure steps have been taken post-flood to further mitigate flooding?
3. What municipal infrastructure (wastewater management, water management, etc) has to be updated to meet the high water mark recommendations? What will this cost?
4. Where does floodwater drain during heavy rains?
5. How did the stormwater drainage system perform during the 2015 and 2016 flood?
6. With the outdated flood maps being an issue for the flood of 2015 and 2016, and federal funding being cut to the NFIP for its Flood Hazard Mapping Program, what is the Parish planning to do to update these maps?
7. How did the stormwater drainage system perform during the 2015 and 2016 flood?
8. Shreveport Metropolitan Planning Commission of Caddo Parish released a 2030 Master Plan that was adopted in 2010. In this master plan, there were suggestions to mitigate flooding such as protecting wetlands, implement reliable stormwater management and drainage systems, implement land use and landscape regulations, promote preservation of natural drainage, use permeable surface construction, build "green streets," etc. Has there been momentum to implement any of these suggestions? What action has been taken in regard to flooding mitigation? If no, why not?

EM & Risk Management

1. What are the strategies for your agency _____ in relation to flooding?
    a. Mitigation, Protection, prevention, response, and recovery
    b. What is the evacuation plan? Shelters?
    c. Do you conduct any flood trainings or exercises?
    d. Do you conduct any flooding awareness outreach?
2. Do you have process for helping people with the National Flood Insurance Program?
    a. If so, what is that process?
    b. What are your experiences dealing with the NFIP?
    c. How successful is this process?
3. Do you have a framework for evaluating emergencies?
4. Tell me your own emergency management program plan?

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