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Stranded Residents in Berkley and Williamsburg, SC, 2015
Photo by U.S. Coast Guard/Stephen Lehmann

Columbia, SC, 2015
Photo by Aon Benfield Impact Forecasting/Matt Schmitt & Steve Bowen

# EXECUTIVE SUMMARY

Saturday, October 3, 2015 was drizzly and wet in Columbia, SC. Many residents went to bed thinking the forecast for intense rainfall and flash flooding was wrong. Fortunately, emergency personnel remained on alert. Less than 24 hours later the city was awash, and first responders and residents alike were in motion working to secure lives, safety and physical assets in the midst of an unexpected and rapidly changing risk landscape.

In Charleston, SC – a city subject to far more regular flooding – schools were closed in anticipation on Friday, October 2, and residents prepared. Nonetheless, the combination of record rainfall and extreme tides resulted in unanticipated flooding. Emergency personnel, already on alert and well practiced in flood response, responded quickly.

The October 2015 torrential rainfall and flooding in South Carolina is the story of one storm, but very different floods. This study, by ISET-International, a non-profit organization committed to building resilience and catalyzing adaptation to critical social and environmental challenges, and Zurich Insurance Group, the global insurer, looks in detail at the Columbia and Charleston floods. Based on interviews with impacted households and people involved in risk reduction, response and recovery at the city, county, state and federal level, the study identifies lessons learned from the floods and provides recommendations for enhancing flood resilience. We believe that these insights and learnings can be applied not just in Charleston and Columbia, but across the US and globally.

# RESILIENCE LESSONS FROM THE FLOOD

## RISK REDUCTION

We need to foster a cultural shift where people seek out information on their risks and where government agencies make that information readily available. At the same time, we need to recognize that built infrastructure and planned development are and will continue to alter the risk landscape. Future floods will bring new surprises, and we need to find ways to plan for this uncertainty. This should include:

(1) placing major assets (critical infrastructure, houses) outside of known floodways and flood-prone areas;

(2) using buy-out funds to remove high risk properties from the stock;

(3) including design elements such as safe failure to ensure that failures do not have cascading impacts and/or are not catastrophic;

(4) using green infrastructure to reduce flood risk; and

(5) incentivizing meaningful risk reduction, not just insurance rate reduction.

## RESPONSE

As technology changes, people are both increasingly connected and increasingly expectant of immediate, detailed information. We need to both leverage the opportunity provided by technology, by strengthening early warning systems and making the warnings themselves more relevant and actionable, while at the same time, communicating the limits of our knowledge and the places where individuals need to be prepared, informed, and use their best judgment. Absolute predictive accuracy with extreme events is impossible. The public needs to understand these gaps, be prepared to respond to the unknown, and know how to act in the context of the information that has been provided.

We can further support people to act by developing disaster response in ways that allow people to leverage their social capital. All too often in post-disaster environments, those impacted are seen as victims in need of help. This response has two significant disadvantages: it disempowers those impacted and it places an unnecessary burden on responders to "rescue" people that may not need rescuing. We also often see that help as needing to come from established sources—emergency responders, the city, and the state. We need to change our mindset, and instead focus on helping people leverage their capacities and resources on their own behalf and on behalf of others.

## RECOVERY

As a society, we have become good at risk reduction and response. We need to get better at planning for recovery. In South Carolina and globally, conceptualizing what long-term recovery should look like and coordinating it has been a major challenge. Governments and non-profit organizations involved in disaster risk management need to ask themselves: based on previous experiences, what does long-term recovery entail and what can we do now before the next disaster, to ensure that recovery processes can begin sooner and that engagement around recovery can continue over the long-term? Individuals need to understand what private insurance, government and non-profit support will provide. Residents need greater support in understanding their options for addressing gaps.

There is no doubt that the floods in both the Columbia and Charleston metro areas were extreme events. However, they are similar to past events in South Carolina, and current temperature, precipitation, and sea level trends suggests they will continue and may get worse.

These events should be a call to action, engaging cities nationwide to rethink their risk landscape and how they continue to modify it, regardless of whether or not they have faced floods in recent years. These events should also push the nation as a whole to rethink what it means to recover from a disaster and how to leverage the recovery phase as an opportunity to build resilience.

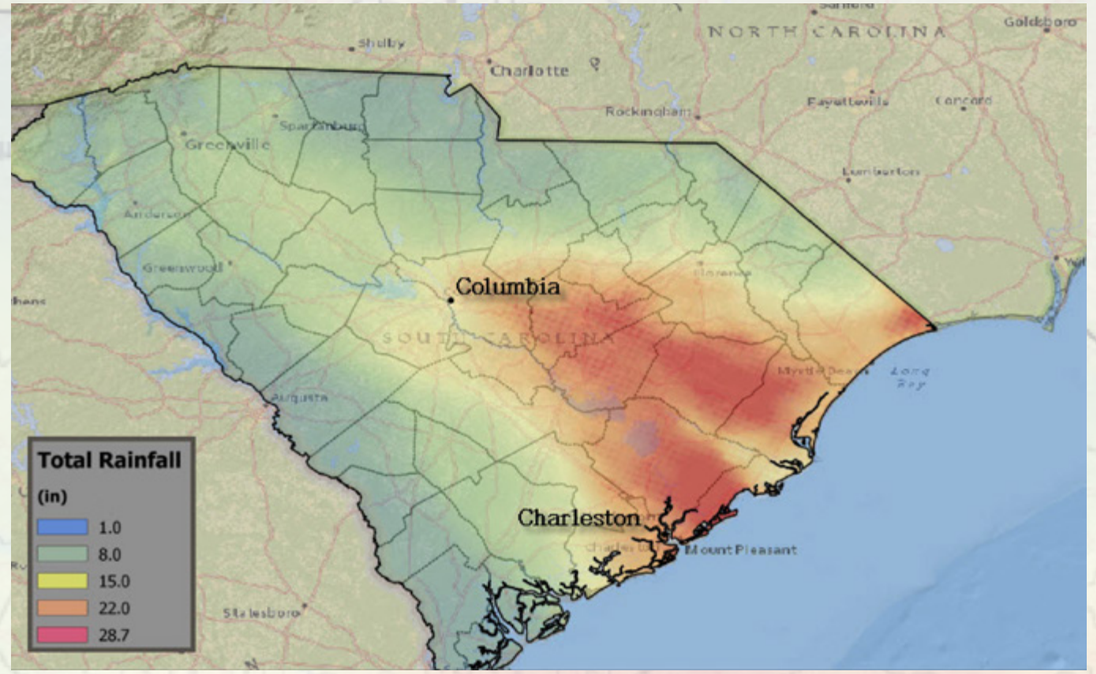
# Contents



As part of Zurich's flood resilience program, the post event review capability (PERC) provides research and independent reviews of large flood events. It seeks to answer questions related to aspects of flood resilience, flood risk management and catastrophe intervention. It looks at what has worked well (identifying best practice) and opportunities for further improvements.

This PERC analysis was written by ISET-International and Zurich. It uses a combination of two complementary conceptual frameworks: the ISET Climate Resilience Framework (http://training.i-s-e-t.org) and the Zurich flood resilience alliance framework (http://www.zurich.com/en/corporate-responsibility/flood-resilience).

**FIGURE 1:**
MAP OF SOUTH CAROLINA, SHOWING COUNTY BOUNDARIES, THE LOCATIONS OF COLUMBIA AND CHARLESTON, AND THE TOTAL STORM RAINFALL IN INCHES (OCTOBER 1 - 5, 2015)




*Notes: Figure from Aon Benfield Impact Forecasting

# INTRODUCTION

From October 1 through October 5, 2015, historic rainfall fell in the Carolinas, resulting in flooding and flash flooding, dam failures, and bridge and road closures. The worst effects were concentrated in South Carolina, where 22 counties were declared federal disaster areas (O'Conner, 2015a). Statewide, there were at least 19 deaths, thousands of damaged structures, and billions in losses, an event comparable to Hurricane Hugo in 1989 (O'Conner, 2015b).

This study focuses on the flooding and flood impacts in the Columbia and Charleston metro areas. While the floods heavily impacted rural areas in Georgetown and Sumter counties, we focus on the Columbia and Charleston metro areas for two reasons. First, both areas are expected to grow dramatically in the coming decades, with growth rates near 2 percent per year (Tippett, 2015). This population growth, in combination with increasing risk of disaster will exacerbate exposure. Second, the October 2015 storm unfolded very differently in these two locations, and highlights differences in the response and recovery process in the two areas.

The case studies in this post-event review:

(1) deconstruct why the floods manifested in the way they did and became a disaster;

(2) highlight how one event can cause dramatically different types of flooding and impacts across cities in one state;

(3) explore successes and challenges experienced in response and recovery; and

(4) identify avenues and opportunities for building resilience. While these floods provide lessons for Columbia and the Charleston areas, we believe that these lessons can also be applied to a variety of contexts within and outside of South Carolina.

The information presented in this report was collected via:

(1) interviews with individuals from key governmental agencies and departments, faith-based groups, non-profits, for-profits, and academic institutions involved in disaster risk management;

(2) interviews with flood-impacted households; and

(3) review of secondary literature such as newspaper articles, reports, and peer-review papers.

# ONE STORM, TWO FLOODS

Columbia, SC, 2015
Photo by Aon Benfield Impact Forecasting/Matt Schmitt & Steve Bowen

## The Physical Event

Hurricane Joaquin began as a tropical depression on September 28, 2015, well southwest of Bermuda. With rapid intensification, it reached Category 3 status on October 1 and almost reached Category 5 on October 3. Although it never made landfall in the United States, the hurricane interacted with a large low pressure system over the south-eastern states, battering them with record-breaking rainfall that persisted for almost three days and resulted in severe flooding (Halverson, 2015). Soils saturated from earlier rains and swollen stream channels were unable to contain the volume of water unleashed by the unusual weather.

Rainfalls surpassed historic records in both the Columbia and Charleston areas (Table 1). The rains began in the region on Thursday, October 1 and extended through Tuesday, October 6, with the greatest volume falling between Saturday evening, October 3, and the following morning (National Weather Service hourly precipitation data, www.ncdc.noaa.gov/cdo-web/). Heavy rainfalls led to flooding in many parts of the state (Table 1).

Charleston commonly floods. The Charleston metro area lies within an estuarine delta located at the midpoint of the South Carolina coast on Charleston Harbor, an inlet of the Atlantic Ocean formed by the confluence of the Ashley and Cooper rivers.

**TABLE 1:**
STORM TOTAL RAINFALL, OCTOBER 1-5, 2015, IN VARIOUS LOCATIONS ACROSS SOUTH CAROLINA

| Location | Storm Total Rainfall | Location | Storm Total Rainfall |
|---|---|---|---|
| Charleston downtown | 16.02” | Gills Creek | 21.49” |
| Charleston Airport, North Charleston | 17.29” | John’s Island | 18.79” |
| Columbia Metro Airport | 11.44” | Mount Pleasant | 26.88” |
| Georgetown | 23.88” | Sumter | 20.77” |

*Source: National Weather Service

Topography is flat and drainage has been an issue since Charleston was first founded in 1670. Documented sea level rise – a foot in the past century – is exacerbating drainage issues (City of Charleston personal communication). Flooding during the October 2015 event was caused by intense rainfall coupled with extremely high tides. Most of the flooding was in familiar patterns and places, allowing for a coordinated and effective response. A secondary round of riverine flooding was experienced several days later as flood peaks from the rains inland made their way to the coast.

While parts of Columbia flood regularly, the city as a whole has not experienced severe floods in many years. Columbia is located at the break between the Southern Piedmont, or foothills, and the Coastal Plain, equidistant between the Blue Ridge Mountains and the Atlantic Coast. The Southern Piedmont has gentle to moderately steep slopes dissected by numerous, branching streams. Intense rainfall led to flash flooding Saturday night, October 3, and into Sunday morning, October 4. Flooding was exacerbated in many areas by dam failures and emergency dam releases. Lacking practiced flood responses and faced with unexpected conditions, impacts were high and responses were improvised by necessity.

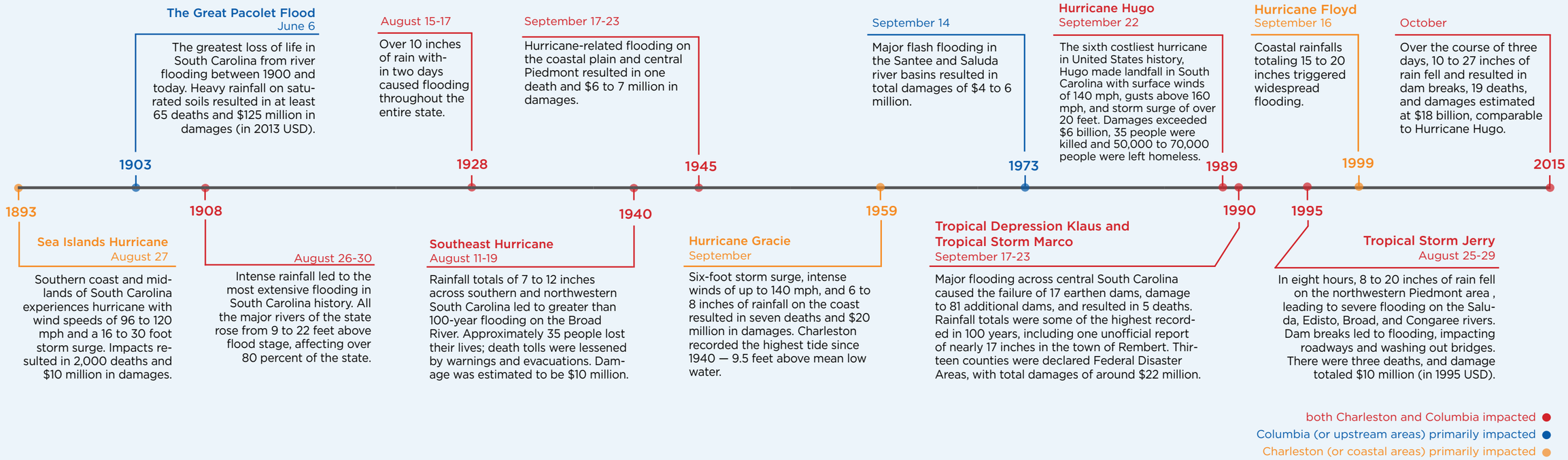
Throughout both cities and surrounding areas, there was significant inundation of residential property, public infrastructure, and farmland. The floods caused at least 75 dam failures and over 540 bridge and road closures, including a 74-mile stretch of Interstate 95 (Baynes & Tyndall, 2016; Collins, 2015; Schafer, 2016). Nineteen people were killed. In the immediate aftermath, many businesses in the region experienced a four to six week period of major disruption (McDermott, 2015). Homes and structures across the state suffered profound losses; statewide, there were over 159,000 damaged structures. To date, approximately $452 million has been paid out by the federal government across South Carolina for Individual Assistance, Small Business Administration (SBA) and National Flood Insurance program (NFIP) payouts. Estimated storm losses range from $1.2 billion to $18 billion; the State has estimated losses at $1.5 billion. These estimates vary greatly as different models use different methodologies, exposures, and parameters to measure losses. Higher estimates are likely to include secondary and tertiary losses as well.

**TABLE 2:**
STORM DAMAGE BY COUNTY FOR COLUMBIA AND CHARLESTON METRO AREA COUNTIES. DATA FROM (O'CONNOR, 2015).

| | Richland County | Lexington County | Dorchester County | Berkley County | Charleston County |
|---|---|---|---|---|---|
| Total Damages | $3.2 billion | $2.1 billion | $1.9 billion | $1.4 billion | $507.5 million |
| Total Number of Damaged Structures | 21,212 | 18,114 | 14,977 | 15,137 | 3,667 |

*Notes: Data from (O'Connor, 2015)

# Historical South Carolina Flood Events



# The Policy Context

*“The policy landscape for managing disasters differs significantly from county-to-county and city-to-city.*

South Carolina is a “Home Rule” state; municipalities and counties may create their own laws and policies provided they follow the state and federal constitutions. Such decentralization allows municipalities and counties substantial autonomy in governance. Cities and counties decide which issues they will address and how they will address them. As a result, the policy landscape for managing disasters differs significantly from county-to-county and city-to-city.

The Columbia and Charleston metro areas cross several counties, which creates administrative and governance challenges. Columbia is located in Richland and Lexington counties; North Charleston is located in Berkeley, Charleston, and Dorchester counties; and Charleston is located in Charleston and Berkeley counties. To increase cross-jurisdictional coordination, multi-county-and-city government systems have been created and are known as the Council of Governments (CoG). Charleston and North Charleston are served by the Berkeley-Charleston-Dorchester CoG, which has 30 member governments, and Columbia is served by the Central Midlands CoG, which has 14 member governments. The CoGs provide local and regional planning services and technical assistance to their member governments.

Cities and counties rely on the state to:

(1) provide state-level services and resources;

(2) distribute federal funds for disaster mitigation, response and recovery;

(3) administer the National Flood Insurance Program; and

(4) advise when needed.

The South Carolina Emergency Management Division (SCEMD), for example, can only become involved in a disaster if a County Emergency Management Division (EMD) requests their involvement. The SCEMD’s role during a disaster is to provide counties with the resources they request, not to coordinate local response. The state has some regulatory authority, but their ability to regulate is constrained by limited resources.

The federal government’s disaster management role includes:

(1) providing some federal regulation;

(2) aiding in response;

(3) supporting recovery through financial resources, technical support and capacity building; and

(4) incentivizing disaster risk reduction.

In the event of a disaster that overwhelms the resources of local and state authorities, the state governor can declare a state of emergency and formally request from the president that the federal government respond to the disaster. In such a presidentially declared disaster, the Federal Emergency Management Agency (FEMA) will move personnel on-site to support response and recovery efforts. Response and recovery funding comes from the president’s Disaster Relief Fund, managed by FEMA, and disaster aid programs of other participating federal agencies.

There are five major categories of federal disaster recovery funding:

- **Individual Assistance** grants are FEMA grants of up to $33,000 per household to cover temporary housing, repairs, and replacement of assets. The SBA also provides low-interest loans.
- **National Flood Insurance Program (NFIP)** provides payouts to impacted homeowners and businesses that purchase policies. Policy payouts are capped at $250,000 of dwelling coverage plus $100,000 for damage to personal property. Commercial entities can receive up to $500,000.
- **Public Assistance** is FEMA aid to state or local governments to rebuild damaged infrastructure. Public assistance pays for 75 percent of approved project costs. Approved projects generally only consider building back, not building back more resiliently.
- **Community Development Block Grant Disaster Recovery Program (CDBG-DR)** are flexible grants allocated by the Department of Housing and Urban Development (HUD) to cities, counties and states to support recovery from presidentially declared disasters, especially in low-income areas. This funding is released through supplemental appropriations by Congress.
- **Hazard Mitigation Grant Program** are FEMA grants awarded to reduce the potential for future disasters. Funding is limited to 15 percent of the total disaster spending by FEMA for that particular disaster.

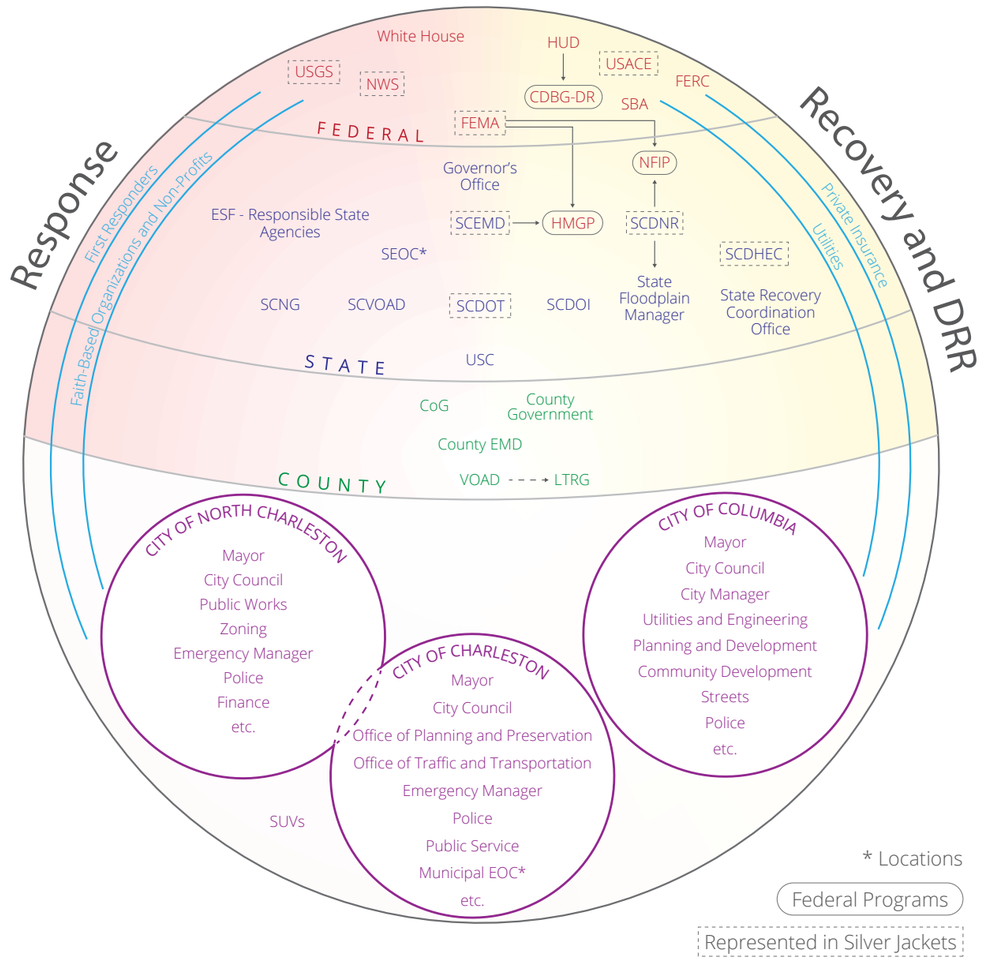
Columbia, SC, 2015
Photo by Aon Benfield Impact Forecasting/Matt Schmitt & Steve Bowen

*Navigating the different scales of regulation and ensuring that they operate in ways that complement each other and reflect local needs is a challenge.*

Navigating the different scales of regulation and ensuring that they operate in ways that complement each other and reflect local needs is a challenge. Programs such as the Silver Jackets are helping with collaboration and communication across scales in disaster risk management. The Silver Jackets are an intergovernmental group tasked with increasing coordination and efficiency between state and federal government agencies. Their involvement catalyzes and facilitates the development of comprehensive and sustainable solutions for flood and coastal risk management and flood hazard issues, including mitigation planning, flood hazard mapping, risk reduction activities, and response and recovery planning. The team includes representatives from the U.S. Army Corps of Engineers (USACE), FEMA, the U.S. Geological Survey (USGS), the National Oceanic and Atmospheric Administration (NOAA), the U.S. Department of Agriculture (USDA), the Natural Resources Conservation Service (NRCS), the State of South Carolina Department of Natural Resources (SCDNR), the South Carolina Department of Health and Environmental Control (SCDHEC), the South Carolina Department of Transportation (SCDOT), and SCEMD.

This section describes the formal disaster management system; there are also a host of other non-profit, civil society and private players that are active in the disaster management system. These entities include humanitarian aid groups and chapters of Voluntary Organizations Active in Disasters (VOAD) that are heavily involved in disaster response and recovery. There are also riverkeepers and waterkeepers that monitor water quality and advocate for better water policy, and organizations that work to protect and conserve watersheds. Civil society groups that create communities, and organizations that engage in disaster risk management, resilience, and poverty reduction are also involved, including policy advocacy groups. In addition, insurance firms, risk modelers, researchers, and risk mitigation advocates play a role in the disaster management system.

**FIGURE 2:**
STAKEHOLDERS ACTIVE IN DISASTER RISK REDUCTION, RESPONSE AND RECOVERY AT THE CITY, COUNTY, STATE AND FEDERAL LEVEL




**City Government:** government at the city-level, with several departments involved in disaster risk management.

**Community Development Block Grant Disaster Program (CDBG-DR):** administered by HUD, provides funding for recovery from federally declared disasters.

**Council of Governments (CoG):** regional governing and coordinating bodies.

**County Government:** governing body at the county-level, with several departments involved in disaster risk management.

**Department of Insurance (DOI):** regulates insurance industry.

**Emergency Manager:** responsible for building and maintaining relationships with and between disaster risk management. Typical at the state and COG or county level; in Charleston and North Charleston, also at the city level.

**Emergency Operations Center (EOC):** during activation, the space in which all relevant agencies sit to coordinate disaster response. Functions at the county and state levels; in Charleston, also at the city level.

**Emergency Support Function (ESF):** grouping of critical capabilities into an organizational structure to coordinate response and early recovery. There are 17 ESFs. Each ESF is led by a state agency.

**Faith-based Organizations and Non-profits:** exist at multiple scales and provide a wide variety of primarily volunteer services for disaster risk management.

**Federal Energy Regulatory Commission (FERC):** regulates interstate electricity sales, wholesale electric rates, etc. License and regulate major hydroelectric facilities.

**Federal Emergency Management Agency (FEMA):** coordinates responses to federally-declared disasters.

**First Responders:** anyone trained to respond to an emergency. Includes firefighters, paramedics, police, in-state and out-of-state emergency response teams.

**Governor's Office:** requests a federal disaster declaration, submits and allocates the executive budget, and ensures that state laws are enforced.

**Hazard Mitigation Grant Program (HMGP):** provides funding to implement hazard mitigation measures following a federally-declared disaster.

**Long-term Recovery Group (LTRG):** multi-agency coalition tasked with assessing unmet needs, seeking financial and in-kind resources and determining priorities for funding recovery efforts.

**National Flood Insurance Program (NFIP):** administered by FEMA, provides flood insurance.

**National Weather Service (NWS):** produces weather forecasts for a spectrum of stakeholders.

**Private Insurance:** exists at multiple scales; provides different types of insurance to a variety of customers.

**State Floodplain Manager:** promotes effective management of floodplain resources and flood mitigation.

**Small Business Administration (SBA):** provides support to small businesses. Disaster Loan Program provides homeowners and renters with low-interest loans to support rebuilding efforts.

**South Carolina Department of Health and Environmental Control (SCDHEC):** is responsible for regulating public health and natural resources; inspects and regulates dams.

**South Carolina Department of Natural Resources (SCDNR):** provides scientific information about natural resources and the environment, manages natural resource-related activities, produces flood maps, administers the NFIP.

**South Carolina Department of Transportation (SCDOT):** constructs and maintains state transportation infrastructure, provides traffic control and information about road closures, detours, etc.

**South Carolina Emergency Management Division (SCEMD):** leads the state's emergency management program, responsible for mitigation, preparedness, response and recovery from disasters. County EMD are the county-level counterparts.

**South Carolina National Guard (SCNG):** provides support during emergency response, e.g. distribution of relief, search and rescue, etc.

**South Carolina Silver Jackets:** inter-agency team to increase coordination between state and federal agencies in developing risk management solutions.

**Spontaneous Unaffiliated Volunteers (SUVs):** Volunteers unaffiliated with formal disaster management agencies that emerge in the immediate aftermath of a disaster.

**State Recovery Coordination Office:** established following the 2015 floods; working with USC to prioritize community long-term recovery.

**University of South Carolina (USC):** provides advisory services and research on disaster risk management, primarily through the Hazards and Vulnerability Research Institute.

**US Army Corps of Engineers (USACE):** federal engineering, design, and construction management agency focused on major dams, canals, and flood protection.

**US Department of Housing and Urban Development (HUD):** responsible for housing policy and community development that supports the most vulnerable.

**US Geological Survey (USGS):** collects and provides data about hydrologic and natural hazards.

**Utilities:** provide services at a variety of scales and are managed either by government or privately.

**Voluntary Organizations Active in Disaster (VOAD):** multi-agency coalition for coordinating service delivery, sharing knowledge and resources for managing disaster risk. Operate at the state, COG and county levels.

**White House:** the President, by request of a State Governor, can designate a disaster as a federally declared disaster, allowing the State to receive federal support for response and recovery.

# CASE STUDY I
# Columbia Flooding

Columbia, SC, 2015
Photo by Aon Benfield Impact Forecasting/Matt Schmitt & Steve Bowen

## The Physical Context

Columbia, the capital and largest city in South Carolina, lies within Richland and Lexington Counties. Columbia enjoys a diversified economy. Major employers include government, healthcare, higher education and the U.S. military. Columbia is prone to a spectrum of hazards including earthquakes, winter storms and ice storms, tropical cyclones, tornadoes, and droughts. While flooding has been rare in recent decades, Columbia does have a long history of flooding caused by tropical cyclones.

Columbia is located at the confluence of the Broad and Saluda rivers; the rivers converge to form the Congaree River that flows south and east through Columbia and onto the coastal plain. The Broad River is largely free-flowing; the Saluda River is controlled by the Saluda Dam that forms Lake Murray. The Saluda Dam, located about 10 miles west of downtown Columbia, is operated for flood control and hydroelectric power generation. Multiple small watersheds flow into the Broad, Saluda and Congaree rivers. Originally agricultural, conversion has left these watersheds dotted with small, dammed ponds. Many of the ponds, designed for agricultural use, are now located in heavily developed areas.

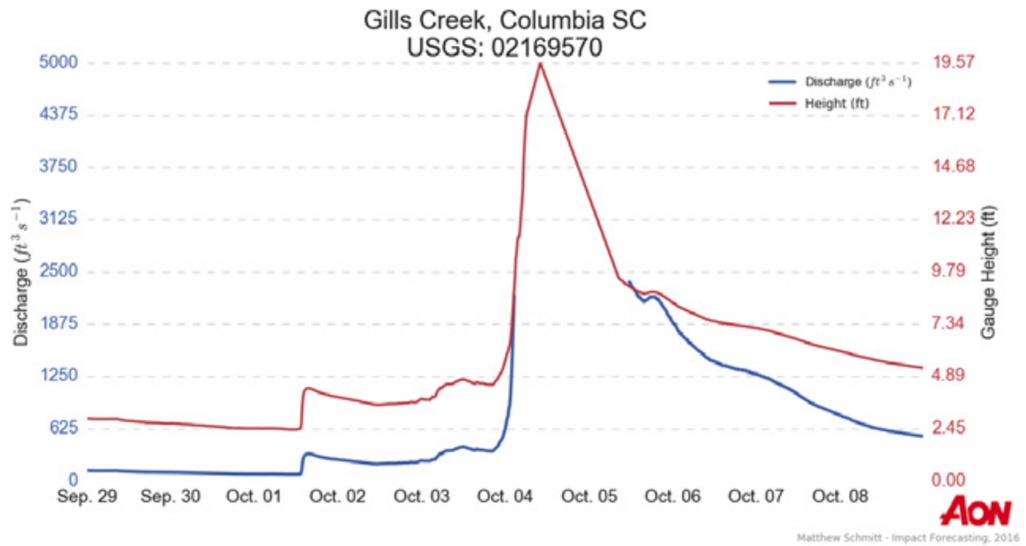
The heaviest rain in Columbia occurred from late Saturday night, October 3, through early Sunday morning, October 4. Columbia Metro Airport set a new record for both the greatest one and two day rainfall totals (see table below). Storm total rainfall for the Columbia Airport was 11.44 inches.

**TABLE 3:**
MAXIMUM 1-DAY, 2-DAY AND STORM TOTAL RAINFALL AT COLUMBIA METROPOLITAN AIRPORT

| Location | 1-day rainfall | 2-day rainfall | Storm total (Oct 1-5) |
|---|---|---|---|
| Columbia Metropolitan Airport | 6.87” | 10.44” | 11.44” |
| Previous record for this location | 5.79” | 7.69” | |

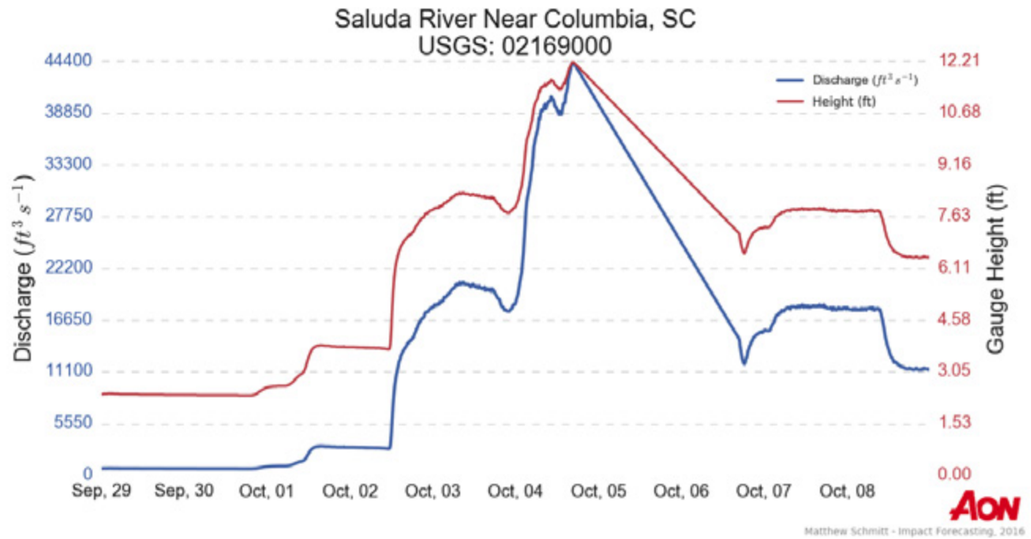
*Source: National Weather Service, Record of Climatological Observations

**FIGURE 3:**
GILLS CREEK HYDROGRAPH




*Notes:
- Data: USGS, including reconstructed peak on October 4;
- Graphic: Aon Benfield Impact Forecasting

**FIGURE 4:**
SALUDA RIVER HYDROGRAPH JUST BELOW THE SALUDA DAM




*Notes:
- Data: USGS;
- Graphic: Aon Benfield Impact Forecasting

The Gills Creek Watershed in eastern Columbia experienced the most rainfall in the Columbia area, totaling 21.49 inches. Gills Creek crested at an estimated 19.6 feet on October 4 as shown in Figure 3; the previous record was 8.66 feet (Feaster et al., 2015). Failure of several small dams in the watershed contributed to the flooding and flood impacts.

NOAA identified this event as a 1,000-year rainfall event (Voiland, 2015). However, this did not lead to 1,000-year flooding at any gauged locations, though stream gauges did record new record flows at 17 locations (Feaster et al, 2015). Most USGS gauges documented peak flows within the 10-year flood range, with a few gauges indicating 25-year and 50-year flood events. Within Gills Creek, flows have been reconstructed as a 1-in-500 year event[1] (Figure 3; Musser et al., 2016).

Flood flows also resulted from emergency dam spills. Figure 4 clearly shows increased releases beginning October 2 and the opening of the spill gates on October 4. Maximum discharge during normal operations of the dam is less than 1,000 $ft^3/s$; peak discharges tend to be around 12,000 $ft^3/s$. During the spill, discharge was nearly 44,400 $ft^3/s$.

1 USGS does not calculate above a 1-in-500 year event as there is insufficient data to characterize events more rare than 1-in-500 year events.

Columbia, SC, 2015
Photo by Aon Benfield Impact Forecasting/Matt Schmitt & Steve Bowen

BOX 1.

## A 100-YEAR FLOOD, THE 100-YEAR FLOODPLAIN

In 1973, the United States government decided to use the "100-year flood" as the basis for the National Flood Insurance Program. A 100-year flood is a term used to describe a flow event for which there is a calculated 1 percent chance of occurrence in any given year. This was thought to be a fair balance between protecting the public and overly stringent regulation. Since the 100-year standard was adopted, it has become quite universally used to describe a reasonable flood protection level.

The flow level required to produce a 100-year flood is statistically determined using past flow data. The "recurrence interval," such as the 1 percent chance each year of experiencing a 100-year event is based on the probability that that event will be equaled or exceeded in any given year (water.usgs.gov/edu/100yearflood.html). The "100-year flood" is therefore a mathematical estimate of the long-term average recurrence interval for a flood of this magnitude; it does not mean that once we have a 100-year flood we will not have another for the next 100 years. Floods happen irregularly, and 100-year floods can happen two years in a row, like in Houston, Texas in 2015 and 2016.

The 100-year floodplain is a term used to describe the area that would be flooded by a 1-in-100-year flood event. Typically, the 100-year floodplain is determined through computer modeling. In many areas this modeling can be validated through comparison with recent flood events.

So what if your home is in the 100-year floodplain? Over the course of a 30-year mortgage, this is the flood risk you could be exposed to:

- The 25-year flood zone gives you a 71 percent chance of being flooded
- The 50-year flood zone gives you a 45 percent chance of being flooded
- **The 100-year flood zone gives you a 26 percent chance of being flooded**
- The 500-year flood zone gives you a 6 percent chance of being flooded

When you look at the 100-year flood zone in this way, you have at least a one in four chance of experiencing flood damage during your 30-year mortgage, and depending where you are in the floodplain, possibly much higher. Many times, homes are badly flooded by what is eventually rated as a 25- or 50-year event. People often say that their property has not flooded in 100 years so there is no way it is in a 100-year flood zone. Unfortunately, they are wrong; they have just been lucky.

However, any discussion of the 100-year floodplain must include a strong caveat – just because you are not in the 100-year or 500-year floodplain, does not mean you will not experience a flood. People outside of mapped high-risk flood areas file over 20 percent of all National Flood Insurance Program claims. "Everyone lives in a flood zone." (www.floodsmart.gov)

# VULNERABILITY

*“Historical settlement patterns have helped shape the vulnerability landscape in Columbia.*

## Vulnerability in the Built Environment

Columbia is located on the fall line of the Congaree River. It is the furthest inland point on the Congaree that is navigable, and to the west, steep rivers provided the power for mills. This location allowed Columbia to develop as a trade center, both for surrounding areas and for the extensive agriculture that developed locally, particularly of cotton and rice, and associated textile manufacturing. Small agricultural ponds were built throughout the region for water supply and to power small mills.

At the end of the Civil War in the late 1860s, large numbers of freed slaves settled onto vacant lands, most of which were marginal and flood-prone. These settlement patterns helped shape the vulnerability landscape in Columbia. Today, there are pockets of elevated social vulnerability[2] in the southern portion of Richland County, in Columbia around the urban core, in parts of the Gills Creek Watershed, and across the river in West Columbia[3]. For these residents – primarily lower-income groups, students, and renters – recovering from financial impacts of any sort is challenging. Many are on fixed incomes and/or lack the resource base to quickly rebuild homes, find new rental space or replace critical possessions. They rely heavily on federal and state safety nets and on their social networks in disasters.

2 Social vulnerability refers to the inability of individuals to withstand the impacts of shocks and stresses, and it reduces the ability of individuals to prepare for, adapt to, respond to, and recover from hazards. Critical factors that influence social vulnerability include: (1) access to resources (liquid assets, knowledge, information), (2) access to decision-makers, (3) cultural and legal norms, (4) access to critical infrastructural services (electricity, water, transportation, communications, shelter), and (5) individual strength (as determined by age, health, etc.) (Cutter et al, 2000; Mustafa et al, 2011).

3 http://www.scemd.org/files/Mitigation/State_Hazard_Mitigation_Plan/5_Appendix_C_Part2_Local%20Hazard%20Risk%20Assessments.pdf



*“There is substantial risk posed by the small lakes and dams that dot the South Carolina landscape, particularly those in urban areas.*

The suburbs to the northeast, northwest, and southeast of the city are less socially vulnerable. Lakefront property in these areas is particularly high in value. Though these lakes come with an associated flood risk, many of the individuals and families owning lakefront homes have the resource base needed to quickly recover from floods.

The Gills Creek Watershed, which covers a 75 square mile area in the southwest corner of Columbia, is an example of mixed-income and higher-end housing. Urban development began in the 1960s and the watershed is now highly urbanized. There are about 100 lakes in the watershed — most of which are legacies from a more agricultural past. These lakes were created by damming the small tributaries that extend throughout the watershed. Most of the lakes are private, with the larger lakes owned and operated by homeowners associations; almost all of the dams forming these lakes are unregulated by the state.

The maintenance and operation of these private dams is problematic. Some homeowners associations actively maintain their dams and operate spillways, others do not. Neighborhoods and businesses below the dams have no control over dam releases or any say in how the dams are managed and dam owners have no control over downstream development. In some cases, maintenance issues arise where roads are constructed across private dams by the state; it is unclear who is responsible for what, and the dams often go unmaintained.

While the state is responsible for performing routine inspections of high-hazard and significant-hazard dams, and conducting classification checks for low-hazard dams, a lack of resources has made it difficult to carry out the volume of inspections and checks needed. South Carolina oversees the safety of 2,400 regulated dams – dams that reach a specific height or hold a certain amount of water. Federal agencies oversee a handful of major dams, such as at Lake Murray, as well as those on the Army’s Fort Jackson training base. There are an estimated 10,000 to 20,000 additional dams in the state (S.C. Emergency Management Division estimate) that are not regulated by government dam safety programs. The lack of capacity to review the classification of these unregulated dams, many of which were built before development began downstream, means large numbers of dams are still classified as ‘low-risk’ even though they now pose significant risk. In the few cases where dams have been reclassified as ‘high-risk’ due to downstream development, there have been financial implications for dam owners for changes beyond their control.

## Perceptions of Risk

Flood risk awareness in Columbia is low. FEMA floodplain maps should help inform people of their risk. However, very few people in the United States check the maps, particularly those outside designated floodplains. The few that do are often unaware of subsequent changes; there is little

**TABLE 4:**
NATIONAL FLOOD INSURANCE POLICIES IN CHARLESTON, LEXINGTON AND RICHLAND COUNTIES

| County | NFIP Policies | Total Premiums Paid Annually | Insured Value |
|---|---|---|---|
| Charleston | 45,522 | $33,232,804 | $12,768,664,000 |
| Lexington | 2,439 | $1,748,371 | $527,487,700 |
| Richland | 1,724 | $1,293,332 | $404,527,000 |

*Notes: Data from Aon Benfield Impact Forecasting

outreach to communicate updates to the flood maps that reclassify homes as higher risk. Indeed, many homeowners consider the designation of the 100-year floodplain as a government imposed penalty that should be avoided, if possible, rather than useful information about risk, coupled with a government program to help mitigate that risk.

In addition to the mapped floodplain, there is substantial risk posed by the small lakes and dams that dot the South Carolina landscape, particularly those in urban areas.[4] However, there has been little evaluation of the potential flooding that dam failures would cause, and downstream residents are largely unaware of the risks the dams pose. There have been attempts to increase risk awareness for those downstream of major dams; for example, dam managers for dams such as the Saluda Dam mail information to homeowners in the floodway about flood risk, annually.

## Disaster Risk Reduction

Households have the option of reducing the financial risk of floods through insurance. In general, private insurance does not cover flood losses or damage with the exception of car insurance. NFIP is usually the only flood insurance option available to property owners.

Flood insurance is mandatory for households that hold a federally backed mortgage, are located in the 100-year floodplain, and live in an NFIP participating community. Communities are not officially required to participate in NFIP. For a community to join the NFIP program, they must adopt and enforce a flood ordinance that meets or exceeds FEMA requirements to reduce the risk of flooding. In non-NFIP communities, lending institutions must consider the risks of making loans on properties within the flood hazard area given that flood protection is limited; it is sometime impossible to obtain conventional mortgages on such properties.

In South Carolina, about 72 percent (August 2015 estimate) of those mandated to purchase flood insurance are enrolled in NFIP (Brady, 2015); many others within the floodplain who are not mandated to hold insurance choose not to. The number of NFIP policies reflects neither the number of homes in the floodplain (Table 4), nor the extent to which homes are protected. Structures situated just outside of the 100-year floodplain boundary, or in areas where the risk has been displaced by the construction of levees, are technically considered not at risk. However, flood damage outside the 100-year floodplain now accounts for 30 to 47 percent of all flood-related losses (Highfield et al., 2013).

The majority of NFIP policies in South Carolina are held in coastal areas. Only about 1,700 households in Richland County and 2,400 households in Lexington County carry flood insurance. Many within the 100-year floodplain choose not to purchase insurance if they are not required to, primarily due to a combination of risk awareness, perceived risk, and cost. Flood insurance costs for those within the 100-year floodplain are significant, and may be prohibitively expensive for those lower on the socio-economic spectrum.

At a county level, there have been efforts to limit further development along the floodplain. Box 2 recounts one such successful example.

## Preparedness

At the city and county levels, preparedness initiatives in Columbia primarily focus on earthquake and hurricane risk; Columbia does not have a flood emergency plan. Since Hurricane Hugo in 1989, the hazard events in Columbia that have required mobilizing a large response have primarily been ice storms.

At the state level, the disaster preparedness focus has been on building networks and capacity. Within the government, as part of the state's preparedness training, the EMD runs regular multi-departmental trainings and exercises. Recent exercises that have been conducted with federal participants have helped develop strong partnerships with federal agencies and an understanding of federal processes, which is critical in responding to and recovering from a federally declared disaster.

**BOX 2.**
**PREVENTING DEVELOPMENT IN THE FLOODPLAIN: THE GREEN DIAMOND CASE**

In 1999, developers Burroughs & Chapin purchased 4,500 acres of Congaree River floodplain southeast of downtown Columbia. The land lies at the bottom of the Gills Creek watershed next to the Columbia sewage plant. The developers planned to build an entire community there: houses, shopping complexes, golf courses, hotels and nature areas.

In the early 2000s FEMA redrew the floodplain maps in Richland County and determined that 70 percent of the property was within a floodplain, making any major development impossible. Burroughs & Chapin sued Richland County, claiming that the county, by adopting the federal flood lines, unfairly restricted development.

The case went to the South Carolina Supreme Court. In August of 2015, the court unanimously ruled in favor of Richland County, noting the county is not the 'involuntary guarantor of the property owner's gamble that he could develop the land as he wished despite the existing regulatory structure.' (Wilkinson, 2015)

In October, immediately post-flood, the property resembled a lake: the water a combination of rainfall, inflow from surrounding creeks including Gills Creek, and possible failure of one of the earthen levees on the land. Yet, FEMA has proposed to loosen some of the controls over development.

4 http://www.rcgov.us/Government/Departments/Planning/FloodplainManagement/Mapping.aspx

# WHAT HAPPENED

Columbia, SC, 2015
Photo by Aon Benfield Impact Forecasting/Matt Schmitt & Steve Bowen

> *Though emergency officials were on alert, most residents were not. This was in part due to skepticism over whether forecasts were correct. People were surprised to wake up to major flooding.*

## The Event

Due to Hurricane Joaquin's proximity to South Carolina, SCEMD was on alert and activated their pre-landfall decision making process 96 hours prior to predicted landfall. By Wednesday, September 30, it was clear Joaquin would not make landfall, but the National Weather Service (NWS) issued a hazardous weather alert for extremely heavy rain. SCEMD began to mobilize the State Emergency Operations Center (SEOC). On Thursday evening, the NWS issued a flash flood watch and predicted that Columbia would receive an average of 4 to 6 inches of rain with some locations receiving up to 8 to 10 inches of rain. By the morning of Friday, October 2, the NWS issued a watch for life-threatening flash flooding; at 2 a.m. on Saturday, October 3, the warning was revised to indicate that flash flooding was imminent or occurring.

The advance notice gave SCEMD ample time to prepare. This was important as Columbia does not have a flood emergency plan. Had there been no advance warning, it would have taken the SEOC 72 hours to mobilize once the disaster had already hit. Between Wednesday and Friday, the state and FEMA agreed to bypass the typical rapid damage assessments and immediately declare a presidential disaster if disaster impacts were major. This agreement meant that FEMA was on alert and preparing to mobilize staff and resources as needed. In addition, SCEMD was conducting daily conference calls with, for example, the NWS, state officials and responders, individual counties, and the state VOAD. The state and county EMDs worked through Saturday to mobilize resources and preposition supplies.

Meanwhile, SCDHEC was communicating with lakeside homeowners associations to begin dam releases to drop lake levels and provide space for stormwater. While some associations complied, others did not because they did know what to do, could not find the person in charge of dam releases, and/or could not unlock the spillways.

Though emergency officials were on alert, most residents were not. This was in part due to skepticism over whether the forecasts were correct. Rains were light on Friday and Saturday and as a result residents let down their guard. The most intense rains fell between Saturday night and early Sunday morning, and people were surprised to wake up to major flooding.

Nine lives were lost in Columbia during the floods, five caused by individuals drowning in submerged vehicles and four from traffic accidents exacerbated by flood conditions (Wilks, 2015). Roads and bridges were closed during the event (Collins, 2015; Schafer, 2016). Railroad bridges, embankments and highway walls backed up water and worsened flooding. Saturated soils along with strong winds caused trees to fall onto power lines leading to temporary power outages.

Flooding was exacerbated by both intentional dam releases and dam failures. On Friday, October 2, the Saluda Dam began early flood releases. The dam operators were initially unable to increase releases due to downstream water quality and dissolved oxygen requirements. Only once the governor ordered dam releases in preparation for potential flooding — about 48 hours in advance of the rains — could they begin releasing. Unfortunately, even early releases failed to provide the needed storage, and the spillway gates were opened on October 4. This was the first spill since 1969 and resulted in flood impacts to homes located downstream in the Saluda floodway.

At least three regulated dams in Lexington County and 16 in Richland County, many of which were in the Gills Creek Watershed and Fort Jackson military base, and multiple smaller unregulated dams were damaged,[5] releasing floodwaters that

5 http://www.scdhec.gov/HomeAndEnvironment/DisasterPreparedness/FloodUpdates/

> *During the floods, emergency personnel were stretched thin and were unable to reach places that needed help. In response, communities self-organized.*

inundated downstream homes. Cascading dam failures sent flood waves downstream. A series of dams upstream to Forest Lake and Lake Katherine (the two largest lakes in the Gills Creek watershed) failed; Forest Lake and Lake Katherine dams held, but water was 6 feet deep flowing over the dams. The high waters coupled with infrastructure that limited flow caused water to pool up, and some homes had water up to their eaves. Below Lake Katherine, water backed up behind a railroad embankment and multiple lower socio-economic single-family homes and a Section 8 apartment complex were completely flooded. Further downstream, rushing floodwaters backed up at a bridge and heavily impacted multiple businesses.

Flood flows in the Congaree River just below the confluence of the Saluda and Broad rivers impacted the Columbia Canal and Columbia water treatment plant intake. Initially constructed for navigation and power generation, the canal is now the water supply for the Columbia Canal Drinking Water Plant. The canal was breached, impacting the only water source for 375,000 customers. The water system was further impacted as damage to roads and bridges resulted in associated damages to the distribution network.

## Response

### Critical Infrastructure

The Columbia Canal was breached between 1 a.m. and 2 a.m. on Monday, October 5. Multiple roads and bridges with water and sewage lines running underneath were also damaged. Together, this caused at least 50,000 people to lose access to potable water. Boil water advisories were issued through the media, but did not reach everyone. While the water treatment facility had a plan for handling damage to the canal, they did not have an emergency plan for a full breach. Attempts to build an emergency dam were unsuccessful and caused a second breach. Plant operators successfully ran bypass pumps that drew water from the Broad River; they were also able to leverage existing relationships and piping infrastructure connecting to the water treatment facilities in Cayce and West Columbia to procure additional water.[6]

The floods impacted all of the wastewater utilities in the area. Floodwaters overwhelmed sewage systems, and road and bridge closures made accessing the plants difficult. The East Richland and Gill's Creek plants were flooded. The City of Columbia's wastewater treatment plant stayed functional despite damage to several pipes and pumps, in part because the plant is surrounded by levees and in part because they were able to use boats to transport workers in and out of the plant. Overall, millions of gallons of sewage spilled across Columbia; no communities were evacuated, but there are certainly ecosystem impacts and possibly undocumented health implications.

Roads and bridges were widely damaged, inhibiting the restoration of critical infrastructure

6 This connection only existed because a chemical spill in Cayce years prior had necessitated connection to the Columbia water treatment facility to provide Cayce with safe water.

Columbia, SC, 2015
Photo by Aon Benfield Impact Forecasting/Matt Schmitt & Steve Bowen

services. Road and bridge closures impacted emergency responders and prevented utilities staff from getting to line breaks, valves and other access points to restore services such as water and sewage. The interruption of the transport network caused and continues to cause delays for commuters, months later. The delay in restoring the transport network is partly attributed to a lack of funds.

### Emergency response

Formal emergency management groups organized search and rescue, evacuations, and shelters. Many evacuations were only ordered after dams were already breached. During the floods, emergency personnel were stretched thin and were unable to reach places that needed help. For some communities, water came unexpectedly and quickly due to dam breaches, and first responders were not always aware of new areas that were flooding. In response, communities self-organized. In the Gills Creek watershed, for example, people used boats to rescue neighbors and strangers alike. Social media further enabled rescues; one family in a rental unit on Timberlane Drive posted to Facebook that they were trapped in the attic by floodwaters and were subsequently rescued by a neighbor in a boat. People opened up their homes as impromptu shelters for evacuated households.

Rumors of dam failures were difficult to contain, leading people to take unnecessary risks and evacuate safe locations out of fear. Warnings pushed to phones were less effective than they could have been; recipients were not always able to interpret the warnings, nor were they certain if the warnings even applied to them.

## Early Recovery

### State and Federal

A National Disaster was declared late Monday, October 5. Across the state, all but eight counties and 195 communities were declared impacted. Designated as a National Disaster, the standard rapid assessment process that generally occurs prior to declaration was bypassed. As a result, early recovery began, but without clarity regarding the range and extent of impact.

FEMA brought in 1,600 staff to conduct damage assessments, work with city, county and state departments, and help coordinate and deliver response and early recovery functions. The state began working with counties to prepare local floodplain managers for assessments and to answer questions. This included holding webinars on how to do substantial damage assessments for FEMA and on requirements to bring infrastructure

> *Following any disaster, there are always more needs than resources and decisions about how to prioritize recovery spending are challenging.*

into compliance if assessed damages exceeded 51 percent of the property value.

### Household

By Monday and Tuesday evacuated people started returning to their homes. The immediate need was to get floodwaters and mud out of houses. Non-profit agencies that utilized volunteers were a major source of effective manpower. Spontaneous unaffiliated volunteers (SUVs) also provided help. Some formal groups tried to quickly train SUVs in the field on safety and best practices; the Get Connected website was also used to connect SUVs to more formal volunteer opportunities. However, there were significant challenges in ensuring that SUVs were helping in ways that were safe and effective. Formal agencies were worried about liability issues, and lacked the resources to provide SUVs with the extent of training, protective gear, and coordination needed.

Within days of the event, 'hawks' – predatory service providers – began arriving in communities and pushing homeowners into making costly recovery decisions before they fully understood their recovery needs and financing options. In response, the state set up a phone line to report price gouging and predatory contractors.

## Long-Term Recovery

### State level

Long-term recovery, which begins about six months post-event, is largely left to locals and households and often takes a decade or more. FEMA supports the establishment of Long Term Recovery Groups (LTRGs) to handle case management for unmet needs. LTRGs generally begin with the local Volunteer Organizations Active in Disaster group (VOAD), if there is one, or with local humanitarian organizations if there is no VOAD. In Columbia, interviewees expressed frustration that the LTRG was still not operational five months post-disaster; however, the timeframe is not unusual. Getting the LTRGs set up post-disaster generally takes three to nine months. In the interim between the disaster and getting LTRG case management up and running, the VOAD focused on identifying households below the poverty line with residents greater than 65 or disabled who were awarded $3,000 or less in individual assistance from FEMA. For this population, they worked to get their homes functionally livable by December.

Following any disaster, there are always more needs than resources, and decisions about how to prioritize recovery spending are challenging. In South Carolina, the state is using the Social Vulnerability Index® (SoVI®)[7] to identify the most vulnerable communities. It is expected to help prioritize areas for recovery, with more detailed case assessments of individual homes and households determining what funds should be distributed and what types of contracts should be awarded. But, it has its limitations. Since the index is applied at the census tract level (1,000 homes), it can neither identify smaller areas where vulnerability and impact overlap nor identify individual homes that are having trouble accessing recovery funding and face going into heavy debt.

The state is also wrestling with what recovery is needed for the communities that are prioritized.

Post-flood dam recovery and regulation is another issue the state is facing. Dam regulations are often based on the assessed risk-level at time of construction and do not account for development,

7 The Social Vulnerability Index (SoVI®) 2006-10 measures the social vulnerability of U.S. counties to environmental hazards. The Index was created by Dr. Susan Cutter and associates at the Hazards and Vulnerability Research Institute at the University of South Carolina.

**BOX 3.**
**WHO IS RESPONSIBLE FOR THIS DAM? (BASED ON LOMAS, 2013)**

Fourteen households live on Arcadia Woods Lake (Coopers Pond) near the top of Gills Creek Watershed. The dam that forms the lake was built in 1937 and was topped with a single lane road, about 10 feet wide, leading to the home of T. D. Taylor. In 1948, Mr. Taylor sold the right-of-way of the dam to SCDOT, which subsequently widened the dam by adding fill to the downstream side and built a two-lane public road across the dam.

Following her husband's death in 1960, Ms. Taylor sold the home and moved to a property just below the dam. For unknown reasons, the dam remained in her possession. In 1988, Mrs. Taylor, through a lawsuit, tried to transfer ownership of the dam to the homeowners association and to SCDOT based on the order of the original deed of 1948 that T.D. Taylor signed, giving the right-of-way to SCDOT to control, operate, manage, and maintain the dam. The judge would not allow the transfer of ownership to these parties. In 1991, Mrs. Taylor attempted a second lawsuit, which resolved that, though Mrs. Taylor owned the dam, she could not control the water level behind the dam.

Similarly, Mrs. Taylor and the homeowners association have no control over the traffic across the dam road. Over the years, road traffic has increased across the dam. The road and the dam under the road were never constructed for the type and frequency of vehicle traffic they now carry. Because SCDOT did not build the dam, they maintain that they cannot determine a load limit, though in recent years, the residents have partially succeeded in having truck restriction signs installed.

DHEC regulations say the owner of a dam is someone who owns, controls, operates, and maintains the dam. If one entity has full control over these dam elements and functions, they have the ability and should have the responsibility to maintain that dam. However, in cases such as the Arcadia Woods Lake Dam, where the water operations infrastructure, the dam itself, and the roadway use across the dam are all under different jurisdictions, and where the dam owner benefits from neither the lake nor the road but cannot control the use of either, who should be responsible?

Columbia Riverfront Canal, Columbia, SC, 2015
Photo by South Carolina Air National Guard/Jorge Intriago

either upstream, which changes hydrology patterns, or downstream, where dam releases or failure could impact structures. Because of the changed risk, there is substantial debate over whether rebuilding dams is the best path forward. The policy and cultural web surrounding this debate is complex and includes issues of land tenure, dam inspection, dam ownership, dam regulation, compliance, and also individual rights and lifestyles spanning generations. Most homeowners with lakefront property want to keep the lakes, but are not sure that they have the capital to rebuild the dams to their previous condition, let alone stronger and in compliance with increased permitting and maintenance that more regulation will require. In some cases, homeowners do not feel they should be paying for the dams. Lakefront homes typically bear the cost of dam and lake maintenance, as there is no public access to the lakes; however, lakefront homes do not want to bear the cost of rebuilding dams which support public roads (Box 3). Homeowners are frustrated that SCDOT will not replace the dams nor will they replace dam roads with bridges; SCDOT is only willing to install roads on rebuilt dams. In many areas, these dam road closures have increased travel times and complicated transport. Moving forward on removing or repairing dams – and in many cases the roads that used to run over them – relies on the development of new policy.

### County level

Counties are working to determine how to most effectively spend limited recovery funds. While there are substantial funds to cover damages to critical infrastructure such as the water treatment intake and distribution network, roads and bridges, and the sewage system, funding for property buyouts is limited and likely far short of demand. How to allocate these funds is a major challenge.

Buyouts are a critical flood risk mitigation mechanism in the United States. Buying out high-risk properties and converting the land to open space is one of the few mechanisms by which local and state governments can reduce flood risk of existing infrastructure. Funds are generally spent in one of two ways: 1) for the removal of repeat loss properties, which provides financial relief both to property owners with few other options and to NFIP in removing expensive properties from coverage; and 2) for the removal of structures that are highly problematic to water flow and increase flood risk for other properties. Federal post-disaster buyout funds are the majority of the money most local and state governments have for this type of action, so counties need to be strategic about which properties they focus on, as funding is limited. For example, buying out the designated properties in the South Beltline community in Gill's Creek watershed alone would cost about $6 million. Yet, homes in other communities across the city and state are also hoping for buyouts.

### Community level

Many extensively damaged communities are working to advocate for community recovery needs. There are concerns that existing safety nets do not benefit the middle class and that middle class families will have to go into debt to fix their homes in compliance with FEMA regulations. The South Beltline community in Gills Creek Watershed, for example, has come together to collectively navigate the recovery landscape and work to influence how buyouts proceed in their neighborhood. They are hoping to connect the buyouts with a planned greenways project to expand open space and provide added value to the community. Other communities have banded together to pursue litigation over dam failures. This litigation is helping shape the dialogue about how dams should be constructed and managed. At the same time, people are seeing litigation as a source of recovery funding, but at the expense of upstream neighbors and/or the federal government.

### Household level

Household-level recovery manifests differently across socio-economic settings and locations in the city. Middle, lower-middle and lower-income households are facing a particularly challenging recovery. Many homes are gutted and few have

> *For people in the floodplain, the decision of whether to recover or walk away is largely based on recovery funding.*

been able to repair their homes. While some are still staying with family and friends or renting, others continue to live in homes that have been condemned and wait to hear about buyouts and/or insurance payouts. Some have decided to sell their homes and walk away. Of those who stay, some are still waiting for contractors to provide quotes.

Wealthier neighborhoods, on the other hand, were able to secure contractors to rebuild their homes soon after the floods. In these neighborhoods, it is clear repairs are underway. However, many people feel the floods were an exceptional event they will not see again in their lifetime, and consequently some homeowners expect special exemptions to rebuild. Many believe they will be safe once recovery from the event is complete and dams have been repaired. They do not see the floods as an indication of ongoing flood risk.

For people in the floodplain, the decision of whether to recover or walk away is largely based on recovery funding. Those without NFIP can access recovery funds up to $33,000 through FEMA's Individual Assistance Program. Following the floods, the Individual Assistance Program had over 80,000 applicants in South Carolina; only about 30,000 were eligible. This was largely because FEMA does not cover losses caused by 'deferred maintenance'—maintenance issues that existed before the event. This means that some of the most vulnerable households in the state—those living in sub-standard housing and trailer homes with poorly maintained roofs, for example—are unable to receive a sufficient amount of much-needed recovery funding.

While SBA loans provide an additional source of recovery funding, the timeframe on which households need to make decisions about SBA loans is often much shorter than the timeframe on which they have clarity about reconstruction requirements (see Box 4). Homeowners also expressed frustration with FEMA conditions on how their homes are to be repaired. Licensed contractors that work for rates outlined by FEMA are challenging to find, and work that households undertake themselves is sometimes used against them.

Renters are also facing challenges. Most renters do not carry NFIP's renter's insurance policy, and funds from the Individual Assistance Program are only sufficient to replace some lost belongings, for a few months of rent, or to move. Because Columbia has a rental unit shortage, moving is not easy. Renters who have bad credit or are unable to pay the security deposit struggle to find rentals. Some landlords have not returned security deposits post-flood, claiming that flood-impacted units are habitable even if they are not. Many low-income renters in flooded Section 8 housing – housing assistance for very low-income families, elderly, and disabled – are particularly challenged to find new units as there was already a waiting list pre-flood. Many continue to live in their damaged, and in some cases, condemned units.

**BOX 4.**
**A MIDDLE CLASS HOUSEHOLD'S CHALLENGES WITH ACCESSING RECOVERY**

The Smiths live in a tri-level home built in 1955 in the South Beltline neighborhood in the Gills Creek Watershed. The neighborhood is prone to flooding, particularly the houses right along the creek. Nonetheless, many of the owners who have paid off their mortgages have chosen not to retain flood insurance as it is expensive.

The lowest level of the Smiths' house is a tenth of a foot above Base Flood Elevation (BFE, the water level during a 100-year flood). During the October 2015 flood, water was 82 inches deep in their lowest level and 32 inches deep on the main floor; the third floor did not flood. Four months post-flood their lowest level is gutted and the main floor stripped to the studs from the floor to waist high.

Richland County determined that damage to the Smiths' home exceeds 51 percent of its value. To rebuild, the Smiths have been told they must elevate the lowest portion of the living space two feet above BFE. If the Smiths did not need to elevate, they could complete their repairs fairly quickly and inexpensively. Because volunteers came in immediately post-flood and stripped out the drywall and insulation, there is no mold. All that is needed is new insulation, drywall, baseboard and flooring. The kitchen stove, washer and drier, though they were submerged, still work; the house is structurally sound. It is unclear why this home is designated "substantially damaged." Though the Smiths have yet to receive a quote, elevating the home is likely to be cost-prohibitive. Tri-levels, similar to any home built on a slab, can not simply be jacked up and a higher foundation inserted underneath.

The Smiths describe the recovery process as "oppressive from every direction." Ideally, they would be bought out at pre-flood value. However, they have had no indication of whether a buyout is probable. They have been offered an $81,000 SBA loan to cover repairs and personal losses, but have to make a decision about the loan soon, well before buyout information will be available. If they take the loan now, they will be required to buy flood insurance on a damaged property that they are unable to live in; because of pre-existing conditions, the insurance would not pay out if there were another flood and the house was not yet repaired.

And so the Smiths continue to talk with different agencies, hoping to create a solution to an impossible situation.

# LESSONS LEARNED

## Physical Capital

**Dams are caught in a complex policy web.** Comprehensive dam regulation in South Carolina is a challenge. The state government has not allocated enough funding to inspect the thousands of regulated dams in the state, let alone track and periodically review unregulated structures. Even if they did, the question of who should be responsible for what is not always clear. Reclassifying older dams from low to high risk due to downstream development would incur financial costs for the owners, which is arguably unfair given they had no control over that development. In other cases, private dams support public infrastructure, bringing to question who should be responsible for maintaining the dam.

**The question of whether failed dams should be rebuilt is contentious.** Many people perceive the floods as a 'black swan' event that will not recur in their lifetimes. However, the dam failures in this event, as in previous flood events in South Carolina, clearly indicate that dams can pose a major risk during floods. Awareness of this risk is increasing, but how to address it is complicated. Whether to rebuild the failed dams, how to rebuild them, and who should pay for what is a complicated issue rife with conflict.

**Critical assets are often at risk.** Sewage and water treatment facilities in Columbia faced failures due to their location in the floodway, and facilities did not fail safely – millions of gallons of sewage spilled, and thousands of people were without drinking water for days due to these failures. The water supply facility fortunately had a backup option; the connection to the Cayce water treatment facility was critical in continuing water delivery to Columbia.

In addition, in Columbia, as in many places, there are homes located in floodways; many of these homes were built prior to floodplain regulations. People who live in these homes are often unaware of their risk, particularly if they do not have federally backed mortgages.

## Financial Capital

**NFIP penetration in areas that do not regularly flood is low.** Homeowners in the 100-year floodplain often choose not to carry flood insurance unless required by a mortgage lender. It is likely that most of those outside the 100-year floodplain, even those that were flood-impacted, will choose to forego purchasing flood insurance unless it is required.

Columbia, SC, 2015
Photo by Aon Benfield Impact Forecasting/Matt Schmitt & Steve Bowen

**Accessing recovery funds is challenging.** Renters and homeowners without flood insurance are eligible for federal Individual Assistance. However, those who most need it often do not receive as much as they need because of deferred maintenance in their homes. Even many homeowners with flood insurance struggle financially due to the rigid ways in which damages are assessed. For many homes with "substantial damage," the cost of elevating their home may exceed the aid and insurance money they receive. Accessing funds is further complicated by conflicting timelines, such as decisions about applying for SBA loans versus waiting for a possible buyout. Such challenges with accessing recovery funding may cause people to build back to their original, vulnerable state or worse.

## Human Capital

**The public, by and large, did not take the early warnings seriously.** The NWS and local weather outlets did an excellent job of pushing warning information out to the public, to the government, and to first responders. The government and first responders acted on this information, substantially mitigating what could have been a much larger disaster. However, the general public had little sense of the implications of the warnings or did not believe them and quickly let down their guard.

**Lack of risk perception is a widespread, chronic issue.** There are homeowners in the floodplain who choose not to purchase flood insurance, people in the Saluda Dam floodway who become irate when dam operators open the spillway, and those who went to bed on Saturday night assuming that the NWS got the forecast wrong again. Messaging that this was "rainfall that we won't get again for 1,000 years" is further intensifying the lack of risk perception and inhibiting the potential for resilient recovery. While this was an unusual event for Columbia, this was not an unusual event for the state. Storms in 1990 and 1995 caused severe flooding in parts of South Carolina and a series of dam failures that exacerbated flood impacts. There were also back-to-back '100 year' floods in 1928 and 1929 in the Columbia area, indicating that the

Forest Acres, Columbia, SC, 2015
Photo by South Carolina Air National Guard/Jorge Intriago

statistically attributed frequency of a particular flood event provides little indication as to when it might occur next.

**The flexibility to innovate was critical in response.** While the Columbia Canal breach and subsequent loss of drinking water was a complete surprise and the water treatment facility did not have an emergency plan for flooding, facility staff thought on their feet and implemented solutions. At the community level, individuals used boats to rescue neighbors and strangers, and families opened their homes to flood evacuees. The ability of people to respond to the needs they saw around them helped fill gaps in the formal emergency system's capacity to reach everyone that needed help.

## Social Capital

**Coordination during response was very successful.** Despite not having a plan for this type of flooding, communities and the city responded well; pre-existing networks and relationships were critical to this success. In particular, an SCEMD multi-agency disaster scenario simulation in July 2015 established strong partnerships between state and federal agencies.

**Those most impacted wait months for recovery support.** The LTRG is just beginning case management in Columbia, five months after the floods. While this timeline is typical of disasters nationally and reflects the level of coordination needed between a variety of entities (government, non-profit and faith-based), ultimately, flood-impacted people from vulnerable groups are left to wait for months before case management is operational and unmet needs can be more systemically addressed. This has increased the sense of disenfranchisement within these groups.

Renters have few options. Finding new lodging is difficult as there is high demand for, but low supply of rental units. Section 8 renters are particularly challenged; many are being told their dwellings are legally uninhabitable, but the lack of available Section 8 housing means that those displaced have few options.

The lower-middle class feels they do not have the safety nets and concessions given to low-income households, but lack the financial resources of the middle and upper classes. Many will go into significant debt as they try to recover from the floods, regardless of whether or not they have flood insurance. Those faced with "raise or raze" decisions may wait one or two years before knowing whether a buyout is an option.

Emergent groups are an important source of volunteer labor, but coordinating them is challenging. The issue of SUVs is getting bigger with every disaster, and yet there are few effective ways to best leverage the outpouring of human capacity and effort that emerges post-disaster. Humanitarian aid and faith-based organizations are working to develop systems to corral, train and utilize SUVs.

## Natural Capital

**Where development has been kept out of the floodplain, flood impacts have been avoided.** Had the Green Diamond project gone ahead (Box 1), the widespread flooding that occurred in that area could have had significant social and economic impacts. For high-risk areas that are already built up, the buyout program is a way of phasing especially risk-prone development out of the floodplain. However, there is limited funding for buyouts relative to the number homes that are hoping to be bought out.

Sumpter County, SC, 2015
Photo by U.S. Coast Guard/Stephen Lehmann

# CASE STUDY II
# Charleston Flooding

North Charleston, SC, 2015
Photo by Ryan Johnson

## THE PHYSICAL CONTEXT

The Charleston metro area includes the cities of Charleston and North Charleston. These cities have their own distinct city governments with their own mayors, but share utilities. Charleston lies within Charleston and Berkeley counties; North Charleston lies within Charleston, Berkeley and Dorchester counties. These three counties make up the tri-county area. In this area, earthquakes and hurricanes are the primary natural hazard concerns, though heavy rains and extreme high tides are increasingly causing nuisance flooding.

The Charleston metro area is a flat, estuarine delta. Drainage and flooding from heavy rains and high tides have been an issue since the city was founded in 1670, and are becoming an increasing concern over time, particularly in areas where small creeks and drainage features have been filled. Sea level has risen 0.13 inches per year (1.08 feet/century) from 1921 to 1999, further exacerbating flooding and drainage issues. Planning for future sea level rise of 1.5 to 2.5 feet over the next 50 years is underway.

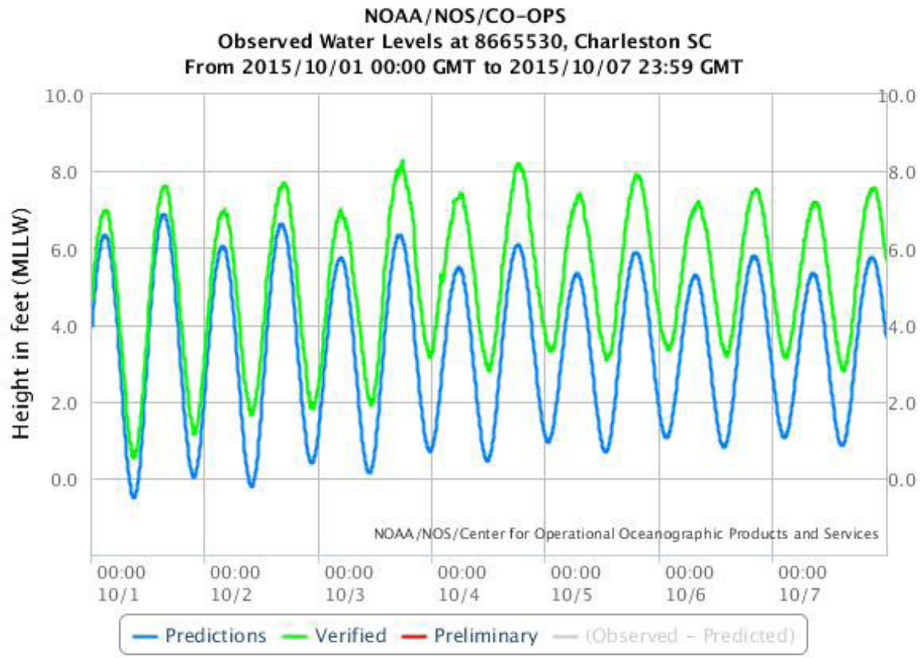
The October 2015 storm brought about 16 inches of rainfall to the Charleston-North Charleston urban area. Rainfall was a key contributor to the flooding. However, in addition, there was a persistent onshore wind and tides were high. This exacerbated coastal flooding, especially in downtown Charleston.

**TABLE 5:**
MAXIMUM 1-DAY, 2-DAY, 3-DAY AND STORM TOTAL (OCTOBER 1-5) RAINFALL AT THE CHARLESTON AIRPORT AND IN DOWNTOWN CHARLESTON IN OCTOBER 2015

| Location | 1-day rainfall | 2-day rainfall | 3-day rainfall | Storm total |
|---|---|---|---|---|
| Charleston Airport | 11.50” * | 14.31” * | 15.92” * | 17.29” * |
| Downtown Charleston | | 11.74” | 13.80” | 16.02” |
| Downtown Charleston previous record | | 11.74” | 12.39” | 13.80” |

*exceeded previous record

**FIGURE 5:**
PREDICTED (BLUE) VS. MEASURED (GREEN) TIDES, MIDNIGHT OCTOBER 1 THROUGH MIDNIGHT OCTOBER 8, 2015.




Tides greater than seven feet above mean lower low water (MLLW) cause problems in Charleston. During the October rainfall event, tides peaked at 8.29 feet above MLLW on October 3. Equally problematic, low tides remained high, as shown in green in Figure 5 above. Low tides remained above three feet for nearly a week, and drainage was severely constrained.

Tides in late September and October 2015 were expected to be high; the forecast was for "King tides" seven feet and higher above MLLW coincident with the full moons and new moon (September 27th full moon, October 12th new moon and October 27th full moon). In late October 2015, Charleston experienced a second round of tidal flooding when high tide reached 8.69 feet above MLLW[8] coincident with the full moon. This was the fourth highest tide recorded at this location since 1921. Many people in the coastal region noted that the flooding was as bad or worse than during the rainfall event at the beginning of the month.

8 https://www.washingtonpost.com/news/capital-weather-gang/wp/2015/10/27/historic-high-tides-from-supermoon-and-sea-level-rise-flood-the-southeast-coast/

# VULNERABILITY

## Vulnerability in an Urbanizing Environment

The tri-county area, with its protected port, river access to the interior, and fertile soils, has a long history of settlement. The area plunged into poverty after the Civil War and a series of hurricanes led to the collapse of the rice industry; freed slaves became the poorest residents. Towards the end of the 1800s, wealthy northerners started to move into the rural lowcountry, creating hunting clubs and winter retreats and starting cotton plantations. In the 1920s, severe drought and a crash in cotton prices in the rural lowcountry devastated the economy. Poor, black farmers and seasonal laborers moved into urban areas for employment (Tibbets, 2010).

The 1950s onwards saw frequent surges in population. As the population grew, so did development in flood-prone areas and along the beach. This is not to say the shoreline had never been developed. People had lived along the shore for generations, primarily the wealthy who built homes on bluffs, along coastal rivers, and on sea islands. Those who flooded either moved upland or, if they could afford it, elevated their homes. The introduction of NFIP in the 1970s changed this. NFIP provided people with a financial safety net in case they flooded. As a result, development along

**BOX 5.**
**KING TIDES AND SEA LEVEL RISE**

King tide is a colloquial term for an especially high tide, such as those that occur three or four times a year during a new or full moon when the moon is closest to the earth.

King tides provide a glimpse of what sea level rise will bring. However, unlike sea level rise, king tides are fleeting. Peak king tide only lasts for about a minute before slowly receding. However, when coupled with events like the October 2015 rainfall and on-shore winds, we get a more extended picture of what sea level will cause.

These events are our "canary in the coal mine;" we need to treat them as the advance warning they are, not as anomalies.

the shoreline exploded, pushing up property prices (Tibbets, 2006). The majority of this development bypassed the most marginalized groups, largely located in the urban core (Wren, 2016).

Urban expansion is continuing to disenfranchise many middle class and poor communities, pushing them into greater relative social vulnerability (Schmidtlein, 2008). Urban areas in South Carolina, particularly in the tri-county area, are growing very rapidly and comprise 25 percent of the state's total population gain — an average of almost 43 new residents per day in 2014 (Behre, 2015). Gentrification, rising rents, and increasing insurance premiums have displaced poorer communities (Slade & Parker, 2014), many of whom are likely to move to North Charleston, an area of high social vulnerability.[9] This displacement is changing known patterns of vulnerability and may lead to incentives to develop less expensive, high-risk marginal lands.

**BOX 6.**
**IS THE FLOODPLAIN PHYSICAL OR POLITICAL?**

The '100-year floodplain', the basis of much flood policy in the US, is widely thought to be a designation of physical risk. Yet, the federal government provides avenues for US residents to appeal floodplain designations. In many respects, this is needed – no agency is correct one hundred per cent of the time, and therefore opportunity to present conflicting information for consideration should be available. However, this option, in practice, is not open to all, and for those who can access it, appeals should be reviewed critically.

Kings Grant, a gated neighborhood, lies along Wildcat Creek on the eastern side of the Gills Creek watershed, just downstream from Fort Jackson. When FEMA released the current Richland County flood maps, the maps showed that Kings Grant homes along Wildcat Creek were within the 100-year floodplain. The community hired an attorney to fight the flood designation, and won. In the October 2015 floods, many homes in Kings Grant flooded and did not have flood insurance. The blame has been placed on the failure of the federally-regulated Semmes Lake Dam; the extent to which the dam failure contributed to downstream flooding is currently under litigation. Yet, we have to wonder on what basis these homes were exempted from the original 100-year floodplain given their proximity to the creek and an upstream dam.

On the other hand, there are communities that fear being placed into the 100-year floodplain for flooding during what may have been a greater than 100-year event. In North Charleston, many of the flood-impacted homes in the Pepper Hill and New Rider Road neighborhoods were not in the mapped floodplain. The question now is whether or not these areas should be included in the mapped floodplain. This designation would have major consequences in what are lower-income areas: people, especially those on fixed incomes, could be priced out of their homes. These people are unlikely to have the option of hiring attorneys and consultants to contest the floodplain designation. They will either have to bear the cost, or move elsewhere.

> *"Flooding is a major issue for newer residents. Recent in-migrants who do not understand the risk landscape do not know what action is needed in that landscape to preserve assets and increase safety, and when to take those actions.*

High in-migration and subsequent development are likely to increase flood risk. Charleston has an extensive drainage network that dates back to 1859. In recent years these drains have been less and less effective, largely due to the minimal height between the drains and the ocean. Infilling tidal and riverine creeks, building on floodplains and barrier islands, and filling wetlands have exacerbated drainage issues.

Urban expansion in the tri-county area is partly driven by the influx of major corporations such as BMW, Volvo, and Boeing. Increasingly, international supply chains are segmented such that specific factories are responsible for producing specific products. Any halt in supply chains both impacts operations locally and have worldwide implications. Consequently, these companies are putting money into resilience research and initiatives in the tri-county area.

These resilience initiatives are coming at an important time. New construction changes the local hydrology, including both surface water and ground water. Sea level rise will further exacerbate urbanization impacts on hydrology. Yet, how urbanization and sea level rise will impact hydrology, modify flood risk, and change known patterns of vulnerability is poorly understood and not yet being considered proactively.

## Perceptions of Risk

People who have lived in the tri-county area for a long time know that the area is flood-prone. However, they largely see floods as an inconvenience, a nuisance, and not as a risk that poses inherent danger. Most flooding is localized, without major city- or county-wide impacts. Accordingly, people have adapted. Most of the houses in areas that experience nuisance flooding are raised, and people know that in certain parts of town, if it rains they will have to wade to their car. During major events, people know to evacuate.

9 http://www.scemd.org/files/Mitigation/State_Hazard_Mitigation_Plan/4_Appendix_C_Part1_Local%20Hazard%20Risk%20Assessments.pdf

> *As people become more aware of sea level rise, they also begin to expect the tri-county area to do what it can to adapt.*

Flooding is a greater issue for newer residents. Recent in-migrants who do not understand the risk landscape do not know what action is needed in that landscape to preserve assets and increase safety, and when to take those actions. Furthermore, there are few incentives to help people understand flood risk as they make decisions regarding where and how to live. Realtors want to sell, insurance agents want to receive their commissions, and communities want to grow and thrive. In such a situation, people are incentivized to withhold risk information unless required by law to divulge it.

## Preparedness

Charleston, Berkeley and Dorchester Counties coordinate action and share resources and capacities. Emergency managers from the cities within the tri-county frequently work together, and there is a very active VOAD, the Trident VOAD.

Within the tri-county, Charleston and North Charleston are fairly self-sufficient, with a strong culture of emergency preparedness and response. For example, North Charleston responded to an ice-storm a few years ago without requesting support from the county; Charleston has their own emergency operations center (EOC), which is unusual at the city level; and both Charleston and North Charleston have emergency managers to build and mediate the networks required to address disasters. This culture grew out of the cities' experiences during Hurricane Hugo in 1989. Today, multiple groups are proactive and engaged around preparedness and response. Hospitals and school systems are a part of the EOC, and the water sector, electricity sector, and railroad are willing to be pulled in when needed.

Hurricane Hugo also gave the tri-county area a strong awareness of when events can be handled locally and when full-scale evacuation is needed. Charleston can shelter 8,000 people in the northern part of the city. In a major event, the city would evacuate – an existing element in the tri-county plans, even before a recent federal mandate required emergency plans to include evacuation routes. The current evacuation protocol is heavily based on lessons learned from hurricanes Hugo and Floyd. One of the major challenges with evacuation, however, is that only the governor can order mandatory evacuations. This makes localized evacuations for smaller-scale events, or events in isolated areas, challenging; the cities and counties can only recommend, but not require, evacuation.

At the household level, preparedness varies across demographic and income brackets. In general, lower socio-economic classes (i.e. minority, single, female, elderly) have lower preparedness. They often have less insurance, fewer assets, and lack means by which they can leave their homes if necessary. Transient populations and short-term residents, including seasonal workers and students, who are often unaware of local risk, can be among the hardest to reach and educate through public outreach efforts. In light of this, the city, non-governmental organizations (NGOs) and insurance companies are attempting to engage more with churches and schools.

## Disaster Risk Reduction

In recent years, Charleston has been proactive in reducing flood risk and increasing public safety and service as a means to build resilience. This momentum came with the realization that sea level rise and nuisance flooding will only continue to get worse. As people become more aware of sea level rise, they also begin to expect the tri-county area to do what it can to adapt. The Charleston Resilience Network (CRN) was recently established to bring together diverse stakeholders to streamline disaster risk management and resilience planning and develop strategies for coastal hazard identification, mitigation, and information communication (see Box 7).

### BOX 7.
### THE CHARLESTON RESILIENCE NETWORK

**The Charleston Resilience Network (CRN)** is a volunteer-based effort composed of public and private sector stakeholder organizations within the Charleston metropolitan area. These stakeholders have a collective interest in the resilience of communities, critical infrastructure and socio-economic continuity to periodic natural disasters and chronic coastal hazards. The CRN's goals are to foster a unified strategy, educate stakeholders, and enhance long-term planning decisions that result in resilience.

The formation of the CRN was catalyzed by the outcomes of a one-and-a-half day tabletop exercise, organized by the Department of Homeland Security's Office of Infrastructure Protection. The exercise examined the region's capacity to protect infrastructure during extreme events and identified opportunities to build resilience to chronic environmental stress and climate-related hazards. The collaboration included participants from several sectors including telecommunications, water, energy, emergency management, banking, port facilities, federal and state resource managers and major businesses. Many of these groups have stayed engaged with the Charleston Resilience Network. CRN has also partnered with the National Academy of Sciences and the associated Resilient America Roundtable to examine regional vulnerabilities and identify potential mitigation strategies.

Prior to the CRN, there was limited coordination among groups working on resilience-related challenges. The network has made it easier to provide streamlined information and to introduce a common language and shared goals for resilience planning. The CRN is working to produce detailed, localized flood vulnerability maps that incorporate the adaptive capacity of infrastructure. The network also provides access to data resources that may be used by municipalities to apply for Hazard Mitigation Grants. The CRN continues to build relationships among regional stakeholders and is identifying organizational capacities to deliver analysis, products and services.

> *There has been and continues to be strong political support at the city-level for disaster risk reduction and resilience initiatives. However, obtaining support at other levels of government has been challenging.*

Pepperhill, North Charleston, SC, 2015
Photo by Ryan Johnson

For years, Charleston County has had one of the highest NFIP Community Rating System (CRS) scores east of the Mississippi. However, the effectiveness of the CRS is increasingly being questioned. The CRS is designed to incentivize communities to pursue comprehensive mitigation strategies. The concern, however, is that the score is not a true measure of better floodplain management; that instead, the CRS incentivizes reducing insurance costs over reducing disaster risk. Communities achieve higher scores if they implement as many small-scale activities as possible (as disparate as they may be), rather than enacting cohesive change that could significantly reduce disaster risk and vulnerability.

Accordingly, Charleston is moving beyond just the CRS and working on proactive, coordinated efforts to reduce flood risk. The city has spent $240 million on stormwater drainage projects on the Charleston peninsula and plans to spend more in the next 20 years. New drainage systems, which rely on large collection tunnels and huge pumps, are being installed on the peninsula in areas where nuisance flooding is high. The first of these systems are now operational and have been highly successful. In parallel, the city is requiring that new development report pervious cover, and construct drainage that is able to hold a 100-year storm event for 24 hours to allow the rest of the basin to drain before runoff from these developments enters the system. Ultimately, new development should be more resilient to floods, and should not exacerbate flood issues in surrounding areas.

Charleston also began the Upper Peninsula Initiative (UPI) three years ago. The goal of the UPI is to ensure that development is urban, walkable, and avoids suburban sprawl. To date, one eco-district has formed and is implementing incentives-based strategies such as height and density bonuses, encouraging best-management practices for stormwater control, and promoting sustainability measures such as green spaces, green roofs, and Leadership in Energy and Environmental Design (LEED) certification. In areas that are built out and height and density can not be incentivized (i.e. the historic district), the city is considering creating a system by which people can receive credits for their parcel if they pursue stormwater management practices such as green roofs and porous pavements.

Although Charleston's overall disaster reduction strategy is to mitigate risk while maintaining development, the city is also looking into more adaptation-oriented strategies. The city is exploring incentives-based models for changing behaviors (i.e. using tax policy as an avenue for reversing growth in coastal areas). Other projects, such as the Charleston Illumination Project, are more focused on building social cohesion. It is thought that faith-based communities have helped build the strong social cohesion present in the tri-county area today.

There has been and continues to be strong political support at the city-level for disaster risk reduction and resilience initiatives. However, obtaining support at other levels of government has been challenging. The recent floods are helping push the conversation forward and are generating increased support for the work cities are doing.

The Disaster Risk Reduction (DRR) strategies discussed thus far are flood-related. At the city-level, there is an interest in transitioning to an all-hazards approach, but there are many challenges to integrating vastly different types of hazards into one plan. There are concerns that measures taken to reduce flood risk can exacerbate earthquake impacts, and that earthquakes could destroy sea level rise mitigation structures. Charleston is currently wrestling with how to plan for a multitude of hazards.

# WHAT HAPPENED

> *While the forecasts correctly predicted the rains and the genesis of the storm, people were surprised by the actual intensity, the way in which the city filled up with water, and the resulting impact.*

## The Event

The EOCs were on alert due to Hurricane Joaquin's proximity to the coast. As the forecast changed, indicating Joaquin would not make landfall but the tri-county area would receive more than 10 inches of rain, preparations shifted. The EOCs began to talk to the school district and major employers three days in advance of the event. School districts cancelled school and city staff were told to stay home on Friday. The mayor held a press conference a day and a half in advance of the event to get the word out. These efforts were supplemented by media weather reports and warnings.

Rains began in Charleston on Thursday, October 1, and by Thursday evening, the tri-county and state activated their EOCs. Moderate to heavy rains continued through Monday; rainfall totals ranged from 15 to 25 inches throughout the tri-county area. While the forecasts correctly predicted the rains and the genesis of the storm, people were surprised by the actual intensity, the way in which the city filled up with water, and the resulting impacts. An onshore wind blowing into the harbor, coupled with already high tides and extreme runoff led to unanticipated flooding and prevented floodwaters from receding for days. Tide levels remained elevated for nearly three weeks. Several days after the initial rainfall event, Charleston suffered a second bout of riverine flooding caused by the upstream rainfall in Columbia days earlier.

North Charleston was more impacted by the floods than Charleston. This is not purely because of the socio-economic differences between Charleston and North Charleston, but also because the flooding was more severe in North Charleston. Waters took a longer time to recede, which may have contributed to the number of homes that flooded. Over 500 homes in North Charleston were flooded, and over 80 percent of those homes had major damage. In Pepper Hill alone, 100 homes were damaged, of which only seven were in the mapped floodplain. On New Rider Road, around 40 homes were damaged, none of which were in the mapped floodplain. In Charleston, there were fewer housing losses (approximately 60 homes), and many of the homes that were damaged were repeat loss properties. Flooding and damages were in areas where flood risk was well established. Aside from homes, there was little damage. The flat topography means that floodwaters do not have the energy to take out critical infrastructure.

> *Emergency personnel focused their efforts on the places that they knew would flood.*

## Response

### Emergency Response

Emergency personnel focused their efforts on the places that they knew would flood. In Charleston, for example, the EOC went door-to-door in flood-prone areas and recommended that people self-evacuate.

In North Charleston, emergency personnel set up a transfer shelter and evacuated 115 people from their homes in Pepper Hills. At the transfer site, evacuees were given dry food, clothing, and an opportunity to call either family or friends to organize their own longer-term sheltering. Longer-term shelters were set up for those who could not organize their own shelter options. Setting up these longer-term shelters was more cumbersome as emergency shelter protocols required that shelters have wind-bearing walls – a critical feature for hurricane shelter, but not relevant to floods caused by non-hurricane events.

North Charleston saw a large influx of volunteers from businesses, faith-based groups, and non-profits. Communication issues and a lack of clarity on who would coordinate the volunteer reception center (i.e. tri-county VOAD or city emergency personnel) made coordinating volunteers challenging.

### Critical Infrastructure

Critical infrastructure was not greatly impacted by the floods. Power was shut down in some flooded areas before people were evacuated and there were sporadic, short-term power outages throughout the floods. The drinking water system stayed intact and functional. Communications systems also stayed intact. There were sewage spills, but the most significant spill would probably have been avoided if a new conveyance pipe currently under construction had been operational. Much of the drainage system was overwhelmed, including the Church Creek Drainage, which was completed in 2010 and designed for a 25-year event.

Aside from drainage and housing, transportation was probably the most impacted service. Interstate 95 was shut down due to the flooding, a closure that emergency personnel did not expect. Updates on major road closures were regularly disseminated; updates about secondary road closures were not as timely.


Flooded Street Pepperhill, North Charleston, SC, 2015
Photo by Ryan Johnson

## Early Recovery

In the immediate aftermath of the disaster, both Charleston and North Charleston conducted rapid assessments. North Charleston had 50 to 60 employees trained in damage assessment. Each area had a site leader that followed up with the damage assessors to ensure gaps were identified and met. As a part of the rapid assessment, they honed in on 86 homes that particularly needed help. It is possible, however, that some homes that needed help may not have been identified since some of the flood-impacted areas were small pockets in larger neighborhoods. In Charleston, FEMA went door-to-door, checking with households in flooded neighborhoods repeatedly. The city government connected FEMA with the city police to increase FEMA's outreach and ability to identify households that required assistance.

Disaster recovery centers were set up in both cities in the middle of the hardest hit areas. These are ideally a one-stop shop for recovery information and support, with representatives from FEMA, SBA, SCEMD, and other relevant agencies to explain disaster assistance programs and help people apply for aid.

Businesses worked to reopen soon after the floods. This allowed people to get back to work relatively quickly, and helped limit the economic impact of the floods.

## Long-term Recovery and Resilience

### Tri-County level

Much of the state's focus in the aftermath of the floods has been on Columbia, partly because Columbia was more impacted, but also because there is a perception that the Charleston area is well equipped to handle floods given the regularity with which it floods.

As a result, the COG is leading recovery efforts in the Charleston-North Charleston urban area. The focus is on getting FEMA grants that can help fund recovery and risk reduction efforts, and on forming a tri-county LTRG through which recovery efforts can be coordinated. While the tri-county area has historically had a VOAD, this is the first time a LTRG, a coalition of groups active in recovery, is being formed. The role of the LTRG is still being

> *The floods have increased public support for resilience and risk reduction actions to address both rainfall induced and tidal flooding.*

discussed, and, in addition to case management and addressing unmet needs, may include:

(1) putting together code requirements and identifying sector-specific contacts for each locality that can provide information related to reconstruction; and

(2) building, coordinating and maintaining public, private, and volunteer partnerships to streamline recovery efforts, resources, and capacities.

The recovery phase is spurring discussions around strengthening infrastructure. The Charleston water system is investing in improvements, particularly on improvements to the Pinopolis Dam, as its failure would be devastating for the tri-county area. There is also growing awareness that reliance on a single drinking water and sewage treatment plant is risky. The current sewage treatment plant is in a low-lying marsh prone to flooding, but where a second plant should be built is contentious; people do not want it in their backyard. In the transportation sector, there are ongoing discussions about:

(1) how to modify roads designed to be passable during a 25-year event to be passable during a 100-year event;

(2) how to keep public transportation running during floods and people alerted about routing changes; and

(3) improving communications about road closures during floods.

### City level

Many city-level recovery and resilience actions are an extension of disaster risk reduction initiatives that predate the floods. The floods have increased public support for resilience and risk reduction actions to address both rainfall induced and tidal flooding.

In terms of sea level rise, the federal government is sending a strong message that Charleston should retreat from the coast, but local communities do not consider retreat an option. Charleston's three-year Sea Level Rise Strategy, released soon after the floods, reflects this. This strategy outlines the types of structural mitigations the city will pursue to harden its edges, along with non-structural resilience initiatives. The strategy may be integrated into the City's Comprehensive Plan. The Sea Level Strategy, along with new hazard mitigation plans that are being drafted by the counties and COG, is expected to leverage FEMA funding to support mitigation activities; the tri-county area has not received FEMA funding since Hurricane Hugo. Other cities and towns in the tri-county area are following suit and developing their own sea level rise strategies.



> *The city is thinking of introducing a combination of basin-specific policy changes and more integrated design standards that ensure development-specific drainage systems take basin hydrology into account.*

In recognition of the impacts of development, Charleston has been modifying design standards for new developments. The floods have actually brought in funding for more basin-level studies to inform how design standards should be changed. Preliminary findings indicate that recent changes to the stormwater drainage requirements may not be enough. In West Ashley, for example, studies indicate the basin takes 96 hours rather than 24 hours to recover from a 100-year event. As a result, the city is thinking of introducing a combination of basin-specific policy changes and more integrated design standards that ensure development-specific drainage systems take basin hydrology into account.

Beyond development-related policy change, the city is grappling with a host of other issues that need to be addressed as recovery initiatives emerge and proceed. These issues include dealing with an increasingly contaminated low water table, areas with critical infrastructure that have sunk, and flooding on high tide days. To support the city as it moves forward with these issues, a lot of information can be, and is being produced by local experts, largely on Geographic Information System (GIS) platforms. Much of this information can be accessed and visualized online. However, it is unclear to what degree this information is being used by emergency personnel, planners, and decision-makers to make better choices for development, planning and disaster risk management.

### Household level

Most homeowners in Charleston have been accessing recovery funding through NFIP and SBA loans. Payouts have, by and large, not been enough as property and contractor services in Charleston are expensive. There is less insurance penetration in North Charleston. Many of the impacted homes did not have flood insurance, partly because they were not in designated floodplain areas. While households did apply for Individual Assistance, fewer than 30 percent of applicants have been approved because of issues with deferred maintenance and because homes damaged by rain coming through the roof rather than by overland flow do not qualify as 'flooded.'

The COG and local organizations are exploring alternative funding sources to help households that have unmet needs. The county is also advocating that existing hurricane grants for upgrading homes be extended for all hazards. Mitigation grants for hurricane improvements in coastal areas provide a $5,000 grant-match for homes valued from $150,000 to $300,000, and a $5,000 grant for homes valued below $150,000. This has been

widely taken up across the tri-county area. The COG is also trying to create a rainy-day fund to purchase materials for available volunteer labor that want to help with housing recovery. This initiative would be supported by a provision in South Carolina that a licensed contractor can obtain the needed building permits and oversee volunteers doing the work.

Those in repetitive loss housing are hoping for buyouts. Owners of townhomes that have now flooded four times kept thinking that the city government could engineer them out of their risk; it has become apparent to them that this is not possible. The city can apply for grants through the Hazard Mitigation Grant Program for buyouts, but it is unlikely that enough funds will be awarded to buy out all interested homes.

BOX 8.

**DEFERRED MAINTENANCE PERPETUATES AND EXACERBATES INEQUITY**

FEMA's deferred maintenance policy disproportionately impacts low-income households. Many households do not receive the full amount of assistance needed due to "deferred maintenance". Others are deemed ineligible to receive any assistance due to "insufficient damage".

In the aftermath of Hurricane Ike, for example, FEMA denied 85% of at least 578,000 recovery assistance applicants; the majority of these denials were on the basis of "insufficient damage" (Sloan and Fowler 2015). Similarly, in Texas, after Hurricane Dolly, 22,000 of 38,000 applications were denied (Oliver, 2011). "Insufficient damage" denials are frequently based on "deferred maintenance". These denials tend to be concentrated in low-income and minority neighborhoods (Sloan and Fowler, 2015).

While households can file appeals over ineligibility designations, many choose not to. For example, after a tornado in Alabama, only one per cent of the 25,081 aid applicants declared as ineligible appealed.

.

While in some cases this was because homes truly did not have damage, others clearly did and yet did not appeal (Daily Mail, 2011).

Deferred maintenance "delays recovery and increases costs" (Sloan and Fowler, 2015, p. 11). First, "deferred maintenance" issues largely occur in households that could not afford repairs in the first place. The combination of disaster losses and a lack of recovery funding could push households to build back far worse, exacerbating hazard risk and increasing vulnerability. Second, it allows homes to deteriorate to a point that they need to be reconstructed entirely. Third, many ineligible homeowners end up having to find temporary housing, the costs of which exceed the cost of repairing their homes (Sloan and Fowler, 2015).

While HUD's CBDG-DR program is expected to help meet this need, there are no standard regulations or federal guidance for how states should distribute these funds internally (Sloan and Fowler, 2015).



# LESSONS LEARNED

## Physical Capital

**There is little redundancy and flexibility in the drinking water and wastewater treatment systems.** The cities within the tri-county area share utilities: one drinking water plant and one sewage treatment plant. Failure of either plant during a disaster could require evacuation of the metro area for days to weeks.

**The development strategies that are being discussed and pursued are very forward-looking.** Charleston is changing building requirements to improve stormwater management, looking into creating basin-specific regulations for more integrated management of basins, and working to incentivize green infrastructure. However, the majority of these changes are only required for new developments; the opportunity to adapt existing development has not yet been exploited. There is also concern that these forward-looking strategies may not be enough. For example, new design standards require that drainage systems in new developments be able to hold stormwater from a 100-year flood event for 24 hours; however, recent studies indicate some basins take up to 96 hours for recovery.

## Financial Capital

**FEMA's deferred maintenance policy is inhibiting resilience.** FEMA's policy to deny assistance to homeowners with deferred maintenance makes it particularly difficult for low-income groups to access much needed funds to recover from the floods and improve their homes. Without access to adequate recovery funds, households are likely to build back worse.

**Updating floodplain maps may have major socio-economic consequences.** If poorer people are required to get flood insurance and are subsequently priced out of their homes, it is unclear where they would go. Such migration could exacerbate the vulnerability of these people, and is also likely to change known patterns of vulnerability in the tri-county area.

## Human Capital

**Risk awareness is currently high in Charleston, but this may change with in-migration.** There are many people migrating into Charleston, many who come from different risk contexts. In addition, long-term residents are being and will continue to be pushed to relocate due to rising costs and gentrification. Maintaining risk awareness in new populations is challenging. As people move and patterns

North Charleston, SC, 2015
Photo by Ryan Johnson

of vulnerability change, communicating with vulnerable groups will require different strategies and targeting.

**There is poor understanding of what government (federal to local) and private insurers will cover in recovery.** In the aftermath of the disaster, many households have been surprised to find that FEMA and insurance (private and federal) do not cover all their recovery costs and needs. LTRGs and other non-profits and faith-based organizations help households address unmet needs to the best of their ability, but many households are left with costs or gaps they did not anticipate and must fill themselves.

**Weather forecasts have their limitations, particularly in terms of predicting impacts.** Weather forecasts reached most residents and most people believed them and acted accordingly, significantly mitigating what could have been a much larger disaster. However, estimating impacts is challenging, especially in the context of land-use change and a changing risk landscape (i.e. sea level rise).

**Existing emergency response protocols do not always support appropriate action.** The tri-county area is able to handle small-scale, localized flooding, and is prepared to handle larger-scale disasters such as hurricanes where the main response is early evacuation. Events the size of this flood, where individual neighborhoods require evacuation, are a challenge. Currently, only the governor can mandate evacuations; during the flood, evacuation notices in the tri-county area were only recommendations. Local emergency personnel need the authority to mandate targeted evacuations, if needed.

**Incentive-based programs can help change behaviors.** Programs such as the UPI and the CRS allow people to choose how they want to adapt and reduce their risk to disasters and reward them for making those decisions. However, the structure of the CRS can incentivize communities to implement as many activities as possible, however disparate, to reduce their insurance costs, rather than incentivize them to take meaningful and impactful actions to reduce their risk.

## Social Capital

**Cross-jurisdictional networks are important for managing disaster risk and building resilience.** City and county communication during emergency response was very good. Communication gaps that did occur have been identified and city and county officials are working to build the necessary relationships to ensure that similar gaps do not occur in the future. Had established networks and cross-jurisdictional entities not existed, 20 different governments within the tri-county would have been issuing their own information, substantially complicating preparation for and response during the event.

**The transfer housing system was a success.** It gave citizens a place to recover from the initial trauma of the disaster, a means to leverage their own networks and resources, and organize their own long-term shelter arrangements. It also allowed emergency services to prioritize those who needed the most support and did not have networks and resources to immediately fall back on.

Overall, there is a lot of energy within cities in the tri-county area to build resilience. Cities have brought together multiple actors and organizations and are beginning the process of integrating resilience and disaster risk reduction initiatives across sectors and scales.

## Natural Capital

**Development is taking precedence over preserving open spaces and wetlands.** Economic growth is a priority for most places; accordingly, resilience initiatives will only be taken up if they enhance and/or do not curb economic growth. Yet, in the meantime, infilling wetlands, tidal creeks, and riverine creeks is exacerbating drainage issues and overall flood risk.

Columbia, SC, 2015
Photo by Aon Benfield Impact Forecasting/Matt Schmitt & Steve Bowen

# RECOMMENDATIONS

## Risk Reduction

**Maintaining risk awareness.** Lack of risk awareness was a major problem in Columbia and is likely to become a growing problem in the tri-county area. Poor risk perception may lead to a population that is underprepared to deal with disasters. We need to foster a cultural shift where people seek out information on their risks and where government agencies make that information readily available.

**Planning for a changing risk landscape.** Built infrastructure and planned development will alter the risk landscape. Future floods will bring new surprises as water moves into different places, impacting different communities and infrastructure. Planning for this uncertainty should include: (1) not placing major assets (critical infrastructure, houses) in known floodways and flood-prone areas, and overall keeping floodways natural, (2) including design elements such as safe failure to ensure that failures do not have cascading impacts and/or are not catastrophic, (3) redundancy to ensure that key infrastructural services are not compromised by the failure of individual structures, and (4) where possible, using a multi-hazard approach to ensure that building resilience for one type of hazard does not pose a threat in the context of other hazards.

For example, in the tri-county area, there needs to be more than one plant or multiple delivery pathways for sewage treatment and water treatment. Similarly, flood mitigation strategies such as the new drainage systems with pumps, need back-up power. In the Columbia area, dams need to be assessed for flood risk to downstream and surrounding communities, high-risk dams regulated, and dam owners educated about how to maintain and operate dams.

**Increasing insurance penetration and accessibility.** Local governments should develop outreach materials and work with both federal and private insurance providers to increase flood insurance penetration in their jurisdictions. Flood risk information needs to reach everyone, and not only those that live in the 100-year floodplain and have federally backed mortgages. However, it must be noted that insurance penetration alone is not enough. The rigidity of FEMA processes and rules, and the narrow conditions under which it pays out makes NFIP unappealing to many homeowners. Unless these processes and rules are made more flexible, it will be difficult to increase insurance penetration.

**Building incentives for risk reduction across scales rather than imposing regulations.** Incentives can be as effective at changing behaviors as regulation, and can be extended to several aspects of reducing disaster risk across scales. For example, in the tri-county area, maintaining open space can be incentivized through height and density bonuses. Households and communities can be encouraged to implement disaster risk reduction activities using rewards systems like insurance cuts and tax credits. However, incentives programs should be assessed regularly to assure they truly promote meaningful activity and reduce risk. For example, the CRS has been criticized for incentivizing insurance rate reductions over meaningful disaster risk reduction activities. It has been suggested that the CRS shift its approach to provide cities and counties with significant benefits for spending on strategic buyouts and the retirement of flood-prone properties.

**Using green infrastructure solutions to reduce flood risk.** Parks and greenways can add value to land through both aesthetic and recreational benefits, while also buffering households and communities from floods. There are also opportunities for introducing solutions that reduce flood risk while supporting development. Porous pavements and green roofs, for example, can increase infiltration and reduce nuisance flooding within and around developments while also improving water quality.

**Buyouts need to be strategic.** Given the limited funds for buyouts relative to the number of homes that hope for them, buyouts need to be conducted in a way that maximizes flood risk reduction. If there are ways to link these buyouts to existing parks and greenways, ongoing maintenance issues will be less complicated and it may be easier to find local matching funds for the purchases.

## Response

**Making early warnings more relevant and actionable.** As technology changes and people are increasingly connected, there is opportunity to push out early warnings in new ways. However, messages need to be accurate, focused, and provide relevant information. Warnings should be geo-located or otherwise tailored to people in the relevant geography, and should provide actionable information. At a minimum, warnings should convey that conditions are dangerous, rapidly changing, and that people need to use their best judgment. Absolute predictive accuracy with extreme events is impossible. The public needs to understand these gaps, be prepared to respond to the unknown, and know how to act in the context of the information that has been provided.

**Generating localized situational and verifiable information.** Responding to the unknown could potentially be supported by crowdsourcing of highly local information. This could include geo-located weather conditions, road closures, water depths, etc. Ideally, it would be built on apps and websites people already use (e.g. Waze, Google Maps, MyCoast, etc), since people are unlikely to learn a new technology that will only be useful in a disaster.

**Developing disaster response in ways that allow people to leverage their social capital.** All too often in post-disaster environments, those impacted are seen as victims in need of help. This response has two significant disadvantages: it disempowers those impacted and it places an unnecessary burden on responders to “rescue” people that may not need rescuing. We need to change our mindset about those impacted by disasters and, instead of seeing them as victims, see their capacities and resources and help them leverage those assets. This is what North Charleston accomplished with their transfer housing during the flood, and it was highly successful.

## Recovery

**Planning for recovery.** In South Carolina, and globally, conceptualizing what long-term recovery should look like and coordinating it has been a major challenge. Governments and non-profit organizations involved in disaster risk management need to plan for recovery in advance of disasters. They need to ask themselves, based on previous experiences, what does long-term recovery entail and what can we do now before the next disaster, to ensure that recovery processes can begin sooner and that engagement around recovery can continue over the long-term. This could include maintaining relationships created during prior disasters, maintaining institutional memory, and engaging in lateral learning with other areas that have experienced disasters.

**Providing better recovery information.** Prior to disasters, residents need to understand what FEMA, SBA and private insurers will cover. In the recovery phase, residents need greater support in understanding their options. The role of disaster recovery centers should be expanded to provide household-level information that people need to support their own recovery. This could be modeled on existing programs such as the United Kingdom’s National Flood Forum, which advises people how to best get help and provides unbiased information and quotes on repairs/reinstatement after flood losses.

**Creating a more integrated, contextually-based system for damage assessment.** In both Columbia and Charleston, people expressed frustration with FEMA’s damage assessment process, and did not believe that the process fairly and accurately assessed damages. The damage assessment process needs revision; inspectors should be hired locally, have experience in damage assessment or home construction/maintenance, and should conduct more comprehensive assessments that look at the home as a whole space rather than a sum of individual parts. This would limit cases where the loss of moveable and non-critical possessions push homes into the ‘substantially damaged’ category.

**Using volunteers for recovery.** After disasters, particularly those that are highly publicized, there is usually an outpouring of volunteers who want to help in any way they can. Volunteer labor can significantly reduce the cost of reconstruction and repairs, and volunteer hours are often used by cities and counties to create a soft-match for FEMA funding. However, this requires knowledge of FEMA’s documentation requirements, what activities and hours FEMA will accept, and a system in place and operating across multiple organizations. This system needs to be put in place in advance of, or immediately following a disaster, in order to claim the thousands of donated volunteer hours.

Columbia, SC, 2015
Photo by Aon Benfield Impact Forecasting/Matt Schmitt & Steve Bowen

# CONCLUSIONS

*“These events should be a call to action, engaging cities nationwide to rethink their risk landscape and how they continue to modify it, regardless of whether or not they have faced floods in recent years.*

There is no doubt that the floods in both the Columbia and Charleston metro areas were extreme events. However, they are similar to past events in South Carolina, and current temperature, precipitation, and sea level trends suggest they will continue and may get worse. As we write, there are major floods unfolding in Houston, Texas, the second 100+ year flood the city has faced in 12 months. News articles about the floods bear headlines such as, “Stop building neighborhoods that cause other neighborhoods to flood” (Crossley, 2016), “‘Extremely High Risk Dams a Concern Amid Historic Houston Floods” (Borrello, 2016), “Houston flood damage: chronic, expensive, and avoidable” (Ferris, 2016), and “As floodwaters subside, housing fears swell up” (Elliot, 2016). All of these articles recount very similar narratives to those in South Carolina.

The impacts of floods are greatly influenced by age-old paradigms of engineering nature, pitting development against risk reduction, focusing on response and not planning for recovery. These events should be a call to action, engaging cities nationwide to rethink their risk landscape and how they continue to modify it, regardless of whether or not they have faced floods in recent years. These events should also push the nation as a whole to rethink what it means to recover from a disaster and how to leverage the recovery phase as an opportunity to build resilience.

Thanks to initiatives like the Resilient America Roundtable, 100 Resilient Cities, and a host of other locally driven initiatives, many people and places are already thinking about, discussing, and moving forward with resilience initiatives. The contention is around what it actually means to build resilience. Is it mitigation? Is it adaptation? In many places, the comfort is with mitigation; in particular, there is an expectation that protection structures will effectively and indefinitely protect people from certain types of extreme events. However, as cities, counties and states move forward with structural mitigation, they need to understand that structures can fail – globally, we regularly see extreme events overwhelm design standards. Therefore, risk perceptions and embedded knowledge and capacities on how to handle disasters should be maintained. Local governments should incentivize best building practices and "soft" mitigation actions such as leaving room for water, and recovery mechanisms should be strengthened. Building resilience to uncertainty is really about integrating mitigation, adaptation, and lessons learned from past events.

Columbia, SC, 2015
Photo by Aon Benfield Impact Forecasting/Matt Schmitt & Steve Bowen

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Columbia, SC, 2015
Photo by Aon Benfield Impact Forecasting/Matt Schmitt & Steve Bowen

This report presents a snapshot of events and responses during the October 2015 flood in South Carolina. It is not comprehensive - much more could be said on the degree of resilience of South Carolina's social-econolical systems during the floods. What this report does provide is a collection of short, field-tested examples of resilient systems and actions and a discussion of what it is that makes those resilient. It also describes factors which limited the ability of people and systems to weather the storm.



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