Hurricane Florence: Building resilience for the new normal

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Foreword

When people live through a catastrophic event their experience becomes a milestone moment that colors everything moving forward. However, the intense colors, so clear directly in the aftermath, soon fade.

Many of the people interviewed for this review expressed the feeling that what happened during Florence was an anomaly. That it is unlikely to happen again. This sentiment is not unique to North Carolinians. From Southern Germany to South Carolina, from Naples, Italy to Nepal, and now in North Carolina, we find people view "their" storm as unique.

This new study on Florence is our 14th post-event review of flooding events. We focus on floods because they affect more people globally than any other natural hazard – 250 million people each year. We focus on opportunities and successes and what we can learn from these events to help people in North Carolina and elsewhere avoid or reduce losses. We thank everyone who took the time to engage with us for their hospitality, and their generosity in sharing everything they learned from this disastrous event.

In my role as chief claims officer for Zurich North America and 30 years helping customers resolve insurance claims, I've seen firsthand how resilient people and businesses can be – able to overcome and persevere through some of the most devastating experiences. However, it usually takes a trailblazer to insist on change and build back better or develop something innovative and new.

We are proud to feature several trailblazers in this report including Captain Terry Bragg, a retired navy captain and the executive director of the Battleship North Carolina, the State's living memorial to their WWII veterans and the 11,000 North Carolinians who gave their lives during World War II. Captain Bragg has launched a campaign to preserve the battleship in an innovative way that focuses on living with water instead of fighting against it.

We also revisit Charleston, South Carolina, where we conducted a study of the floods in 2015. In the past three years, the Charleston tri-county region has taken action, from siloed efforts to building the networks needed for collaborative action. These and other examples of embracing and acting in response to challenges and change blaze a trail for the rest of the nation.

We encourage those reading this report to act on what they read. Zurich itself is taking a direct recommendation from this and many other post-event reviews which call for greater clarity and understanding of insurance offerings available to mitigate losses from severe weather events and include options for building resilience. With the release of this review, we are developing a new training program for the insurance community that will educate brokers and customers on the methodology used to complete these post-event reviews, as well as explain the types of insurance offerings and resilience measures available to businesses.

We live in a fast-paced world – one that seems to move faster every day. It is easy to confront the next challenge without taking a step back to examine what can be learned from prior events. This is why this review and the many others conducted over the years are so important. After a disaster is an opportune time to keep our sights on resilience.

Best regards,

Paul Lavelle
Chief Claims Officer
Zurich North America

Executive Summary

On September 14th, 2018 Hurricane Florence made landfall near Wrightsville Beach, North Carolina as a category 1 hurricane. Florence's extremely slow progression inland, coupled with its status as the wettest tropical storm to hit the Carolinas, resulted in catastrophic flooding.

The storm, together with riverine flooding and storm surge caused over 50 fatalities[1], approximately 2,600 rescues, and 15,000 people to seek emergency shelter[2].
The storm resulted in an estimated USD $17 billion in damages to residences, businesses and industry in North Carolina[3]. Like Hurricane Matthew in 2016 and Hurricane Floyd in 1999, the flooding from Hurricane Florence pushed the region to its breaking point, highlighting both where people had learned from prior storms and where challenges remain.

This study, written in collaboration by Zurich North America, the Zurich Flood Resilience Alliance, and ISET-International[4], looks in detail at the floods and their consequences that resulted from Hurricane Florence in North Carolina. Based on interviews with impacted households and businesses, and with people involved in risk reduction, response and recovery at the city, county and state level, as well as researchers and those within the nonprofit sector, the study identifies lessons learned from Florence and provides tangible recommendations for enhancing flood resilience, which we believe can be applied to communities around the world that are exposed to flood risk.

Our key findings revolve around a variety of human, social, economical and political themes. Society continues to support and subsidize investment and unprotected development in high-risk areas such as exposed coasts and river inlets. Insurance that does not accurately price for risk exacerbates the problem. The consequences of Hurricane Florence themselves were exacerbated by secondary failures and losses beyond the immediate property losses, such as outflow and subsequent contamination of the environment by harmful human, agricultural and industrial waste. These problems are technologically solved but are not socio-economically implemented in many cases. This calls for better regulation in some situations where it is not yet available, and in others for a better enforcement where regulation already exists.

Some of these consequences, especially as they occur downstream of big industrial and agricultural complexes, but also in less affluent environments, hit the socially vulnerable the most. We have seen not only in Florence but earlier events that floods and other natural hazards contribute to marginalizing vulnerable populations and communities.

On a more technical level, we still find that adequate hazard mapping, identifying and managing risk through exposure and vulnerability control, communicating possible consequences as early warning messages, and getting stakeholders to take the right and timely action are challenging. Not everyone evacuated when they should have, others did not take adequate precautions to limit losses and consequences, and many failed to understand the consequences that Florence would bring. In part, explaining how dangerous storms can be only by identifying the wind force using the Saffir-Simpson-Scale is missing the flood threat that such storms bring more often and more intensely.

The key insights and recommendations outlined in this report are part of a wider series of post-event reviews, using the Post Event Review Capability (PERC) methodology, that the Zurich Flood Resilience Alliance has been conducting since 2013. The trends are clear – impacts from disasters are getting worse. After a disaster there is rarely the time to learn what happened and what could be done better in the future. However, the recovery period is also a key window of opportunity to take action to reduce future risk. The PERC methodology (publicly available at: floodresilience.net/PERC) helps meet this urgent need. PERCs generate actionable recommendations for reducing future damages right when they are needed most[5]. The aim is to answer questions related to various aspects of flood resilience, including flood risk management, catastrophe intervention and recovery. It looks at what has worked well, shares best practices, and identifies opportunities where there is room for further improvements. This report follows 13 PERC studies conducted over the past five years and adds to the global insights gathered from previous big flood events. It also complements prior studies conducted in the U.S. by ISET-International and the Zurich Flood Resilience Alliance following flooding from intense rainfall – in Boulder, Colorado in 2013 – from intense rainfall and high tides – the South Carolina floods of 2015 – as well as from flooding from a slow moving immense storm – Hurricane Harvey in Houston, Texas in 2017.

KEY TAKEAWAYS

- Weather events are changing in nature as climate has visibly changed and sea levels have visibility risen
- Economic motivators can be used as levers for both action and inaction
- Floods contribute to marginalizing vulnerable communities
- The Saffir-Simpson Scale is not sufficient to explain hurricane consequences
- Shift from siloed interventions to a holistic approach
- Now is the time to act on building in community-level resilience
- Critically assess where all stakeholders chose to build
- Insurance plays an important role in resilience

PERC METHODOLOGY

- Pre-event context
- Analyze the event
- Post-event context based on in-person field interviews

1 The Washington Post, March 21, 2019 "Florence and Michael permanently retired from list of Atlantic hurricane names." Brian McNoldy.
2 CNN, September 18, 2018. "These are the staggering numbers behind Florence's wrath." Holly Yan.
3 North Carolina State Office of Budget and Management, October 26, 2018. "Hurricane Florence Recovery Recommendations."
4 ISET-International is a non-profit organization committed to building resilience and catalyzing adaptation to critical social and environmental challenges. www.i-s-e-t.org
5 A summary of key global lessons gleaned from the full library of PERC reports to date can be found in "Zurich's Post-Event Review Capability: Global lessons for reducing risk and increasing resilience."

Section I:
The Physical Context

Hurricane Florence, which initially looked like it would make landfall in North Carolina as a Category 4 hurricane, came ashore on September 14th, 2018 near Wrightsville Beach, North Carolina as a Category 1 hurricane, bringing with it a 10-foot storm surge and wind gusts up to 112 mph[6].

As Florence moved inland, it was downgraded to a Tropical Storm. Due to a ridge of high pressure to the west, which prevented the system from advancing quickly, the storm dumped over 35 inches of rain over the next four days leading causing widespread riverine flooding across North Carolina and neighboring states in addition to storm surge and estuarine flooding.

The storm and ensuing floods resulted in over 50 fatalities[7], close to 3,000 rescues, and left over 500,000 customers without power for several days[8]. Both minor and major roads were flooded, including sections of I-40 and I-95, limiting mobility, hampering response, and in some places isolating communities for day.[9]

Overall, the storm is estimated to have caused $17 billion[10] in damages with impacts to residences, businesses and the agricultural sector, with only $5.3 billion covered by insurance[11]. 30 percent of households in North Carolina were impacted by the storm, at an estimated cost of $5.6 billion, and 26,800 businesses suffered an estimated $5.7 billion in damages from water and wind effects and associated losses[12]. Many of these homes and businesses were still struggling to recover from Hurricane Matthew in 2016, which further amplified the impacts of Florence. Impacts to schools, medical centers, food banks and other critical infrastructure hampered response and slowed recovery. In some communities, such as New Bern, public schools were closed for a month. Statewide, $23.5 million was allocated towards school repairs in the recent Senate Bill 823 passed in late 2018.

Impacts to the state's agricultural sector were also severe. Total agricultural damages have been estimated at $2.4 billion. Impacts include the death of 4.1 million chickens/turkeys and 5,500 hogs, $987 million worth of lost crops, and $117.7 million in damage to farm infrastructure. Close to 10,000 farmers and thousands of farmworkers, many who are migrant laborers, were impacted by these damages, and impacts will continue to accrue over what would have been the animal lifespans and cropping cycle.

FLORENCE BY THE NUMBERS

Over 50 fatalities[17]

~2,600 rescues[18]

$17 billion in damage[19]

$5.3 billion insured damage[20]

$648 million paid in NFIP claims[21]

$11.7 billion protection gap

AGRICULTURE IMPACT

$2.4 billion in agriculture damage to crops and livestock[12]

10,000 farms impacted

4.1 million poultry lost[13]

5,500 hogs lost[13]

INFRASTRUCTURE IMPACT

129 roads closed (including sections of I-40 and I-95)[22]

~ 500,000 people lost power[17]

6 CNN, September 18, 2018. "These are the staggering numbers behind Florence's wrath." Holly Yan.
7 The Washington Post, March 21, 2019 "Florence and Michael permanently retired from list of Atlantic hurricane names." Brian McNoldy.
8 CNN, September 18, 2018. "These are the staggering numbers behind Florence's wrath." Holly Yan.
9 CNN, September 18, 2018. "These are the staggering numbers behind Florence's wrath." Holly Yan.
10 North Carolina State Office of Budget and Management, October 26, 2018. "Hurricane Florence Recovery Recommendations."
11 Aon Benfield, 2019. Weather, Climate & Catastrophe Insight: 2018 Annual Report.
12 North Carolina State Office of Budget and Management, October 26, 2018. "Hurricane Florence Recovery Recommendations."
13 North Carolina State Office of Budget and Management, October 26, 2018. "Hurricane Florence Recovery Recommendations."
14 The Charlotte Observer, September 18, 2018. "Florence kills 4.1 million chickens and turkeys, 5,500 pigs in NC." Kevin Keister.
15 The News & Observer, September 26, 2018. "Agriculture losses from Hurricane Florence will top $1.1 billion, and that's just in NC." Richard Stradling.
16 North Carolina State Office of Budget and Management, October 26, 2018. "Hurricane Florence Recovery Recommendations."
17 The Washington Post, March 21, 2019 "Florence and Michael permanently retired from list of Atlantic hurricane names." Brian McNoldy.
18 CNN, September 18, 2018. "These are the staggering numbers behind Florence's wrath." Holly Yan.
19 North Carolina State Office of Budget and Management, October 26, 2018. "Hurricane Florence Recovery Recommendations."
20 Aon Benfield, 2019. Weather, Climate & Catastrophe Insight: 2018 Annual Report.
21 FEMA, Significant Flood Events as of January 31, 2019. https://www.fema.gov/significant-flood-events
22 North Carolina Department of Transportation. October 3, 2019.

Previous events

Flooding timeline in North Carolina

1916 tropical cyclone related flooding – Caused extensive and destructive flooding, particularly in the western third of NC. In Altapass, NC, 22.22 inches of rain fell in 24 hours. Lives lost, 80; damages, $22 million (1916 USD).

1933 Outer Banks hurricane – Heavily damaged southeastern NC near New Bern. Storm tides rose 2 feet above previous high-water marks, flooding much of the town. Lives lost, 21 (mostly due to drowning); damage, $3 million.

1940 South Carolina hurricane – Category 2 hurricane that dropped over 15 inches of rain across northern NC, resulting in flooding and once in a century landslides.

1944 Great Atlantic Hurricane – Passed over the Outer Banks with Category 3 winds, knocking out telecommunications networks and leveling small homes. Storm surge pushed coastal flooding 50' inland, destroyed hundreds of boats and boardwalks, inundated coastal farmland and destroyed crops.

1945 Homestead Hurricane – Storm-related heavy rainfall caused flash flooding, particularly along the Cape Fear River in NC. The Cape Fear River at Fayetteville was 34 feet above flood stage. Flooding also occurred on the upper Neuse, Haw, Cape Fear, Lumber, Rocky, and lower Pee Dee Rivers.

1954 Hurricane Hazel – Made landfall as a Category 4 with a storm surge of over 18 ft. Landfall coincided with the highest lunar tide of the year, exacerbating coastal damage. The official report from the Weather Bureau in Raleigh stated that "all traces of civilization on the immediate waterfront between the state line and Cape Fear were practically annihilated." Major flooding also occurred on the eastern coastal plain.

1955 Hurricanes Connie, Diane and Ione – Hurricanes Connie and Diane resulted in major flooding in the estuaries of the Neuse and Pamlico Rivers with damages of $58 million. Hurricane Ione caused flooding from New River to Chowan River, killed 7, and resulted in damages of $88 million.

1995 Tropical Storm Jerry – Resulted in up to 10 inches of rainfall in southwestern North Carolina and set flood stage records in Charlotte and Mecklenburg County. Lives lost, 3; damages: $11 million.

1996 Hurricanes Bertha and Fran – Hurricane Bertha made landfall on the North Carolina coast as a Category 2, causing a total of 12 deaths and $335 million in damage. A little over a month later Hurricane Fran made landfall in the same general area with a 12-foot storm surge, unexpectedly high wind damage, intense rains and dangerous river flooding, causing 37 deaths and $5 billion in damage. These were the first really significant storms to hit the NC coast in over three decades.

1999 Hurricane Floyd – Category 2 storm that dropped 15 to 20 inches of rain across the Coastal Plain, resulting in record–breaking flooding in the eastern portion of North Carolina. Lives lost, 52; damages: $8.58 billion, making it the costliest hurricane on record for the state, at that time.

2004 Hurricanes Frances and Ivan – The remnants of Hurricane Frances dropped 8 to 15+ inches of rainfall in the SW mountains of North Carolina, causing widespread flooding across the region. Nine days later, the remnants of Hurricane Ivan brought an additional 4 to 8 inches of rainfall, resulting in repeated flooding and numerous landslides. Combined, Frances and Ivan resulted in 11 fatalities and $252 million in damage.

2011 Hurricane Irene – Hit the Outer Banks as a Category 1 storm. Some coastal towns received more than 32 inches of rain. Rain and high winds forced at least 10,000 people into shelters and caused extensive damage. Lives lost, 7; damages: $53 million in North Carolina and over $15 billion nationwide.

2016 Hurricane Matthew – Category 1 storm which resulted in 3 to more than 15 inches of rain across the central and eastern parts of the state, causing major flooding. USGS streamgages recorded peaks of record at 26 locations. Lives lost, 28; in North Carolina and 5 in South Carolina; damages: $1.5 billion, including 100,000 structures.

2018 Hurricane Florence – Made landfall as a large, slow-moving Category 1 storm. Maximum 4-day total rainfalls of almost 36 inches set new statewide rainfall records exceeding the previous NC 4-day rainfall record from Hurricane Floyd of 24.06 inches in Southport. New peak streamflow records were set at 28 USGS streamgages.

2018 Hurricane Michael – Less than a month after Hurricane Florence, remnants of Michael moved through NC with severe winds. Particularly for homes damaged by Florence, Michael further exacerbated damages. 490,000 Duke Energy customers were left without power; 342,000 remained without power 24 hours later.

Florence was the third major hurricane to impact North Carolina in 19 years. Hurricane Floyd in 1999 and Hurricane Matthew in 2016 are commonly referred to by North Carolinians as they discuss Florence.

Hurricane Floyd

Hurricane Floyd made landfall in Cape Fear in southeastern North Carolina as a very strong Category 2 hurricane. Floyd produced torrential rainfall, including 19 inches in Wilmington and 24 inches in Southport, adding more rain to an area that had received up to 15 inches of rain from Hurricane Dennis just weeks earlier. The rains caused widespread flooding over a period of several weeks. Nearly every river basin in the eastern part of the state exceeded 500-year flood levels. In total, Floyd was responsible for 57 fatalities, 51 of them in North Carolina, and $6.5 billion (1999) in damage, much of that from freshwater flooding. Storm surge along the southeastern portion of the state reached 9–10 ft (2.7–3.0 m). Damage to power lines left over 500,000 customers without electricity at some point during the storm's passage.

Hurricane Matthew

Hurricane Matthew made landfall in the continental United States near McClellanville, South Carolina as a Category 1 hurricane on the morning of October 8, 2016. Matthew killed 47 people in total, 26 in North Carolina and 4 in South Carolina. Flooding shut down sections of Interstate 95 in South and North Carolina. In North Carolina, sections of the interstate were closed for over a week. Across South Carolina, at least 600,000 individuals lost power and significant flooding occurred in Charleston after a seawall was breached. In North Carolina, 680,000 individuals lost power, roughly 100,000 structures were flooded across the state, and damage reached $1.5 billion. River stage records were set on the Lumber River near Lumberton, the Neuse River in Smithfield and Kinston, and the Tar River near Greenville. Many of these areas were still struggling to recover when Hurricane Florence hit.

Hurricane Threat – Can a Category 1 storm be more dangerous than a Category 4?

The Saffir-Simpson wind scale was introduced in 1973 to describe the wind speed and associated danger of hurricanes. The challenge with the Saffir-Simpson rating system is that it only describes wind speed. What makes hurricanes dangerous includes not just wind but also storm surge, tides, and rainfall, and effects depend on where you're located.

As the National Hurricane Center notes "Hurricanes reaching Category 3 and higher are considered major hurricanes because of their potential for significant loss of life and damage. Category 1 and 2 storms are still dangerous, however, and require preventative measures."[23]

Hurricanes Floyd, Matthew, Harvey and Florence are among the most memorable and expensive of all storms to hit the continental United States in the last several years, yet their destructive power lay not in their wind speed but in their size, slow forward motion, and in the moisture they carried. All four of these storms resulted in torrential flooding and damages that extended far inland.

For communities on rivers and in low-lying areas well inland, these slow, wet, enormous storms pose a far greater risk than the rarer Category 4 and 5 hurricanes, which rapidly lose strength over land. Unfortunately, these huge, wet, slow storms seem to be growing more frequent. Sea surface temperatures have warmed, resulting in larger, wetter hurricanes. At the same time, stronger, stationary high pressure systems are more frequently slowing the forward motion of hurricanes as they make landfall, resulting in massive amounts of rainfall.

We will no doubt continue to be challenged by Category 4 and 5 storms, and their destructive power is immense. Hurricanes Irma and Maria in 2017 and Hurricane Michael in 2018 clearly illustrate this. At the same time, however, we need to recognize the equally immense risk posed by large, wet, slow Category 1 and 2 storms. They may leave buildings standing behind them, but three feet of water can be nearly as destructive of lives and livelihoods as a completely demolished building, and the footprint of where and who those storms impact can be much larger and extend far further inland.

23 National Hurricane Center. Saffir-Simpson Hurricane Wind Scale. https://www.nhc.noaa.gov/aboutsshws.php

Section II: Socio-Economic Disaster Landscape

Hurricanes are complex storm events that include hazards from high wind, storm surge, tornados and rainfall. The exposure to these multiple threats varies from storm to storm based on specific location and geography. Policy and regulatory decisions that fail to discourage development in highly exposed areas, or fail to encourage development in ways that acknowledge and address that exposure, are resulting in increased flood risk statewide. This risk is further exacerbated by development and an increase in impermeable surfaces, by poor stormwater management practices, by environmental degradation, and by observed changes in sea level rise and intensification of storm events, all of which increase individual and community vulnerability to storm damage.

Physical Landscape

Hurricanes Floyd, Matthew and Florence all brought with them high winds and storm surge that impacted towns on barrier islands and the coast. In Wilmington, Florence's high winds and storm surge damaged infrastructure, but it was inland flooding of roads that left the city inaccessible for over a week. Farther inland but east of the Piedmont, the intense rainfall associated with these storms caused extreme flooding, particularly for communities along rivers. In Lumberton, for example, as for many towns in the coastal plain, flooding badly impacted homes and the business districts when the river flowed over its banks in response to Florence and Matthew's intense rainfall. The impacts of that river flooding were magnified by already high water tables, flat low-lying land and poor drainage.

Some of Floyd, Matthew and Florence's greatest impacts, however, lie between the coast and the region just inland from the coast. In particular, coastal communities that sit at the mouths of large rivers experience dramatically amplified flooding when storm surge pushing inland meets floodwaters moving downriver. During Florence, New Bern, which sits at the confluence of the Neuse and Trent Rivers where they become tidally influenced, experienced a 10 foot storm surge as ocean waters were pushed up into the river mouth, flooding homes and the downtown business district and prompting over 100 rescues.

Sea level rise and increasing rainfall intensity is exacerbating all three of these types of flooding in North Carolina and placing more people and communities at risk. In the past 100 years, sea levels have risen nine inches and the rate at which sea level is rising has sped up over the past several decades. This sea level rise is placing more development at risk, and is starting to lower the values of real estate in coastal areas in the United States (see Figure 1).

It is also increasing coastal erosion rates, which results in less of a buffer for coastal infrastructure and increases the potential for damage from storms. High seas also mean higher storm surge levels during extreme events, and slower drainage of inland rivers in response to intense rainfall. When coupled with more intense rainfall, for example the 36 inches in four days seen in Florence as opposed to the previous record of 24 inches in four days seen in Floyd, the flooding experienced during Florence is unsurprising.

One of the drivers behind the increase in rainfall intensity and larger, wetter storms, is warmer sea surface temperatures. This is increasingly overwhelming drainage and water conveyance structures such as culverts and ditches. As they back up, floodwaters rise behind them, flooding surrounding land and buildings and impacting critical services. In 2018, this was further exacerbated by much higher than normal rainfall – about 100 inches rather than the annual average of 52 inches – which resulted in water tables remaining high for months. This left no capacity for the ground to store rainfall, making flooding worse, and causing many wastewater systems that rely on infiltration – including septic tanks, land application, public systems, and stormwater systems – to fail.

Another of the critical services increasingly impacted by flooding is transportation. Across the United States, transportation routes not built for the kinds of storms that are now occurring are increasingly flooding during storms. Both I-95 and I-40 in North Carolina were closed in multiple locations during and following Florence. The roads are not built high enough or with enough space for water to flow around and under them. Most were also built to remain operational in 100-year or smaller event, with no plan for how to communicate or address more extreme events. Yet increasingly public expectation is that they will remain operational in events more severe than the 100-year storm.

A five state analysis of total homes that lost value due to sea level rise and flooding

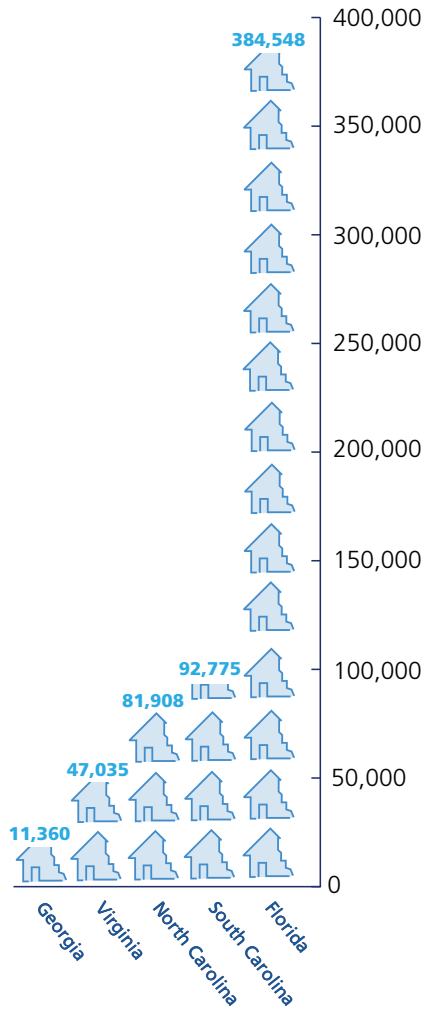


Figure 1: Home Value Loss Due to Sea Level Rise and Flooding. (Source: First Street Foundation, 2018).

These closures create cascading impacts by hindering evacuation and rescues and limiting the ability of responders and needed supplies to reach impacted communities. These closures also prevent and/or slow goods and services from reaching people and places not otherwise impacted by the storm. If we want these roads to remain open during extreme events like Matthew and Florence, they need to be built with such scenarios in mind and in coordination with other agencies who could outline additional benefits and ensure integration of further needs.

Population Change

Counties around Charlotte, the Triangle area[24], and coastal counties saw an increase in the population in the floodplain from 2000-2016. The increase in hurricane intensity coupled with population growth in or around floodplains means that, without some change in awareness, preparedness, and risk reduction, the social and economic impacts of major natural hazard events like Floyd, Matthew and Florence will continue to increase until we begin to factor resilience into our decision-making. To address this, we need to be more intentional about where we build, how we build, and in managing our expectations for how we will live within and interact with our environment to stay safe.

"Across the United States, transportation routes not built for the kinds of storms that are now occurring are increasingly flooding during storms."

24 The Triangle, shorthand for "The Research Triangle" is a region in North Carolina that consists of the cities of Raleigh, Durham, and Chapel Hill and the three research universities they house: Duke University, the University of Carolina Chapel Hill and North Carolina State University.

Understanding the Risk Landscape

To understand the varying levels of flood risk across a region or a state, we need to unpack risk into its three main components: hazard, exposure and vulnerability and be able to locate them geographically. A hazard, such as a natural flood, on its own does not necessarily create humanitarian problems and disaster risk. Hazards have the potential to become disasters only when assets are exposed to them, e.g. communities are built in floodplains – and those exposed assets are vulnerable to the hazards, e.g. the structures built in the floodplain are not elevated well above base flood elevation. Flood maps address the first two of these three components. In the United States this is typically done through FEMA and its Flood Insurance Rate Maps (FIRM).

FIRMs are produced at the community level. They are official maps that delineate both the special flood hazard areas (such as floodways and 100-year return period and 500-year return period flood zones) and the risk premium zones applicable to a community. The intent of these maps is to highlight areas prone to flooding so that development in those areas can be limited (to lower the potential exposure), to outline the need for flood protection or different building standards (to lower the vulnerability), and to price flood insurance coverage (to address situations where the hazard, exposure and vulnerability result in losses). However, it is important to note FIRMs are just hazard maps – they do not look at existing exposure or vulnerability within a community, nor do they identify how a community should develop to minimize its exposure or vulnerability. They also typically only address riverine flooding. The potential for flooding caused by overland runoff, poor or blocked drainage, and storm surge are not included on these maps.

In North Carolina, in 2001 following Hurricane Floyd, FEMA delegated authority to North Carolina to develop a state flood mapping program. The North Carolina Division of Emergency Management (NCDEM) creates and updates flood maps that are relatively uniform across the state, provides support and knowledge to local communities around flooding, and supports the use of flood maps in decision-making leading up to and during flood events. To support this third effort, the NCDEM developed FIMAN – the Flood Inundation Mapping and Alert Network. FIMAN[25] is a real-time tool that combines streamgage measurements taken by NCDEM and the USGS with elevations maps and aerial imagery to identify, down to the structure level, the flood hazard. As a real time system, it is used for emergency planning including alerts, for assessing evacuation situations, and also as a forward-looking scenario-based planning tool (which structures, roads, etc. would be at risk if the river streamgage exceeded various hypothetical levels).

FIMAN is interesting because it provides not only hazard information (maps highlighting areas where flooding from river systems can occur), but also flood risk information. Depending on the height of the flood waters, the exposure of buildings, roads, and infrastructure is identified, and based on the flood water depth in the buildings and associated building vulnerabilities (how quickly a structure is damaged), estimated damage costs are also displayed. This additional information could help reduce property damage and people affected if it was used to prioritize protection in areas with high loss potential and to avoid the additional creation of new risk in hazardous areas.

FIMAN, as is true of any model, has limitations. It's driven by river elevation and therefore doesn't address flooding caused by rainfall runoff, poor or blocked drainage, or storm surge. It's also reliant on a set of pre-generated libraries of flow levels – additional scenarios could be run, but they require a special request and a lot of computing power. Nonetheless, those working with FIMAN describe it as a successful state-of-the-art tool, which saw 50 million internet visits during Florence. The challenge now is to increase usage and further develop FIMAN's potential by enhancing its accuracy and better integrating it into early warning communication and using it more actively in designing and implementing risk reduction projects.

"Those working with FIMAN describe it as a successful state-of-the-art tool, which saw 50 million internet visits during Florence."

Socio-Economic Landscape

For many of the smaller, more socially vulnerable communities located in the state's coastal plain, the impact of Florence comes hard on the heels of a slow recovery from Matthew. This pattern of shortened recovery time and limited recovery support from various authorities exacerbates existing disparities in recovery. Higher income, better resourced and insured communities recover and rebuild faster, and more likely in time for the next storm, than their lower-income, resource scarce neighbors.

Recovery after Recovery

In 2016 Hurricane Matthew made landfall as a Category 1 hurricane and swept across North Carolina causing widespread flooding in the eastern part of the state. While $236.5 million of federal aid was allocated to help communities recover, there were delays in the disbursement of recovery funds to impacted communities. As a result, many smaller, more vulnerable communities, particularly in the eastern part of state, had not yet recovered when Hurricane Florence hit. These small towns were already struggling to keep up with employment trends that were shifting away

25 States and communities that do not have a similar program to FIMAN can obtain some benefit through the Hazus program offered by FEMA. https://www.fema.gov/hazus-mh-flood-model

from agriculture, manufacturing and textiles. Being hit hard in 2016 and again in 2018 may have pushed many of them past the point of where recovery will be possible.

The town of Lumberton, located in North Carolina's coastal plain in Robeson County, one of the poorer counties in the state, was one of the harder hit communities during Hurricane Matthew. With over a third of the population living in poverty and with several public housing complexes damaged, many residents did not have the resources they needed to rebuild. When Hurricane Florence hit, Lumberton was still waiting on recovery funds, meaning repairs to structures and homes damaged by Matthew hadn't even begun, resulting in compounded damage in Florence. Communities that are even smaller than Lumberton, like Fair Bluff and Princeville, with even fewer resources to begin with, may be unable to recover at all. Nearly all the small businesses in Fair Bluff were impacted by Matthew and only half had reopened by the time Florence hit and flooded them out again.

This experience is echoed in virtually all communities that experienced Florence. Based on Matthew and other previous storm experiences, many county and local level governments had updated zoning ordinances and codes in ways that successfully reduced flood impacts to new homes and businesses. Challenges persist, however, for neighborhoods and communities that consist of older buildings that are not up to present day code and that lack updated stormwater management systems. It was these older neighborhoods that flooded in Wilmington, for example.

Where change does not require new construction or retrofitting old construction, learning and implementing better practices based on past storms has been faster. North Carolina's experience with Hurricane Matthew in 2016 led to changes at both state and local levels in interagency coordination, communication between actors, the staging of key resources and an increased awareness of the need to prepare for recovery prior to an event. For example, the Food Bank of Central & Eastern North Carolina prepped branches and stocked local partners not just along the coast, but across the state in anticipation of inland flooding, which they hadn't done during Hurricane Matthew.

Environmental Risk

The flooding from Hurricane Florence brought to the forefront the environmental impacts of current industrial practices and the ongoing challenges associated with their management. Particular environmental issues that Hurricane Florence highlighted include:

- coal ash[26] disposal practices which resulted in coal ash spills into rivers,
- wastewater treatment plants spills and
- poultry and hog farms located in low-lying areas and floodplains where animal waste was mobilized and animals drowned.

In North Carolina, the energy industry and concentrated animal feeding operations (CAFOs) are powerful economic and political entities. Following Hurricanes Floyd, Matthew and now Florence, these industries and the existence and enforcement of rules regulating their waste storage and disposal practices have come under increased scrutiny.

Coal ash waste, a byproduct of burning coal in coal-fired power plants, has historically been disposed of in unlined storage pits in close proximity to rivers. Most hog farms in the state process their waste in open lagoons and with spray fields, and in spite of ongoing buy-out programs, many are located within the 100-year and 500-year flood plains. More recently, there are a growing number of highly unregulated poultry CAFOs within the state.

In Floyd, Matthew and Florence, there has been documented contamination of water and soil and catastrophic environmental disasters due to the escape of coal ash waste from storage pits and from hog waste lagoons breaches. Nonetheless, political response and regulatory change and enforcement has been limited. Instead, over the past decade, the Department of Environmental Quality has lost funding and staff, compromising their ability to address emergency and ongoing environmental monitoring and regulatory enforcement. In response, private and nonprofit entities including the Waterkeeper Alliance, riverkeepers, and the Southern Environmental Law Center (SELC) are taking an active role in environmental monitoring, tracking regulations violations, and through legislative efforts and lobbying. Despite these efforts, as of September 2018, when Hurricane Florence hit, numerous coal ash waste storage sites remained unmitigated, or were in the process of being mitigated but without safety measures in place to avoid toxic releases of waste to the environment. Sixty-three hog farms were still operating in the 100-year floodplain, and 4.1 million birds drowned inside CAFO barns.

Hog Waste

The state placed a moratorium on new hog waste lagoons in 1997. In 2007, the moratorium on new farms became permanent for those farms utilizing anaerobic waste systems (lagoons). New farms or farms that wish to expand are required to meet several performance standards that deal with the discharge of waste into surface and groundwater, atmospheric emissions, odor, pathogens dispersal and soil contamination. However, efforts to replace the lagoons with more environmentally sound options have, in the past, been met with resistance because of their expense. While the cost of these options has come down in recent years, few farms have adopted them.

Buy-outs of hog farms in the 100-year floodplains is slow and funding is limited – 43 farms have been bought out and currently funding is only available to buy out five to eight of the more than 45-62 remaining farms in the floodplain. Meanwhile, the documented links between hog farms and human health risks are increasing. Failure to proactively respond may be detrimental to the North Carolina hog industry in the long run. Poultry farms should consider taking similar preventative action for their – albeit different – operations.

Coal Ash

A 2014 law, the North Carolina Coal Ash Management Act, required state power utilities to excavate and close wet coal ash storage pits by 2029, required Duke Energy to excavate all the coal ash from four of its coal-fired plant sites, and put in place a process to evaluate whether the remaining 10 sites would be excavated. Excavation did not begin until after the passage of the Act in late 2014, a delay which led to at least one of the coal ash spills that occurred during Hurricane Florence. In comparison, just over the border in South Carolina, state-owned utility Santee Cooper had finished excavating the principal coal ash pit at its Conway facility in advance of Hurricane Florence's landfall, and erected a temporary, inflatable dam on top of the levee next to a second coal ash pit they were excavating. Floodwaters came within inches of the top of the temporary dam, but it held and an ash spill was avoided. The excavated pit was flooded, but the prior excavation avoided what could have been an expensive and damaging environmental catastrophe.

Wastewater Treatment Plants

Solutions for municipal wastewater treatment spills are a little more challenging. Unlike the hog and power industries, upgrading and/or relocating existing wastewater treatment plants falls directly on the taxpayer, it cannot be offset by income generating activities in the same way, and most municipalities that are dealing with overflow from their wastewater treatment plants are small and have a limited tax base. Recognizing the increasing intensity and frequency with which extreme rainfall events are occurring, and knowing the challenges such events pose for wastewater utilities, the state may need to work with these smaller communities to upgrade wastewater plants. Failure to do so could result in increased wastewater spills to state rivers and streams, with associated implications for the environment, including riverine and coastal fisheries, and downstream communities.

Coastal development

Along the coast, tourism and real estate development are the economic backbone for many communities. Despite a growing number of realtors in the industry openly acknowledging the risk to coastal properties from storm surge and beach erosion and emphasizing that property owners should consider location and buy flood insurance, people continue to develop and buy oceanfront properties. Yet these properties are becoming increasingly vulnerable. Beach erosion rates have accelerated over the past several decades and the demand for beach nourishment is increasing year-on-year. Nags Head beaches in Dare County, for example, are eroding at a rate of about six feet per year (North Carolina Division of Coastal Management). In response, the town of Nags Head is "spending $48 million – and raising taxes for property owners – dredging sand from the seafloor and pumping it onto beaches," the Washington Post reported (Aug 20 2018).

Beach nourishment projects are increasingly used to combat coastal erosion. Beach nourishment involves taking sand from an offshore area and pumping it onshore where it is sculpted into dunes and beach. As seas rise, larger and more frequent enhancement is required, and as a result the cost of these projects is increasing. At some point in the future, beach nourishment will no longer be economically feasible.

Currently, beach nourishment projects are supporting continued development in high hazard areas along the coast. Beach nourishment projects initially funded with local and state tax dollars are defined by FEMA as "public infrastructure" eligible for disaster aid to rebuild them, just as money is provided for school and courthouses. However, flood insurance is not required for beaches, as it is for structures, and beaches are eligible for repeat loss payouts. FEMA payouts to beach towns are some of the biggest disaster bills after a storm paid by the federal government. This aid has resulted in continued federal expenditures on beach renourishment without Congress ever authorizing new federal beach renourishment projects.

This type of aid raises concerns regarding who should ultimately pay for the inherent risk of businesses and homeowners in risk-prone areas along the coast – the federal government, the state government, or the business owners and residents who choose to work and live in these environments? How this question is answered highlights how risky behavior can be incentivized. As long as taxpayers subsidize coastal fortification and maintenance, there is little incentive to retreat from the coast as risk increases. It also highlights the increasing economic risk under which we are placing these communities. By masking the true risks and costs, we are negating market signals that would allow for gradual conversion of these economies and assets.

In contrast to beach nourishment and coastal fortification through sea walls is the implementation of living shorelines at the mouths of coastal rivers. These nature based projects protect the shoreline by replacing harder infrastructure materials such as bulwarks with materials such as plants and sand. Over the past several years communities and local governments have increasingly turned towards this green/soft infrastructure solution to protect vulnerable areas along coastal rivers and estuaries. Studies have shown that living shorelines are less susceptible to erosion than harder infrastructure solutions such as bulwarks. They also support estuarine and coastal habitat and key ecosystem services, particularly fisheries. Though not applicable everywhere, where they can be used, as the authors of one such study note, "living shorelines may be a rare win-win solution, whereby they help to reduce saltmarsh loss over the long term by buffering waves and increasing rates of sediment accretion, but also offer increased resistance during storms without the high rates of damage that have been attributed to traditional hardened infrastructure."

26 Coal ash, the powdery remnants of coal burned at power plants, is a toxic substance that poses risks to environmental and public health.

27 North Carolina Department of Agriculture & Consumer Services. "Swine Floodplain Buyout."

28 NC Policy Watch, October 4, 2018. "What's next for proven, but underfunded hog buyout program after Florence?" Lisa Sorg.

29 Kravchenko, J., Rhew, S. H., Akushevich, I., Agarwal, P., & Lyerly, H. K. (2018). Mortality and Health Outcomes in North Carolina Communities Located in Close Proximity to Hog Concentrated Animal Feeding Operations. North Carolina medical journal, 79(5), 278-288.

30 NC S729| 2013-2014 | Regular Session. (2013, September 20). LegiScan. Retrieved April 04, 2019, from https://legiscan.com/NC/research/S729.

31 Smith, C. S., Puckett, B., Gittman, R. K., & Peterson, C. H. (2018). Living shorelines enhanced the resilience of saltmarshes to Hurricane Matthew (2016). Ecological applications, 28(4), 871-877.

Section III: What Happened?

Florence pushed the region to its breaking point. Coastal communities located at the mouth of or alongside rivers experienced the dual impacts of coastal storm surge and riverine flooding while more inland communities were inundated by historic rainfall and flood waters from nearby rivers. The floods caused widespread damage to homes, businesses and key industries both within and outside mapped floodplains, and released contamination from wastewater treatment plants, hog and chicken farms, and power plants. In some communities, cascading failures exacerbated the primary and secondary impacts of the floods. Towns lost power and floodwaters made over 200 roads across the state impassable, including two major interstates, I-40 and I-95, isolating communities for days.

Response

Given the expected intensity of the storm, many coastal towns, beaches, and inland communities issued mandatory and voluntary evacuation orders in the days leading up to the storm. For Craven County, the decision to issue a mandatory evacuation for the entire county for the first time ever was based on the modelled impacts of a Category 4 storm across the eastern coastline. The projected 13-15 foot storm surge would have enveloped 80 percent of the population across the county[32]. On top of these evacuation notices, Governor Roy Cooper also issued the state's first mandatory evacuation order for the Barrier Islands.

As it neared the North Carolina coast Florence weakened, making landfall as a Category 1 hurricane on Friday morning. By Friday evening Florence was downgraded to a tropical storm. These categorizations, however, were based on the Saffir-Simpson scale, which estimates damage from wind but does not account for the impacts of storm surge or rainfall. When the storm was downgraded, many people chose to disregard the mandatory evacuation orders and ride out the storm at their homes, only realizing later the limitations of the Saffir-Simpson categorization when a 10 foot storm surge came up the Neuse river and inundated homes in New Bern, when floodwaters isolated the city of Wilmington, and when power outages lasted for days, taking with them refrigerators, freezers, air conditioning and every other service requiring power.

Pre-deploying state and federal resources in advance of the storm was, for the most part, effective. However, the scale of the event rapidly outpaced planned response. Craven County, for example, received 1,800 calls for emergency evacuation over the course of six hours. Emergency responders rescued 400 people from homes in one neighborhood alone in Wilmington as floodwaters set in. These demands for emergency rescue and shelters rapidly outpaced local capacity. Capacity was further limited as some pre-identified shelters were impacted by wind and floodwaters and a couple others by generator failures which required them to be re-established elsewhere. As a result, the number of people needing shelter rapidly increased during the storm and many shelters were overwhelmed.

As part of the Coastal Region Evacuation and Sheltering Plan (CRES), the state opened several shelters in inland counties in advance of the storm. Nonetheless, during the storm both Craven County and New Hanover County had to open several "shelters of last resort" to house those who had not evacuated to inland shelters and to accommodate the increasing numbers seeking shelter as their homes unexpectedly flooded. Demand for shelters was exacerbated by cascading failures of water, power and evacuation routes in the city of Wilmington, with people seeking shelter a day or two after landfall because of power and water outages which extended far beyond anything they had envisioned and had more far-reaching impacts than anticipated.

In Wilmington, a third, unexpected wave of sheltering demand hit a week to 10 days post-landfall just as the county was preparing to start closing shelters. Many of the hardest hit properties in the city were inexpensive apartments in low-lying parts of town. In the hot, humid aftermath of the storm, water-damaged properties rapidly started to mold and landlords began issuing lease termination notices, in many cases giving residents no more than a week to move out themselves and all their belongings. With affordable and section 8[33] housing options already in tight supply and with no other immediate options, many of these residents were forced to seek county housing support.

Recovery

As impacted communities transition from response to recovery, some communities are faring better than others. Households and businesses with assets and insurance are, in general, recovering better than those without. Communities that were still dealing with the aftermath of Hurricane Matthew in 2016 when Florence hit are faced with the challenges of navigating two parallel recoveries.

Since Hurricane Matthew, North Carolina has increased its capacity and understanding of the integrated nature of short-term and long-term recovery and how decisions made during the response and early recovery can influence longer-term recovery. Leveraging this experience, the state activated their state recovery task force and are staffing full-time positions devoted to recovery to ensure continuity of operations when the federal government completes response and early recovery engagement and reduces their support. Nonprofits that support recovery are similarly settling in for the long-term, knowing that for many people and communities, long-term recovery takes years.

Even those best positioned to recover quickly – households and businesses with assets, comprehensive insurance coverage that paid out quickly, buildings that had been well maintained so damages were minimized, an existing network of contractors and builders they could put to work immediately, and the knowledge and skills needed to navigate

32 PERC interviews. January 2019.

33 The Housing Choice Voucher Program Section 8 is a U.S federal government program which provides rental housing assistance to low-income families.

challenges – are only just completing repairs, six months post-Florence, to buildings that received a couple of feet of water. For structures that were more heavily impacted or for households and businesses with anything less than the perfect recovery scenario, it is almost impossible to re-establish a "normal" life in less than a year, and some things can never be recovered.

The natural environment was also badly damaged by Florence. About 39.3 million gallons of raw or partially treated human sewage spilled into the Cape Fear River from Greensboro to New Hanover County due to overwhelmed wastewater treatment systems, power outages, equipment failures and "severe natural conditions" (The Fayetteville Observer, Oct 13, 2018, "What Florence left in the Cape Fear"). Hog and poultry waste, fertilizers, and pesticides were flushed from thousands of acres of land. And failures of coal ash waste storage sites released heavy metals, which can cause cancer, nervous system impacts, developmental delays, and a host of other health issues, into rivers. In particular, during Hurricane Florence, at the Sutton power plant outside Wilmington, heavy rains caused the wall of a coal ash landfill to fail and flood waters inundated old coal ash pits that had not been fully excavated, resulting in nearly 2,000 cubic yards of coal ash being released into Sutton Lake and to the Cape Fear River.

In the short-term, these events badly contaminate flood waters, with associated human health risks. There can also be lasting impacts. For example, excess nutrients from fertilizers and human, poultry and hog waste released into the environment left the lower section of the Cape Fear River, from Sutton Lake to the ocean, completely without oxygen, killing off any life the river contained including thousands of fish. Where fish and other wildlife survived, they are likely contaminated, as are river sediments. Many of the industrial pollutants, including the heavy metals from coal ash, have poorly understood health risks and may persist for extended periods in the river sediments. A University of North Carolina Wilmington marine biologist noted "The big catfish are loaded with mercury. I wouldn't eat them." (The Fayetteville Observer, Oct 13, 2018)

The numbers are only one side of the story

Calculations of losses and damages caused by flooding are usually numerically based assessments that provide a summary of the impacts of the floods to industry, infrastructure, human lives and the economy. While these numbers provide one measure of the extent of the impacts, what they leave out are the stories behind those numbers, stories that reveal the limitations of how we assess financial damage to buildings and activities without taking into account the cascading impacts that flooding can have on people's livelihoods and wellbeing.

The storm disrupted day to day life for many students of the Girls Leadership Academy of Wilmington (GLOW Academy), a single gender 6th through 12th grade charter school to prepare first generation college students in Wilmington. Families lost affordable housing, parents could not get to work, and students experienced a three week school closure. These events are a challenge for any family, but for families like those of many of the GLOW students who face chronic financial and life stress, the impact of these events was magnified.

The school assisted families in applying for FEMA support. However, that support only goes so far. It doesn't make up for lost opportunity – for these students the three-week school closure, coupled with the trauma and stress of the event, was equivalent to losing two months' worth of educational support. It doesn't provide a safe and affordable house or apartment. It doesn't replace a job lost because a mother was unable to get to work because she was ensuring her family's safety. It doesn't assuage the trauma experienced by students who saw family members injured or killed as a result of the storm. And it doesn't make up for disrupted and lost community connections.

FEMA support is vital in enabling people to recover following disasters. But if we go by solely the numbers, we miss the other side of the story, a side that can't be as easily quantified. Though unquantified in damage assessments, fully recovering from a disaster and emerging resilient means also addressing issues like affordable housing, mental health and job security.

Tourism Impacts

As the intensity of storms increase and sea level rise erodes shorelines, communities whose economies depend on tourism will see multifaceted challenges including protecting tourists who flock to beachfront properties during hurricane season and addressing the economic threat posed by storms and nuisance flooding.

In New Bern, North Carolina, Hurricane Florence storm surge badly flooded the two largest downtown waterfront hotels and the convention center. Almost six months later, the hotels are still being renovated and the convention center could be closed for a full year. As a result, many downtown businesses and hotels have lost business. One of the impacted hotels laid off over 80 percent of its staff and downtown businesses have seen a 15-20 percent downturn in revenue[34]. These types of impacts can reverberate through a community for years.

Nuisance flooding associated with high tides brings with it a slightly different economic impact. Unlike the one-time hit and slow recovery of an event like New Bern's, as sea levels rise tidal flooding is increasing in places like Wilmington, NC and Charleston, SC. This chronic and increasing low-level stress poses a rising risk for these communities, particularly for businesses and real estate. Locals may become accustomed to impacts and know how to avoid flooded streets, or when to wear clothes that will allow them to wade back to their car after dinner. Tourists and potential buyers, however, are more likely to be deterred by these floods and decide to find a drier restaurant, or town, to frequent. For example, Annapolis, Maryland is estimated to have lost 3,000 visits and $172,000 in local business revenue in 2017 due to high-tide "sunny-day" flooding[35].

Even as coastal towns work to attract and retain tourists and new community members, they must address the risk posed by an influx of new people. Many visitors and new residents may not be aware of or appreciate the dangers posed by hurricanes and how to respond if a hurricane is forecast. This puts an additional burden on these municipalities and counties to develop plans and approaches for clear communication targeted to these audiences, including overnight visitors who increasingly may be staying in private homes and apartments, about approaching risk, what to do during a hurricane, evacuation procedures, and where and how to access key resources.

34 WITN, December 2018. "Businesses still recovering three months after hurricane Florence."

35 L.A. Times, March 2019. "Destruction from sea level rise in California could exceed worst wildfires and earthquakes, new research shows." R. Xia.

Section IV: Key Insights

Lived experience, even repeat experience, doesn't make people take action

North Carolina residents, businesses, governments and nonprofits learned and made changes in how they behave and act based on lessons from Hurricanes Floyd, Matthew and Florence. Nonetheless, in areas where action requires broader coordination, political risk, or significant financial investment, things that had been problems when Floyd hit in 1999 were still problems in 2018 when Florence hit.

The double hit of Matthew and then Florence, coupled with the extremely active though not directly damaging to North Carolina hurricane season in 2017, is leading people to view storms of this scale as more common than they thought. New Bern is now talking about requiring two feet of freeboard above current flood levels for construction. Emergency managers and non-profits active in the Florence response are developing after action reports specifically for the purpose of addressing weaknesses and acting on lessons learned.

Yet, real estate along the coasts is still booming despite the growing threat of sea level rise, ash ponds are being cleaned up and hog farms bought out of the floodplain far too slowly, unregulated poultry farms are setting up to be new environmental disasters, and people who saw completely new impacts – flooding in places they'd never seen it flood before – appear to be viewing Florence as exceptional, not something they should plan for. There is still little public appetite for widespread, decisive action to invest in broad, multi-scalar, multi-sectoral risk reduction. Unfortunately, it may take another Florence before people are willing to voluntarily make difficult decisions.

As a Nation, we continue to support high-risk investments and unsustainable development

Before 1950 flood insurance was part of standard homeowner insurance policies. During the 1950s increasingly high losses caused many insurance companies to begin dropping flood coverage from standard policies. The National Flood Insurance Program (NFIP) was established in 1970 with the intent to reduce future flood damage through community floodplain management ordinances, while providing stopgap flood protection for property owners while the nation transitioned to a lower flood-risk environment. NFIP premiums, however, are not set by market risk valuation. Instead, they are artificially low, leading to increased investment in and development of high risk properties in flood plains and along the coast because those investments can be insured cheaply and easily, although one of the stated purposes of NFIP is the contrary – to avoid excess development in flood plains. Property owners with NFIP policies are receiving government subsidies to live in areas with high flood risk.

The basis of this system, which has allowed for the proliferation of homes and businesses in high hazard areas, is now leading to increased state and federal government investment in maintaining these areas. FEMA financial compensation for rebuilding engineered beaches is a prime example. Beaches are critical to maintaining waterfront property values yet are paid for by state and federal taxpayers. At the same time, we are failing to invest in buying out repeat loss properties, failing to invest in elevating interstates so they remain functional during extreme events, and are housing some of our poorest, hardest hit citizens in hotels for extended periods rather than giving them the support they need to avoid losses in the first place. If storms like Florence are becoming more frequent, we need to more effectively invest our money before they hit to avoid the magnified costs of cleaning up afterwards. Research from the Zurich Flood Resilience Alliance has shown that community-level resilience-building projects avoid, on average, five dollars of losses for every dollar spent up front. A recent study by the National Institute of Building Sciences (NIBS)[36] conducted on available data in the United States found cost-benefit ranges of 1:4 up to 1:12, and for flooding specifically ranging from 1:5 up to 1:8 – solid numbers highlighting that investing early in resilience building pays off.

36 National Institute of Building Sciences, 2019. "National Hazard Mitigation Saves Study."

"Funding for the program has been increasing year-on-year, but at $175 million in 2018, is still far smaller than the need or demand."

National Flood Risk Reduction

Much of the US government flood resilience and risk reduction funding and engagement is administered by the Federal Emergency Management Agency (FEMA) through the National Flood Insurance Program (NFIP) and three mitigation grant programs: the Pre-Disaster Mitigation (PDM) grant program, the Hazard Mitigation Grant Program (HMGP), and the Flood Mitigation Assistance (FMA) program.

NFIP essentially has two interrelated policy purposes: to provide access to primary flood insurance, thereby allowing for the transfer of some of the financial risk of property owners to the federal government, and to mitigate and reduce the nation's comprehensive flood risk through the development and implementation of floodplain management standards. As of February 2018, NFIP had over 5 million flood insurance policies providing nearly $1.28 trillion in coverage. However, on average nationwide only 30% of homes in the highest risk areas have flood coverage and less than 25% of the buildings flooded by Hurricanes Harvey, Sandy, and Irma had insurance[37]. Even with these low uptake levels, FEMA estimates the program saves the nation $1.87 billion annually in flood losses avoided because of the NFIP building and floodplain management regulations. Nationally, as of March 2018, about 22,315 communities in 56 states and jurisdictions participated in the NFIP.

HMGP assistance is triggered by a major disaster declaration by the President under the Stafford Act. Program funding supports measures such as buyouts of repeat flood properties, elevation of properties, and flood control projects. The PDM program supports similar measures but makes awards on an annual basis to states and, in recent years, through a competitive process.

The FMA awards are made on an annual basis, traditionally funded through NFIP insurance premiums. The FMA Program awards grants for state and local mitigation planning; the elevation, relocation, demolition, or flood proofing of structures; the acquisition of properties; and other activities. Funding for this program has been increasing year-on-year, but at $175 million in 2018 is still far smaller than the need or demand.

FEMA also provides funding for little-known resilience training programs through its National Exercise Division (NED), which specializes in exercises for local, state, and federal agencies. The University of North Carolina Wilmington took advantage of this program to conduct a collaborative, UNC system-wide, multi-agency, six-day full-scale exercise simulating a category 5 hurricane event. FEMA NED funding was complemented by support from the university and the UNC system. The simulation was critical to the successes UNC Wilmington had in their response to Hurricane Florence, including the advance evacuation of the entire campus. As a UNC Emergency Manager noted, "if we hadn't done this, it would have been chaos."

An improved and consistent approach is needed to address large concentrations of harmful waste located in high hazard areas

Successive hurricanes have highlighted the risks associated with storing harmful and hazardous waste in large concentrations in areas that are susceptible to floods. Hurricane Florence called attention to ongoing issues regarding the enforcement of coal ash storage waste and hog waste in North Carolina. Yet other communities are faced with similar challenges regarding toxic substances such as industrial chemicals, nuclear waste, mine tailings, superfund sites, etc. Following Hurricane Harvey, for example, there were close to 100 chemical spills along the Houston petrochemical corridor - in one case, a plant in Baytown released close to half a billion gallons of wastewater into nearby floodwaters[38]. A proactive approach to identifying and mitigating the mobilization of these substances during flood events can help to avoid potential environmental catastrophes during future floods. Strengthened enforcement of current regulations, such as those requiring the mitigation and closure of coal ash waste pits in North Carolina, is one mechanism for reducing risk, as is increasing funding for buyouts of hog farms in floodplains.

Floods contribute to marginalizing vulnerable communities in multiple ways

Floods and other hazards often hit the most marginalized communities hardest. Poorer communities also disproportionately bear the impacts of living near pollution sources such as power plants, landfills, hazardous waste sites and on less expensive land which can be more vulnerable to flooding. A lack of resources and financial capital makes it difficult to recover and rebuild.

In addition, if federal, state, or local elections are held shortly after a disaster, the ability to vote could be hampered. Many of those most impacted by events like Florence already find it challenging to get to a polling place. If they face additional hurdles – a car lost to flooding, lost identification or proof of residency documentation, their children aren't back in school and they don't have childcare, they lost their house or apartment, are living in another community and can't easily get to their polling place, even just the trauma and disorientation of displacement can prove overwhelming. Elections are important, as local and state politicians have the ability to address situations where communities are suffering the consequences of years of structural and systemic inequities. In the United States, hurricane season is during the election season. Jurisdictions will ideally recognize the potential for disruption and put into place plans and support systems to facilitate voting by those impacted and/or displaced by flooding, particularly in repeat flood areas.

Climate has visibly changed, sea levels have visibly risen, and these trends are likely to continue

There is growing recognition, across sectors and geographies in North Carolina, that the climate is changing. Government officials in New Bern noted that sea levels have increased 9 inches in the past 100 years and are continuing to rise, and are beginning to work on a municipal resilience strategy in response. Realtors on the Outer Banks and the North Carolina Real Estate Commission acknowledge that coastal properties and communities are being increasingly impacted by rising seas and communities are thinking critically about their futures. The North Carolina Coastal Federation is working with homeowners, counties and cities to implement living shorelines projects, and is getting increasing recognition for and interest in their work. And on October 29, 2018, Governor Cooper established the North Carolina Climate Change Interagency Council.

This is substantial progress from the proposed 2012 state legislation limiting state agencies from developing policies to address sea level rise, or even acknowledge that sea level rise was happening. Yet it is only the beginning of the transition that North Carolina needs to make. In 30 years, downtown Wilmington can expect at least 70 days a year of sunny day flooding. Coastal communities across the United States are beginning to see real estate value losses from sea level rise and flooding. The communities and states that are proactive and aggressive about responding to these challenges have the opportunity to prosper.

Economic motivators can be used as levers for both action and inaction

Hurricane Florence illustrated how economics can motivate both action and inaction. Florence drew attention to several industries that contributed to environmental damages. In spite of proven technologies to reduce such damages, and despite regulations on the books requiring the industries to act, the types of spills that occurred during Floyd and Matthew happened again in Florence. Effectively, some in these industries are externalizing the environmental and health consequences of poor waste management to those living downstream of waste storage sites. Yet these industries continue to avoid action rather than accept operating cost increases that are already being successfully borne by the same industries in other states.

This inaction strongly contrasts with economic entities that are acknowledging change and actively working with it. New Bern, when faced with buckling under the impacts of the Florence flooding or rising to the challenge, opted to host their annual MumFest less than a month after flood water receded. They noted that getting people back into town even while they were in the midst of early recovery was critical for morale, to give the downtown economy a much-needed jump start to get back up and running, and to clearly communicate to the outside world that they were open for business.

"Coastal communities across the United States are beginning to see real estate value losses from sea level rise and flooding. The communities and states that are proactive and aggressive about responding to these challenges have the opportunity to prosper."

37 Wharton Risk Center, "Closing the Flood Insurance Gap"

38 Houston Chronicle, 2018. "Silent Spills: Part 1: In Houston and beyond, Harvey's spills leave a toxic legacy." Bajak, Frank and Lise Olsen.

The USS North Carolina faces its next challenge head on

The USS North Carolina, a former World War II battleship, now a memorial to veterans and the 11,000 North Carolinians who died during World War II, sits just across the Cape Fear River from downtown Wilmington, adjacent to tidal wetlands and intertidal shoreline. Dedicated as a memorial in 1962, the battleship is no stranger to the impacts of extreme events and flooding. The battleship and its facilities weathered hurricanes Matthew and Florence and have been subject to repeated flooding since their dedication. Indeed, the battleship has seen more flood stage events in the past decade than in the previous 60 years[39].

Faced with increasing flood frequency, Captain Terry Bragg, the executive director of the battleship and retired Navy captain after 30-years of service, and his Assistant Director Lt. Cmdr Chris Vargo knew that something needed to change to ensure that the memorial remained protected and that visitors could continue to access the facility. Working with a local engineering firm, Moffatt & Nichol, and the National Ocean and Atmospheric Administration (NOAA), they reached the conclusion that instead of fighting the water, they should learn to live with it.

Out of that discussion was born the "Living with Water Plan." Based on the idea of living shorelines (see Section II: Coastal Development) the plan will restore 800 feet of intertidal shoreline, including replacing the flood-prone section of the battleship parking area with subtidal estuarine salt marsh habitat. This ecosystem-based approach protects and restores fish habitat at the same time that it provides protection for the battleship facilities and neighboring infrastructure.

The battleship is also implementing changes to their facilities that will make them more resilient to extreme events. In response to the $2 million damages incurred by Hurricane Florence, rather than simply restoring damaged buildings to their prior condition, the battleship is learning from their points of failure and critically assessing how to build back better. As Captain Bragg noted, "we don't want the same kind of roof, because we know it failed." As an enterprise, they have flexibility with their budget and are optimizing this flexibility to make the following changes to their facilities with the ultimate goal of building their resilience to future events:

- New roof has peaks to better shed water and is fully adhered to withstand higher wind speeds;
- Redesigned windows to increase wind ratings and reduce angles, seams and potential sources of leaks;
- Installed mold/moisture resistant drywall;
- Increased the size and more than quadrupled the number of anchors securing water and sewer lines that run under the river;
- Cleaned and sealed all exposed wood under the building;
- Replaced diesel generator with cleaner burning, more environmentally friendly LP gas (with future hopes of converting to natural gas if it becomes available);
- Replaced landscaping with more hardy and durable plants and larger decorative stones to withstand future flooding;
- Brought in over 20 truckloads of fill dirt to replace fill that was washed away and to redirect rain and flood water away from the visitor center;

- Replaced areas of damaged stucco around windows with more watertight and durable siding;
- Installed insulation where there was none, and increased insulation thickness and rating in other areas to reduce energy demands;
- Installed additional windows to reduce lighting demand during the day;
- Improved ADA ramps and handrails;
- Installed non-slip, ADA approved tile flooring;
- Removed non-structural walls to create an open floor plan, improve air flow and simplify egress routes in the event of an emergency.

This example provides insight into how one organization is wrestling with the challenges posed by flooding and extreme events and highlights the opening that storm damage brings to review and improve upon business as usual. The USS North Carolina is leveraging this opening to change their operations in ways that will better position them for future weather and sea level rise challenges. By doing so, they build their resilience. This, in turn, supports them in fulfilling their mission to honor veterans and the thousands of North Carolinians who died during WWII even as it supports tourism and the Wilmington area economy.

39 According to Captain Terry Bragg's own assessment of available data, the Battleship has experienced more flood stage events from 2000-2015 than in the previous 60 years.

The Saffir-Simpson scale is not sufficient to characterize potential hurricane impacts

The Saffir-Simpson scale used to characterize hurricane strength is proving increasingly inadequate as a way to describe to the general public the risk posed by a hurricane. Category 4 and 5 hurricanes are terrifyingly destructive storms and should clearly be acknowledged as such. But large, wet, slow Category 1 and Tropical storms like Hurricanes Harvey and Florence that result in torrential rainfall and flooding can be just as destructive and deadly. In communicating hurricane threat, we need the media to clearly communicate not just wind speeds but potential area of impact, duration of the storm, and rainfall totals, as well as what those characteristics could mean in terms of impacts. Simultaneously, we need to educate the public to actively seek this type of information about incoming storms and to prepare accordingly.

Just prior to Hurricane Florence's landfall, the Weather Channel released a video which graphically illustrated what a 3 to 9 foot storm surge could look like and what that would mean in terms of potential impacts to life and property. This type of visual simulation, coupled with cutting edge forecasting increasingly provided by the National Weather Service, National Hurricane Center, and National Oceanic and Atmospheric Administration, has huge potential to improve risk communication and inform resident decisions about whether to take action or evacuate.

Even the best data has limitations and can't substitute for caution and common sense

One of the greatest challenges with storm forecasts is estimating what those forecasts might mean in terms of impacts on the ground. We do this through past experience, through flood modeling and developing flood maps to identify hazard areas that are most likely to flood, through real-time measurement of wind, tides, rainfall and river flow, and through probabilistic forecasting of, for example, how expected rainfall could influence river stage. However, none of these can tell us for certain what the impacts of a storm may be at any specific location. Storm surge is still very hard to forecast, and as a result areas along the coast need to be ready for the worst. Flood maps and river stage provide some estimate of how inland areas will flood and how deep water will be, but debris in rivers, blocked culverts, new construction, failure of dams or levees, and even simple things such as limitations in modeling detailed topography can all result in water flowing in different ways and at different depths than expected. Additionally, really heavy rainfall can overwhelm ditches and culverts and result in extensive flooding in areas that are supposed to be well out of the floodplain.

The other challenge with models, maps and forecasts is that they are only as good as the data that goes into them, are based on historical measurements, and yet we can see weather patterns changing around us. It seems likely the future will not mimic the past, which becomes a particular challenge when we attempt to describe the probability of a given storm event or river stage. Does it matter that Hurricanes Floyd, Matthew and Florence were all 1-in-500 year events – events that have a 0.2 percent chance of occurring in any one year in a given place? In the past 100 years there have been 15 major storm events in North Carolina. While not all of them affected Wilmington, or Nags Head, or New Bern, or Raleigh, they all impacted the state. Given this history, over the past 100 years it appears that major storms in North Carolina have been 1-in-7 year events and that these storms are getting bigger. The three worst of these storms have been the three most recent ones — Florence, Matthew and Floyd.

Section V: Recommendations

Now is the time to act – failure to do so will be far more expensive in the long run

There is broad recognition that sea level is rising and storms are increasing in intensity. Consequently, we need to take action now to prepare our communities for future events. While each event presents communities with an opportunity to learn from the past and to implement key insights in preparation for the next event, often the momentum for learning and change wanes in the face of more pressing needs and recovery efforts. Hurricane Floyd in 1999 and Hurricane Matthew in 2016, for example, highlighted numerous environmental health concerns and areas of risk. Some action was taken regarding those risks, but not enough and they again emerged as issues during Hurricane Florence. Given that extreme events will become potentially more frequent and more severe, communities and states should take steps to learn from past events and implement key insights as part of their recovery and development to mitigate areas of known risk.

Several US cities are confronting these challenges and paving the way forward. Cities such as Boston, which has launched the Climate Ready Boston initiative to address extreme heat, rain, snow and flooding; Charleston, which has made flooding their number one priority and begun implementing an extensive sea level rise action plan; and Norfolk, Virginia, which is fostering community connections, economic diversity and protecting their harbor, are models for other coastal states and communities to look to as they face similar challenges.

We need to critically assess where we are building and how we are incentivizing risk.

We are rapidly approaching the point at which protective actions such as beach nourishment will no longer be viable. The longer we support investment in this type of risk mitigation, the more likely it is that there will be negative economic consequences in the future. Acknowledging this, communities should plan for the impacts of eroding shorelines, disincentivize development in areas of risk, and plan in advance so that if state or federal buy-outs are offered in the future they have already begun the discussions necessary to inform decisions. Individual owners and businesses should remain aware of changing risks and options, and prospective buyers should research full potential costs carefully before committing. Finally, the state and federal governments should realistically assess the potential economic tradeoffs and educate and work with communities and individuals well in advance of potential changes. One of the biggest challenges to our nation's coasts is not rising seas but coastal areas littered with the remains of flooded structures, no longer fit for recreational use. Coasts will continue to draw people, providing economic and tourism benefits, as long as we thoughtfully steward them.

Shifting from siloed interventions to a holistic approach is key.

Rather than solely addressing issues in isolation, communities and government officials should work together across sectors and levels to assess and address systemic risk. The Department of Transportation (DOT), for example, ensured that I-95 was protected and safe elevated I-95 to protect it from flooding. However, in so doing they failed to identify the wider implications of their construction. Ultimately, because of the way I-95 was constructed, during the floods it acted akin to a dam, but without the key function of a dam that allows water to be released. Instead water backed up and was funneled through disparate small openings. In the future, the DOT, floodplain managers, city risk managers and other key stakeholders should collaborate to ensure that each department/stakeholders' perspective is incorporated into interventions to address risk. Doing so will help support efforts that reduce risk across the board, rather than reducing risk for one component of the system while increasing the risk for other components.

Change how we communicate risk

Using the terms "100-year flood" or "500-year flood" is not sufficient to communicate risk – all too often people assume if they've lived through the "100-year flood," that they won't see another in their lifetime. Communicating disaster risk in terms of probability could help, for example saying an event has a 1 percent chance of occurring in any given year rather than calling it a "1-in-100-year event." This shift in language would reinforce that these events can occur any year, and an event this year provides no protection against another such event next year.

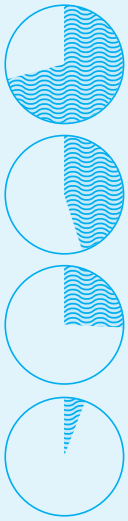
Further, we need to go beyond the perception of one percent risk each year to the potential impact that risk poses. Many people don't appreciate that a few inches of water in a home might be something easy to mop up, but the mold it will leave behind in a post-flood environment may require fully gutting the house and disposing of most of their possessions. Similarly, people often feel they can ride out a storm because they know they have the resources they need in their house to be safe, but don't consider that once the floodwaters rise if anything unexpected happens that requires outside resources, conditions may prevent them from being able to act and they will have to rely on an outside rescue, accommodations in a shelter and other help that will keep them alive but not necessarily comfortable.

Only by fully recognizing the probability of a risk and the impacts that risk could have can we really effectively make decisions about the value of mitigation and prevention actions.

Reframing insurance, perceived flood risk, and potential loss

To enhance the uptake of flood insurance, one of the things insurers and brokers should consider doing is reframe the problem. Often, people choose not to buy insurance because it seems excessively expensive when compared to what they perceive is their flood risk. However, perceived risk is frequently underestimated, as is the cost of insurance compared to the potential loss (such as the entire value of the house on which there is a mortgage). Simply reframing the question can often incentivize uptake. E.g. can you afford to lose your $500,000 house in a flood when the flood insurance premium is $1,000 per year?

Also, flood probabilities can be understood differently if they are discussed relative to the use or life cycle of a structure. For example, over the course of a 30-year mortgage:



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 six percent chance of being flooded

Insurance is vital, but it needs to be the right type of insurance and it should be a last resort.

Flood insurance is critical to recovery. Time and time again we see how households and businesses with insurance fare better than those without. The recommendation for home and business owners who realize or are told they have flood risk is "buy flood insurance." This is unquestionably a valuable risk mitigation strategy, and one that arguably almost every owner and renter should take advantage of. However, purchasing the right type of insurance for the right situation and understanding the details of the coverage is vital. For example, many mobile home owners in low-lying areas who owned a dwelling policy believed that floods were covered under their policy only to find out later that there was a flood exclusion attached to the policy. A mobile home policy, on the other hand, would have included flooding.

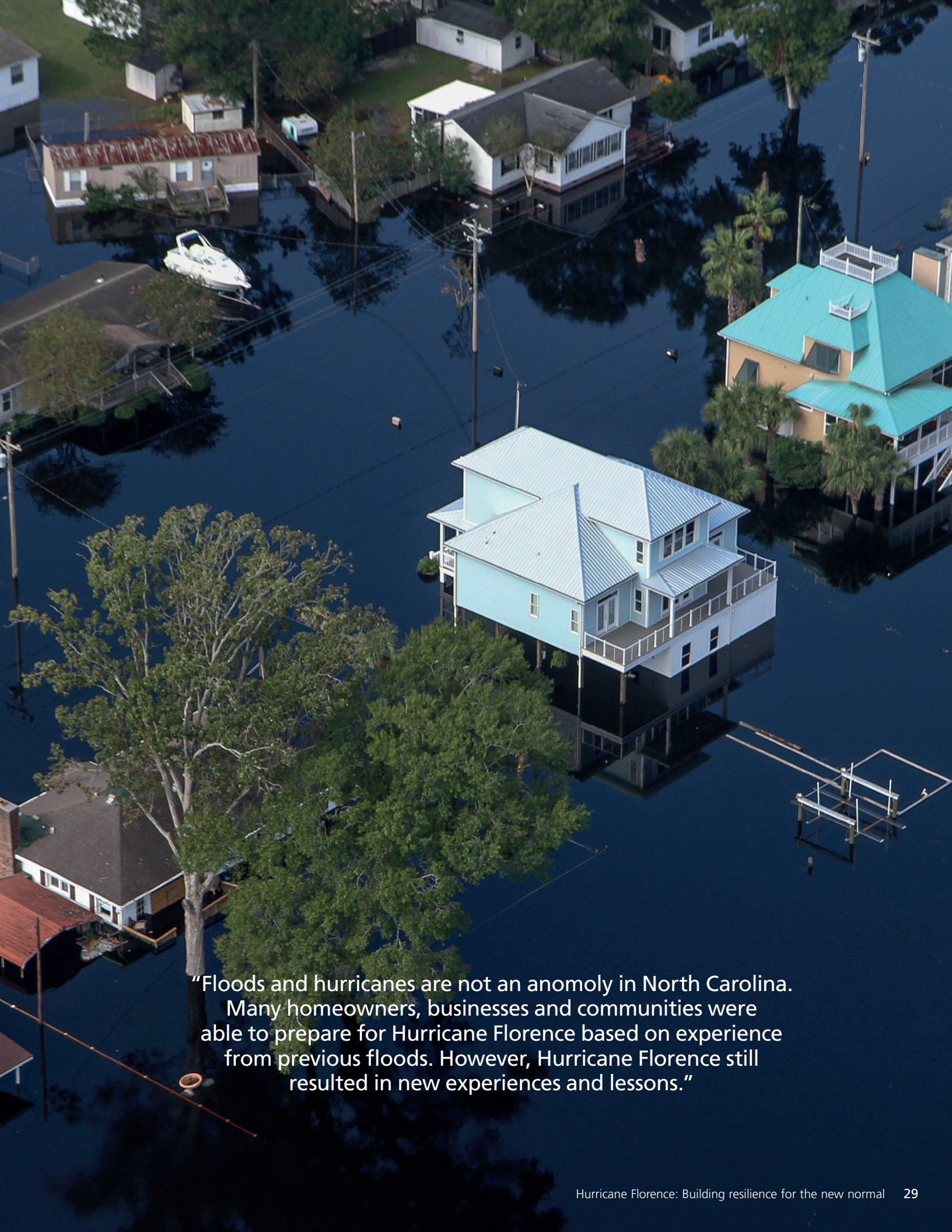
In the face of known flood risk, insurance should be one of a suite of actions. Insurance can only go so far if it is not coupled with other preventative/risk reduction measures. For example, many buildings are not constructed to withstand wind blown rain, and in many cases neither wind nor flood insurance will compensate property owners for this water damage. Understanding how your building is constructed and, if necessary, mitigating so that the structure isn't susceptible to this type of damage could save significantly in the long run.

Given the time and effort necessary to navigate the complexities of the recovery landscape and the potential limitations of insurance coverage, even those impacted who have insurance are unlikely to recoup all of their costs. Taking steps ahead of time to mitigate your risk and to facilitate your recovery can help to reduce these costs after an event.

Imagine how bad it could be and plan for worse.

Floods and hurricanes are not an anomaly in North Carolina. Many homeowners, businesses and communities were able to prepare for Hurricane Florence based on experience from previous floods. However, Hurricane Florence still resulted in new experiences and lessons. As one resident of Wilmington put it, "whatever you think can't happen, assume it will". The following anecdotes reveal how organizations and people prepared for the bad, but not for the worst:

- The county emergency management team had recently purchased a new generator that they tested weekly. Notwithstanding its stellar performance prior to the storm, during Hurricane Florence it failed, not once, but three times during the event. Ultimately, they had to switch to a second backup generator. This, in turn, necessitated taking the 911 call center off-line for eight hours while it and the rest of the emergency operations center was moved to the other side of the building.
- The university emergency management team, the IT department, and facilities management all had plans in place for impacts of a Category 5 hurricane. However, the IT department's plan to shut down the campus network as they evacuated, and facilities management's plan to shut down power directly impacted the emergency operations center. They were able to shift to backup generator power and rely on cellular hotspots and satellite telephones, but that they had to, and had to do so unexpectedly, could have been avoided. Had emergency management not had multiple options for obtaining these core services, the lack of coordination between departments could have resulted in more catastrophic results.
- One New Bern resident who lived through Hurricanes Floyd, Irene and Matthew felt that he had prepared sufficiently and could comfortably and safely shelter in place. At 10pm, however, as floodwaters were rising and he was preparing to move to his upper floors, firefighters arrived at his door and explained he had to evacuate because the house across the street was engulfed in flames (their generator had caught fire) and the fire department couldn't guarantee his safety. His evacuation experience – by swift boat to a bus to an unplanned and uncomfortable night in a flood shelter taught him that sheltering in place only works if nothing goes wrong. In the future, if officials tell him to evacuate he will.



"Floods and hurricanes are not an anomoly in North Carolina. Many homeowners, businesses and communities were able to prepare for Hurricane Florence based on experience from previous floods. However, Hurricane Florence still resulted in new experiences and lessons."

Section VI: Ways Forward

Hurricane Florence, though a record-breaking storm in North Carolina, was not unique. Florence was just the latest in a series of severe events that have impacted North Carolina in the past century, many of which were at the time "the biggest," "the most severe," "the wettest," until they were supplanted by a storm yet worse.

There is reason to believe that, at least for the foreseeable future, damages from storms such as Florence may get worse. Sea levels have risen in the past 100 years, and the rate at which seas are rising is increasing. As sea levels rise, beach erosion, tidal flooding, storm surge, and waterlogging of low lying areas, sometimes well inland, increase, all of which can increase the damage an individual storm can cause. At the same time, sea surface temperatures are measurably warmer, resulting in hurricanes that contain more energy and moisture than those of 100, 50, or even 20 years ago. This increase in natural hazard is impacting areas which contain more people and more buildings, assets, and services every year, particularly along the coast where development is often growing faster than in inland areas.

In the face of this increasing risk, it is critical to learn from events such as Florence, to minimize the damages and streamline the response and recovery for the next storm. We can no longer afford business as usual, quite literally. The growing economic and human cost of these events requires that we not only change how we respond, but do so far more quickly than we have in the past.

Fortunately, there is growing expertise and leadership across the United States in building resilience to precisely these challenges. Miami, FL, Norfolk, VA and Charleston, SC in particular are at the forefront of building flood resilience in coastal, sea level rise impacted communities. They are five to ten years ahead of North Carolina in this work, and can serve as a road map for successful strategies, saving the states that follow them significant time and effort. Coupled with extensive, existing in-state expertise, and leveraging the direct learning that has come most recently from Hurricanes Matthew and Florence, North Carolina needs to now commit to similar action. To do so will position the state to serve as a leader in the flood resilience space and will provide economic and human benefits for the future.

"There is reason to believe that, at least for the foreseeable future, damages from storms such as Florence may get worse. Sea levels have risen in the past 100 years, and the rate at which seas are rising is increasing."

Building Flood Resilience in the Charleston Tri-County area in South Carolina – A Model for the Future

Charleston, South Carolina has, for years, been dealing with growing "nuisance flooding" – water ponding in low-lying neighborhoods and streets during extreme high tides and intense rainstorms. In the past five to ten years, this flooding has gotten noticeably worse. Extensive flooding in 2015, 2016, 2017, and 2018 moved flooding from "an" issue to "the" issue for the city. In 2019, the City of Charleston's Mayor Tecklenburg in his State of the City address talked of nothing else.

In 2016, the Zurich Flood Resilience Alliance conducted a post-event report on the 2015 Tropical Storm Joaquin flooding in South Carolina. As part of our research for this new report, we revisited Charleston to talk with resilience stakeholders about what they are doing now, what has changed in the past three years, and what they see as the next big hurdles in building regional flood resilience.

In 2015, the flooding associated with Tropical Storm Joaquin was a wake-up call for the region. As the first acute event since Hurricane Hugo in 1989, the flooding associated with Joaquin made it clear that things had changed. The subsequent major disruptive events every fall since then have kept that realization at the top of everyone's mind and turned up the heat on taking action. Initially the discussion focused on the problems themselves and whose fault they were, but increasingly the focus is moving to what can be done. This is supported by both decision-makers and the public asking the right questions – what are the root causes of current challenges, and what needs to change if the region wants to preserve its future.

Key changes in the past three years have included:

- Broad recognition that flooding is a regional challenge and needs a regional response.
- Direct acknowledgment of the underlying issues and recognition that addressing those issues will require a much stronger watershed approach.
- Direct action to build intergovernmental coordination across municipalities and counties and increase the spectrum of departments and decision makers involved. For example, the importance of land zoning in building flood resilience is becoming increasingly apparent and entities involved in land use across the region are being encouraged to come to the table and collaborate.
- Recognition that implementing isolated solutions is not enough. Resources need to be coordinated and consistent engagement will be required to make a real difference.
- Acknowledgement that resilience projects are very expensive and the federal government is currently not supporting them. However, delaying until there is funding isn't an option. Instead, the cities and counties themselves are going to have to figure out how to identify the funding to secure their future.

The Charleston Resilience Network (CRN), a regional network of government, non-government and academic stakeholders, has taken the lead on the relationship development needed to support this work. Their value in brokering relationships and providing consistency and avenues for participation is being increasingly recognized and respected. They are also actively exploring regional interdependencies and governance to identify opportunities for and roadblocks to action, and looking for ways to engage the private sector.

CRN and other regional resilience stakeholders, however, realize these are just the beginning steps in what needs to be accomplished. In the not too distant future, the tri-county region will need to begin addressing head on far larger, more challenging questions. Among these are issues such as clearly delineating areas they will commit to protecting, areas that are safe without intervention for the next 30 or 50 years, and areas that are currently at risk and cannot realistically be protected. For these latter areas, there is then the even larger challenge of determining, in collaboration with those communities, what that means.

These are not challenges unique to the Charleston region – coastal communities across the nation are beginning to face these challenges. Charleston is one of the first communities to openly acknowledge them and to take on the challenge of acting. By doing so, they provide a roadmap for the trajectory that coastal communities across the United States are on, whether they choose to acknowledge it or not. That trajectory includes:

- Repeated damages, each viewed as a unique event for which recovery is required but not transformation.
- Recognition that transformation is needed.
- Building the commitment, networks, and funding needed to support transformation.
- Taking transformative action.

Charleston is solidly on the third step and positioning themselves for the fourth. In that fourth step, they will face difficult choices and decisions, but it will be decisions they make, rather than decisions that are forced on them by nature.

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We have done our best to reflect the input and interests of our sources. However, the opinions and perspectives expressed in this report remain those of the authors alone.

This report presents a snapshot of events and responses during the Hurricane Florence flood in North Carolina in September 2018. It is not comprehensive - much more could be said on the degree of resilience of North Carolina 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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About the Zurich flood resilience alliance

The Zurich Flood Resilience Alliance is a multi-sectoral partnership which brings together community programs, new research, shared knowledge and evidence-based influencing to build community flood resilience in developed and developing countries. We help people measure their resilience to floods and identify appropriate solutions before disaster strikes. Our vision is that floods should have no negative impact on people's ability to thrive. To achieve this we are working to increase funding for flood resilience; strengthen global, national and subnational policies; and improve flood resilience practice.

Find out more: www.floodresilience.net

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