FLOOD MITIGATION IN THE SOUTHEASTERN UNITED STATES

Summary of Stakeholder Meetings Across Four Communities

2019

ResilientAmerica Program
The National Academies of Sciences, Engineering, and Medicine

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Flood Mitigation in the Southeastern United States

Resilient America Program

In 2012, the National Research Council (NRC) released a report, *Disaster Resilience: A National Imperative*,[1] about critical issues and strategic steps the United States can take to reduce impacts on the nation's communities from natural and human-induced disasters. The 2012 report defines *resilience as "the ability to prepare and plan for, absorb, recover from, or more successfully adapt to actual or potential adverse events."* The report provided several recommendations the nation could take to reduce impacts on communities from disasters and build resilience to those disasters.

> ***Resilience** is the ability to prepare and plan for, absorb, recover from, or more successfully adapt to actual or potential adverse events.*

The National Academies of Sciences, Engineering, and Medicine's Resilient America Roundtable was created in 2014 to implement four of these recommendations in communities:

1. Understand, communicate, and manage risk;
2. Measure resilience in communities;
3. Build or strengthen partnerships with stakeholders vested in building community resilience;
4. Share information about and get access to tools, data, best practices, and experts needed to build community resilience.

The Roundtable provides the venue for current research, science, and evidence-based foundations to inform whole community strategies for building resilience. It focuses on the implementation and innovation of new approaches to build resilience to disasters and other disruptions; application and testing of tools for improved understanding of risk; and connecting and facilitating partnerships among scientists, data providers, practitioners, and decision makers. In its first five years, the Roundtable's core program was its community pilot program that partnered with four U.S. communities—Cedar Rapids/Linn County, IA; Charleston, SC; Central Puget Sound region, WA; and Tulsa, OK—to implement the above four recommendations. Through this community pilot program, Resilient America developed new mechanisms for community engagement, facilitated relationship building among diverse community stakeholders, and brought science into local decision making. The community pilot came to a successful close in 2018.

In its first five years, the roundtable expanded from being just a roundtable to becoming the Resilient America Program[2] to reflect its expanded portfolio of work: the community pilot program, convening activities, consensus studies, community engagement efforts, and role-playing games. Resilient America has hosted workshops, conferences, and tabletop exercises nationally and internationally. It has conducted three consensus studies: *Building and Measuring Community Resilience: Actions for*

[1] National Research Council. 2012. Disaster Resilience: A National Imperative. Washington, DC: The National Academies Press. https://doi.org/10.17226/13457.
[2] For more information about the Resilient America Program, visit https://sites.nationalacademies.org/PGA/resilientamerica/

Communities and the Gulf Research Program (2019)[3]; *Framing the Challenge of Urban Flooding in the United States (2019)[4];* and *Strengthening Post-Hurricane Supply Chain Resilience: Observations from Hurricanes Harvey, Irma, and Maria (2020)*.[5] It partnered with the Koshland Science Museum (now LabX[6]) to develop the role-playing game, Extreme Event.[7] And its stories have been published by the World Economic Forum (2015) and *European Review* (2018). Since the close of its community pilot program in 2018, the RAP continued its community engagement focus in the southeastern region of the United States and in southeast Texas to tackle issues around flood risk, preparedness, and mitigation.

Project Overview

Resilient America visited select communities in the southeastern region of United States that recently experienced flood-related disasters to advance understanding of what mitigation efforts look like at the local level. Specifically, this project investigated the range of mitigation actions and investments taking place in communities, the challenges communities face mitigating floods, and what communities need that will enable them to make investments in mitigation.

Resilient America conducted discussions with diverse stakeholder groups in four different communities—Biloxi, MS; Ellicott City, MD; Roanoke, Salem, and Vinton, VA; and Savannah and Tybee Island, GA—about their flood mitigation efforts, successes, and challenges.

[3] *Building and Measuring Community Resilience: Actions for Communities and the Gulf Research Program* is available at https://www.nap.edu/catalog/25383/building-and-measuring-community-resilience-actions-for-communities-and-the.
[4] *Framing the Challenge of Urban Flooding in the United States* is available at: https://www.nap.edu/catalog/25381/framing-the-challenge-of-urban-flooding-in-the-united-states.
[5] *Strengthening Post-Hurricane Supply Chain Resilience: Observations from Hurricanes Harvey, Irma, and Maria* is available at: https://www.nap.edu/catalog/25490/strengthening-post-hurricane-supply-chain-resilience-observations-from-hurricanes-harvey.
[6] More information about LabX is available at https://labx.org/.
[7] More information about the Extreme Event game is at https://labx.org/extreme-event/about-the-extreme-event-game/.

Project Goals

The goal of the project is to better understand flood mitigation at the community level in terms of:

- the risks and impacts of floods on communities;
- the actions communities are taking to mitigate future floods;
- the challenges communities face related to flood mitigation;
- what communities need to enable them to make informed decisions about flood mitigation;
- how communities are funding their flood mitigation activities; and
- community success stories, lessons learned, and best practices.

Project Activities

This project carried out community stakeholder meetings in the four communities from July through September 2019, and a flood mitigation workshop in December 2019.

The community stakeholder meetings included a diversity of stakeholder groups in order to capture a comprehensive range of perspectives on flood experiences and mitigation efforts. Box 1 shows examples of the different stakeholder groups that participated in the meetings.

Box 1
Examples of Stakeholder Groups that Participated in the Project

- local and county government (e.g., elected officials, public works, economic development, floodplain management, engineering, planning and zoning, infrastructure, stormwater management, etc.)
- state and federal government
- nonprofits and community- and faith-based organizations
- academia (e.g., researchers, scientists)
- emergency management and first responders
- natural environment and sustainability groups
- historic preservation societies
- small businesses
- real estate
- insurance agencies

The community stakeholder discussions were guided by a set of questions to better understand flood mitigation at the community level. Examples of questions that were asked included:

- What are the main flood risks/flood hazards in your community?
- How does flooding impact your community?
- What actions has your community already taken to mitigate floods?
- What are your plans for future mitigation actions?
- What are examples of how your community coordinates flood mitigation efforts across the public, private, and/or nonprofit sectors or across jurisdictions?
- How are you/ your community funding your flood mitigation activities?
- What are the main barriers or challenges that impede your ability to take action to mitigate against floods?
- What flood mitigation best practices or lessons learned can you share with other communities?

Summary of Stakeholder Meetings

Resilient America conducted 32 community stakeholder meetings in 2019 as well as numerous one-on-one meetings and teleconferences with community stakeholders. Resilient America learned about successful flood mitigation activities, challenges and needs, and lessons learned and best practices.

Successful Flood Mitigation Activities

Communities have successfully implemented flood mitigation efforts, including the completion of infrastructure projects (e.g., dune restoration, flood proofing, stormwater and drainage system improvements, levees); the implementation of existing policies and the enforcement of regulations (e.g., flood mitigations plans, building codes, elevations); the formation of cross-jurisdictional and cross-sector partnerships (e.g., mutual aid agreements, formal special interest groups/networks, statewide emergency management training); the communication of flood risk and preparedness (e.g., flood awareness campaigns, early warning systems); and the participation in FEMA flood mitigation programs (e.g., the National Flood Insurance Program, Community Rating System). In these pursuits, communities have learned that including diverse community stakeholders and members in the planning process and having them take an active role in flood preparedness and mitigation have facilitated successful outcomes.

Below is a selection of community flood mitigation activities.

Biloxi, MS

Coastal Flood Risk Maps: The Southern Mississippi Planning and Development District (SMPDD) is working with Michael Baker International Inc. in partnership with Arcadis to develop new flood maps for Harrison, Hancock, and Jackson counties that incorporate new data and models that more accurately reflect the coastal landscape and flood risk. This project, "The Mississippi Coastal Map Revision Project (MCMRP)," [8] began at the grassroots level through outreach meetings in local communities, including the Native American Tribal Nation. The map development process will be closely coordinated with FEMA Region IV to ensure that the resultant mapping can be incorporated into the National Flood Hazard Layer. The purpose of the maps is to ensure that coastal Mississippi communities understand and proactively mitigate their flood risk. There are seven stages of the mapping process (see Figure 1):

1. Defining the Base Topography
2. Evaluating Water Levels and Storm Surge
3. Defining Cross-Shore Transects and Identifying the Primary Frontal Dune
4. Evaluating Storm-induced erosion and shore protection structures
5. Conducting Wave Hazard Modeling
6. Conducting Coastal Flood Hazard Mapping
7. Producing the FIRM and Preparing the Flood Insurance Study (FIS) Report[9]

[8] More information about the Mississippi Coastal Map Revision Project is available at: "Project Information," Mississippi Coastal Map Revision Project, Accessed January 27, 2020, https://mscoastalmap.com/project-information/.

[9] "Coastal Flood Mapping Process," Southern Mississippi Planning & Development District, Accessed January 27, 2020, https://mscoastalmap.com/coastal-flood-mapping-process/.

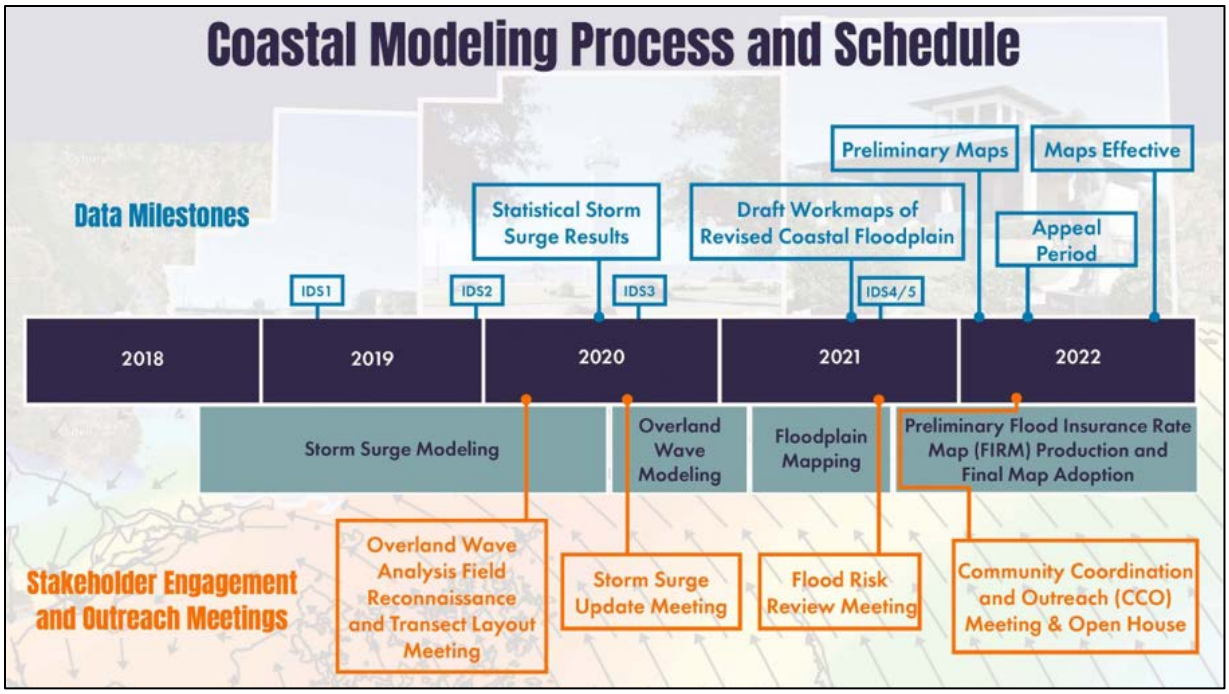

Figure 1. The MCMRP coastal modeling process and schedule for milestones and meetings.[10]

Low Impact Development of Mississippi Wetlands: Mississippi State University's Gulf Coast Community Design Center in Biloxi,[11] in partnership with the MS Department of Environmental Quality (MDEQ) and the Gulf Coast Ecosystem Restoration Council, led an initiative to promote low impact development (LID) approaches to stormwater management. LID approaches promote the management of stormwater close to its source, utilization of specific plant species to metabolize pollutants on-site, and a slower disbursement of stormwater to enable it to filter through vegetation and infiltrate the soil before reaching a natural body of water. One goal of the LID initiative is to integrate upland management strategies in Mississippi's wetlands and activities with downstream coastal restoration projects.

MEMA4KIDS Campaign: The Mississippi Emergency Management Agency and its Public External Affairs Department developed the MEMA4KIDS campaign to teach children and their families about various regional hazards and how to prepare for them, and provides advice about mitigation (see Figure 2). Children can learn how to build an emergency supply kit and be awarded an official "Disaster Prepared Certificate."

[10] "Project Schedule," Mississippi Coastal Map Revision Project, Accessed January 27, 2020, https://mscoastalmap.com/?da_image=172#.

[11] For information about the Gulf Coast Community Design Studio, visit http://gccds.org/ (accessed January 8, 2020).

Figure 2. Homepage for MEMA4KIDS campaign.[12]

Ellicott City

Flood Sensor Pilot Project: The Department of Homeland Security Science and Technology (DHS S&T) Directorate's Flood Apex Program applies new and emerging technologies to improve community resilience to floods.[13] One of its projects involves partnering with five communities around the country to test and evaluate low-cost flood inundation sensors.[14] Ellicott City was selected as a pilot community for the Flood Apex Flood Sensor Project. In 2018, DHS S&T partnered with Howard County and the National Weather Service to deploy 16 flood sensor units throughout the Tiber-Hudson watershed around Historic Ellicott City. Each unit consists of one sensor from three different vendors (48 flood sensors total). The purpose is to test the performance of each sensor at each location. The sensors are also placed at locations where there is a USGS river gauge to compare them to the USGS gauges which provide highly accurate and reliable data. Each vendor sensor is different. For example, they may test soil moisture content, catchment levels, or stream levels. Some sensors have cameras. Normal gauges, like those used by the USGS, typically cost $10,000 to $20,000. DHS expects the new pilot sensors to cost under $1,000 each.[15]

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[12] "Homepage," MEMA4KIDS, The Mississippi Emergency Management Agency, Accessed January 24, 2020, http://mema4kids.org/en/.

[13] Department of Homeland Security Science & Technology Directorate website, "Flood Apex Program." Available at: https://www.dhs.gov/science-and-technology/flood-apex# (accessed January 16, 2020).

[14] A 2019 update about the DHS-S&T flood sensor project is available at: https://www.dhs.gov/sites/default/files/publications/floodsensor_factsheet.pdf[15] "Ellicott City Is Hoping DHS' Flood Apex Program Is a Match Made in Heaven," Government Technology Emergency Management website, Accessed January 28, 2020, https://www.govtech.com/em/preparedness/Ellicott-City-is-Hoping-DHS-Flood-Apex-Program-Is-a-Match-Made-in-Heaven.html.

[15] "Ellicott City Is Hoping DHS' Flood Apex Program Is a Match Made in Heaven," Government Technology Emergency Management website, Accessed January 28, 2020, https://www.govtech.com/em/preparedness/Ellicott-City-is-Hoping-DHS-Flood-Apex-Program-Is-a-Match-Made-in-Heaven.html.

Enhanced Stream and River Cleaning: Until County Executive Ball took office at the end of 2018, streams and rivers were cleared of debris on a quarterly basis. Ball's new "Clearing the Waterways" clean-up protocol monitors and removes debris from public properties after every weather event. An interactive web-based application shows the progress of the "Clearing the Waterways" program, inspection sites, and sites slated for clearing (see Figure 3).[16] Priority debris for removal includes debris within and immediately upstream of culverts or other areas of constriction, debris that has the potential to mobilize during an event and create a blockage downstream, and debris that otherwise poses or may pose a risk to adjacent infrastructure. [17] Ten tons of debris had been removed from waterways by November 2019.[18]

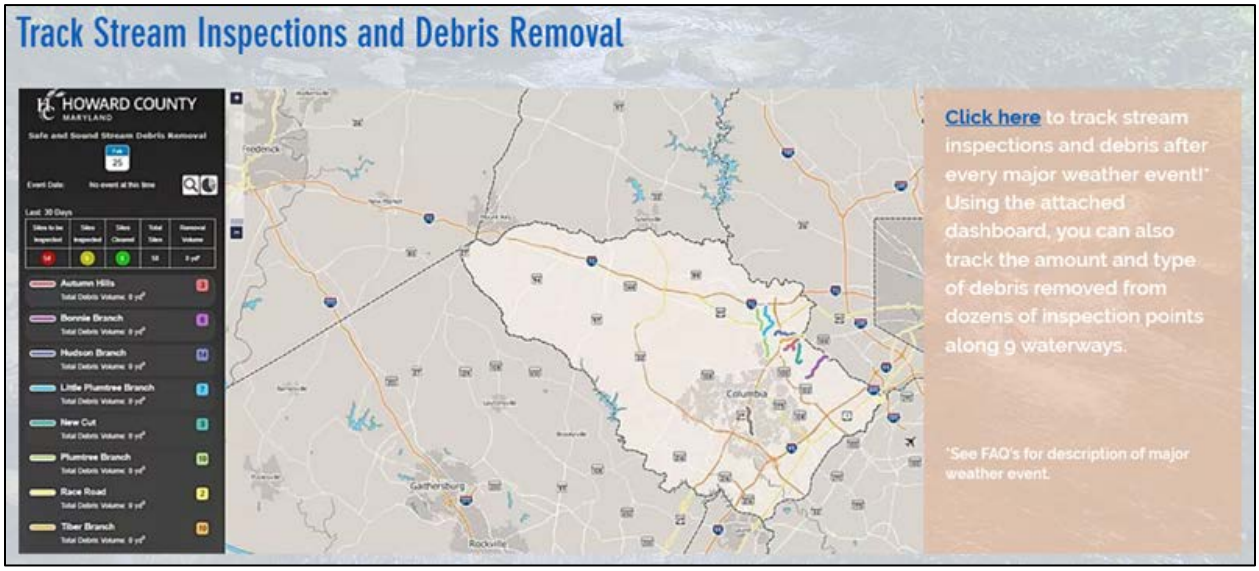

Figure 3. Interactive stream tracking and debris removal application.[19]

Ellicott City Safe and Sound Plan: In May 2019, Howard County's new administration rolled out the Ellicott City Safe and Sound plan, a "multi-phase plan built around the need for public safety, supporting business and property owners, preparing the county for a changing climate, and creating a more inclusive, community driven process for decisions regarding Ellicott City's future" (see Figure 4).[20] This plan includes new flood mitigation initiatives such as enhanced stream and river cleaning, high-ground access points in Historic Ellicott City for flood evacuation, and several large-scale infrastructure projects. The cost of the entire plan is estimated at about $140 million over 5 years.

[16] The Clearing the Waterways tool is available at: "Safe & Sound Stream Debris Removal," Howard County, MD, Accessed January 16, 2020, https://data.howardcountymd.gov/SafeandSoundStreamDebrisRemoval/Web.aspx

[17] "Clearing the Waterways," Ellicott City Safe & Sound, Accessed January 28, 2020, https://www.ecsafeandsound.org/clearing-the-waterways.

[18] Kristin Danley-Greiner, "Residents Updated On Safe And Sound Plan In Ellicott City," Patch News, November 22, 2019, Accessed January 28, 2020, https://patch.com/maryland/ellicottcity/residents-updated-safe-sound-plan-ellicott-city.

[19] Image source: "Clearing the Waterways," Ellicott City Safe & Sound, Howard County, MD, Accessed January 28, 2020, https://www.ecsafeandsound.org/clearing-the-waterways.

[20] "Safe and Sound: Phases one and Two," Ellicott City Safe & Sound, Accessed November 18, 2019, https://www.ecsafeandsound.org/ec-safe-and-sound-phases-1-2.

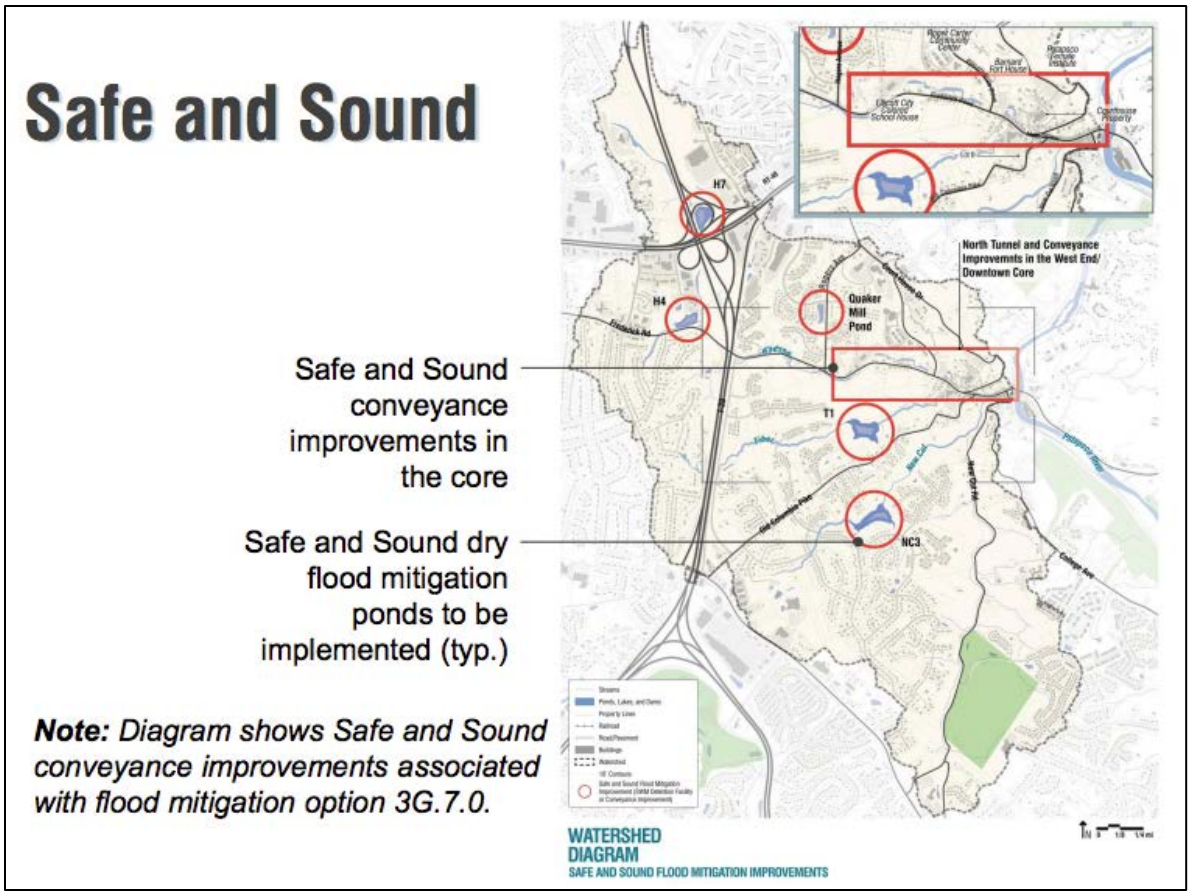

Figure 4. The Ellicott City Safe and Sound 3G.7.0 flood mitigation plans, including water conveyance improvements and retention ponds.[21]

Roanoke

Greenways: The Roanoke Valley Greenway Commission (RVGC) promotes and facilitates coordinated direction and guidance in the planning, development, and maintenance of a system of greenways throughout the Roanoke Valley (see Figure 5).[22] As a regional planning body, the RVGC worked with local governments and the state to convert part of the floodplains into paved greenways that provide off-road transportation for cyclists and pedestrians, which provides both flood control and community development benefits. The greenway project has since become part of local identity and symbolizes the quality of life in a region that promotes and values outdoor activities. In 2017, the Town of Vinton received FEMA funds to remove flood-prone structures along a portion of Tinker Creek that borders the Town of Vinton and the City of Roanoke to create a greenway extension.

[21] "Ellicott City Watershed Master Plan: Public Meeting Presentation," The Howard County Department of Planning & Zoning with Mahan Rykiel Associates, Arnett Muldrow & Associates, RK&K, Land Studies, South Coast Consulting, and Preservation Consulting, Ellicott City, MD, 2019, Accessed January 28, 2020, https://www.howardcountymd.gov/LinkClick.aspx?fileticket=fq5I8URjyUg%3d&portalid=0.

[22] "Roanoke Valley Greenway Commission," Roanoke County, VA, Accessed January 27, 2020, https://www.roanokecountyva.gov/280/Roanoke-Valley-Greenway-Commission

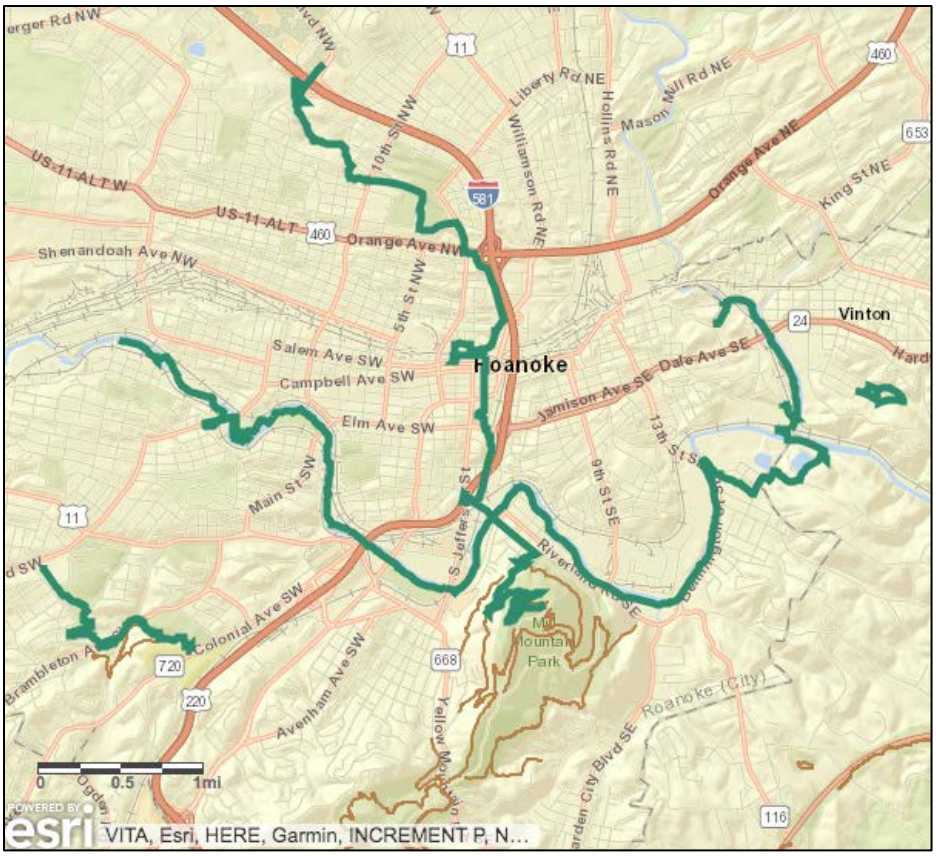

Figure 5. Map of greenways across Roanoke, Salem, and Vinton.[23]

Roanoke Stormwater Projects: In Roanoke County, stormwater projects have included drainage improvements, stream restoration and repair, and a partnership with the nearby City of Salem to install storm drainpipes that cross city and county jurisdictions. The county's stormwater website includes a public education portal[24] with videos, monthly newsletters, and resources for residents (e.g. *Tips for Homeowners: Stormwater Best Practices*[25]), businesses (e.g., *Stormwater Best Management Practices for Restaurants*[26]), and youth (e.g., *Clean Stormwater Makes for Happy Kids*[27]).[28]

[23] Map Source: "Regional Interactive Bicycle Map," The Roanoke Valley-Alleghany Regional Commission, Accessed January 27, 2020, http://rvarc.org/transportation/bicycle-pedestrian-greenways/interactive-bicycle-map/

[24] For more information about Roanoke County stormwater public education, visit https://www.roanokecountyva.gov/1648/Stormwater-Public-Education-Documents.

[25] "Tips for Homeowners: Stormwater Best Practices." Roanoke County website. Available at https://www.roanokecountyva.gov/DocumentCenter/View/7072/SW-Tips-for-Homeowners-?bidId= (accessed January 8, 2020).

[26] "Stormwater Best Management Practices for Restaurants." Roanoke County website. Available at https://www.roanokecountyva.gov/DocumentCenter/View/9344/Restaurant-Brochure-5-30-17?bidId= (accessed January 29, 2020).

[27] "Clean Stormwater Makes for Happy Kids." Available at https://www.roanokecountyva.gov/DocumentCenter/View/12084/Clean-Water-Happy-Kids?bidId= (accessed January 29, 2020).

[28] More information on the county of Roanoke's stormwater public education resources is available at: https://www.roanokecountyva.gov/1648/Stormwater-Public-Education-Documents (accessed January 29, 2020).

The City of Roanoke's Stormwater Utility has completed several stormwater capital improvement projects, hosted a public art event to promote the improvement of Roanoke's water quality,[29] and hosts the Sharks and Minnows water quality management application[30]—an exploratory data analysis tool that allows people to do real-time monitoring of stream flow and water quality, daily mean discharge and gauge height data for the Roanoke River, and monitor 1-day weather forecasts. The City of Roanoke's website includes a variety of stormwater resources, such as information on how to obtain stormwater utility credits from rain gardens, rain barrels, and the cultivation of native plant species, and other stormwater best management practices.[31]

Stormwater Utility Flood Mitigation Program: In March 2019, Roanoke's city council approved an innovative *Stormwater Utility Flood Mitigation Program* that provided a new option to acquire the city's repetitive flood loss properties. This program is based on the FEMA cost-share model that allows FEMA funds to cover up to 75 percent of eligible costs with the remaining 25 percent covered by non-federal resources. In the case of the stormwater utility flood mitigation program, the city's stormwater utility funds cover 25 percent of project costs and a property owner's flood insurance proceeds cover 75 percent. In order to participate in this program, a property owner must have flood insurance. [32]

Savannah and Tybee Island

Smart Sea Level Sensors Project: The Georgia Institute of Technology is partnering with the Chatham County Emergency Management Agency (CEMA) and the City of Savannah to install a network of state-of-the-art sea level sensors across Chatham County. The Smart Sea Level Sensors Project was created in response to shortfalls in data that were revealed after Hurricanes Matthew (2016) and Irma (2017).[33] The available data at the time had shown the two hurricanes to be similar events; however, their impacts on the community were very different. The goal of the sensors project is to provide real-time data on water levels that can better inform decision-making (e.g., emergency planning, first response) before, during, and after flood-related events (e.g., storms, king tides, hurricanes).

Special-Purpose, Local-Option Sales Tax: The City of Savannah generates revenue for flood mitigation efforts through the *Special-Purpose, Local-Option Sales Tax* (SPLOST).[34] After joining the CRS program, the city invested over $165 million in major drainage projects (e.g., canals, pumps, piping) funded primarily through SPLOST revenue. These projects have significantly improved drainage in certain areas of Savannah. In November 2019, the City of Savannah voted to approve additional drainage improvements for the next SPLOST Initiative (SPLOST 7).[35]

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[29] More information on Roanoke's "Stormdrain Inlet Art Project," is available at: https://www.roanokeva.gov/2290/Stormdrain-Inlet-Art (accessed January 9, 2020).
[30] The SHARKS app is available at: "Sharks," BigBadCrad, Accessed January 27, 2020, https://bigbadcrad.shinyapps.io/SHARKS/.
[31] More information on the City of Roanoke's stormwater public education resources is available at: https://www.roanokeva.gov/513/Stormwater-Resources (accessed January 8, 2020).
[32] City of Roanoke. 2019. "Roanoke City Council Regular Session," pp. 18-21. Available at https://www.roanokeva.gov/AgendaCenter/ViewFile/Item/613?fileID=10331 (accessed October 8, 2019).
[33] Sea Level Sensors. "Smart Sea Level Sensors in Chatham County, GA." Accessed on October 19, 2019. https://www.sealevelsensors.org/.
[34] For more information about SPLOST, visit https://www.savannahga.gov/2568/Your-SPLOST-Penny-at-Work.
[35] Savannah Area Chamber. "Thank You for a Successful Campaign for SPLOST & the Freeport Exemption." Accessed December 13, 2019. https://www.savannahchamber.com/news-and-events/news/chamber-news/thank-you-for-a-successful-campaign-for-splost-the-freeport-exemption/.

Sand Dunes: The City of Tybee Island has adopted a 3-prong approach to flood mitigation that includes defense, adaptation, and retreat.[36] Defense has been and will continue to be established through the creation of sand dunes and beach re-nourishment projects on the beachside of the island (see Figure 6). Adaptation is occurring through home elevations. And retreat will be accomplished through zoning.

Figure 6. Tybee Island dune restoration project with depleted beach landscape (left) and restored dunes (right). (Source: https://www.wtoc.com/2019/06/07/look-dune-restoration-process-tybee-island/).

In 2018, the Tybee Beach Task Force (TBTF)[37] installed a high-tech sandbag system at 19th Street, where Hurricane Matthew had breached the existing dune. Designed by Guardian Retention Systems, the sandbag system is strong enough to withstand the weight and movement of emergency and maintenance vehicles.[38] In addition, as part of a pilot program approved by the Georgia Department of Natural Resources (DNR), the TBTF installed fencing in strategic areas to reinforce the dunes with the help of native dunescape vegetation.[39] Wild sea oats–known to produce a massive, deep root system–have taken hold on the seaward side of the fencing. Overtime, their roots will serve as an anchor to stabilize the dunes.

Lessons Learned & Best Practices

Community stakeholders shared some of their lessons learned and best practices based on their flood experiences and mitigation efforts.

[36] Also see: Williams, A. September 18, 2019. "'Defend, Adapt, Retreat': Tybee's plan to grow resilient against sea level rise." *WSAV3*. Available at https://www.wsav.com/weather-news/our-changing-climate/defend-adapt-retreat-tybees-plan-to-grow-resilient-against-sea-level-rise/.

[37] For over 25 years, the Tybee Beach Task Force (TBTF) has *promoted the health, safety, morals, convenience, order, prosperity and general welfare of the City and to provide recommendations to the Mayor and Council of the City regarding issues affecting the beach including but not limited to beach erosion and re-nourishment*. Tybee Beach Task Force. (2019). City of Tybee. Retrieved on October 20, 2019, from https://www.cityoftybee.org/227/Beach-Task-Force

[38] Tybee Shores Up Its Dunes. (2018). Savannah Now. Retrieved on October 20, 2019, from https://www.savannahnow.com/news/20180619/tybee-shores-up-its-dunes

[39] City of Tybee Island Dune Restoration. (2018). Georgia Department of Natural Resources Coastal Resources Division. Retrieved on October 20, 2019, from https://coastalgadnr.org/PNTybeeDunes

Building and Cultivating Relationships

Building and cultivating relationships across the various community sectors (e.g., nonprofits, community organizations, government, private sector, emergency response, academia) is crucial for effective planning, response, and recovery. Through these relationships, community stakeholders can build trust; share knowledge and data; leverage resources and coordinate their efforts during disaster response and post-disaster recovery; rally around and promote politically charged topics such as "resilience" or "climate change;" collaborate on projects; and address flood resilience more holistically.

Community Outreach and Engaging the Public

It is important for governments to engage the public in local flood mitigation efforts. This can include providing the public with opportunities to give feedback on flood mitigation options and projects, attending local community meetings and events, and holding town halls. Community outreach and public engagement efforts raise public awareness, build trust, promote government transparency, and ensure different sectors of the community feel seen, heard, and valued. Public engagement and outreach is also important for managing community expectations. For example, when local government is embarking on or implementing flood mitigation efforts, keeping the public informed about project timelines, completion dates, and expected impacts can manage unrealistic expectations.

Partnerships and Collaboration

Interdepartmental coordination, public-private partnerships, and regional collaboration are important for advancing flood mitigation efforts. Partnerships across government agencies can leverage resources for flood mitigation initiatives and projects, coordinate messages to the public, and garner support for new or innovative projects and approaches. Partnerships among the public, private, and nonprofit sectors can be beneficial during disaster response and recovery. Regional efforts can reduce flooding across multiple jurisdictions, improve water quality of rivers and streams, and assist local governments in meeting mandated stormwater management activities. Regional partnerships and collaborations are particularly important for developing and implementing watershed planning. Partnerships between local government and the state can facilitate the development of successful proposals and applications for state flood mitigation funding.

Risk Communication

Effective risk communication messages and methods are critical for ensuring the public understands the flood risk and what they can do about it. This can include:

- Translating data and information so it is understandable to a variety of groups (e.g., what does the 100-year floodplain mean, how will sea level rise affect me, what can I do to protect my assets from floods).
- Using a variety of methods to convey flood preparedness and risk information (e.g., Facebook, WhatsApp, Twitter, radio, factsheets, online tools and dashboards, text messages).
- Finding ways to talk about politically charged topics such as "climate change" (e.g., framing discussions within the context of flooding frequency and sea level rise).
- Training community stakeholders (e.g., small business owners, realtors), for example, about the importance of flood insurance and how it works and business continuity planning.

Business Continuity Planning

Many businesses are not prepared for disasters. Small business owners should create a business continuity plan to ensure they can maintain operations during a disaster and through recovery.

Flood Documentation and Recordkeeping

Communities should keep accurate documentation and recordkeeping of their flood disasters. Documentation of an area's flood history, challenges, impacts, and mitigation strategies is helpful for several reasons. These records can help maintain and increase CRS program points. They can also help first responders and the general public understand flood-prone areas and the risks these areas pose. And they can provide individuals, business owners, and the local government with information needed to apply for grants and funds post-disaster.

Beware of Institutional Knowledge Loss

Major disasters tend to occur every several years. In the intervening years, there may be staff turnover and, with it, loss of knowledge of how to effectively respond to, recover from, and mitigate those major disasters. To address this, communities should institutionalize documentation practices to avoid knowledge loss in the event of staff turnover; for example, communities should create a system to document knowledge, what worked and did not work, lessons learned, best practices, etc., related to response to and recovery from major flood events.

Prioritizing Damage Assessments

Under presidentially declared disasters, communities are eligible for federal disaster assistance. In order to understand the magnitude of a storm's damage and impact, communities need to conduct disaster assessments. Because these assessments need to be completed within a very short timeframe, communities should come up with a method to prioritize the damage assessment process. For example, using GIS data to develop a social vulnerability "score" for different neighborhoods (i.e., those most likely to have the greatest damage and impacts) can prioritize where to send assessment teams first and provide an efficient way to distribute scarce resources in a timely manner.

FEMA disaster assistance is not immediate

FEMA disaster assistance does not flow to communities immediately after a disaster. Communities should have a financial plan that addresses immediate and mid-term needs.

Reimbursing Nonprofits' Recovery Efforts

Nonprofits are often under-resourced despite providing a variety of services and resources to community members during a disaster. Government agencies often refer community members to these nonprofits to get needed assistance both during and post-disaster. Yet, federal and state agencies do not reimburse nonprofits for the post-disaster services they provide to affected communities. Federal and state agencies should consider changing reimbursement mechanisms to allow nonprofits to be reimbursed for services they provide.

Incentivizing Flood Mitigation

Builders and developers need more incentives to design with flood mitigation in mind. News about new practices or programs needs to be widely circulated. Potential solutions could include developing a building science community that can share and teach best practices or offering incentives (e.g., tax and other cost savings) that encourage developers to incorporate flood mitigation measures into new infrastructure and construction projects.

Flood Mitigation and Multiple Benefits

Communities should pursue flood mitigation efforts that provide multiple benefits. For example, some communities convert acquired properties into community amenities such as greenways, parks, or community gardens. Developing greenways to mitigate floods provides additional benefits such as community well-being, recreational opportunities, and alternate transportation options.

Worst-case Scenario Planning

Communities should train and plan for worst-case disaster scenarios to ensure they are prepared for real-life events.

Taking Care of the Families of First Responders

First responder agencies should require all staff and personnel to create a personal emergency plan for hurricanes and for other types of disasters such as floods. The plan should include emergency phone numbers, plans for family evacuations, 72 hours of food, clothes, and toiletries (one set to be carried in the service vehicle at all times and one set at home). Though families of first responders should evacuate when the government issues an evacuation order, first responder agencies should consider having a space reserved to shelter first responders and their families.

First Responders are also Victims of Disasters

As public servants, first responders manage disasters and respond to emergency requests. However, community members often forget that first responders are also victims of the disasters they are responding to and have families and property to take care of. First responders should ensure there is a plan for keeping their families safe. And, community members can help first responders by heeding public warnings and evacuation orders.

Challenges and Needs

There were several common challenges and needs shared across the four communities.

Lack of Flood Insurance

There are a variety of reasons why individuals do not have flood insurance:

- In general, people are not well-informed about the NFIP, who administers it, and what it does and does not cover; about surplus line carriers and admitted carriers; other private flood insurance options; or details about depreciated versus replacement costs.

- Communication methods that relay information about flood risk and flood insurance are not tailored to the needs of diverse populations, so this information may not reach some people.
- Some people think they do not need flood insurance because they are not located in a mapped flood zone.
- Some people believe that existing mitigation measures (e.g., levees) will protect them.
- For many residents and business owners, flood insurance is too costly.
- Some people own their homes outright and are not required to purchase flood insurance so they may be less inclined to do so.
- There have been examples of insurance companies discouraging homeowners from purchasing flood insurance.

Unpredictability of Flash Flooding

There are several challenges associated with the unpredictable nature of flash flooding:

- There are no effective tools that can predict flash flooding.
- It is difficult to know when or where flash floods will occur.
- There are no effective flash flood warning systems.
- Because of their unpredictability, it is difficult to prepare for flash floods. First responders do not have adequate time to prepare and there is often not enough time to warn residents.

Mitigating the Impacts of Flooding for Vulnerable Communities

Many vulnerable populations live in flood-prone areas, but available flood preparedness and mitigation measures are often not practical or possible to implement for individuals who live in these areas. Additionally, there is a lack of social science research about how floods impact vulnerable communities.

- The elderly and disabled may have a difficult time accessing homes that are elevated high off the ground.
- People with lower-incomes often cannot afford to rebuild or flood-proof their homes to comply with building codes and regulations.
- The amount of money received to buy out properties in low-income neighborhoods does not provide enough money for homeowners to relocate to a safer area.
- Many people who live in flood-prone areas do so because they have deep historical roots to that location and may not want to move.
- Smaller community-based organizations and nonprofits that serve vulnerable communities have a difficult time obtaining and accessing funding to better serve these communities during flood response and recovery efforts.

The Economic Costs of Flood Mitigation

There are several economic costs associated with flood mitigation efforts.

- Upstream flood mitigation efforts (e.g., opening spillways, diverting floodwaters) can have a negative economic impact on downstream communities (e.g., loss of marine resources; contamination of waters requiring beach closures which can lead result in loss of tourism revenue)
- Property acquisitions are costly for local governments to maintain. Not only is there a cost to maintaining these properties but local governments can no longer collect tax revenues from these properties.

- Construction-related disruptions associated with large-scale flood mitigation projects can interrupt business operations, making it difficult for the public to access businesses (e.g., if streets are shut down or parking lots closed off). Long-term business interruption can be severe enough to force a business to close permanently.
- Flood mitigation strategies along the coast (e.g., development of sand dunes) can obstruct ocean views and beach access resulting in lowering the value of a home.
- Flood proofing historic structures while also meeting preservation requirements can be costly.
- Some flood awareness campaigns (e.g., flood warning signs, high water marks, flash flood warning systems) can make it appear that the flood danger is worse than it is and could discourage the public, tourists, new businesses, or new residents from visiting, setting up shop, or moving to a community.

Understanding the Impact of Development on Flooding

Many communities are grappling with the negative impacts of development on the flood risk.

- New development is replacing the natural environment (e.g., wetlands) with impervious surfaces (e.g., asphalt, concrete) resulting in less areas for water to drain.
- There is a general lack of understanding and consensus about how development actually affects present and future flooding and what could be done to mitigate those impacts.
- While some local jurisdictions and developers have implemented flood mitigation measures (e.g., retention ponds, stormwater drainage), they often do not consider how these flood mitigation measures might impact surrounding communities, communities in other jurisdictions, or communities downstream.

Communicating Flood Risk

Flood risk communication is challenging across stakeholder groups. Although communities develop and distribute flood risk communication resources and information, there are a number of barriers that may interfere with its reach, perception, and/or effectiveness.

- There is a lack of information about flood risks for new residents and new businesses.
- For realtors, there is often no single source of information that they can direct their clients to about the local flood history of a property and local flood risks.
- Risk communication to vulnerable (especially low-income) communities is challenging because they may not have reliable access to web- or phone-based warning signals or information guides.
- In the context of sea level rise in coastal communities, communicating to elected officials and the public about climate change can be challenging if the term is politically charged.
- Although local governments utilize a variety of social media communication tools, people do not always receive these messages.
- Some community members, particularly subgroups such as immigrants or refugees, do not perceive the local government to be a credible source of flood risk messaging.
- For local governments, it can be difficult to compete with other sources of flood risk communication, such as weather apps, Facebook, or other social media outlets.
- Across different levels of government, there is no unified message across local, county, or state agencies and messages may even contradict one another.
- Among the general population, there is a lack of understanding of what a "100-year flood" and "500-year flood" means, resulting in some people believing it will not flood again for many decades if their community recently experienced a 100- or 500-year flood.

- Regarding the actual messaging itself, some community stakeholders believe that flood risk messages do not adequately communicate the severity of the risk or what people should do to be better prepared.
- Accurate flood risk maps or flood prediction models that could inform the development of effective and targeted flood risk messages do not exist.