



# Urban Flooding

MOVING TOWARDS RESILIENCE

A Summary Report Based on the 6<sup>th</sup> Assembly of the  
Gilbert F. White National Flood Policy Forum

Washington, D.C. 2019



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## Letter from the Foundation President

Urban flooding is not new. Ever since humans began constructing infrastructure and adding buildings to an urban landscape, we have had to reckon with low level chronic and higher-level extreme flooding. Sometimes we accounted for urban flooding successfully and other times we underestimated or ignored the flooding condition. In some cases, we took into account increased runoff due to more paved surface areas and in other cases we did not. Recently, catastrophic urban flooding, sometimes displacing entire populations, has provided images that are indelibly burned into our collective minds. And more and more, as urbanization continues, the challenge of urban flooding is rising to be an area of national and international policy focus—and to be perhaps the number one future flood risk for the United States.

The reasons why are multi-layered, but center around two critical elements. First, the nation is experiencing dramatically increased flooding due to changes in rainfall intensity and frequency, sea level rise and coastal storms, exacerbated by inadequate and deteriorating infrastructure. The larger and more densely developed the urban area, the greater the total impact. Second, for a variety of reasons we have adopted by default the 100-year flood as a standard of choice in high value, high density urban areas. This is a standard developed for an insurance program. Many would argue it is inadequate to manage flood risk, considering the economic consequences of flooding and the value of our urban areas.

Increased urban flooding will stress communities, states and the nation in new ways. Even minor events have substantial economic impacts, but urban flooding leads to more than interruption of economic activity and costly system failures. It introduces stressors into vulnerable communities and repeatedly exposes populations to polluted waters, leading to new public health challenges. Normally flood solutions target severe flooding, but urban areas will demonstrate that chronic flooding can be just as impactful over time.

The ASFPM Foundation does not have all the answers, but we know that we must start a dialog and we must start taking steps to deal with this rapidly emerging future, because the consequences are great and failure to act is unacceptable. To jump-start the process, we assembled 100 leading experts in Washington, D.C. for a two-day meeting to begin the discussion and to outline next steps. The report that follows captures this meeting and its conclusions. We hope it provides a starting point for further policy discussions and actions that will make a difference.

**Doug Plasencia, PE, CFM**

ASFPM Foundation President

# The Challenge of Urban Flooding

Urban flooding is becoming more frequent and persistent, with increasingly serious physical, economic and social impacts.



**Heavier rains, higher tides, growing urbanization, chronic flooding.** Every day, across the U.S., streets and parking lots turn into rivers and lakes, storm and sewer waters mix and filthy water backs up into basements and bathrooms. With more extreme urban flooding, neighborhoods become unlivable, transportation links shut down, businesses suffer devastating losses and regional economies flatline.

Patrice Johnson has the messy, smelly job of cleaning up her basement Thursday after heavy rains caused a sewage backup. Her home was one of a number of houses in the neighborhood that experienced sewage damage.

(Source: Milwaukee Journal Sentinel)

## What do we mean by “urban” flooding?

Urban flooding, put simply, is flooding that occurs in a densely populated area. Whatever the specific cause(s) of inundation—cloudburst, hurricane, groundwater seepage, river overflow, infrastructure failure—stormwater systems are overwhelmed, and water accumulates in the paved-over, built up urban environment with nowhere to go.

An individual urban flooding event may be a heavy rain rather than a disaster. But even a minor flood has major effects, particularly in low- to middle-income neighborhoods.

Chronic or extreme, disruptive or catastrophic, the flooding is particularly problematic because it affects a dense interconnected web of people, homes, businesses, jobs, civic institutions and the lifelines that support them. There was a time when much flooding could be dealt with through “retreat”—preserving natural functions, moving buildings out of harm’s way. Now, for many urban zones, retreat is no longer possible. You can’t just move Chicago. Urban flooding demands solutions that span a wide spectrum of technical, social, economic and cultural domains.



When storm waters overwhelm pipes and sewers, water seeks other paths. Sandbags are a final line of defense.



Floodwaters are a health hazard. The water itself can be toxic.



**Grade assigned to the nation’s wastewater and stormwater systems in an American Society of Civil Engineers 2017 infrastructure report card.**

**\$ 271 BILLION** Capital investment needs for wastewater conveyance and treatment facilities, combined sewer overflow correction and stormwater management over a 20-year period.

**\$ TRILLIONS** Total estimated reconstruction and maintenance costs across dams, levees, aqueducts, sewers, and water and wastewater treatment systems.

(Source: Fourth National Climate Assessment, 2018, Ch 3 p 7 and 3 p 10)

## Infrastructure under stress

Inadequate, aging or deteriorating dams, levees, aqueducts, water treatment systems and the various elements of the stormwater infrastructure or “sewershed” create particular problems for urban areas.

**Urban areas have grown. Water control infrastructure has not.** In older cities, some stormwater infrastructure dates back centuries, and most stormwater, water supply and wastewater systems were designed decades ago. The rainfall calculations and design standards no longer fit today’s hydrology, or the ever more complex human ecosystem that expands out from the historic core. Systems are undersized and overworked.

**Heavier rainfall and higher tides further add to system stress.** The Northeast and Midwest, in particular, are experiencing more days with heavy rainfall. Nine of the top 10 years for extreme one-day precipitation have come since 1990. (EPA 2017). Tidal events are increasing in frequency, pushing seawater into drainage systems and causing pump failures.

**Deferred maintenance is contributing to system failure.** Adding injury to insult, many stormwater systems have been poorly maintained over the years. Drain blockage, pipe collapse, or restrictions in capacity can cause urban flooding.



These New Orleans residents learned from Katrina that flood waters can damage everything you own.

## People at risk

Urban flooding disproportionately affects lower income, minority neighborhoods. The people who live there are the most likely to be flooded again and again, and the least likely to have the resources to repair the damage or protect against future events. The serious impacts to their economic well-being and that of the larger community are too often ignored.

Health issues are also a concern. Urban flood waters expose people to a toxic soup of chemicals, feces, sharp objects and pathogens. Mosquitoes breed in the stagnant pools left as the floodwaters recede. Flooding's public health impacts have not received the attention they deserve.

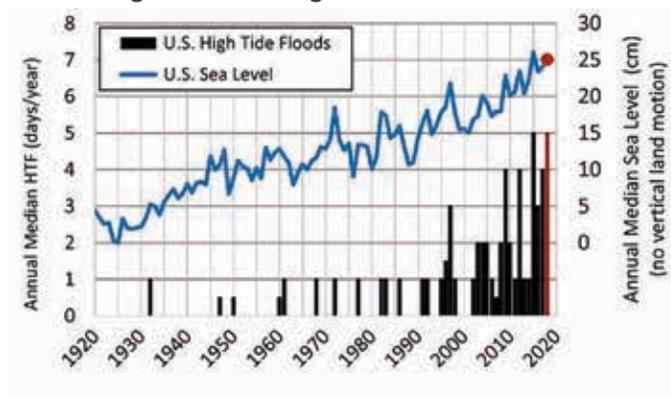
## Climate change, continuing urbanization and greater risks ahead

As the Fourth National Climate Assessment chillingly points out, the impacts of climate change and extreme weather on urban areas' natural, built and social systems will only increase.

**Many cities will see more heavy precipitation. Most will see increasing urbanization.** With some regional variation, U.S. cities are projected to see more days where heavy rains overwhelms already stressed systems. Continued urbanization will put stress on low-lying and downstream systems.

**“Today's flood is tomorrow's high tide.”** Coastal properties and infrastructure are already feeling the effects of increases in sea level, storm surge and tidal

## U.S. High Tide Flooding and Coastal Sea Level Rise



flooding. Groundwater is also a growing contributor to coastal urban areas' flood problems.

**Chronic flooding can lead to catastrophic failure.** The Fourth National Climate Assessment points out that because water management and planning principles typically do not take the probable effects of climate change into account, the potential for catastrophic failure is increasing.

**Current standards for protection are not enough.** In recent years, homeowners and municipal governments have learned the hard way that the 1% annual chance (100-year) flood should not be their sole measure of flood risk. Looking forward, it's becoming clear that over time today's standards for levee and stormwater system construction, critical infrastructure, sea walls, building elevations in floodplains and future development are likely to prove inadequate. Past conditions can no longer predict the future.

## Responding to the challenge

The 2019 Gilbert F. White Policy Forum examined both the problem and ways to move towards resilience through policy and programming.

**Urban flooding remains primarily a local issue.** Forum participants shared multiple examples of innovative and successful efforts, neighborhood level to watershed-wide. You'll find case examples throughout the report.

**State and federal governments and the private sector have important roles to play.** Local action alone is not enough. Resilience requires coordinated action across multiple domains and multiple levels of government. The Forum's suggestions for policy changes and new partnerships guided the report's organization and recommendations.

“Resilience: The capacity of individuals, communities, institutions, businesses and systems within a city to survive, adapt and grow no matter what kinds of chronic stresses and acute shocks they experience.”

(Source: 100ResilientCities.org).

“Resilience: The ability to anticipate, prepare for and adapt to changing conditions; and withstand, respond to and recover from disruptions. Principles of resilience are summarized as Prepare, Absorb, Recover and Adapt (PARA).”

(Source: USACE ECB 2018-2)



## CASE EXAMPLE

### Turning vacant lots into stormwater lots to manage runoff



The New Orleans Redevelopment Authority (NORA) is finding new uses for abandoned properties it manages within the urban core. A series of detention basins now accept runoff from neighborhood streets. Each lot manages an average of 34,000 gallons of runoff water, while serving as green space and reducing localized flooding.

(Source: Dana Brown Associates.)



# Building Resilience: Starting With a Fuller Picture of the Problem

We need to better understand urban flooding: where, how and why it is taking place, and the social, environmental, economic and cultural impacts. Detailed data and strong visualizations can help.

Urban flooding is underreported. Citizens come to accept flooding as a fact of life, even as conditions worsen. First responders, floodplain managers and transportation personnel are aware of inundation areas but may not collect information in consistent form or share it across departments. Communities fail to communicate risks to property for fear of negative economic impact. Regions and states lack coordinated information about flood events and system failures. Federal flood and disaster programs focus more on riverine flooding and coastal storm surge; stormwater programs focus on water quality. We need a much fuller picture of urban flood risks and consequences.

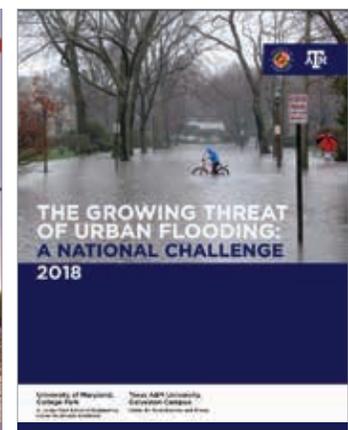
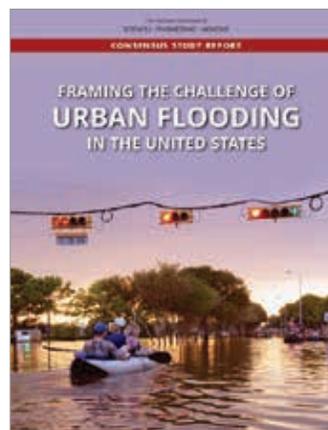
## Needed: neighborhood-to-national data

Better data is starting to emerge. Some private sector insurers now have maps that show flood risk for individual buildings, and FEMA is moving in that direction for the National Flood Insurance Program. Forum participants suggested that communities check what private sector data is available and consider sharing their own data on urban flooding to inform risk. Federal agencies could allow more widespread access to existing datasets (post-disaster individual assistance data, for example,) to help communities assess their risk.

Recent studies of urban flooding from the National Academy of Sciences and University of Maryland/Texas A&M University provide useful insights at multi-city and national levels, based on interviews and surveys. But both reports make clear that there is much more to learn about urban flooding and its multiple impacts.

To address the need for national data Congress could direct the Administration to find an interagency body to develop a national data structure and collect unified data on flood hazards, impacts and risks. A risk identification grant program could help communities identify their risks. Ideally, there should be a national assessment of urban flooding, a follow-on to *Floodplain Management in the United States: An Assessment Report* published by the Federal Interagency Task Force on Floodplain Management in 1992. The assessment could serve as a template that states could feed into.

More widespread access to existing datasets and a national assessment of urban flooding are needed.



(Sources: National Academy of Sciences <https://www.nap.edu/catalog/25381/framing-the-challenge-of-urban-flooding-in-the-united-states>  
University of Maryland/Texas A&M University <https://cdr.umd.edu/urban-flooding-report> )

## Using modeling, mapping and more to present data effectively

Communities are starting to use more sophisticated two-dimensional modeling and digital mapping technologies to visualize risk. The modeling can enable drainage analysis, simulations of storm patterns and system stresses and more precise flood risk assessments. GIS maps can detail where flooding is likely to occur and at what depths of inundation, where stormwater infrastructure is located, where it has underperformed or failed and where the historic drainageways are that water will continue to seek out. Heat maps can show “hot spots” for reported flooding—for example, the locations of 311 calls over time.

Yet for most urban areas, the only maps available are FEMA’s Flood Insurance Rate Maps (FIRMs), which identify areas at risk for 1 percent annual chance (100-year) flooding and do not consider lower-impact urban flooding.

In visualizing urban flood risk, super-precision (“this property actually sits one-inch higher than the 100-year Base Flood Elevation”) is less important than a comprehensive picture of where and to what extent inundation and runoff are likely to occur. Chronic low-level flooding can be as debilitating as a larger event.

Attention should be paid to other kinds of tools as well—tools that could give a sense of the larger problem-solution context. Urban flooding is about more than the water.

**Communities and their residents need locally developed identification, visualization and explanation of risk and vulnerability, not just the FEMA FIRMs.**

**As the recent National Academy of Sciences report points out, we need “a new generation of flood maps and visualizations that integrate predictions and local observations of flood extent and impact.”**

## CASE EXAMPLE

### Fort Worth models urban flood risk



When Fort Worth’s Stormwater Management Division modeled local flood risks, they found chronic flood risks concentrated in areas well outside the 100-year flood zone.

In this flood hazard map of a Fort Worth neighborhood, the FEMA Special Flood Hazard Area (100-year flood) is shown in purple. The locally identified areas subject to a 1-year flood are shown in blue/green (shallower flooding) and orange/red (deeper flooding) and were derived from a two-dimensional planning model that integrates lidar and storm drain information.

(Source: Stormwater Management Division, City of Fort Worth)

# Taking Integrated Approaches to Address the Issues

Urban resilience is about much more than the water. Lasting resilience comes when different interests come together to find solutions that span multiple domains.

Siloes don't solve problems. The urban landscape is packed with people, commerce, traffic and services extending well beyond the city line. Beneath the occasional open spaces—the streets and sidewalks and parks that dot the landscape—lie a maze of utilities and transportation networks supporting the above-ground human ecosystem. Stakeholders are numerous and diverse; operational, advisory and regulatory responsibilities are spread horizontally and vertically across offices, agencies, departments and levels of government; impacts from the same flooding event will affect different players in ways that range from nuisance to life altering.

## Local coordination to advance shared goals

Integrated planning lets communities leverage multiple sources of funding and develop more comprehensive solutions. The key is to find ways to work across the organizational siloes that constrain concerted action. Public works, social services, transportation, housing and health, water and sewer authorities, planning departments, emergency services and a range of organizations and businesses all have a stake. A mayor's committee, a task force structure or special authorization may be needed.



Above, Copenhagen's integrated planning process for cloudburst resiliency.

(Source: Ramboll)



In Flushing, New York, a cloudburst street combines permeable pavement and green infrastructure to capture runoff.

(Source: Ramboll)

## Problem solving through regional coalitions and stormwater authorities

Throughout the country, multi-agency and multi-jurisdictional coalitions are being formed to discuss shared water concerns and create common standards and programs. Watershed coalitions with representatives from jurisdictions and stakeholder groups help enforce a philosophy of “do no harm” when it comes to ongoing and future development.

Municipal and multi-jurisdictional stormwater utilities and regional water districts have also been successful. They enable stable, dedicated sources of funding, offer a locus for bringing together stakeholder points of view, and conduct operations, resilience planning and flood data management at appropriate scale.

Often, creating such entities requires state legislative action or taxpayer approval, and the challenges can seem daunting. Federal technical assistance could be provided through, for example, FEMA’s Cooperating Technical Partners program.

### CASE EXAMPLE

## Integrated Stormwater Management (iSWM) in North Central Texas

The North Central Texas Council of Governments is helping communities work together in a region-wide effort to reduce flooding, emphasize sustainable systems, improve water quality and meet state and federal regulations. The NCTCOG provides workshops and meetings, design manuals, technical assistance and a three-level certification program. To date, 18 communities, including Dallas and Fort Worth, are



Street sign denoting community participation in the iSWM Program.

(Source: NCTCOG)

iSWM certified and more than 60 local governments are cooperating members.

Learn more at <http://iswm.nctcog.org>

### CASE EXAMPLE

## Integrated Planning for a Colorado Watershed



Denver’s Upper Montclair basin is a large intensely built-up area that tracks the path of a former creek. The area’s stormwater infrastructure was created in the early 20th century. It is no longer adequate to deal with today’s built environment and changing rainfall patterns. The traditional approach to addressing the problems would be more “grey infrastructure” to convey the water, along with areas for detention. Denver took a different approach.

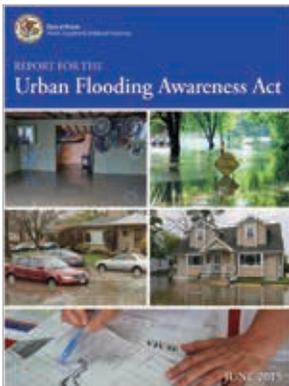
The first step was to work with communities’ residents and businesses to understand the interplay between the built environment and flooding, and to spark conversations around alternatives. The result: a multi-year master plan for watershed-wide resilience, incorporating both “grey” and “green” approaches and solutions both large and small.

(Source: Enginuity)

Regional coalitions and water management structures can engage jurisdictions and stakeholders to create solutions at scale.

## State-level integration of planning and programs

States have differing operating structures and play different roles in water management. Some states maintain centralized control; others default to community home rule. Many states mirror in their own structures the fragmentation that exists at the federal level, with different agencies implementing different elements of water-related legislation. Some states are equipped to handle integrated planning and programs; many are not. Yet states are key linchpins for change.



The State of Illinois [Report for the Urban Flooding Awareness Act](#), June 2015.

A state that has taken strong steps is Illinois, which in 2015 conducted a comprehensive study of urban flooding and passed legislation to enable new types of stormwater authorities and better alignment of state capital projects.

As a starting point for state-led change, having professional organizations rally around this issue may help. For example, the Illinois Association of Flood and

Stormwater Management partnered in Illinois' landmark review of urban flooding. The New Jersey Association of Floodplain Management actively worked for recently passed legislation to form stormwater utilities in the state.

## Key partners—professional groups and the private sector

Associations dealing with water management and urban development can play key roles in enabling integrated approaches to floodplain and stormwater management, formation of appropriately scaled water management authorities, and inclusion of social and environmental considerations in planning. Working together, ASFPM, NAFSMA, the American Water Works Association, the Water Environment Foundation and research organizations could help bring about a new understanding of how water quality and quantity concerns must work together in an evolving urban environment. Private sector interests—developers, the real estate community, lenders, banks—are additional and essential voices for change.

### CASE EXAMPLE

## Involving the private sector in Charleston



Nearly 75% of all construction in the United States emanates from private sector interests, who can be essential allies in efforts to address vulnerabilities and build resilience. After heavy floods in 2015 the [Charleston Resilience Network \(CRN\)](#) brought together 120+ connecting organizations, plus local, federal and academic partners and advisors, to review performance and foster a unified regional strategy for resilience. Among CRN's current projects: localized flooding models that incorporate tides, meteorological events, wind, surge, and infrastructure such as tunnels and drains to provide parcel-level vulnerability assessments.

Support from associations and stakeholders can help drive greater program integration, formation of appropriately scaled authorities to manage water, and more holistic approaches to urban flooding resilience.

## National integration—a Unified National Program for the 21<sup>st</sup> century

The United States cannot wait until the next disaster to focus on urban flooding. The potential economic loss and impact to human life are too great. But where will leadership reside? The ASFPM Foundation estimates that ten Cabinet departments, two non-cabinet departments, and at least three offices within the Executive Office of the President have a stake in the issues. Within the legislative branch a very large number of subcommittees and full committees on both the House and Senate sides could be engaged in the discussion. The notion that we can assign a single agency to resolve urban flood issues for the Federal family is simply not workable.

The Forum proposed that federal agencies organize collectively for success. To that end:

1. The Federal Interagency Task Force on Floodplain Management should prepare an updated Unified National Program on Floodplain Management that specifically looks into the issue of urban flooding. The report can look beyond mitigation to consider the economic, social and public health challenges posed by urbanization and chronic flooding, as well as specific issues of water quantity and quality and public health. The goal would be to develop a roadmap and subsequent directives for the design, governance and implementation of comprehensive floodplain, stormwater and flood risk management.
2. As part of the creation of the Unified National Program there should be a call for a national assessment of urban flooding that will quantify the extent and trend of the problem.
3. Congress should be part of the dialogue, and be prepared to craft a federal legislative response to the urban flooding threat, including mitigation, economic, social and environmental actions.

Implementing the new Unified National Program would be a nationally coordinated effort involving federal agencies (FEMA, NOAA, EPA, HUD, USACE, DOT, HHS and others), regional planning agencies, state governments, community-centric perspectives, non-governmental organizations and the private sector, with buy-in from Congress and the White House. Stakeholder involvement throughout is key to success.

This is a big ask. Success depends on significant executive and legislative support and dedicated effort. But the challenges we face call for nothing less.

## With stakeholder involvement, update the Unified National Program.



**There are precedents for a Unified National Program. It's time to renew it!**

(Copies of covers of Unified National Program documents, 1966, 1976, 1979, 1986, 1994)

# Addressing Social Vulnerability and Inequity

In many cities, affluent neighborhoods are largely flood-free, while lower income areas and their residents face surface and basement flooding, job losses, health issues and devastating losses in extreme events—and displacement once problems are addressed.

The U.S. Centers for Disease Control and Prevention Social Vulnerability Index maps and rates community resilience to stresses on health, such as disasters or disease outbreaks, by census tract. Overlaying the tracts where America's most vulnerable populations live with areas of known urban flooding yields a striking match-up. The people who live in dense, aging urban cores and low-lying inundation areas—their neighborhoods served by undersized and deteriorating infrastructure—are the low-income, elderly and other socially vulnerable people who have the highest risk of urban flooding and the fewest resources to combat it. Those who can afford to move to less flood-prone areas retreat, and the marginalized are left behind.

That said, many of these vulnerable neighborhoods are marked by strong cultural networks and community ties. Projects that attempt to greenify or gentrify without attention to the whole community and its concerns are rife with unintended consequences. Good urban design demands inclusivity and social equity.

**“Engineers shall consider the diversity of the community, and shall endeavor in good faith to include diverse perspectives, in the planning and performance of their professional services.”**

(Source: ASCE Canon 8)

## At the household level: Finding ways to help

Property owners are responsible for remediating problems affecting their property. But that responsibility breaks down when owners can't afford to take the needed action—or when those affected are renters.

Community help with improvements like backflow prevention or floodproofing can make a real difference. The City of Wheaton, Illinois, for example, offers drainage reviews for property owners free of charge. Non-profit and neighborhood groups can offer assistance as well.



Floodwaters erode land and house foundations.

(Source: ASFPM)

## Planning *with* the community, not *for* the community

Having neighborhood and advocacy groups and affected residents be part of the decision-making process builds trust. It also ensures that solutions take into account the cultural fabric of affected areas, people's need for safe, affordable housing, and the places where help is most needed. Community involvement also helps when applying short-term solutions like temporary demountable barriers or improvements to private sewer pipes. The near-term fixes provide benefits while longer-term solutions are still in the planning stage.

## Re-examining the criteria used to justify return on investment

Should property values be the driving factor for capital improvement planning? When mitigation and redevelopment projects are prioritized, lower-income property improvements and even buyouts may not meet federal or local project criteria. An ROI equation based on property value doesn't factor in social equity, public health considerations or preservation of a community's cultural identity. It is important to consider people as well as properties. An approach might be to add a weighting factor for funding based on the Social Vulnerability Index, or to set aside funding specifically for disadvantaged areas.

**We have a moral imperative to consider social equity in solutions to urban flooding. Refocusing the criteria used to set project priorities can help enable more inclusive solutions.**



Houston residents are rescued by U.S. Border Patrol riverine agents.



The Center for Neighborhood Technology offers the free [MyRainReady](#) do-it-yourself online home assessment tool. It targets water problems affecting Illinois urban areas.

(Source: [cnt.org/rainready](http://cnt.org/rainready))

### A resilient community:

1. Develops comprehensive risk data, conducts real-time monitoring
2. Shapes policy for all socioeconomic stakeholders
3. Talks with residents, businesses, developers, builders and other stakeholders to build engagement
4. Educates the public about risk, remediation and insurance
5. Partners with stakeholders, nonprofits, agencies and neighborhoods to provide needed help
6. Partners with low-income financial programs and institutions—including those that fund simple home repairs and assist with code violation repairs
7. Financially invests in mitigation strategies
8. Increases flood insurance policy coverage

(Source: Jacobs)

# Making Future-Informed Decisions

Many urban areas are realizing that they must plan now for future conditions that could look very different from today's. For some, the work is already well underway.

Climate change, urbanization, aging infrastructure and social injustice have impacts that will only increase over time. Communities already facing imminent sea level rise, rapidly increasing rainfall, water quality and runoff issues or chronic flooding are developing innovative programs that take the long view. Four of them are highlighted here.

## Miami Beach Rising Above

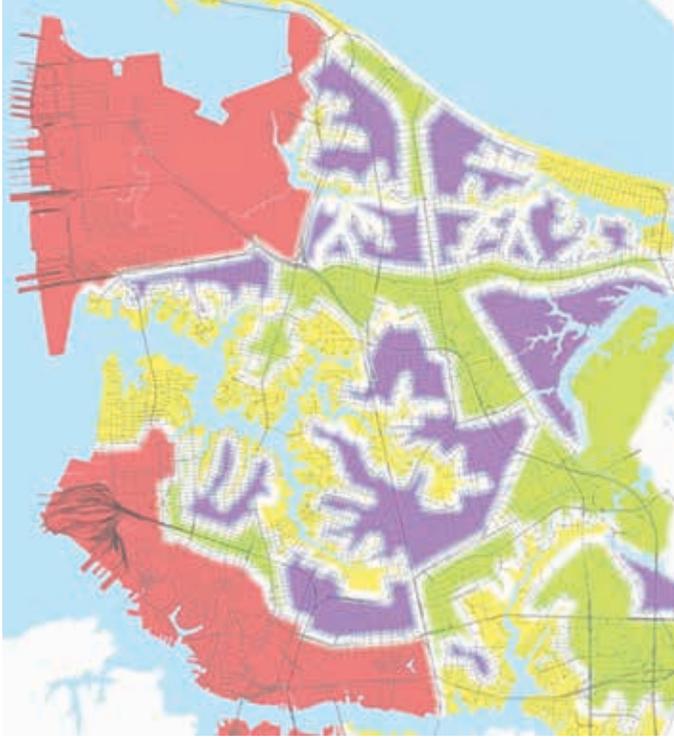


For Miami Beach, Florida, sea level rise and tidal flooding are a constant concern. The city's Rising Above program is taking a broad-based approach to risk reduction over time. The elements include infrastructure improvements, land use policy, road elevation, guidance for private properties, blue and green infrastructure, incremental finance districts, low interest loans, public communications and community engagement. Detailed economic impact analyses help inform investments. A key innovation has been to add resilience adaptations into the city's land use codes. Many of the initial adaptations allow further adjustment over time, saving money in the near term and enabling flexibility as conditions change.

Among the code changes the city is adopting are:

- Requiring higher freeboard of up to five feet
- Facilitating raising first-floor slabs incrementally
- Embedding water management goals into development recommendations
- Adopting higher commercial building standards
- Establishing higher ground and seawall elevations
- Increasing greenspace through larger setbacks

## Norfolk's Vision 2100 for the coastal community of the future

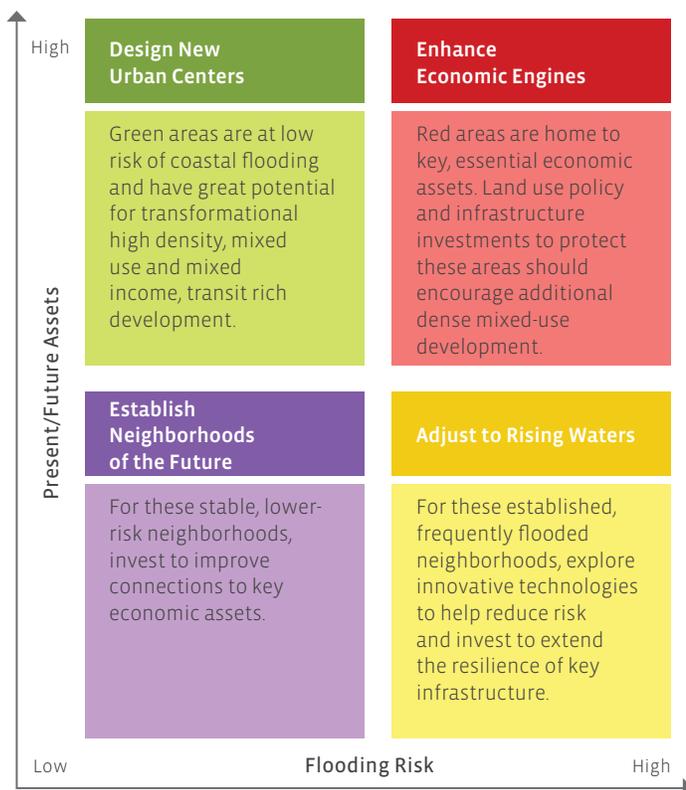


Faced with the reality of rising seas, growing population, a changing economy and aging infrastructure, Norfolk, Virginia is looking at nothing less than transformation. The mechanism is a visioning process with an 80+ year timeframe. With community-wide buy-in, the city has mapped its assets and risks, prioritized what matters most, and created four broad “vision areas” that will guide future resilience efforts. The vision will be implemented in concert with the city’s 2030 general plan and a new resilience-focused zoning ordinance, in line with these overarching strategies:

- Focus major infrastructure investments in the most resilient areas
- Improve transportation connections throughout resilient areas
- Be a model for responsibly addressing resilience, embracing enhanced stormwater reduction, green building and green infrastructure citywide
- Use tools and incentives to develop a more resilient housing market
- Seize the economic opportunities of emerging resilience based industries, and provide support such as tax credits and other financial incentives

Norfolk has also developed specific strategies for transportation, development and protection for each of the four vision areas. The strategies can be implemented over time as conditions change and land becomes available. Learn more at [Norfolk Vision 2100](#).

With a long-term vision agreed to, implementation can take place over time, lessening the potential for immediate opposition and allowing goals to remain clear as conditions change.



Each of the four color-coded vision areas represents a different combination of present or future key assets and flood risks.

(Source: City of Norfolk)

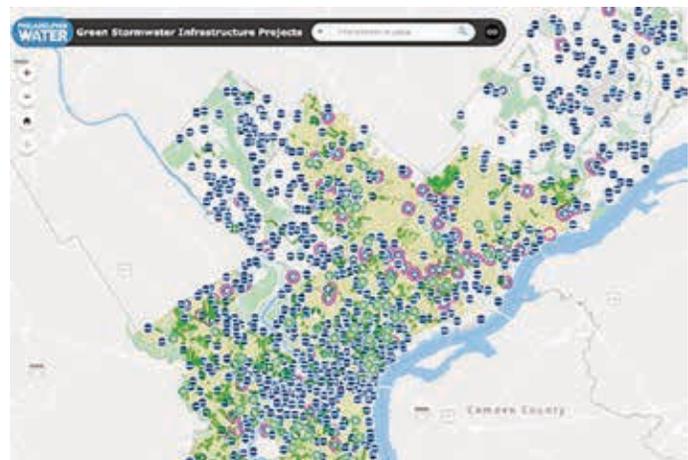
## Philadelphia's 25-year Green City Clean Waters plan



The idea of managing stormwater through natural systems isn't new, and the benefits of green infrastructure are well known. What *is* new, as the Urban Land Institute points out in [Harvesting the Value of Water](#), is using municipal policy to create coordinated citywide green infrastructure networks. Such networks require extensive participation from the private sector, with policy requirements enforced for both development and redevelopment. The public sector incorporates green design into public spaces, buildings and rights-of-way, while the private sector does so for privately owned buildings, open spaces and roofs. Developers benefit through reduced runoff and a value-add to their buildings. Municipalities benefit through improved quality of life and a sustainable approach to resilience.

Such networks need not rely on high-profile, high-cost redevelopment projects for success. Philadelphia's holistic approach to incorporating green infrastructure is the multi-neighborhood level Green City Clean Waters plan. Over 25 years it will transform the health of the city's creeks and rivers and reduce sewer overflows and runoff, primarily through a land-based approach.

Results will include reduced water pollution impacts, improved essential natural resources and lessened risk of urban flooding. Progress is tracked on an interactive map on the water department's website. To date it shows more than 400 privately constructed and nearly 500 publicly constructed features, from tree trenches, planters, bump outs and rain gardens, to reclaimed stormwater wetlands and porous paving projects. The majority of amenities and services are concentrated in low income communities to improve environmental and physical health. The \$1.6 billion estimated lifetime cost is 15 to 20% of the estimated cost to upgrade and expand the city's conventional combined sewer overflow system.



As shown on this map, hundreds of projects have already been completed.

(Source: City of Philadelphia)

## Washington, D.C.'s short-, medium- and long-term plan for a neighborhood's resilience



Medium term engineering solution: First Street NW Tunnel

(Source: Washington DC)

While flooding in the National Mall area captures headlines, Washington, D.C. is also working hard to address problems far from the monumental core. In 2012, the Bloomingdale neighborhood, a “Zone X” area of low flood risk far from the district's rivers, experienced multiple events that led to stormwater and combined sewage flooding—and not for the first time. The sewer serving the area was built in 1879, when the area was much more rural. System upgrades were long overdue. The district decided to take a comprehensive, multi-year approach to risk reduction.

The mayor set up a Task Force on Prevention of Flooding to find solutions that could be implemented through coordinated efforts over time, with an emphasis on community engagement. The plan included engineering, regulatory, code change, operational, maintenance and public outreach components:

- Surveys and meetings with residents to determine the locations and costs of flooding
- Mapping of overland surface flow and subsurface pipe performance
- Ongoing public outreach and risk communication covering flood preparedness and response
- Short-term engineering solutions, beginning with a mandatory backwater valve program with cost rebates, flood proofing consultations, a rainbarrel

program and green infrastructure

- Medium-term engineering solutions involving construction of temporary stormwater storage and a new tunnel, plus additions to the rain barrel and green infrastructure efforts
- A long-term engineering solution to advance construction of a larger Northeast Boundary Tunnel, originally planned for completion by 2030 as part of the DC Clean Rivers Project
- Regulatory changes to prevent sewer backups and surface flooding
- Sewer backup insurance requirements and real estate disclosure requirements
- Code changes for new projects and projects exceeding 50% of assessed value
- Backwater valve education and permanent flood risk signs

The scope of the project and an aggressive timetable meant that numerous agencies would have to be involved and that the task force leader must be empowered to direct them. Multi-year budgets, dedicated staff, easements, fee-waived permits, street closure coordination, and the myriad other details that a successful project requires were put in place and efforts are well underway. Learn more at [dcwater.com/projects](http://dcwater.com/projects).

# Taking a Fresh Look at Funding, Financing and Insurance

While new approaches to federal funding are needed, there are also new options available for local and regional financing and insurance.

Urban flooding is taking a tremendous and growing toll on communities and the nation. Finding and paying for solutions should be a responsibility for all levels of government and the private sector.

## Ensuring that federal grant, loan and cost-sharing priorities address urban needs

For more than half a century, the nation's flood policy, programs and projects have been premised on large flood events, with a heavy emphasis on the 100-year flood. Federally declared disasters have been a major catalyst for concerted action; lesser and chronic flood events have been individual localities' responsibility.

To help lessen the risks and potential impacts it will be necessary to re-evaluate federal program missions and consider new funding sources to augment local taxes. The reasons for change reach well beyond the flooding itself. Economic and job losses, health impacts and increased demand for social services need to be factored into governmental reasoning for spending.

HUD, FEMA, USACE, EPA and other agencies should prioritize solutions that improve the performance of local infrastructure and lessen future risks. There is also a clear need to step back from benefit-cost analysis (BCA) as the primary or sole factor to prioritize public works and engineering projects.

**More urban-centric priorities for federal grants and projects are needed.**

## CASE EXAMPLE

### The vision for a more resilient Boston harbor includes future-ready developments like Clippership Wharf



The privately funded Clippership Wharf project is revitalizing a neglected section of Boston waterfront, in keeping with the city's Resilient Boston Harbor concept. Elevated park spaces and buildings, easy public access to the waterfront and transportation links are all part of a design that anticipates climate change.

(Source: Lend Lease/ ULI Climate Forum)

## CASE EXAMPLE

## China's "Sponge Cities" concept: urban flood control and sustainable water use as a national priority



The scale of China's recent urbanization has created unprecedented urban water problems, and the People's Republic of China is taking major steps to address them. The Sponge City Program aims to create cities with water systems that operate like sponges to absorb, store, infiltrate and purify rainwater and release it for reuse.

The primary objectives are to retain 70-90% of annual rainwater on-site through use of green infrastructure and low impact development, to prevent urban flooding, and to improve urban water quality while mitigating impacts on natural ecosystems.(Li, Ding, Ren, Li & Wang, 2017).

In 2015, China's Ministry of Finance, with support from the Ministry of Housing and Urban-Rural Construction and the Ministry of Water Resources, selected 16 pilot cities to be the first implementers, with central government and city funding. By 2020, the Chinese government is expecting 20% of urban areas to follow the sponge city requirements, and, by 2030, 80% of urban areas are scheduled to comply with the requirements.

(Source: Huffpost kafka4prez/Flickr, CC BY-SA)

### Options for local and regional project financing

Municipalities regularly fund infrastructure improvements and other resilience-focused projects through property taxes, special assessment districts, municipal bonds, state grants or low interest loans. But better keys to success may be to fund upgrades through stormwater utility fees, or to use a mix of government and private sources to fund comprehensive solutions. Innovative financing options can help spread out the costs and buy down risk.

#### Creating a stormwater utility with a dedicated fee structure.

No, we're not recommending a rain tax, though that's what opponents may say. Utilities charge fees, not taxes, and, in the case of stormwater utilities, they are typically proportionately based on the extent of impervious surfaces: pave more, pay more. Credits for property-specific mitigation can also be applied. The process of setting up a new utility takes time, a good communications plan and legal and cost structure due diligence. However, the results for urban areas as diverse as Salem, Oregon; Chicago, Illinois; and Washington, D.C. have been highly positive.

**Use of Federal funding.** There are federal grant programs and project cost-sharing initiatives to draw on from FEMA, HUD, EPA, USACE and other agencies. Two caveats: (1) Federal dollars rarely address ongoing costs of operation and maintenance, nor do they address the full current or long-term costs of a comprehensive project. (2) Waiting to act until disaster strikes and more federal aid becomes available is foolhardy at best.

**Public-private partnerships.** To make sure the objectives of both developers and the larger community are met, communities may need to apply carrots and sticks. Incentives can include density bonuses and tax abatements. Disincentives where regulatory authority is impractical can include taxation of impervious cover.

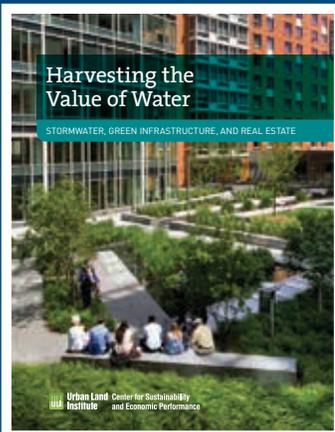
**Incremental and life cycle costing.** By planning and funding a long-term project incrementally, higher levels of protection can be set to phase in over time. If extensive climate change is anticipated, planning for a limited life cycle or use of long-term leases in lieu of individual ownership may be valuable options that lower individual risk. Lifecycle approaches to asset management help avoid unpleasant, unfunded surprises.

## CASE EXAMPLE

## The Rose: A creative partnership combines mixed income redevelopment and stormwater management in Minneapolis



Built on a previously contaminated site, with 33% green space and rain gardens that infiltrate and reuse 90% of rainwater for community gardens, the Rose is a testament to sustainable design. The project is a public-private partnership that combines market rate and affordable housing, as well as supportive housing for the long-term homeless. Further partnerships between design and construction teams were the key to achieving sustainability standards while preserving affordability.



In this report, the Urban Land Institute offers numerous examples of projects underway across the country. Find them at <http://ULI.org/stormwater>

(Source Above: Aeon/MSR Design, courtesy of the Urban Land Institute)

**Bonds that help buy down risk.** Bond rating agencies now ask questions about climate change in their evaluations, and new financing options to reduce risk are appearing in the private marketplace. Catastrophe (Cat) Bonds work like 3- to 5-year insurance policies that pay if a disaster reaches a certain event level. Resilience bonds offer a financial incentive to institute projects that measurably reduce risk. Environmental impact bonds can be used to support green infrastructure. If the project is successful in reducing stormwater costs, bond investors receive a further payout based on the savings.

**Public-private partnerships and a mix of financing options can help in funding future-facing solutions.**

### New directions for federal and private flood insurance

Having insurance protects against financial disaster and speeds recovery and resilience. Changes to the National Flood Insurance Program to enable property-specific risk rating and the surging growth of private insurers into the marketplace promise new opportunities for affordable flood insurance. However, aggressive community education is needed to spur voluntary participation.

Part of the education effort needs to be clear information on what policies do and don't cover. Federal flood insurance has a specific definition of what constitutes a flood. The flood must cover at least two acres or two properties. There must be an "unusual and rapid accumulation" of floodwater, and the condition must be "temporary." And there are limits to what is covered in basements. Private insurance policies typically follow



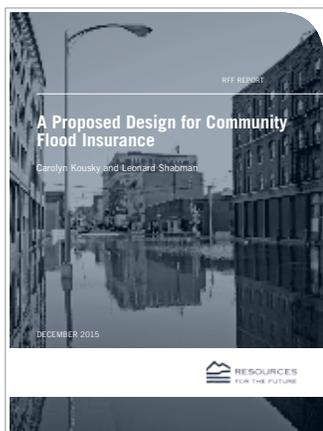
**As high-tide flooding becomes a more and more regular occurrence, will the flooding still be considered "unusual" or "temporary"?**

Source: Catalina Kurt/Save Newport

the federal definition but may offer additional basement coverage. Seepage and sewer backup will likely not be covered, except as an extra-cost endorsement to homeowners policies.

### Community-based and parametric insurance options

The idea of community-based flood insurance (CBFI) has spurred interest. A CBFI policy could be set up based on the total potential flood loss for all insured structures in a given area, with premiums collected through property taxes, utility fees or direct sales. The pros and cons of creating such a policy are highlighted in the National Research Council report [A Proposed Design for Community Flood Insurance](#).



Parametric insurance is another way to provide coverage against catastrophic events. A parameter is set (wind speed, rainfall level, flood depth) and when it occurs the pre-determined limit is paid. Loss adjustment is not needed, as the trigger is established and measured by a credible third party. Communities can look at this risk-transfer option to cover their own infrastructure, or get creative and use it to

offer coverage for their constituents. Puerto Rico, for example, has considered parametric “micro insurance” to help its lower income citizens recover more quickly after a hurricane of a specific strength. A “Flood Flash” policy is now available in the United Kingdom that provides coverage for a given flood depth. When real-time sensors are triggered by the flood depth in the policy, the claim is immediately verified and payment is made.

**Federal and private flood insurance and community and parametric insurance options all help to speed recovery and resilience.**

#### CASE EXAMPLE

### Funding green infrastructure through an Environmental Impact Bond (EIB)



To address increasingly heavy rainfall and sewer overflows, Washington, D.C. has been applying a range of solutions, including green infrastructure. For funding, DC Water pioneered with Goldman Sachs and the Calvert Foundation to create the nation’s first “pay for success” EIB.

DC Water pays the costs of installing the green infrastructure, but the performance risk is shared with the investors. Payments will vary based on the success of the environmental intervention.

Atlanta has adopted the EIB approach as well. However, while DC Water’s bond was sold in a private placement, Atlanta’s is a publicly issued bond, with all the hallmarks of a traditional public municipal bond offering, such as a designated CUSIP number and a Moody’s rating (Aa3).



# Committing to Resilience

**Think globally. Plan regionally. Act locally. Resilience starts with community ownership and action—and succeeds with the nation’s support.**

The risks that communities face often result from actions taken decades or even centuries ago, compounded by failures to face facts and adapt. Here’s the hard truth: the risks are real, they’re growing, and at the end of the day it is the community that will bear the brunt of the impact. The path to the future starts with community commitment. But the path can be made easier through focused support.

## A national call to action

Individual communities know—or are quickly learning—the costs of urban flooding and the need for resilience. Surrounding regions are learning that the economic and social health of the whole region depends on the health of its participants. And the reality is that everyone in our interdependent society has a stake in the resilience of our high-density, high-value urban areas. If the federal paradigm for flood-related assistance does not change, if programmatic siloes aren’t replaced with more integrative approaches, if developers and redevelopers don’t embrace the concepts of resilient design, the nation as a whole will feel the pain.

The ASFPM Foundation is committing to continue making urban flooding a priority and is asking others to do the same. To this end we propose two immediate steps:

**A jointly sponsored summit on urban flooding.** The ASFPM Foundation is proposing to join with other stormwater, infrastructure, urban development and environmental groups, key policy makers and other involved parties to host a summit meeting on urban flooding. The meeting

would lay out the policy roadmap for urban flooding resilience and identify opportunities for collective action.

**A toolbox to aid action.** Community representatives at the Forum requested a toolbox to help urban areas in developing comprehensive and integrated approaches to resilience. The tools would include links to examples of plans, design and zoning standards, outreach programs, financing partnerships and infrastructure upgrade efforts.

### Elements of an Urban Flooding Toolbox

- Recommendations for integrated planning processes
- Locally driven approaches to modeling, mapping, visualization
- Guidance on design standards for resilience
- Examples of successful adaptive building practices
- Approaches to risk awareness and risk mitigation communications
- Federal and state programs to draw from
- Funding sources and grants available
- Incentives to spur responsible development

## The time to begin: right now!

The time to address urban flooding is now. The ASFPM Foundation is making urban flooding a priority in our own work. We urge that every neighborhood, city or region faced with urban flooding review the recommendations of this report and do the same.

# Synthesis of Recommendations

## **Make having a clear picture of urban flood risk and impacts a local to national priority.**

Collect, visualize and share data locally; enable information gathering through grants; share data; conduct research to better understand changes in precipitation and public health impacts; develop a national assessment of urban flooding.

## **Prioritize local and regional coordination to find comprehensive solutions for flooding and rainwater.**

Create special task forces and watershed level coalitions to deal with problems; develop partnerships with the private sector; provide association, state, and federal support for such efforts.

## **Enable and incentivize dedicated authorities for stormwater management.**

Explore local or regional authorities; provide state level legislation, if needed, to overcome barriers to their formation; offer federal training.

## **Refresh the Unified National Program for Floodplain Management.**

Bring together agencies and stakeholders; address urban flooding and stormwater issues; develop a plan and deliver on it.

## **Consider inclusiveness, social equity and public health impacts in valuing projects.**

Include representatives of vulnerable populations in planning; place value on social benefits in justifying funding; move beyond over-reliance on property-based cost-benefit calculations; make the business case from a broad city- and region-wide perspective.

## **Consider climate change and urban flood realities in setting standards.**

For urban areas, institute stronger standards that exceed the 100-year flood standard for critical infrastructure; also recognize that much urban flooding occurs outside of federally designated Special Flood Hazard Areas; develop long-term goals for resilience based on social, cultural, economic and technical considerations.

## **Take the long view.**

At the local to regional level, develop a vision and long-term goals for resilience, taking into account anticipated changes in climate, population, urbanization and land use, as well as social, cultural, economic and technical considerations.

## **Take advantage of financing options and insure against financial risk.**

Look at a mix of options to enable adaptation and lessen flood risk; educate the public about the realities of flood risk; broaden insurance coverage.

## **Jump-start needed change with an Urban Flooding Summit and tools for communities.**

Bring together the major organizations dealing with the issues and opportunities, together with key stakeholders, to set the agenda for change; as a first step, explore a multi-partner approach to leadership in planning and conducting the summit and provide tools and support for community efforts.

## **Don't wait; begin today.**

Don't wait for disaster to act; own the problem at the community level; educate the public; break down the siloes; start now to move towards resilience.

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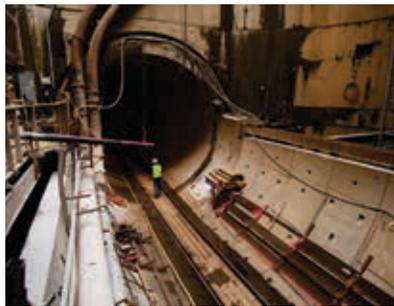
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## List of Acronyms

ASFPM	Association of State Floodplain Managers
BCA	Benefit Cost Analysis
CAT	Catastrophic Bonds
CBFI	Community-based Flood Insurance
CFM	Certified Floodplain Manager
CRN	Charleston Resilience Network
DOT	U.S. Department of Transportation
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
GIS	Geographic Information System
HHS	U.S. Department of Health & Human Services
HUD	U.S. Department of Housing & Urban Development
NAFSMA	National Association of Flood & Stormwater Management Agencies
NOAA	National Oceanic and Atmospheric Administration
NFIP	National Flood Insurance Program
PARA	Prepare, Absorb, Recover & Adapt
PE	Professional Engineer
ROI	Return on Investment
USACE	U.S. Army Corps of Engineers



This report is available on the ASFPM Foundation website at <http://www.asfpmfoundation.org>

### **Association of State Floodplain Managers Foundation**

The mission of the ASFPM Foundation is to promote public policy through select strategic initiatives and serve as an incubator for long-term policy development that promotes sustainable floodplain and watershed management. The Foundation's hallmark event, the Gilbert F. White National Flood Policy Forum, brings together national and international experts to evaluate and provide recommendations on pressing policy issues.