SECOND EDITION

Flooding and Sea Level Rise STRATEGY

Charleston
SOUTH CAROLINA

FEBRUARY 2019

(THIS PAGE INTENTIONALLY LEFT BLANK)

CONTENTS

ON THE COVER

The City has installed 22 check valves to prevent tidal backflow and has plans for additional valves. For more information **see page 10.**

The Spring/Fishburne Drainage Project is under construction. For more information on drainage projects **see page 8.**

The City meets with community stakeholders to gain feedback about a new flood awareness program. For more information **see page 24.**

VISION

This Strategy sets a vision for the protection of Charleston providing a guiding framework to protect lives and property, maintain a thriving economy, and improve quality of life by making the City more resilient to the existential threats of flooding and sea level rise.

(THIS PAGE INTENTIONALLY LEFT BLANK)

A

RISING TO THE CHALLENGE

For nearly 350 years, the people of Charleston have been shaped and defined by their relationship with the sea. The very thing that provides the founding heartbeat for our area also makes us vulnerable.

In the face of recurrent flooding, the rising seas, and more frequent extreme weather, **our mission is clear**; as a City, we strive every day to **preserve and enhance the quality of life** of the citizens of the City of Charleston. We recognize that water is an asset and, as such, we must learn to live with the water. We will approach challenges as opportunities and embrace innovation and learning.

"...we simply must make flooding and drainage our City's top long-range priority."

- Mayor John J. Tecklenburg, State of the City Address 2018

OUR GOALS

GOALS TO ADDRESS FLOODING AND PROMOTE A MORE RESILIENT AND SUSTAINABLE FUTURE

1. **Protect our citizens and neighborhoods.** Vibrant neighborhoods have been at the core of our City for hundreds of years. It is imperative that we ensure, through innovative policies, that we are building future neighborhoods resilient to flooding that will maintain their value in spite of future challenges. Likewise, we will continue to make retro-active improvements and modifications, using multiple solutions, to improve the resilience of existing neighborhoods, including elevating homes as appropriate and acquiring homes for removal when necessary.

2. **Protect and enhance critical City infrastructure.** Maintaining the safety of our citizens, public spaces and neighborhoods is our highest priority. We must ensure that critical lifesaving resources such as hospitals, fire stations, police substations and the transportation corridors first responders use to connect our citizens to the services they provide remain as flood free and accessible as possible.

3. **Preserve economic viability for businesses and organizations.** A strong economy that works for everyone depends on businesses and institutions that are flood resilient and organizationally flexible to adapt and thrive in the future. Likewise our city of the future needs to be designed and built, in partnership with these important institutions, with resilience and adaptability at the forefront to ensure our future economic viability.

4. **Protect and enhance vital resources that protect our cities.** We will treat our environment as both a natural and economic resource and seek opportunities to improve conditions and to embrace the guiding qualities nature provides to help us reshape the way we live with water. Therefore, we must promote natural floodplain function and increase our natural systems' ability to mitigate effects of sea level rise while enjoying the co-benefits of improving the place we live.

5. **Enhance collaboration and partner with others.** We recognize that we are part of a larger region and ecosystem that connects with many other cities and governments. Likewise we recognize and acknowledge that water knows no boundaries. In order for us to be successful we will need to work with our neighbors, both public and private.

PUTTING SCIENCE FIRST

The Charleston Harbor tide gauge has been measuring sea level continuously since 1921. In that nearly 100-year time span, local sea level has risen 1.07 ft (Fig 1). The Fourth National Climate Assessment (NCA4), which was released in 2018 and assesses the science of climate change and impacts across the U.S., provides the latest projections of sea level rise for our region based on different scenarios of climate conditions from Low to Extreme (Fig 2). One way we can clearly track local impacts from sea level rise is documenting "minor coastal flooding". Commonly called nuisance, sunny day or high tide flooding, "minor coastal flooding" is a threshold from the National Weather Service that indicates when the tide has reached a certain height (7.0 ft MLLW in the Charleston Harbor). At this height, low-lying areas on land begin to flood. For example, Lockwood Blvd begins to flood at 7.2 ft. The City of Charleston has experienced a marked increase in the number of days of "minor coastal flooding" over time (Fig 3). Other flood thresholds are listed on pg 32.

FIGURE 1: OBSERVED SEA LEVEL RISE IN CHARLESTON HARBOR[1]

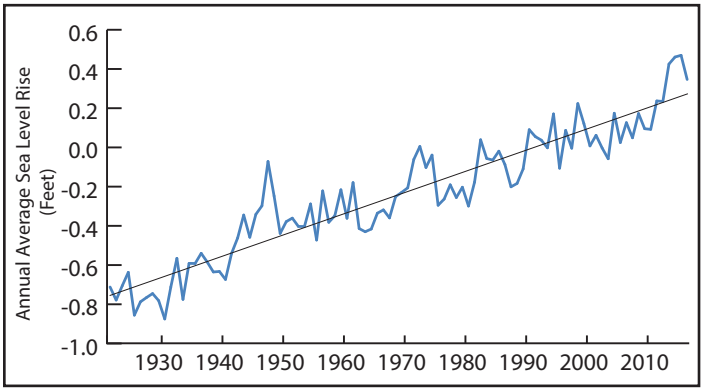


FIGURE 2: SEA LEVEL RISE PROJECTIONS FOR CHARLESTON[2]

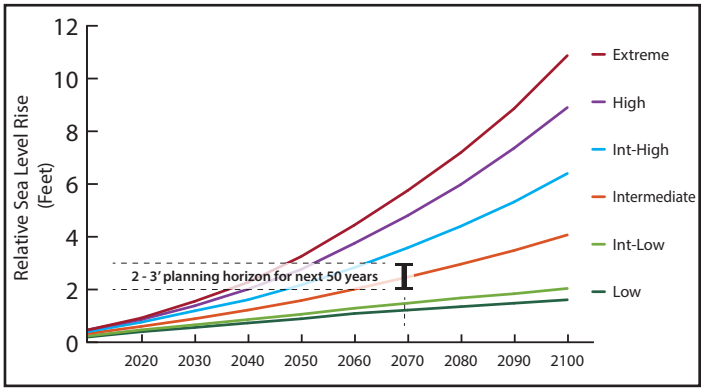
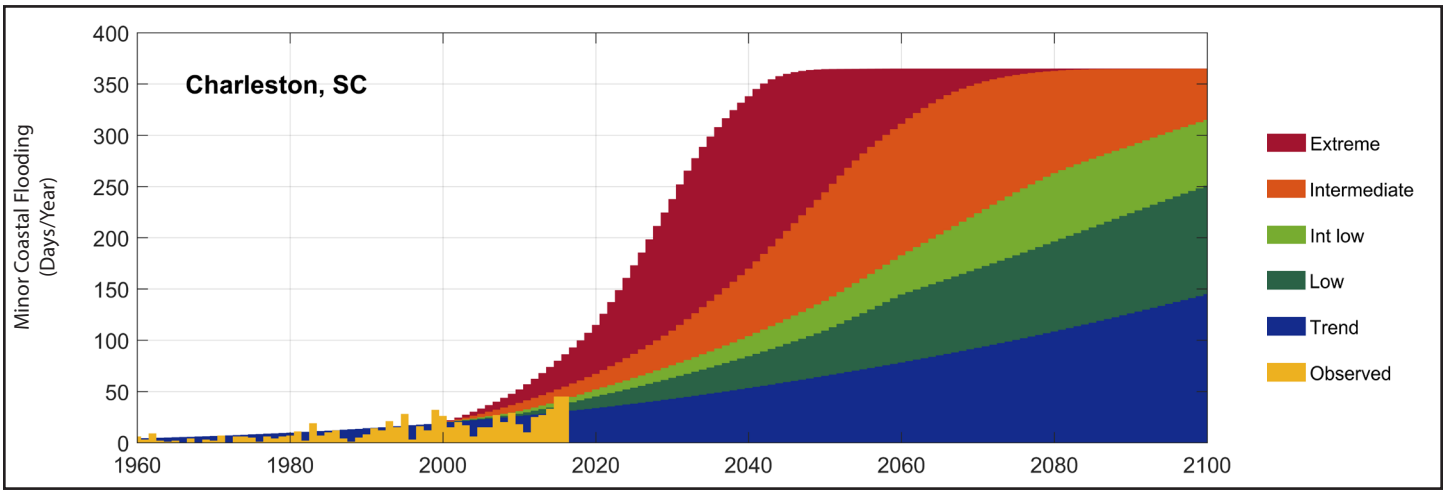


FIGURE 3: OBSERVED AND PREDICTED "MINOR COASTAL FLOODING" IN CHARLESTON[3]



It is imperative that we use the most relevant data to make thoughtful, informed decisions. In the 2015 Sea Level Rise Strategy, the City recommended a 1.5 to 2.5 foot elevation increase for new facilities and infrastructure to account for sea level rise over 50 years.

Considering the latest sea level rise projections, **the City is increasing the recommendation to 2 to 3 feet.** The range accounts for varying types of investments: a 2-foot increase is intended for less vulnerable infrastructure such as parking lots, while a 3-foot increase is for more critical long term infrastructure, such as medical facilities.

In addition to tidal flooding and sea level rise, recent data is indicating that changes in national precipitation trends are occurring. Rain events such as the one which occurred on July 20th, 2018, have a profound effect on public safety, economic viability, and overall quality of life. Data presented in the NCA4 indicate that precipitation has increased in frequency and project that current climate trends will continue to increase extreme weather events for this region.

The City will continue to incorporate the latest science-based findings as updates are made to this Strategy.

B | A STRATEGIC PLAN

As Charleston transitioned from planning to implementation of its Flooding and Sea Level Rise Strategy, it was understood that the framework needed to be practical.

This updated plan has a more specific approach that targets long-term solutions through **five critical components: Infrastructure, Governance, Land Use, Resources, and Outreach.**

These five critical components will be integrated into the core business of City departments.

FIVE CRITICAL COMPONENTS

RESOURCES

To meet the City's immediate and long term goals under the Flooding and Sea Level Rise Strategy, sufficient funding and proper staffing are critical. Together, dedicated engineers, planners, and architects as well as new, specialized City staff can optimize projects and identify alternative funding.

GOVERNANCE

Good governance establishes policies and regulations aimed at protecting both public and private investments. Governance aligned with strategic direction toward resilience will set precedence for long term planning in our City.

INFRASTRUCTURE

Adapting Charleston to the rising sea levels and more extreme wet-weather events means identifying innovative solutions and prioritizing projects to protect the most critical and vulnerable areas.

LAND USE

Effective land use planning can maximize value and minimize risk from potential external influences to strengthen community resilience. It is important to direct growth to where it makes the most sense over the long term, to high, dry and connected areas able to support it, and to seek innovative opportunities to adapt and retreat in higher risk areas leading to stronger neighborhoods and improved quality of life.

OUTREACH

The welfare of our City is a shared responsibility involving the entire community. Through outreach, we can educate people about the threat of flooding and sea level rise, its causes, and what all of us can do and are doing to protect Charleston. We are all responsible for the resilience of our community.

OUR INITIATIVES

For the Flooding and Sea Level Rise Strategy to fulfill its purpose, it must be supported by initiatives. This is why in 2015 the City created a list of initiatives that reinforce the Strategy to lead Charleston on a path to resilience. As we uncover opportunities to strengthen the Strategy, this list will continue to evolve.

City staff members have been hard at work to review and refine the initiatives for this update. This recent list acknowledges that success requires a multi-departmental effort, so each action-item has been assigned to a critical component that is championed by a group of City departments. Regular City meetings will allow departments to report the latest developments on their initiatives. The status of each initiative will be available online at www.charleston-sc.gov/SLR.

COMPLETE / IN PROGRESS

INFRASTRUCTURE

- Collaborate with federal partners on flood protection projects.
- Identify coastal edges ripe for flood protection and absorption.
- Install shoreline protection to protect public infrastructure and mitigate erosion.
- Identify opportunities and install backflow prevention devices to prevent tidal inundation.
- Complete drainage projects already in progress.
- Complete the repair and reinforcement of the Battery seawall.
- Implement green infrastructure strategies on public property.
- Implement new maintenance initiatives to improve performance of existing stormwater systems.

GOVERNANCE

- Annually reevaluate science for appropriate planning levels.
- Implement building codes that support construction and retrofits more resilient to SLR.
- Strengthen stormwater management regulations.
- Increase freeboard to 2.0 feet above Base Flood Elevation for all new and substantially improved structures.
- Build or retrofit City-owned and critical facilities for greater than 3 feet of SLR.
- Aggressively seek and support new NFIP acquisition legislation.
- Reduce flood insurance premiums by improving our CRS rating.
- Incentivize private property owners to implement green infrastructure.
- Incentivize flood mitigation measures for more resilient construction in the 100-year floodplain.
- Implement flood detection devices, alerts, warnings, and reporting systems.
- Implement a formal City flood parking plan for flood events.
- Implement the City's stormwater response plan.
- Create a City of Charleston Hazard Mitigation Plan.
- Build City-owned facilities to stage City resources during flood events.

PLANNED

INFRASTRUCTURE

- Retrofit public housing units in flood prone areas.
- Update the City's Master Road Plan for SLR.

GOVERNANCE

- Ensure critical facilities have access plans that account for SLR.
- Partner with Charleston County and the SC Department of Transportation to establish road design standards that are resilient to SLR.
- Strengthen the City's Zoning Ordinance to promote more resilient development in low lying areas.
- Establish and nurture partnerships throughout the tri-county region to coordinate on land use and stormwater policy.

STAY UP TO DATE ON THE STATUS OF OUR INITIATIVES BY VISITING OUR WEBPAGE:

www.charleston-sc.gov/SLR

RESOURCES

- Seek new legislation and streams of revenue to support projects.
- Aggressively participate in FEMA programs to protect private property.
- Annually align City operational priorities to reflect the current assessment of SLR impacts.
- Identify and implement strategies to fund wetland restoration.
- Acquire appropriate response assets for public safety flood response.
- Hire a Stormwater Program Manager consultant to assess the City's stormwater plan.
- Hire a Chief Resilience Officer to coordinate resilience efforts.
- Designate a full time position for floodplain management.
- Collaborate with and learn Dutch and other methods of managing and living with water.

- Create and pursue new and emerging revenue sources, both public and private, for the future.
- Seek additional staff capacity in future budget cycles.
- Investigate additional external best practices that may transfer to Charleston.

LAND USE

- Evaluate how City properties are designed with additional SLR in mind.
- Conduct a Vulnerability Analysis to inform the Comprehensive Plan Update and reevaluation of the City's Zoning Ordinance.
- Evaluate and implement tree planting and protection recommendations.

- Minimize the impact to natural floodplains from future development.
- Identify open space that could double function as storage areas.
- Update the City's Comprehensive Plan for SLR and reevaluate the City's Zoning Ordinance.
- Update the City's Consolidated Plan for SLR.

OUTREACH

- Continue partnerships with agencies, organizations and institutions of higher education that actively engage in resilience.
- Actively engage in the development of national building codes.
- Create design guidelines for retrofitting historic buildings and assist property owners in developing resilient design solutions.
- Develop a web portal dedicated to flooding.
- Conduct annual review of this Strategy.
- Partner with FEMA to share flood maps with the community and adopt new maps.
- Utilize the Resiliency and Sustainability Advisory Committee and their public forum to obtain feedback and discuss action items that promote resilience and sustainability, including mitigation strategies that reduce emissions.
- Collaborate with partners to perform outreach to the community, particularly vulnerable populations.

- Measure impacts of flood events.
- Coordinate with neighboring jurisdictions on development activities and long range plans.

INFRASTRUCTURE

CAPITAL IMPROVEMENTS

Adapting Charleston to rising sea levels and more extreme wet-weather events means identifying innovative solutions and prioritizing projects to protect the most critical and vulnerable areas.

The City is collaborating with the U.S. Army Corps of Engineers on a peninsula wide Flood Risk Management Study to determine cost effective strategies to provide long-term risk reduction from flooding. The Corps has brought in experts from around the country to assist on this project and is working in collaboration with City departments and stakeholders. This study will particularly focus on the edges of the Peninsula and will evaluate many strategies for protection with the goal of identifying the most cost effective solutions. The City anticipates a combination of strategies will need to be utilized and is looking forward to the results of this 3-year effort.

For more information on infrastructure projects please visit www.charleston-sc.gov/SLR.

PROGRESS SPOTLIGHT

LOW BATTERY SEAWALL

In early 2019, the City will begin an extensive reconstruction project of the iconic Low Battery Seawall to replace and raise the seawall to account for sea level rise projections. It was built over 100 years ago and the new seawall will be engineered and built to last another century. This presents a once-in-a-lifetime opportunity to create a signature public space worthy of Charleston's character and history while also strengthening the City against regular flooding, storm surge and imminent sea level rise. The City's Design Division studied this site and used extensive stakeholder input and technical data to suggest general ideas and design concepts for the new seawall which are viewable online at www.charleston-sc.gov/SLR. New construction is anticipated to begin where the wall is in the poorest condition, which is on the western side at Tradd Street, and then progress to White Point Garden.

The residential and garden edges make up the Low Battery.

Final design concepts for the Low Battery Seawall involve shrinking the median, allowing parking to remain, and a slightly widened and elevated Low Battery walkway with seating to create a signature public space that also better protects the City.

INFRASTRUCTURE

PROGRESS SPOTLIGHT

FOREST ACRES DRAINAGE

Not far from the banks of the Ashley River is the Forest Acres Basin of West Ashley, an area that had time and again proved to be susceptible to flooding. The area's vulnerability stemmed in part from an undersized and antiquated stormwater pump station first constructed in the 1960s. Storm runoff from the Forest Acres Basin would drain to the pump station, which transferred the flow out to the Ashley River. Because the system did not have enough capacity to pump all of the stormwater, the drainage pipes recurrently experienced backlog that resulted in the flooding of roads, yards, and homes.

The City of Charleston and its engineering consultant have worked over the past several years to develop an efficient and cost-effective drainage improvement plan for the Forest Acres and 5th Avenue drainage basins. During the conceptual design phase, it was determined that the system could be safely and efficiently drained using a gravity system. The new system will consist of stormwater channels and dual box culverts along the West Ashley Bikeway, under St. Andrews Blvd., and under 5th Avenue.

The City of Charleston has completed construction on the Phase 1 drainage improvements within the Forest Acres and 5th Avenue Drainage Basins. The drainage improvements are designed to alleviate various drainage and flooding issues including recurring structural flooding.

The system was replaced by more than 2,500 linear feet of box culvert improvements and 2,000 linear feet of channel improvements. The new system flows entirely by gravity, which means that it does not rely on electrical power. In the event of a power outage, which can happen during events that cause flooding, the new system can continue to provide drainage to the Forest Acres Basin.

At the end of the Phase 1 improvements, parts of the West Ashley Bikeway that were affected by construction were renovated, creating a more aesthetically pleasing environment. **The bikeway now boasts a newly paved path complete with robust landscaping.** Phase 2A work will extend from the bikeway to past Playground Road. Phase 2 construction of the Forest Acres Drainage Project is expected to begin in the fall of 2019, and will build off the improvements made in Phase 1. It will include installation of another 800 linear feet of channel, 100 linear feet of culvert, and 800 linear feet of gravity pipe to complete the full drainage system. Phase 2 is expected to be completed in 2021. For more information please visit www.charleston-sc.gov/SLR.

The project included 4,500 linear feet of box culvert and channel improvements to alleviate recurrent flooding in nearby homes, local businesses and roadways, and nearly 3,000 feet of the bikeway was repaved and designed with enhanced safety features.

INFRASTRUCTURE

PROGRESS SPOTLIGHT

DRAINAGE PROJECTS

In addition to the Forest Acres Drainage Project spotlighted on the previous page, below are other drainage projects recently completed or in the works.

For more information on drainage projects please visit www.charleston-sc.gov/SLR.

Church Creek Drainage Project - A thorough analysis of the basin has been completed and City Council passed new development/stormwater requirements to increase water retention and improve flow in the basin in 2018. The next phase will be tidal protection for the basin.

Dupont/Wappoo Watershed Master Plan - This is a joint project of the City and Charleston County involving a complete inventory of all drainage features (conveyance pipes, culverts, ditches, etc.) in the basin, which includes Citadel Mall, Hazelwood, and the neighborhoods adjacent to Dupont, Wappoo, and Orleans Roads.

Westwood Drainage Improvements - This project will provide relief to St. Theresa Dr and the Westwood neighborhood and includes new pipes and structures.

Ashley Hall Manor Drainage Improvements - In 2018 City Council approved a drainage improvement project for this neighborhood that includes upsizing drainage pipes and ditches and a new outfall. The work should alleviate the frequent flooding of the Salisbury/Falmouth area in the neighborhood.

Spring/Fishburne Drainage Project - This is a complex project including more than 8,000 linear feet of deep underground tunnels that will all be connected to an outfall and pump station between the Ashley River bridges. This project will serve more than 500 acres of the western Peninsula and will keep the Septima P. Clark Parkway open during most rain events when complete.

Calhoun West Drainage Improvement Project - This anticipated tunnel and pump system would serve the western Peninsula from Cannon St. to the Battery.

King and Huger Drainage Project - This corner is notorious for flooding, and engineers have been engaged to study the basin and recommend a design.

Market Street Drainage & Streetscape Project - There is a new tunnel underneath Market Street that connects to the Concord St pump station (which can pump about 7.2 million gallons of water out of the City in an hour). To date 3 drop shafts along Market St. are connected to the tunnel and are already making a difference in the market area. Soon, the entire drainage system will be greatly improved and connected to the tunnel, and the sidewalks and streetscape of Market St. will also be improved.

Central Park/Wambaw Creek Watershed MP- The City and County are partnering to inventory all the drainage features of this basin, create a model, and recommend any maintenance and infrastructure improvements.

Signal Point Rd Area Improvements - Charleston County is leading this project to determine recommendations.

James Island Drainage Master Plan - Charleston County is taking the lead on an overall plan to delineate all the watersheds on James Island, and then to evaluate and prioritize them. In the meantime, the City, County, Town of James Island, James Island PSD, and the SCDOT are working cooperatively on maintenance.

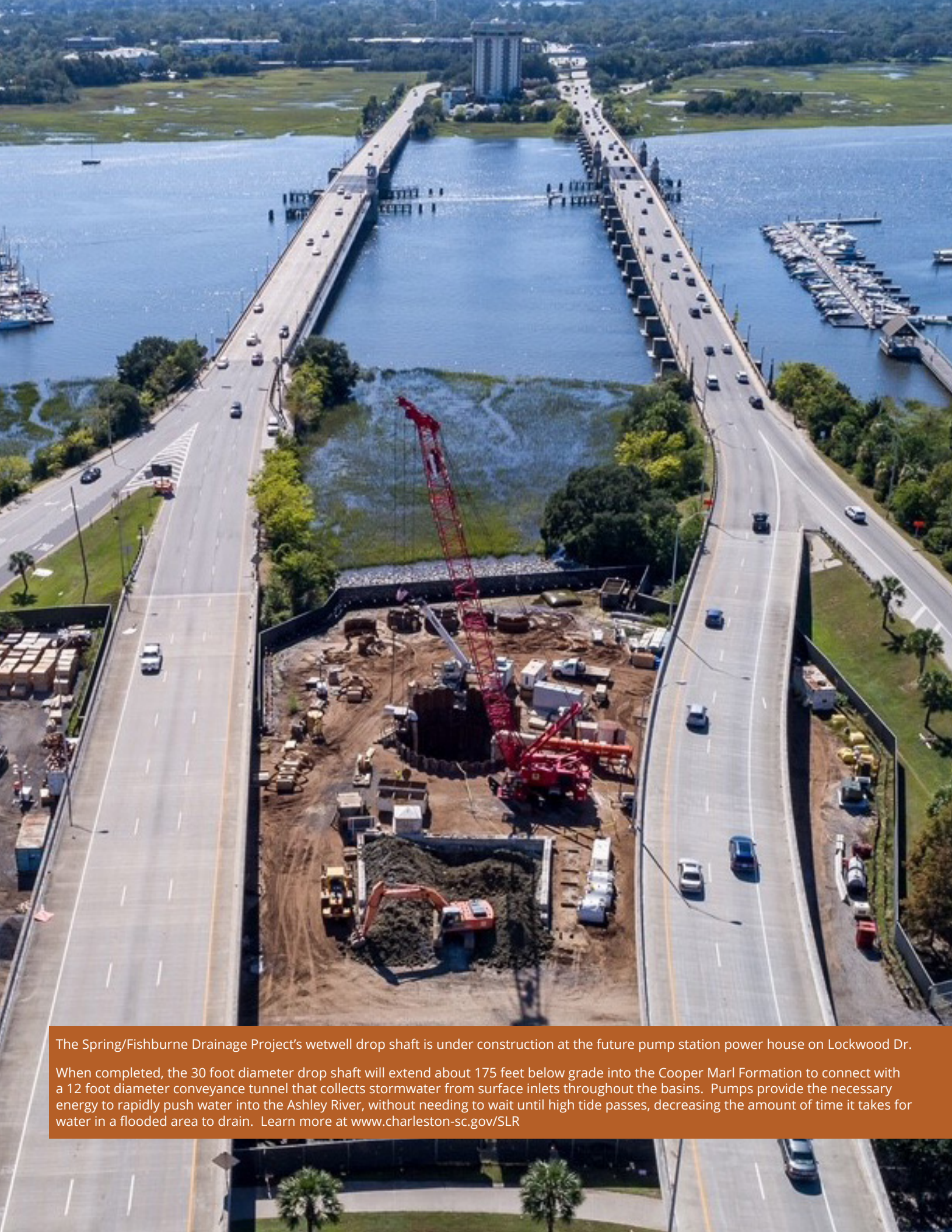
Johns Island Drainage Master Plan - The City has contracted with engineers to perform a "rain on grid model" for the island. Specific projects will follow, particularly for the Barberry Woods neighborhood.

St. Andrews Drainage Basin Improvement Study - The basin and downstream conveyances are being studied to determine what improvements can be made in the watershed to alleviate tidal flooding and drainage issues.

Barberry Woods Drainage Improvement Project - This project will alleviate flooding in the Barberry Woods area.

There are numerous smaller projects underway or recently completed (less than $200,000), that include:

- Heathwood Dr/Elton Ct.
- W. Robinhood and Prince St.
- Lord Calvert Dr.
- George Griffith canal
- Sunnyside
- Morrison Dr, and others.



The Spring/Fishburne Drainage Project's wetwell drop shaft is under construction at the future pump station power house on Lockwood Dr.

When completed, the 30 foot diameter drop shaft will extend about 175 feet below grade into the Cooper Marl Formation to connect with a 12 foot diameter conveyance tunnel that collects stormwater from surface inlets throughout the basins. Pumps provide the necessary energy to rapidly push water into the Ashley River, without needing to wait until high tide passes, decreasing the amount of time it takes for water in a flooded area to drain. Learn more at www.charleston-sc.gov/SLR

INFRASTRUCTURE

PROGRESS SPOTLIGHT

CHECK VALVE PROGRAM

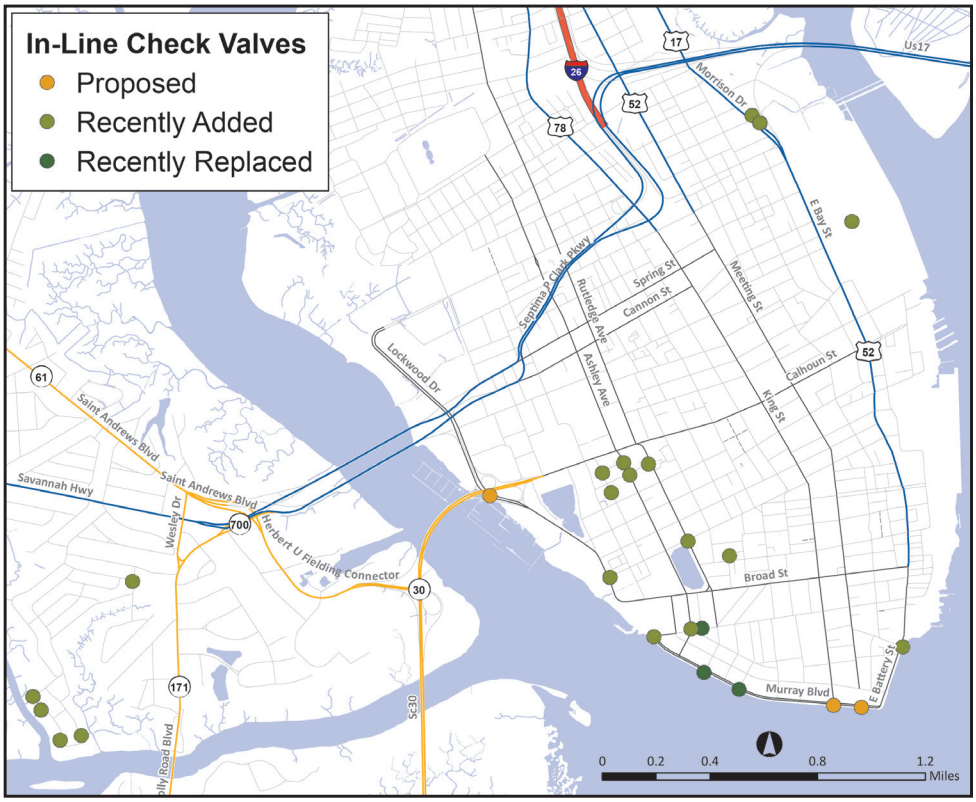
Coastal flooding (or high tide flooding) has long been common in Charleston's low-lying areas. As relative sea level rise increases, however, so too do the frequency and severity of these events, particularly the impacts this flooding has on and around streets. An effective way to manage coastal flooding from stormwater pipes is to use backflow prevention devices, or check valves. **A check valve prevents seawater from backing up into drainage infrastructure to mitigate tidal flooding, while still allowing the outfall to drain stormwater as usual when the tide recedes.**

In the wake of Hurricane Matthew, much of the City's stormwater infrastructure was in need of repair. One hard-hit area was the neighborhood immediately adjacent to the Battery, which had standing water for three days following the storm. There, the City discovered two 20-year-old check valves that were not opening as the tide receded. As a result, flood waters on and around Murray Boulevard were not able to drain through the valves as they typically did when a high tide receded. After discovering the cause, the City acted swiftly to clear the Battery of flood waters by pumping the water back into the harbor as a temporary solution until the new check valves were able to be installed shortly thereafter.

This minor capital improvement is economical and has proven to be successful in mitigating this particular cause of flooding. It is also one reason why City staff have worked deliberately to identify needs and provide repairs in low areas susceptible to tidal inundation via stormwater pipes.

Further progress in this program includes a backflow preventer that was recently installed in a 12-inch storm pipe at Water Street to relieve flooding in the East Battery, much to the delight of its neighborhood association. In another example, $40,000 was allocated to install valves on Ashley Avenue and Rutledge Avenue to help Cannon Park stay dry.

To date, Charleston has installed 22 new in-line check valves in West Ashley and the Peninsula and has plans for more. The City intends to continue investigating how this Strategy for managing tidal inundation can further be utilized in other low-lying areas in West Ashley, James Island, and Johns Island.



Photos below show check valve installations at Morrison Drive (top), Beaufain (middle) and Rutledge (bottom).

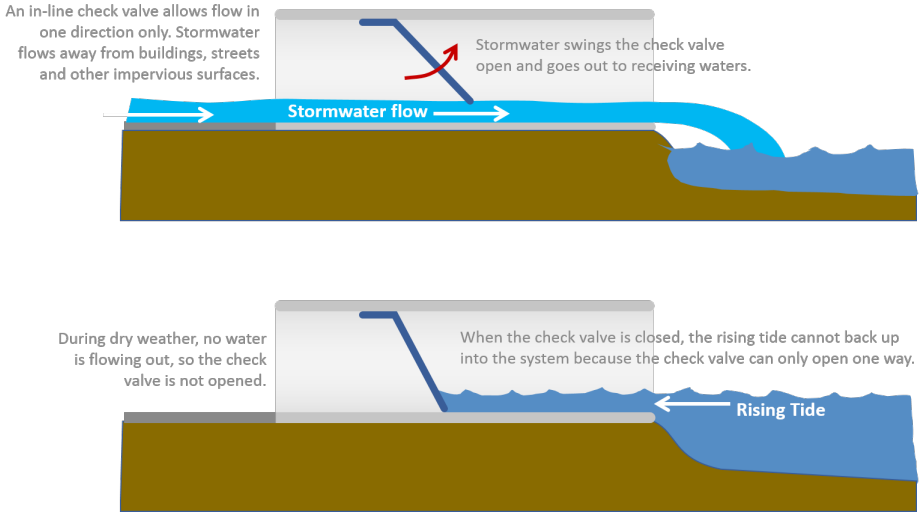
Many outfalls in the City are gravity fed and drain to bodies of water that are tidally influenced. During high tides, seawater often enters stormwater outfalls and water can back up far enough in low lying areas to result in backflow flooding on streets, even on a sunny day. Check valves can be installed in appropriate areas to prevent this tidal intrusion nuisance and protect salt sensitive vegetation near storm drains.

While check valves can work well to mitigate flooding from high tides entering storm drains, rainfall and storm surge are completely separate challenges. Check valve or not, rain that falls during a high tide still has little room to drain until the tide recedes because stormwater collected on the surface has no place to go if the pipes and ditches are full of seawater or if the check valve is in the closed position as it holds pressing seawaters out from additional ponding on streets.

At high tide, the water elevation of the Cooper River is higher than this tidally influenced stormwater outfall.

After the tide recedes, this stormwater outfall uses gravity to convey stormwater into the Cooper River. The rubber tip on the end is actually a duckbill type check valve, one the City is phasing out in favor of in-line valves which function even better and have less maintenance costs.

HOW DOES AN IN-LINE CHECK VALVE WORK?



Left: An in-line check valve is a custom made insert designed to fit into a drainage outfall pipe to prevent tidal backflow.

SUCCESSFUL CHECK VALVE INSTALLATION AT MORRISON DRIVE

After check valves were installed on Morrison Drive in early 2018, the street remains dry from average high tide flooding events.

INFRASTRUCTURE

PROGRESS SPOTLIGHT

DRAINAGE MAINTENANCE

A stormwater drainage system performs best when properly maintained. Keeping the many drainage ditches, conveyance pipes, storm drains, and detention ponds as clean as possible is a major goal and a top priority for the City.

Throughout the entire City of Charleston, we continue to invest resources to ensure we are keeping our systems working as efficiently as possible. A major focus of both the new Stormwater Department and the Stormwater Program Management contract will be to ensure we are doing all that can be done to meet this goal.

NEW AND ONGOING ACTION ITEMS

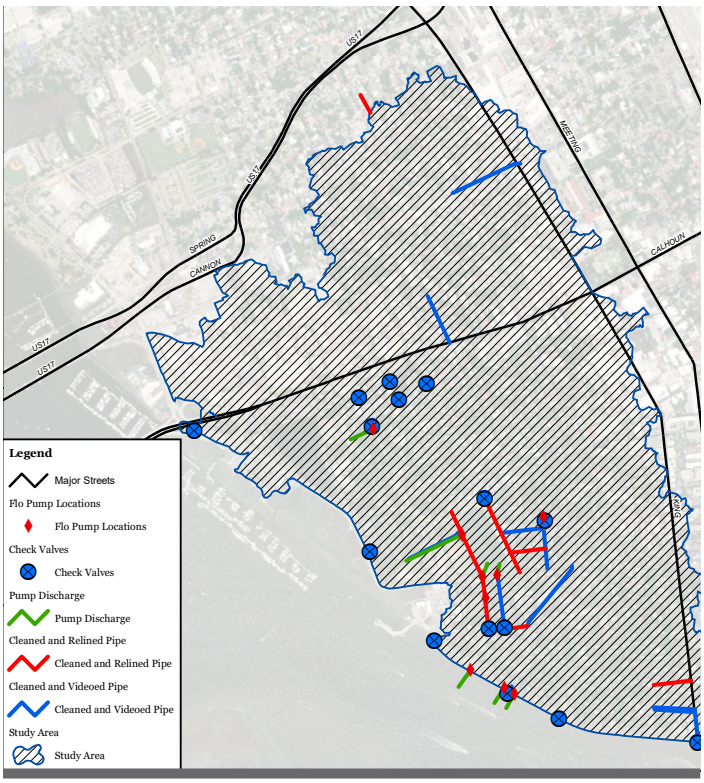
- Two full maintenance crews were added in the 2019 budget exclusively for stormwater maintenance.
- The City is using GPS and other new technologies for scheduling drainage ditch maintenance and repairs to ensure the most efficient and effective use of existing personnel and equipment.
- Collaboration with counties and SCDOT has been enhanced to ensure adjoining drainage systems are working in conjunction with each other for the best possible performance.
- Repair and relining of the brick arch system will continue to increase its life expectancy and improve performance.
- The use of cameras has increased to inspect underground drainage pipes to look for obstructions, damage, corrosion, and cracks so the appropriate repairs and maintenance can be performed in the shortest possible time, ensuring optimal performance.
- Maintenance at existing stormwater pump stations will continue to ensure they are performing at maximum capacity. Periodic upgrades will be performed as necessary.
- Check valves will continue to be installed on drainage outfall pipes, as appropriate, to prevent tidal flooding backing up into the system and in some cases onto low-lying roadways.
- With appropriate notice, the City is using strategically-located temporary pumps to remove stormwater and tidal inundation quickly ensuring that roadways remain open, are closed for the shortest time possible, and to mitigate the risk of flooding entering homes.
- A new GIS based drainage ditch maintenance tracking system launched in January 2019. The project utilizes updated GIS map data for drainage ditch maintenance areas and improves the tracking and reporting of maintenance records. The new system will be used to more effectively track, plan, and schedule ditch maintenance throughout the City.

The arch-ways of original drainage tunnels were constructed of brick. Over the years, the brick arch system became full of sediment and difficult to clean safely, it also showed signs of aging and crumbling, indicating a need for attention.

This brick arch-way has been relined with wire mesh and spray gunite on the walls to stabilize the structure with a reinforced concrete liner. A smooth surface allows more efficient flow too.

An 1878 map shows original Tidal Drains. The original drains (in red) were brick arches of various sizes controlled by tide gates. The rest of the old system is comprised of 12″-18″ clay pipes, which are undersized by today's standards.

Crews uncovered a broken clay pipe beneath a street. Clay pipes are no longer the industry standard but were common hundreds of years ago. Over time, clay pipes crumble and are susceptible to root intrusion and leaks.



Maintenance improvements in the Calhoun West Drainage area include cleaning and addressing unreliable clay pipes. Clay pipes are hard to reach; many are located under streets.

A Vacuum Truck cleaning out a neighborhood drain. Stormwater Service cleans pipes, inlets and ditches regularly.

CHAPTER 2

GOVERNANCE

CRITICAL COMPONENT

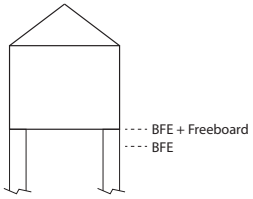
REGULATORY TOOLS

Good governance establishes policies and regulations aimed at protecting both public and private investments. Governance aligned with strategic direction toward resilience will set precedence for long term planning in our City.

The City is strengthening stormwater regulations in the Church Creek Drainage Basin by implementing the policy recommendations identified in the 2018 study to help protect basin capacity, reduce flood levels and improve flood control in the basin. While Church Creek is a unique area, **strengthening stormwater management regulations** for the entire City is also underway. This effort includes updating the City's Stormwater Design Standards Manual, which will include taking sea level rise projections into account.

In early 2019, a citywide **All Hazards Vulnerability and Risk Assessment** will commence to identify assets (i.e. critical infrastructure, historic buildings, etc.) that are vulnerable to various threats (i.e. sea level rise, extreme precipitation, etc.). Each asset's vulnerability will be assessed based on their exposure to harm. This information will be used to estimate risk for each asset and to ultimately inform of potential strategies that could reduce risk to vulnerable assets.

Another regulatory tool the City implemented in 2015 is a one foot **freeboard requirement**. This means new buildings are to be elevated one foot above NFIP minimum height requirements. The City is working on strengthening this requirement to two feet so investments are better prepared for SLR. Freeboard also helps improve our Community Rating System class to reduce flood insurance premiums.



"**Base Flood Elevation**" (BFE) is FEMA's elevation requirement

"**Freeboard**" is additional height above BFE required to meet City Code

The City is also working on enhancing it's **flood prevention parking plan**. For the last few years the City has encouraged residents in low lying areas to park and protect their vehicles for free in City garages during major flooding events. The City will look to identify flood prone areas and warn motorists to not park in these areas to prevent damage to their vehicles.

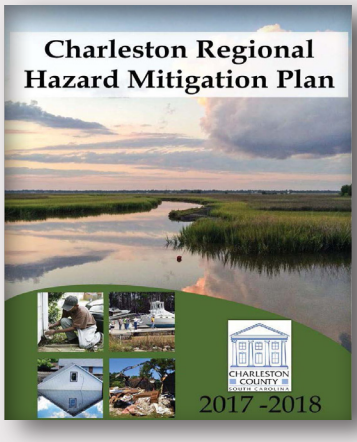
Regulatory techniques on existing buildings are complex, particularly in a historic context. The City's Planning Department has been collaborating with preservation experts, engineers and community stakeholders to establish **design guidelines for elevating historic buildings.**

PROGRESS SPOTLIGHT

PARTNERSHIPS

Further supporting our readiness is our partnership with Charleston County. The County's Hazard Mitigation Plan is an appropriately regional effort toward being more disaster-resistant. The plan includes methods for addressing various types of hazards across and supported by multiple jurisdictions in the region.

To piggyback off the County's plan, the City applied for and received a Hazard Mitigation Grant Program award from FEMA for $75,000 to develop a City specific Hazard Mitigation Plan that will identify specific actions the City can take to help reduce or eliminate long term risks posed by multiple hazards. The project is scheduled to commence in mid- to late 2019 and it will integrate results from the All Hazards Vulnerability and Risk Assessment, anticipated to begin in early 2019.



Track our Progress! Visit www.charleston-sc.gov/SLR

PROGRESS SPOTLIGHT

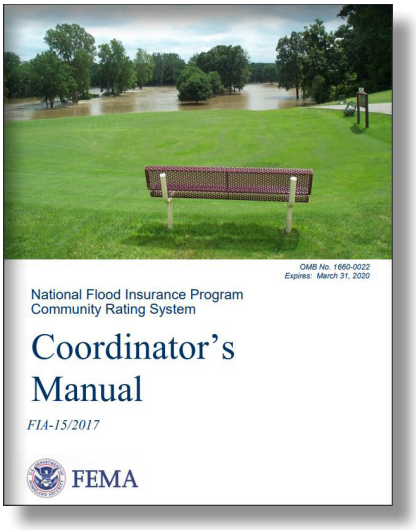
COMMUNITY RATING SYSTEM

To provide Charleston's property owners the opportunity to federally insure their homes and businesses against flood damage, the City of Charleston participates in the National Flood Insurance Program (NFIP), which is administered by the Federal Emergency Management Agency (FEMA). The program offers insurance policies only in communities that adhere to minimum standards for floodplain management and Charleston's regulations have been crafted to meet these criteria.

Additional benefits are available to citizens of communities that go above and beyond the minimum standards. **The NFIP's Community Rating System (CRS) incentivizes community actions that reduce risks associated with flooding.** Communities that participate in the NFIP can be eligible for the CRS by fulfilling criteria in four activities: Public Information, Mapping and Regulations, Flood Damage Reduction, and Warning and Response.

Because of the importance of providing both flood protection and insurance benefits to citizens, the City of Charleston is an active participant in the CRS, and the Flooding and Sea Level Rise Strategy is one activity that supports CRS eligibility. For example, one of the Strategy's initiatives is to implement additional freeboard requirements for buildings. This is a regulatory method for protecting lives and property during flooding events, and it also helps to improve Charleston's CRS rating.

The City earns points for executing eligible activities



Left: "The Coordinator's Manual is the guidebook for the CRS. It explains how the program operates, what is credited, and how credits are calculated." Source: FEMA

and more points equate to a better CRS rating. The framework not only encourages action to reduce a community's flood risks, but also allows citizens' flood insurance rates to be discounted based on the rating.

The City currently has a rating of 6, which provides a 20% premium discount to policy holders – an annual savings of about $5 million for City residents.

The City of Charleston has an upcoming review, and is actively working towards improving this current rating. **To learn more please visit www.charleston-sc.gov/SLR.**

Table 110-1. CRS classes, credit points, and premium discounts.

CRS Class	Credit Points (cT)	Premium Reduction	
		In SFHA	Outside SFHA
1	4,500+	45%	10%
2	4,000–4,499	40%	10%
3	3,500–3,999	35%	10%
4	3,000–3,499	30%	10%
5	2,500–2,999	25%	10%
6	2,000–2,499	20%	10%
7	1,500–1,999	15%	5%
8	1,000–1,499	10%	5%
9	500–999	5%	5%
10	0–499	0	0

SFHA: Zones A, AE, A1–A30, V, V1–V30, AO, and AH

Outside the SFHA: Zones X, B, C, A99, AR, and D

Preferred Risk Policies are not eligible for CRS premium discounts because they already have premiums lower than other policies. Preferred Risk Policies are available only in B, C, and X Zones for properties that are shown to have a minimal risk of flood damage.

Some minus-rated policies may not be eligible for CRS premium discounts.

Premium discounts are subject to change.

"A community receives a CRS classification based upon the total credit for its activities. There are 10 CRS classes. Class 1 requires the most credit points and gives the greatest premium reduction or discount. A community that does not apply for the CRS, or does not obtain the minimum number of credit points, is a Class 10 community and receives no discount on premiums. The qualifying community total points, CRS classes, and flood insurance premium discounts are shown in Table 110-1." Source: FEMA

YOU CAN HELP! Review options to purchase flood insurance to protect your property (if not already required), and support initiatives to improve Charleston's CRS rating and reduce insurance premiums.

PROGRESS SPOTLIGHT

FEMA HAZARD MITIGATION ASSISTANCE

Especially in a historic city like Charleston, many structures have been built that do not comply with modern building codes and floodplain management regulations that we now know are important to protecting lives and properties in a major flood event. Many of these structures also have significant historic context and architecture to consider and strive to protect, as possible.

The City of Charleston has recognized the identification and mitigation of properties that experience repetitive flood damages as a priority for the long-term resilience of our City as sea levels rise and intense storm events become more common. FEMA shares this vision and offers several assistance opportunities to communities and property owners for mitigating damage to flood prone structures. These programs provide funding for a wide range of projects including pre-disaster or post-disaster elevation, relocation, or demolition. **For more information about the application process for the assistance opportunity that may be best suited to your property, please contact the City's Floodplain Manager and visit www.charleston-sc.gov/SLR.**

The City of Charleston has submitted applications in each of the last three years for FEMA's Hazard Mitigation Grant Program (HMGP) and Hazard Mitigation Assistance (HMA) program following the recent major events.

FEMA awarded the City assistance for properties damaged in the 2015 flood and funding in response to Hurricane Matthew in 2016, the City is awaiting a decision on the other applications. **If all grants are awarded, a total of 54 properties will be mitigated as a result of the recent flooding events.** These include the elevation of 3 historic structures and the acquisition of 51 structures in the floodplain. When acquired structures are demolished, the properties are restricted to remain undeveloped in perpetuity, gradually restoring portions of the floodplain to its natural function. The City will continue to apply for FEMA Hazard Mitigation Assistance opportunities as they become available in order to protect citizens of Charleston and their properties.

An active elevation of a historic building in Charleston.

An example of a successful elevation of a historic structure in Charleston that maintains a similar and important relationship to the street front. The City's Planning Department has created preservation guidelines for elevating historic buildings so they remain architecturally harmonious with the original site and the surroundings, including streetscape and context considerations. For more information, please visit www.charleston-sc.gov/SLR.

Panelists of architects, preservationists, engineers, and contractors meet to collaborate on ideas for design guidelines for elevating historic buildings in Charleston.

CHAPTER 3

LAND USE

CRITICAL COMPONENT

INNOVATIVE PLANNING

Effective land use planning can maximize value and minimize risk from potential external influences to strengthen community resilience. It is important to direct growth to where it makes the most sense over the long term, to high, dry and connected areas able to support it, and to seek innovative opportunities to adapt and retreat in higher risk areas leading to stronger neighborhoods and improved quality of life.

Planning for development, open space and preservation requires a holistic approach that integrates many dynamic factors and external forces that together shape our City; these include hazards (such as sea level rise, storm surge and extreme heat), in addition to many other factors (such as the housing market, population changes, transportation, social equity and the economy).

Moving forward, Charleston will enhance integration of resilience to hazards in our next Comprehensive Plan update. For sea level rise projections to inform future land use planning decisions, **it is imperative Charleston acknowledges a long term strategy of evaluating land systematically into three main categories**: 1) land to resist flood events (naturally or retrofitted), 2) land to be retrofitted to adapt to living with flood events, 3) land to be returned back to nature or remain natural.

Comprehensive planning and zoning are two key components of land use planning and there are innovative efforts already underway in these areas.

For more information on land use projects please visit www.charleston-sc.gov/SLR.

PROGRESS SPOTLIGHT

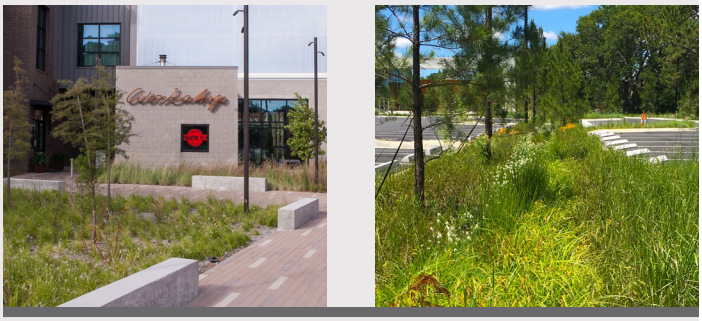
SUSTAINABLE ZONING

UPPER PENINSULA ZONING DISTRICT

It is important to allocate density to high, dry and connected areas able to support it. Low risk areas can be prime opportunities for community growth that will support limiting investment in high risk areas.

For example, the Upper Peninsula area has long been envisioned as a priority area for growth identified due to its elevation, proximity to transportation connections, and environmental suitability. In 2015, a new incentive based zoning district was created to encourage sustainable and responsible development in this area.

The Upper Peninsula Zoning District provides an opportunity to earn height and density bonuses to support growth in this prime area in exchange for developers implementing a menu of community identified benefits, such as: energy resilience, open space protection, alternative transportation options, workforce housing, green infrastructure and more.



A rain garden (left) and bioswale (right) in the Upper Peninsula are two common Best Management Practices that allow stormwater to flow into them; this provides multiple benefits, such as stormwater storage, pollutant filtration by plants and soil, and beautification.

A green roof in the Upper Peninsula; these can provide a host of benefits such as reduced stormwater runoff and improved water quality, added building insulation to conserve energy, carbon sequestration, reducing the urban heat island effect and more.

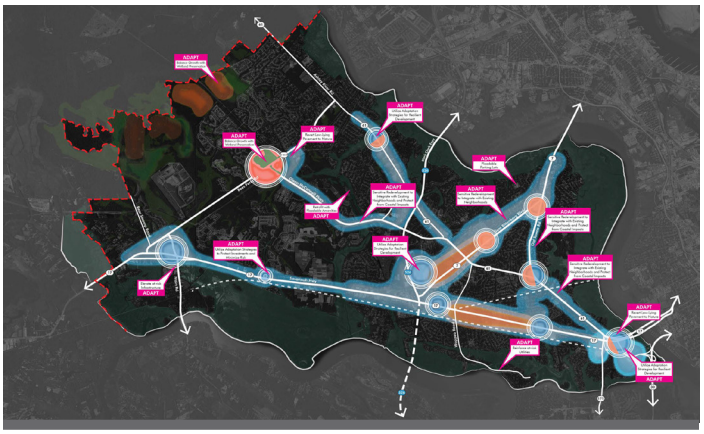
PROGRESS SPOTLIGHT

RESILIENT PLANNING

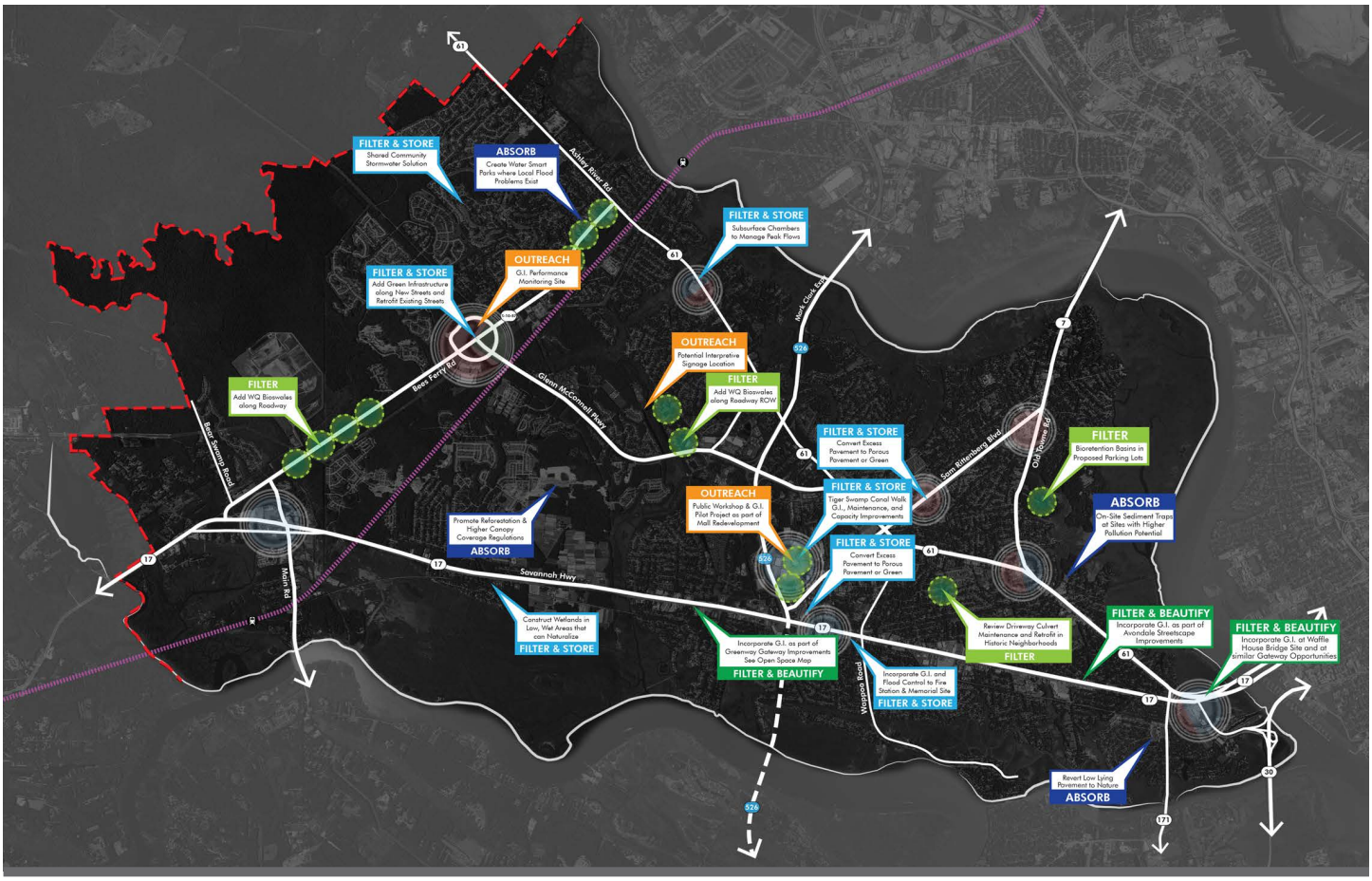
PLAN WEST ASHLEY

Published in 2018, Plan West Ashley establishes a framework for resilient growth consistent with the community's vision for its future. The plan includes the aforementioned approach to land evaluation, outlined on page 17, which will be integrated into Charleston's Comprehensive Plan update.

This master plan for West Ashley weaves Low Impact Development and Green Infrastructure principles (such as trees, permeable pavement, rain gardens, etc.) into the built environment as an approach to limit the impact of development on the environment and promote the natural flow of water. For areas less suitable to build, the City is evaluating a variety of growth management tools designed to help land owners adjust by compensating them for their development rights and/or offering incentives for them to enter into these arrangements.



A map from Plan West Ashley (2018) identifying areas evaluated to be retrofitted to "adapt" to living with flood events, a process of changing our standard methods for expansion to better suit future climate uncertainties.



A map from Plan West Ashley (2018) identifying green infrastructure opportunities to help the area become more resilient. Filtering, absorbing, and beautification improvements across West Ashley will incrementally improve water quality, mitigate flooding, and improve aesthetics. Some examples illustrated on the map include water smart parks, bioswales along roadways and porous pavement.

LAND USE

PROGRESS SPOTLIGHT

GREEN INFRASTRUCTURE

TREES TO OFFSET STORMWATER

Trees have natural flood-mitigating benefits through their absorption, deflection and purification of stormwater, and are well suited to support the built environment to mitigate hazards such as flood events and extreme heat.

The City received a technical assistance grant in 2016 for a project that analyzes how trees in urban areas can help manage and reduce stormwater runoff, largely because trees soak up tremendous volumes of stormwater. The more trees in the landscape, the less runoff and flooding may occur. The study indicates:

"...a typical street tree's crown can intercept between 760 gallons to 3000 gallons per tree per year, depending on the species and age.

If a community were to plant an additional 5,000 such trees, the total reduced runoff per year could amount to millions of gallons annually."

- Case Study Final Report (2018)

The project assessed Charleston's tree canopy coverage and analyzed Charleston's existing codes and used that data to inform future decisions on potential code amendments and tree plantings. The study was completed in August 2018 and provides many recommendations the City is integrating and codifying as appropriate.

For example, one recommendation is to work with developers to shrink the development footprint, minimize impervious surfaces and promote tree conservation; this proactive Low Impact Development approach challenges designers to expand their site analysis stage and prioritize natural hydrologic processes first, (including tree absorption), prior to configuring architecture.

YOU CAN HELP! For more information on planting trees and using green infrastructure visit www.charleston-sc.gov/SLR.

The study created land cover data to identify specific areas where trees could be planted (on both private and public property), and created a tool that models the impact of tree plantings by estimating the potential decrease in stormwater runoff.

The work upon which this project is based was funded, in whole, through a sub-recipient grant awarded by the USDA Forest Service through the South Carolina Forestry Commission to the Green Infrastructure Center and Charleston. The Green Infrastructure Center was the project partner and technical services consultant.

Left: A West Ashley parking lot is made of porous pavement and designed so any excess water unable to infiltrate can flow to a bioswale where further infiltration and filtering can occur.

Right: One tree can absorb thousands of gallons of water annually. Trees can reduce the urban heat island effect by 2-9 degrees F during the hot summer and their shade of structures can also help lower utility costs. In addition, well treed areas encourage people to walk and bike. **Trees are a simple, low cost and effective tool to both mitigate and adapt to sea level rise.**

RESOURCES

ESSENTIAL FUNDING, DATA AND STAFF

To meet the City's immediate and long term goals under the Flooding and Sea Level Rise Strategy, sufficient funding and proper staffing are critical. Together, dedicated engineers, planners, and architects as well as new, specialized City staff can optimize projects and identify alternative funding.

The City is actively pursuing all forms of funding and has received multiple sources of hazard mitigation funds for planning, property acquisition, structure elevations, and innovative solutions. The City is also investigating mitigation funding available under the Community Development Block Grant Recovery (CDBG-R) program. We will continue to work with our state legislative delegation to push for the ability to use more funding from our accommodations tax for flooding and drainage projects.

Public safety officials continue to seek appropriate vehicles to respond to the threat of increased flooding and the City is committed to improving our response to flooding by increasing staff capacity.

PROGRESS SPOTLIGHT

DUTCH DIALOGUES™

"If the City of Charleston is carrying out the initiatives in its Strategy to battle flooding and sea level rise, then you are on the right path."

- Delegate from the Royal Netherlands Embassy

This was the light-hearted but genuine comment that City staff heard during a visit from representatives of the Netherlands in March 2018, a country well-versed in adapting to frequent floods. The visit gave the Dutch guests an opportunity to understand our City's relationship and vulnerabilities to the very thing that attracts many of us to the area – the sea.

The Netherlands has executed a variety of successful flood mitigation methodologies, and the emerging relationship has already proved to be a valuable one. Select City staff and elected officials visited the Netherlands in October 2018 to witness their innovative practices first hand and bring back lessons learned to Charleston. The City is looking to the Netherlands for ideas to better help us live more naturally with water and integrate water into the fabric of our City through a series of dialogues designed to bring world renowned experts together from multiple disciplines to discuss resilience and risk mitigation challenges in Charleston.

The project commenced in Charleston in January 2019.

Delegates from the Royal Netherlands Embassy are joined by Mayor Tecklenburg as they share Dutch ideas on living with water before an intrigued Charleston community in March 2018.

City staff meet with Dutch experts in March 2018.

RESOURCES

PROGRESS SPOTLIGHT

STAFFING UP

The effort to build the resilience of Charleston requires great ingenuity, expertise and dedication. There are several fundamental resources necessary to make this strategy function. Funding for projects is one example, but perhaps an even more critical resource of which the City is in need is people.

In 2018, Mayor John Tecklenburg and Charleston City Council voted to create **the City's first Stormwater Department** to alleviate flooding and improve drainage throughout Charleston. In addition to the **Stormwater Director**, who will be hired in early 2019, **the department will launch with nine new positions**, including project managers, inspectors, an administrative technician and construction workers dedicated to strategically addressing flooding and drainage issues.

Additionally, several new positions have been created citywide that are greatly improving our capacity to complete the work at hand. These positions include a **Chief Resilience Officer** to establish focused leadership on this critical topic; a **Chief Innovation Officer** to design the data-driven systems that will create accountability in all phases of the City's flooding programs; a **Floodplain Manager** to ensure that any floodplain development is conducted in accordance with City law and national best practices; a **grant writer** to seek out and apply for opportunities to help secure the resources the City needs to fund the initiatives outlined in this strategy; a **Director of Sustainability** to assist implementing natural and sustainable solutions to this complex and challenging problem; and a new **Emergency Management Assistant** to help prepare for and respond to flood events.

Furthermore, the City has contracted with a group of independent, highly skilled engineers and subject area experts to form the new **Stormwater Program Management team**. Working closely with the Stormwater Department, **this team will update the City of Charleston's Master Drainage and Floodplain Management Plan**, which was last revised in 1984. The updated plan will be used to help prioritize, design and manage new and existing drainage projects. This new role represents a considerable capacity need within the City.

While staff capacity is increasing, the truth is that the City is still under capacity. The efforts required to make the vision of a resilient Charleston into a reality are great, and it will take a village of thinkers and doers. The City has made great progress and as challenges continue, we will need to evaluate new resources and positions to carry out the work in this plan.

Specifically, **the pursuit of funding sources takes a dedicated staff and diligent efforts.** Funding projects and strategies is a complicated puzzle, one that the City takes with the utmost seriousness and dedication.

While City staff and elected officials are always seeking new and creative funding strategies, below are some examples of funding sources (in no particular order) the City has been investigating or from which we are already benefiting:

FUNDING SOURCES

- Drainage Fund / Stormwater Budget
- General Fund
- Tax Increment Finance (TIF) Districts
- Charleston County
- State Infrastructure Bank
- Accommodations Tax (state & local) / Hospitality Tax
- S.C. Rural Infrastructure Grant and Loan Fund
- Federal Transportation Investment Generating Economic Recovery (TIGER) Grant
- FEMA Hazard Mitigation Assistance
- Army Corps of Engineers Federal funding
- Charleston Water System
- S.C. Department of Transportation
- Bloomberg Philanthropies
- Federal Community Development Block Grant Recovery (CDBG-R)
- and more

RESOURCES

PROGRESS SPOTLIGHT

LOOKING & PLANNING FORWARD

Adaptation planning for flooding from sea level rise and extreme weather events requires a thoughtful look to the future using the best science and information available.

Building from the information provided in the 2015 Sea Level Rise Strategy, the City of **Charleston began a series of planning efforts in 2018** that will provide the information necessary for City leaders to make the best possible decisions within each of the five critical components, for many years in the future. Each of these efforts will complement and build on each other to form a robust collection of information and data about threats, hazards, potential adaptation and mitigation measures and the funding resources required.

1 | DUTCH DIALOGUES™

The City of Charleston has spent considerable time learning about the "Dutch Approach" to managing water. We have hosted Dutch experts in Charleston and likewise a group of City staff and elected officials including the Mayor, along with other stakeholders, visited the Netherlands for a first-hand look at their approach to "Living with Water".™ From these various interactions we collectively concluded that a next step effort was to bring the Dutch Dialogues™ to Charleston, and **the project commenced in January 2019**.

The Dialogues will involve a look at 4 areas in the City:

1. Lockwood Corridor
2. Vardells Creek and Newmarket Creek basins
3. Johns Island (through the lens of building and development practices)
4. Church Creek Basin (will involve a Dutch Approach review of proposed actions within the basin)

The Dialogues will include a 5-day planning effort concluding in community briefings and displays. By design, the Dialogues are community focused and tailored to bring the Dutch way of thinking to select areas throughout the world. This effort will be funded through private donations and City funding and will be coordinated with neighboring jurisdictions.

2 | ALL HAZARDS VULNERABILITY AND RISK ASSESSMENT

This project will commence in early 2019 and will identify populations and assets (e.g., economic, cultural, historical, critical facilities and ecosystem services) that are vulnerable to various physical threats such as sea level rise, extreme precipitation, extreme heat, etc. The assessment will highlight the most critical areas and assets at risk from these various physical threats, the consequences associated with each and potential adaptation measures that could be implemented.

This project will focus on the entire City and help inform decision makers to establish priorities among competing projects and resources. Consequently, it will assist in setting budget priorities, long-term resilience planning, comprehensive planning and capital expenditures.

3 | HAZARD MITIGATION PLAN

This project **scheduled to commence in mid to late 2019**, funded by a FEMA Hazard Mitigation Grant program award, will identify specific actions the City can take to help reduce or eliminate long-term risks posed by multiple hazards. It will use the Vulnerability Assessment results as the starting point to commence the plan. It will involve citizen and stakeholder input.

The plan will focus on the entire City and is intended to highlight various projects both big and small that can help to reduce our risk through proper mitigation planning.

Representatives of the Hoogheemraadschap De Stichtse Rijnlanden Water Board meet with City staff and elected officials in Houten, Netherlands in 2018. Their mission is "Safe Dikes, Dry Feet, Clean Water", and they are responsible for flood control, water quantity, water quality and treatment of urban wastewater in their region.

4 | ARMY CORPS OF ENGINEERS PENINSULA FLOOD RISK MANAGEMENT STUDY

This 3 million-dollar, 3-year study **commenced in October 2018**. It is funded by federal dollars and will examine flooding risks to the Charleston Peninsula. In doing so it will account for current and planned actions and projects, predicted future conditions and will ultimately develop a preferred set of actionable solutions to protect the Peninsula from surge. The study will involve experts from many disciplines including economists, hydrologists, engineers, environmentalists and a robust project planning team as well as City and community stakeholders.

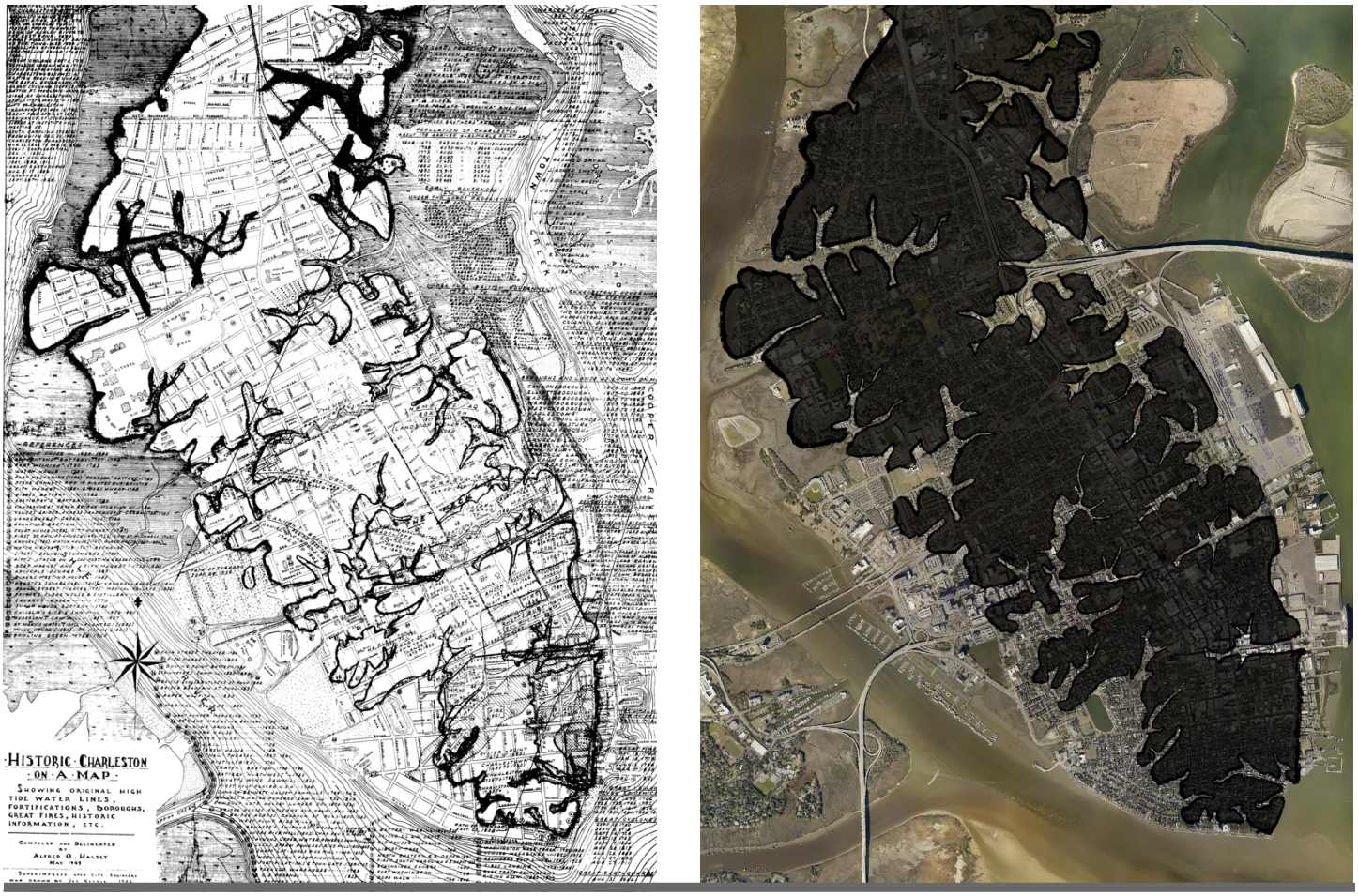
Within one year the team will recommend a preferred solution which will be forwarded to the Army Corps of Engineers headquarters for consideration for future funding and construction. It is expected to take up to two years for the review. This project will focus solely on the Peninsula and will develop the cost benefits of protecting the Peninsula required to be competitive for future funds.

5 | STORMWATER PROGRAM MANAGEMENT TEAM (CONTRACTED OUTSIDE CONSULTANT)

The City has recently contracted with a group of independent, highly skilled engineers and subject area experts to form the **new Stormwater Program Management team,** this contract was awarded in early 2019. Working closely with the Stormwater Department, this team will update the City of Charleston's Master Drainage and Floodplain Management Plan, which was last revised in 1984. The updated plan will be used to help prioritize, design and manage new and existing drainage projects. The team's focus may also include identification and prioritization of future drainage projects, management of existing projects and the identification of and securing of funding from a variety of sources.

It will be informed by the Vulnerability Assessment and will likely help to inform the Hazard Mitigation Plan.

For more information on all these projects please visit www.charleston-sc.gov/SLR.



Left, a historic Halsey Map depicts original creek bed lines on the Peninsula, and to the right this map is overlayed on a current aerial image.

OUTREACH

EDUCATION AND COMMUNICATION

The welfare of our City is a shared responsibility involving the entire community. Through outreach, we can educate people about the threat of flooding and sea level rise, its causes, and what all of us can do and are doing to protect Charleston. We are all responsible for the resilience of our community.

The City is committed to improving the information flow to residents and is creating a **new website dedicated to flooding**, particularly about flood risk, actions taken to reduce the effects of flooding, and emergency flood preparedness. Recently, the City reformatted the **Resiliency & Sustainability Advisory Committee** so it is more representative of the community and provides a public forum for residents to learn about, suggest and provide feedback on initiatives. In addition, **residents can now easily report flood damage** and location for major events to help track data and conditions, and recently the City hosted informational sessions and accepted numerous applications from citizens who were interested in participating in FEMA Hazard Mitigation Assistance.

Recognizing water knows no jurisdictional boundaries, the City is actively working with neighboring jurisdictions and regional organizations to explore opportunities for **managing by watershed**. Information is empowering, and that is why one of the key aspects of achieving resilience is dedicated to outreach.

PROGRESS SPOTLIGHT

FLOOD AWARENESS

An example that is ongoing yet already yielding results, involves a grant awarded to the City by Bloomberg Philanthropies. The grant allowed the City to research a program to enhance citizen and visitor responsiveness to flooding.

The idea is to establish a Flood Condition Awareness Program (FLOODCON) to guide users in making informed decisions to avoid flooding. FLOODCON could be a proactive planning tool delivering forecasted and real-time flooding information so commuters, businesses, residents, visitors and public institutions can confidently make informed decisions, adapt plans, and protect public safety to enhance quality of life. Information would come from new flood sensors strategically positioned around the City that would gather and feed data into the program instantaneously. Additionally, input and information from technical partners including the local National Weather Service (NWS) and the National Oceanic and Atmospheric Administration (NOAA) would contribute to generating alerts to identify the level of risk in a particular geographic area.

Such information could be tailored to individual user preferences to alert users to areas where flooding is occurring and predicted to occur, allowing them to alter their routes or schedules to stay out of harm's way. FLOODCON has the potential to provide the information our citizens need to adapt in order to mitigate major disruptions in livability and economic vitality when flooding occurs, particularly if the flooding is predicted. The City, with hopes to create this program, is seeking additional resources.

OUTREACH

PROGRESS SPOTLIGHT

ADOPT-A-DRAIN

The familiar phrase "of the people, by the people, for the people" comes from Abraham Lincoln's famous Gettysburg Address. It describes democracy as a system grounded in citizenship and public participation. The path to resilience is similar in the sense that we are all stakeholders and, therefore, have a role to play. **Each of us can reduce or prevent flooding in our own way.**

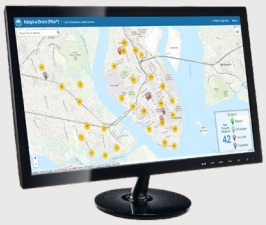
One way is by clearing debris and litter from entry points to storm drains. These pollutants can build up and prohibit stormwater from properly flowing off of streets and sidewalks, ultimately resulting in flooding. A drain can be cleared one day, and blocked by leaves or litter the next. With thousands of these inlets throughout the City, crews are in a never-ending battle to keep the storm drains clean, and can use all the help they can get.

Within a few short steps from your home or business, a storm drain is likely in need of your support. The City of Charleston's Adopt-A-Drain Pilot Project encourages citizens to help monitor and maintain our drains. For those interested in joining the initiative or already participating in their own neighborhoods, the Adopt-A-Drain Pilot Project offers additional resources for personal safety, tips on inspecting and cleaning a drain, and forums to report issues.

YOU CAN HELP! To adopt a drain today visit www.charleston-sc.gov/SLR.

There is a stormwater inlet under all those leaves and garbage.

Adopt this Drain!



PROJECT GOAL

The Adopt-A-Drain project allows citizens to "adopt" a storm drain. The primary goal of the project is to engage and educate the public about the benefits of keeping storm drains clear of debris, litter, and pollutants.

BENEFITS

Help Reduce or Prevent Flooding
Clogged storm drain inlets can cause or worsen flooding. Keeping drains free of debris will help water drain properly.

Help Protect Our Waterways from Pollution
By keeping litter and pollutants out of storm drains you are helping protect the area's water bodies. Stormwater is the #1 contributor of pollution to our waters.

Help Keep Your Neighborhood Clean and Free of Litter
Set a positive example by being an active steward of your neighborhood.

Clogged drain

Clean drain

OUTREACH

PROGRESS SPOTLIGHT

A CALL TO ACTION

Citizens and businesses play a critical role in helping the City of Charleston manage the challenges of flooding and extreme weather. **We are all part of the solution.**

Take a proactive approach to reduce flooding around your home, business and neighborhood. More information can be found at www.charleston-sc.gov/SLR.

YOU CAN HELP!
Action items are listed below and discover even more ways to get involved at www.charleston-sc.gov/SLR.

1	Purchase Flood Insurance	Protecting your home with flood insurance is one of the best investments a homeowner can make to prevent economic loss from flooding. Also consider other insurance that can protect the contents of a home, vehicles and other property.
2	Maintain a Clean and Litter Free Yard	Wind and rain move debris, yard waste and litter easily to drains and waterways. Keeping these items from getting into the streets and storm drains protects water quality and prevents drains from clogging, which helps our crews be more efficient.
3	Adopt a Drain	Consider adopting a drain in your neighborhood. Information is included in this Strategy on the program and it's a great way to show neighborhood pride and responsibility.
4	Plant Trees & Conserve Trees	Trees provide incredible and cost effective flood-mitigating benefits including absorbing, deflecting and purifying stormwater. Trees also offer many other benefits such as providing shade to manage extreme heat and lower utility bills.
5	Utilize Rain Barrels and Rain Gardens	Consider the use of stormwater best management practices such as rain barrels and rain gardens to store water and reduce the amount of runoff moving to drains. As an added benefit, save rain water and reuse it, such as for irrigating plants.
6	Limit Use of Impervious Material	Look for opportunities to use pervious materials where practical and maintain them. Capturing even small amounts of rain water and slowing the speed helps prevent drainage systems from becoming overwhelmed during heavy downpours.
7	Be Flood, Tide and Weather Aware	Flooding can quickly become dangerous under extreme circumstances. Knowing the weather and high tides and planning accordingly can help prevent you and your family from being caught in traffic from flooded roadways and intersections.
8	Make a Plan	Tropical weather and flooding is familiar to citizens. It is imperative and prudent that all citizens have an up to date family emergency plan. Know your evacuation zone, designated evacuation routes, have supplies on hand and be prepared.
9	Report Flooding	Report flooding when you see it, call our Citizens Service Desk at (843) 724-7311. Knowing where, when, and how much flooding is important to developing effective solutions and applying for post event funding.

C | AN INFORMED FUTURE

The natural flow of water takes the path of least resistance, but for many years we have forced our rivers, creeks, and wetlands to adapt to our needs. Perhaps it is time we take water's approach. Instead of fighting against the sea, we are learning to adapt and coexist with it. **Living with water™ and treating it as a resource rather than a constraint** can open up all sorts of opportunities to make the City more resilient, greener and more attractive for generations to come.

Hazard and disaster mitigation activities outlined in this Strategy have been proven to lessen the financial impact on individuals, communities and society as a whole. A 2018 study commissioned by the Federal government released a finding that **every $1 invested in hazard mitigation saves the nation $6 in future disaster costs**. As demonstrated in the initiatives, our Strategy is evolving, melding existing plans with new insights and actions. At the core of it all is the common goal – to weave resilience into everything that we can.

Since this will involve public and private spaces, such as rooftops and streets, this shared challenge affects the entire City and will require us to collaborate using a network-based approach involving all stakeholders to work together to become more resilient.

Charleston is driving full steam ahead; however, the job is greater than our current capacity and will require collaborative partnerships. With regional partnerships, expert consultants, and the continued engagement of the local community, our shared mission will continue to strengthen. There is momentum in Charleston to rectify existing problems and together prepare for a more resilient tomorrow. **Our vision is solidified, our determination is strong, and we will rise with the tide.**

D | A DEEPER LOOK

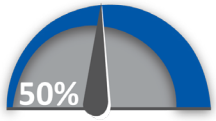
WHERE IT ALL BEGAN

To meet the challenges of planning for sea level rise, a guiding framework was essential. The original plan from 2015 provided the framework by identifying three essential aspects of resilience: Ready, Respond, and Reinvest. The City has made significant headway on these initiatives in the last three years. Following is a report on how the City has utilized this framework to progress Charleston on its path to resilience.

READY

Promote readiness, including prevention and preparedness, through continued planning, monitoring and identification of changing vulnerabilities and risks.

Embarking on a voyage, a captain prepares in numerous ways. Weather forecasts are consulted, food supplies and safety resources are stocked, the route is meticulously planned, and so on. Like a captain, Charleston is on a journey. Our destination is resilience, and the City has prepared in numerous ways to get there. Many of our "Ready" initiatives are a function of partnerships with other entities. That's because flooding does not recognize jurisdictional or political boundaries. In other words, Charleston realizes it is necessary to engage with local, regional and federal partners. Sharing knowledge and resources achieves the best results.



Over the last three years we have made progress on 50% of our Ready Initiatives.

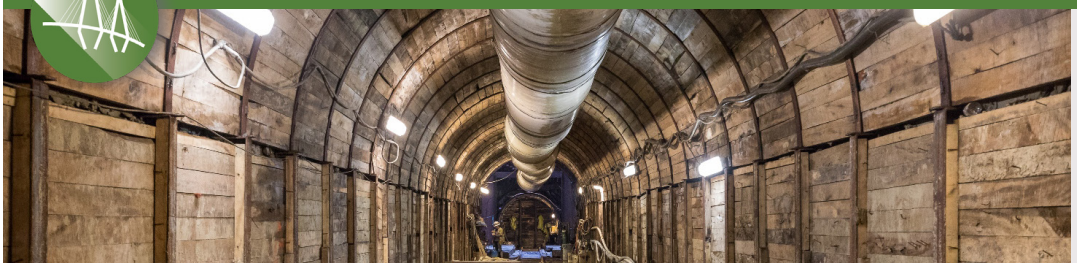
RESPOND

Improvements in our ability to respond to flooding and related events, to minimize service disruptions and threats to public health and safety

An important measure of resilience is our ability to adapt to unexpected or unavoidable situations. As we work to build and plan for increasing occurrences of tidal flooding and extreme wet weather-related events, Charleston must anticipate unexpected or unavoidable circumstances that require response actions. The time since the 2015 document was released has been a period of action, by way of increased investments in people and processes that improve our response to flooding. Charleston has strengthened the City's resilience to increasing occurrences of tidal flooding and extreme wet-weather events. The FLOODCON project described previously is one example of utilizing technology, such as flood gauge devices, for safety awareness and management of flooded roadways.

Over the last three years we have made progress on 100% of our Respond Initiatives.

REINVEST



Reinvestment in infrastructure and other physical assets to promote long-term public health, safety, and quality of life.

An investment yielding high results for a relatively low cost is the creation of the Check Valve Program. In the wake of Hurricane Matthew, much of the City's water infrastructure was in need of repair. One hard-hit area was The Battery, which had standing water for three days following the storm. There, the City discovered two 20-year-old check valves that were not opening as the tide receded. As a result, flood waters on and around Murray Boulevard were not able to drain through the valves as they typically did when a high tide receded. After discovering the cause, the City acted swiftly to clear the Battery of flood waters by pumping the water back into the harbor as a temporary solution until the new check valves were able to be installed shortly. City staff continue expand this ongoing program and work deliberately to identify and provide repairs in low areas susceptible to tidal inundation via stormwater pipes.

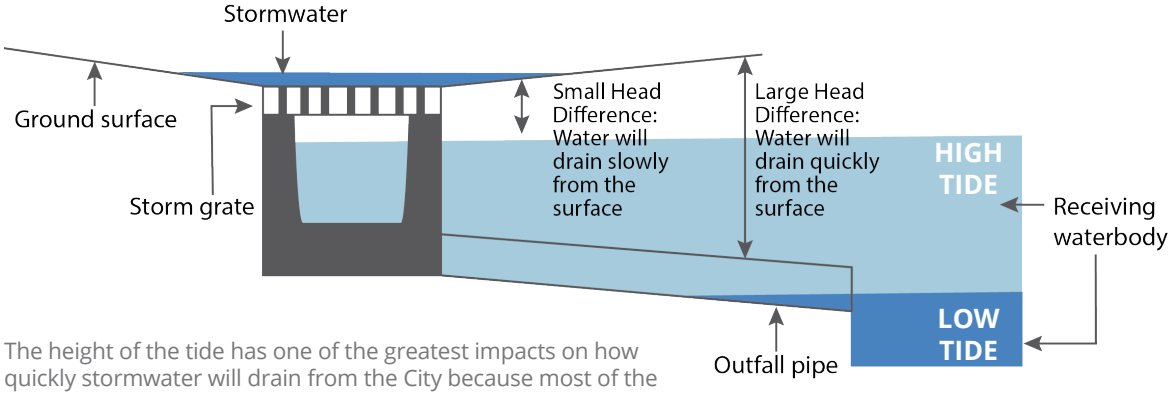
Over the last three years we have made progress on 73% of our Reinvest Initiatives.

THE BIG PICTURE

Sea level rise can be difficult to see. Nonetheless, even a small increase in sea level can exacerbate extreme wet-weather events, tidal flooding, and drainage issues. The combination of these factors is a recipe for significant flooding in our low-lying City, and Charleston has been repeatedly stormed with this reality in the last few years. As proof, since October 2015, three major events have caused historic flooding in our streets, businesses, and homes.

If Charleston is to be resilient to future flooding, we must commit to understanding the multi-faceted problem. We know the issue is not only related to sea level rise. The amalgam of causes also includes geography, frequent extreme weather-related events, increased precipitation, higher groundwater tables, antiquated infrastructure, subsidence and more. All contributors to flooding in our City are and will continue to be monitored and evaluated.

HOW DOES THE TIDE LEVEL AFFECT OUR STORMWATER SYSTEM?

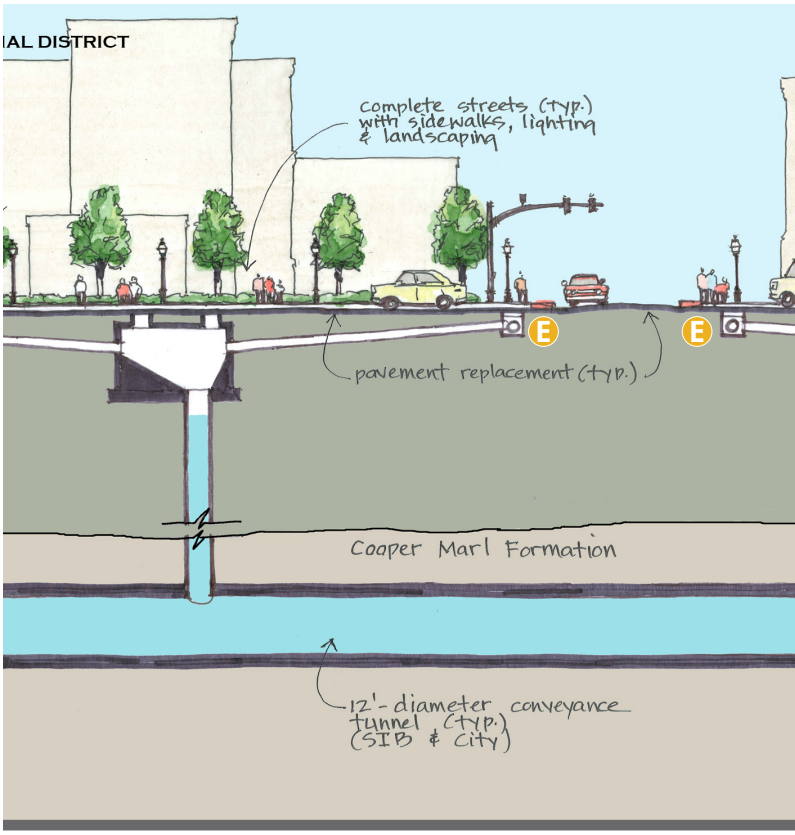


The height of the tide has one of the greatest impacts on how quickly stormwater will drain from the City because most of the outfalls of the City drain to water bodies that are tidally influenced. The tunnel projects help overcome some high tide challenges.

YOU CAN HELP! To be more flood, tide and weather aware visit www.charleston-sc.gov/SLR.

YOU CAN HELP! Stormwater (rainwater runoff) empties directly into our waterways (G) and is not treated like wastewater is. One way you can help protect water quality and prevent clogged drains is by maintaining a clean, litter free yard.

HOW DO TUNNEL PROJECTS WORK?



DATA SOURCES

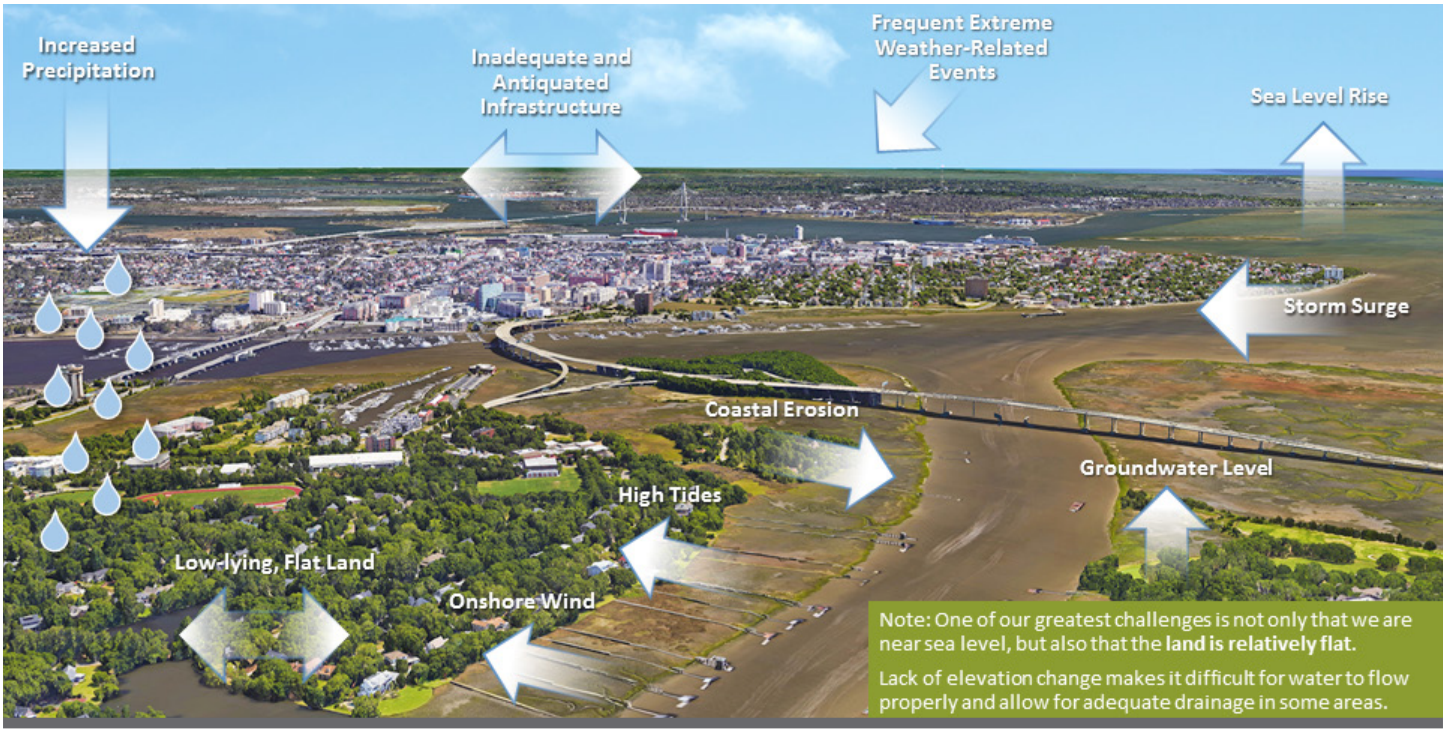
(1) Datums for 8665530, Charleston, Cooper River Entrance SC, NOAA: https://tidesandcurrents.noaa.gov/datums.html?id=8665530

(2) Fourth National Climate Assessment (NCA4), Volume I Chapter 12 Sweet, W.V., R. Horton, R.E. Kopp, A.N. LeGrande, and A. Romanou, 2017: Sea level rise. In: Climate Science Special Report: Fourth National Climate Assessment, Volume I [Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 333-363, doi: 10.7930/J0VM49F2.

(3) Adapted from: Sweet, W. V., and J. Park, 2014: From the extreme to the mean: Acceleration and tipping points of coastal inundation from sea level rise. Earth's Future, 2, 579–600, doi: 10.1002/2014EF000272.

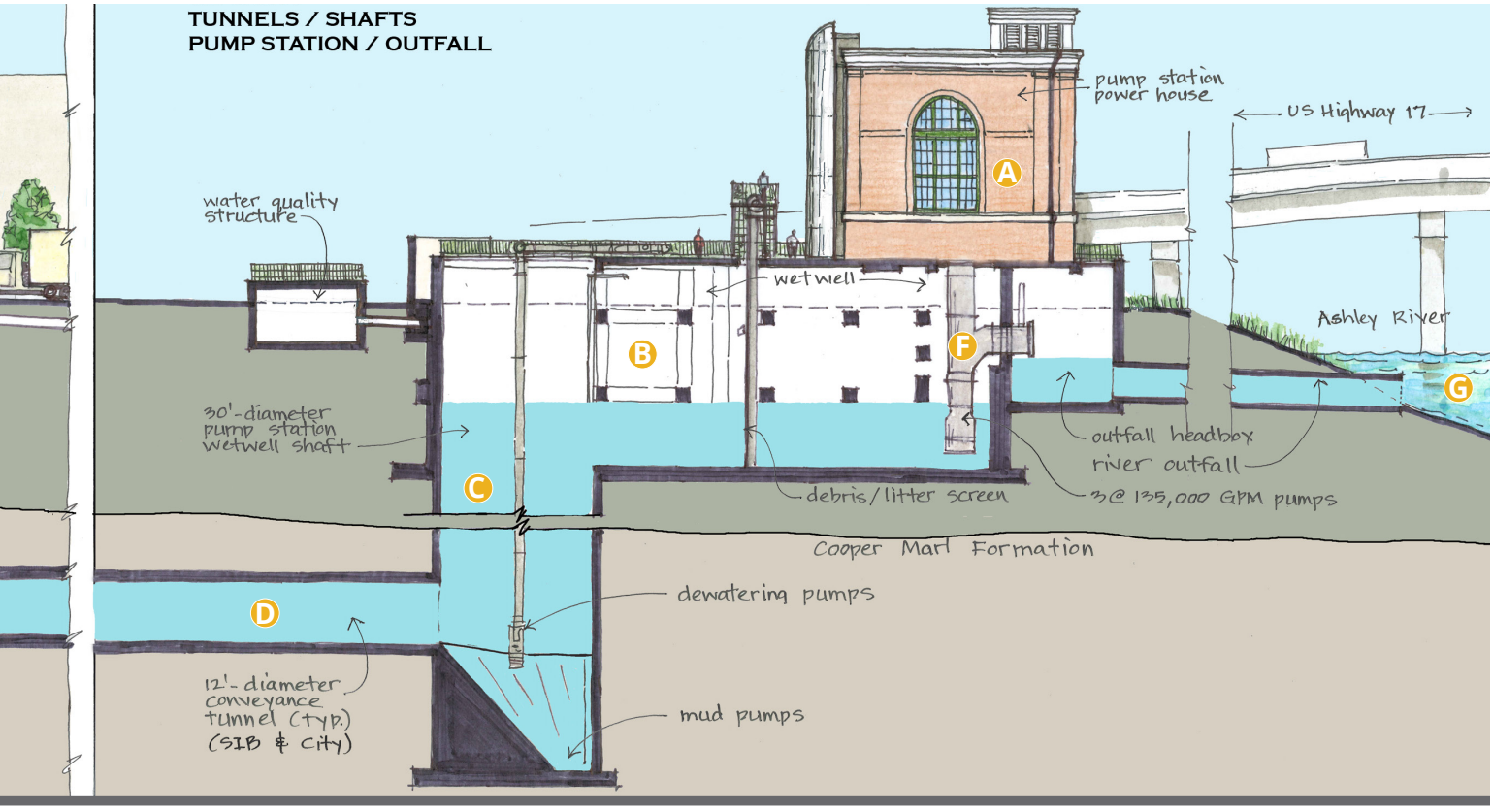
(4) Historic Crests: NOAA: https://water.weather.gov/ahps2/crests.php?wfo=chs&gage=chts1&crest_type=historic

WHAT CAUSES FLOODING?



Above: Flooding is caused by many factors, which often combine simultaneously to form a complex, multi-faceted challenge.

Below: A concept plan created by Davis & Floyd illustrates how the Spring/Fishburne tunnel and pump station project works. This same concept also applies to the City's other major tunnel projects. Generally, each system has a pump station (A) with a wetwell (B) and/or drop shaft (C) that extends up to 175 feet below grade and into the Cooper Marl Formation to connect with a conveyance tunnel (D) that collects stormwater from surface inlets (E) throughout the project's associated basin(s). Pumps (F) provide the necessary energy to rapidly push water into a waterbody (G) without needing to wait until high tide passes, decreasing the amount of time it takes for water in a flooded area to drain. Learn more at www.charleston-sc.gov/SLR.



FREQUENCY

3 HISTORIC FLOODS

3 CONSECUTIVE YEARS

2015: 'THOUSAND YEAR RAINFALL'

From October 1 through October 5, 2015, Charleston experienced the first in the series of record setting events. Among the weather systems was the aftermath of Category 4 Hurricane Joaquin, which fed a continuous stream of moisture into South Carolina. As a result, the Charleston region received more than 20 inches of rainfall. The City's harbor had the highest recorded tides since Hurricane Hugo made landfall in 1989, causing significant flooding. The water that infiltrated Charleston caused road closures, property damage, and required rescues by emergency personnel.

8.2 FEET

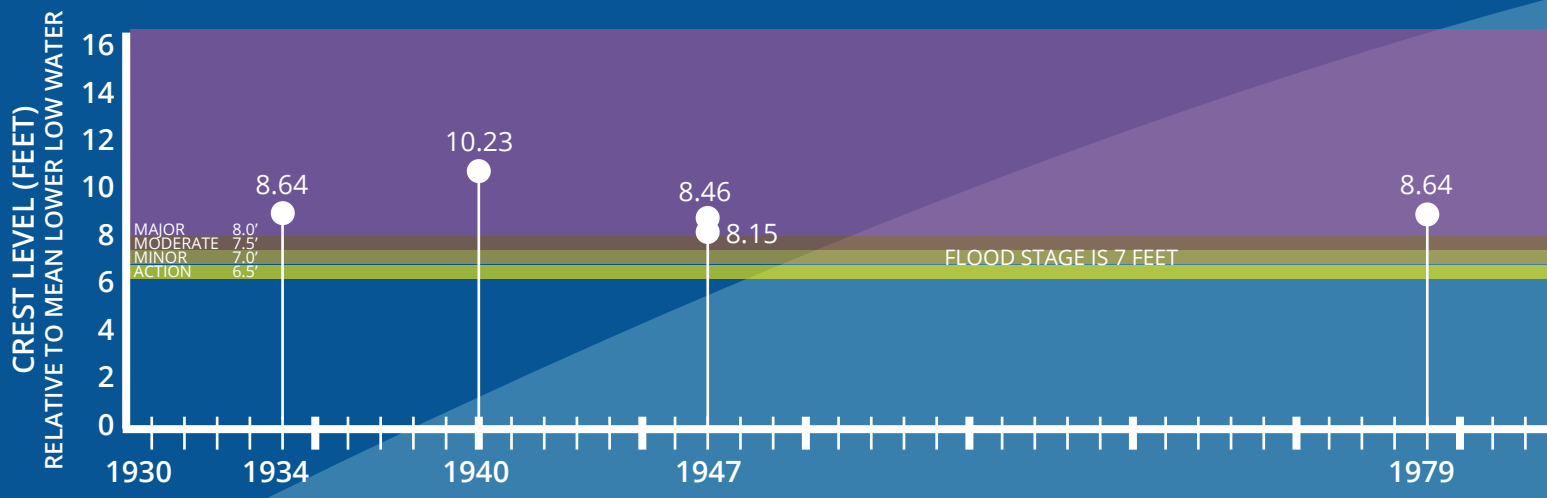
20 INCHES

FLOOD CATEGORIES (IN FEET)

- AT 8.0′ MLLW, MAJOR COASTAL FLOODING OCCURS
- AT 7.5′ MLLW, MODERATE COASTAL FLOODING OCCURS
- AT 7.0′ MLLW, MINOR COASTAL FLOODING TYPICALLY BEGINS
- AT 6.5′ MLLW, ACTION BEGINS

Source: National Weather Service (2017)

TOP 15 CRESTS AT CHARLESTON HARBOR[4]



2016: HURRICANE MATTHEW

One year following the October 2015 flood, almost to the day, Hurricane Matthew swept through Charleston. Though it arrived during low tide and had weakened to a Category 1 storm, Matthew delivered significant inundation from storm surge. A peak storm tide of 9.29 feet was recorded in the Charleston Harbor, which was the third-highest level on record to date. Flooding from the harbor along with 9-10 inches of rainfall took days to drain.

9.3
FEET

10
INCHES

2017: HURRICANE IRMA

Most recently, Charleston felt the swirling effects of Hurricane Irma. Arriving at high tide, Irma produced a peak storm tide that exceeded both Hurricane Matthew and the October 2015 flood event, measuring an astounding 9.9 feet. On September 11, 2017, Charleston Harbor was at the doorsteps of the neighborhoods along The Battery. Though the eye of the storm was quite a distance from Charleston, Irma brought continuous and heavy bands of rain. Throughout the City, 111 roads were closed because of flooding, significantly interrupting lives and business.

9.9
FEET

7
INCHES

IN THE LAST 4 YEARS,
CHARLESTON EXPERIENCED 8 OF THE TOP 15
TIDES EVER RECORDED.
NOT ALL WERE ASSOCIATED WITH STORMS.