JOHNS ISLAND

RESTORATION PLAN TO IMPROVE FLOOD RESILIENCY

FINAL REPORT

Funding for The Johns Island Restoration Plan to Improve Flood Resiliency was provided by the City of Charleston and a National Coastal Resiliency Fund grant from the National Fish and Wildlife Foundation.

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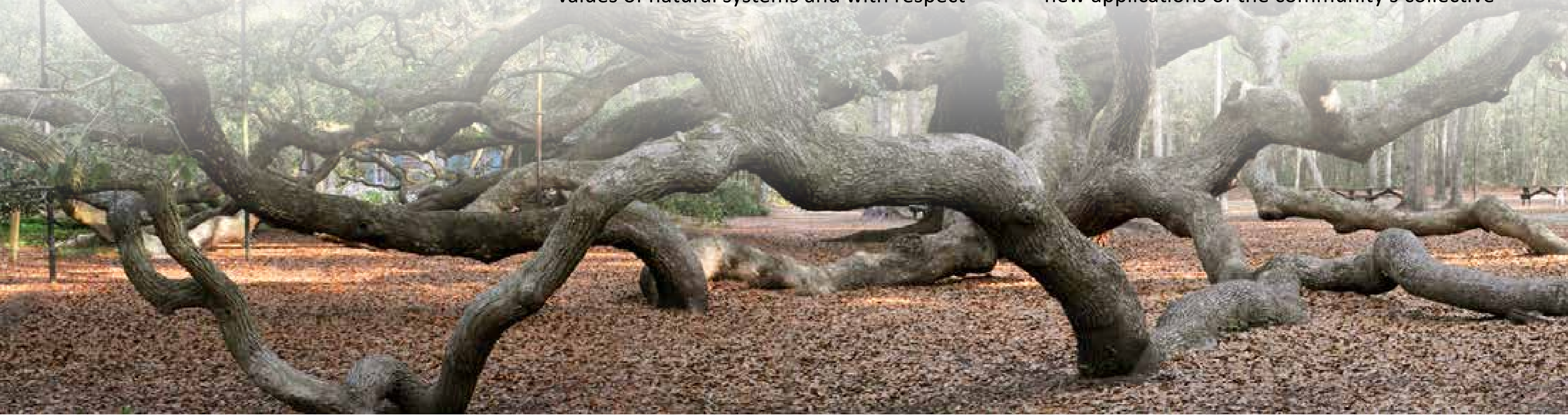
Introduction

Despite endemic flooding, Johns Island continues to be a magnet for new residential development. The island's natural soils, elevations and climate all exert controls on surface hydrology such that significant risks to public safety and private property occur from routine summer storms and less frequent tropical storms alike. However, the natural environmental features are the assets that make Johns Island a great place to live, and residents agree that ecosystems should be protected. Ecosystems provide regulating services for the storage and conveyance of stormwater, so the preservation, restoration and stewardship of these natural systems are essential components of a sustainable flood mitigation and management plan.

Flood risk on Johns Island has many drivers. Organic soils hold water like a sponge but underlying horizons are often poorly drained. Low relief extends tidal influences far into the island's interior, so that when heavy rains come during high tides the streams and storm drains are swamped. The vast increases in pavement and rooftops that come with new development is increasing runoff and escalating flood management challenges. Flood mitigation strategies to control risks to people and property must therefore manage development to promote resiliency.

The JOHNS ISLAND RESTORATION PLAN TO IMPROVE FLOOD RESILIENCY was developed with an appreciation of the compound values of natural systems and with respect for real estate development. The planning process combined complex spatial analysis and engineering studies, public outreach, contributions from local residents and technical experts, and field assessments. This plan presents both policy and project strategies to reduce environmental impacts from new development and leverage ecosystems and natural processes for mitigation of flood risk.

The Plan flows from concepts developed through the Dutch Dialogues™ Charleston (DD) and applies those concepts at ground level. The DD process starts with a shared acceptance of the inexorable influences of water on the community. The process elicits new applications of the community's collective



ingenuity to determine the shared path toward long-term resilience. Mapping that path requires understanding of localized risk and the uncertainties of a dynamic climate, as well as recognition of specific opportunities to leverage the flood mitigation capacities of natural systems.

This plan is the next step on the path to flood resilience. Generally, the task was to evaluate how and where stream naturalization, floodplain protection and enhancement, wetland restoration/creation, and other nature-based infrastructure can be used to mitigate current and likely future flood risk on the Island. More specifically, the City charged the project team to assess and prioritize tracts for potential projects, easements or other utilization strategies to maximize flood risk mitigation and ecosystem function.

The desired outcome is flood resilience, for present conditions and reasonably anticipated future conditions. “Flood resilience” can be understood as the ability of a community to withstand, respond to, and recover from a flood event. The task then is to develop a restoration planning framework based on natural infrastructure and flood risk mitigation.

The JOHNS ISLAND RESTORATION PLAN provides specific solutions for land protection to mitigate flood risk, preserve wildlife habitat and improve recreation opportunities. Three key projects are defined to protect or restore natural form and process to altered and degraded ecosystems. The projects are ‘modular’, meaning that each project is comprised of multiple components. In most cases, executing an individual component (e.g., securing an easement on a key conservation parcel) will significantly advance flood resiliency.

The plan also provides policy recommendations to establish flood resiliency as a key component of long-term growth management. Policy considerations that promote protection of existing green infrastructure, coordinated decision making and resilient transportation planning are outlined.

Funding for The Johns Island Restoration Plan to Improve Flood Resiliency was provided by the City of Charleston and a National Coastal Resiliency Fund (Design) grant from the National Fish and Wildlife Foundation.

DUTCH DIALOGUES | CHARLESTON

A Vision for Charleston's Future

Throughout most of 2019, the Charleston community joined together in a unique collaboration for the *Dutch Dialogues Charleston* process (Dutch Dialogues Charleston process). The Dutch Dialogues (DD) are a series of civic engagements that revolve around LIVING WITH WATER concepts. The concepts evolved in The Netherlands where for over eight centuries, the Dutch have been living and thriving in a lowland much like Charleston: dissected by rivers and bounded by the sea.

The structured collaboration integrated community knowledge in science, planning, engineering, finance, and other areas. Johns Island was one of six focus areas for which the diverse perspectives of individuals, neighborhoods, civic and business groups, government officials and staff developed a set of localized priorities to guide future growth toward community resilience.

For the Johns Island focus area, the Dutch Dialogues™ set elevation as a guiding framework to reduce and prevent development impacts on flooding.

Tidal reach of Church Creek Tributary

Typical forested wetland on Johns Island

Dutch Dialogues Charleston Johns Island Recommendations

- Do no harm
- Conserve and protect natural and cultural assets
- Respect elevation
- Update Johns Island Plan with a regional perspective
- Maintain and improve over-land drainage
- Use market-based tools

Johns Island's rapid change has stimulated well-organized community engagement in City and County plans and projects. Building on the lists of contributors to previous planning efforts, the most recent of which was the Charleston City Plan, this project engaged the public through open forums and input solicited from a Technical Advisory Group (TAG) of specialists representing various sectors of the Johns Island community.

The first meeting of the Technical Advisory Group (TAG), in February 2021, was part of the discovery process, offering local stakeholders and experts a chance to explain their perspective on previous planning efforts and become familiar with the project. This was followed by a presentation to the Johns Island Task Force and an informal discussion of maps and sites with a few key stakeholders in April.

In June 2021, an open public meeting was conducted virtually to provide an overview of the project and the team's understanding of the historical context of flooding impacts on the island. Participants responded with suggestions and ideas for data sets and further engagement. Afterwards, stakeholders were invited to maintain contact using two tools: a dedicated project email and an interactive map where participants could offer site-specific commentary.

The final TAG meeting, in August 2021, presented the completed suitability analysis and regulatory precedents and posed questions about resources that should be regulated on Johns Island.

Technical Advisory Group

Esther Adams	Heirs Property Representative
Lori Bataller	Charleston Co. Soil & Water Conservationist
Josh Dix	MetroRealtors
Elizabeth Fly	The Nature Conservancy
Paul Gayes	Coastal Carolina University
Al George	SC Aquarium Conservation Director
Bria Graham	Gullah Geechee Corridor staff
Scott Harris	College of Charleston
Rick Karkowski	Thomas & Hutton
Raymond Molinaroli	SCDOT
David Ray	Low Country Land Trust
Brooke Saari	SC Sea Grant
Lisa Vandiver	NOAA Restoration Center
Chris Wannamaker	Charleston County Stormwater Program Manager
John Zlogar	Johns Island Task Force

PLANNING AREA

Johns Island is located southwest of downtown Charleston and includes the southwestern extents of the City. At approximately eighty-four square miles, Johns Island is the largest island in South Carolina. The Stono River separates Johns Island from James Island to the east and West Ashley to the north. The Kiawah River and associated marshes lie to the south between Johns Island and the Kiawah-Seabrook barrier island complex. Bohicket Creek and Church Creek bow into the west side of the island. The planning effort focused on the approximately 16.2 square miles within the City of Charleston's Urban Growth Boundary (UGB). However, because hydrologic processes cross political boundaries, significant work included adjacent portions of Charleston County and County staff participated in the planning process.

Landscape Setting

Johns Island is a large sea island that was formed as a barrier island dune complex. The dunes migrated back and forth between the mainland and the ocean as sea levels fluctuated over the last several thousand years. As coastal processes formed the sand ridges, freshwater and tidal creeks carved valleys and produced most of the streams we see today.

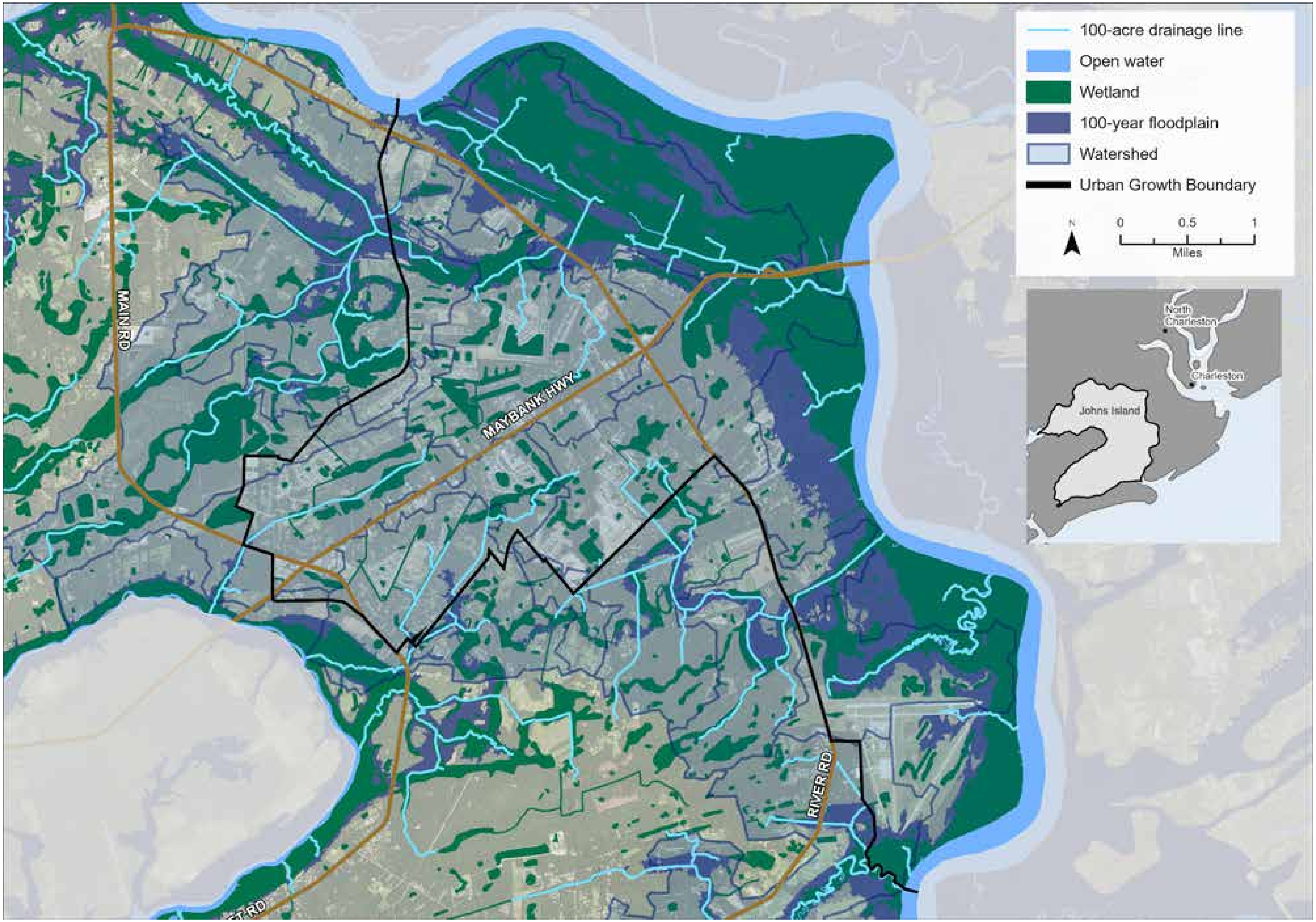
Climate

The climate of Johns Island is humid-subtropical. Summers are long, hot, and humid, and warm weather persists until mid-November. Winters are very mild, freezing temperatures are uncommon, and average highs return to the mid-60s Fahrenheit by March. The island is vulnerable to storm surges, as hurricanes are a threat during the late summer and early fall. On average, Charleston County receives 49" of precipitation per year, with the majority occurring as afternoon thunder showers during summer. All of Charleston County, including Johns Island, is vulnerable to flash flooding, especially during high tides that impede stormwater drainage systems. Because the area is also vulnerable to tropical storms, rainfall in a single event can range from ten to twenty inches or more, increasing flood risk across the island.

Ecological Communities

The high ridges on Johns Island support mixed hardwood-pine forest, while the low areas are generally a network of streams and forested riparian wetlands. The tidally influenced areas are dominated by saltmarsh at low elevations and coastal maritime forest at higher elevations. Both the riparian wetlands and maritime forests serve crucial roles in stormwater storage and filtration, and the marsh is critical for storm surge mitigation.

Natural forests and wetland habitats support diverse flora and fauna across Johns Island.



Johns Island Hydrology Map

Hydrology

GIS data show five named streams in the project area: Stono River, Church Creek, Bohicket Creek, Pennys Creek and Burden Creek. Most of the island is drained by unnamed first and second order tributaries to these creeks. The island is also replete with ditches: roadside ditches, agricultural ditches and natural streams that were deepened and straightened are all part of the surface drainage network.

The few undisturbed freshwater streams that remain on Johns Island are generally low gradient, sinuous, sand bed channels flowing through broad forested wetlands. Sediment loads from the watersheds are very low, so woody debris is the forcing mechanism for sustaining habitat niches in the beds and banks.

All of the named streams are tidal or tidally influenced, as are all of their major tributaries. While there is much local variability, this tidal influence is the cause of many Johns Island flooding problems. When tides rise in the named streams, the mouths of smaller tributaries become flooded and their flow backs up. At high tides the culverts at road crossings may become fully or partially submerged, backing water up into ditches and contributing to street flooding during heavy rains. Severe increases in tidal influences on local flooding are expected to accompany sea level rise.

Naturally meandering tributary to Pennys Creek flows through forested riparian wetlands

Future Conditions

According to the City of Charleston's 2019 All Hazards Vulnerability and Risks Assessment, climate change will exacerbate all types of flooding. Floodplain inundation could result from heavier precipitation. Stronger more frequent tropical storms will increase storm surge flooding, and current high-tide flooding will increase as sea levels rise.

Given the island's interconnected ditch and drainage system and outfalls to tidal waters, both land use changes and sea level rise will affect each type of flooding. An intermediate scenario of five feet of sea level rise (SLR) is the criterion set by the city to define exposure and vulnerability, alongside inundation events with a 1% annual chance of exceedance and the surge associated with Category 3 hurricanes.

On Johns Island, roadways were at consistently high risk across the island, whereas there was more variation in vulnerability for residences and commercial structures.

WHAT SHAPES THE LANDSCAPE: GEOLOGY, HYDROLOGY AND MAN

Water shapes the earth's surface. It reacts chemically with soils and plants and rocks, dissolving and transporting various constituents. It freezes and expands, and water on the surface carves gullies, streams and valleys and carries the sediment to the sea. In recent centuries man and his machines have taken over the landscape, clearing, draining and cultivating fields, building highways and malls and houses. Johns Island's agricultural and mining history replaced the natural meandering and anabranched streams with straight, efficient ditches.

Ditches are usually designed to lower the water table and/or to contain stormwater and move it off the landscape. Natural streams can move the same amount of water past a given point just as fast as a ditch, but if the natural curves and deep pools are in place, the meandering channel can hold over 50% more water than the straight ditch. If the adjacent riparian wetlands are intact, water storage is even greater with comparable conveyance.

All of the streams on Johns Island discharge into tidal waters, leaving no pathway for water to drain when storms hit during high tides. This landscape interaction drives the critical need to store water on the landscape. Ecosystem restoration practices can recreate natural sinuosity and riparian wetlands to improve community resilience to storm events by increasing water storage and conveyance.

Active and historic agricultural ditches (dark linear features) dissect the Adapt Zone near Burden Creek (image courtesy of Scott Harris).

Channelized tributary to Church Creek near Johns Island Park.

APPROACH

This planning process started from two basic premises: (1) land development on Johns Island will continue and, (2) natural ecosystems are a cost-effective watershed management tool. Two primary areas of analysis are emphasized: flood hydraulics and the spatial distribution of ecosystems. Integrating the two lines of inquiry identified those locations and ecosystem types best suited to protect and defend against flooding on Johns Island, with additional benefits for fish and wildlife.

The geodatabases and refined hydraulics model used in the analyses provide a durable restoration planning framework for subsequent analyses suggested by future hydrologic and land use conditions, evolving community goals and funding opportunities.

The technical analyses were designed to identify potential project sites, but the results also support policy recommendations to advance the City's resiliency goals. Potential policy concepts were outlined and recommendations are presented in this report.

"Growth is inevitable, let's grow in the most sustainable way possible."

Comment from the Johns Island TAG Workshop, August 26, 2021

Naturally meandering tributary to Pennys Creek flows through forested riparian wetlands

LOCAL KNOWLEDGE, PUBLIC ENGAGEMENT

The approach for identifying and evaluating policy alternatives emphasized the stakeholder group and public engagement. Due to COVID-19, most of these important interactions occurred virtually.

The Johns Island Restoration Plan to Improve Flood Resiliency project team formed a Technical Advisory Group (TAG) at the outset of the project. TAG members are scientists, concerned citizens, civic group leaders, and City, County, state and federal agency staff. The TAG members participated in virtual group meetings, a workshop, and individual and small group consultations. The TAG provided invaluable insights on local conditions, specific problems and potential opportunities.

How can we best leverage natural processes to solve anthropically induced problems?

This planning process also included outreach to the public in several ways. In addition to a public meeting, the team has maintained a dedicated email for public comments. An interactive map hosted by the City's website allowed people to record specific locations of flooding problems and project opportunities. Email blasts to homeowners' associations also solicited input.

This Johns Island plan also has the fortunate ability to draw on other recent, successful City planning efforts, each of which included extensive public engagement that produced viable policy ideas. Three members of the planning team were actively involved in the Dutch Dialogues, including the Johns Island focus group. One team member led the Dutch Dialogues Charleston and was also a leader in the Land and Water Plan to support the draft City Plan. The project team reviewed documents and presentations from these efforts and was particularly attentive to City Plan's listening session for Johns Island.

Planning Context

The Urban Growth Boundary figures prominently as a limit to development on Johns Island, and several recent efforts have focused on maintaining the unique character of sea islands under intense development pressure. All of the recent planning efforts address flood risk as an existential threat to areas of the island.

2020 The Maybank Highway and Main Road Overlay Zoning Project

Charleston County and City of Charleston Planning Departments created consistent land use, zoning, and development requirements for the Maybank Highway and Main Road Corridors on Johns Island. After approval by County Council, they became effective December 17, 2020. The primary provision was to divide the corridor into a Mixed Use District with higher intensity commercial development at three major nodes along the corridor and a Limited Commercial District for service and neighborhood commercial uses. Restrictions include items with implications for water management, such as street frontage buffers, buffers for industrial uses, and curb cut requirements.

2020 All Hazards Vulnerability and Risk Assessment

This report identifies 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 highlights the most critical areas and assets at risk from these physical threats. Mobility and road closures are significant flood-related threats on Johns Island.

2019 City of Charleston Stormwater Regulations

The recent revision of the City of Charleston's stormwater design manual takes a stronger approach to reducing flood risk by defining improved stormwater techniques in response to elevation and flood risk. The updates strengthen requirements for redevelopment and further regulate "fill and build" practices. Some of the most important changes for Johns Island will be in the allowable forms of development in low-lying areas. This Johns Island Restoration Plan to Reduce Flood Risk responds directly to an approach of managing stormwater close to where precipitation falls, maintaining undisturbed wetland areas, and using natural features for stormwater management.

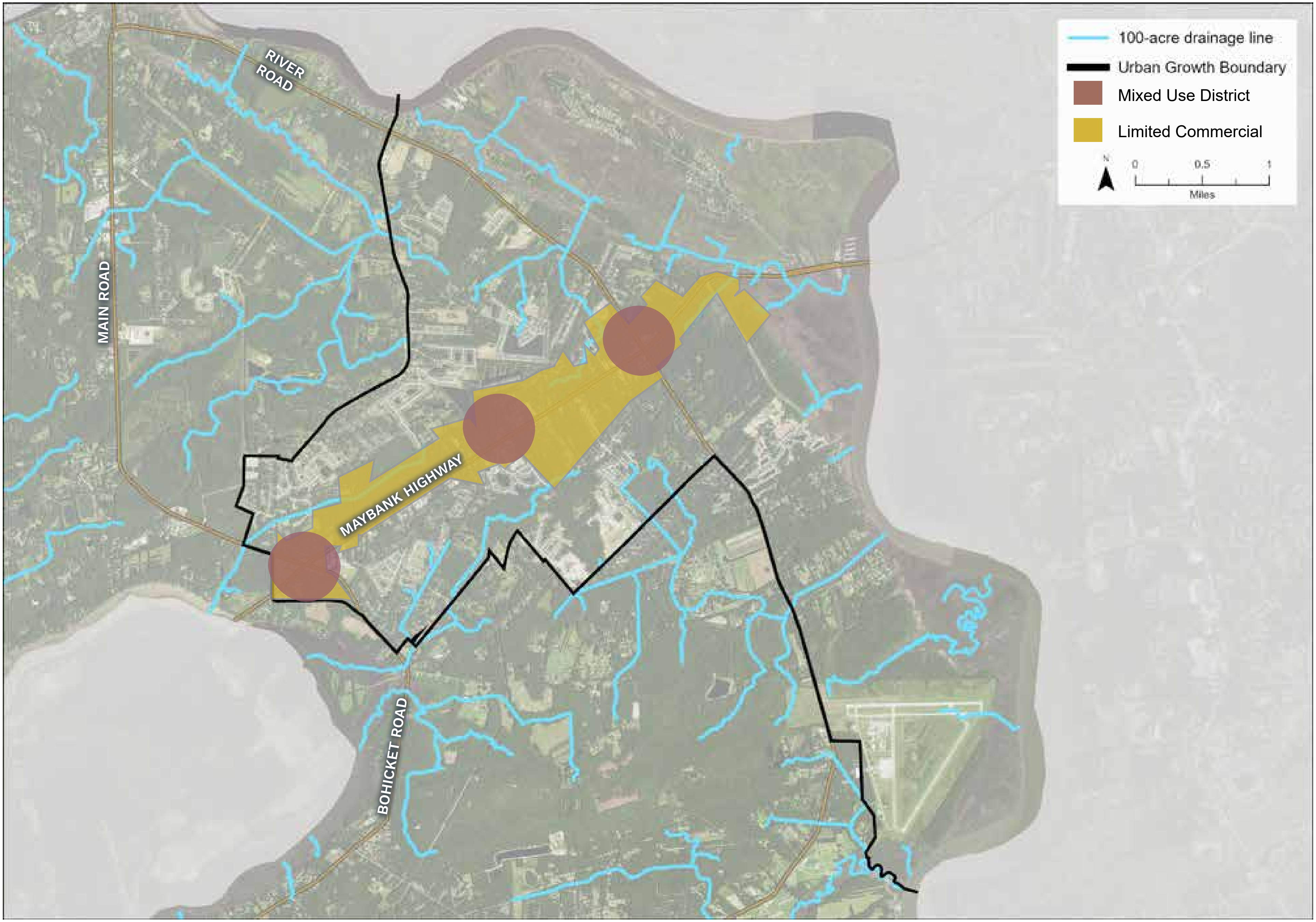
2020 Land and Water Analysis

This analysis supports the Charleston City Plan and considers land use within a rubric of elevation, natural forms, and soil types. The analysis defines elevation risk zones as a robust framework for planning and zoning. The distinctions among High Ground, with the greatest capacity for development and stormwater detention, the Adapt Zone with predictable but infrequent flooding, and the Compound and Tidal Flood Risk Zones, are drivers for important elements of the full City Plan. The Land and Water Analysis did not include precipitation-driven flooding in communities.

2021 Charleston City Plan

The 2021 plan includes land-use maps based on the Land and Water Plan that recommends how the city should grow and adapt to flooding, sea-level rise and the future effects of climate change. The goal is to highlight the parts of Charleston that are most vulnerable to tidal and stormwater flooding, and to pinpoint other areas that are best suited for more dense development in the future. Throughout the city, areas appropriate for dense development are based on land elevation and the proximity to public transportation routes. The city described those areas as "city centers." On Johns Island, three of these areas are distributed along Maybank Highway within the Urban Growth Boundary.

Maybank Highway Corridor Overlay District



ECOLOGICAL COMMUNITIES

Johns Island's upland ridges support mixed hardwood-pine forest. The quality of these forests ranges considerably, from remnant stands with mature oaks to younger forest on depleted soils with a heavy burden of invasive species.

The lowland floodplain was once characterized by mighty swamp forests, but they were cleared centuries ago, drained by ditches that modified the hydrology that supported those forests. Today the lowland floodplain plant communities still lean towards wetland species that can tolerate periodic freshwater and/or brackish inundation, but the modern soils are much drier.

Nearer the rivers, the coastal edge community is dominated by saltmarsh at low elevations, with occasional shrubs and trees transitioning to a coastal maritime forest community at higher elevations.

Johns Island's ecological communities can be examined from a human perspective, defining them in terms of the benefits they provide to society. This approach is an adaptation of the concept of ecosystem services, which fall into four basic categories of services as defined by the Millennium Ecosystem Assessment: provisioning, regulating, cultural and supporting services. Regulating services enhance resilience and that moderate natural phenomena such as erosion and flooding.

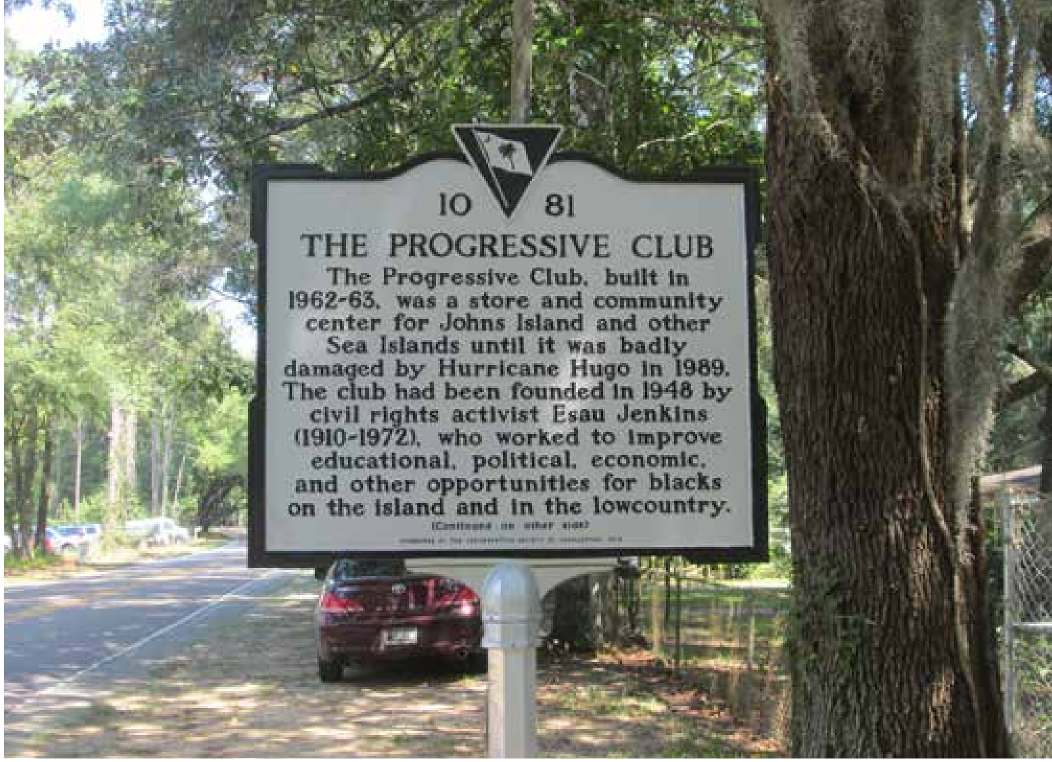
Mixed hardwood-pine forests provide infiltration and transpiration

Lowland floodplain systems provide conveyance, storage, and energy dissipation

Regulating Services That Increase Flood Resilience

Ecosystem	Services
Nontidal Wetland	Storage, infiltration/recharge
Stream (ditch)	Conveyance, storage
Riparian Buffer	Storage, conveyance, energy dissipation
Tidal Marsh	Surge reduction/energy dissipation
Upland Forest	Infiltration, transpiration

Coastal salt marsh protects the island with surge reduction and energy dissipation.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THE PROGRESSIVE CLUB
The Progressive Club, built in 1962-63, was a store and community center for Johns Island and other Sea Islands until it was badly damaged by Hurricane Hugo in 1989. The club had been founded in 1948 by civil rights activist Esau Jenkins (1910-1972), who worked to improve educational, political, economic, and other opportunities for blacks on the island and in the lowcountry.
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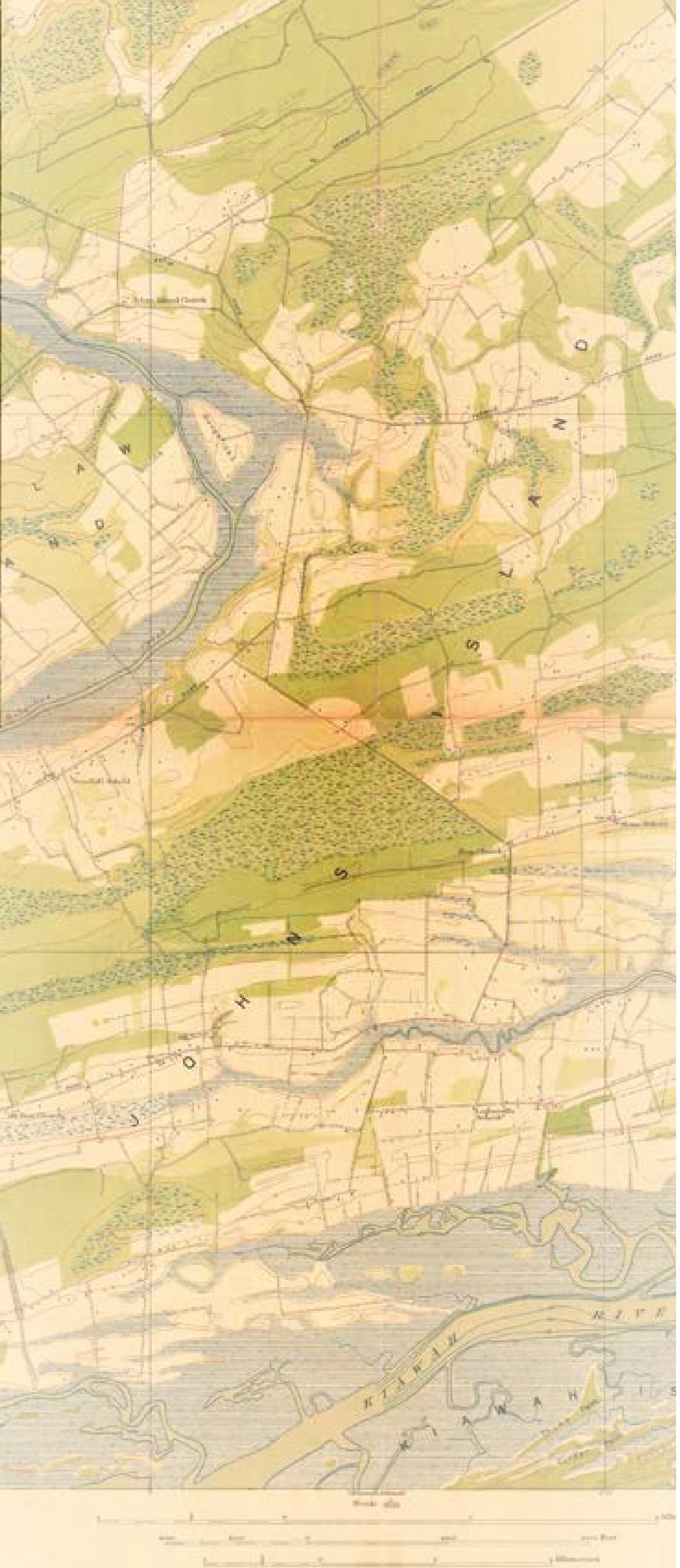


SOCIETAL CONTEXT

Throughout its history, Johns Island has gone through several cycles of land use. Initially home to a number of largely nomadic indigenous groups, permanent settlement of the island is believed to date back to the late seventeenth century when European colonists moved into the region.

Following European settlement, agriculture became the dominant land use on the island. Much of the land was stripped of native vegetation and the landscape was modified for agricultural production. Phosphate mining, which alters drainage patterns, also occurred on the islands. Following the decline of the major rice and cotton farming activities, a large portion of the island reverted to a natural succession process or was converted to commercial pine plantations. Some commercial agriculture remained but at a smaller scale. In the latter half of the 20th century, Johns Island became increasingly attractive for human settlement and now provides locations for multiple uses, including neighborhoods, restaurants and shops.

Of particular cultural importance for Johns Island are the African-American settlement communities that occur across much of Charleston County. African-American settlement communities are a significant cultural group resource. In the years following the Civil War a large number of formerly enslaved African American families remained on land close to the Plantations on which they had worked. These free people of color created their own self-sustaining communities, quite frequently close to waterways. The coastal waters provided crab, fish and shrimp for sustenance and profit. Today, these settlement communities remain largely rural and represent an important social and cultural aspect of life on Johns Island. At least four communities on Johns Island are eligible for the National Register of Historic Places for their significance in community planning and development and black ethnic heritage. The county notes that several of the other settlement communities may be eligible as well.

LAND USE AND THE BUILT ENVIRONMENT

Johns Island is attractive to residents who seek a more rural environment in close proximity to the urban core of Downtown Charleston. The pace of development is rapid and accelerating, with many of the residential development practices contributing to flood risk.

The typical new development employs practices that are largely consistent: deforestation, followed by mass grading, placement of fill, and slab on grade home construction. The process nearly eliminates the hydrologic storage and infiltration services provided by the predevelopment forests. Clearing land removes vegetation that intercepts and slows rainfall runoff. Mass grading removes the benefits of topsoil, compacts the subsoil, and fills in depressions that provide natural storage. As a result of land use changes, infiltration is drastically decreased and rainfall that once seeped into the ground runs off the surface at an accelerated rate. The prevailing 'fill-and-build' practices for residential subdivisions on Johns Island severely alters the natural distribution hydrologic storage across a watershed and concentrates conveyance through stormwater infrastructure.

The map at right shows some of the land use changes 2001 to 2019, including:

- 1,500 acres of new development, 80% inside the UGB
- 250 acres of redevelopment that significantly increased impervious surface
- Forest cover decreased by 370 acres

Key Themes for Flood Risk and Solutions

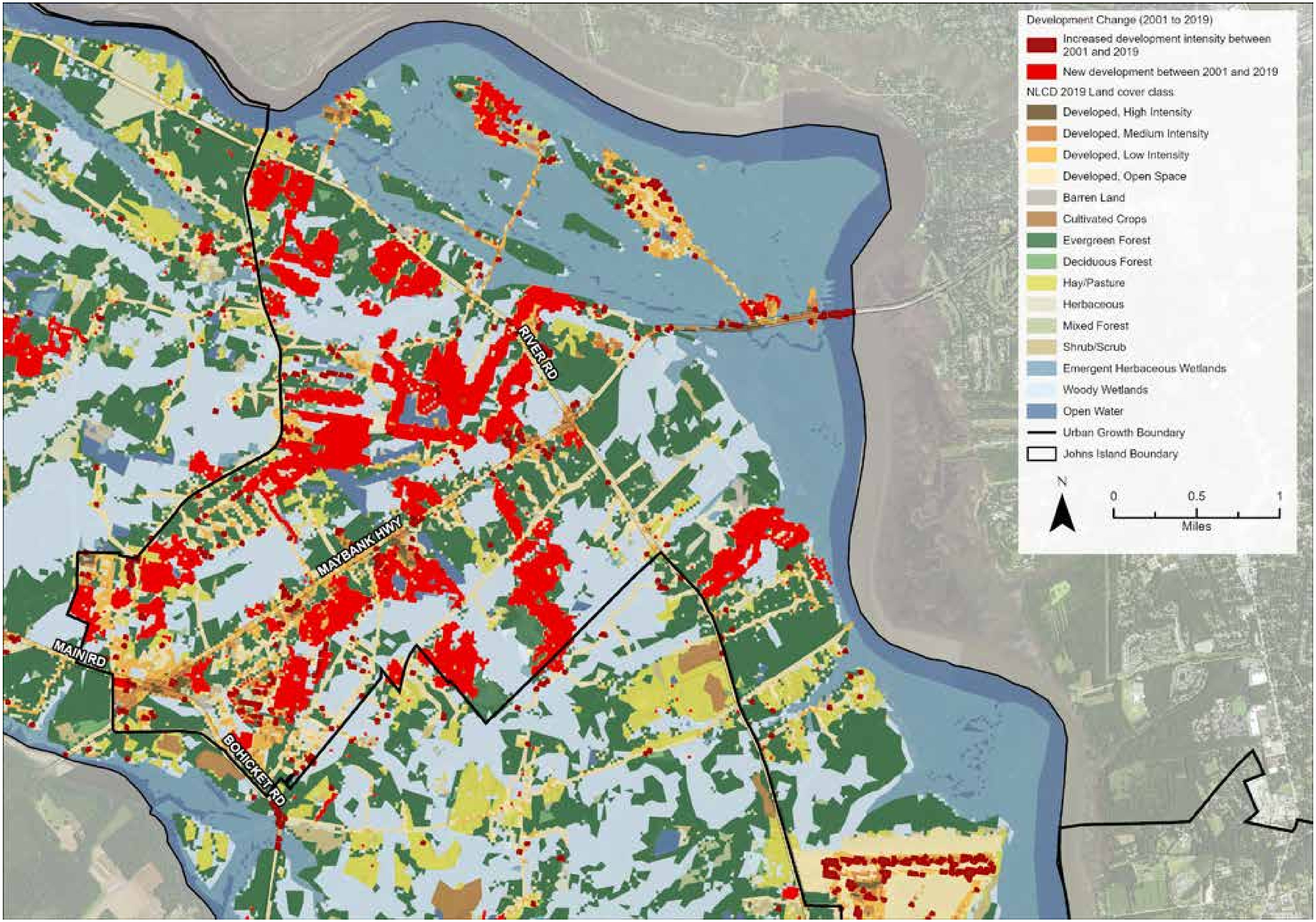
The ecological, social and planning context of Johns Island established several parameters for restoration planning to reduce flood risk.

1. The large, flat, tidal watersheds and poorly-draining soils mean that the current pace and techniques of development will create or exacerbate downstream hazards.

2. Coastal edge habitats that currently protect the island by dissipating wave energy and preventing erosion are vulnerable to sea level rise and storm surge

3. The central dune ridge along Maybank Highway offers Johns Island high ground for development. This is where water should be stored and infiltrated for three reasons:

    - greater distance from tidal influence
    - higher porosity of the soils
    - Maybank is targeted for more intense development with higher impervious surface.



Land Use Change, 2001 — 2019

METHODS

FLOOD RISK

The Restoration Plan for Flood Resiliency must answer three questions:

1. Where is the flood risk on Johns Island?
2. Which areas are suitable for projects to reduce flood risk?
3. Which of the possible project sites are most feasible?

This plan uses road flooding as a governing analytic approach to defining flood risk. The risk map integrates information from hydraulics modeling of several kinds of flooding, individual reports of flooding, and the record of road closures from the City of Charleston.

AccelAdapt Flood Models

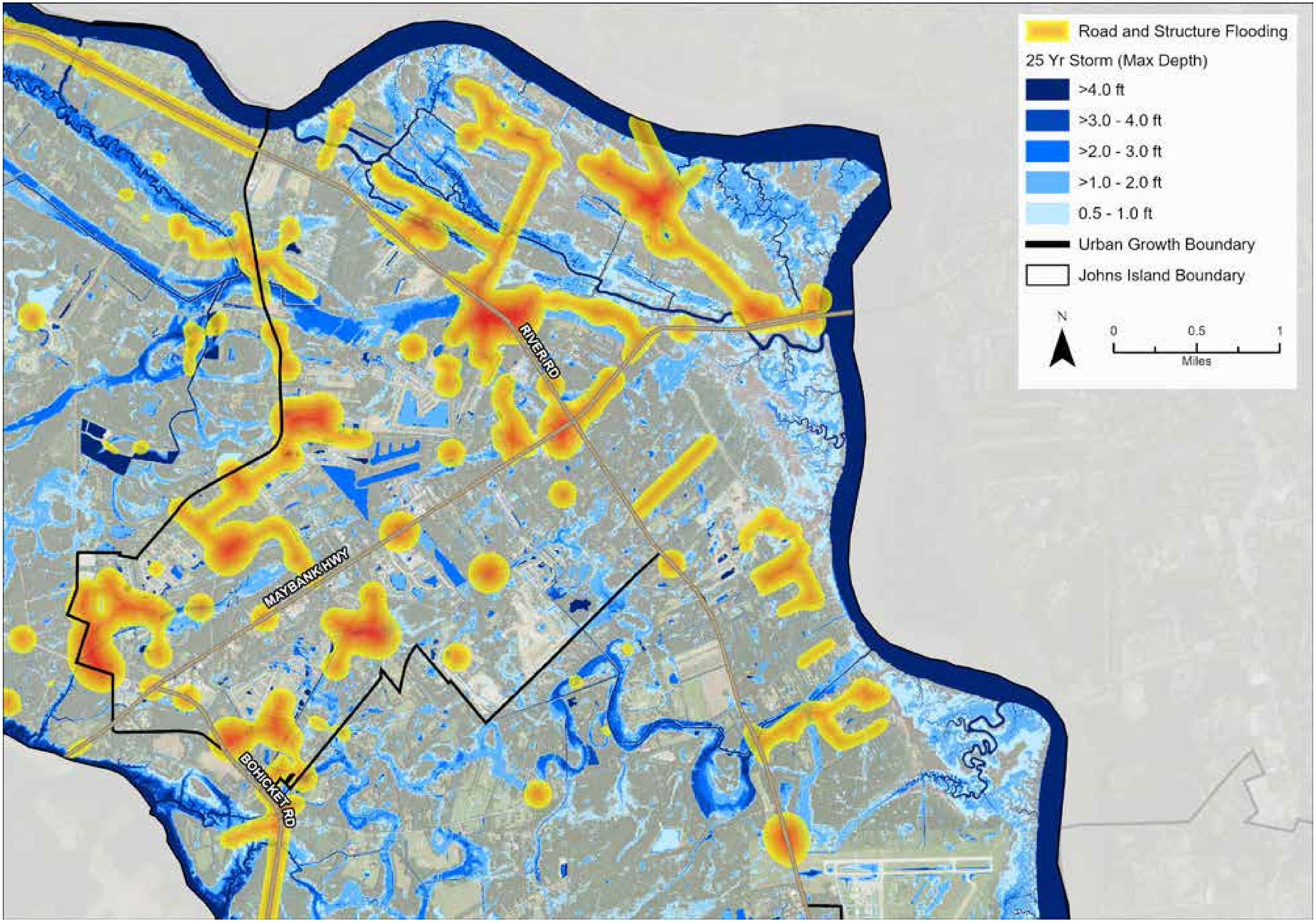
For the All Hazards Vulnerability and Risk Assessment, the City of Charleston and consultant team developed a web-based application that identifies localized climate vulnerabilities, risks, and social vulnerabilities called AccelAdapt. In its parcel-level dataset for the City of Charleston, there are attributes related to a number of flood threats, including floodplain inundation, high tide flooding, and sea level rise. Floodplain inundation is represented by FEMA flood zones, which represent a combination of rainfall-induced and storm surge flooding. High tide flooding is flooding of the low-lying land along the coastline from a high tide that is not associated with a tropical storm, commonly referred to as "high-high tide," "king tide," or "sunny day" flooding. The high tide flooding layer produced by NOAA was used in AccelAdapt to assess current vulnerability and risk to high tide flooding. Finally, relative sea level rise was derived from the NOAA Sea Level Rise Viewer. The 3-foot threshold is consistent with the city's 2019 Flooding and Sea Level Rise Strategy planning threshold. None of these data sets incorporate current drainage infrastructure such as ditches, so it is most powerful near the major waterways and during larger rain events that can overwhelm drainage infrastructure. It is also important to note that the FEMA flood zones mapped for Johns Island only include coastal modeling, so they tend to underestimate both extreme events and flooding in the drainage network.

HEC-RAS Model

The second flood model can look at how water from rainfall moves across the landscape in a dynamic way. The City's Johns Island hydrologic and hydraulic modeling was completed by others in 2019. The Hydrologic Engineering Center's River Analysis System (HEC-RAS) software was chosen due to its ability to effectively combine 1- and 2-Dimensional modeling elements to simulate complex flow regimes and dynamic tidal boundary conditions. For this plan, WK Dickson made minor revisions to the existing HEC-RAS model to more accurately reflect current conditions and to conform the model to the City's new Stormwater Design Manual, particularly with changes to the 24-hour rainfall depths. This model includes small topographic features such as ditches, but it has very limited information on culverts under roads, drainage pipes or grey stormwater infrastructure. It also places the roads layer on top of the topographic data, so that road flooding is underestimated for small rain events.

Additional Information

Given the known limitations of both models, local information and reports were also important in defining areas at risk for flooding. The City of Charleston's Neighborhood Services desk maintains reports of flooding any time a resident calls to inform about a problem. The City also has records of road closures due to flooding during storm events. Finally, two citizen science efforts, the SC Aquarium's SeaRise Anecdata and the SC Coastal Conservation League's Flood Reporter, have unverified reports of flood conditions.



Johns Island Flood Risk Map

RESTORING NATURAL FLOOD RESILIENCE

The 2020 City of Charleston Stormwater Design Manual emphasizes cost-effective, low-impact, nature-based designs as important tools in water management. Such methods are the focus of this plan, though they work in concert with traditional stormwater practices. Broadly applied, techniques meet the goals of managing stormwater close to where precipitation falls, maintaining undisturbed wetland areas and using natural features for storage ad infiltration.

Wetland Restoration or Creation

To prevent floods from the sudden pulse of water near the bottom of Johns Island watersheds, more water must be stored in upland areas. This can be achieved by restoring former wetlands and waterways that have been drained or by adding storage wetlands to prevent water from rushing downstream. The island's rich agricultural history has left ditches, drainages, and remnants thereof scattered throughout wooded lots. Some of these areas only require modest alterations to significantly increase their water storage capacity.

Stream Naturalization and Restoration

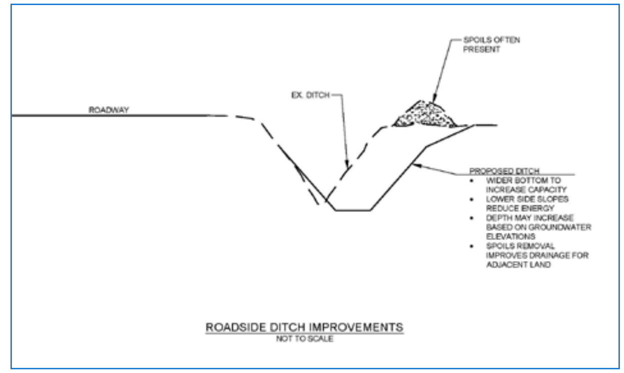
Straight, hydraulically efficient, manmade ditches move water quickly, creating erosional forces and lowering the groundwater table. Recreating sinuous waterways that are hydrologically connected to their floodplains is a restoration technique with great potential on Johns Island. The use of natural drainageways can allow for storage of stormwater runoff, lower peak flow rates, slow the runoff down, and treat pollutants. Restored streams can be used for mitigation credits and provide habitat value to local plants and animals.

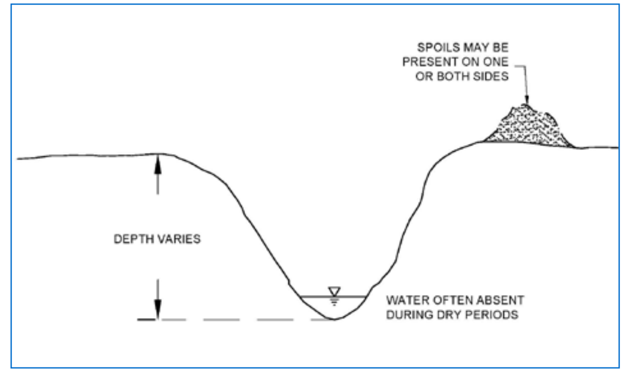
Floodplain Protection

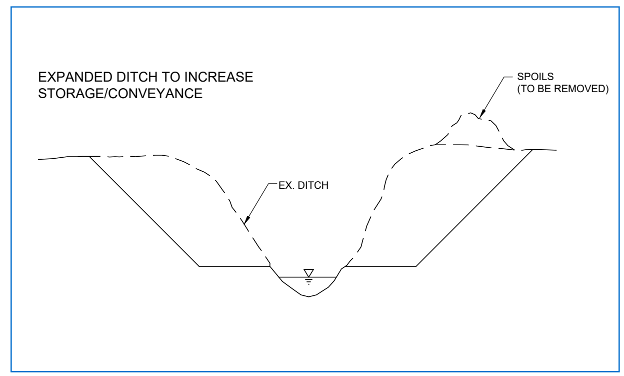
Protecting low-lying ground that is frequently inundated by floodwaters both reduces hazards to public safety and infrastructure and can increase infiltration. Riparian forest buffers reduce flood energy and add hydraulic roughness, which reduces water velocity. Floodplain protection is commonly achieved by regulatory tools, such as Floodplain Ordinance provisions that regulate special flood hazard areas or Critical Line Buffer Requirements defined in local zoning ordinance. Other municipalities explicitly regulate hydrologic storage and conveyance corridors.

For hundreds of years, people have dug ditches to move water out of the way faster. Straightened streams make more land available for other uses; agricultural ditches lower the water table; roadside ditches get stormwater off the streets for safer travel.

On Johns Island, ditch improvements can increase water storage and may be particularly helpful in lower elevation communities where tidal influences reduce the efficiency of culverts. The project team identified multiple unmapped ditches and inconsistencies in ditch geometry (width and depth) and discontinuous ditches.







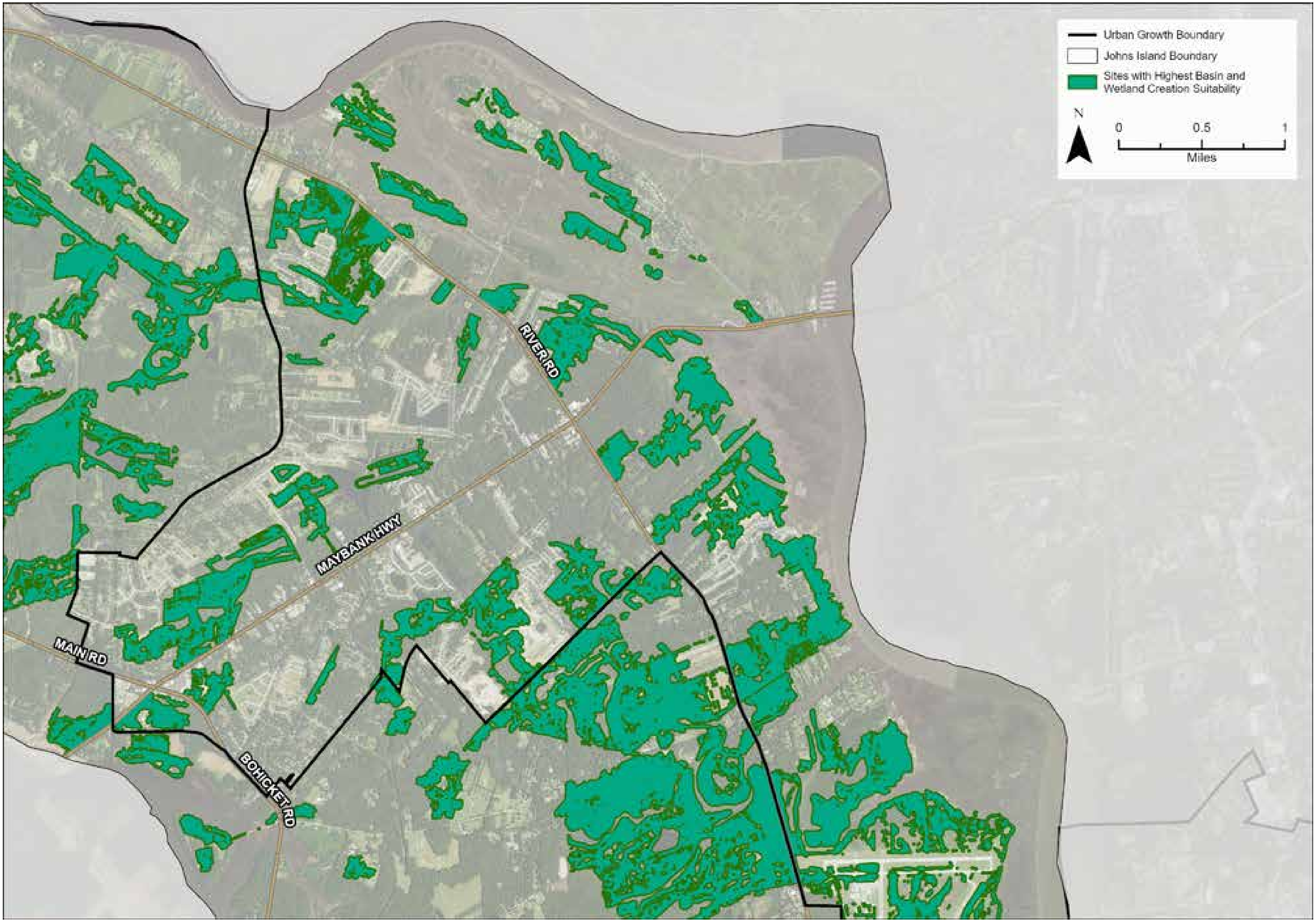
SUITABILITY ANALYSIS

Defining the areas suitable for projects to reduce flood risk was primarily a Geographic Information Systems (GIS) exercise with an iterative process. The first step was to define flood mitigation suitability based on bio-physical feasibility, potential effectiveness, and habitat value. Continuous maps were created to score suitability according to current land cover, soils, water table depth, slope, wetland migration area, proximity to existing wetlands, floodplain, and modeled flood depths at the 10% AE storm. Areas suitable for stream restoration, wetland restoration, and stormwater detention were mapped using combinations of these criteria. Priority areas for conservation of intact natural systems offering conveyance services were simply defined based on the waterways of the island, FEMA floodplains, and areas predicted to flood by the HEC-RAS model.

The second iterative step was to bring this analysis to the parcel level and apply a screening based on project size. For this refinement, project sites were selected based on their potential size. Two lenses were applied to screen for top sites: the largest potential project sites, and individual parcels with the greatest area of land suitable for restoration. The resulting suite of potential project sites have some predictable relationships to the Land and Water Plan. All areas that ranked high as potential sites for storage basins are on High Ground or in the Adapt Zone because only areas with greater depth to water table and that fall well outside the FEMA floodplains are suitable for water storage. The highly ranked sites for wetland restoration are usually located within the Tidal and Compound Flood Risk Zones.

In the final step, three major areas with downstream flooding and upstream project potential were selected for closer examination based on the professional judgment of restoration designers and the Department of Stormwater Management. Selections were reviewed with the Technical Advisory Group.

Members of the Technical Advisory Group and the public provided feedback to the project site selection process. They reviewed initial criteria, provided input to an online map of flooded areas, met to review preliminary suitability maps and areas of concern, and ranked the final site possibilities.



Restoration Suitability Map

RESULTS

The objective of the Johns Island Restoration Plan to Improve Flood Resiliency is to assess and prioritize tracts for projects, easements or other utilization strategies to maximize the flood risk mitigation provided by natural ecosystems. The planning process has entailed extensive spatial analyses of natural system characteristics and connectivity (land cover, soils, hydrology, etc.). Follow-on work analyzed sites prioritized for existing ecosystem conditions in a risk management context to evaluate flood mitigation potential.

The GIS models identified several tracts that, based on automated analytical routines, exhibited the highest potential for leveraging the regulating services of existing ecosystems. These potential sites were further evaluated in the office by experienced restoration and preservation professionals. The manual analysis significantly reduced the number of potential sites, often based on the location of an ecosystem opportunity relative to flood risk. The remaining potential sites were then evaluated in the field.

The fieldwork was intended to ground-truth the desktop analyses and to further evaluate specific preservation, restoration and enhancement strategies. It is important to note that previous reconnaissance had determined that the planning area on Johns Island is very dynamic, with real estate development rapidly changing the landscape. The project team therefore understood that the flood mitigation potential of some sites might have been obviated by new construction projects. The team also learned that some potential sites could be expected to be more valuable for future flood mitigation as new developments would substantially stress the hydrologic capacities of watersheds. This forward-thinking mindset became influential and the resultant definition and prioritization of projects required substantial professional judgment.

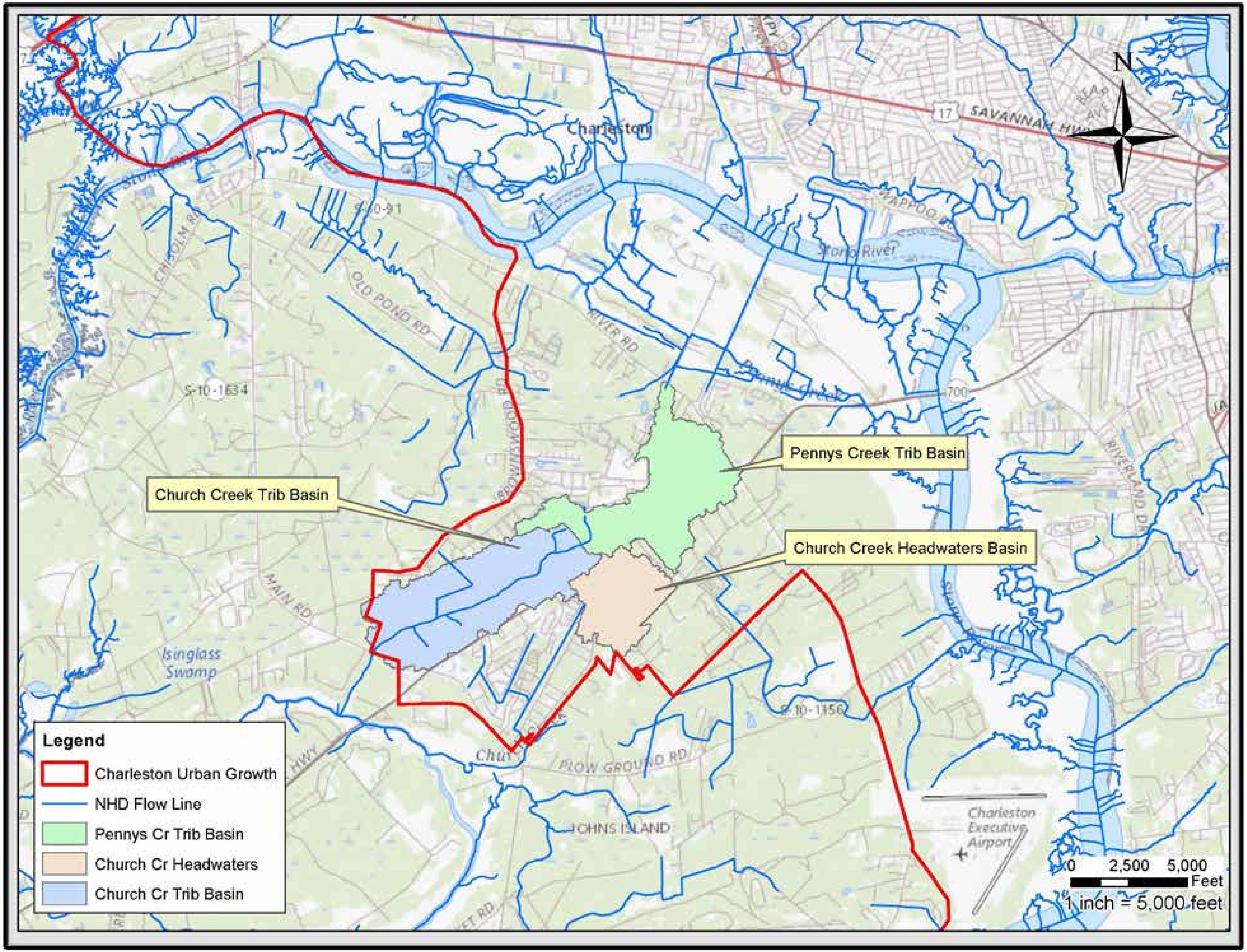
RECOMMENDED PROJECTS

The project team recommends three projects to advance the City's flood mitigation objectives with living infrastructure. Each project is 'modular' in that they include multiple components, each of which can provide some degree of sustainable flood management. Each project also includes opportunities for ecosystem restoration or enhancement to improve flood storage and conveyance. The long-term success of each project is based on protecting these important drainage corridors and maintaining natural riparian forests. Therefore, acquiring property rights to prevent development is the first step in reducing current and future flooding problems. Conservation easements, irrevocable covenants and fee simple purchase are the most common tools for protecting restoration properties.

Mobility and recreational opportunities were raised as priorities during development of the draft City Plan. The Church Creek Tributary Project is intended to accommodate greenway trails. The greenway could establish safe bicycle and pedestrian connectivity between neighborhoods, the Island's premier park and two of the Mixed Use Centers identified in the 2007 Johns Island Community Plan, which have been retained but renamed as City Centers in the draft Charleston City Plan.

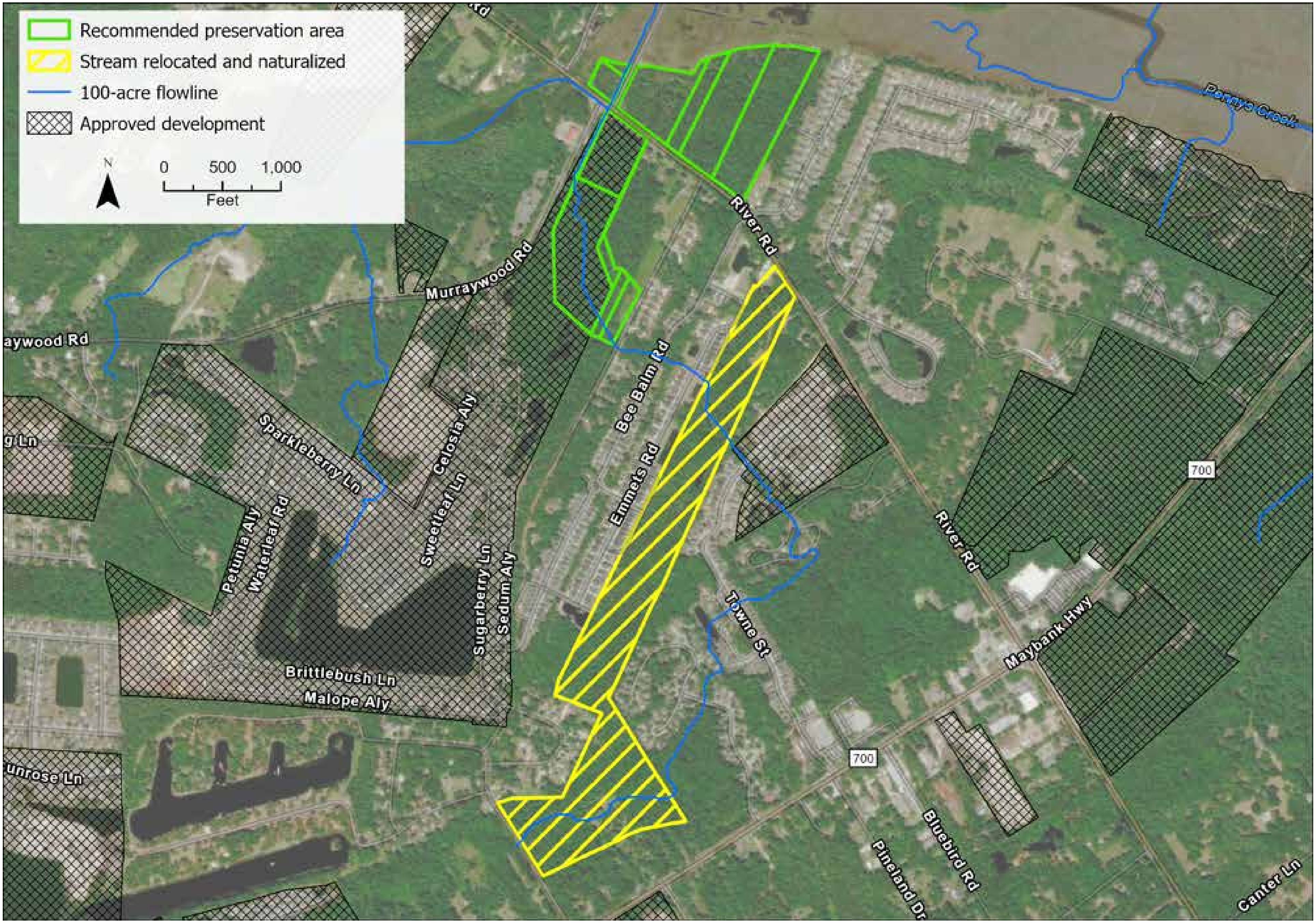
It is significant that the uppermost catchments of all three projects converge on a stretch of Maybank Highway. The Maybank Corridor holds large, undeveloped parcels targeted for high-intensity land use. Even if future projects achieve full compliance with the City's stormwater requirements, the commercial development planned for this corridor will be a major contributor to future downstream flooding. Contemporary best practices (Low Impact Development, distributed stormwater management) emphasize both green infrastructure and locating stormwater controls in the upper portions of watersheds.

As currently conceived, the three recommended projects will all protect and enhance natural storage immediately downgradient of Maybank highway developments. These critical areas for slowing stormwater and buffering flood pulses. Failure to execute at least some components of the recommended projects will likely lead to increased future flooding downstream.



Project Drainage Areas Map

Pennys Creek Tributary Project



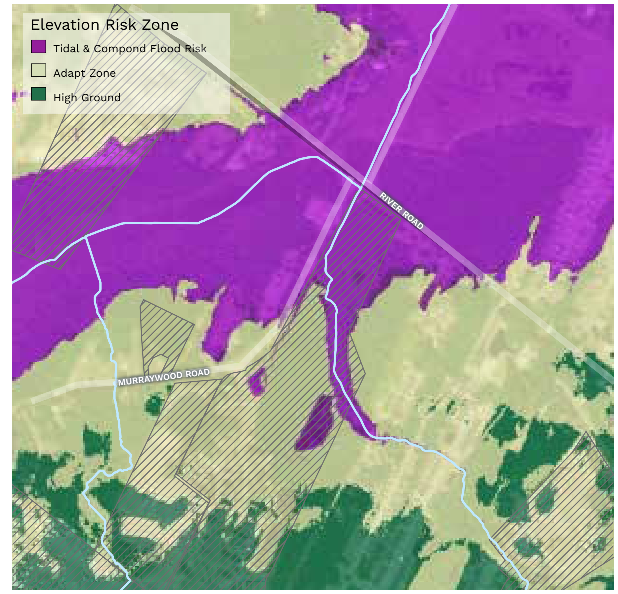
Pennys Creek Tributary

This preservation and enhancement project protects a corridor from the Murraywood Road- River Road-Rushland Landing Road intersection, upstream through the Barberry Woods community to Sailfish Road. Multiple reports of flooding, road closures and AccelAdapt data document existing flooding problems at the Murraywood-River Road intersection. Models show the Jessy Elizabeth Road crossing at the upstream end of the preservation area is overtopped at both the 10% AEP and the 4% AEP floods. The primary purpose of this project is to reduce chronic flood hazards on critical roads and within the Barberry Woods community by protecting and improving the stream/wetland complex from headwaters to tidal marsh.

Key parcels are in the Tidal Flood Risk Zone and the Adapt Zone. Most of the project corridor is forested. The forested property north of River Road is included to provide surge protection and to accommodate future marsh migration. Downstream (north) of River Road the channel was straightened through the marsh. The tidal influence on stream hydrology appears to extend a few hundred feet upstream of River Road.

The extension of I-526 and other anticipated roadway projects will impact natural systems and could increase flood risk. Mitigation measures could include improvements to the multiple ditches that converge at the River Road - Murraywood intersection. The

Riparian wetlands are common along both sides of the Pennys Creek Tributary between Jessy Elizabeth Road and River Road. The natural wetland systems store runoff, improve water quality and provide diverse wildlife habitat.



Elevation Risks Zones at Pennys Creek Tributary Project two ditches under the power distribution lines southwest of River Road should also be modified to increase storage. Other recommended enhancements are to restore natural sinuosity to the tidal section of the stream and to install culverts under Rushland Landing Road to improve hydrologic exchange in the marsh.

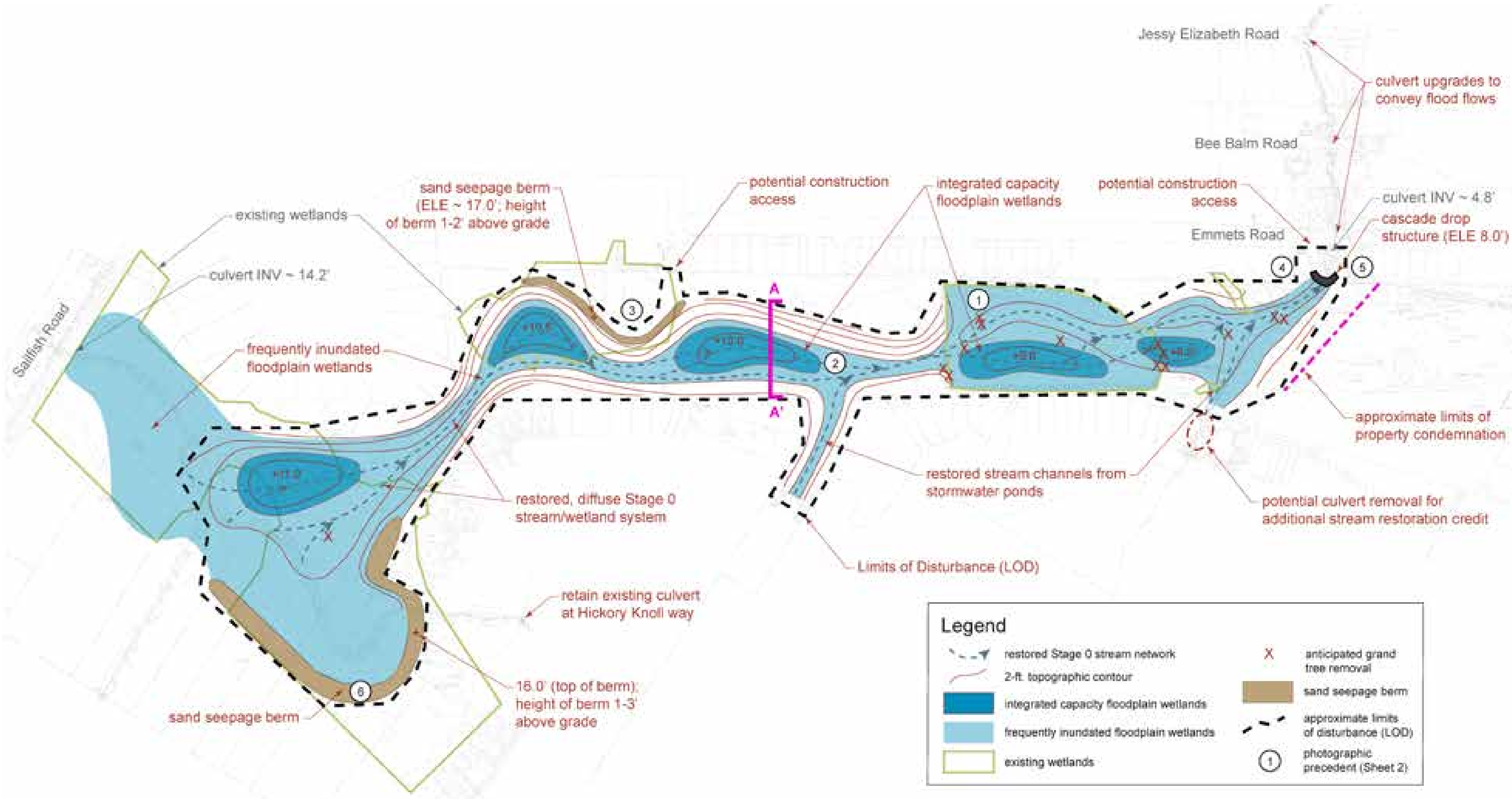
The proposed preservation would protect a high quality stream and wetland system. The subject stream drains approximately one (1) square mile. The reach from River Road to Jessy Elizabeth Road is geomorphically stable as indicated by a natural meander pattern, well vegetated banks, and good hydrologic connectivity to its floodplain. In-stream habitat is excellent with undercut banks and other niches being abundant as well as woody debris. Riparian wetlands are common along the floodplain and exhibit diverse hydrology.

Flooding at Jessy Elizabeth Road

Pennys Creek Tributary exhibits natural meanders and excellent in-stream habitat.

Upstream of Jessy Elizabeth the stream system has been severely impacted by development. Multiple culvert crossings, channel straightening and piping have altered the natural hydrology of the stream-wetland complex. These impacts have resulted in chronic flooding of streets and homes in the Barberry Woods community.

Conceptual designs have been developed to address the flooding problems in Barberry Woods. Bioengineering practices and stormwater engineering immediately will improve storage and conveyance while minimizing downstream impacts (water volume and water quality). The project follows the spirit of recommendations from the Dutch Dialogues applicable to John's Island. Proposed flood mitigation solutions and designs emphasize creating additional watershed storage, creating a stable, naturalized stream alignment, increased wetlands for flood storage, and improved overall infiltration through bio-infiltration and green infrastructure practices.



Design concepts for Barberry Woods drainage improvement project

Church Creek Headwaters Project

Church Creek Headwaters

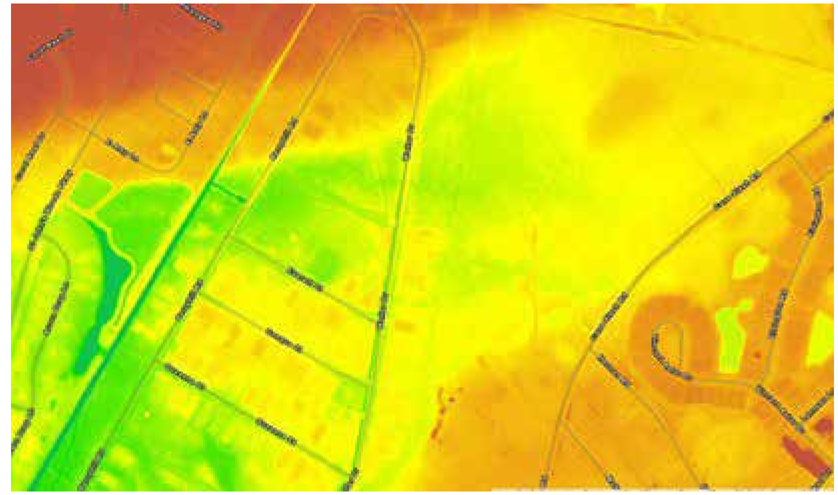
The Church Creek Headwaters Project entails the preservation and potential enhancement of forested wetlands that occupy the northern extents of a paleo- embayment. These parcels were in the first tier of candidate sites meeting the initial suitability criteria for wetland restoration. LiDAR indicates multiple historic works to alter drainage as well as a highly sinuous channel between Walter Drive and Berryhill Road. Current hydrography indicates most of the surface flow is routed to the south-southwest through a ditch on the west side of Walter Drive.

However, significant flow is still carried through the woods to the west, where it is connected to the Berryhill Road ditches north of Everett Street. Berryhill Road is frequently overtopped at this east-west culvert and has required repairs. Stream restoration opportunities should be investigated in the woods between Walter Drive and Berryhill Road. Restoring natural meander geometry and anabranches would improve flood conveyance and storage.

Farther down gradient, street flooding is common during periods of moderate to heavy precipitation at the intersection of Walter Drive and Jewell Street. Flow passes under Jewell Street through a 36 inch RCP. From that outfall, a 24 inch RCP takes much of the flow to the southeast, under Walter Drive to another ditch network that discharges into a tidal section of Church Creek. Both culverts are mostly submerged during dry periods. This area is within both the FEMA 100-yr floodplain and the Compound Flood Risk Zone and includes small patches of Tidal Flood Risk Zone. We suspect that tailwater impairs the efficiency of these culverts, and that this flooding could be reduced by redirecting more flow back through the forested wetlands north of Everett Street.

Currently, water exits the forested wetlands in a ditch approaching Walter Drive (left), and the portion that continues west towards Berryhill frequently overtops the road and causes erosion (right).

The highest priority action in the Church Creek Headwaters is preventing future development from adding to the current drainage and flooding problems. In addition, several ecosystem enhancement opportunities should be investigated more thoroughly for improving storage capacity and conveyance through the forested wetlands, including removing the ditch spoils that line the west side of the Walter Drive ditch to allow high flows back into the woods, restoring east-west stream flows through the woods between north of Everett Street, and improving storage in the woods east of Walter Drive.



In the LiDAR image above, yellow (higher) elevations indicate alterations to previously existing topography between Walter Drive and Berryhill Rd. Area displayed corresponds to black box on figure at left. At the intersection of Jewell Street and Walter Drive (below), flow transitions from 36” to 24” RCP and water stands in the ditch. Shown here under normal condition two hours after low tide.

Church Creek Tributary Project

Church Creek Tributary

The practices recommended for the Church Creek Tributary Project include stream and wetland restoration, enhancement, ditch improvements, and wetland preservation. Implemented together or in discrete sections, this project is the most extensive opportunity identified in the planning process. The subject stream is about 1200 feet north of Maybank Highway and flow is to the west-southwest, roughly parallel to the highway. The project corridor extends from Field Planters Road upstream to Southwick Drive. The drainage area 1.15 mi^2 and the south side of the catchment includes several large, undeveloped parcels along Maybank.

The mapped FEMA floodplain extends to approximately 300 feet west of Brownswood Road, which is rougly 1,800 feet downstream of the project area.

Stream restoration is recommended for approximately 5,150 linear feet of the master stream and 820 linear feet of a tributary that flows from north to south and parallel to Field Planters Road. Both streams have been channelized and should be restored to natural meandering planforms.

Riparian forest and wetlands are integral components to the restoration design. Anabranches may also be feasible in the lower reach of the master stream to improve hydrologic storage. The project also proposes improvements for 1,500 linear feet of ditch that flows parallel to the master stream and is located about 750 feet to the north. Excavating a bench along the south side of the ditch will significantly increase conveyance and structures can be installed to provide storage.

Conservation easements along the mainstem should be at least 300 feet wide, with a 150 ft minimum along the tributary stream, and 50 ft minimum width along the improved ditch. These buffer widths will support riparian forests and wetlands that will also protect water quality from runoff as the Maybank corridor becomes more intensely developed. An additional preservation area covering 50 acres is identified at the upstream end of the project. This area supports a large wetland system and includes an additional ditch improvement opportunity.

A greenway trail connecting Johns Island Park to Southwick Drive would provide safe pedestrian and bicycle access between two planned mixed use/city centers.

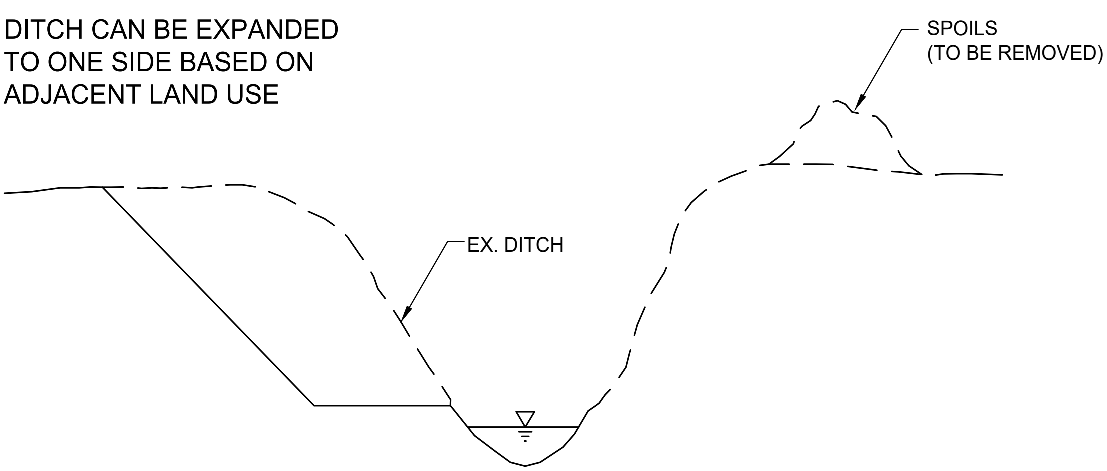
Channelized, entrenched reach of Church Creek Tributary east of Planters Field Road. This section can be restored to natural meander geometry with riparian wetlands to increase storage and conveyance.

Channelized reach of Church Creek Tributary in a proposed preservation area near Boyd Hayes Road. Low bank heights support wetland hydrology in the riparian forest.

Approximately 1500 linear feet of the ditch near Chastain Road can be expanded to increase storage and conveyance capacity. This ditch is 750 ft north of, and parallel to, the main Church Creek Tributary. The ditch flows to the west into another tributary that is recommended for stream restoration. Limiting work to the south side of the ditch will preserve the treeline at right.

A greenway trail could be constructed to connect the neighborhood around Chastain Road to the main greenway recommended for the Church Creek Tributary.

Ditch near Chastain Road flows to the west parallel to the Church Creek Tributary. The ditch can be expanded to improve flood water storage.



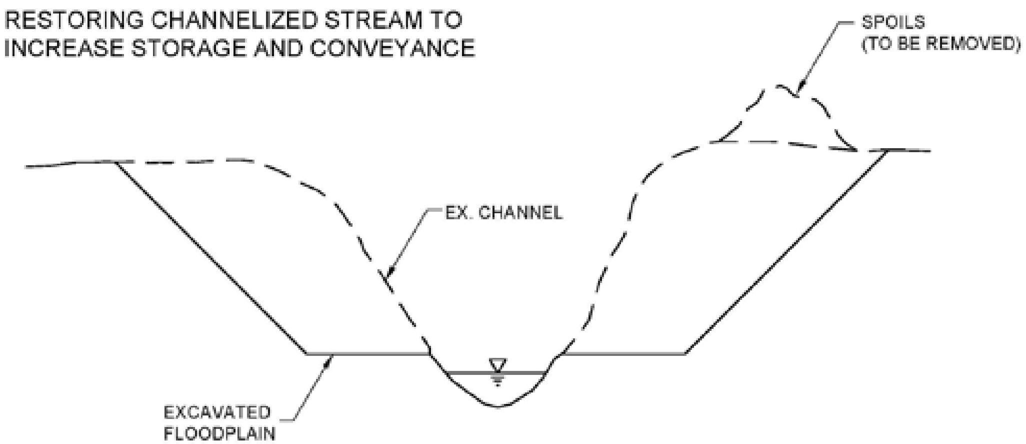
Single-sided ditch improvement to increase conveyance

A small tributary flows north to south parallel to Planters Field Road. The stream was historically channelized and presents what is often called a 'Priority 2' stream restoration opportunity. This is similar to the ditch expansion sketch shown above, whereby a new floodplain is excavated at the elevation appropriate for the design bankfull flow. The main difference with the restoration approach is that the relative width of the new floodplain would be wider than is depicted in the ditch sketch. The new valley floor would be wide enough to accommodate a meandering channel and would support hydrophytic vegetation. In this case, the floodplain and channel would mostly be installed on the east side of the existing ditch to preserve the trees between the existing ditch and the backyards of homes on the west side.

A greenway trail could be installed on the west side to connect Chastain Road to the main proposed greenway.

Entrenched tributary stream east of Field Planters Road provides stream and wetland restoration opportunity.

Strong baseflow over knick-point; this tributary stream should support diverse aquatic flora.



Conceptional ditch improvement to restore stream and wetlands

Ditch draining preservation area near Southwick Drive

An approximately 50 acre preservation area is identified at the upper end of the Church Creek Tributary watershed. The area is part of a larger parcel that is bounded to the north and east by Southwick Drive. Several reports of flooding and past city road closures suggest preserving this parcel can prevent future development from exacerbating existing problems. Despite ditching, the area appears to support multiple wetland habitats. The ditch system can be manipulated to both increase wetland storage and channel conveyance.

Westerly view of roadside ditch for Southwick Drive on north side of preservation parcel

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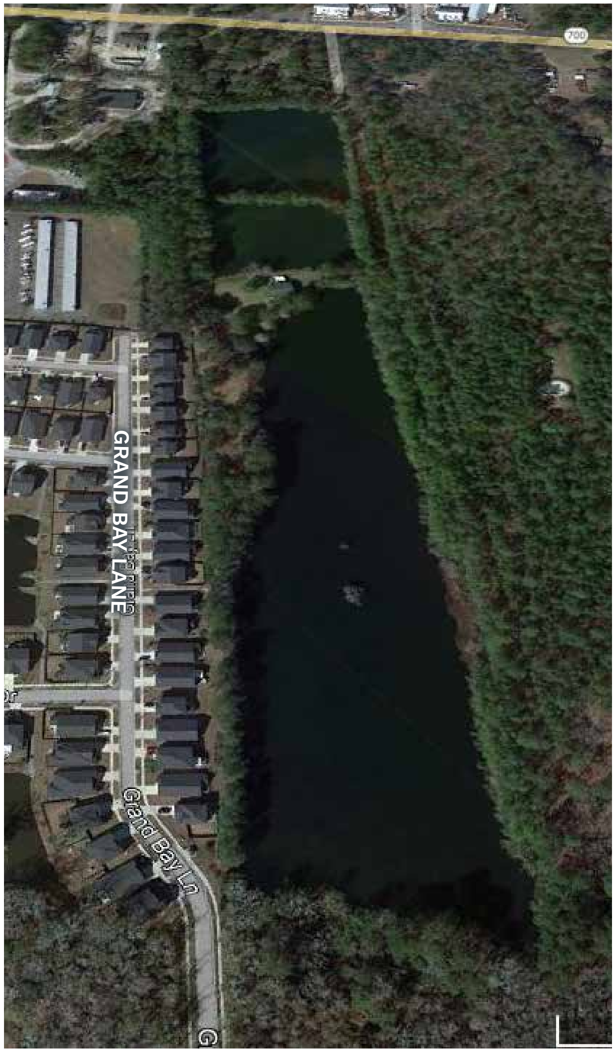
Other Engineered Stormwater Opportunities

Other Engineered Stormwater Opportunities

While this plan focuses primarily on green infrastructure, two traditional "gray" infrastructure opportunities were identified. First is a small pond on the 3400 block of Island Estates Drive. The pond appears to have been installed between 1994 and 2003. The Google Earth image from July 2003 shows the water surface covering 0.25 acres. Subsequent images show varying levels of inundation and apparent sedimentation. Vegetation colonized the pond but some maintenance appears to have been performed sporadically over the years. A large ditch runs north-south immediately east of the pond, but there is no apparent hydraulic connection to the pond. This ditch is not mapped by the 100 acre flowlines and appears to have been dug to lower the water table. Another unmapped ditch on the west side of Island Estates Drive runs east-west and appears to be connect to the pond via culvert. Approaching this old pond as a typical stormwater retrofit project could be an inexpensive means of adding flood storage for the neighborhood. We note that Island Estates Drive has been closed at least once in the past due to flooding (10/3/2015).

The other opportunity is an approximately 17 acre pond located 400 feet southeast of 3135 Maybank Highway near Griffith Lane. The pond appears to have been excavated in the late 1970s, probably for as a sand mine. The pond is currently has negligible storage capacity above the normal water surface elevation but could conceivably be pumped down in advance of major flood events such as tropical storms. Developing any potential project would require bathymetry, groundwater investigations and complex engineering. However, the site is on the Maybank dune and has potential to store massive amounts of water.



The stormwater pond on Island Estates Drive is filled with trees and shrubs (top left), and neighborhood ditches have not been maintained (bottom left). The large borrow ponds near Maybank Village (right) could offer significant water storage in storm events.

POLICY RECOMMENDATIONS

The pace and scale of residential development is one of the most significant challenges that requires prompt attention from the City. A major concern is that multiple large scale developments are rapidly reducing opportunities for natural (or restored) ecosystems and other green infrastructure to provide effective, long-term flood management.

General modifications to land development and stormwater policies were a major topic for the Technical Advisory Group (TAG) workshop. After discussing basic concepts, the TAG ranked area for policy improvements that would advance resiliency goals for Johns Island as follows:

1. Riparian buffer protections for ditches and streams
2. Forest conservation (mandatory preservation of some percentage of existing forest cover)
3. Stronger incentives (e.g., higher densities for Low Impact Development (LID design)
4. Additional stormwater design standards focused on conveyance
5. Mandatory Low Impact Development (LID)
6. Restrictions of fill placement

Subsequent discussion and Mentimeter voting determined a strong preference for buffer protections of fifty (50) to one hundred (100) feet in width. Buffers for wetland protection were also preferred but there was no consensus on the buffer width.

A new ordinance to codify the Dutch Dialogues' "living with water" concepts is recommended to protect and preserve existing ecosystem assets on Johns Island. The primary objective of the buffer ordinance would be to protect public safety and private property by preserving the hydrologic storage and conveyance capacities of existing, linear drainage features on Johns Island, including streams, ditches and associated wetlands and forests. This approach is consistent with Dutch Dialogues outcomes and objectives and recommendations in the draft City Plan.

Multiple large scale developments are rapidly increasing the need for flood management while simultaneously reducing opportunities to protect and maintain existing natural systems that attenuate flooding. Riparian buffer regulations on Johns Island will protect ecosystems critical to long-term resilience and allow the City or others to implement more effective resilience projects identified in this plan and elsewhere. Buffer protection requirements can be added to the City's stormwater manual with enforcement integrated into the existing development review process for other stormwater management requirements.

Riparian Buffer Primer

Riparian buffers provide many ecosystem services, including flood attenuation. The Final Report of the Statewide Task Force on Riparian Forest Buffers (Center for Environmental Policy, Institute of Public Affairs, University of South Carolina, July, 2000; (http://media.clemson.edu/public/restoration/carolina%20clear/toolbox/sctaskforcebuffersreport.pdf) summarizes the benefits of buffers:

Riparian forest buffers - areas of vegetation adjacent to the water body that help to maintain the integrity of the water resources – provide important benefits that include the protection and enhancement of water quality, flood protection, water temperature moderation, stream bank stabilization, and habitat and food supply for aquatic and terrestrial life.

SC DHEC Stream Buffer Recommendations

Drainage Area (acres)	Stream Class	Stream Side Zone (ft)	Managed Use Zone (ft)	Upland Zone (ft)	Total Buffer Width on Each Side of the Stream (ft)
>100	1	30	NONE	15	45
>300	2	30	20	15	65
>640	3	30	45	25	100

Stream buffer regulations are common throughout South Carolina and nationwide, and are typically imposed to protect flood zones, water quality, stream channel stability and natural habitats. Protected buffer widths vary considerably based on the physical characteristics and specific objectives of a given jurisdiction. The SC DHEC recommendations provide starting points and a basic framework to consider across a physically and hydrologically diverse state. Wider buffers may be advised to protect flood storage in low lying landscapes with tidal influences on the drainage system.

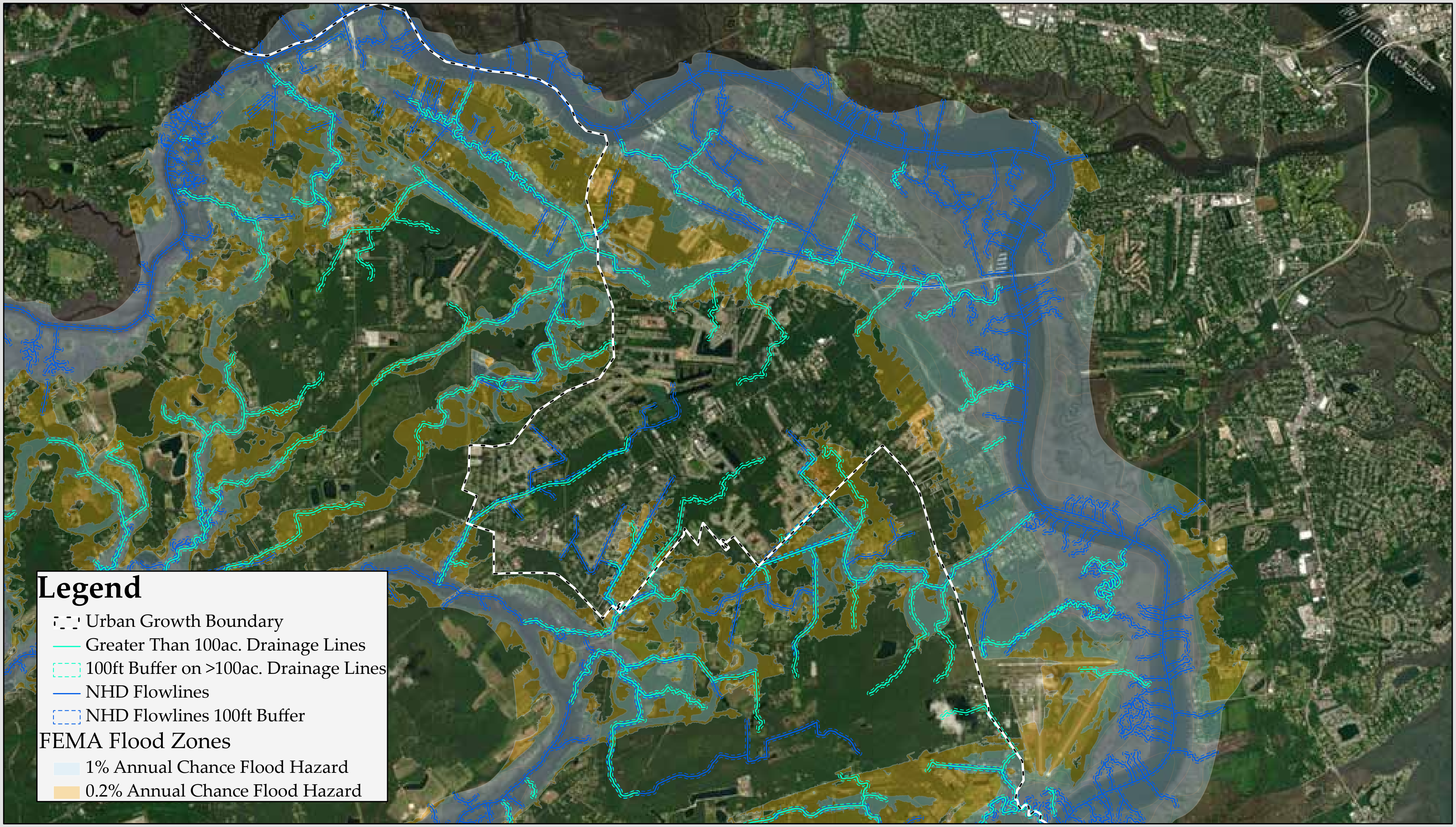
LOCAL CONSIDERATIONS FOR RIPARIAN BUFFERS ON JOHNS ISLAND

Typically, the jurisdictional boundaries of "streams" are defined in rules and regulations and regulated buffers are measured from the tops of banks perpendicular to the channel. This approach applies well to natural single thread channels with moderate slopes (0.5-2%) and coincides well with the scales of buffer protections cited above from the South Carolina Department of Health and Environmental Control Best Management Practices (SC DHEC BMP) handbook. However, this approach may not be sufficient for flood resilience on Johns Island due to the scales and variability of hydrologic features.

On Johns Island, the ecosystem services of hydrologic storage and conveyance are provided by natural stream and wetland complexes as well as anthropic ditches. Many of the natural systems on Johns Island flow through relatively broad valleys that exhibit little topographic expression at the margins, which confounds precise delineation of a conveyance system's hydrologic boundaries. In addition, the hydraulic geometry of anthropic ditches is highly variable. Some ditches were excavated to promote surface drainage or lower the local water table for tillage, while others are natural streams that have been channelized (straightened and deepened). The larger, deeper ditches and channelized streams can provide significant storage as well as flood conveyance. Finally, riparian wetlands are integral to the regulating services provided by many Johns Island ecosystems, so additional public protections would be achieved by extending regulated buffers to protect riparian wetland boundaries.

The project team, with concurrence from the Technical Advisory Group, recommends regulated buffers of 100 feet on each side of all watercourses draining areas greater than or equal to the one hundred (100) acre threshold in the SCDHEC stream buffer recommendations. This buffer would be measured from the centerline of all streams and ditches mapped by the City's GIS data layer of mapped flowlines for 100 acre drainages. For several major conveyance corridors this buffer width corresponds with the 1% AEP flood inundation. The buffers should be extended as needed to encompass all riparian wetlands field delineated and surveyed by qualified professionals and considered jurisdictional Waters of the United States by the U.S. Army Corps of Engineers.

The rationale for establishing the regulated buffer from the mapped centerline is three-fold. First, the natural channels in the small drainages are usually commensurately small, often less than five (5) feet in width, and the topographic expression of delineative features such as the bankfull elevations and ordinary high water marks is often subtle, inconsistent or absent. Using a publicly available, mapped centerline prevents disparities between field observers and any increase in protection gained by measuring the buffers from the tops of banks would be negligible given the small size of the channels. Second, this approach is cost effective because it utilizes data previously developed by the City; no new watershed studies or modelling would be required. Finally, the flowlines are based on current LiDAR and provide reliability and consistency for both developers and plan reviewers.



WK DICKSON
community infrastructure consultants

Spatial Reference
Name: NAD 1983 StatePlane South Carolina FIPS 3900 Feet Intl

Johns Island Charleston County, SC
Recommended Riparian Buffers

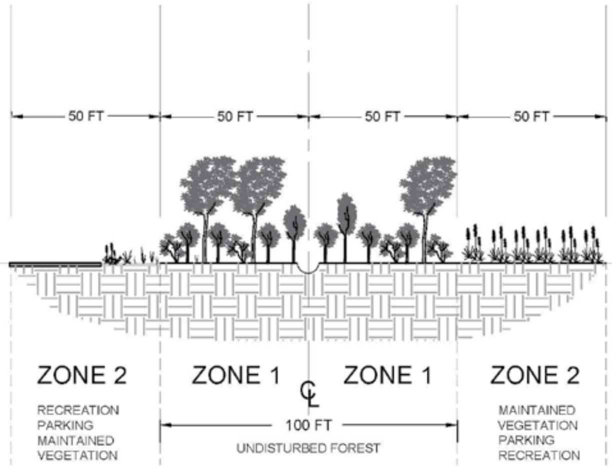
0 0.38 0.75 1.5 2.25 3 Miles

1 inch equals 0.75 miles

To balance the needs of development with the flood management needs of storage and conveyance, we also recommend that the 100 ft buffer be broken into two zones as shown in the figure to the right. The inner zone, shown as Zone 1, would establish a protected natural forest corridor approximately 100 feet in width. This zone would provide the primary hydrologic regulating services for the most frequent flood events. Zone 2 would protect an addition 50 feet landward on both sides of the channel centerline and would provide additional conveyance for the less frequent but more catastrophic flow events. The outer zone should accommodate development activities such as utilities, parking, recreation areas and other improvements that do not include the placement of fill or otherwise change existing elevations. With appropriate design requirements, some stormwater management practices could also be installed in Zone 2.

ROADSIDE DITCH MANAGEMENT

Among the drainage ditches mentioned above on page 23, roadside ditches often present the most urgent threats to safety and infrastructure. As highlighted by input from the TAG, analysis of Acceladapt and other flood data, roadway flooding is both a nuisance and a public safety problem. In addition, the safety and stability of



several roadways are threatened by steep embankments, eroding, or poorly configured roadside conveyance and drainage. We also note that, depending on location and elevation, roadside ditches may provide opportunities for flood storage.
The City of Charleston, Charleston County and the SC Department of Transportation must all work together to improve the flood management and resilience potential of roadside ditches, and we recommend these entities work together to establish unified policies that emphasize flood resilience.

Obviously, roadside ditches were originally installed to promote roadway drainage and they are ubiquitous. However, roadside ditches on Johns Island are also inconsistent. Hydraulic geometry (width, depth, gradient and general configuration) can vary greatly along a single roadway (e.g., Main Road, River Road). The presence of ditch spoils is also inconsistent, with excavated material having been cast onto properties adjacent to some roadway segments but completely absent on other properties.

The project team recommends the following issues be considered by the City, County and SCDOT in the development of shared standards and unified roadside ditch management policies:

- Minimum hydraulic design standards for new ditches that account for contemporary watershed hydrology, SLR and tidal maxima;
- Design criteria to maximize storage for new ditches and retrofits;
- Aggressive plans to upgrade existing ditches and culverts based on risk analysis supported by this Plan and other data sources.
- Shared oversight responsibility for any drainage that ties into existing ditches (i.e. if new development affects an existing ditch, hydraulic standards must be met from the tie-in to the outfall.
- Protection or penalties for actions affecting existing ditches.

TRANSPORTATION PLANING TO PROMOTE FLOOD RESILIENCE

The extension of I-526 and associated improvements to other roadways will cause massive impacts to marshes, wetlands and stream systems, particularly in the northeast portion of the planning area. Large highways drastically alter watershed hydrology and appurtenances such as interchanges often cutoff land from other uses. However, prudent design can reduce adverse hydrologic impacts and provide opportunities to advance the City's flood resilience goals.

It is imperative that the highway design team understand the City's flood resiliency goals and that they work closely with water managers from the City and Charleston County. The preferred alternative for the highway extension includes Connector A, which runs right up Rushland Landing Road through the Pennys Creek Tributary Project. The design of the intersection of Connector A and River Road has opportunities to address historic roadway flooding by providing improved conveyance and storage, but will only produce a resiliency asset if the roadway design goes beyond the basic design requirements. It is imperative that the new roadway protect this sensitive watershed.

I-526 impacts to jurisdictional streams and wetlands will require compensatory mitigation. Current SC DOT documents list several private mitigation banks from which mitigation credits might be purchased. However, none of the banks are located on Johns Island. SC DOT should work with the City and County to develop mitigation opportunities within the Urban Growth Boundary and/or in other location on the island with known flooding problems.

Planned I-526 Connector A and appurtenant upgrades will drastically impact the Pennys Creek Tributary Project area.

Evaluation of Private Sector Funding Opportunities

Three high priority projects have been identified in the planning process: Pennys Creek Tributary Project, Church Creek Tributary Project and the Church Creek Headwaters Project. Each project includes the preservation of high value systems. The Church Creek Tributary Project and, to a lesser extent, the Pennys Creek Tributary Project also propose the restoration, naturalization and/or enhancement of degraded ecosystems. The Church Creek Headwaters Project might possibly include some restoration or enhancement but more robust analyses are needed to confirm the potential extents.

Dozens of nonprofit organizations fund conservation. Most related grant programs are competitive, require matching funds or in-kind services, and have limited resources. Some nongovernmental organizations (NGOs), including the National Fish and Wildlife Foundation (NFWF) that funded this planning effort, also fund implementation projects to accomplish the ecosystem restoration and enhancement needed to achieve project objectives.

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Ecosystem restoration and enhancement work will require substantial costs for engineering analysis, design, permitting, construction and post-construction monitoring. These costs can potentially be offset through the sale of merchantable ecosystem assets. In short, the value generated by the preservation, enhancement and restoration of natural systems on Johns Island can be commoditized and traded in established ecosystem markets. WK Dickson evaluated the ecosystem assets that could be developed by the projects and the existing markets for those assets.

Nationwide, the three most robust markets for ecosystem services are:

- Compensatory mitigation credits for streams and wetlands regulated under Section 404 of the Clean Water Act,
- Endangered Species credits, and
- Water quality credits for compliance with multiple sections of the Clean Water Act. Water quality credits are often integrated with riparian buffer regulations, creating local markets for riparian buffer restoration to offset water quality impacts.

There are several other markets around the U.S., but they are typically highly localized (e.g., thermal stream credits in the Willamette Valley), fraught with uncertainty due to inconsistent governance (Natural Resource Damage Banking) or lacking a reliable market driver (carbon offsets).

Each marketplace has its own ‘rules’ for how eco-assets are quantified and validated, and most markets impose constraints that govern the geographic areas where ecosystem credits can be sold relative to where they are produced. It should also be noted that ecosystem services markets generally prohibit the sale of the same asset in different markets (double dipping). For example, restoring habitat for an endangered salamander may increase the number of 404 mitigation credits generated by restoring a riparian wetland, but that same restored wetland cannot also generate credits for an endangered species bank.

Currently there is no market in Charleston for riparian buffer eco-assets. However, WK Dickson has previously recommended that significant expansion of riparian buffer regulations would advance the City’s objectives for flood mitigation and resiliency. Should the City pursue such regulation, certain exemptions are advised and other unavoidable impacts to regulated buffers should be anticipated. Most municipalities with buffer regulations allow for some impacts for specific activities or within some limited spatial extents. In many cases, compensatory mitigation is required to compensate for buffer impacts.

To protect the flood management benefits of regulated riparian buffers, we recommend that compensatory mitigation be required for unavoidable buffer impacts. We further recommend that project proponents have options for meeting compensatory mitigation requirements and that those options include the purchase of restored riparian buffer credits provided by third-parties.

As the Technical Advisory Group has noted, there are no wetland compensatory mitigation banks on Johns Island. Conversations with mitigation bankers revealed high land costs and the USACE Charleston District's service area policies as the major problems to starting projects on the island. In other jurisdictions buffer mitigation is often combined with other stream and wetland mitigation projects, so codifying third-party buffer mitigation options could provide an incentive for eco-asset investment on Johns Island.

Allowing 'additionality' of buffer credits with stream and wetland mitigation would help entice eco-asset investment. With additionality, buffer mitigation credits could be produced from the same site and sometimes through the same actions that might be required to produce stream or wetland mitigation credits. The buffer credits would be an additional merchandising opportunity for mitigation providers. Providing for third-party buffer mitigation would significantly improve the financial performance of a privately funded Church Creek Tributary Project as described below.

For this analysis WK Dickson focused on compensatory stream and wetland mitigation and endangered species banking. We also considered transferrable development credits and flood storage credits. However, no consistent platforms for trading development credits or flood storage assets currently exist in the area. The City could try to initiate a trade of transferrable development credits by acquiring property rights on a parcel with strong market appeal and arrange a swap with the owner(s) of the project parcels, but the economics would be extremely challenging. Acquiring flood storage assets presents similar economic challenges.

To conduct the subject evaluations WK Dickson analyzed the eco-asset potential of the three primary projects. To estimate credit yields for stream and wetland mitigation, we utilized the credit determination worksheets on the U.S. Army Corps of Engineers Charleston District (USACE) website. We also had multiple conversations with mitigation providers and international eco-asset investment managers regarding the South Carolina credit markets. We also spoke with USACE staff and other agency personnel and attended a session focused on South Carolina at the 2021 National Mitigation and Ecosystem Banking Conference. To evaluate endangered species banking we analyzed the U.S. Fish & Wildlife Service and SC DHEC data on listed species for Charleston County.

Stream and Wetland Mitigation Credit Estimates

Compensatory mitigation credits that might be generated from the proposed projects were estimated using the USACE stream restoration and wetland restoration calculation worksheets. All streams are first or second order streams that fall within the tertiary priority category (i.e. no notable conservation or high quality designation). In general, we were conservative in all credit estimates. While we assumed that the maximum net improvement would be achieved from restoration actions, no credit multipliers for buffer restoration were applied because buffers are largely intact. However, additional buffer preservation could potentially increase credit yield. We also assumed streams would be restored to 1.4 sinuosity, a middling estimate for low gradient coastal streams.

Credit estimates for the Church Creek Tributary and Church Creek Headwaters projects are shown in the tables below. No credits were estimated for the Penny Creek Tributary Project because the project involves stream relocation and will have complex hydrologic impacts. Generally, the USACE views stream relocation as a "self-mitigating project," meaning, in this case, that the benefits of stream naturalization and wetland creation will offset impacts to the existing aquatic resources.

We also did not estimate any wetland credits would be generated for the Church Creek Headwaters Project. The area where restoration activities would be most likely to provide significant functional uplift is between Walter Drive and Berryhill Road. This is a forested parcel that appears to presently support a jurisdictional wetland. No accurate estimate of wetland credit yield can be made until this supposition is field verified and further estimation of potential functional lift from stream restoration is quantified.

Note that no credits were estimated for preservation. Historically, the USACE Charleston District has been extremely liberal in awarding credits for land preservation, including the preservation of upland habitats to offset wetland impacts (contrary to Federal law and rules). This practice has received considerable scrutiny from the Department of the Army and the U.S. Environmental Protection Agency and has largely been curtailed. Mitigation credits from preservation should rarely exceed 10% of the total credits generated by a mitigation project per the 2008 Federal interagency rule. The Charleston District has yet to issue a consistent policy on preservation and related credit awards are inconsistent. Therefore, to keep our estimates conservative, preservation credits were not added to the totals. The ditch improvements suggested for the Church Creek Tributary project could also generate credits but there is no way to estimate amounts at this time.

Church Creek Tributary Project

	Restored Stream (lf)	Estimated Credits
Church Creek Tributary	2,712	9,898
North Tributary	1,008	3,679
STREAM TOTALS	3,720	13,577

	Wetland Restoration (ac)	Estimated Credits
Church Creek Tributary	3.201	13.760
North Tributary	0.827	3.552
PROJECT TOTALS	4.028	17.312

Church Creek Headwaters Project

	Restored Stream (LF)	Estimated Credits
Walter Drive to Berryhill Road	725	1,015

Estimated Mitigation Value

Mitigation credit prices are extremely dynamic and can fluctuate (like equity stocks) over the course of any given day based on supply and demand, as well as by the size of an individual purchase. In the Charleston District, stream mitigation credits have been consistently priced between $85 and $140 per credit for about the past year. Wetland credits are more consistent and run about $10,000 per credit. Applying these prices to the credit estimates above yields the following conservative dollar value estimates for stream and wetland mitigation at the two projects:

Project	Est. Stream Credit Value	Est. Wetland Credit Value
Church Creek Tributary	$1,140,000 — $1,900,000	$173,120
Church Creek Headwaters	$86,275 — $142,100	---