Scalable Toolkit for Coastal Cities

Independent Study
Fall 2024

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Key Research Question

How can green infrastructure strategies be adapted at different scales of the urban fabric to enable a more flood resilient coastal city?

Developing a flood resiliency toolkit for different scales, particularly in the case of St Marys.

Contents & Methodology

This report is a four-part series comprising:

1. **Introduction and Literature Review:** An exploration of various water management strategies, research studies, plans, and concepts.

2. **Case Studies:** An in-depth analysis of 10 exemplary water management plans and green infrastructure strategies implemented in cities around the world.

3. **St. Marys, Georgia:** Data collection and GIS analysis to study and understand the city of St. Marys, focusing on its specific water management challenges and opportunities.

4. **Toolkit:** The development of a scalable and practical toolkit, demonstrating the application of green infrastructure strategies tailored to the context of St. Marys.

1. Introduction & Literature Review

Urban flooding has become a pervasive challenge in the 21st century, with coastal regions disproportionately bearing the impacts. This research investigates how cities can adapt to coexist with water, focusing on the role of green infrastructure in mitigating flood risks. It examines how green infrastructure strategies vary across different urban contexts and explores the influence of urban fabric scales on the design and implementation of these solutions. Specifically, the study evaluates how green infrastructure can be tailored to enhance flood resilience in coastal cities, with a case study centered on St. Marys, Georgia. By analyzing the interplay between urban form, scale, and green infrastructure, this paper aims to provide actionable insights for developing scalable, context-sensitive strategies to address urban flooding in coastal regions.

Introduction to Water Urbanism

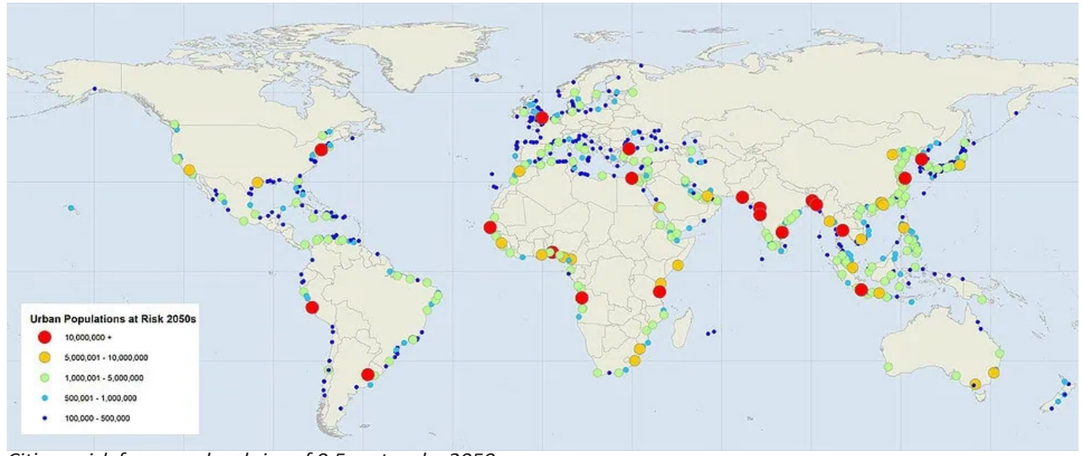
Human settlements historically formed around water bodies due to their fundamental role in sustaining life and supporting livelihoods. However, as urban development progressed, the visible connection between cities and water became increasingly obscure. This shift was largely driven by the introduction of modern water and sanitation systems—an innovative breakthrough that enabled water to be piped directly to homes, offices, and industries. While this convenience revolutionized daily life, it also weakened the physical and emotional bond people once shared with natural water sources.

As a result, urban areas began to neglect their natural water systems, leading to widespread practices such as **land reclamation, the channelization of waterways, the loss of wetlands and riparian zones, and escalating water pollution.**

The concept of water urbanism seeks to reverse this trend by reintegrating water as a core element of urban design. Over the past few decades, there has been a significant shift in urban planning priorities, moving away from conventional grey infrastructure toward green infrastructure solutions. Globally, terms like Green Infrastructure (GI), Low Impact Development (LID), Water-Sensitive Urban Design (WSUD), and “sponge cities” have emerged to describe these approaches. Despite their differences, all these strategies share a unified goal: creating sustainable stormwater management systems to address the growing challenges of climate change, urban flooding, and water scarcity

Climate Change, Sea Level Rise and Coastal Cities

Sea level rise poses a significant threat to coastal cities worldwide, driven by climate change, thermal expansion of seawater, and melting ice caps. As oceans rise, low-lying urban areas face increased risks of flooding, erosion, and saltwater intrusion, impacting infrastructure, freshwater supplies, and livelihoods. Coastal cities must adapt by implementing resilient infrastructure and exploring **nature-based solutions**. As extreme weather events and high tides worsen, proactive urban design and planning are crucial to safeguard coastal populations and mitigate long-term economic and environmental damage.



Cities a risk from sea level rise of 0.5 metres by 2050s
source: C40 cities



source: C40 cities

Cities need to adapt to sea level rise and coastal flooding by **"living with water"**

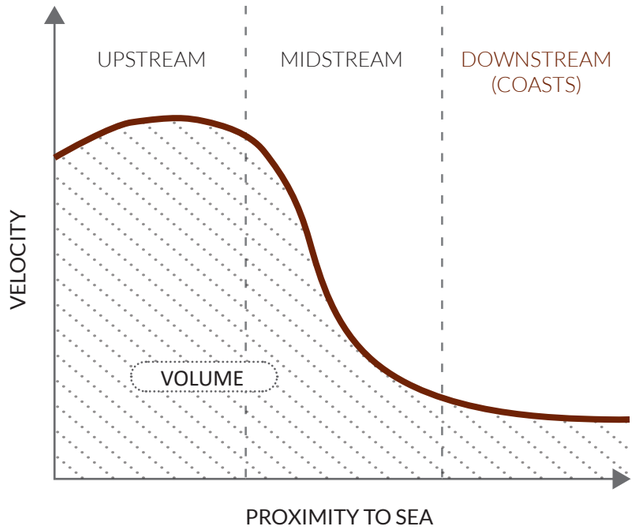
Managing Water

Effectively managing water is a crucial step in addressing urban flooding, as its velocity and volume change significantly across different geographical conditions and landforms. As water flows downstream toward coastal areas, it accumulates a substantial volume while its velocity decreases. This necessitates strategies to slow down the flow, promote infiltration, and ensure proper storage.

The simplified hydrograph below illustrates how various strategies can improve drainage. Reducing reliance on pumping systems is essential, as it is both costly and unsustainable. Instead, retrofitting urban areas with slow and store approaches or implementing **Nature-Based Solutions** (NbS) offers a cost-effective means of redistributing runoff over time. These methods mitigate flooding risks without requiring increased pumping capacity.

Consequently, nature-based solutions play a pivotal role in sustainable water management, providing resilience against urban floods while enhancing environmental and social benefits.

Managing Water

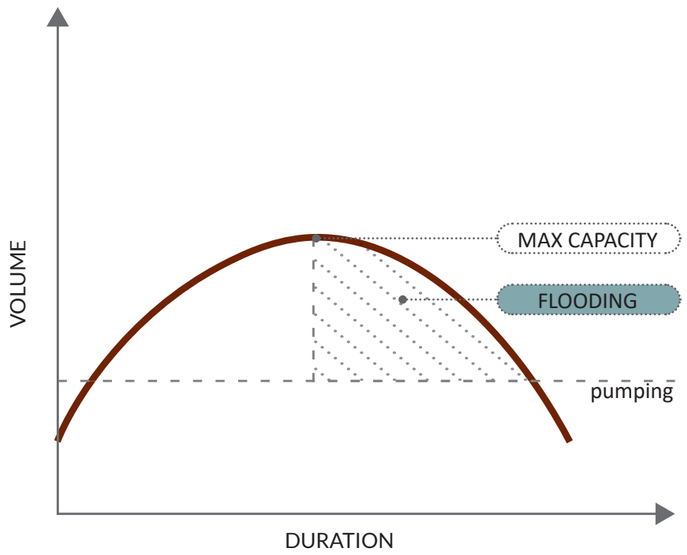


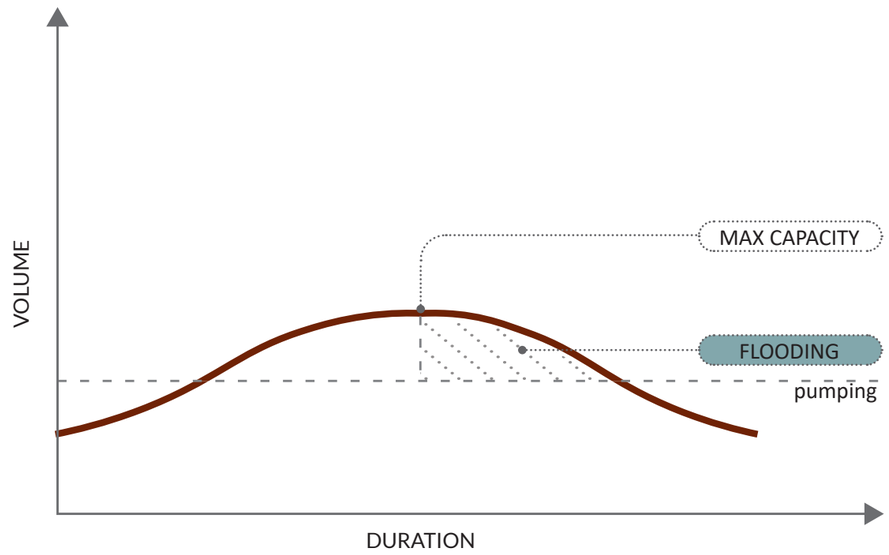
COASTS:

LOW velocity
HIGH water discharge

WHAT WE NEED

IN(FILTRATION) + STORAGE





HOW WE NEED TO DO IT

NATURE-BASED SOLUTIONS (NbS)

Literature Review

Reviewing a wide range of literature was a crucial part of this study. Among the numerous resources explored, a few key references stand out: the New Orleans Water Plan, the Charleston Water Plan, and the principles of Low Impact Development (LID). These sources provided valuable insights into innovative water management strategies and methodologies.

The New Orleans Water Plan highlights approaches to living with water in a flood-prone environment, emphasizing resilience through integrated water systems and urban design. Similarly, the Charleston Water Plan offers comprehensive strategies for managing stormwater and mitigating the impacts of flooding, tailored to the unique challenges faced by coastal cities. Meanwhile, Low Impact Development (LID) principles focus on decentralized, nature-based techniques to manage runoff, reduce urban flooding, and enhance water quality.

These critical references were instrumental in identifying and analyzing scalable methodologies. They offer adaptable solutions that can be customized to address the specific needs of various urban contexts, providing a foundation for sustainable and resilient water management practices.

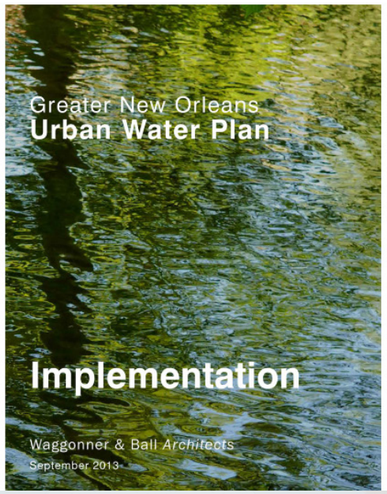
GREATER NEW ORLEANS URBAN WATER PLAN: VISION



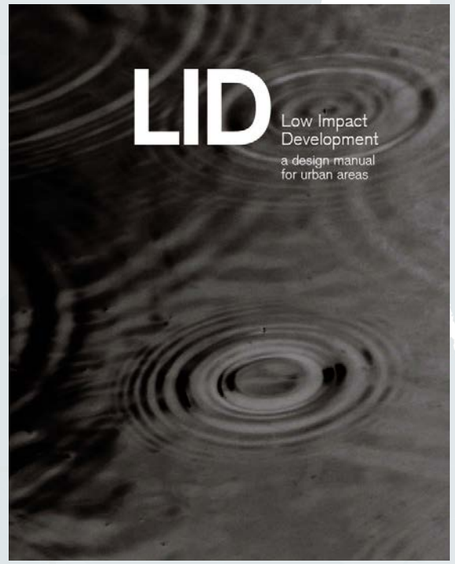
GREATER NEW ORLEANS URBAN WATER PLAN: URBAN DESIGN



GREATER NEW ORLEANS URBAN WATER PLAN: IMPLEMENTATION







Literature Review: key takeaways

New Orleans - Urban Water Plan

Watershed-Based Approach:
The plan emphasizes managing water within the natural hydrological systems of the watershed to promote sustainable and integrated solutions.

“Living with Water” Philosophy:
Shifts from traditional flood defenses to embracing water as a valuable and integrated element of urban life, fostering coexistence with water.

Short-Term Strategies:
Focus on cost-effective retrofits such as green roofs, permeable pavements, and bioswales.
Prioritize immediate interventions to slow water flow and reduce flooding without extensive infrastructure overhauls.

Long-Term Strategies:
Increase water storage capacity through new ponds, wetlands, underground reservoirs, and rainwater harvesting systems.
Plan for sustainable, large-scale solutions to manage excess water and prevent future flooding.

Three-Step Framework:
Slow: Implement measures like green infrastructure to reduce the speed of water flow.
Store & Use: Enhance water retention and reuse through urban reservoirs, rainwater harvesting, and infiltration techniques.
Drain (if necessary): As a last resort, use drainage systems to remove water, reducing dependency on pumps.

Literature Review: key takeaways
Charleston Water Plan

Four Key Principles:
Defend: Strengthen critical infrastructure and protect communities with structural measures like levees, seawalls, and flood barriers.
Adapt: Emphasize flexible, proactive planning tailored to specific basins, designing urban spaces to work with water rather than against it.
Grow: Integrate water management into urban development, promoting resilience through green infrastructure and sustainable land-use practices.
Reserve: Preserve and restore natural water systems, such as wetlands and floodplains, to act as natural buffers and enhance water storage capacity.

“Let Water In” Philosophy:
Encourages urban design that embraces water as an integral element rather than attempting to exclude it entirely.

Slow - Sink - Store Framework:
Slow: Reduce water velocity and surface runoff using green roofs, permeable pavements, and bioswales.
Sink: Increase infiltration with rain gardens, expanded wetlands, and permeable soils to allow water to seep into the ground.
Store: Create systems like detention basins and reservoirs to hold excess water for future use or controlled release.

Literature Review: key takeaways
Low Impact Development

Localized Rainfall Management:
Focuses on managing rainfall at the source to reduce urban flooding and lessen reliance on centralized infrastructure.

“Parks, Not Pipes!”:
Advocates for nature-based solutions over traditional stormwater systems, prioritizing green spaces for water management.

Slow - Spread Framework:
Slow: Implement flow control measures through detention and retention systems, such as rain gardens, bioswales, and detention basins, to reduce runoff speed and volume.
Spread: Enhance water filtration, infiltration, and treatment with solutions like permeable pavements, green roofs, and vegetative buffers.

Design Stategies

From this comprehensive study, it becomes crucial to delineate the strategies into two broad categories: water strategies and planning strategies. Each serves a distinct purpose in addressing water management challenges, offering both immediate and long-term solutions.

Water Strategies:
These are practical, implementable solutions that can be deployed without requiring extensive planning or coordination. They typically involve quick interventions focused on managing water flow, retention, and infiltration. Examples include rain gardens, bioswales, permeable pavements, rainwater harvesting systems, and other nature-based solutions. These strategies are cost-effective and can be integrated into existing infrastructure, offering immediate benefits in terms of flood mitigation and water conservation.

Planning Strategies:
These involve a more structured and collaborative approach, requiring detailed design, engineering, and coordination among multiple stakeholders, such as urban planners, engineers, policymakers, and community organizations. Planning strategies aim to create systemic changes and long-term solutions, such as the integration of green infrastructure in urban master plans, zoning regulations to protect natural water systems, large-scale stormwater management networks, and the preservation or restoration of wetlands and riparian corridors. These strategies ensure that water management is embedded within the broader framework of urban development, addressing sustainability and resilience comprehensively.

Design Stategies

WATER STRATEGIES

- **Slow** — Interventions that slow down the flow of stormwater, reducing peak flows and erosion. Solutions include vegetative measures, urban tree canopies, and permeable surfaces to delay runoff.
- **Sink-Store** — Captures and retains floodwater to mitigate the immediate impact of heavy rainfall. Nature-based storage solutions include wetlands, rain gardens, green roofs, and floodable urban spaces that temporarily hold water.
- **Drain** — Enhances drainage capacity by channeling excess water into natural or built systems that mimic natural hydrology. Canals and channels provide a path for water to safely return to natural water bodies or subsurface storage.

PLANNING STRATEGIES

- **Defend** — Protects built environments through defensive strategies like levees, floodwalls, and natural buffers. These solutions can combine “hard” defenses with ecological elements.
- **Adapt** — Focuses on adaptive urban planning, building retrofits, and resilient infrastructure. Zoning regulations may encourage flood-resilient developments, while properties adapt by raising foundations, retrofitting, or adjusting land use.
- **Reserve** — Ensures land is set aside for future water storage and flood management. This strategy conserves undeveloped or restored areas, such as wetlands, floodplains, or greenbelts, to absorb excess water during extreme events.

Defining the Challenge

These plans often provide broad strategies and ambitious visions but lack a clear framework for implementation across various scales of intervention. By “scales,” I refer to distinct levels of application, including **city/region, neighborhood/water district, block, street,** and **site.** While it is understood that an intervention at one scale may have ripple effects on others within the urban fabric, this study focuses on the scale at which a strategy can be directly implemented.

To clarify, water district refers to the area defined by a watershed, which typically aligns with a neighborhood or block-scale intervention. However, for the purposes of this study, it is considered equivalent to the neighborhood scale.

Each scale involves different stakeholders with varying interests and levels of influence. For instance, the city government may prioritize interventions at the city/region or neighborhood/water district level, as these scales involve broader urban planning and policy considerations. An individual property owner is more likely to focus on their site or street, seeking localized solutions that align with personal or immediate community needs.

Understanding the relationship between strategies and scales is essential for developing a practical and adaptable toolkit. This toolkit should enable stakeholders to select strategies appropriate to their scale of influence and responsibility while acknowledging how these interventions interact with and impact other scales.

The goal of this study is to explore whether strategies can be effectively tailored to specific scales and stakeholder needs. By doing so, it aims to bridge the gap between high-level planning and actionable implementation, offering a flexible framework to support a variety of urban water management goals.

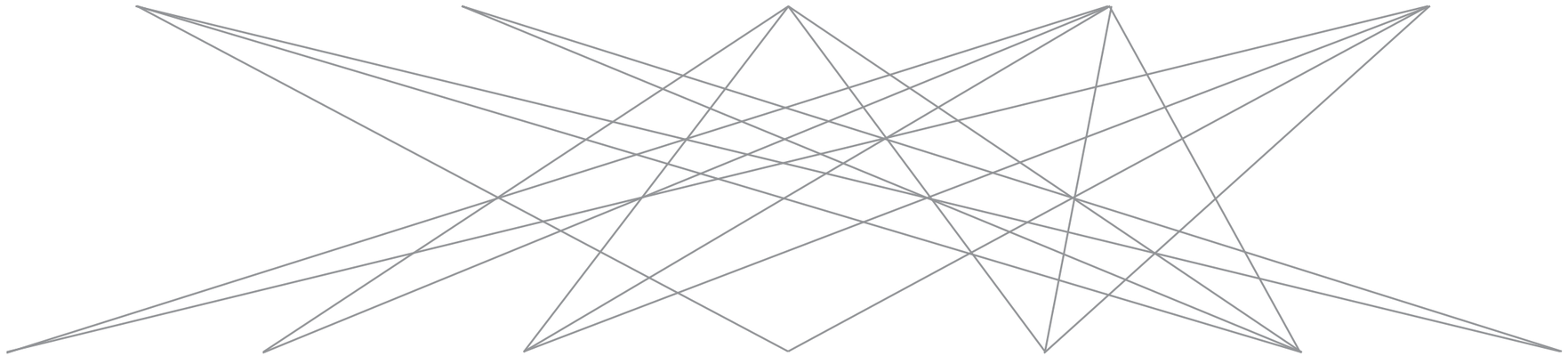
Strategies

Slow | Sink-Store | Drain | Defend | Adapt | Reserve

?

Scale

City/ Region | Neighborhood/ Water District | Block | Street | Site



Stakeholders

Individual | Community | NGO | Academic/ Research | Private/ Business | City government | Federal government

2. Case Studies

Case Studies

To establish a meaningful relationship between scale and strategies, it is essential to analyze case studies from around the world. On the right is a curated list of projects that have implemented or plan to incorporate green infrastructure strategies to safeguard cities against flooding and climate change.

Below is a matrix illustrating the relationship between scale and strategies, which can be populated for each case study. These concepts are designed to be scalable, making them adaptable to projects of various sizes and applicable to diverse land-use types.

For each case study, the aim, challenges, and solutions are clearly identified, and the matrix is populated with specific strategies used at each scale of the urban fabric.

PROJECT NAME	CITY	COUNTRY	FIRM/ ORGANISATION
New Orleans Water Plan	New Orleans	USA	Waggoner & Ball
Charleston Water Plan	Charleston	USA	Waggoner & Ball
Benjakitti Forest Park	Bangkok	Thailand	Turenscape
Sanya Mangrove Park	Sanya	China	Turenscape
Netherlands	Rotterdam	Netherlands	Dutch Water Authorities
Unlock Alameda Creek	San Francisco	USA	SCAPE, Rebuild by Design
Tidal River Management	Bengal delta	Bangladesh	
Chennai Water Management	Chennai	India	
Resilient Hampton & Bridgeport	Hampton, Bridgeport	USA	Waggoner & Ball
Tsurumi River	Tokyo	Japan	Govt. of Japan

	WATER STRATEGIES			PLANNING STRATEGIES		
	SLOW	SOAK-STORE	DRAIN	DEFEND	ADAPT	RESERVE
SITE						
STREETS						
BLOCK						
NEIGHBORHOOD/ WATER DISTRICT						
CITY/ REGION						

New Orleans Water Plan

USA
Waggoner & Ball

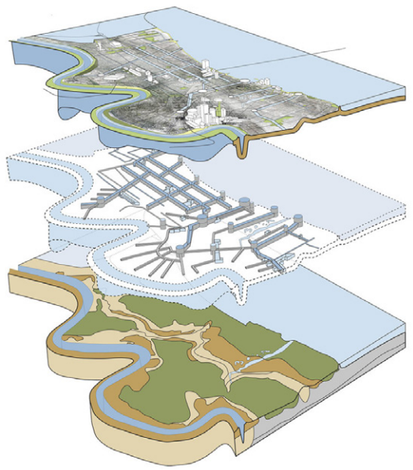




Aim: increase water storage capacity by layering a system of waterways on street grids that supplements the current drainage system.

Challenge: a single-purpose approach to stormwater management is expensive and resource-intensive, yet streets still flood regularly due to rainfall

Solution: an integrated living water system that focuses on nature based solutions for slowing, storing and using water; draining only if necessary



	WATER STRATEGIES			PLANNING STRATEGIES		
	SLOW	**SOAK-STORE**	**DRAIN**	**DEFEND**	**ADAPT**	**RESERVE**
SITE	green roof	rain garden	french drains			
		surface landscape				
		retention pond				
STREETS	**canals without floodwalls**	**sub-surface storage**	**perforated pipes**			
	tree planting strips	"**water lane"/ "floating streets"**	gutter			
	pocket parks	rain garden	catch basin			
		permeable pavement	pumps			
		bioswales				
BLOCK	pocket parks	**retention ponds on vacant lots**				
		sub surface storage (parking lots)				
		filtration terraces				
NEIGHBORHOOD/ WATER DISTRICT	waterways	**constructed wetlands**		pump stations	**widening canals**	
	braided channels	**strategic parklands**			**natural ridges as levees**	
		wetlands/swamps				
		retention basin				
CITY/ REGION			**integrated waterworks**	**pump stations**	**natural ridges as levees**	**marsh restoration**
			circulating canals	levees	**widening canals**	natural bayous
				floodwalls	redirected discharge	hardwood forest
					watershed approach	wetlands/ swamps

Charleston Water Plan

USA
Waggoner & Ball

coastal city

fluvial flood | storm surges | sea level rise

Aim: provides a paradigm to guide appropriate development and redevelopment to safeguard people and structures, conserve ecologically sensitive areas today and for future landscapes, and demonstrate how to adapt areas that are expected to experience the greatest impacts.

Challenge: Charleston's flood risks result from forces of water that can occur at the same time, compounding flooding across the City. Sea level rise is the primary long-term flood risk driver because it affects creeks and drainage capacity upstream: as sea levels rise, drainage slows.

Solution: Reserve, Adapt, Defend, Grow, Slow, Store, Drain - these strategies are fundamentally based on land elevation, land use, water levels, and flood risk factors and are intended to help migrate population and property value to safe ground.

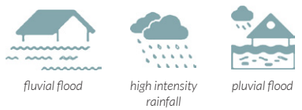


	WATER STRATEGIES			PLANNING STRATEGIES		
	SLOW	SOAK-STORE	DRAIN	DEFEND	ADAPT	RESERVE
SITE	green roof	rain garden	pumps		building above Base Flood Elevation	
		surface landscape	catch basin			
STREETS	tree planting strips	**sub-surface storage**	**subsurface culvert**			
		"green streets"	**perforated pipes**			
		rain garden	catch basin			
		permeable pavement	gutter			
		bioswales				
BLOCK		**retention ponds on vacant lots**				
		sub surface storage (parking lots)				
NEIGHBORHOOD/ WATER DISTRICT		**waterways**		**road raising**	**natural ridges as levees**	
		constructed wetlands		pump stations		
		strategic parklands				
		wetlands/ swamps				
		retention basin				
CITY/ REGION			**tidal and storm gates**	**T-wall/ combo wall**	**watershed approach**	**space for marsh migration**
			circulating canals	**inner & outer alignment zones**	**natural ridges as levees**	**reconnecting tidal creeks**
			culverts	**tunnel system**	**retreat and grow in highlands**	**battery expansion**
			pumps	pump stations	**elevation-based zoning**	**preserve wetlands/ swamps**
				levees	**oyster beds**	**restore marshes**
					raised berms	preserve wetlands/ swamps

Benjakitti Forest Park

Bangkok, Thailand
Turenscape





Aim: transform the site of a former tobacco factory into a low-maintenance regenerative system that intercepts and reduces the destructive force of storm water

Challenge: apart from flooding, a contaminated canal, isolation due to an expressway, a limited budget of $20 per square meter, a tight 18-month timeline, and oversight by the army with limited landscape experience, all while having minimal programmatic requirements.

Solution: mini-islands were created by simple cut and fill procedures to transform the impermeable, concrete-paved ground into a spongy and porous landscape, which is expected to retain up to 200,000M3 of storm water from the surrounding area during the monsoon season



	WATER STRATEGIES			PLANNING STRATEGIES		
	SLOW	SOAK-STORE	DRAIN	DEFEND	ADAPT	RESERVE
SITE						
STREETS						
BLOCK						
NEIGHBORHOOD/ WATER DISTRICT	raceways	lakes (retention ponds)		raised berms at park edges	tree roots higher to avoid floods (due to high ground water levels)	
		mounded islands				
		"tilled landscape"				
		constructed wetlands				
		bioswale				
CITY/ REGION			canals			existing natural vegetation

Sanya Mangrove Park

Sanya, China
Turenscape



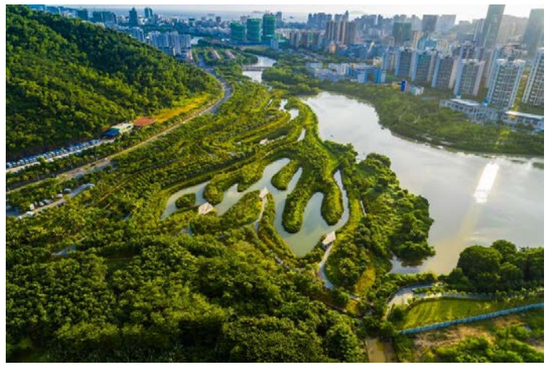


Aim: restore an area of lifeless land fill within a concrete flood wall into a lush mangrove park

Challenge: Waterways have been polluted and filled with garbage. Concrete flood walls were built to claim land for development that killed the mangroves.

Solution: By means of cut-and-fill and making using of the material on site, **ecotones** of water ways and riparian habitats of various elevations are created for diverse fauna and flora, particularly different species of mangroves

	WATER STRATEGIES			PLANNING STRATEGIES		
	SLOW	SOAK-STORE	DRAIN	DEFEND	ADAPT	RESERVE
SITE						
STREETS						
BLOCK						
NEIGHBORHOOD	**terraces with bio-swales**					
CITY/ REGION				**landscape shaped to induct ocean tides and avoid storm**	cut and fill technique creating inter-locked **"green fingers"** maximizing the edge effect	**mangrove rehabilitation**



Netherlands

Rotterdam





Aim: The Netherlands' water management aims to protect the low-lying country from flooding while efficiently managing its water resources for agriculture, urban use, and industry.

Challenge: The main challenge is the constant threat of rising sea levels, river flooding, and groundwater issues due to the country's location below sea level and the effects of climate change.

Solution: A combination of advanced flood defenses like dikes, storm surge barriers, and innovative water management systems such as "Room for the River" to balance safety with ecological preservation.



	WATER STRATEGIES			PLANNING STRATEGIES		
	SLOW	SOAK-STORE	DRAIN	DEFEND	ADAPT	RESERVE
SITE		green roofs (Rotterdam)			**"Floating farm"** - built-in system for collecting and purifying rainwater	
		polder roofs (Rotterdam): roof of parking garage, stores & resuses water from other buildings			**"Floating houses"** - houses balanced in water where the basement replaced by concrete hull that acts as a counterweight	
STREETS		**"Blue-Green corridors"** (Rotterdam): bioswales, rain gardens				
		permeable pavement/ tiles- **"Katshoek Rainaway Garden"**				
BLOCK		underground water reservoir (Rotterdam): **car park with a reservoir** of 10000m3 capacity				
		water squares (Rotterdam)				
		retention ponds				
NEIGHBORHOOD/ WATER DISTRICT	park on railway viaduct (Rotterdam): **Hofbogenpark**	**water squares** (Rotterdam)			Climate proof district (Rotterdam): **Zomerhofkwartier**	
CITY/ REGION	excavating floodplains		canals/ channels	**DELTA WORKS:** curb flooding by shortening coastline and converting them into fresh water lakes **13 dams - barriers, sluices, locks, dikes, levees**	**ROOM FOR THE RIVER:** 1. relocating dykes inland 2. excavating floodplains 3. deepening river bed 4. lowering groin 5. secondary water channel 6. temporary water storage	restoring tidal parks and wetlands
			pumping stations	**POLDERS:** low lying areas created using a system of dykes and channels		
				INNER DYKE/ OUTER DYKE APPROACH (Rotterdam)		

Alameda Creek

San Francisco, CA, USA
ReBuild by Design





Aim: restore sediment and improve habitat connectivity for steelhead trout and other aquatic species in the Alameda Creek watershed.

Challenge: overcoming physical barriers like flood control structures and outdated dams, which block fish migration and disrupt natural water flow.

Solution: preserve tidal ecosystem by sustainably transporting sediment, people, & fish

	WATER STRATEGIES			PLANNING STRATEGIES		
	SLOW	SOAK-STORE	DRAIN	DEFEND	ADAPT	RESERVE
SITE						
STREETS						
BLOCK						
NEIGHBORHOOD/ WATER DISTRICT	**flood terrace trail** - with the **"living levee blanket"** (stabilises the channel)	**"floodrooms"**				
CITY/ REGION				**"Pebble dune"** - combination of barrier and pebble beach - helps protect against tides + creates nesting habitats		**Preserve tidal ecosystem** by sustainably transporting sediment, people, & fish: 1. connect creek to the baylands 2. mudrooms 3. seasonal crossings 4. harvest sediment from upstream to downstream"



Tidal River Management

Bengal Delta, Bangladesh



coastal city



river city



fluvial flood



storm surges



sea level rise

Aim: reduce waterlogging, restore natural sediment deposition, and improve agricultural productivity in the floodplains.

Challenge: managing the complex hydrodynamics of the delta, exacerbated by rising sea levels, siltation, and human interventions like embankments that worsen waterlogging

Solution: overflow irrigation involves controlled tidal flooding of designated areas (beels) to allow natural sediment deposition, which raises the land level and restores drainage

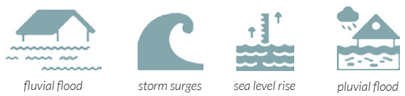
	WATER STRATEGIES			PLANNING STRATEGIES		
	SLOW	SOAK-STORE	DRAIN	DEFEND	ADAPT	RESERVE
SITE						
STREETS						
BLOCK						
NEIGHBORHOOD						
CITY/ REGION			canals/ channels	levees & embankments	**"Overflow irrigation"** (Indigenous method): **"Beels"** - agricultural lots that take advantage of the tide cycle to deposit sediment onto floodplains and keep the river congestion-free"	preserving the mangrove forest



Chennai Water Plan

India

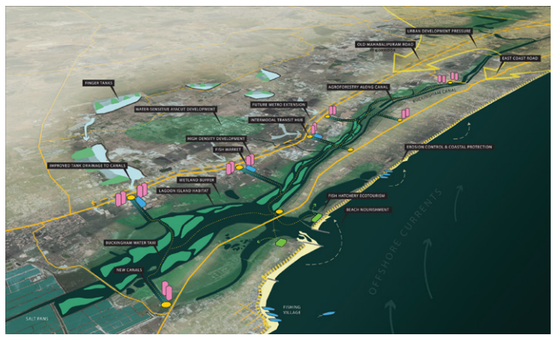




Aim: reduce waterlogging,mitigate impact of floods in a rapidly growing urban environment

Challenge: the city's vulnerability is further exacerbated by rampant violations of building rules, the filling up of water bodies, insufficient drainage systems, and construction over channels.

Solution: focuses on rainwater harvesting, desalination plants, restoration of water bodies, and improved infrastructure for water storage and sponge infrastructure

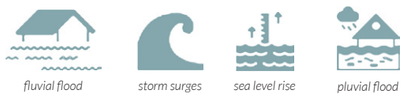


	WATER STRATEGIES			PLANNING STRATEGIES		
	SLOW	SOAK-STORE	DRAIN	DEFEND	ADAPT	RESERVE
SITE	surface landscape	**"sponge infrastructure"**				
		rain water harvesting				
		green roofs				
		storage basins				
STREETS	planting strips	**"sponge infrastruture"**				
		bioswales				
		rain gardens				
		permeable pavements				
BLOCK		**water plaza**				
		constructed wetlands				
		retention ponds				
NEIGHBORHOOD/ WATER DISTRICT	neighborhood parks	**constructed wetlands (Chitra Nagar)**			**widening canal (Buckingham Canal)**	
		water plaza				
		retention ponds				
CITY/ REGION				flap gates (Buckingham Canal)	**widening canal (Buckingham Canal)**	**sand nourishment along the beach**
						restoring tidal park (Adyar Poonga): excavation & desilting
						deepening of lagoon
						increasing biodiversity in lagoon

Resilient Hampton & Bridgeport

USA
Waggoner & Ball





Aim: protect from increasing flood risks while promoting sustainable urban development

Challenge: addressing rising sea levels, recurrent flooding, and storm surges exacerbated by climate change, which threaten infrastructure, homes, and ecosystems.

Solution: employs strategies like natural shoreline restoration, improved stormwater management, flood-resistant infrastructure, and community engagement to enhance resilience



	WATER STRATEGIES			PLANNING STRATEGIES		
	SLOW	SOAK-STORE	DRAIN	DEFEND	ADAPT	RESERVE
SITE	tree plantings				building above Base Flood Elevation	
STREETS	tree plantings	**"green street"**				
	tree vaults	bioswales				
	curb extensions	permeable parking				
BLOCK		**sand filters**				
		stormwater storage				
		bioswales				
NEIGHBORHOOD/ WATER DISTRICT	linear park	**detention pond**	pumps	**elevating roadways with a floodwall (protects historic assets)**	**planting strategies that adapt to salinity**	
		regrading drainage ditches				
		terraced river edge				
		stormwater park				
		wetlands				
		bioswale				
		constructed wetlands				
CITY/ REGION				**surge protection berm with bike path**	**Living shoreline - breakwater structures**	**Restore Riparian ecosystems**
				floodwalls		**Reef structures**

Tsurumi River

Japan



river city



fluvial flood



high intensity rainfall



pluvial flood

Aim: protect Kanagawa and Tokyo from the flood-prone Tsurumi river

Challenge: the flooding risks have increased with urban development encroaching the river basin. This has led to an increase in the flow of water into the river and reduced the time taken for the river to reach peak discharge resulting in flooding.

Solution: the focus was to develop a multipurpose retarding basin used to temporarily store storm water during heavy rainfall



	WATER STRATEGIES			PLANNING STRATEGIES		
	SLOW	SOAK-STORE	DRAIN	DEFEND	ADAPT	RESERVE
SITE						
STREETS						
BLOCK						
NEIGHBORHOOD/ WATER DISTRICT		**mulitipurpose retarding basin** (temporarily store stormwater)		**levees** - between river and basin + basin and neighboring land	**elevated infrastructure**	
		sloping embankments		**overflow embankment**	land excavation	
		surface landscape				
		strategic parklands				
CITY/ REGION						wildlife restoration

Resultant Design Strategies

This process results in a comprehensive **catalog of design solutions** across different scales, including city/region, neighborhood/water district, block, street, and site.

The outcome is a practical resource that highlights actionable strategies for stakeholders operating at various levels. Whether city governments, community organizations, or individual property owners, stakeholders can reference this catalog to identify and implement solutions that align with their specific needs and areas of influence. This approach bridges the gap between conceptual planning and actionable interventions, offering a framework for creating resilient, climate-adaptive urban environments.

Resultant Design Strategies

	WATER STRATEGIES			PLANNING STRATEGIES		
	SLOW	SOAK-STORE	DRAIN	DEFEND	ADAPT	RESERVE
SITE	green roof	rain garden	french drains		elevating structures above Base Flood Elevation	
	surface landscape	retention pond	catch basins		floating farms	
	tree planting strips	polder roofs	gutters		floating houses	
		storage basins				
		“sponge infrastructure”				
		rain water harvesting				

	WATER STRATEGIES			PLANNING STRATEGIES		
	SLOW	SOAK-STORE	DRAIN	DEFEND	ADAPT	RESERVE
STREET	canals without floodwalls	sub-surface storage	perforated pipes			
	tree planting strips	water lane/ floating streets	catch basins			
	pocket parks	rain garden	gutters			
	“green streets”	permeable pavement/ tiles	subsurface culvert			
		bioswales				
		“blue-green corridors”				
		“sponge infrastructure”				

Resultant Design Strategies

BLOCK

WATER STRATEGIES			PLANNING STRATEGIES		
SLOW	SOAK-STORE	DRAIN	DEFEND	ADAPT	RESERVE
pocket parks	retention ponds on vacant lots	perforated pipes			
	sub-surface storage under parking lots	gutters			
	filtration terraces	catch basins			
	water squares/ plaza	pumps			
	constructed wetlands				
	sand filters				
	bioswales				

NEIGHBORHOOD/ WATER DISTRICT

WATER STRATEGIES			PLANNING STRATEGIES		
SLOW	SOAK-STORE	DRAIN	DEFEND	ADAPT	RESERVE
waterways	constructed wetlands	circulating canals	elevated roadways	widening canals	
strategic parklands	retention basins	perforated pipes	pump stations	natural ridges as levees	
raceways	wetlands/ swamps	pumps	raised berms	higher tree roots	
regrading drainage ditches	sponge infrastructure/ tilled landscape	pump stations	floodwalls	“climate proof districts”	
surface landscape	mounded islands	canals	levees/ dykes	adaptible planting strategies	
stormwater park	water squares/ plaza	de-silting	overflow embankment	elevated infrastructure	
excavation	detention ponds		sloping embankment		
flood terraces with bioswales	multipurpose retarding basin				
living levee blanket	floodrooms				

Resultant Design Strategies

CITY/ REGION

WATER STRATEGIES			PLANNING STRATEGIES		
SLOW	**SOAK-STORE**	**DRAIN**	**DEFEND**	**ADAPT**	**RESERVE**
		integrated waterworks	levees/ dykes	watershed approach	marsh restoration
		circulating canals	floodwalls/ T-wall/ combo walls	redirected discharge	natural bayous
		tidal and storm gates	pump stations	widening canals	restoring forests
		culverts	inner and outer alignment/ dyke approach	natural ridges as levees	preserve wetlands/ swamps
		pumps	tunnel system	retreat and grow in highlands	space for marsh migration
		canals/ channels	battery expansion	elevation-based zoning	reconnecting tidal creeks
			shaped landscape to avoid storm surge	living shoreline (breakwater structures) - oyster beds	mangrove rehabilitation
			delta works - dams/ barriers/ locks	raised berms	restoring tidal parks
			polders	“green fingers”/ ecotone	seasonal crossings
			“pebble dune”	“room for the river” - relocating dykes/ excavation/ desilting/ extra water channels	sediment relocation
			flap gates	“overflow irrigation”	mudrooms
			surge protection berms		sand nourishment
					increasing biodiversity
					restoring riparian ecosystmes
					preserve natural vegetation

Scale-Strategy Relationship

The detailed analysis of the case studies establishes a clear relationship between scale and strategy. The following general conclusions can be drawn based on the matrix:

- The **Slow-Soak-Store** method is suitable for implementation across all scales except the city scale, where it is less practical.
- **Drain** strategies are primarily localized, being most effective at the site and street scales, while also playing a role at the city scale for comprehensive drainage management.
- The **Defend** strategy is predominantly planned at the city and neighborhood scales, as it requires large-scale interventions and coordination.
- **Adapt** strategies are highly flexible, with applications either localized at the site scale or implemented at broader scales such as the neighborhood and city levels, depending on the context.
- **Reserve** strategies are generally limited to the city scale, where the preservation and restoration of extensive natural water systems are feasible.

Scale-Strategy Relationship

		WATER STRATEGIES			PLANNING STRATEGIES		
		SLOW	SOAK-STORE	DRAIN	DEFEND	ADAPT	RESERVE
Individual, community, NGO	SITE	●	●	●		●	
community, NGO, private, academic, city	STREETS	●	●	●			
community, NGO, private, academic, city	BLOCK	●	●				
private, academic, city, federal	NEIGHBORHOOD/ WATER DISTRICT	●	●		●	●	
private, academic, city, federal	CITY/ REGION			●	●	●	●

3. St Marys, Georgia

The city of St. Marys, located in southeastern Georgia along the St. Marys River, boasts a rich history dating back to the 16th century. Originally inhabited by the Timucua Native Americans, the area later saw Spanish exploration and settlement during the 1500s. By the late 18th century, English settlers established the town, and St. Marys was officially incorporated in 1792, making it one of the oldest continuously inhabited cities in the United States.

Throughout its history, St. Marys has been shaped by its strategic location near the Florida border and the Atlantic Ocean. During the War of 1812, it was occupied by British forces, and in the Civil War era, it played a role as a Confederate port. Over time, the city evolved into a peaceful riverside community known for its historical significance, charming architecture, and proximity to Cumberland Island, a popular national seashore and wildlife preserve.

Today, St. Marys is celebrated for its maritime heritage, small-town charm, and natural beauty, drawing visitors to its historic landmarks and scenic waterfront. Its connection to the river and its role as a gateway to the Cumberland Island National Seashore remain central to its identity.

However, St. Marys now faces significant challenges posed by climate change and sea level rise. The city's low-lying geography and proximity to the Atlantic Ocean make it particularly vulnerable to flooding, with consistent inundation increasingly affecting its historic downtown area. These floods threaten the preservation of its rich cultural heritage, disrupt daily life for its residents, and pose economic risks to local businesses that rely on tourism and maritime industries. As sea levels continue to rise and extreme weather events become more frequent, addressing these challenges is critical to ensuring the city's resilience and sustainability for future generations.

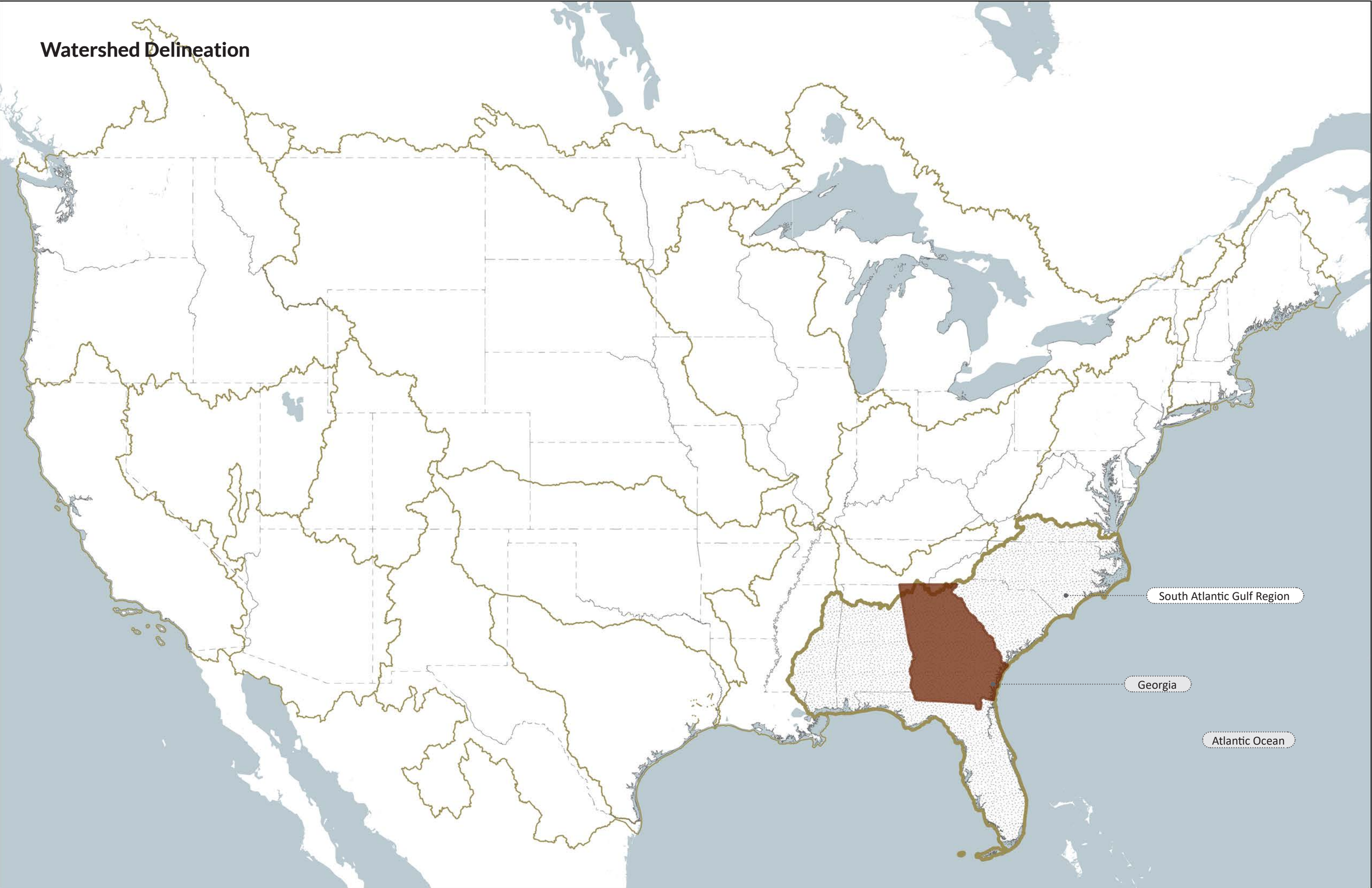
Watershed Delineation

John Wesley Powell defines a watershed as “an area of land, a bounded hydrologic system, within which all living things are interconnected by their shared water course, forming a natural community.” He emphasizes that when human settlements are organized around watersheds, it inherently encourages the conservation of this vital and finite resource.

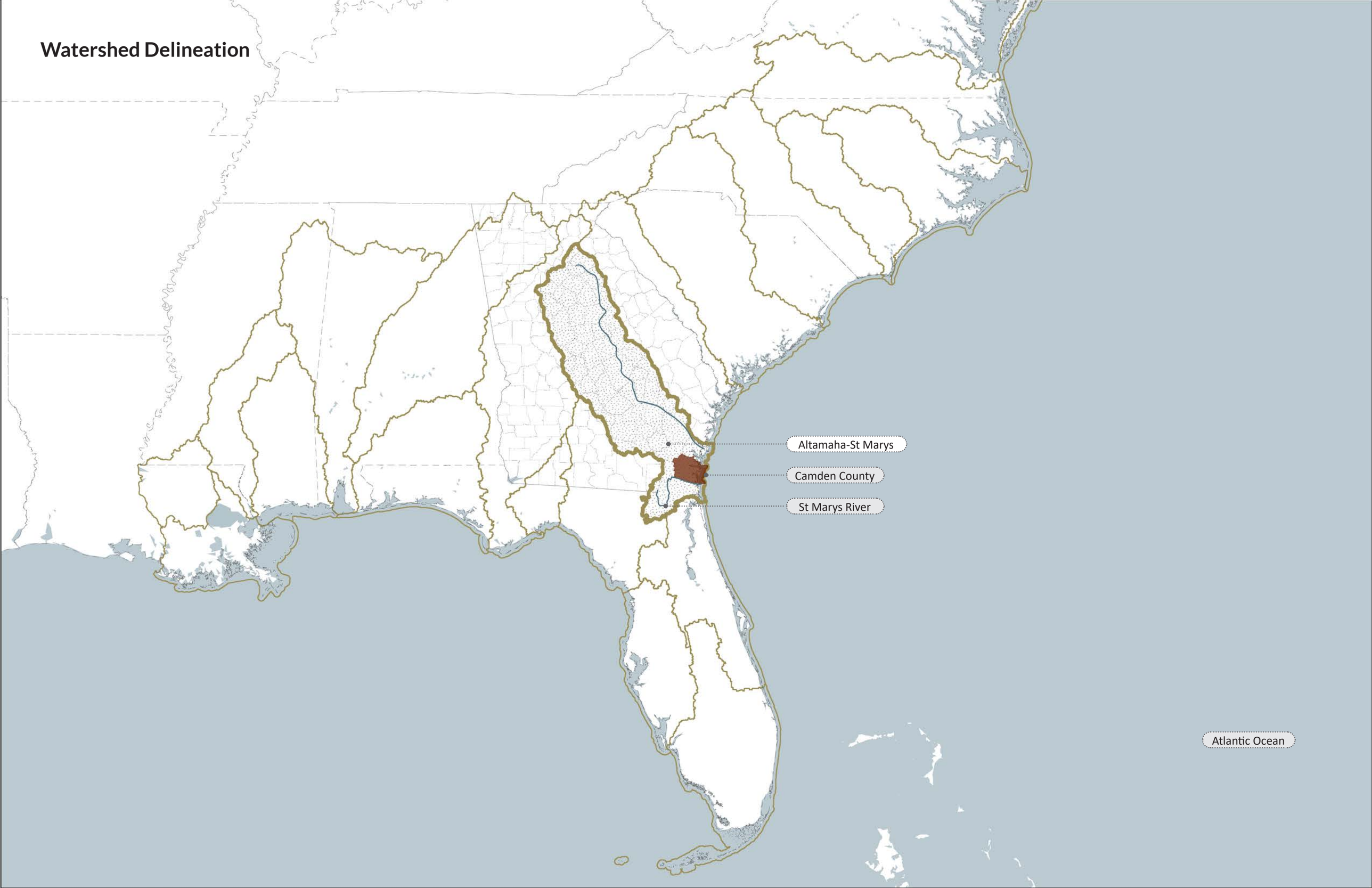
Using watershed boundaries as political boundaries could simplify water management by reducing multi-jurisdictional conflicts and mitigating disputes over water resources. However, there is also a unique advantage to watershed boundaries differing from political ones. This distinction creates an opportunity to use watersheds as a unifying framework, transcending political divisions and fostering collaboration. Watersheds can serve as a platform for expanding the public realm, where features such as trails and green infrastructure can link neighborhoods and reclaim neglected urban spaces, creating a cohesive and interconnected environment.

The following maps illustrate the progression of watershed boundaries, starting from the national scale and narrowing down to the city of St. Marys. These maps provide a clear visualization of how watershed systems are interconnected across various scales, emphasizing their relevance from a macro-regional perspective to localized urban contexts.

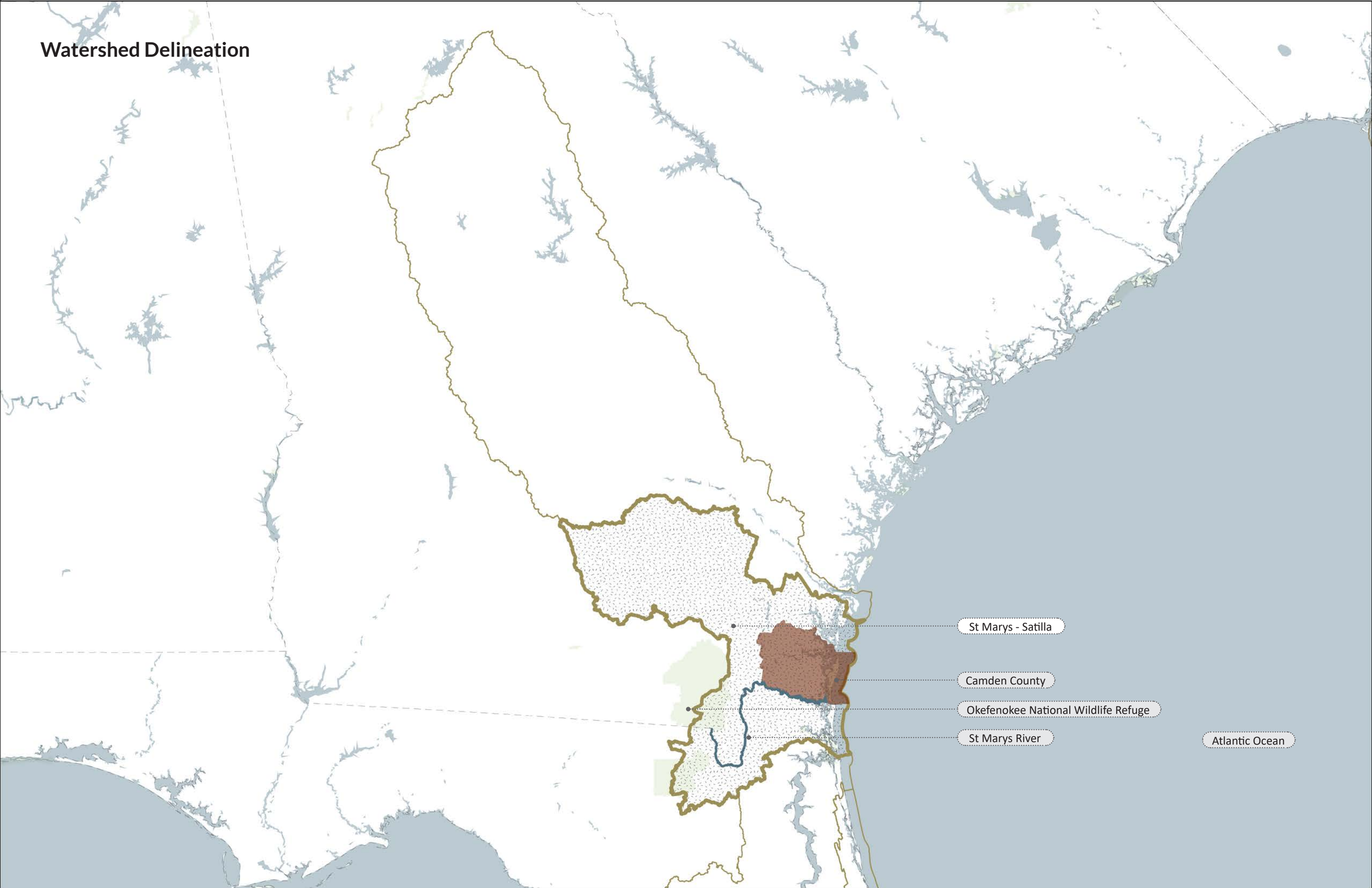
Watershed Delineation



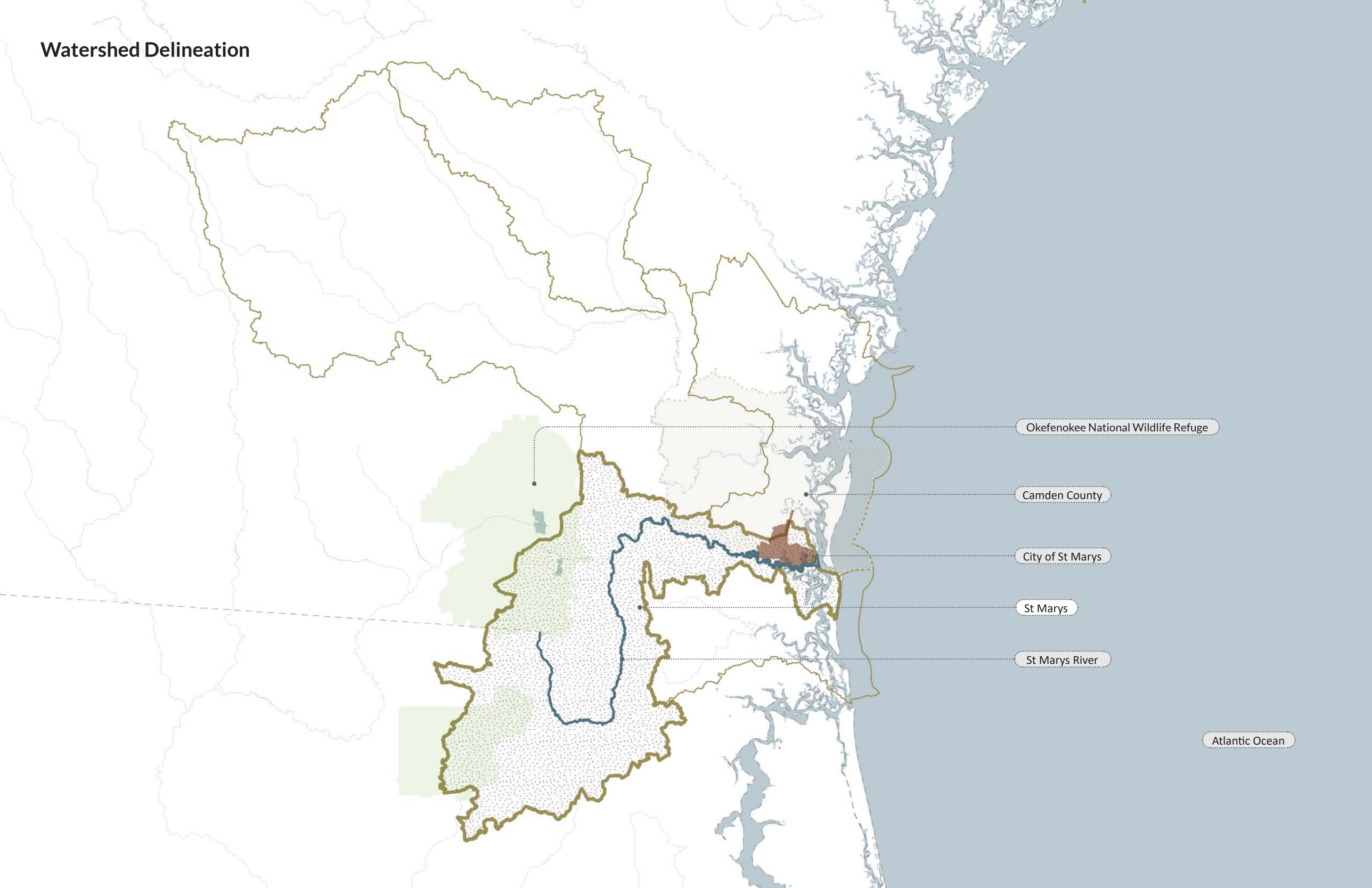
Watershed Delineation



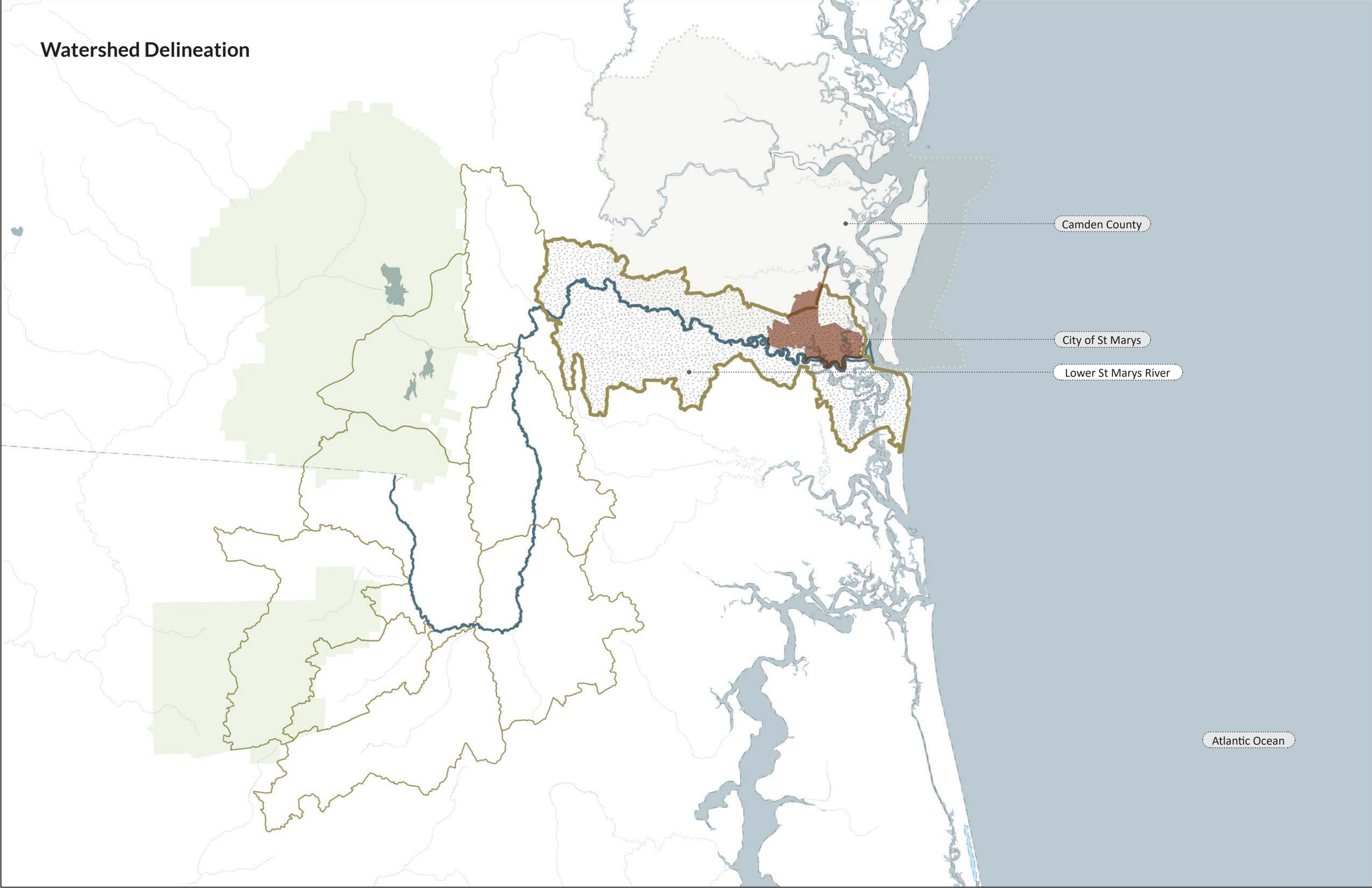
Watershed Delineation



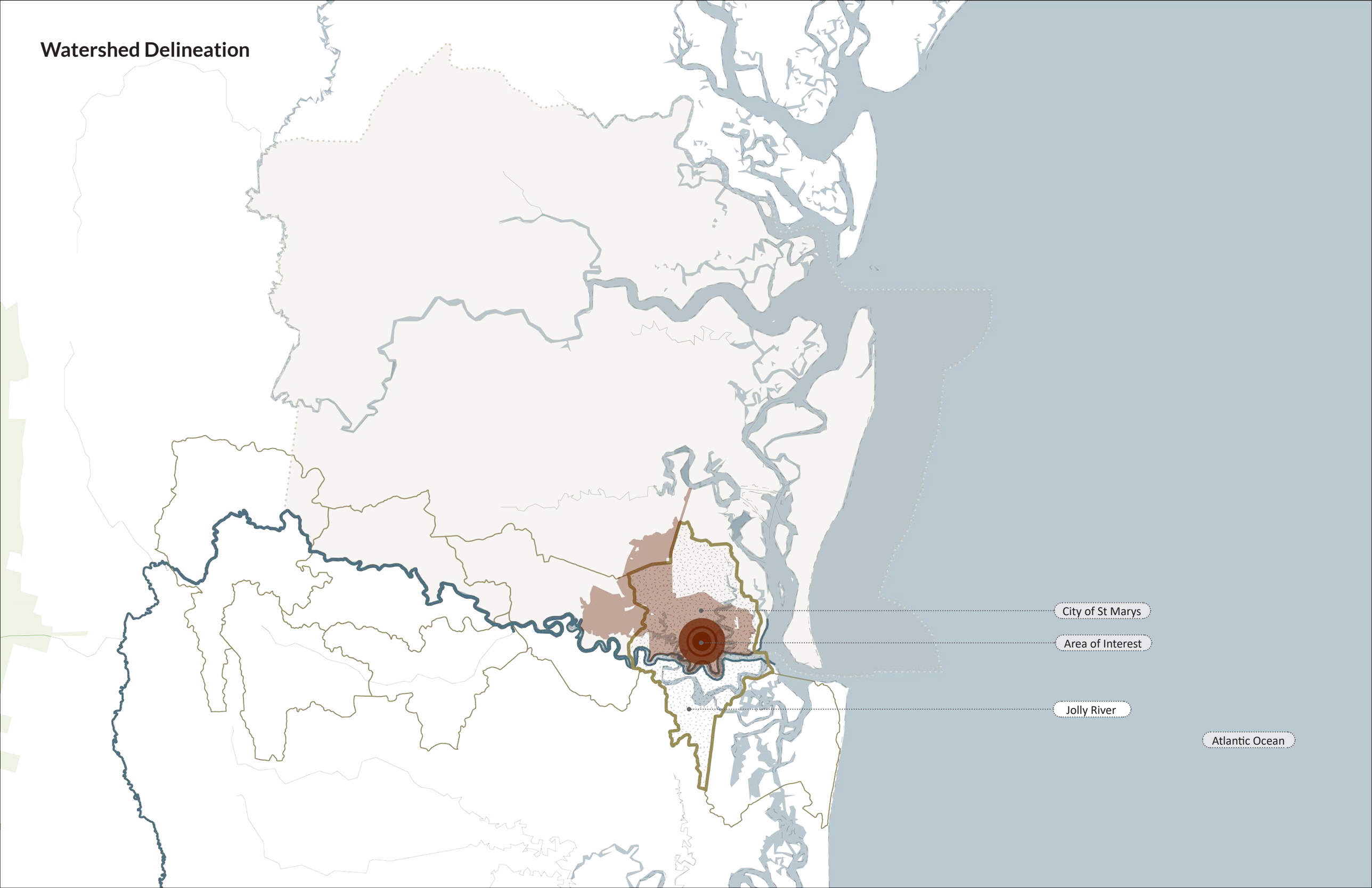
Watershed Delineation



Watershed Delineation



Watershed Delineation



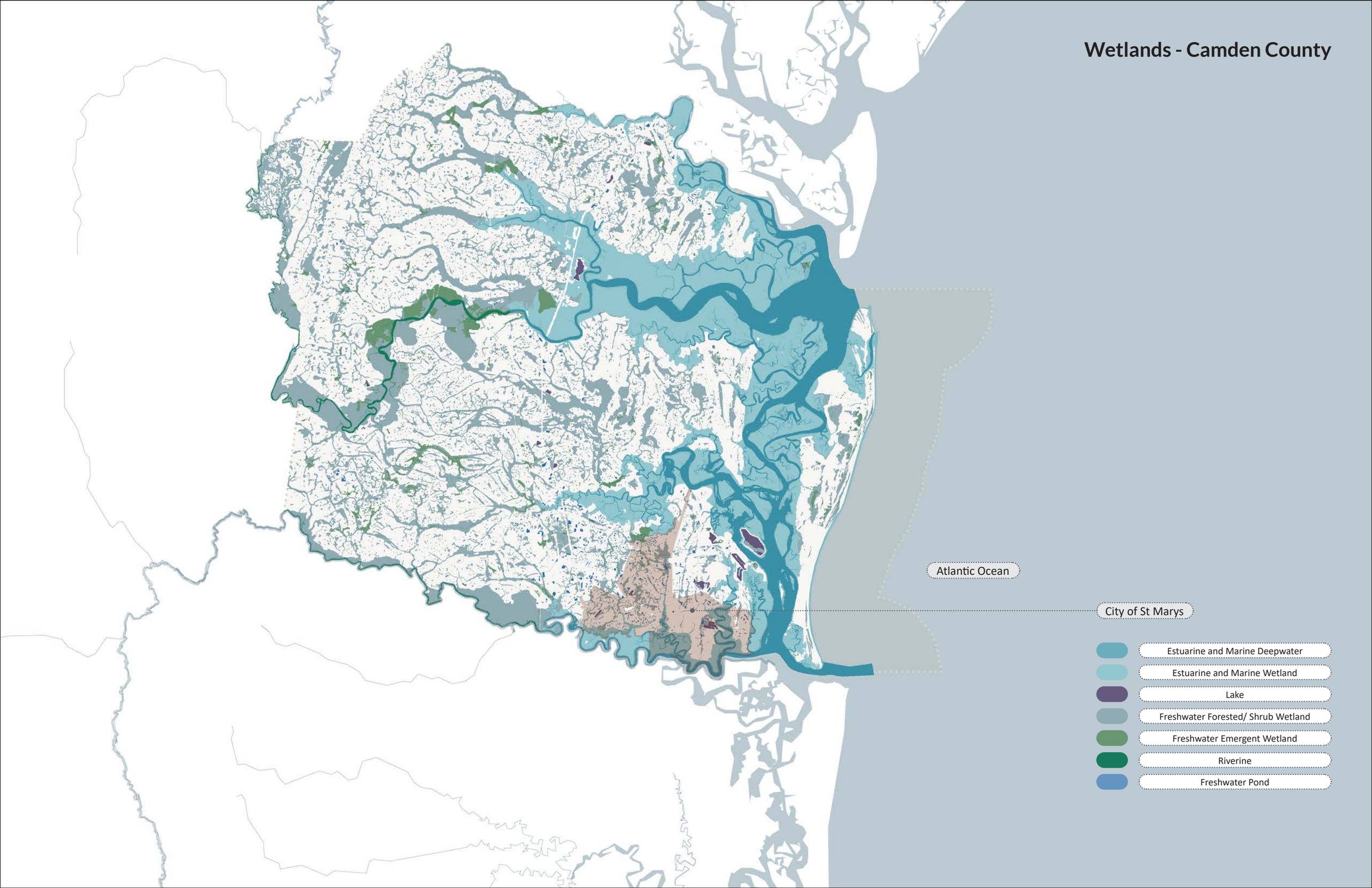
Watershed Delineation

It is noteworthy that none of the political boundaries coincide with the watershed boundaries. The St. Marys River, originating from the Okefenokee National Wildlife Refuge, serves as a natural political border between Georgia and Florida. The city of St. Marys lies within the Jolly River Watershed, positioned just north of the St. Marys River, before the river flows into the Atlantic Ocean.

Wetlands - Camden County

Wetlands constitute approximately 40% of the land area in Camden County, with the majority comprising estuarine and marine ecosystems. These marine wetlands prominently line the southern edge of the city.

Wetlands - Camden County



Special Flood Hazard Area - Camden County

A Special Flood Hazard Area (SFHA) is a designated region identified by the Federal Emergency Management Agency (FEMA) as being at high risk for flooding. These areas are typically located within the 100-year floodplain, meaning they have at least a **1% annual chance of flooding** in any given year.

SFHAs are marked on FEMA's Flood Insurance Rate Maps (FIRMs) and are subject to specific building regulations and insurance requirements to mitigate flood risk. Property owners in these areas are often required to purchase flood insurance if their properties are financed through federally regulated or insured lenders.

These floods often result from the overflow of existing canals and rivers. A significant portion of the Jolly River watershed, to which the city belongs, is highly susceptible to flooding.

Special Flood Hazard Area - Camden County

Atlantic Ocean

City of St Marys

Area of Interest

Jolly River

FEMA 100 year floodplain

City of St Marys

St. Marys is located along the banks of the St. Marys River, where it flows into the Atlantic Ocean. As both a riverine and coastal city, it is vulnerable to riverine and coastal flooding, as well as the impacts of sea level rise.

City of St Marys

Downtown

St Marys River

Special Flood Hazard Area - St Marys

The southern and eastern edges of the city, particularly in much of the downtown area, are highly prone to flooding. Additionally, areas surrounding existing, covered, or encroached canals and wetlands face significant flood risks.

Special Flood Hazard Area - St Marys

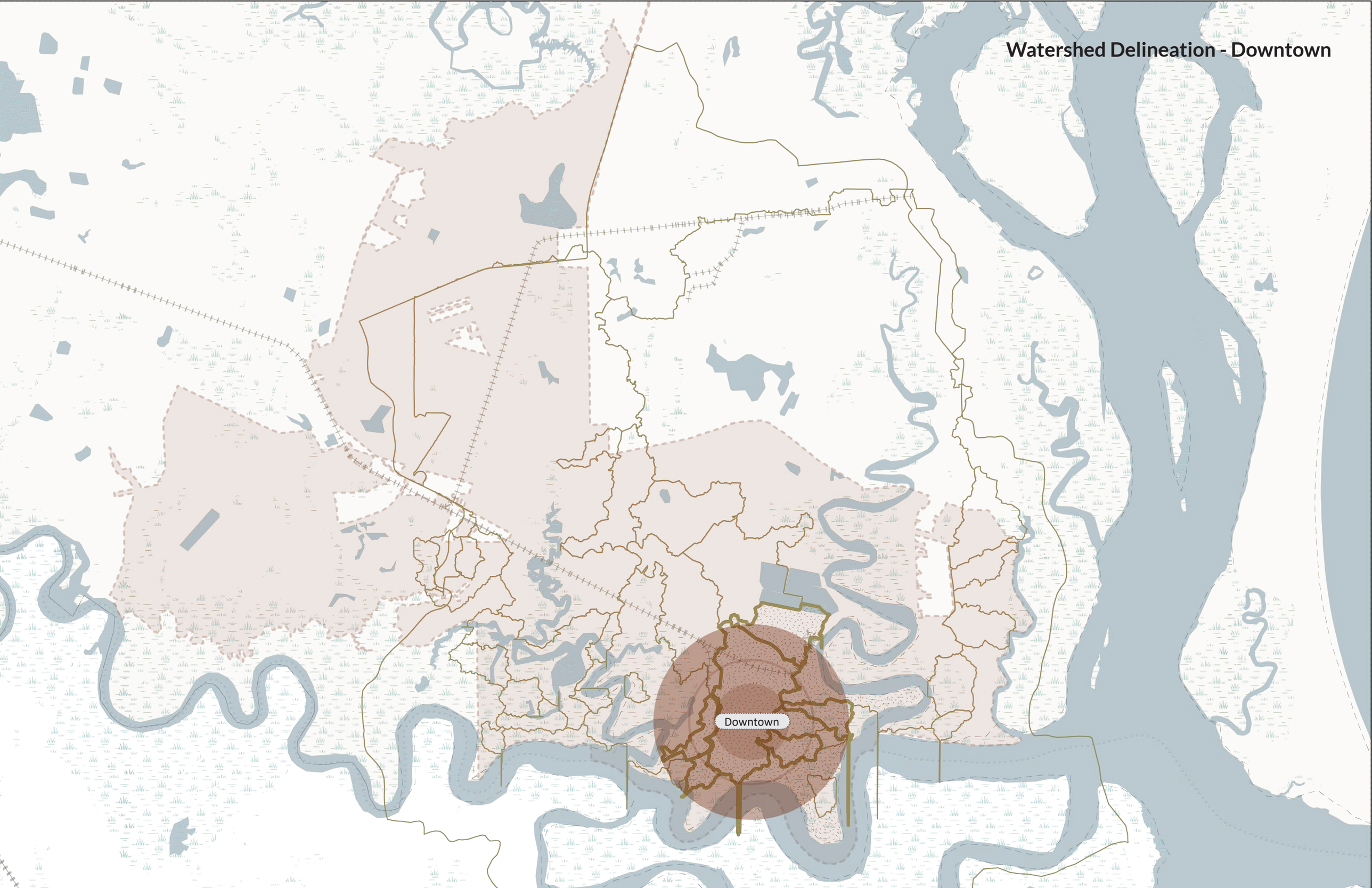
Downtown

FEMA 100 year floodplain

Watershed Delineation - Downtown

The Jolly River watershed can be further divided into sub-watersheds, one of which encompasses most of the downtown area. In this sub-watershed, water is primarily drained into the St. Marys River.

Watershed Delineation - Downtown



Existing Parcels - Downtown

The existing parcels and the boundaries of the historic district are illustrated in this diagram. The main spine, Bartlett Street, features several civic spaces, including St. Marys Park, Remembrance Park, and Oak Grove Cemetery, as well as vacant plots of land. Downtown connects to the rest of the city via Osborne Road, which transitions into Osborne Street, St. Marys Street, and Dilworth Street, forming a loop that reconnects to Osborne Road. Additionally, a railroad terminates and loops around the northern edge of Downtown. The predominant land uses in this area are civic, residential, and commercial.

Existing Parcels - Downtown



Existing Green Spaces - Downtown

The spine is lined with numerous civic parks and vacant plots of land. It serves as a key connector, linking the civic park to the St. Marys River to the south.

Existing Green Spaces - Downtown



Topography - Downtown

The land slopes downward as it approaches the river, with a noticeable dip in the topography around the spine. This low-lying area is highly susceptible to flooding.

Topography - Downtown

12ft

10ft

4ft

8ft

6ft

6ft

-5ft to 1ft
2ft to 9ft
10ft to 16ft
17ft to 24ft
25ft to 31ft
32ft - 38ft
39ft - 46ft
47ft to 53ft
54ft to 61ft
62ft to 68ft

Soil Types - Downtown

Downtown is characterized by poorly drained soil and a high water table, which can result in waterlogging and stagnation in this part of town. This condition can also lead to groundwater subsidence, which refers to the gradual sinking or settling of the ground surface due to the removal or depletion of water from the soil or aquifers.

Soil Types - Downtown

Ru - Rutlege Fine Sand (poorly drained)

BO - Bohicket Caper association (very poorly drained)

CaB - Cainhoy Fine Sand (excessively drained)

Po - Pottsburg Sand (somewhat poorly drained)

Ma - Mandarin fine sand (somewhat poorly drained)

Special Flood Hazard Area (FEMA) - Downtown

FEMA flood maps divide areas into various zones to represent different levels of flood risk. It also has a BFE along with it. The spine has a **Base Flood Elevation** (BFE) of 9 feet. (Base Flood Elevation refers to the computed elevation to which floodwater is anticipated to rise during a base flood, typically associated with a 1% annual chance of flooding in a given area.) As the spine moves closer to the river, the BFE increases significantly, reflecting the heightened flood risk in these areas.

Special Flood Hazard Area (FEMA) - Downtown

ZONE AE
(EL 9)

ZONE AE
(EL 11)

ZONE AE
(EL 12)

ZONE AE
(EL 10)

ZONE AE
(EL 9)

ZONE AE
(EL 11)

ZONE AE
(EL 10)

ZONE AE
(EL 10)

ZONE AE
(EL 12)

Static BFE

-62ft to 0ft

0ft to 8ft

8ft to 10ft

10ft to 12ft

12ft to 19ft

Sea Level Rise - Downtown

This diagram shows the effects of 2ft, 4ft, and 7ft of Sea Level Rise. It is clear that the edges of Downtown and the area around the Spine have high chances of inundation due to Sea Level Rise.

Sea Level Rise - Downtown

2ft
4ft
7ft

Flood Risk - 7ft SLR + 100 year floodplain

Juxtaposing Sea Level Rise and the 100 year floodplain, we see that most of the flood risk areas have an overlap.

Flood Risk - 7ft SLR + 100 year floodplain

100 year floodplain

7ft SLR

1936: Development on Wetlands - Historical Evolution

The following maps illustrate the evolution of Downtown, with a focus on the area around the spine that is at high risk of flooding. Early developments reveal traces of the historic district beginning to take shape, while the railroad forms a complete loop around Downtown. Additionally, the maps indicate clear signs of a wetland in what is now the spine, highlighting the area's natural hydrological features before urbanization.

35'

ATLANTIC, WAYCROSS AND NORTHERN

20

10

10

10

10

30

50

Burnt Pine Creek

North River

ST MARYS
(BM II)

GEORGIA
FLORIDA

ST MARYS RIVER

Rose

Pt Pe

EDEP, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, US
NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, NPS, US Census Bureau, USDA, USFWS

1958: Development on Wetlands - Historical Evolution

By 1958, the western parts of Downtown began to see significant development. Osborne Road had evolved into a loop encircling Downtown, creating a more defined and accessible urban framework for the area.

1958: Development on Wetlands - Historical Evolution



1979: Development on Wetlands - Historical Evolution

Developments slowly start encroaching the central wetland area around the Spine

1979: Development on Wetlands - Historical Evolution

(TOPOGR

T (GA.) 44 35′ 45 KINGSLAND 13 KM. SCOTCHVILLE 4.8 KM. 4645 I SE (HARRIETTS BLUFF) 47 32′30″ 49 50

Water Tank

St Marys Airport

POINT PETER RD

LEVEE

Industrial Waste Ponds

LEVEE

NORTH

POINT PETER

Cr

Dark Entry

ST MARYS

Westside Ch

Calvary Ch

CREEK

Cem

ROAD

Park

ST MARYS

Gilman Hospital

RIVER

Burrill

Oak Grove Cem

Boat Ramp

St Marys

CORPORATE

GEORGIA

FLORIDA

Saint

Light

BOUNDARY

Light

RIVER

Point Peter

Roses

Bluff

FDEP, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community

2014: Development on Wetlands - Historical Evolution

The wetland is fully encroached and the Spine begins to form with developments around it

2014: Development on Wetlands - Historical Evolution

35'
32'30"
490000 FEET (FL)
444
445
446
447
448
449
450
Riverview
Saint Marys Airport
Dark Entry Creek
W RIVERVIEW DR
S JULIA ST
DEVON DR
PARK ST
MILLER ST
S DANDY ST
BOWEN ST
POINT PETER RD
N ST
SEAGROVE ST
N OSBORNE ST
OSBORNE RD
GUNTER ST
NANCY DR
BORRELL BLVD
ST. MARYS
W GALLOP ST
BARTLETT ST
E MEETING ST
W HALL ST
ANNE ST
MAHAN ST
W CHURCH ST
READY ST
NORRIS ST
DILWORTH ST
MARGARET ST
BAILEY ST
WHEELER ST
W CONYERS ST
OSBORNE ST
Oak Grove Cem
CUMBERLAND ISLAND NATIONAL SEASHORE
GEORGIA
FLORIDA
CAMDEN CO
NASSAU CO
CUMBERLAND SOUND FRY
FLORIDA
GEORGIA
Burrells Creek
Bells River
Roses
North River
Cypress Lake Estates
CYPRESS LN
POWDER HORN RD
NEW POINT PETER RD
NEAP TIDE LN
Lands End
Millers Bluff
TEATHER DR
ANCHOR WAY
COBIA LN
CLUBHOUSE
CAMPBELL PKY
STOREY AVE
BECKET RD
Point Peter
CUMBERLAND
20
40
60
10
50

FDEP, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community

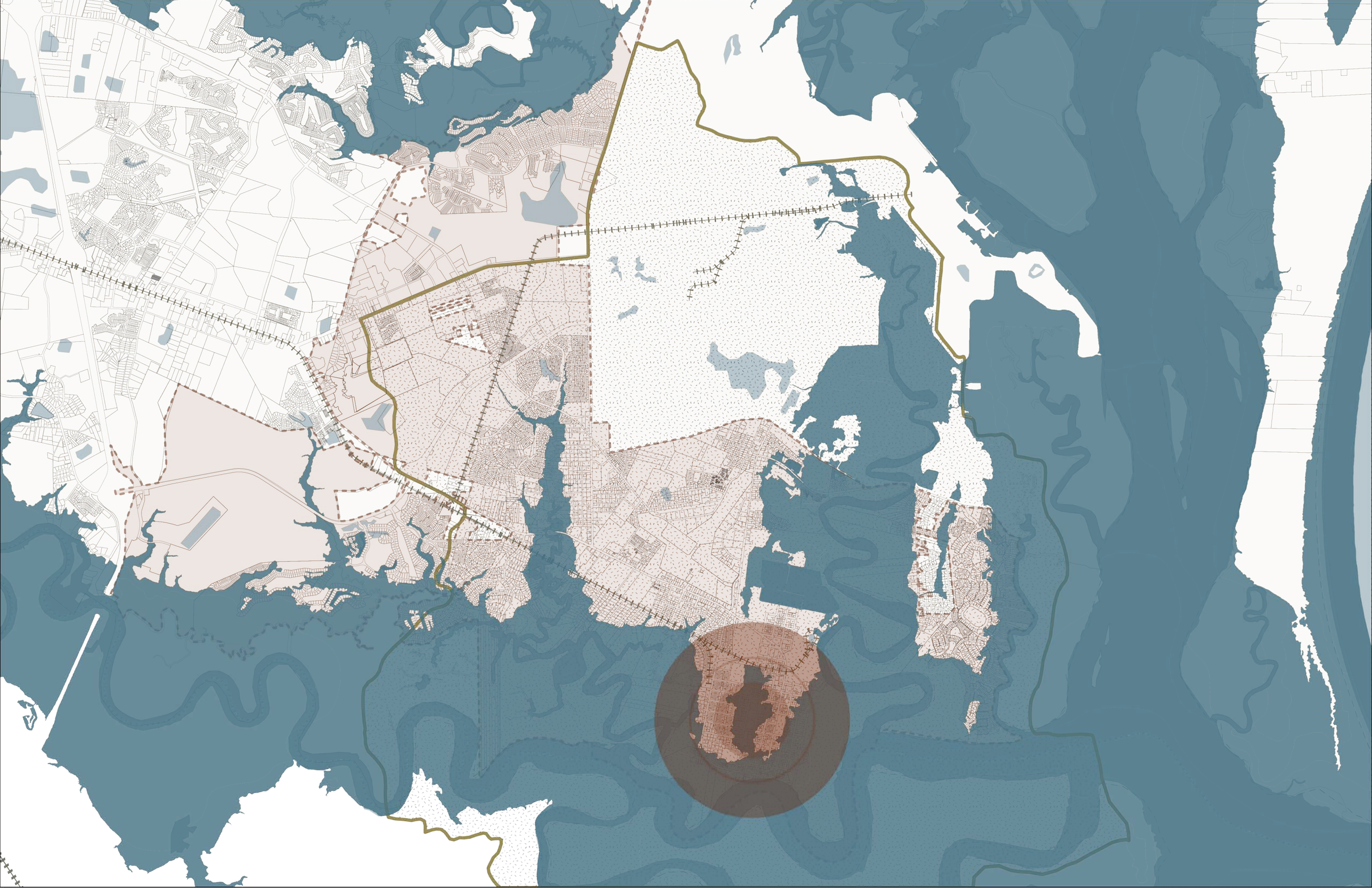
4. Toolkit for St Marys

With the gathered information about St. Marys and in-depth case studies of green infrastructure from around the world, we can develop strategies to protect the city from impending floods. This section of the report proposes the creation of a toolkit offering recommendations at various scales across St. Marys. Additionally, a catalog of tailored solutions will be developed, allowing stakeholders to select and implement strategies specific to the city's needs.

The report examines solutions at multiple urban scales—city, neighborhood, block, street, and site—and identifies appropriate locations to demonstrate these recommendations. While the suggestions provided are not definitive solutions due to the complexity of factors such as culture, economics, and political considerations (which fall beyond the scope of this study), this catalog still holds significant value. It offers context-specific strategies that address St. Marys' unique challenges.

By providing a comprehensive yet adaptable set of recommendations, this effort aims to establish a foundation for implementing flood-resilient measures throughout the city.

CITY/ REGION - Existing



CITY/ REGION - Adapt

SECONDARY CHANNEL

DEEPENING/ WIDENING CANALS

RELOCATE TO HIGH GROUND

HIGH GROUND

1. **Relocate** existing vulnerable areas to higher ground (onto the Planned Development zones)

2. **Deepening/ Widening existing canals** - identifying water channels

3. **Room for the River - secondary channels** that tie back to the main river slowing down the water and forming recreational islands

High Ground

Widening/ deepening canals

Secondary channel

Recreational islands

CITY/ REGION - Defend

INNER DYKE

OUTER DYKE

POLDERS

1. **Inner and Outer Dyke approach:** berms/ levees/ natural floodwalls along vulnerable coastlines acting as an inner primary defense and an outer secondary (lower) defense

2. **Polders** - protect the historic district in Downtown

3. **Dam/ Floodgate** located at the mouth of the river slows down water and controls flooding at the time of storm surges (like Maeslantkering in Netherlands)

Dam/ Floodgate

CITY/ REGION - Reserve

LIVING SHORELINE

MARSH MIGRATION

MARSHLANDS

1. **Living shoreline** - protects and stabilizes the coastline using soft solutions, integrating vegetation and sediments (could be the secondary layer of defense as part of the inner dyke)

2. **Provide space for inland marsh migration**

3. **Preserve existing marshland**

CITY/ REGION - Drain

PUMPS & PUMP STATIONS

DIRECTION OF WATER FLOW

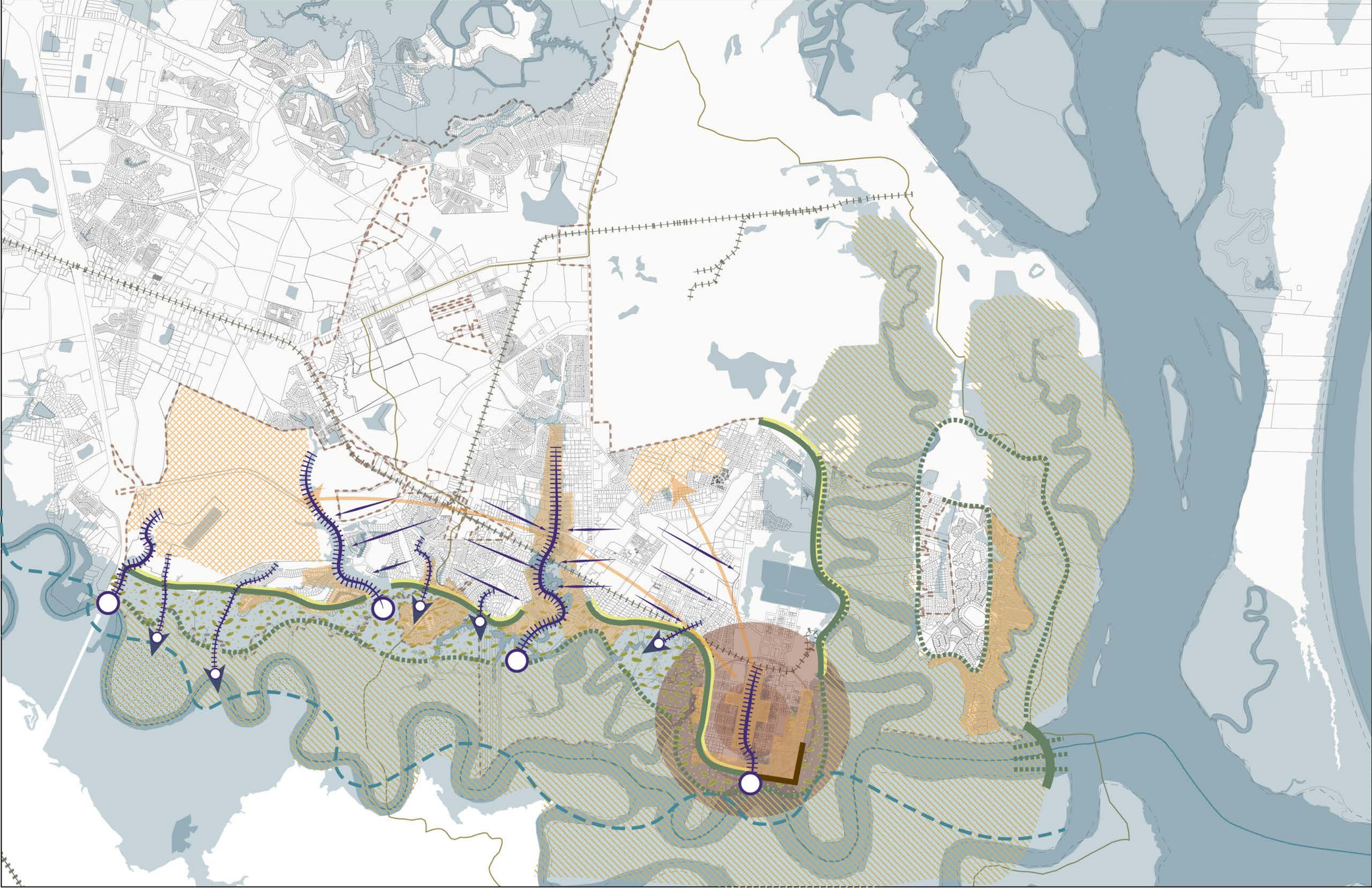
WATERSHED

1. **Pumps and pump stations** at the mouths of the canals help drain any excess water back into the river

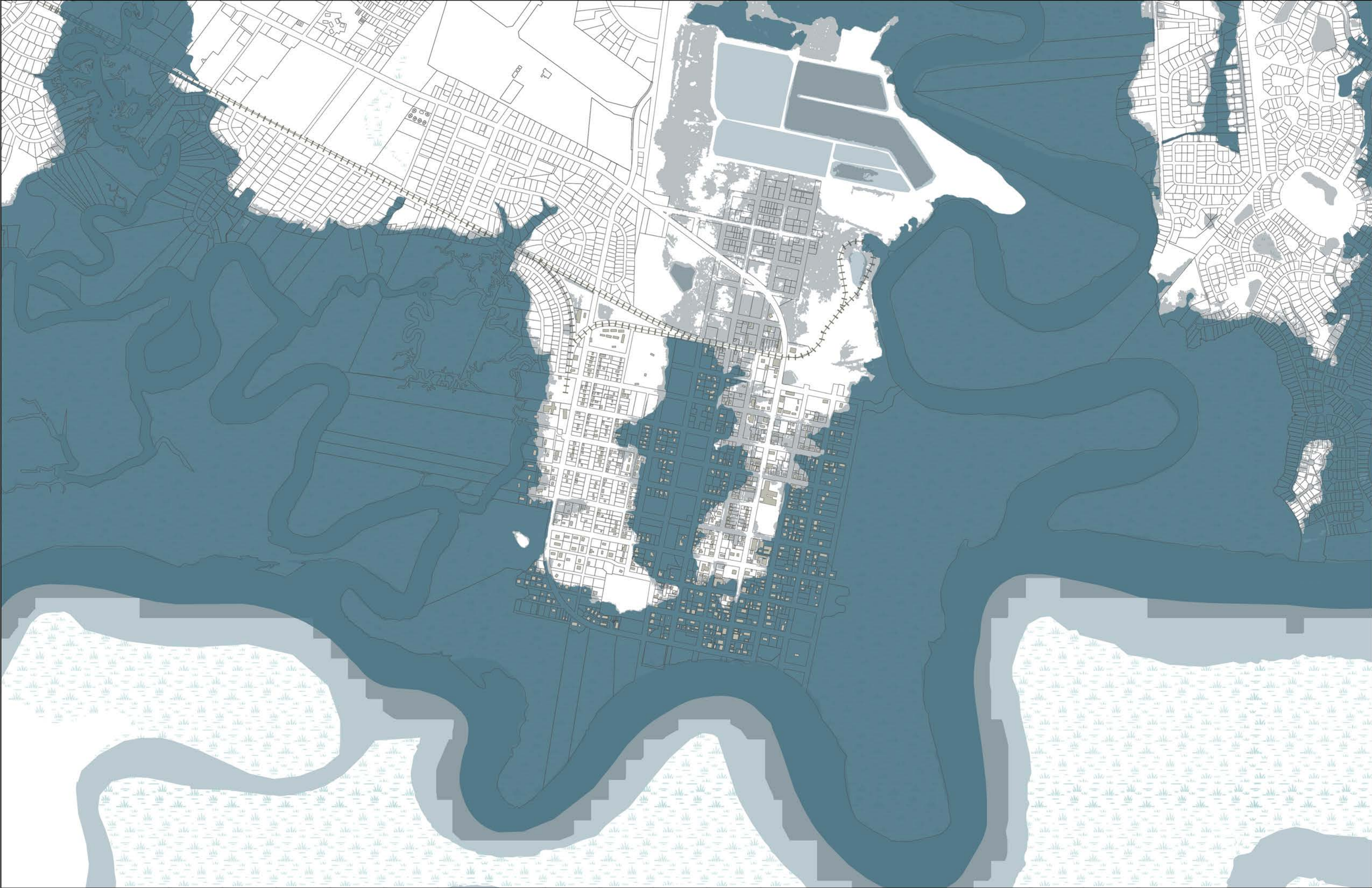
2. **Watershed approach:** decentralised solution to draining cities that mimicks natural hydrology reducing flood risks

3. Direct drainage towards existing canals**, which channel the water into the river.**

CITY/ REGION - Proposed



NEIGHBORHOOD - Existing



NEIGHBORHOOD - Adapt

SECONDARY CHANNEL

DEEPENING/ WIDENING CANALS

RELOCATE TO HIGH GROUND

HISTORIC DISTRICT

ELEVATE INFRASTRUCTURE

1. **Relocate** existing vulnerable areas to higher ground (onto the Planned Development zones)

2. **Deepening/ Widening existing canals** - identifying and widening the existing water channel to make more space for water (BLUEWAY/ CANAL PARK)

3. **Room for the River - secondary channels** that tie back to the main river slowing down the water and forming recreational islands

Secondary channel

Recreational islands

NEIGHBORHOOD - Defend

INNER DYKE

OUTER DYKE

ELEVATED ROADWAYS

POLDERS

PROTECTIVE LEVEE

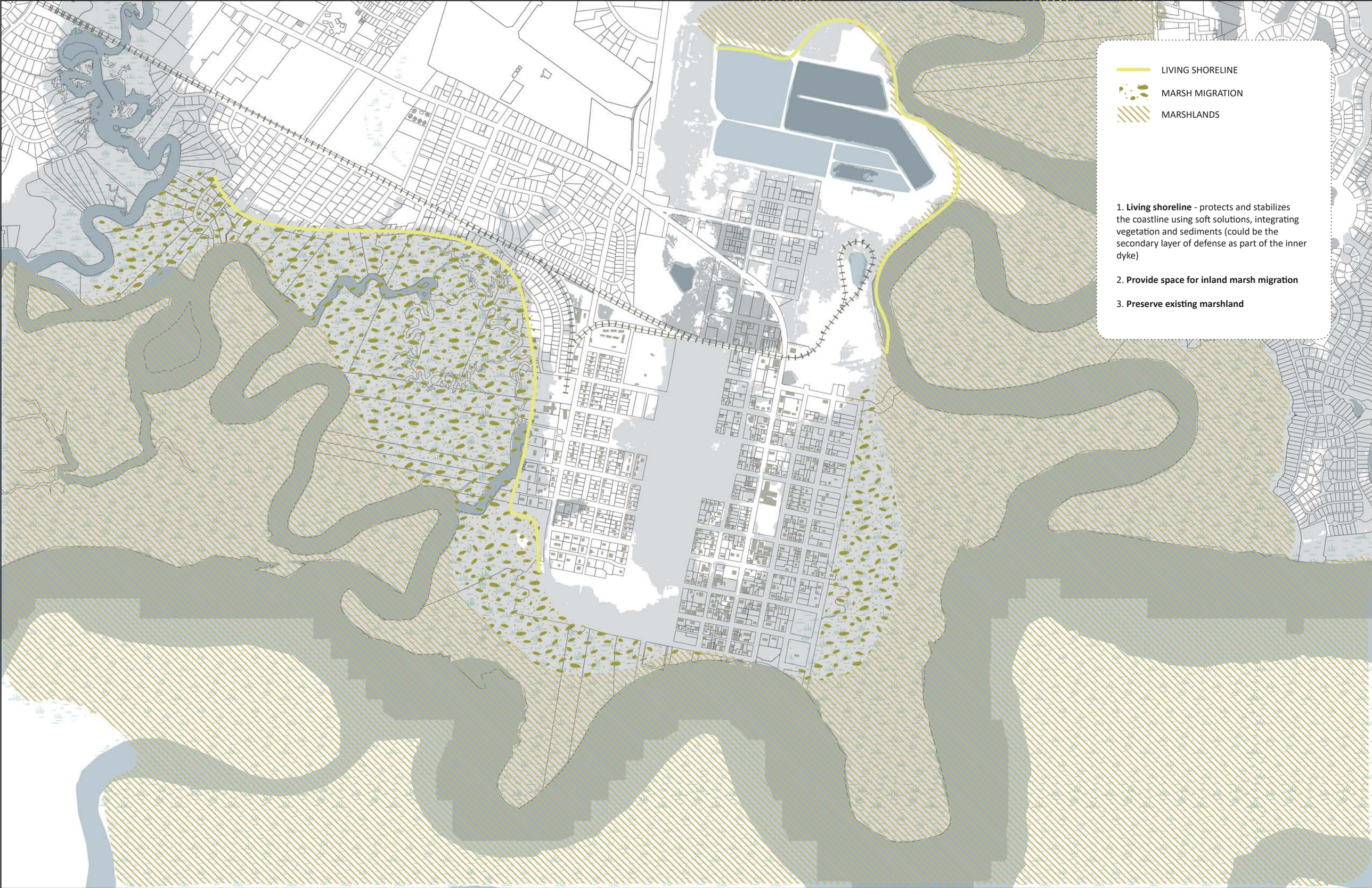
1. **Inner and Outer Dyke approach:** berms/ levees/ natural floodwalls along vulnerable coastlines acting as an inner primary defense and an outer secondary (lower) defense

2. **Polders** - low lying land surrounded by dykes protecting the Historic District

3. **Elevated Roadways -** Streets at the edge of the historic district elevated to protect the neighborhood

4. **Protective levee** - surrounding the lowest lying area (land around the existing canal) with a natural emabankment

NEIGHBORHOOD - Reserve


LIVING SHORELINE
MARSH MIGRATION
MARSHLANDS
1. **Living shoreline** - protects and stabilizes the coastline using soft solutions, integrating vegetation and sediments (could be the secondary layer of defense as part of the inner dyke)
2. **Provide space for inland marsh migration**
3. **Preserve existing marshland**

NEIGHBORHOOD - Slow

PROTECTIVE LEVEE

1. **Minor regrading of the topography** such that it slopes down gradually towards the river

2. **Braided Channel -** retains existing canal as main channel, distributes and slows down water collected due to storm surge and sea level rise directing water back into the river

3. **Riparian Buffer -** Trees and landscape on the sloping levee along the boundary of the park slows down water

4. **Surface Vegetation** - Trees and other vegetation in the park help slow down water

Riparian Buffer

Braided Channel

Strategic Parkland

Trees & Surface vegetation

NEIGHBORHOOD - Soak-Store

PROTECTIVE LEVEE

1. **Retention Pond -** a pond at the lowest part of the terrain as well as a series of other smaller ponds acts as storage basins during times of intense rainfall and storm surge

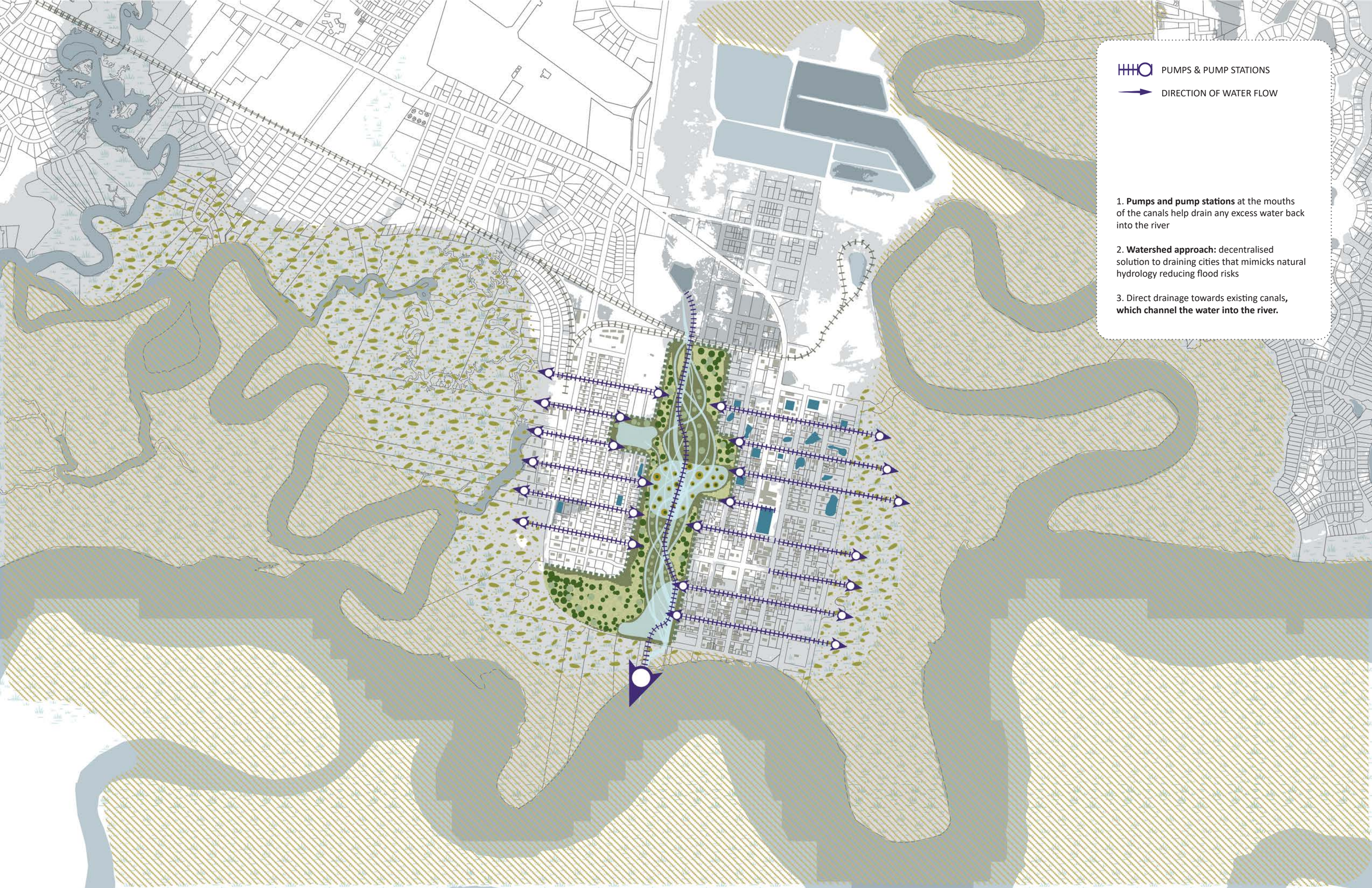
2. **Mounded islands -** tilled islands with rich landscape and vegetation not only support wildlife but also help sink water into the ground

3. **Storage lots -** water storage opportunities in lots in terms of retention basins, parking lots and water plaza

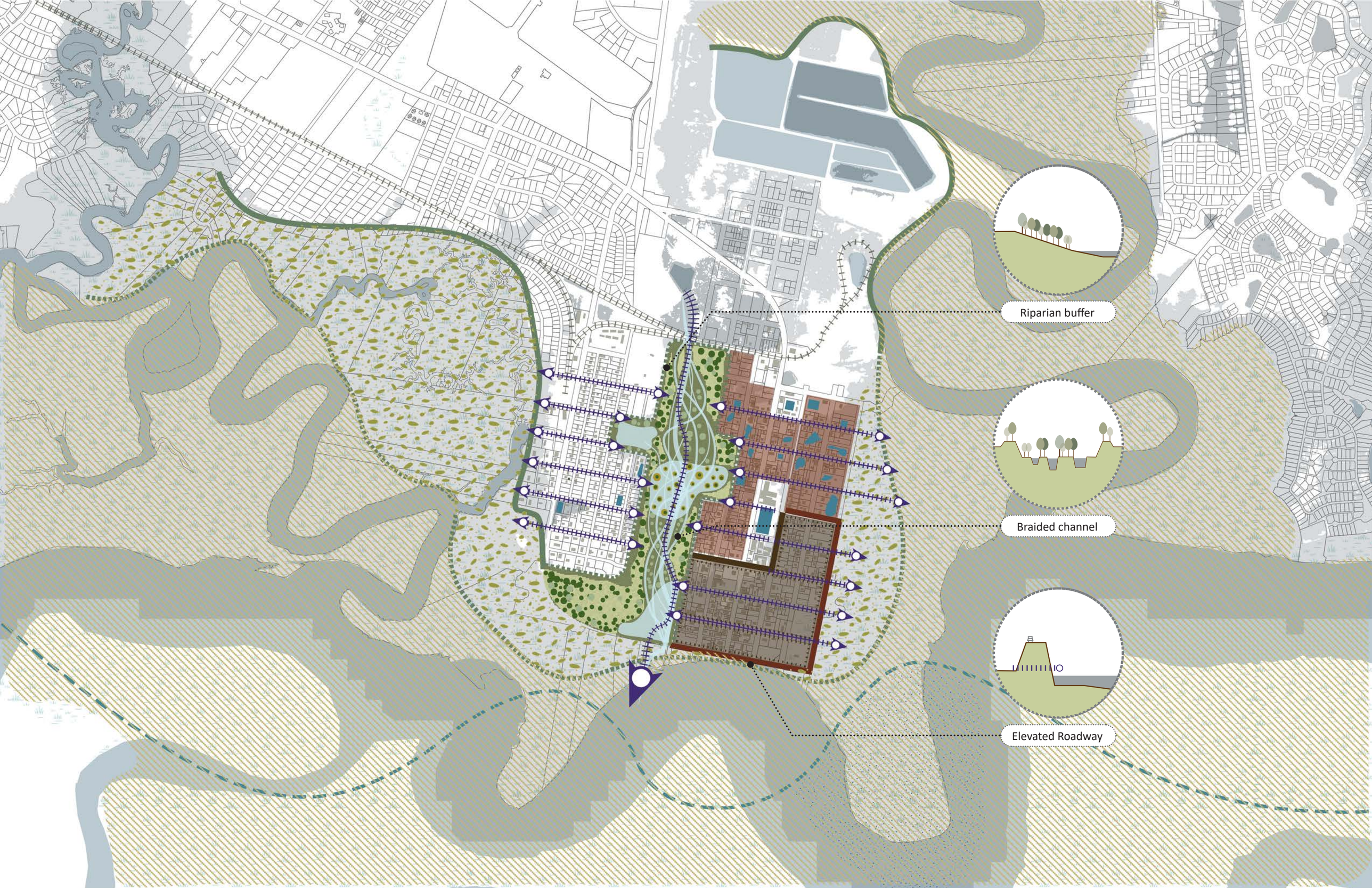
Water plaza/ retention ponds/ undergroud storage

Mounded islands

NEIGHBORHOOD - Drain


PUMPS & PUMP STATIONS
DIRECTION OF WATER FLOW
1. **Pumps and pump stations** at the mouths of the canals help drain any excess water back into the river
2. **Watershed approach:** decentralised solution to draining cities that mimicks natural hydrology reducing flood risks
3. Direct drainage towards existing canals**, which channel the water into the river.**

NEIGHBORHOOD - Proposed


Riparian buffer
Braided channel
Elevated Roadway

BLOCKS- Existing



BLOCKS- Slow

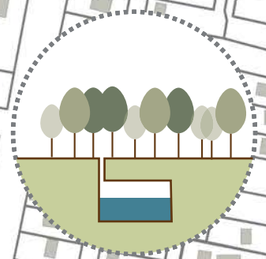
Surface vegetation and Pocket Parks on vacant and undertilsed lots help slow down water and prevents erosion



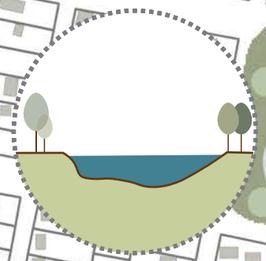
Pocket Park

BLOCKS- Soak-Store

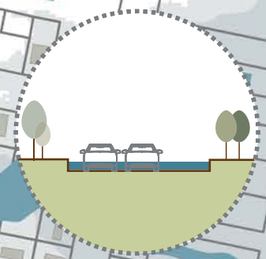
Water retaining features like retaining ponds, subsurface storage, underutilised parking lots and water plaza help store and soak in water



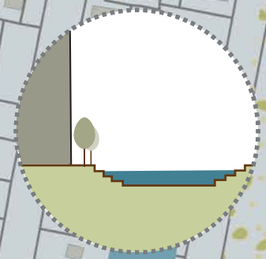
Subsurface storage



Retention pond



Parking lot as water storage



Water Plaza



Pocket Park

BLOCKS- Drain

1. **Water shed approach**: Direct drainage away from the ridge towards the canal park**, (which channels the water into the river) and the wetlands**

2. French drains and catch basins **help control stromwater and soak the water into the soil**

Subsurface storage

Retention pond

Catch basin

French drain

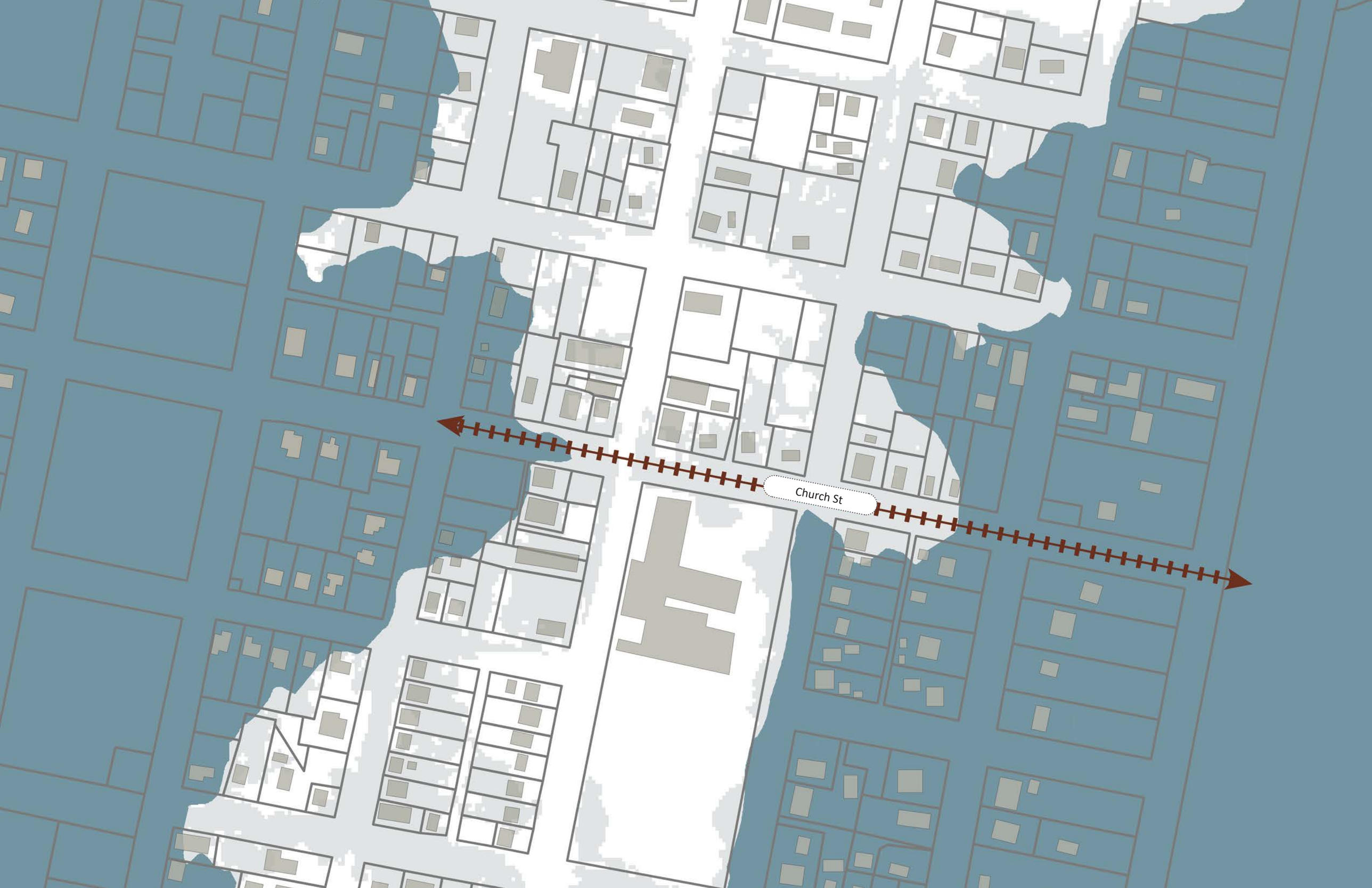
Ridge

Parking lot as water storage

Water Plaza

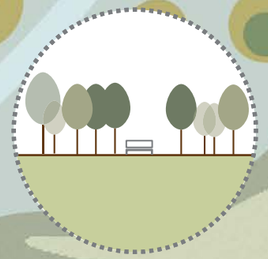
Pocket Park

STREET- Existing

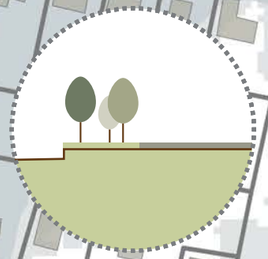

Church St

STREET- Slow

Surface vegetation and Planting strips on sidewalks help slow down water and prevents erosion

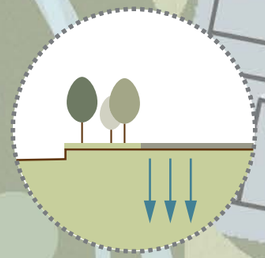


Pocket Park

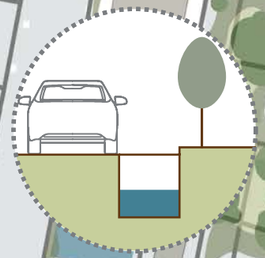


Planting strip

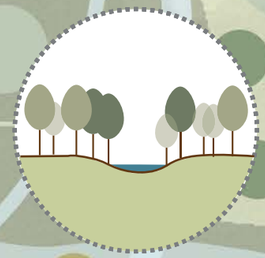
STREET- Soak-Store



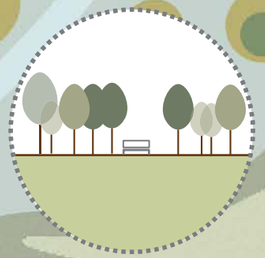
Permeable pavement



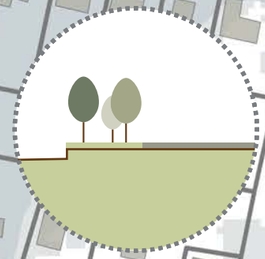
Subsurface storage



Bioswale/ Rain garden



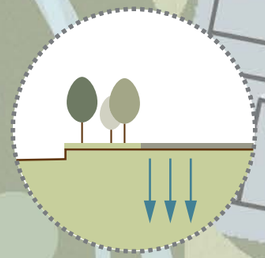
Pocket Park



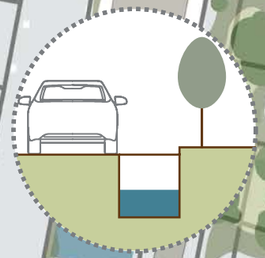
Planting strip

Water retaining features like bioswales, rain gardens, permeable pavement, sub-surface storage etc. store and soak in water

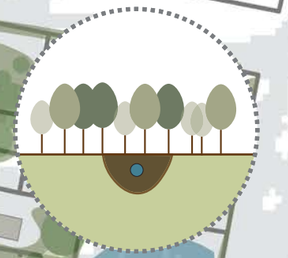
STREET- Drain



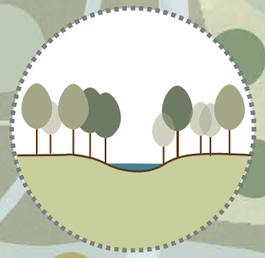
Permeable pavement



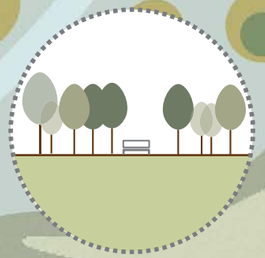
Subsurface storage



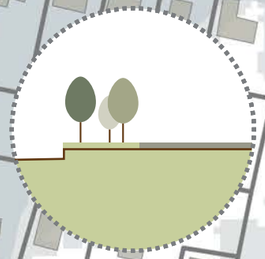
French drains



Bioswale/ Rain garden



Pocket Park



Planting strip

1. **Water shed approach**: Direct drainage away from the ridge towards the canal park**, (which channels the water into the river) and the wetlands**

2. French drains and catch basins **help control stromwater and soak the water into the soil**

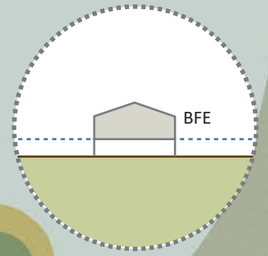
SITE- Existing

SITE - Existing

SITE- Adapt

SITE - Adapt

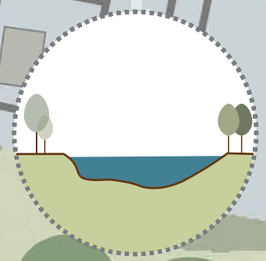
Elevating Infrastructure above the Base Flood Elevation (BFE) (10ft in this case), helps protect buildings against floods



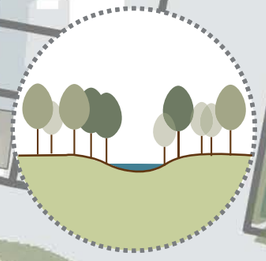
Elevated Infrastructure

SITE- Slow-Soak-Store

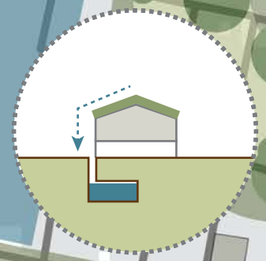
SITE - Slow-Soak-Store



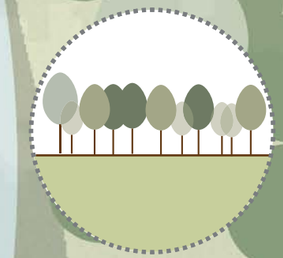
Retention Pond



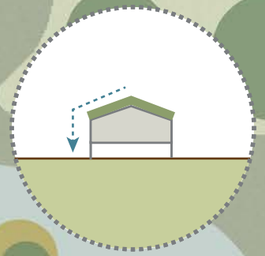
Bioswales/ rain gardens



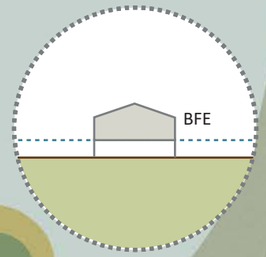
Rainwater Harvesting



Pocket Park



Green Roof



Elevated Infrastructure

Surface vegetation and Planting strips on sidewalks help slow down water and prevents erosion

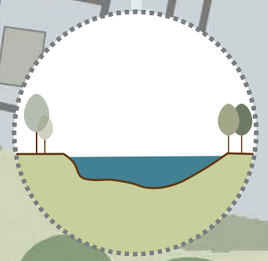
Water retaining features like bioswales, rain gardens, permeable pavement, sub-surface storage etc. store and soak in water

SITE- Drain

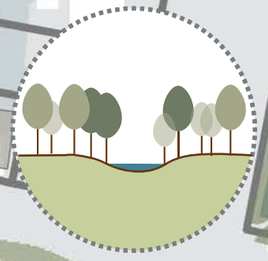
SITE - Drain

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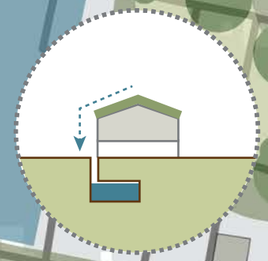
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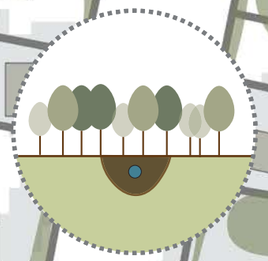
Retention Pond



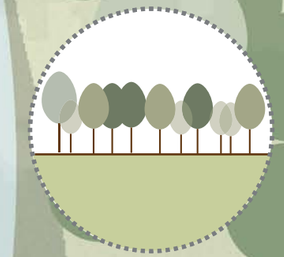
Bioswales/ rain gardens



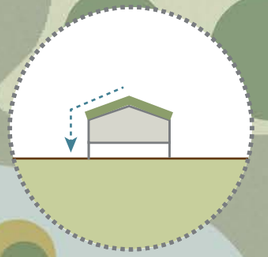
Rainwater Harvesting



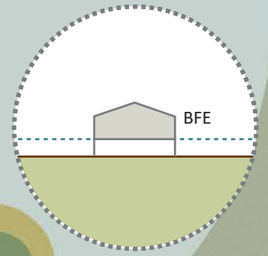
French Drain



Pocket Park



Green Roof



Elevated Infrastructure

Conclusion

Extrapolating the insights from global case studies to the context of St. Marys through a scale-wise approach results in a comprehensive catalog of tailored suggestions. This catalog provides strategies specific to St. Marys, taking the city one step closer to becoming flood-resilient.

The scale-wise approach not only organizes the recommendations systematically but also makes it easier for clients and stakeholders to identify, prioritize, and implement strategies that are most relevant and impactful. By enabling focused decision-making, this approach helps stakeholders execute solutions that address the city's most pressing flood-related challenges.

It is hoped that this report serves as a foundation for envisioning St. Marys as a flood-resilient city, inspiring further exploration and action to mitigate flood risks and adapt to future challenges.

Scalable Toolkit for Coastal Cities

Independent Study
Fall 2024

Mrudhulaa Ranganath