Dale Morris

Chief Resilience Officer and
Senior Advisor to the Mayor

morrisda@Charleston-sc-gov

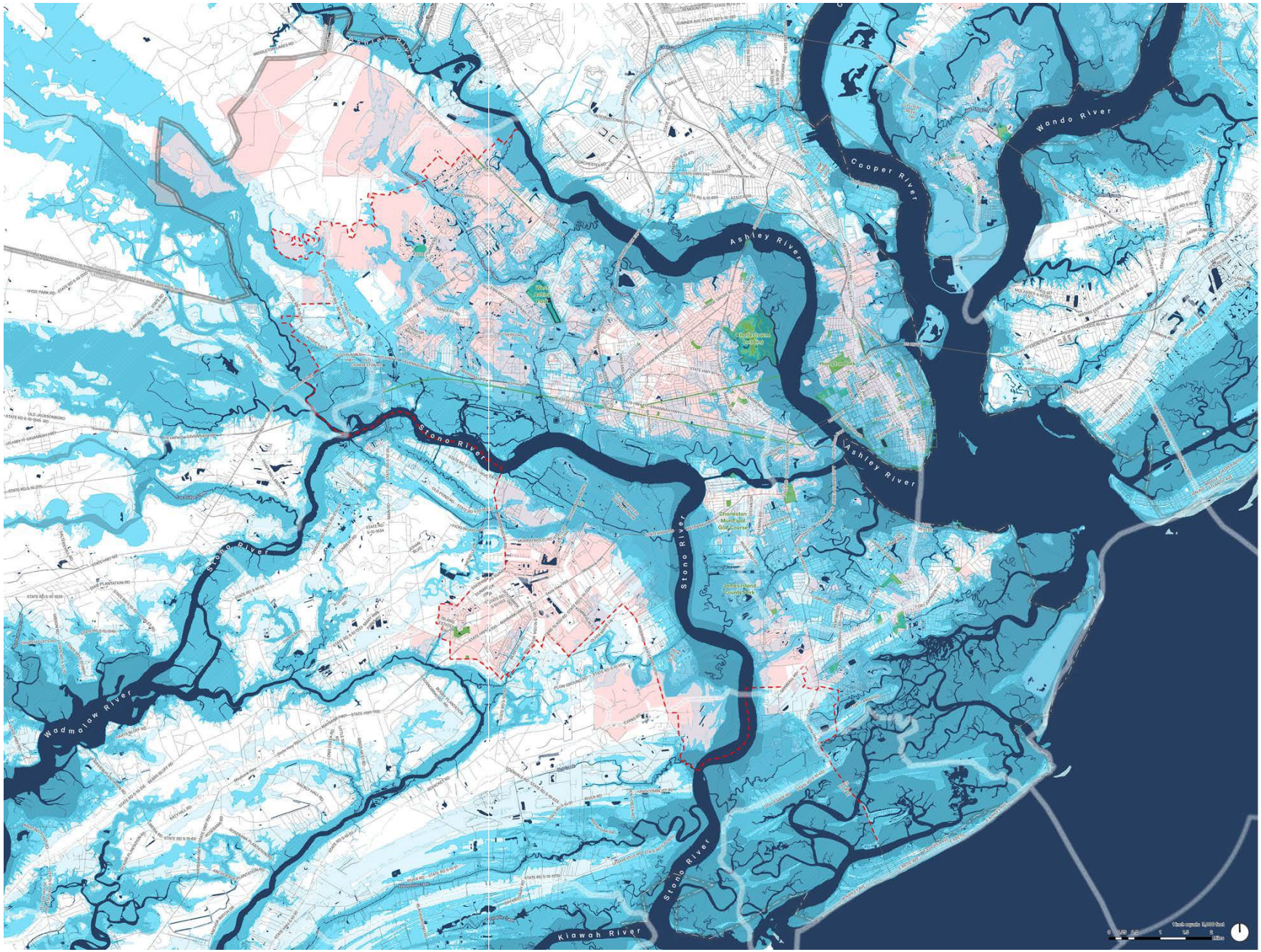
Resilience in Charleston

Peninsula Perimeter Protection

Tides and Sea Level Rise

Comprehensive, Integrated Water Plan

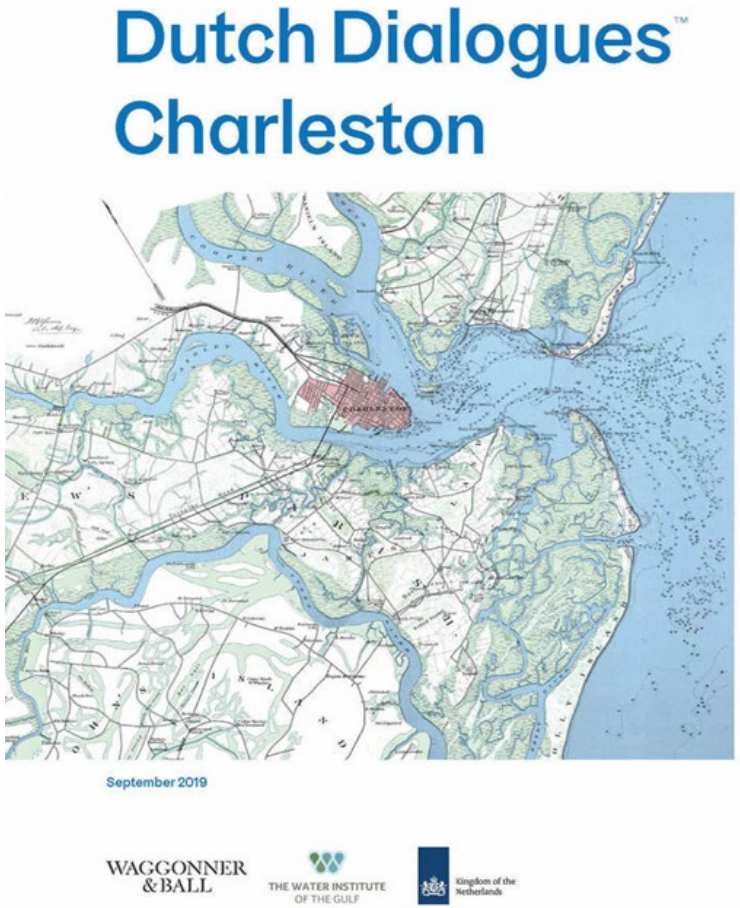
Heat Resilience


Wando River
Cooper River
Ashley River
Ashley River
Stono River
Stono River
Stono River
Stono River
Stono River
Wadmalaw River
Kiawah River

Dutch Dialogues Charleston, Adopted City Council, 2019

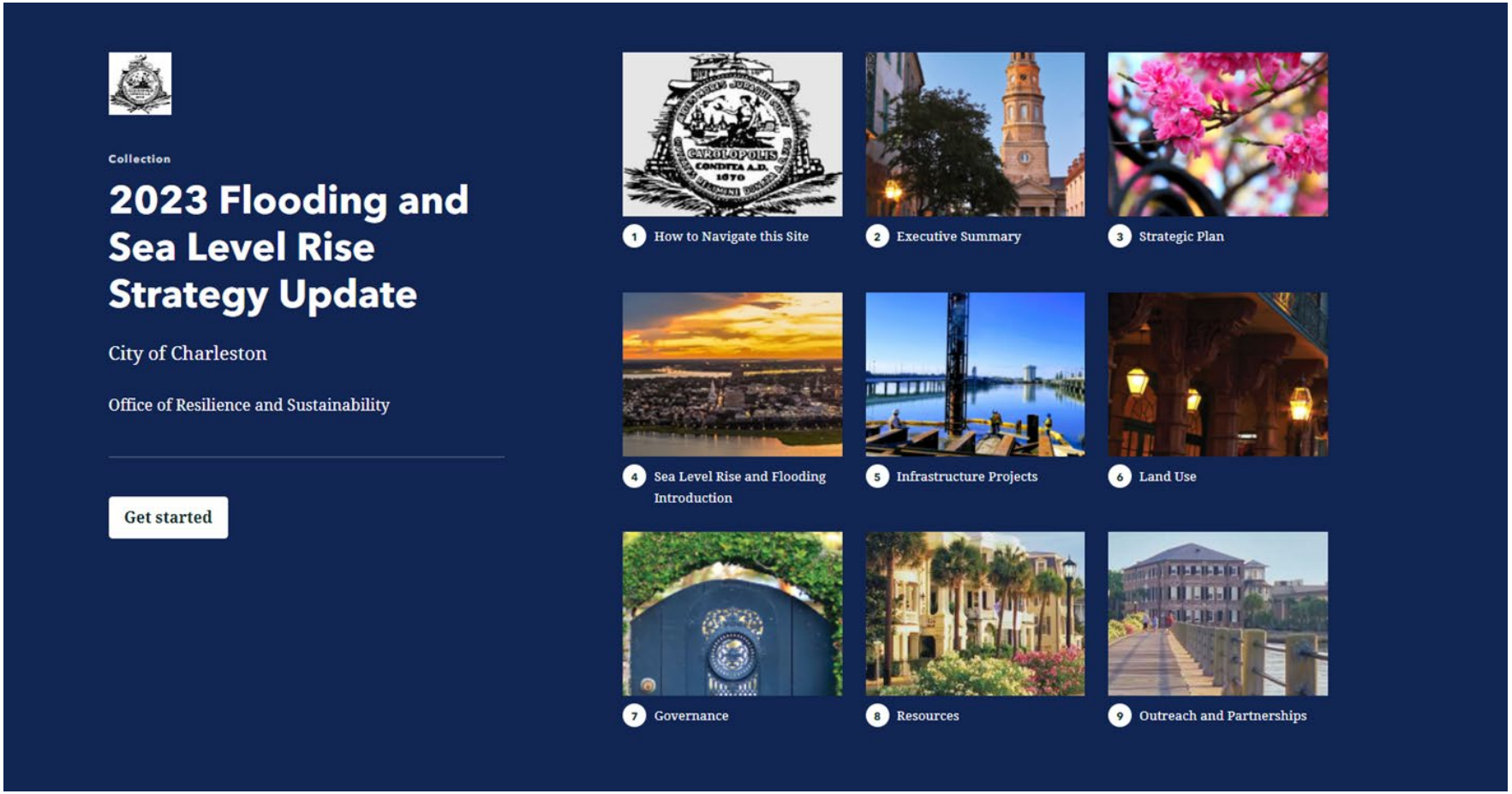
- **Key Recommendations:**

- Slow, Store, Drain (SDSM)
- City-Wide Water Plan (underway)
- Water: (key organizing principle for Comprehensive Plan and Zoning Code)
- Elevation–based development (ZC)
- Watershed-based approach (CIWP)
- Restrict use of fill in low areas (ordinance)
- Rainproof (ongoing)
- Multiple-benefit approach to projects (CIWP, SW Projects)
- Peninsula perimeter protection



Other work? How do we stay here?

SCAN ME



Tidal Inundation Risk Areas

This is not a predicted flood inundation map. This map depicts areas of potential inundation based on ground surface elevation and peak tide elevations. This does not account for weather (e.g., rain and wind).

Miles 0 0.13 0.25 0.5 N

Source: Coastal Emergency Risk Assessment ADCIRC Surge Guidance System (20220929 08:00); Charleston County 2017 LiDAR Elevation Dataset

All Hazard Vulnerability Analysis, 2019

Physical vulnerability: surge, tidal, rainfall, sea-level rise, earthquake, dam failure, heat, hazmat. Social vulnerability.

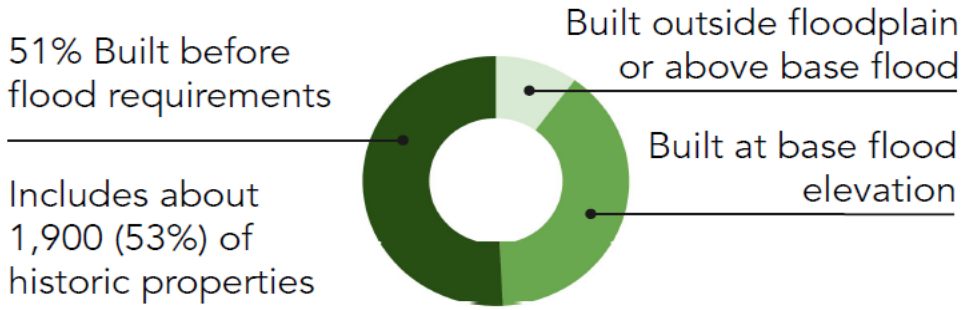
Key Finding 1

Flooding, storm surge, and earthquakes drive vulnerability citywide

	Floodplain Inundation	Storm Surge	Earthquake
Businesses	71%	84%	46%
Homes	70%	87%	39%
Critical Facilities	59%	72%	88%

Key Finding 2

The ability to cope with flood inundation is a main driver of vulnerability



Vulnerability Analysis: Surge on Peninsula

- **Residential**: 99% of Peninsula residential properties at risk from surge.
- **Business:** 98% of Peninsula commercial properties at risk from storm surge.
- **Infrastructure:** 100% of critical Peninsula roads inaccessible during surge event.
- **Critical Facilities**: 90% of critical facilities vulnerable (CMD, colleges / universities). +50% of fire and police stations.
- **Economy and Medical Provisioning:** 47k tourism jobs, 20k+ Charleston Medical District jobs and 4 hospitals at risk

USACE 3x3x3 (4x4x3) Coastal Storm Risk Management Feasibility study

April 2018, CSRM Study kickoff

April 2020, Tentatively Selected Plan (TSP) Public Comments: EIS, NBS, alignment

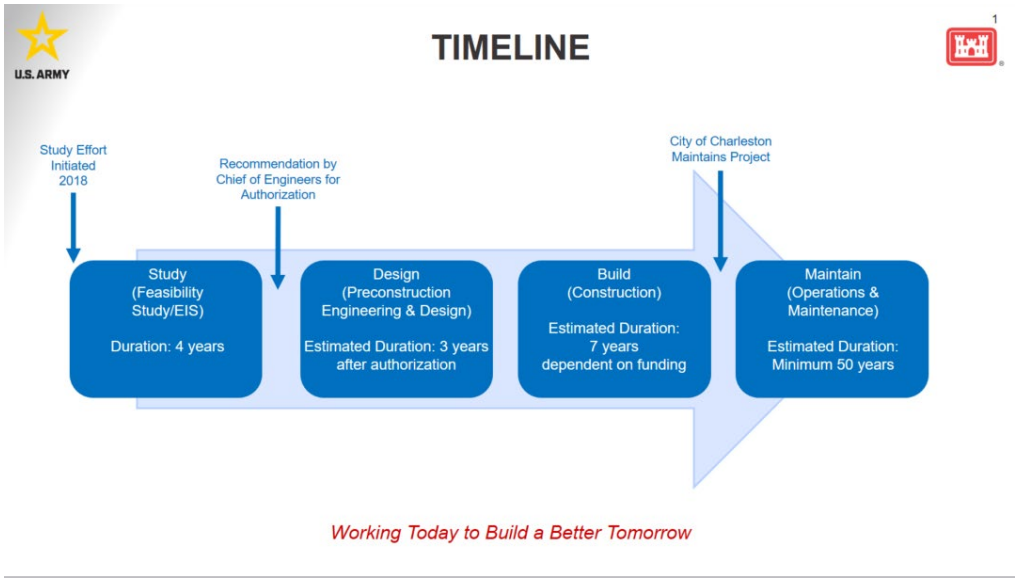
Fall 2020 –Winter 2021: EIS, Discovery Analysis

Sept 2021: Draft EIS, Optimized TSP

Sept – Dec 2021: SCSPA (Port) realignment

Feb – June 2022: USACE Division and HQ review, signed “Chief’s Report”

Dec 2022: US Congress authorized and funded next phases of project



Next up: Pre-construction Engineering and Design (PED)

Construction (only if PED is successful)

USACE Recommended (Feasibility) Plan, with EIS

8 mile storm surge structure @ 12’ NAVD 88 / 15.1’ MLLW

Tentative alignment – all on public property -- at edge of peninsula. SCPA facilities now inside protection

Added nature-based features (more needed)

10 pumps (impoundment and overtopping, more?)

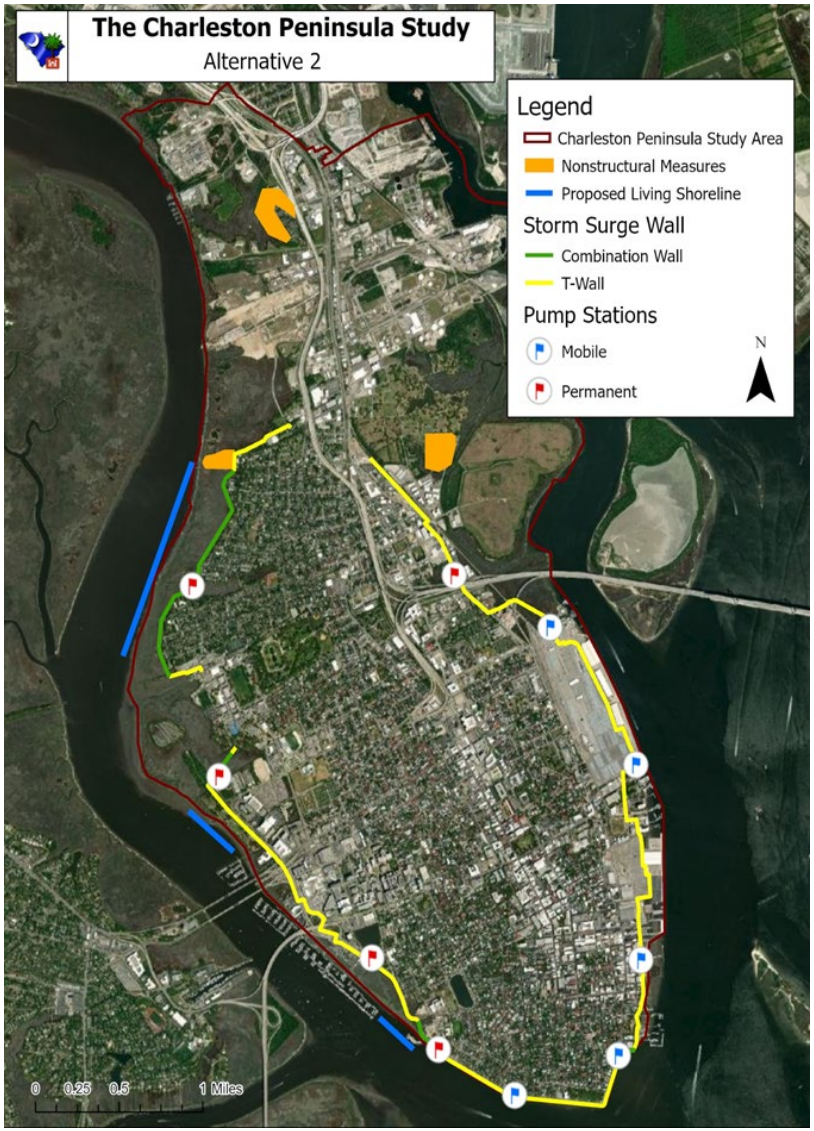
$1.3b, cost shared 65%-35%

City net cost: $300m

USACE / federal investment in City: **$845m**

10.8 – 1 benefit-cost ratio

Overall goal: design and eventually construct a structure acceptable to Charleston with Feds paying 65%



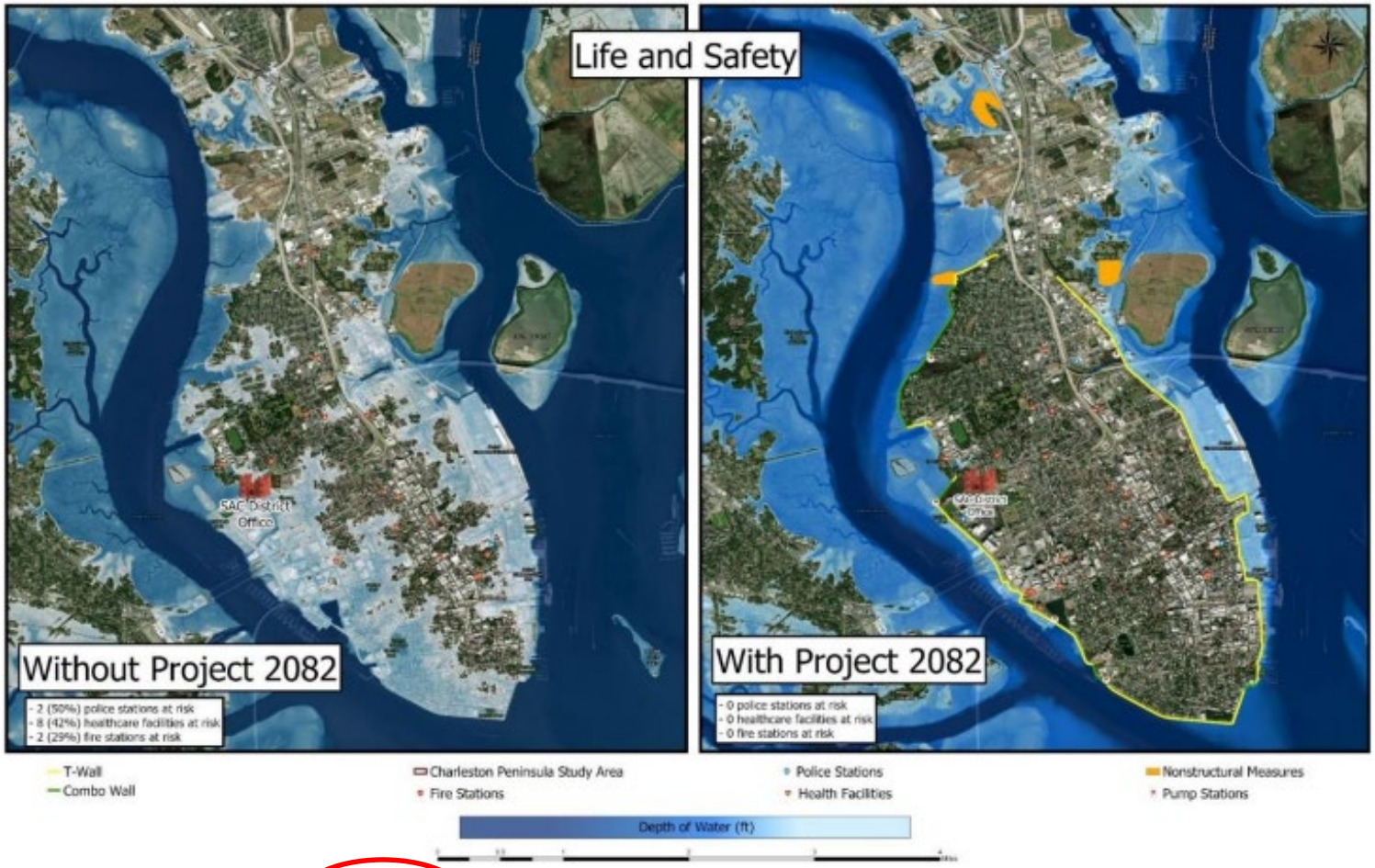
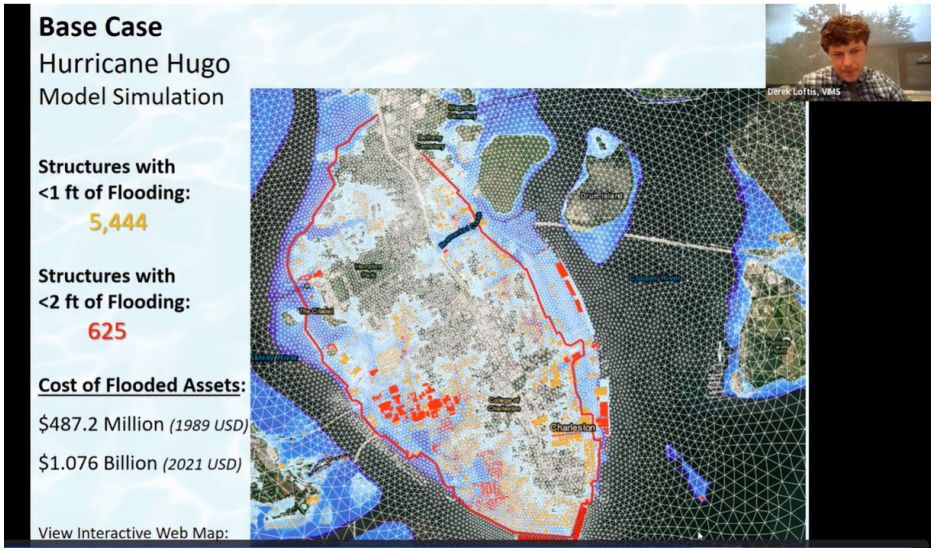


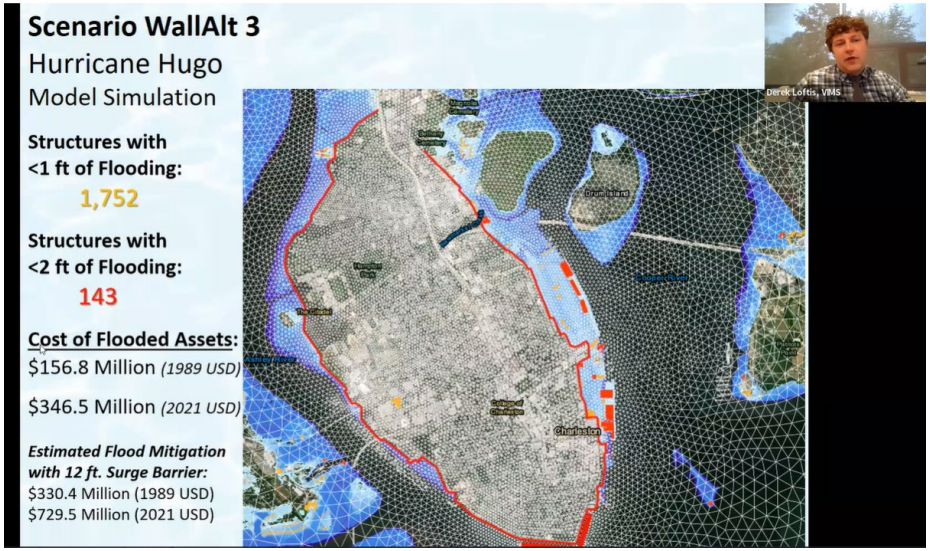
Figure ES 5. Comparison of a 20% AEP coastal storm event in 2082, assuming a high rate of SLR. With implementation of Alternative 2, damages to critical facilities and interruptions in emergency services would be limited and life safety risk would b reduced.

Virginia Institute of Marine Sciences: SCHISM Model.

Hugo conditions; calibration with hurricanes Joaquin and Matthew

*USC has another model; shows same results

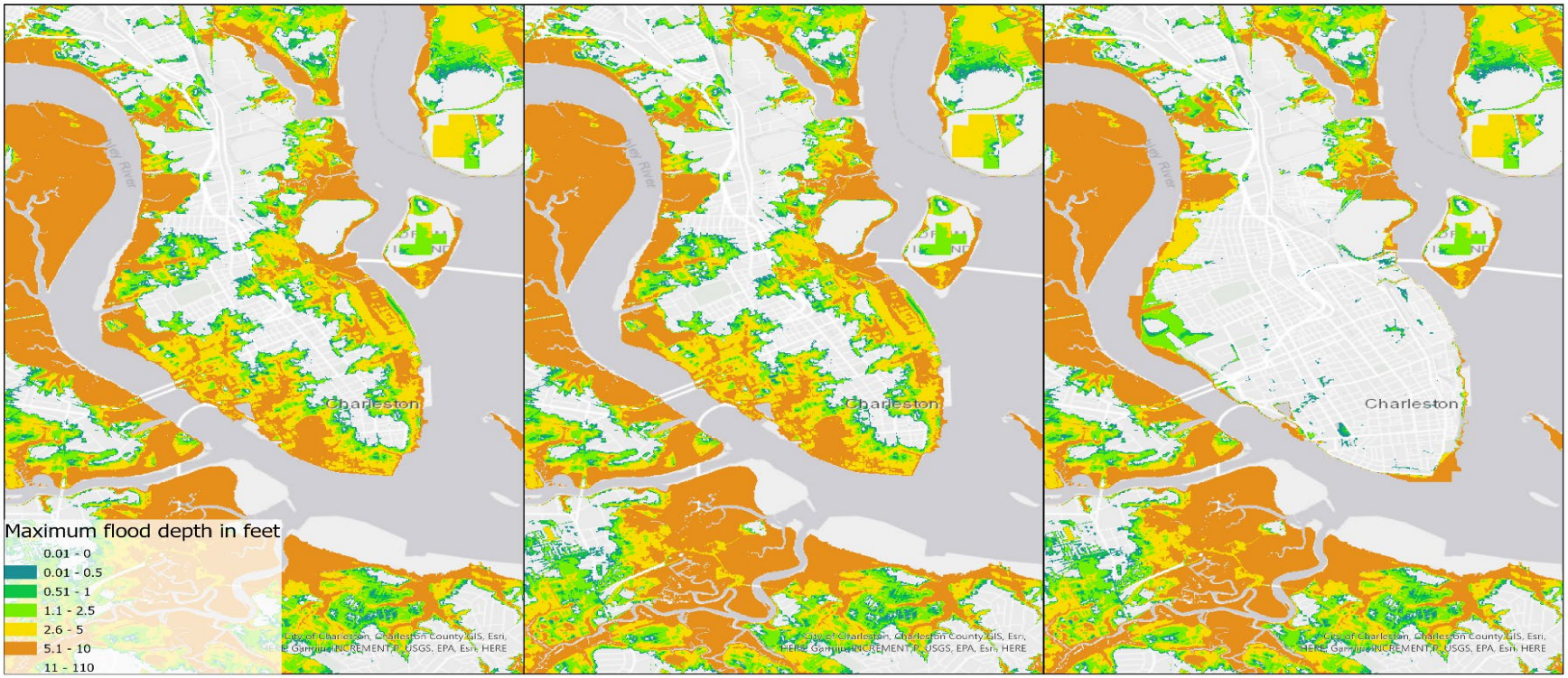




FloodAdapt tool

Conclusion: An “edge” is needed - pumping and drainage alone won’t work long term.

Irma



2.5 ft sea level rise
No adaptation

2.5 ft sea level rise
Pumps

2.5 ft sea level rise
Seawall and pumps

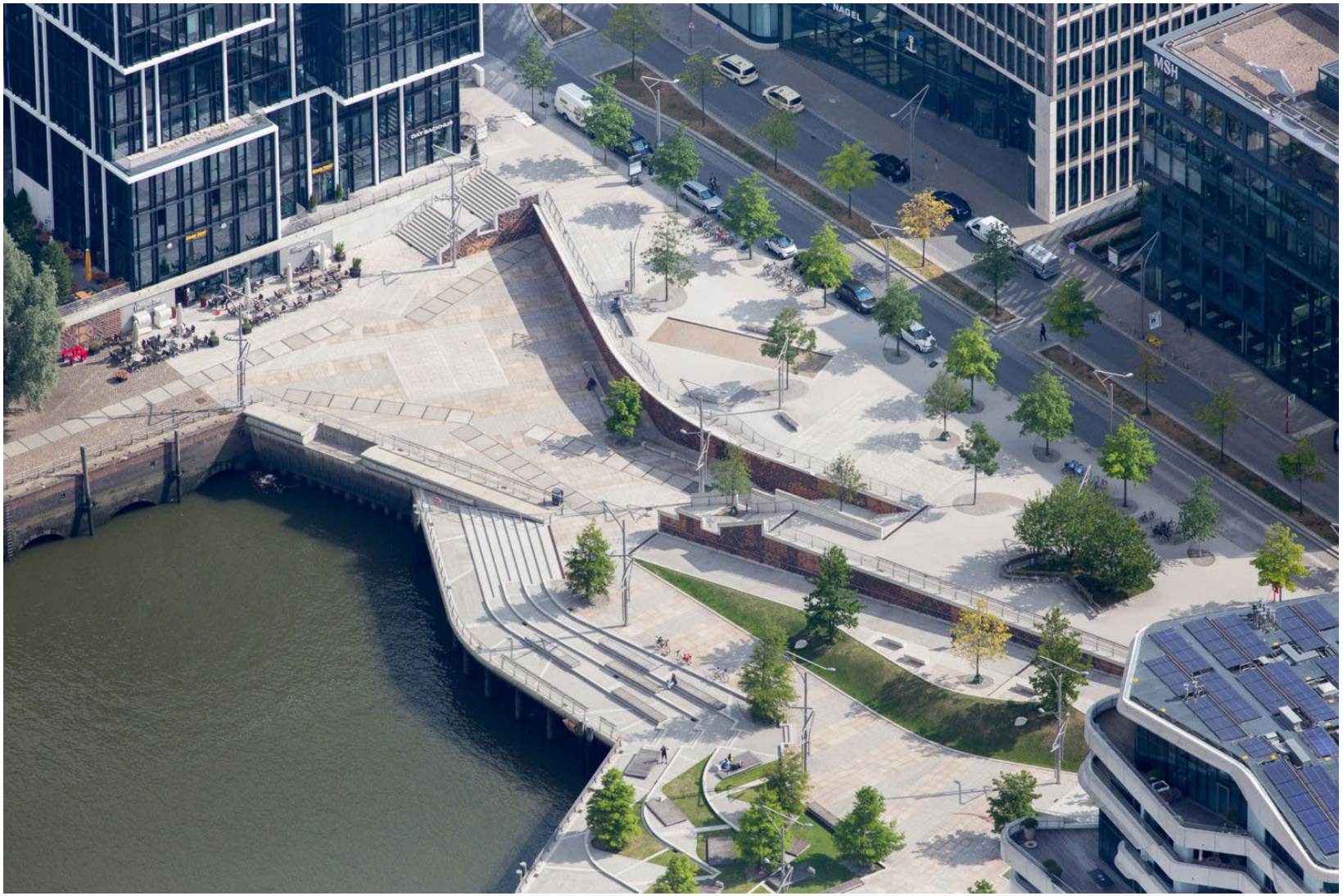
0 0.38 0.75 1.5 2.25 3 Miles

N

The Berlin Wall? Public perception?

USACE in Feasibility Phase did no design. Such a structure is unacceptable, except perhaps at Columbus Terminal.

Scheveningen Boulevard, 4 miles, The Hague


NAGEL
MSH

FLOOD RISK MANAGEMENT → with aesthetics built in

Floodwall – Des Moines River

Rock Island District

Benefits

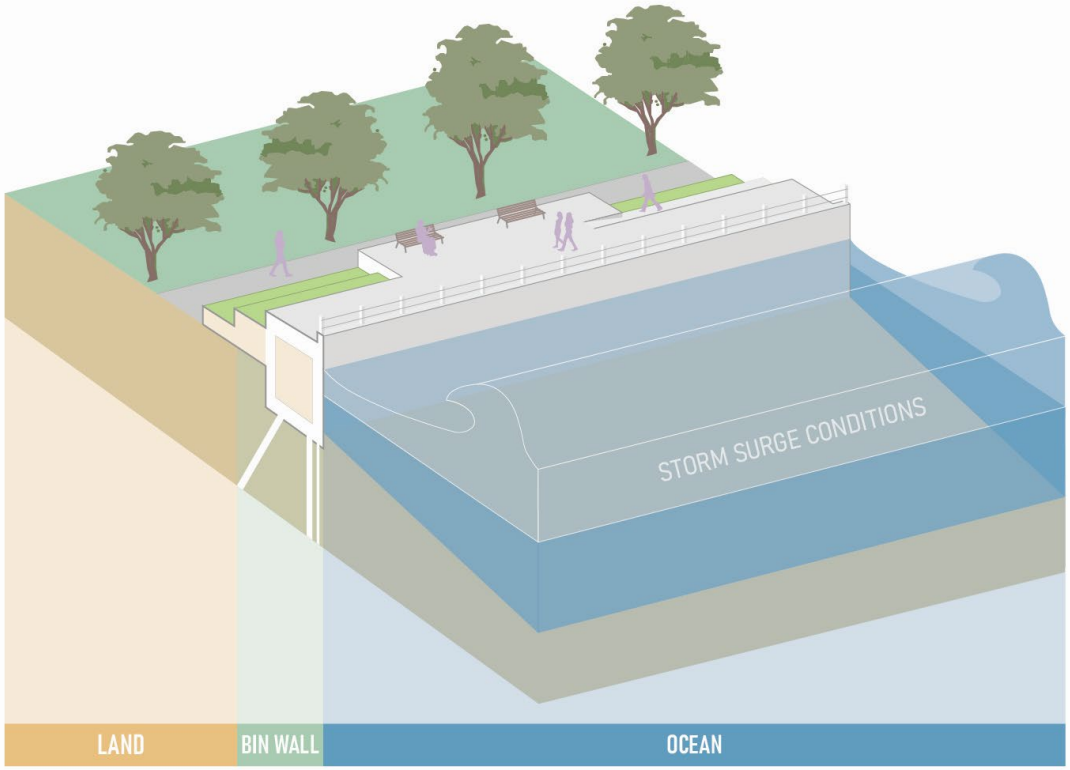
- Improved Flood Risk Management

Floodwall – Cedar River

Rock Island District, Kevin Holden, Landscape Architect

Benefits

- Improved Flood Risk Management
- Improved Human Environment


STORM SURGE CONDITIONS
LAND
BIN WALL
OCEAN


NORFOLK

SOUTHERN END OF WATERFRONT PARK - *Ideas for a Storm Surge Protection System for the Charleston Peninsula*

PED Goal: Extend the Battery

Project Status. Design Agreement negotiations.

PED: interrelated design and engineering tasks, including topographic, geo-spatial, geotechnical, groundwater, hydrology, hydraulics, drainage, design and aesthetics, environmental and economic analysis, hazardous waste, spatial planning.

PED Design Agreement is a contract between City and USACE and sets forth:

- who does what
- how additional issues and risks can be considered
- additional features and benefits (via betterments)
- PED decision-making, process mgmt., dispute resolution

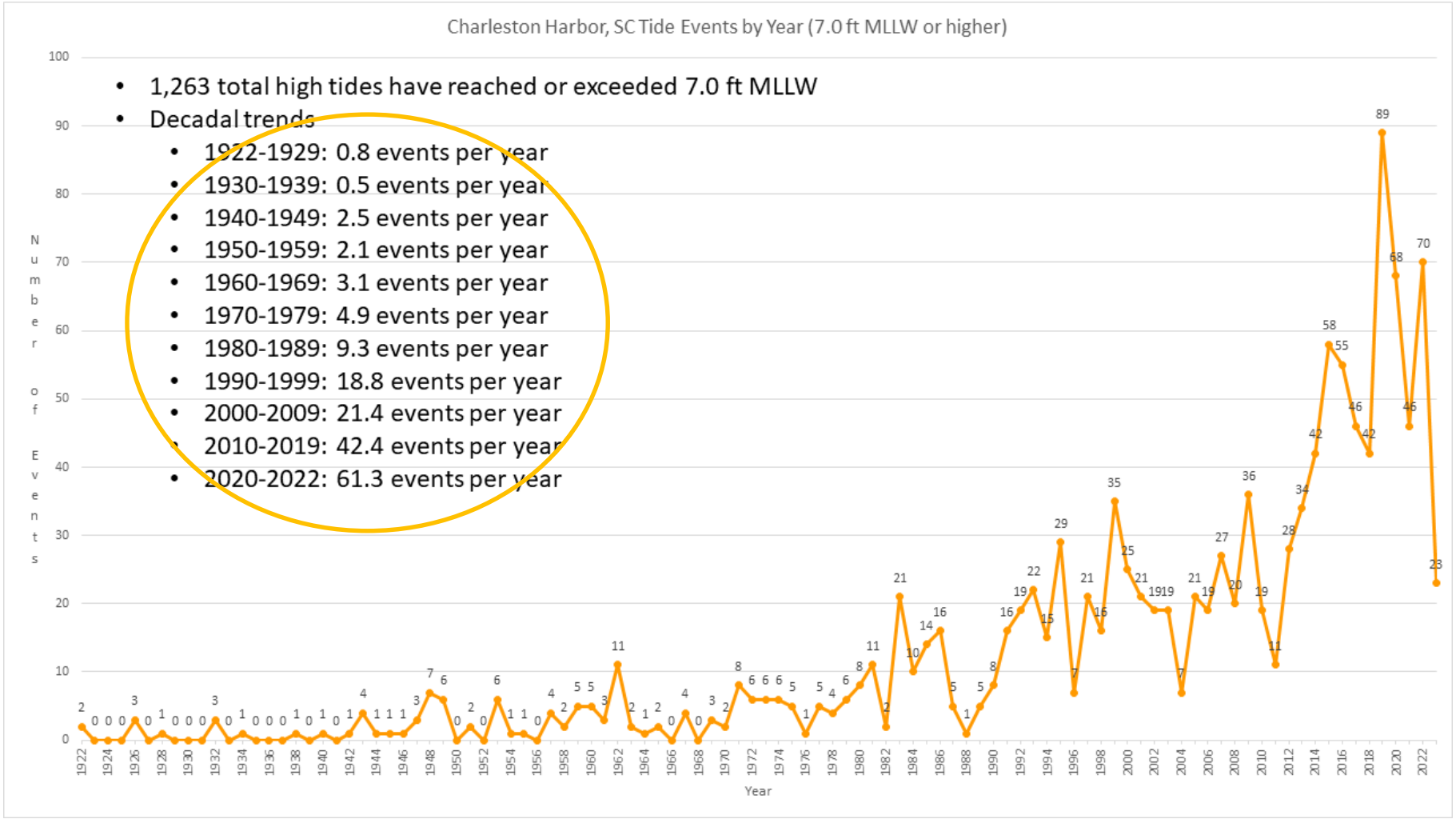
City's goals in PED: **alignment review, structure design, interior hydrology, outreach / education**. Co-establish O&M.


What's going on with the 'seawall'?
How can I stay informed?
For the most up to date information and answers
to common questions on the
PENINSULA PERIMETER PROTECTION PROJECT,
please scan below or visit charleston-sc.gov/SLR
City of Charleston

Tides and Sea Level Rise

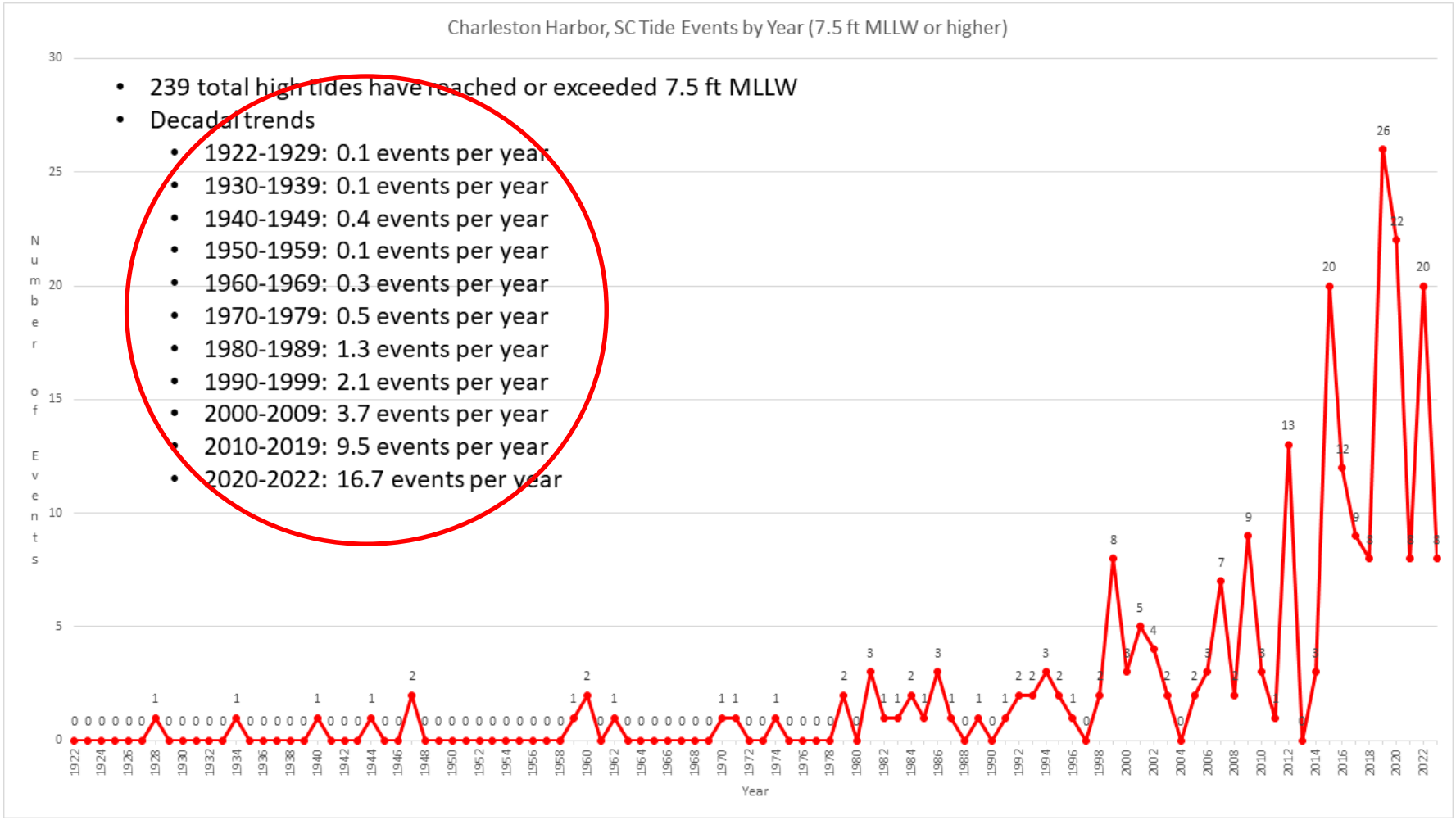
Minor tidal flooding (through June 2023)

Update: through July 2023, Charleston has 30 events of 7 ft or higher; 3rd most ever.

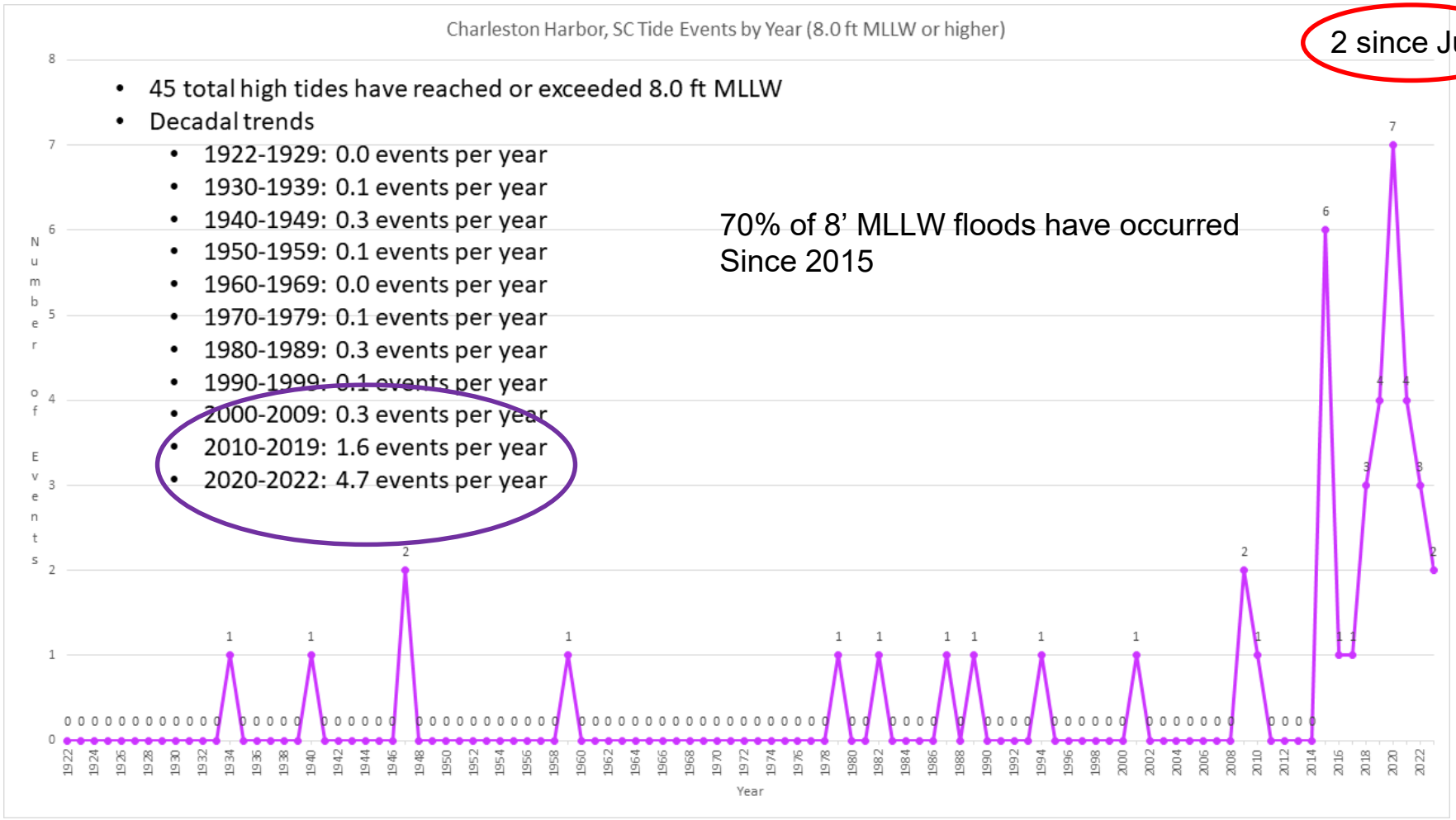


Moderate tidal flooding (through June 2023)

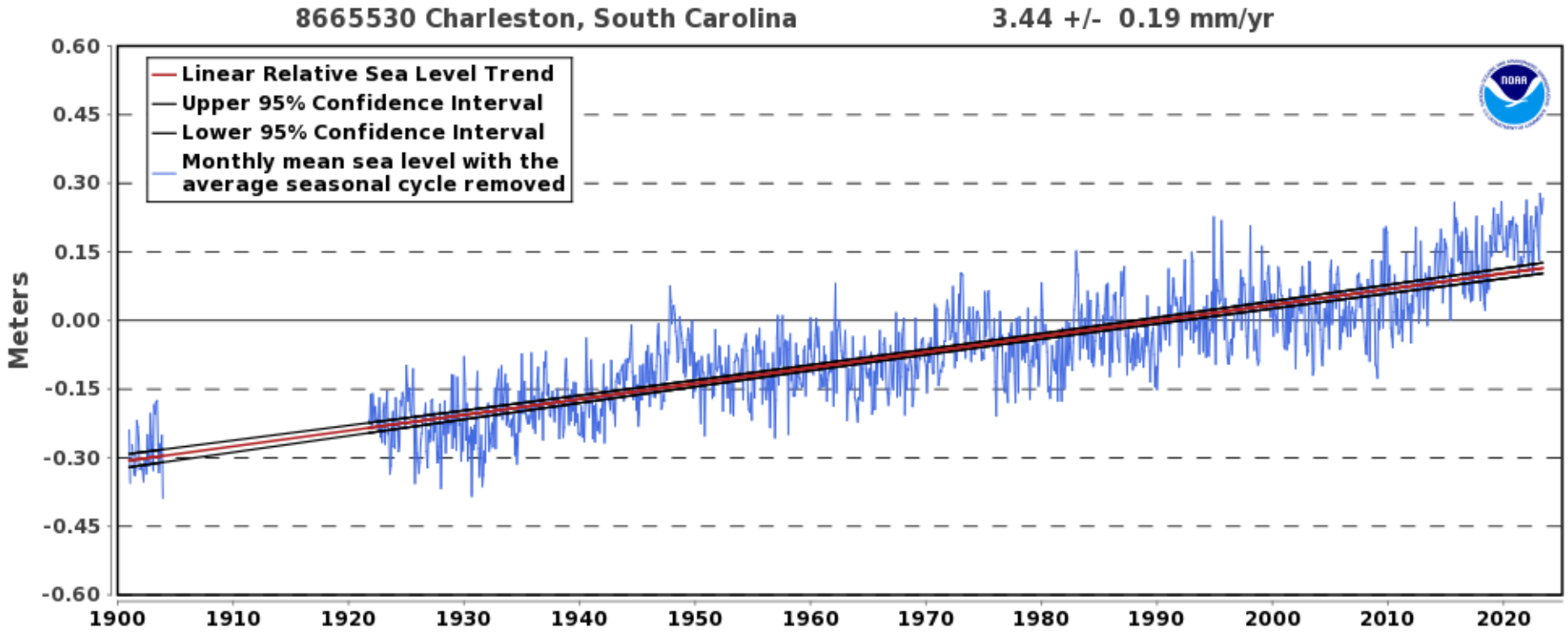
Update: 12 events of 7.5 ft or higher through early August.



Major Tidal Flooding (through June 2023).

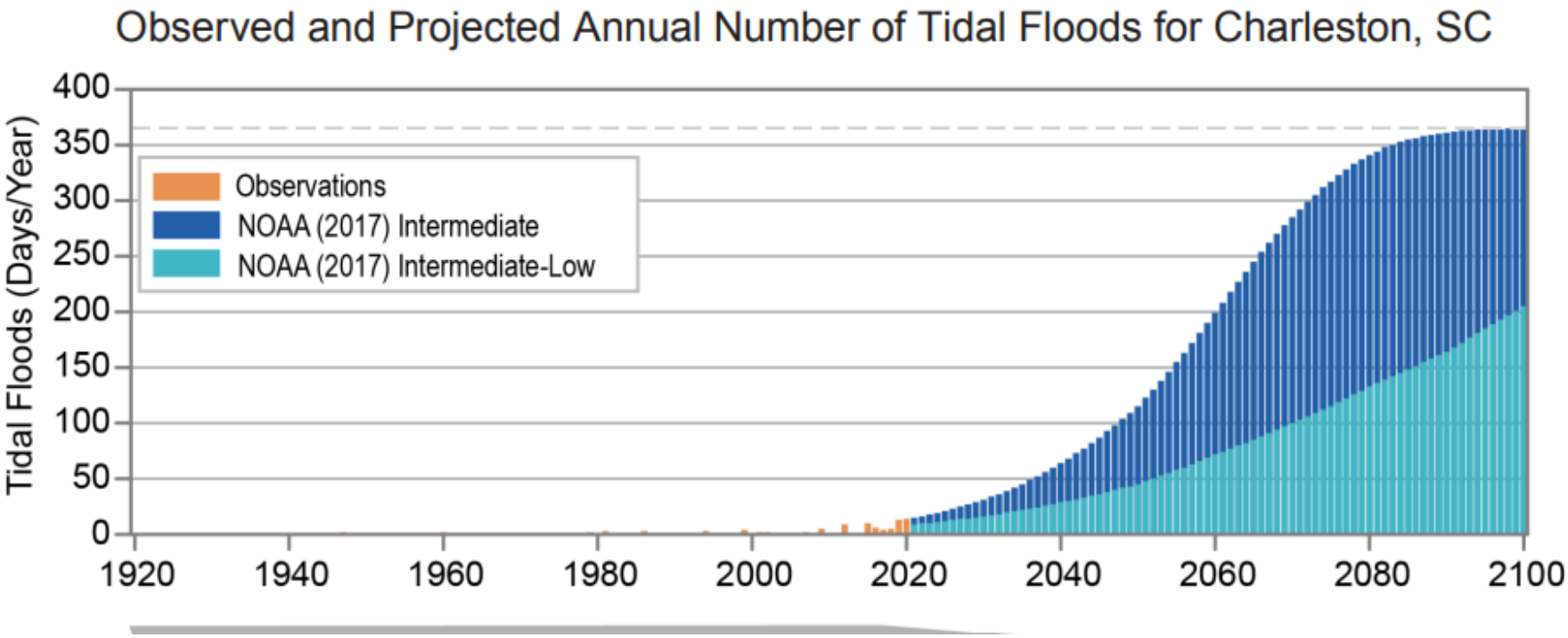


Sea Level Rise since 1920 (+/- 13 inches)



100+ tidal floods / year by 2050

NOAA National Centers for Environmental Information | State Climate Summaries

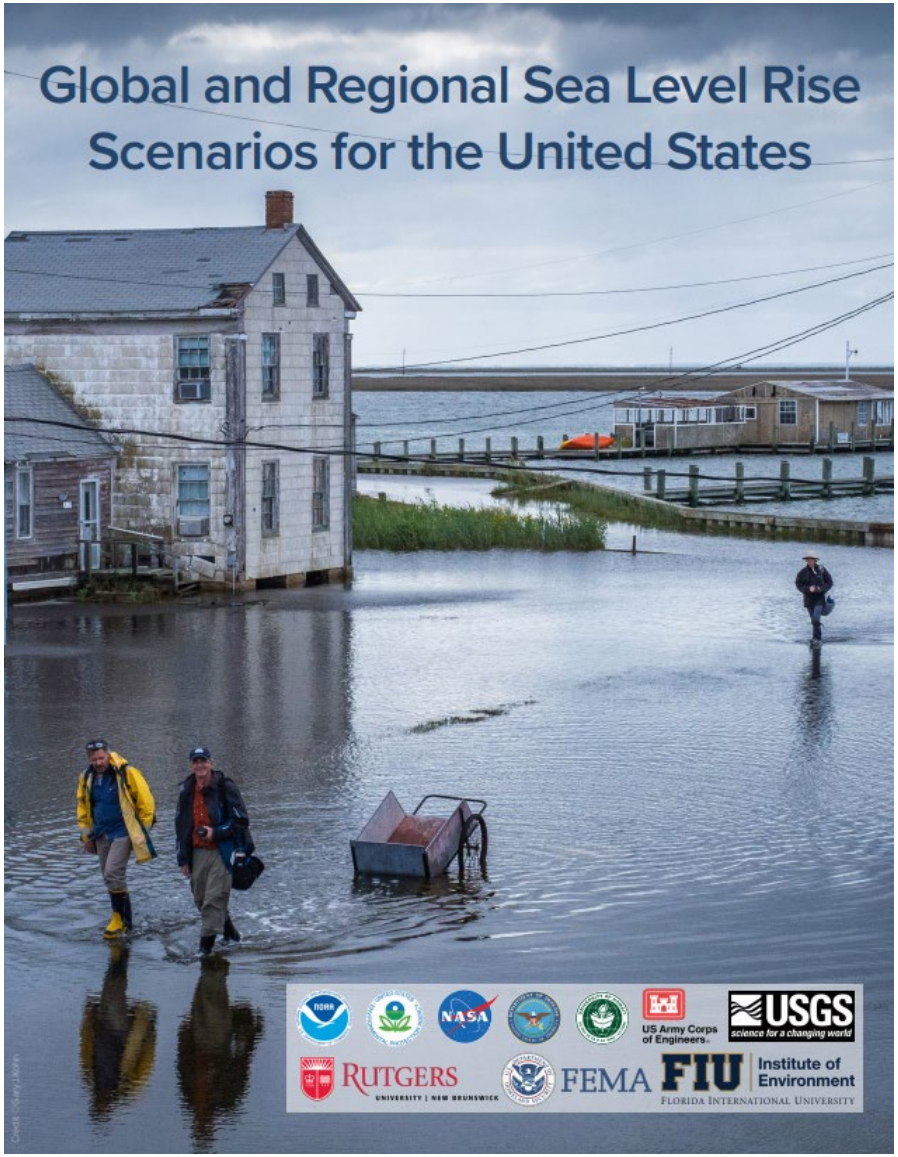


March 2022: Updated info and models

Seas will rise as much over next 30 years as they have over last 100.

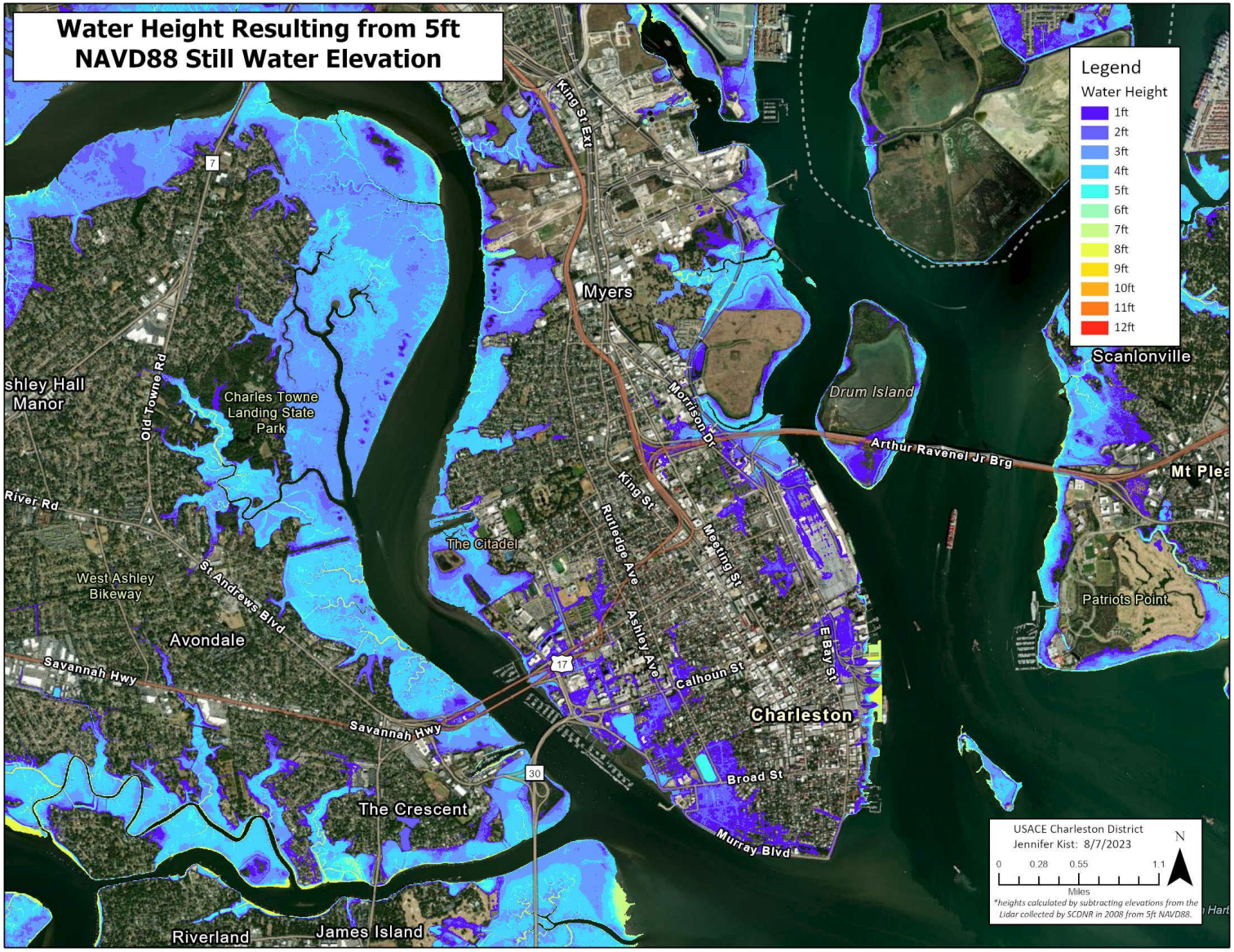
Gulf Coast: 14”-18”
Southeast Atlantic: 10”-14”

City Flooding & SLR Strategy:
14” by 2050



5’ NAVD 88 – 8.1’ MLLW (Major Flood)

Occurrence: 5x / yr today. With SLR: 100+ x / yr by 2050.

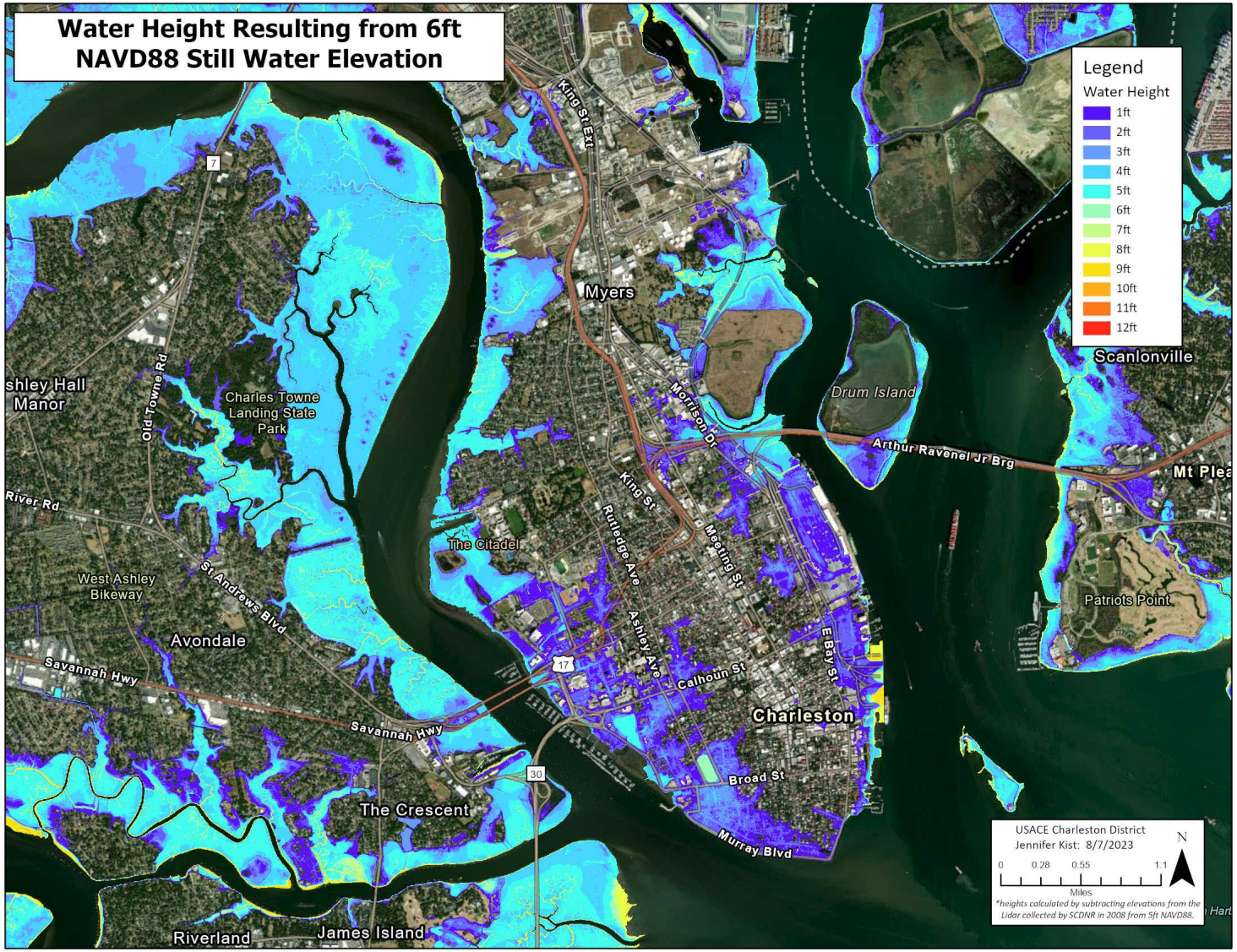


TS Nicole (Nov 2022). (wind and rain) Add 14” of sea level rise?

Photo courtesy of Jared Bramblett

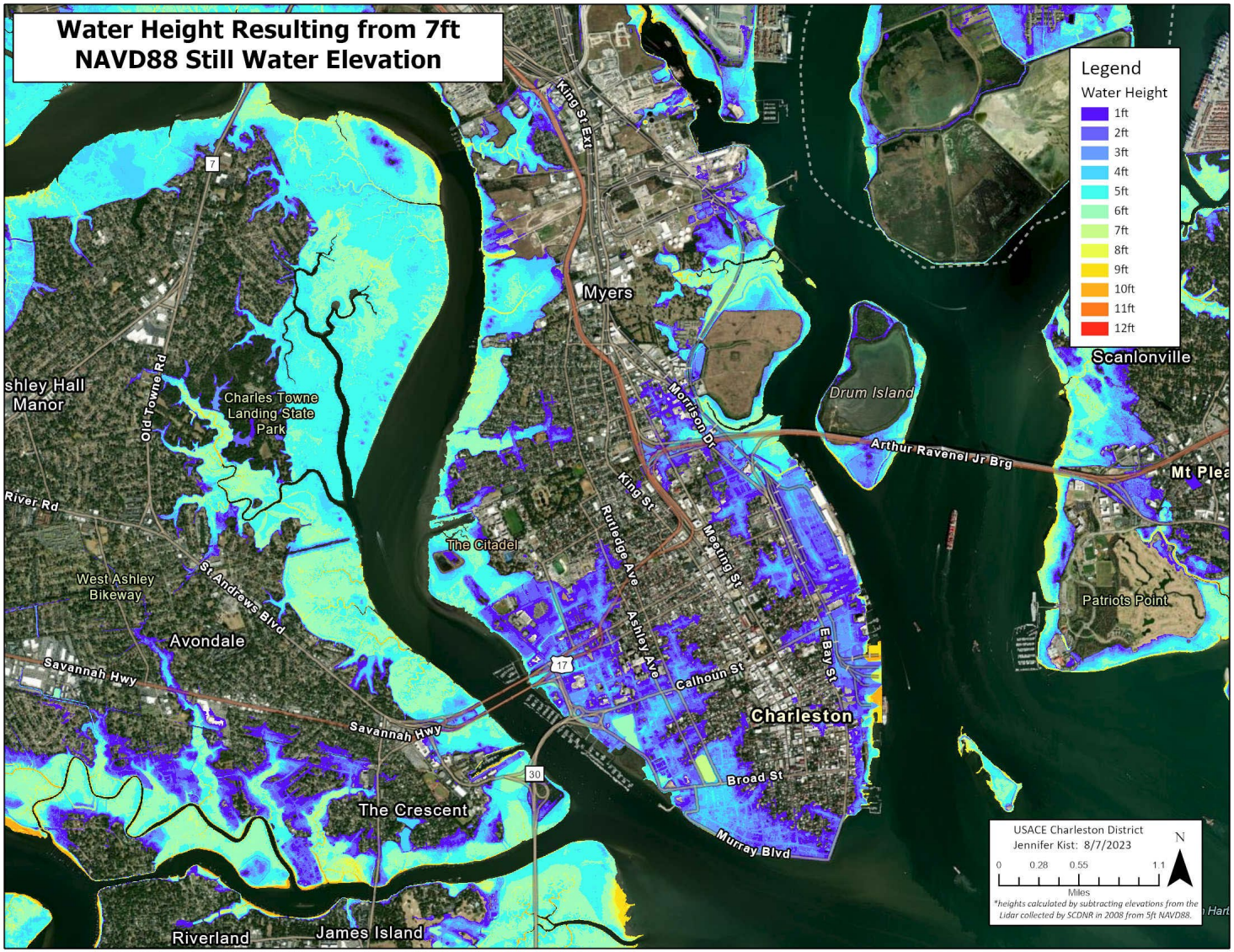
6’ NAVD88 = 9.1’ MLLW. Extreme Flood. Idalia.

Occurrence: 2-3x decade today. With SLR: 16+ x / yr by 2050

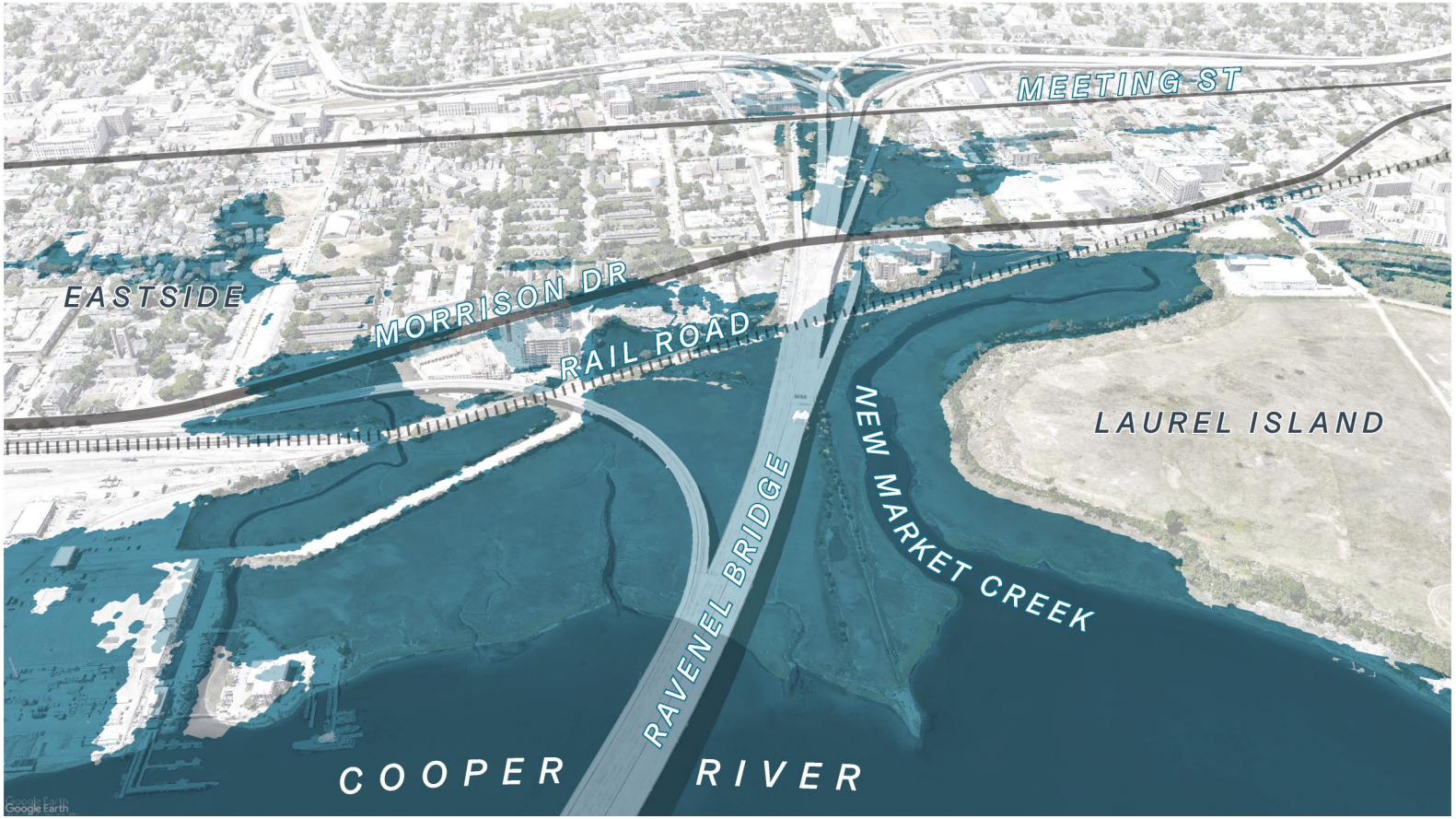


7’ NAVD88 - 10.1’ MLLW Extreme + Flood

Occurrence: once a decade. With SLR: 5x / yr by 2050.

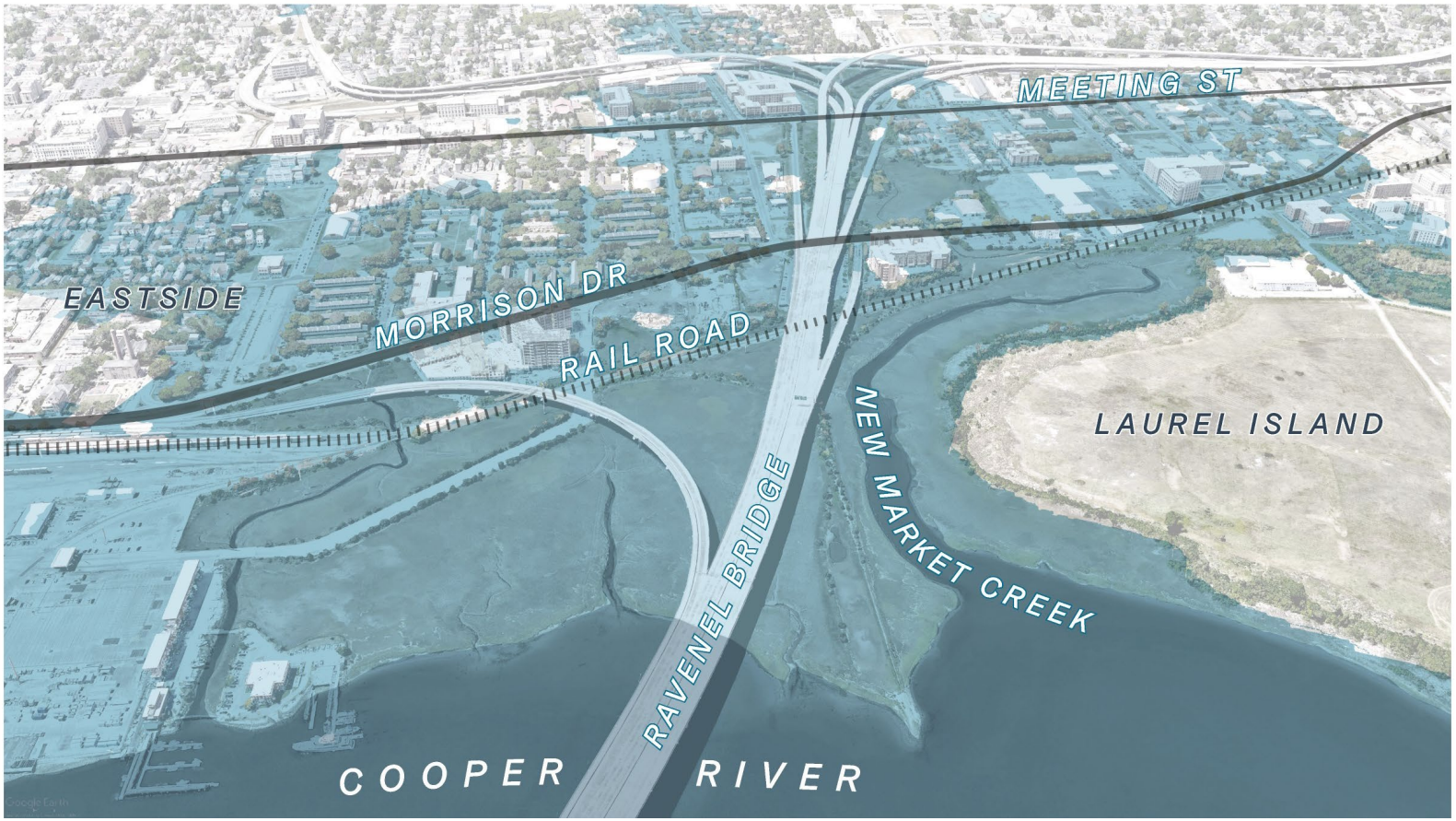


Major Tidal Flooding (8’ MLLW)



Major Tidal Flooding (8’ MLLW) +1.5’ SLR

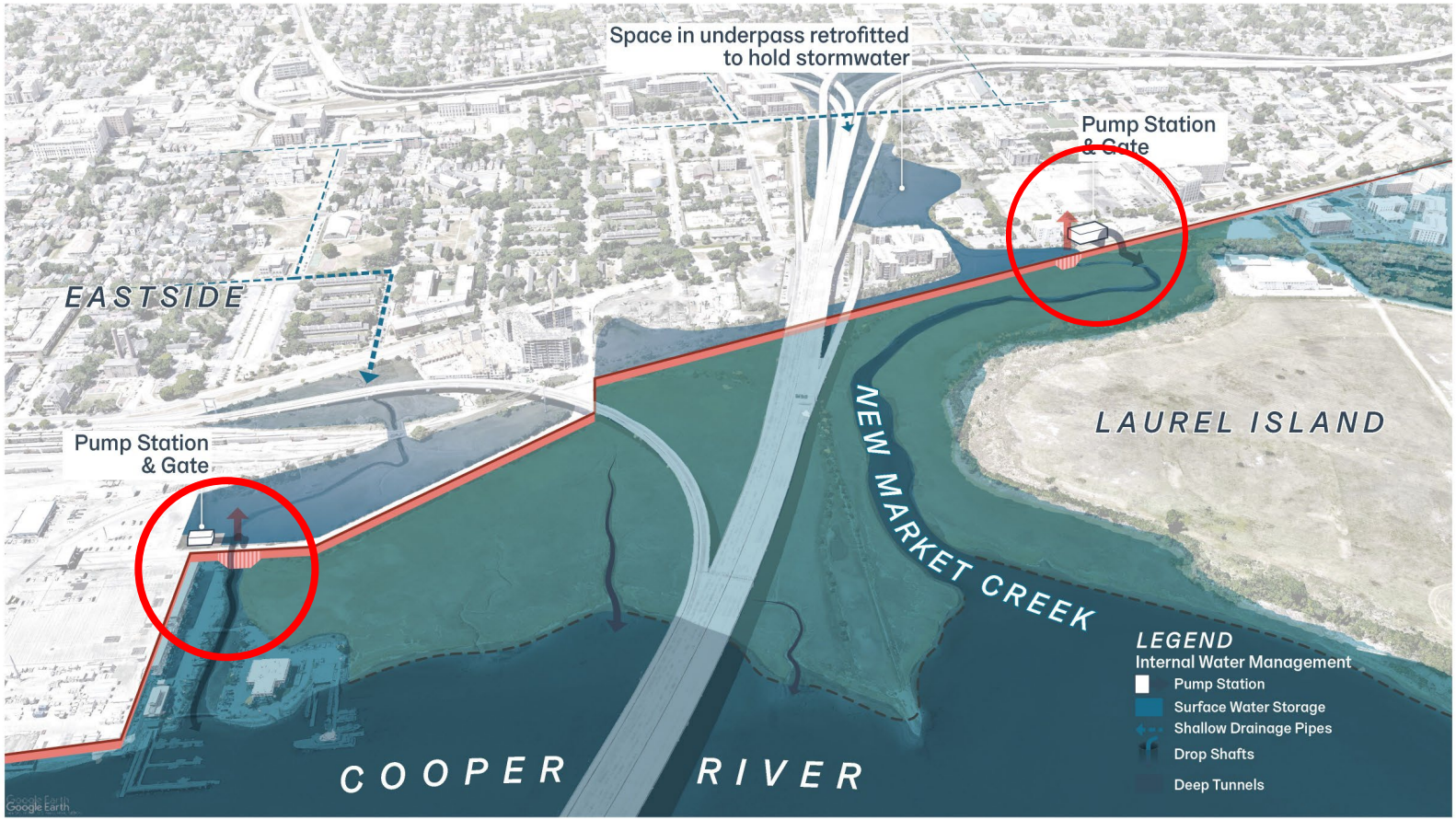
50yr Storm Surge Event



50yr Storm Surge Event +1.5’ SLR

Combined Flood Risk

Internal Water Management



Major Tidal Flooding (8’ MLLW)

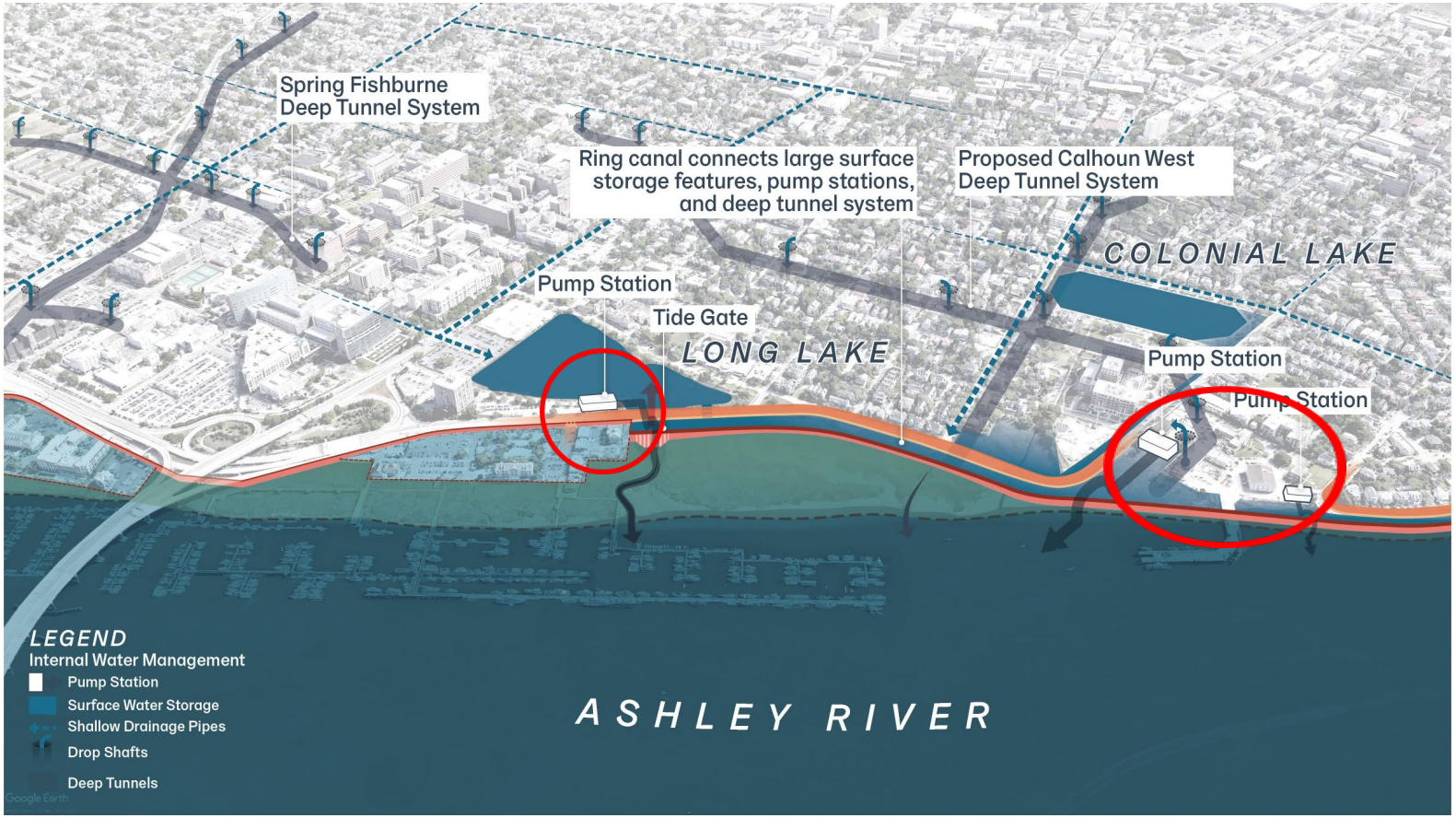
Major Tidal Flooding (8’ MLLW) +1.5’ SLR

50yr Storm Surge Event (today)

50yr Storm Surge Event + 1.5’ SLR

Combined Flood Risk

Internal Water Management – Lockwood Corridor



USACE – City Tidal and Inland Feasibility Study

US Congress authorized study in 2020. Leadership and support of our local Congressional Delegation!

3 x 3 x 3

Funding (federal share) to start study approved FY 2023. Additional $ expected FY 2024. Cost-share: 50 – 50.

At end of study, *recommended projects* would be cost-shared 65% - 35% for design, engineering and construction.

Priority flooding areas identified in Comprehensive Water Plan to jump-start feasibility scoping.

WRDA 2022, S 8106: flooding associated with:

tidally influenced rivers, bays, and estuaries

a rainfall event of any magnitude or frequency

a tide of any magnitude or frequency

groundwater emergence

sea level rise

subsidence

Comprehensive, Integrated Water Plan

"A proactive, aspirational, and achievable vision for the city to embrace its relationship with water."

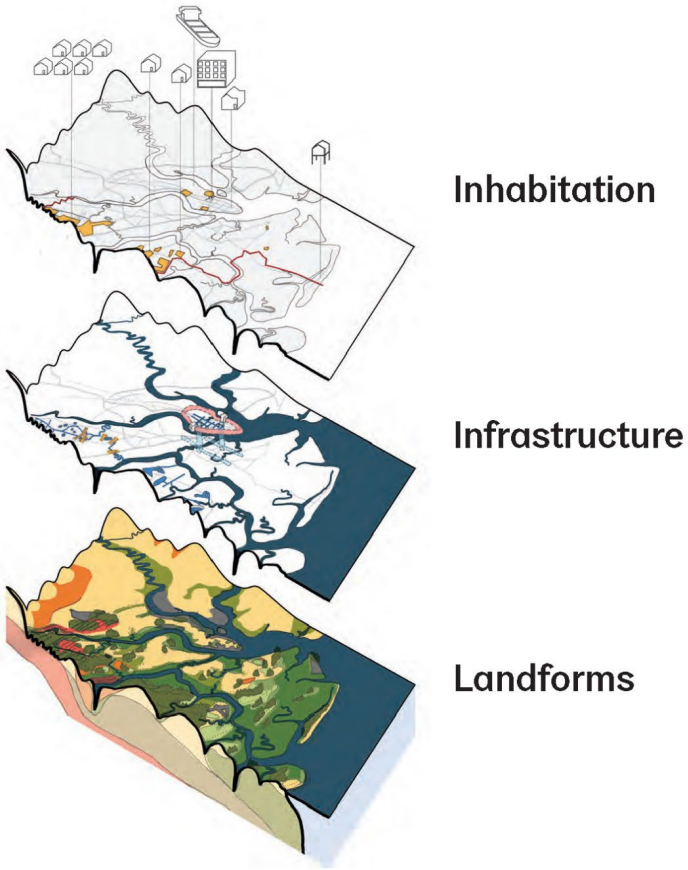
"The Water Plan will aid City staff, City Council, stakeholders and citizens to understand, plan for, prioritize, manage and adapt to current and future compound flood risks across all City neighborhoods, main drainage basins, and floodplains."

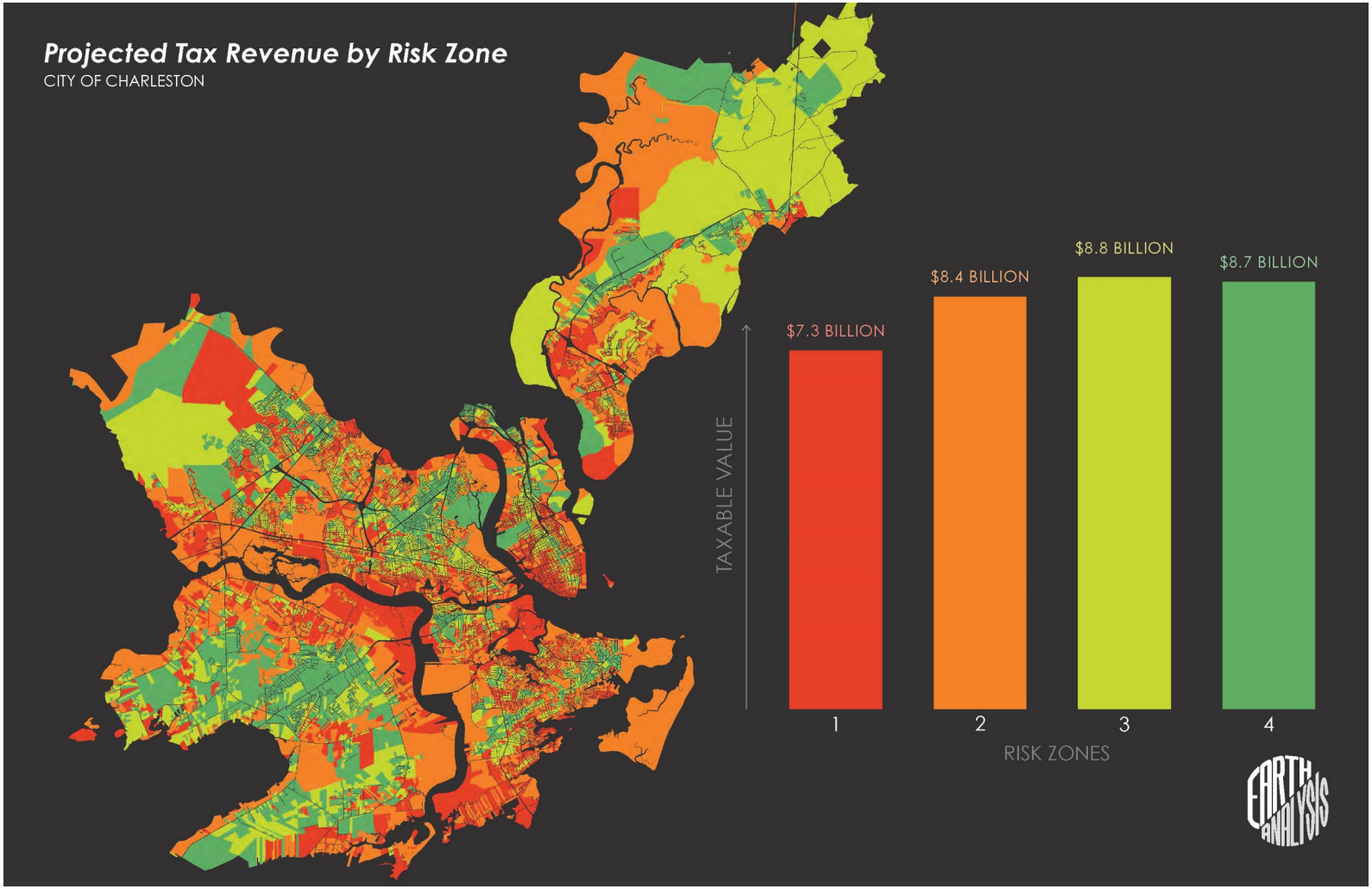
Integration of existing plans, projects, priorities related to water

25 year planning horizon with consideration of longer trends

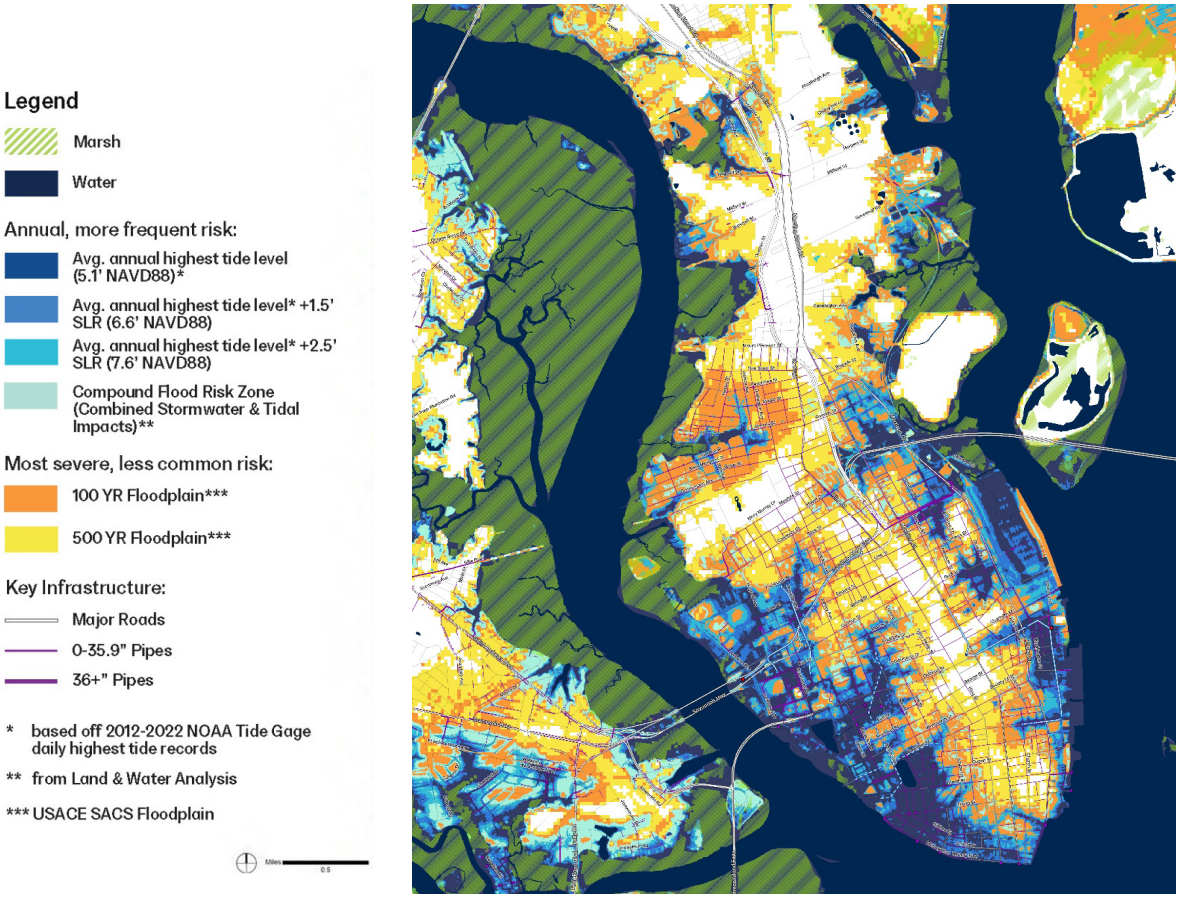
Draft Plan Fall 2023; Final Plan Winter 2023

Layered Approach

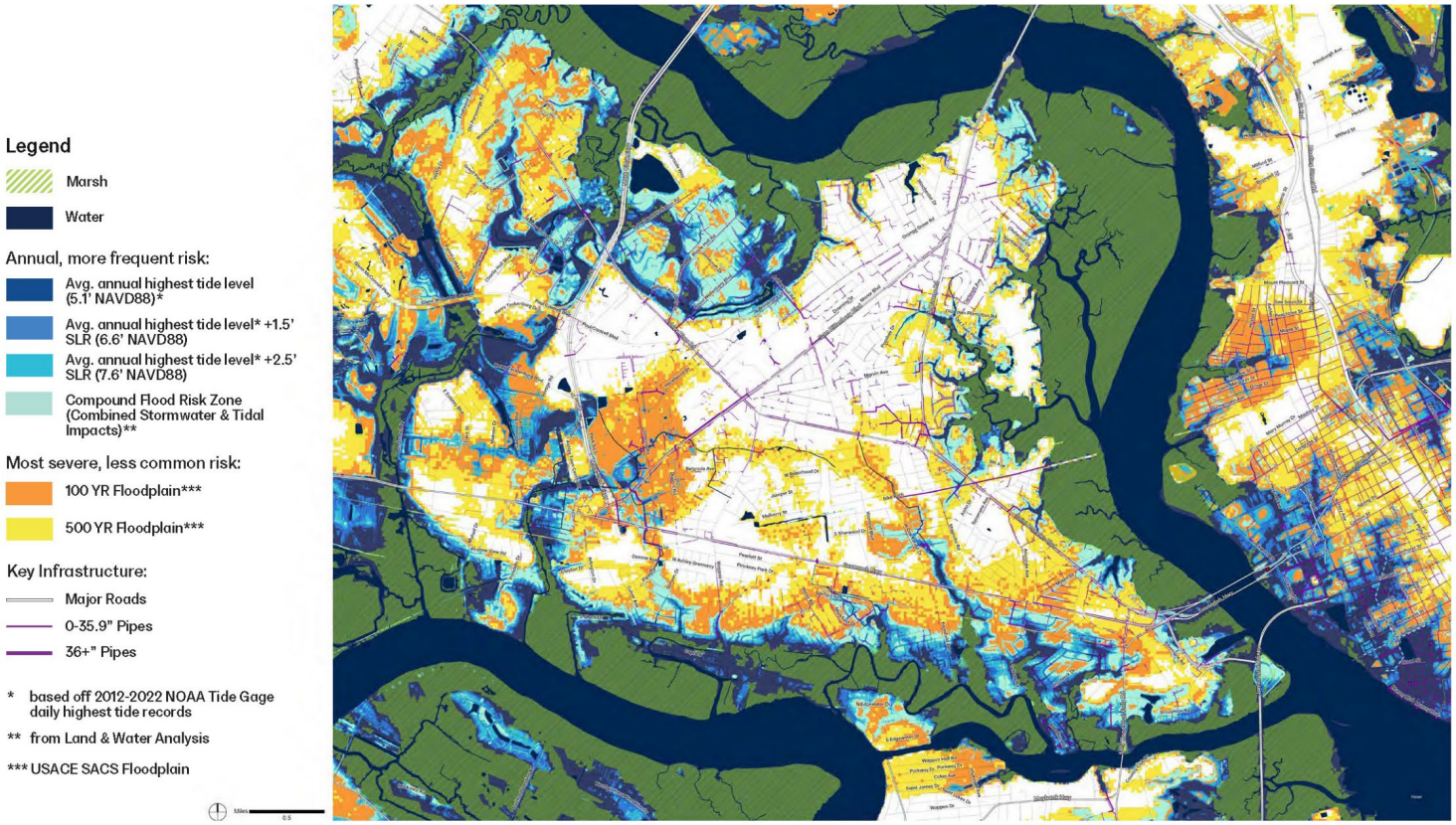



Projected Tax Revenue by Risk Zone
CITY OF CHARLESTON
$7.3 BILLION
$8.4 BILLION
$8.8 BILLION
$8.7 BILLION
TAXABLE VALUE
1
2
3
4
RISK ZONES
EARTH ANALYSIS

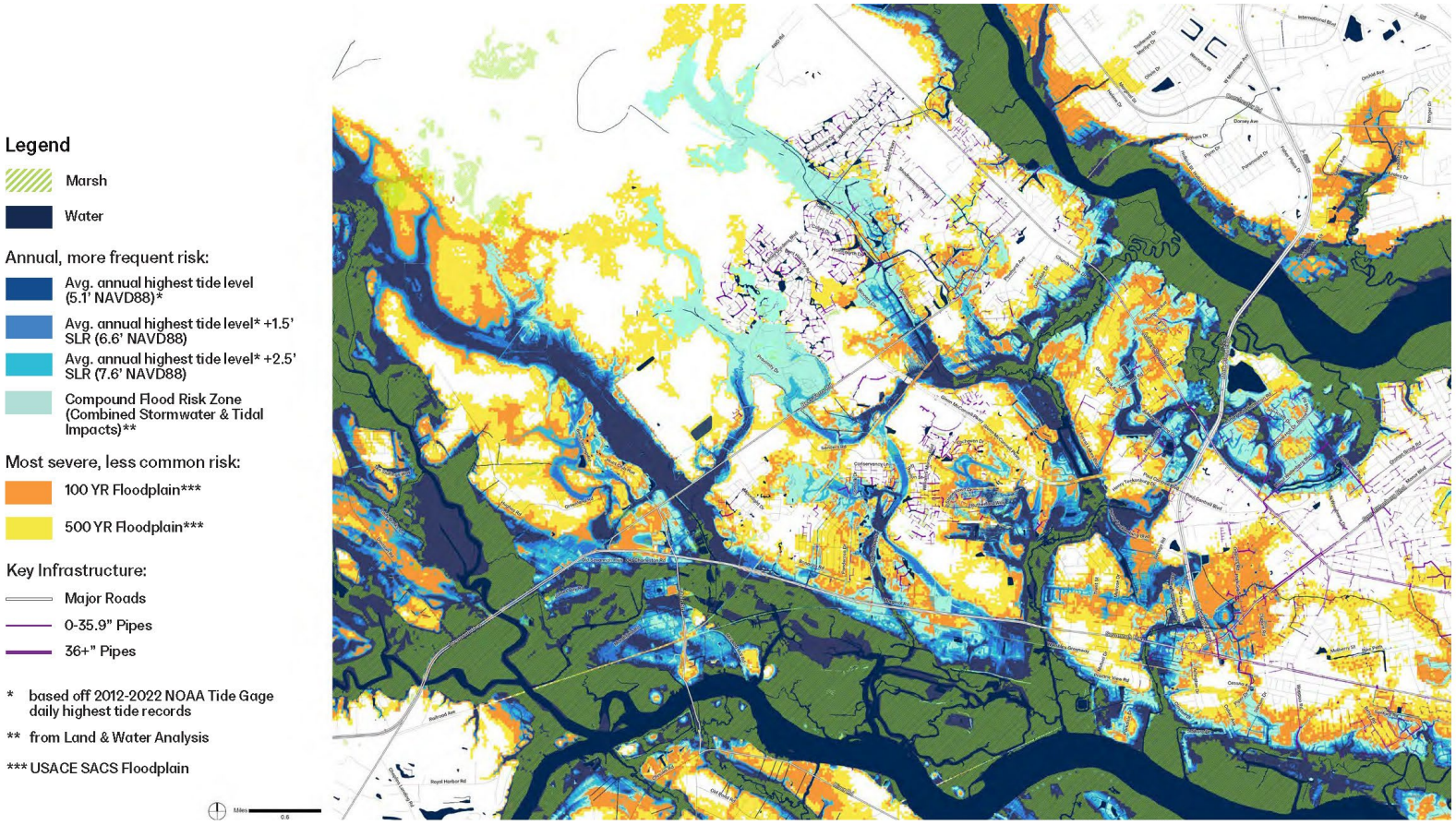
Key Water Levels – Peninsula



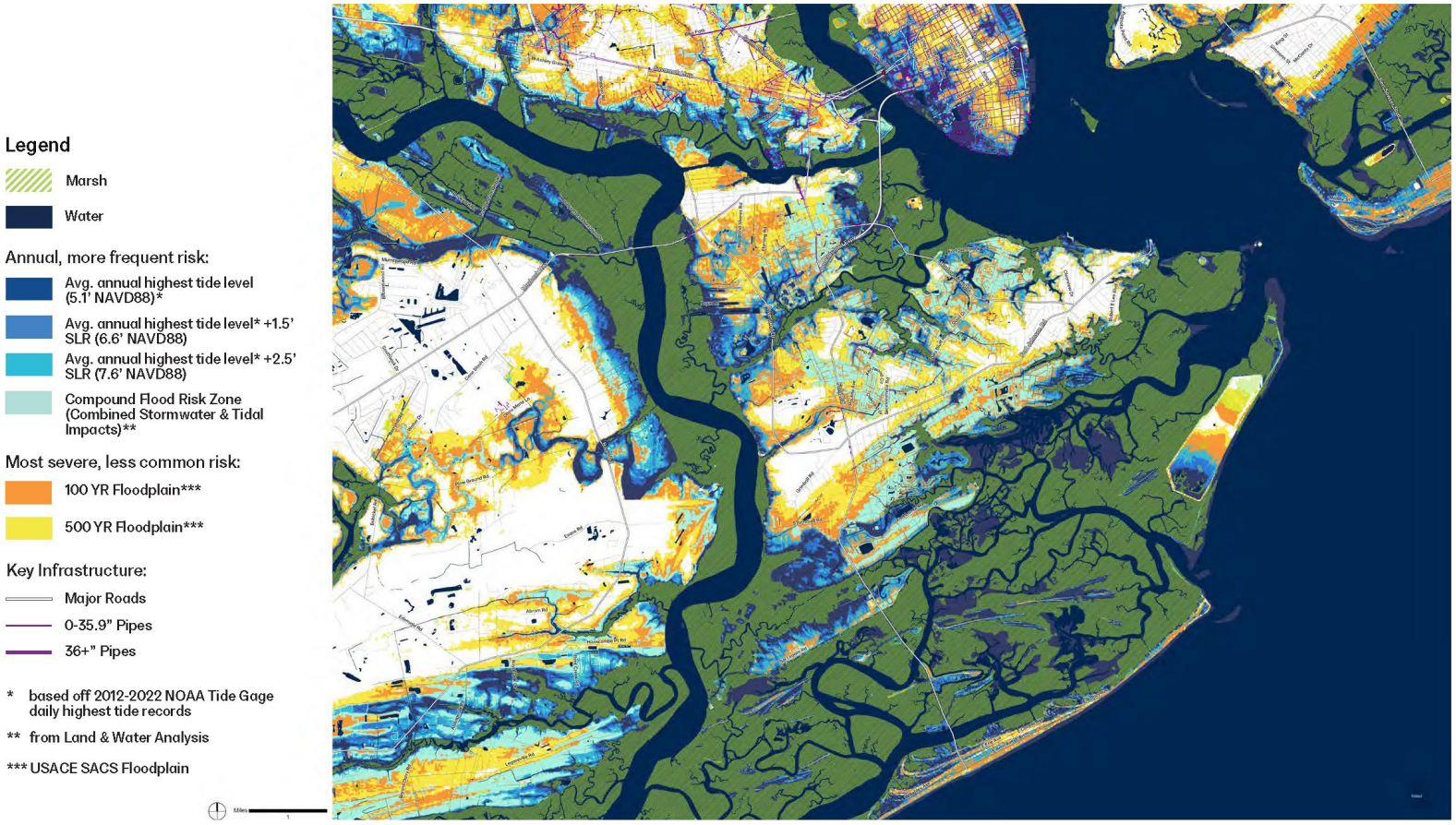
Key Water Levels – Inner West Ashley



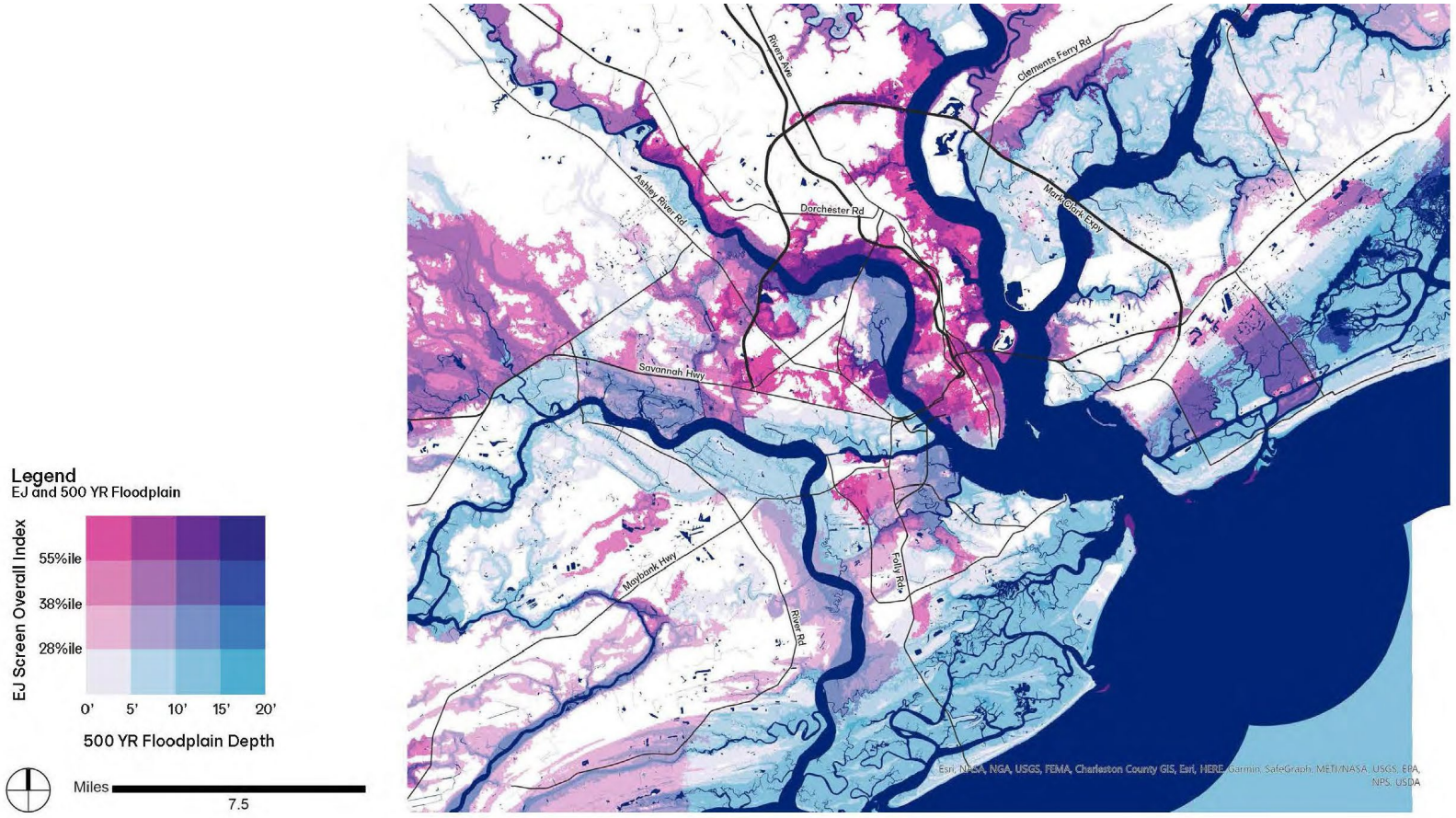
Key Water Levels – Outer West Ashley



Key Water Levels – James Island



Environmental Justice & Flood Risk Map



Conceptual Project Prioritization & Selection

Flood Mitigation & Adaptation

- Provides adaptation pathway for City's 25- and 50-year SLR targets
- Adaptable to future increases in rainfall volume and intensity
- Leverages existing or planned stormwater infrastructure
- Factors subsurface soil and groundwater conditions

Equity & Accessibility

- Project location within an EPA EJ community or settlement community
- Benefits an EJ community upstream or downstream
- Provides public access to water and nature
- Incorporates culture and history of underrepresented communities

Nature

- Demonstrates conservation principles (preservation or restoration)
- Incorporates green infrastructure for water management
- Incorporates strategies for water quality enhancement
- Anticipates future landscape change and succession

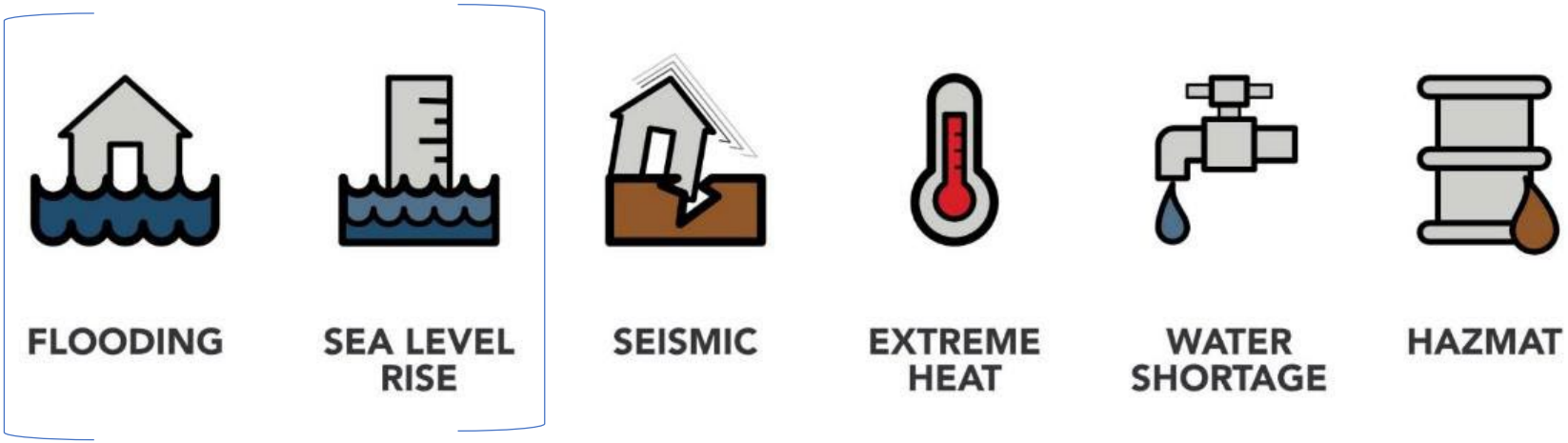
Coordination & Communication

- Aligns with existing plans, studies, and/or planned projects
- Addresses multiple hazards (heat, social vulnerability, etc)
- Stakeholders (and potential stakeholders) are clearly identified
- The project will advance data collection and build local knowledge

Implementation & Investment

- Demonstrates a replicable, scalable, or prototypical solution
- Potential funding and/or revenue source identified, including eligibility for Federal funding and/or cost share (USACE CSRM, Tidal/Inland studies)
- Incorporates an approach to long-term operations and maintenance
- Benefits City tax base / future financial viability

Charleston Vulnerabilities Assessment



Heat is Deadly

In the south, heat is a given, **but it's getting hotter than it used to be**.

Increased heat exposure impacts health.

Heat kills more people annually than any other weather hazard.

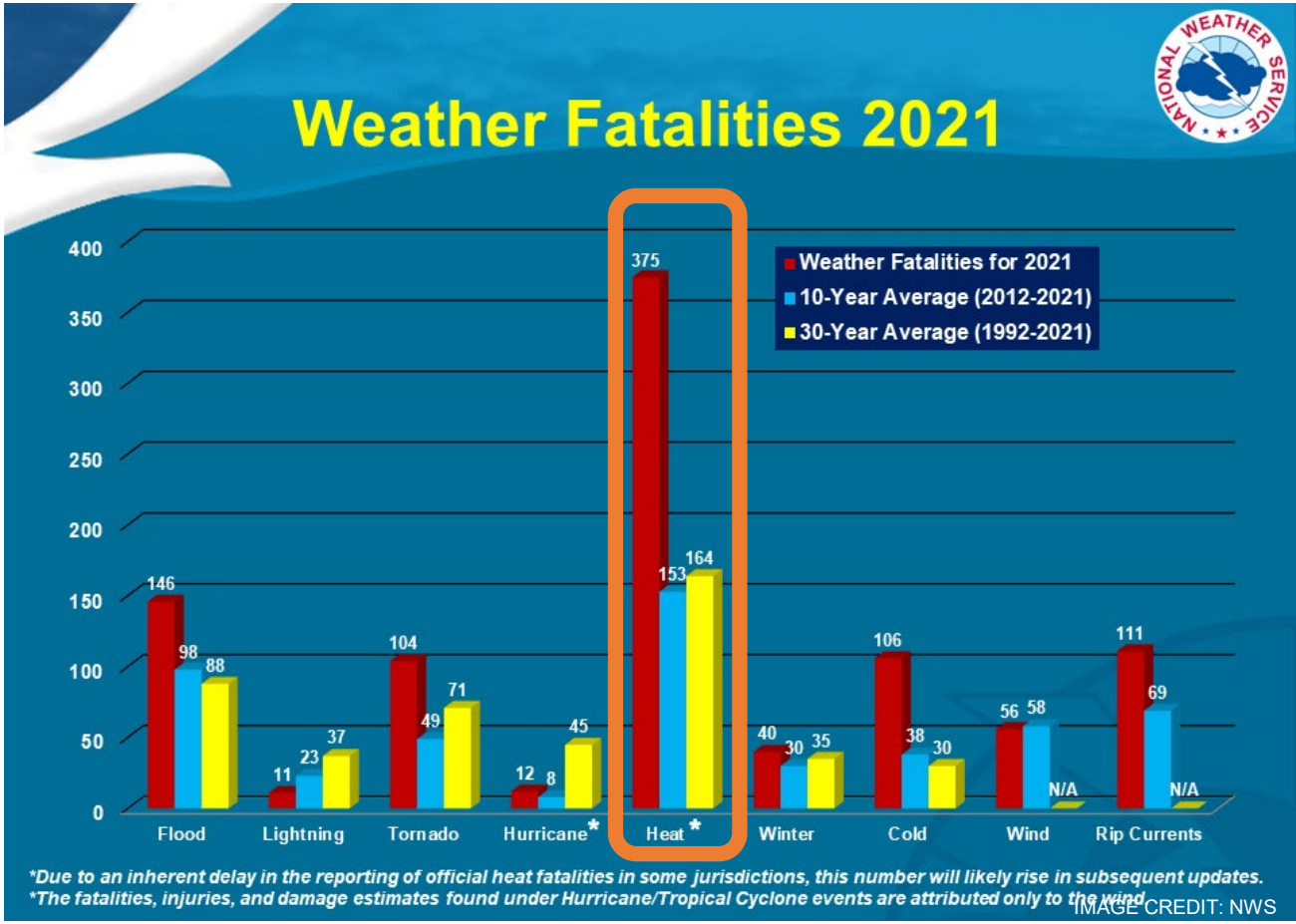


IMAGE CREDIT: NWS

Charleston Heat Research

1 CMD Heat Research

2 CISA Heat Research

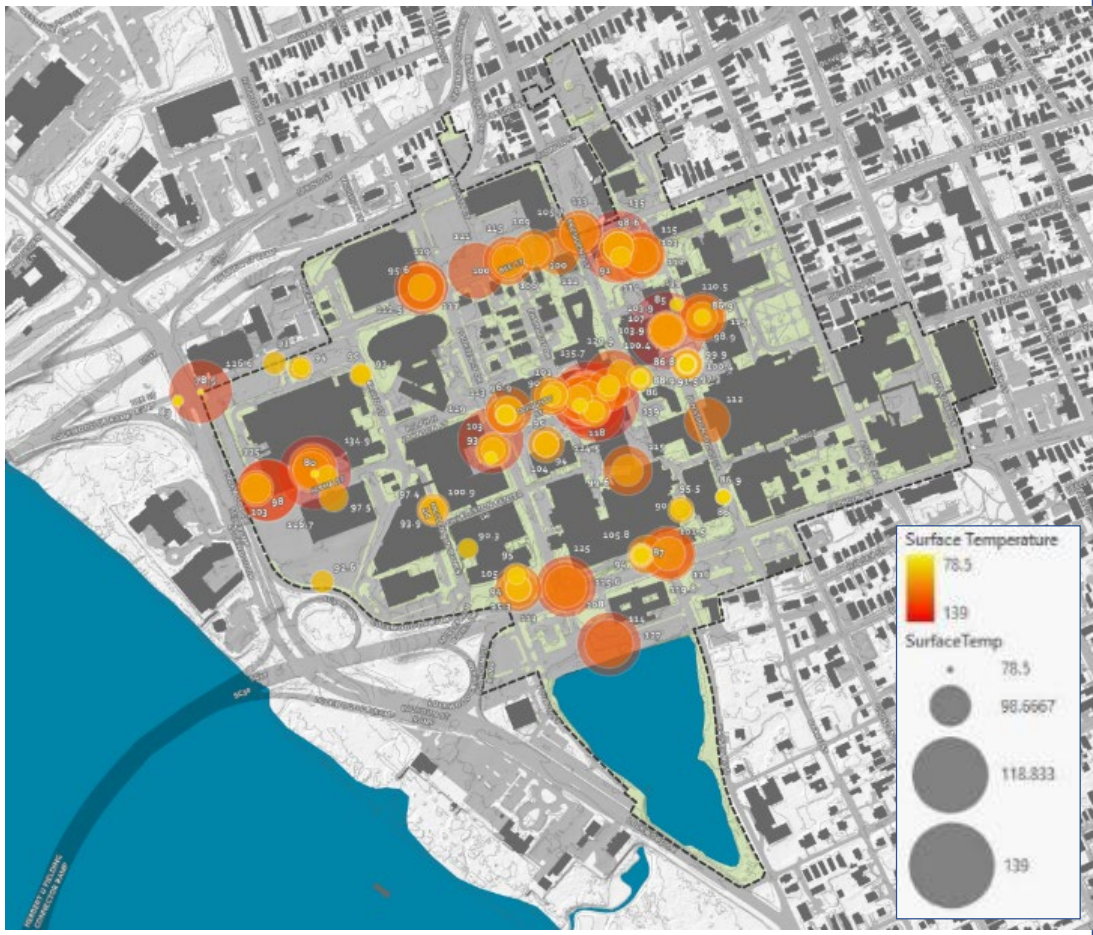
3 HeatWatch Research

4 Expanding and Sharing Research

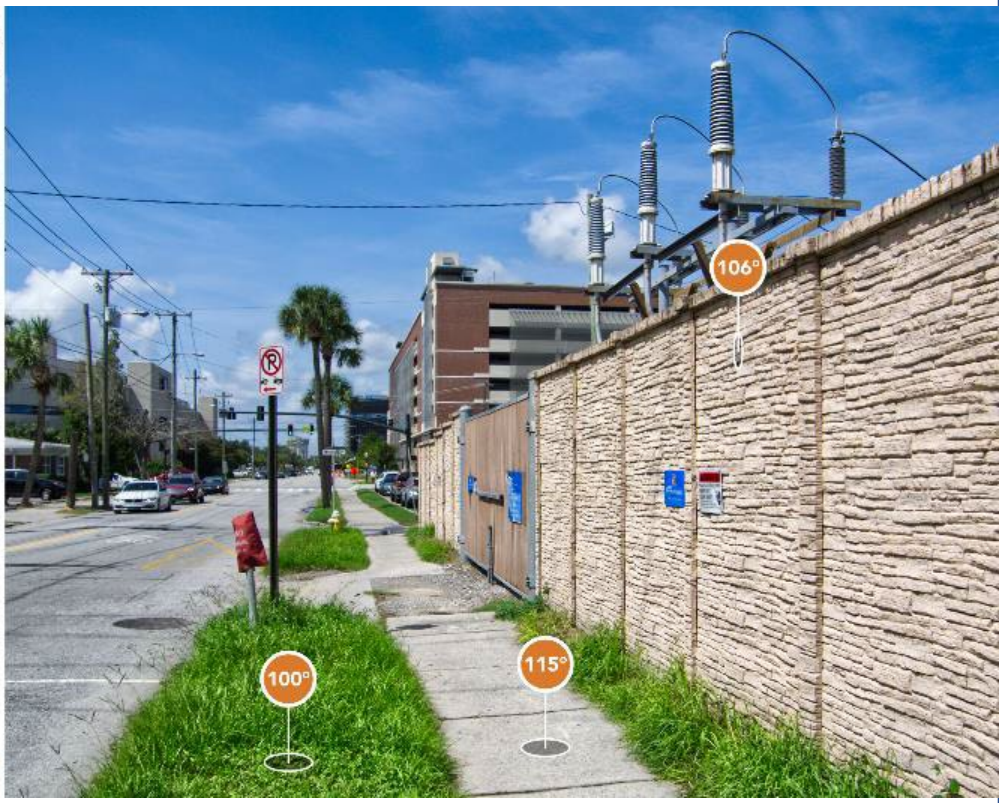
Surface Temperature Points

27 AUGUST 2020	12 am	6 am	12 pm	6 pm
TEMPERATURE deg. f (high)	75	88	91	90
WIND mph (direction)	1 (nne)	2 (w)	9 (w)	8 (ssw)
HUMIDITY %	94	82	63	80

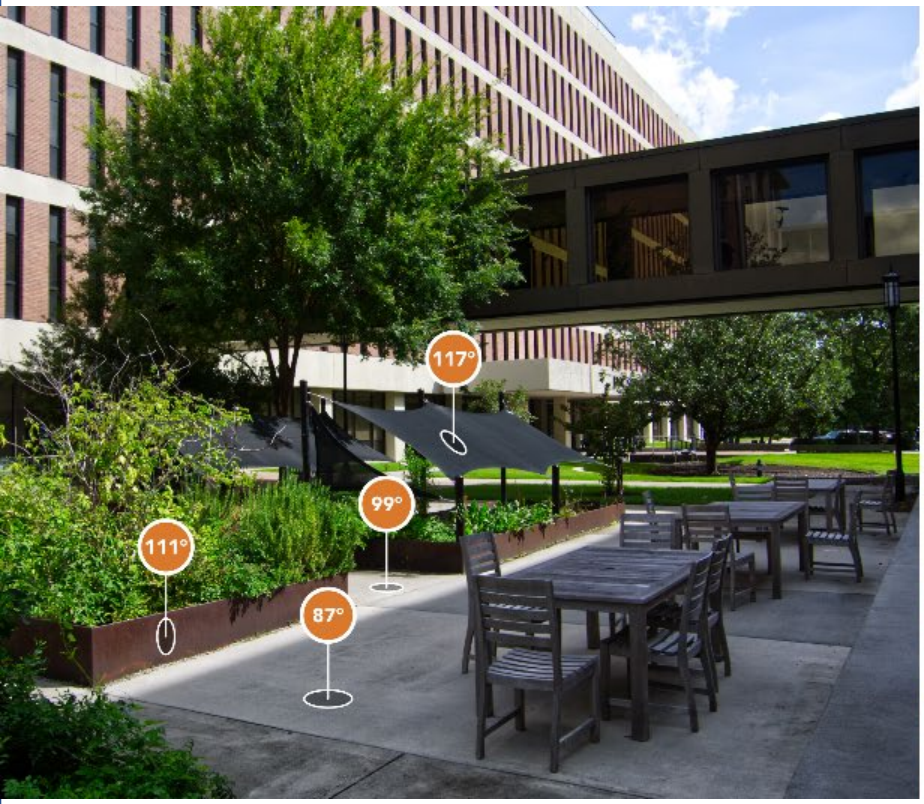
Historical weather data sourced from timeanddate.com
© 2020 Time and Date AS

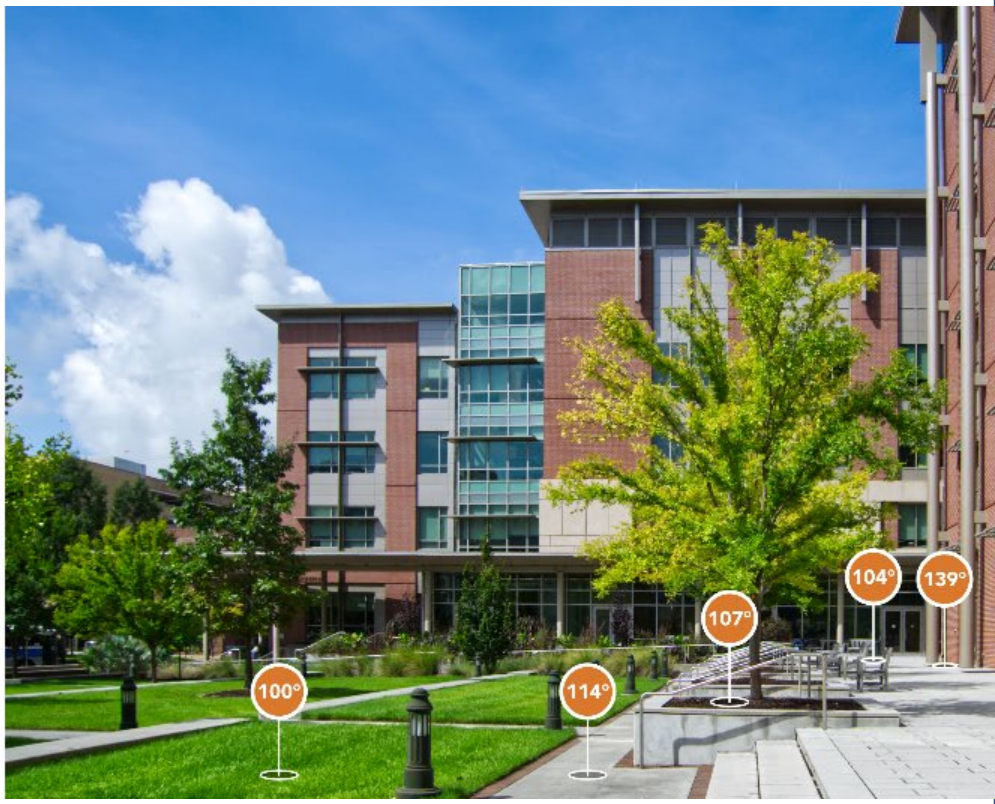


Medical District Research: Bee Street

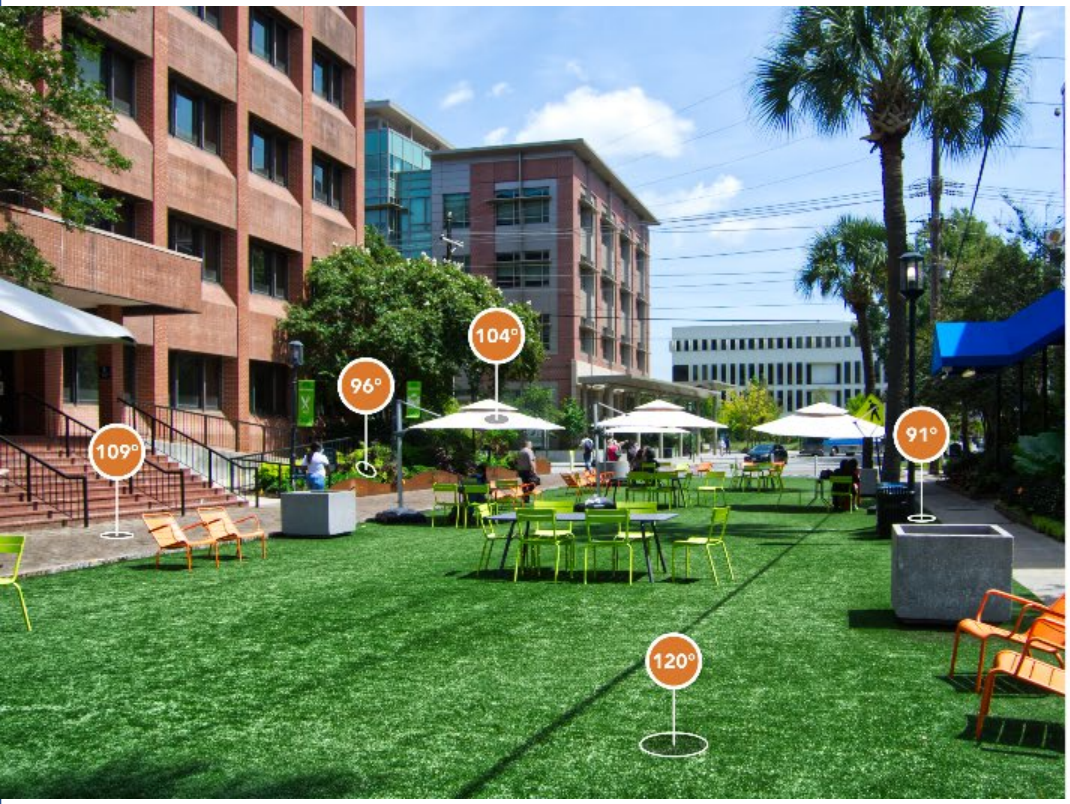


Medical District Research: Memorial Garden





Medical District Research: Doughty Street & Greenway



Charleston Heat Research

1 CMD Heat Research

2 CISA Heat Research

Used ibuttons and gps-enabled watches to monitor participant heart rate during workhours across four weeks

Used wet bulb globe temperature (WBGT) device to measure temperature, humidity and wind speed at designated areas across a number of days

PI: Dr. Kirstin Dow, USC
Stafford Mullin
Grant Farmer
Dr. Jen Runkle, NC State
Dr. Maggie Sugg, Appalachian State

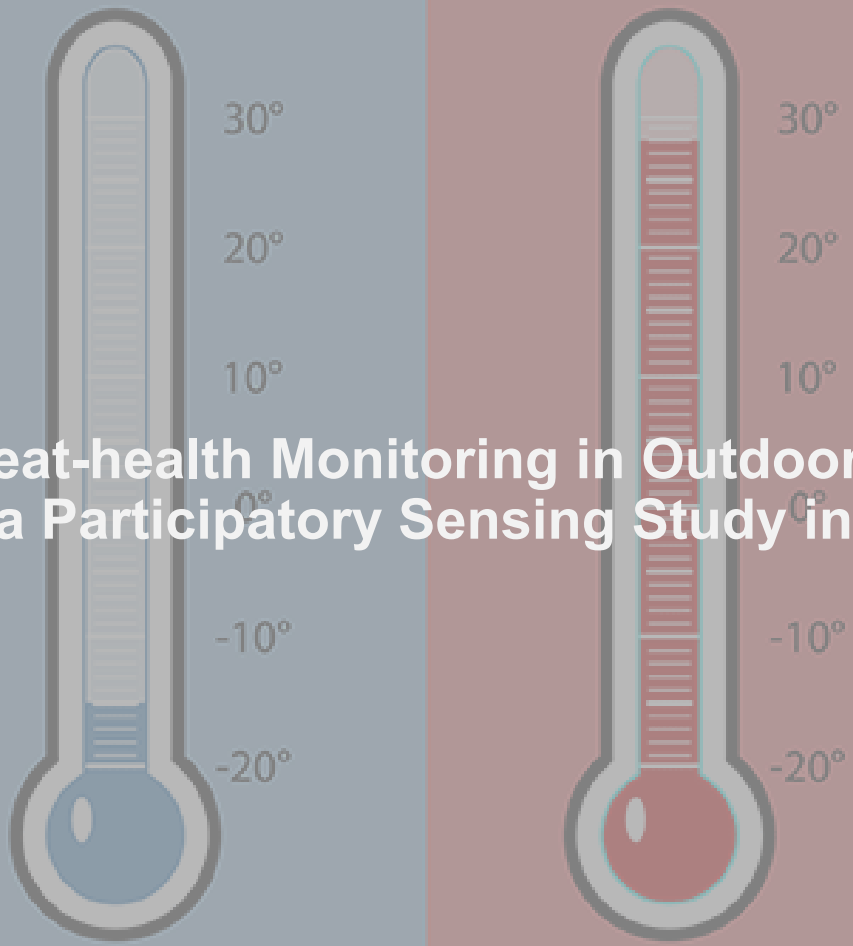
MUSC
Dr. Jerry Reves, MUSC
Robin Smith, MUSC Arboretum and Grounds
Major Dorothy Simmons, MUSC Public Safety
Christine Von Kolnitz, Director of MUSC Sustainability and Recycling

The Citadel
Dr. Scott Curtis, The Citadel James B Near Center for Climate Studies
Jonathan Lewellyn, The Citadel Grounds

Climate Adaptation Partners
Janice Barnes
Leo Temko

3 HeatWatch Research

4 Expanding and Sharing Research



Local Heat-health Monitoring in Outdoor Workers: Results from a Participatory Sensing Study in Charleston, SC

Jennifer Runkle, PhD, MSPH jrrunkle@ncsu.edu Maggie Sugg, PhD kovachmm@appstate.edu

Charleston Extreme Heat Initiatives Overview

City of Charleston Resiliency and Sustainability Advisory Committee Meeting
June 01, 2023

climate adaptation partners
resilience through collaborative partnerships

Charleston Heat Research

1 CMD Heat Research

2 CISA Heat Research

3 HeatWatch Research

4 Expanding and Sharing Research

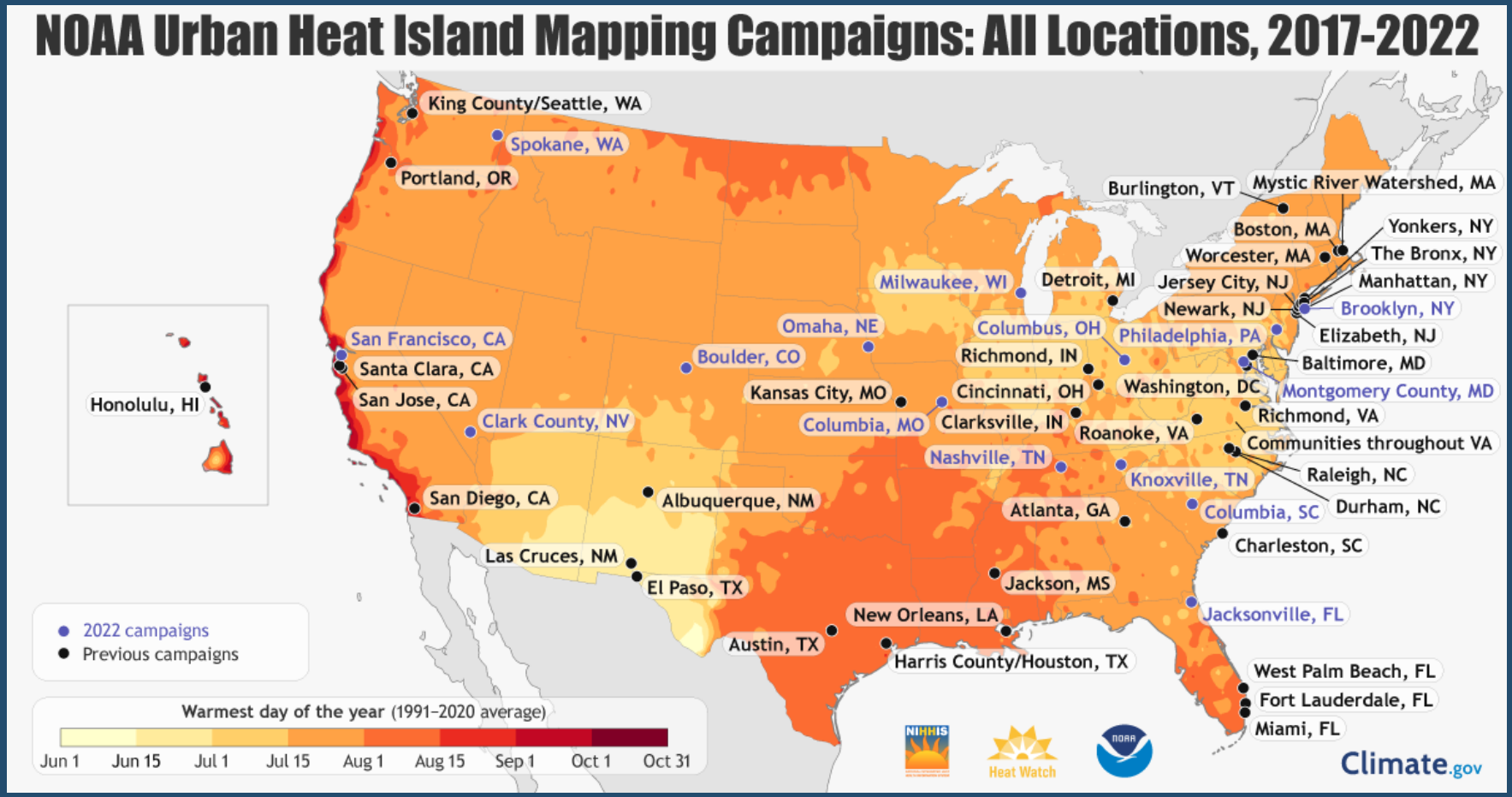
Lead Organization(s)

- City of Charleston, Climate Adaptation Partners

Partner Organizations

- Medical University of South Carolina Arboretum
- Citadel James B. Near Center for Climate Studies
- Charleston Resilience Network (Over 120 organizations)
- Charleston Medical District
- South Carolina Interfaith Power and Light
- Carolinas Integrated Sciences and Assessments
- Medical University of South Carolina Institute for Air Quality Studies
- Medical University of South Carolina Office of Health Promotion
- Medical University of South Carolina Sustainability Office
- National Weather Service Charleston

Used car-mounted devices to measure temperature and humidity on one representative day



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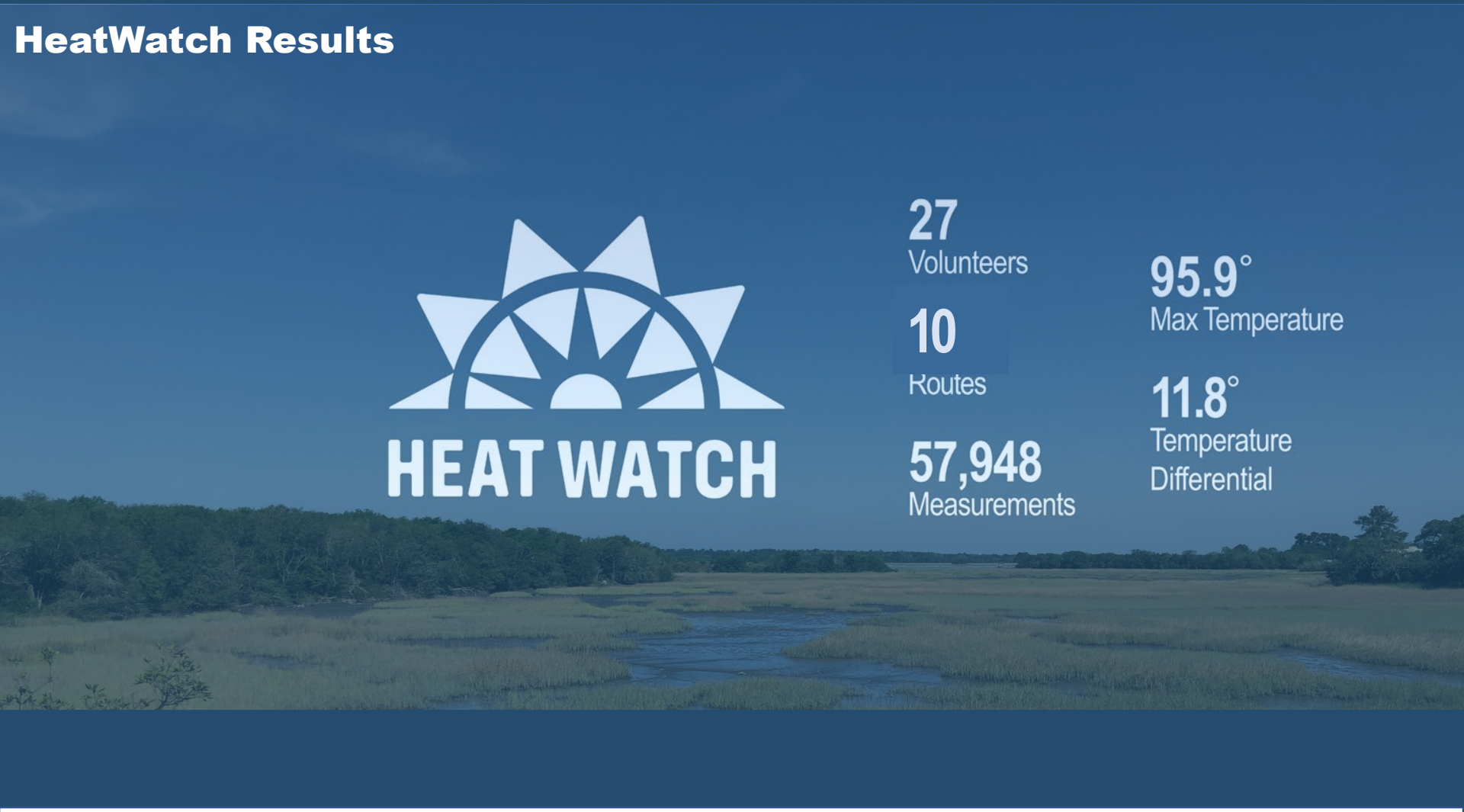
HeatWatch Results



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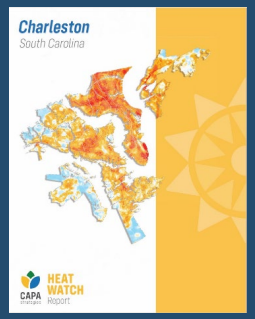
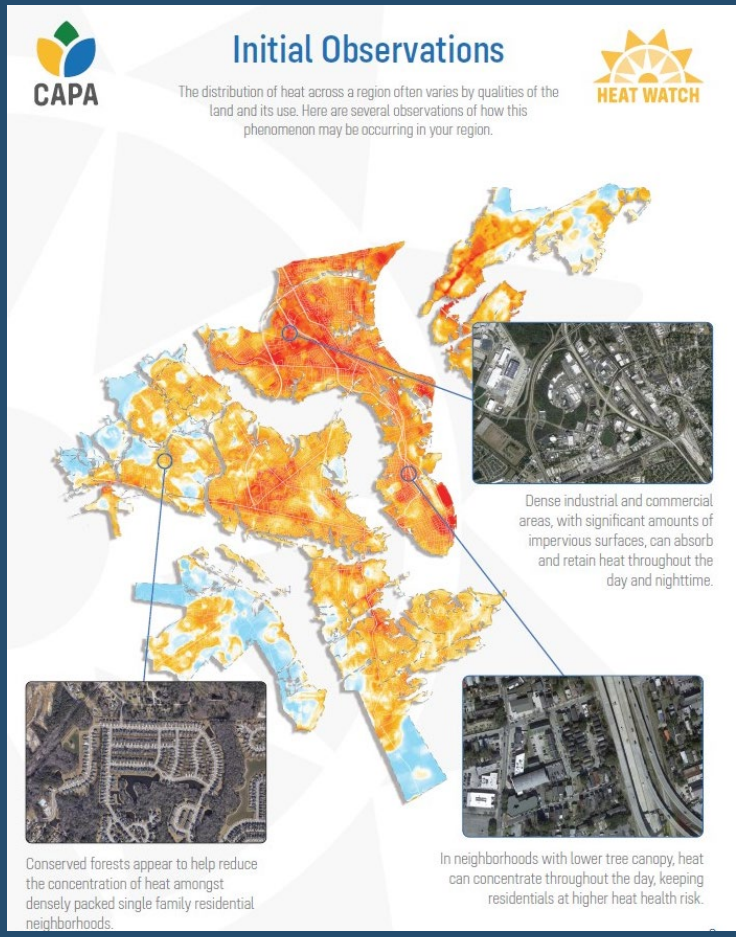
HeatWatch Summary

1. More effect of density of development
2. Peninsula was far warmer
3. Conserved Forest was cooler and offered a bigger impact on cooling than water bodies
4. No effect of swampy areas versus regular forest



Open Science Forum
https://osf.io/b4tfy/

City of Charleston GIS Team
https://www.charleston-sc.gov/2513/HeatWatch-Charleston-2021



Charleston Heat Research

1 CMD Heat Research

2 CISA Heat Research

3 HeatWatch Research

4 Expanding and Sharing Research

City of Charleston Resilience, GIS, and Planning Departments
Climate Adaptation Partners
University of South Carolina
The Citadel James B. Near Center for Climate Studies
South Carolina Sea Grant
UNC-Chapel Hill
MUSC Sustainability, Office of Health Promotion, Nursing, Epidemiology, Emergency Department, and Arboretum
National Weather Service Charleston
State of South Carolina Meteorology Office

NOAA NIHHIS and Pilot Research Team
City of Miami
City of Phoenix
City of Las Vegas
Drexel University

City of Philadelphia
City of Columbus

NOAA Pilot Project

Journal Publications
Philly & Columbia HeatWatch

NOAA Pilot Project

Sea Grant | S.C. SEA GRANT CONSORTIUM
Coastal Science Serving South Carolina

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Charleston Heat-Health Research Project

The Charleston Heat-Health Research Project (CHHRP) was created by a group of health professionals, climate scientists, city planners, students and researchers to learn more about heat impacts in the community.

LEARN ABOUT THE PROJECT

PARTNERS

Funding

+

Sea Grant
S.C. SEA GRANT CONSORTIUM

Administration and Outreach

+

HEAT SEASON DATA COLLECTION

IMAGE CREDIT: City of Charleston

CHAcity.org
HOUSING AUTHORITY OF THE CITY OF CHARLESTON

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Charleston Extreme Heat Initiatives Overview

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HEAT SEASON DATA COLLECTION

Near to the CMD, Gadsden Green is in a hot part of Charleston.

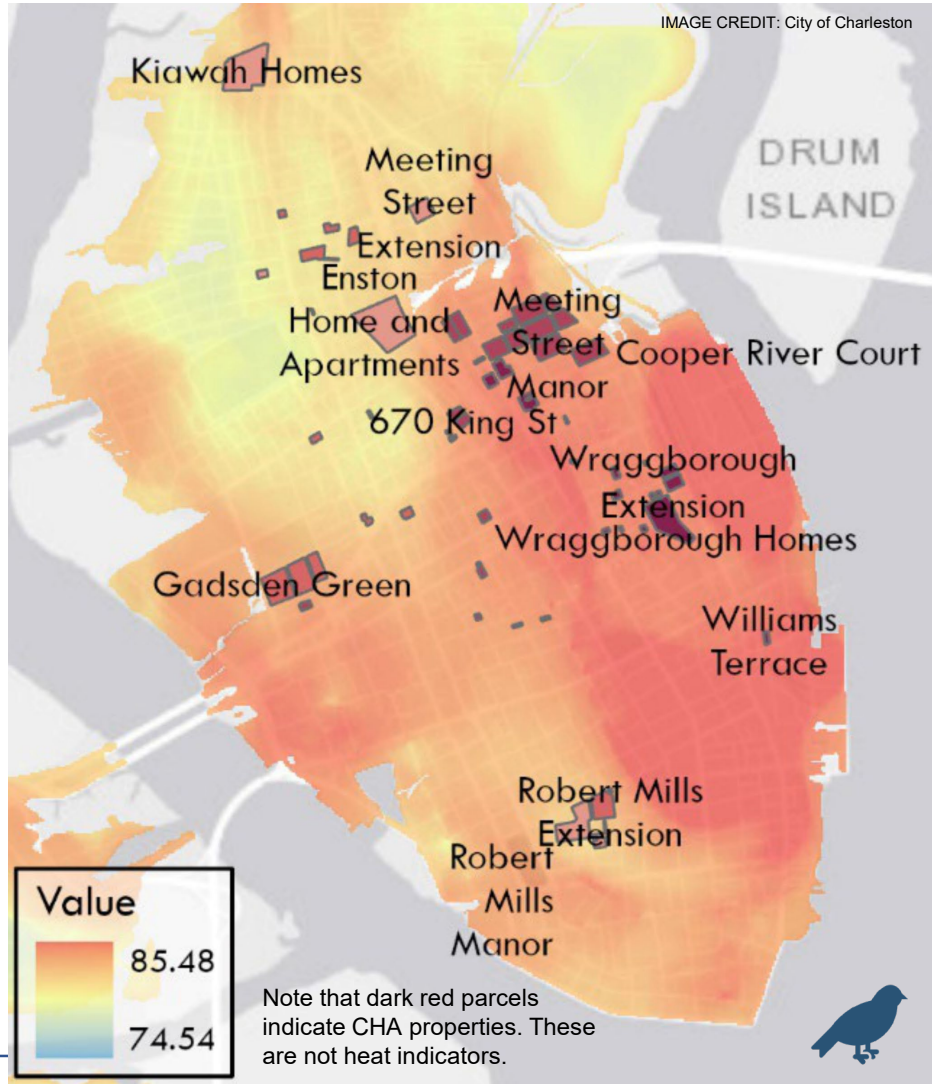
We hoped to better understand heat impacts by:

Phase 1 (LEARN):

- recording hot temperatures in the community
- identifying materials that make heat feel worse
- talking about how heat affects health

Phase 2 (ACT):

- identifying resources to help cope with heat
- finding solutions to help cool the environment



HEAT SEASON DATA COLLECTION

Figure 2: Gadsden Green Land Cover

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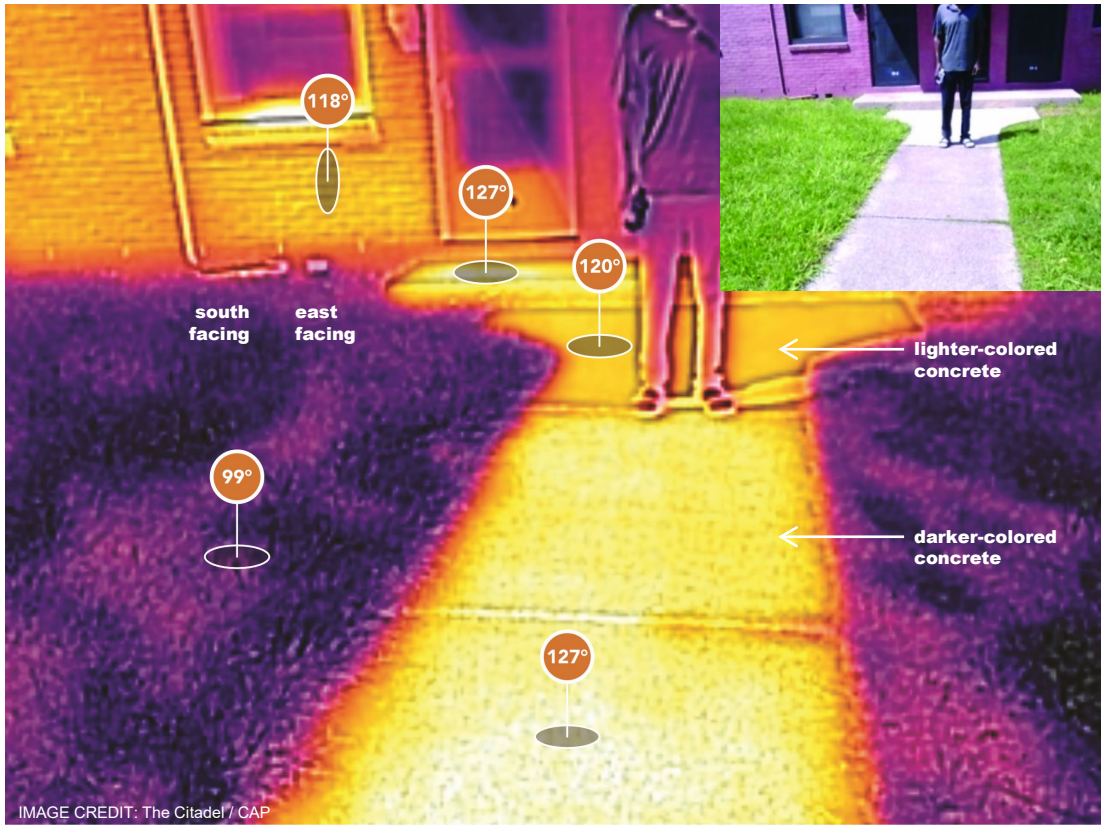
HEAT SEASON DATA COLLECTION

SURFACE TEMPERATURES IN GADSDEN GREEN

The next two images illustrate the surface temperature differences in **sunny** and **shaded** conditions.

This image of an **exposed stoop** in Gadsden Green shows grass, concrete, and brick in direct sun.

Note the temperature differences between the lighter-colored concrete and darker-colored concrete.



HEAT SEASON DATA COLLECTION

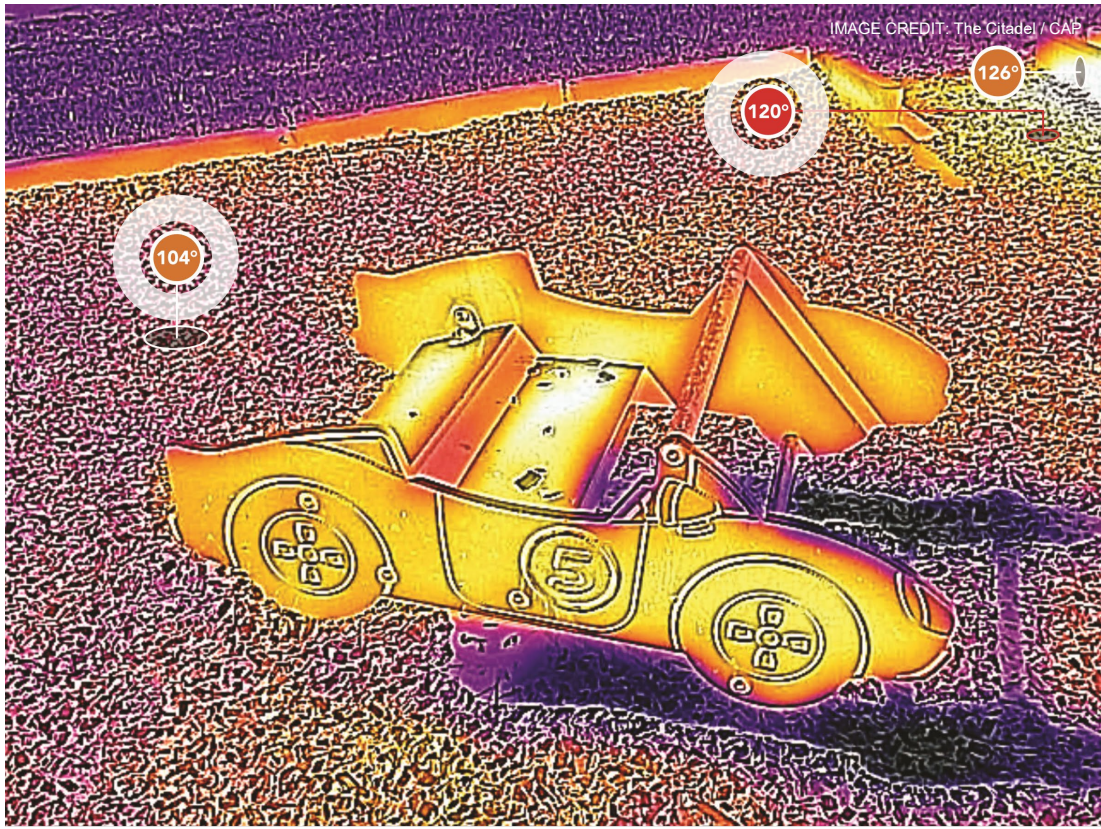
SURFACE TEMPERATURES IN GADSDEN GREEN

Note that the wood chips / mulch areas are significantly warmer than the grass areas.

The hottest surfaces in this area are the plastic and steel surfaces.

But there is also another important principle illustrated by this image

The radiant heat emitted by the plastic is significantly increasing the surface temperature of the adjacent wood chips / mulch by nearly 20°



Examples of Extreme Heat Strategies

Increase Awareness

- Heat-Health discussions with physicians
- Heat risk awareness campaign
- National Weather Service heat warning announcements
- Local news and social media emphasis on heat awareness
- Community

Increase Coping Capacity

- Cooling Center access
- Air conditioner give-aways/subsidies
- Utility bill support
- Swimming pool and spray pads access
- Home weatherization programs
- Alternative

Increase Mitigation

- Tree canopy expansion
- Green space expansion
- Depaving
- Heat reflective building materials
- Cool coatings on existing roads
- Air circulation via “breeze ways”

Increase Adaptation

- Cool corridor development
- Wind channeling to cool urban core areas
- Building code changes to integrate heat reduction
- Alternative paving strategies
- Microclimate management

Heat Research Coalition in Charleston

Climate Adaptation Partners
Charleston Medical District
City of Charleston Office of Sustainability and Resilience
MUSC Office of Sustainability
Roper St. Francis Healthcare
Ralph H. Johnson VA Medical Center
Fernleaf Interactive
MUSC Office of Health Promotion
City of Charleston Wellness Committee
South Carolina Sea Grant
Carolinas Integrated Sciences Assessment
The Citadel James B. Near Center for Climate Studies
Southeast Regional Climate Center
North Carolina State University
Appalachian State

MUSC Arboretum
Charleston Resilience Network
Charleston Healthy Business Coalition
CAPA Strategies
NOAA NIHHIS Team
South Carolina Department of Health and Environmental Control
South Carolina Health Professionals for Climate Action
South Carolina Interfaith Power and Light
College of Charleston
Clemson University
South Carolina Aquarium
City of Charleston Planning
MUSC School of Nursing
MUSC Medical School
University of South Carolina