Stormwater Design in (the Future of) the Coastal Plain

Bay-wide Stormwater Partners' Retreat
April 14, 2023

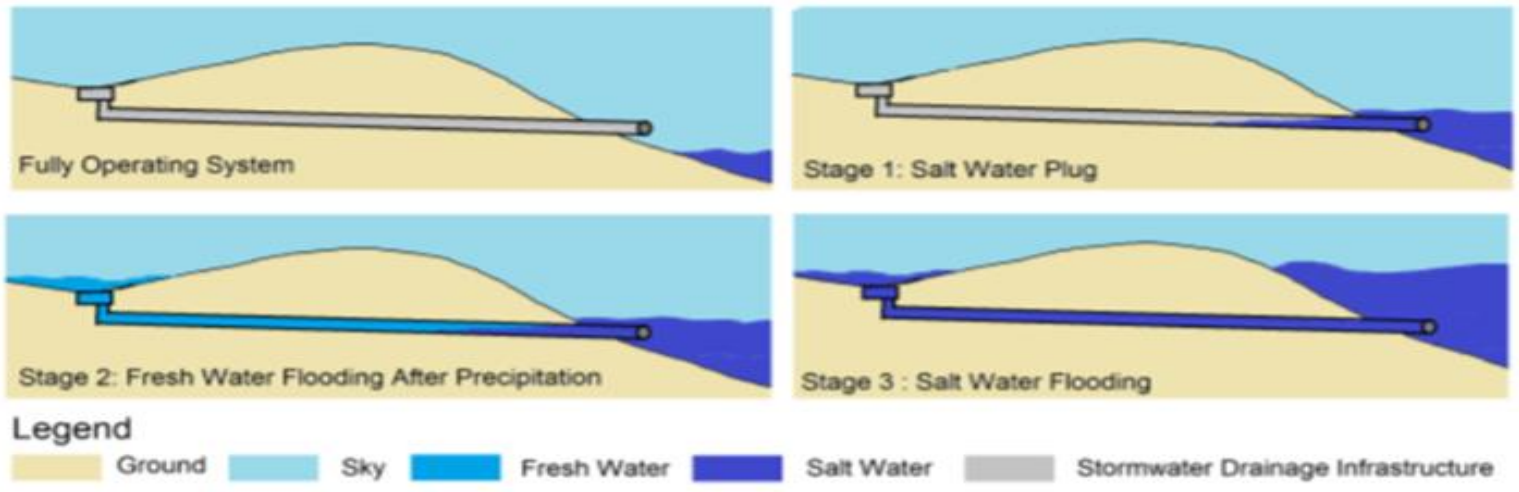
STORMWATER CONSTRAINTS IN THE COASTAL PLAIN

- Extremely flat terrain creates low head conditions
- High water table
- Highly altered drainage (particularly headwaters)
- Poorly drained soils
- Very well drained soils
- Roadside ditches serve as the stormwater receiving system
- Short distance to receiving waters
- Unique development patterns

CLIMATE CHANGE EXACERBATES THIS DYNAMIC

- Reduced infiltration capacity
- Submerged outlet structures resulting in back-up and loss of capacity
- Saltwater intrusion – vegetation and pollutant removal impacts

Figure 2.5: Stages of stormwater drainage failure due to sea-level rise. Graphic by Emily Niederman, Stetson University.



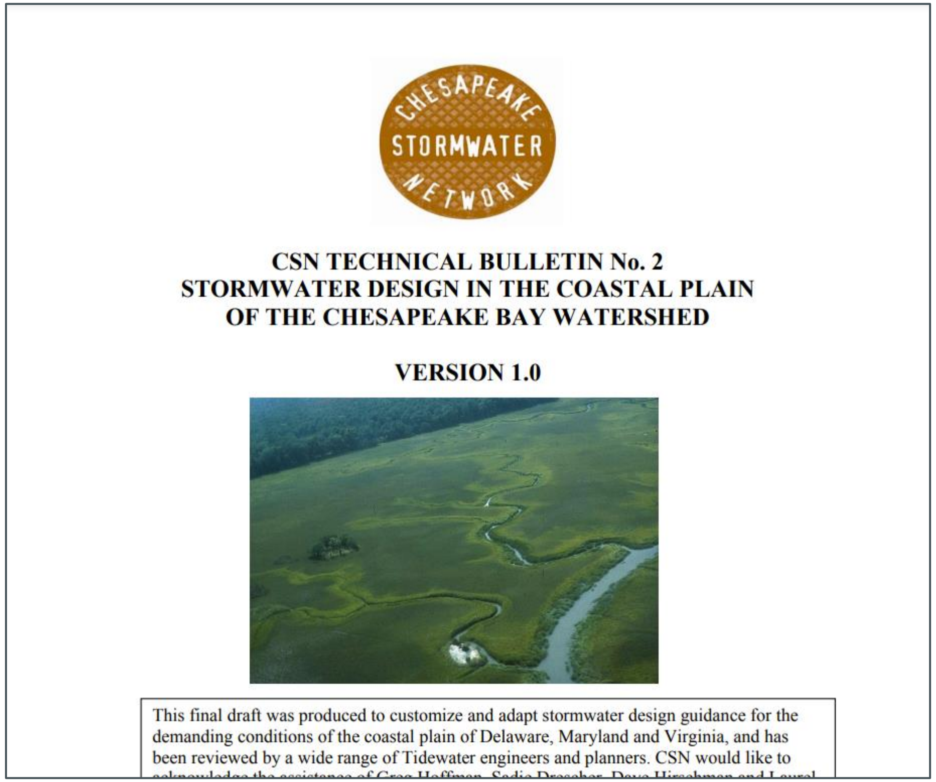
TOP 10 U.S. CITIES INCREASING HIGH TIDE FLOODING

CITY	'Nuisance level': Meters above MHHW mark	Ave. nuisance flood days (1957-1963)	Ave. nuisance flood days (2007-2013)	Percent Increase
Annapolis, MD	0.29	3.8	39.3	925
Baltimore, MD	0.41	1.3	13.1	922
Atlantic City, NJ	0.43	3.1	24.6	682
Philadelphia, PA	0.49	1.6	12.0	650
Sandy Hook, NJ	0.45	3.3	23.9	626
Port Isabel, TX	0.34	2.1	13.9	547
Charleston, SC	0.38	4.6	23.3	409
Washington, DC	0.31	6.3	29.7	373
San Francisco, CA	0.35	2.0	9.3	364
Norfolk, VA	0.53	1.7	7.3	325

NOAA Technical Report NOS CO-OPS 083

TECHNICAL BULLETIN #2

- CSN report developed in 2009
- Focus on importance of ESD and runoff reduction.
- Practices sorted into: Preferred, acceptable and restricted
- 2021 USWG Workshop recommended climate resilient design considerations. Addressing coastal stormwater was a high priority


CHESAPEAKE STORMWATER NETWORK

CSN TECHNICAL BULLETIN No. 2
STORMWATER DESIGN IN THE COASTAL PLAIN
OF THE CHESAPEAKE BAY WATERSHED

VERSION 1.0

This final draft was produced to customize and adapt stormwater design guidance for the demanding conditions of the coastal plain of Delaware, Maryland and Virginia, and has been reviewed by a wide range of Tidewater engineers and planners. CSN would like to

SOME PROPOSED UPDATES

- Incorporating design modifications to water quality or runoff reduction requirements to handle bypass or overflow from more extreme rain events.
- More definitive guidance on submerged gravel wetlands (as a preferred practice)
- More details on “Smart” practices - ponds and possible constructed wetlands
- More resilient stormwater plumbing in the face of rising surface and groundwater levels (pipe flap gates, backwater flow prevention, sedimentation)


PROPOSED UPDATES (CONT.)

- Ditch swale adaptations
- Plant landscaping updates
- Re-design of shoreline management practice to accept and treat some portion of upland runoff before discharge to salt water
- Dealing with soil health and media amendments

THANK YOU!

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Residential Stormwater Drainage Improvement Program - Charles County, MD

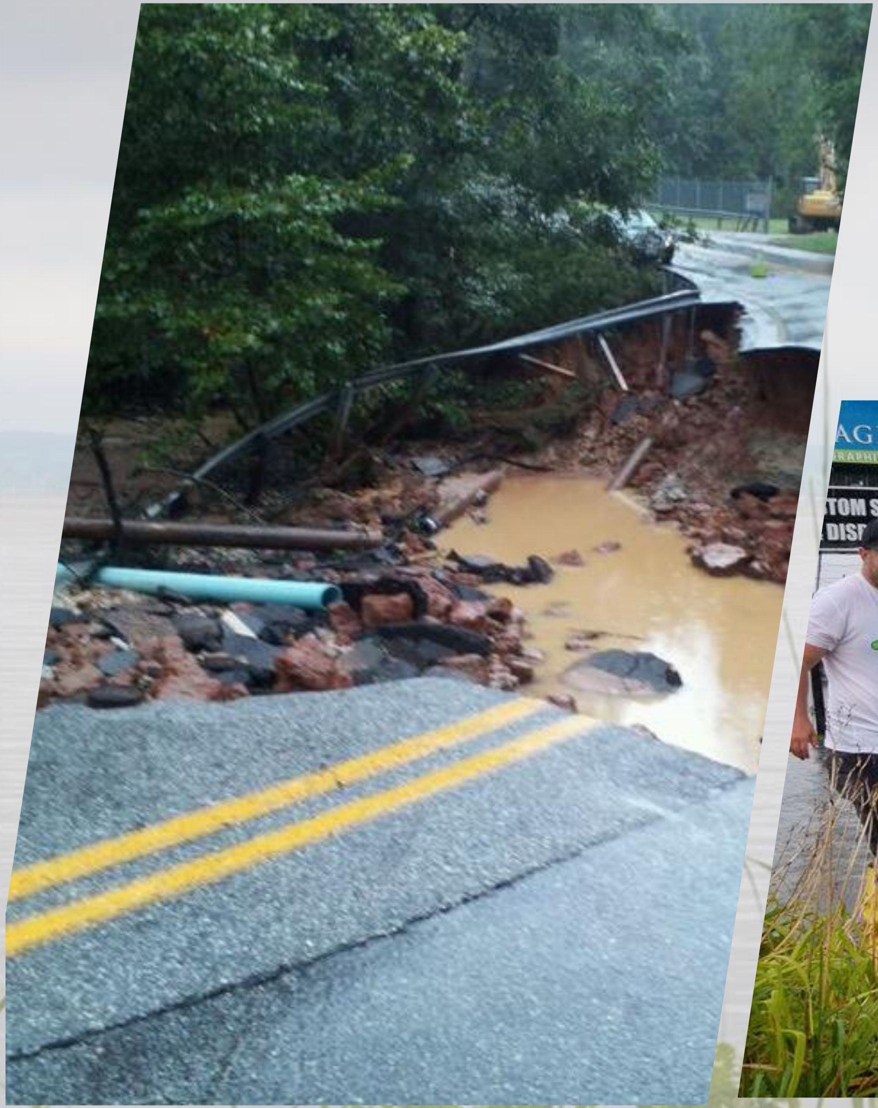
Beth A. Groth

Climate Resilience and Sustainability Officer

Charles County Government

Location and Context

Climate Hazards



- **Extreme Weather Events**
- **Extreme Temperatures (Heat)**
- **Nuisance Flooding**
- **Urban Flooding**
- **Sea Level Rise**

Residential Stormwater Drainage Improvement Program

- **The Problem - Drainage Issues in 100+ Neighborhoods**

Residential Stormwater Drainage Improvement Program

- The Solution
  - Charles County will offer/resolve to take over responsibility for repair/maintenance of these stormwater drainage systems in perpetuity.
  - Property owners will be required to donate the necessary easements for repair and maintenance.
  - Charles County Government partnered with the Charles County Resilience Authority to conduct a project to assess and prioritize neighborhoods.

Residential Stormwater Drainage Improvement Program

- Neighborhood Assessment and Prioritization Project
  - The Charles County Resilience Authority hired Biohabitats.
    - Neighborhoods were assessed and prioritized based on the following criteria:
      - Drainage System Characterization
      - Severity and Feasibility
      - Equity
      - Dual Benefits

Neighborhood Prioritization Dashboard

Charles County Residential Stormwater Drainage Improvement Program

Prioritization Category
None

Select Neighborhood
None

Category 1: Drainage System Characterization

The Drainage System Characterization score considers the age of the system, its ability to convey predicted or anticipated storm flows (capacity), physical condition, and risk to adjacent vital infrastructure. The factors were evaluated through a mixture of desktop analysis and field assessment. The final categorizations were assigned based on score.

Category 2: Severity and Feasibility

Category 2 considers the severity of the initiating drainage complaint in addition to feasibility of implementing a solution. Severity was assessed based on field observations and professional judgement. If the situation would be made worse or threatened additional property or infrastructure by not taking action, the severity was considered high. The ability to address the drainage or flooding issue (or feasibility) included physical parameters such as available space, slope, and soil type.

Category 3: Equity

This category consisted solely of equity based on the neighborhood or parcel's 2020 Social Vulnerability Index (SVI) score. The score is computed based on US census data and looks at the communities ability to adapt to changes. More information can be found online using the SVI Fact sheet.

Category 4: Dual Benefits

Category 4 characterized the opportunities for additional project benefits such as ability to provide water quality treatment towards the County's Municipal Separate Storm Sewer System (MS4) permit requirements or to protect existing public infrastructure.

Huntington

Category	Score	Max Score	Classification
1	40	40	Drainage System: Failed
2	23	30	
3	20	20	High Social Vulnerability
4	10	10	
Total	93	100	

Prioritization: High

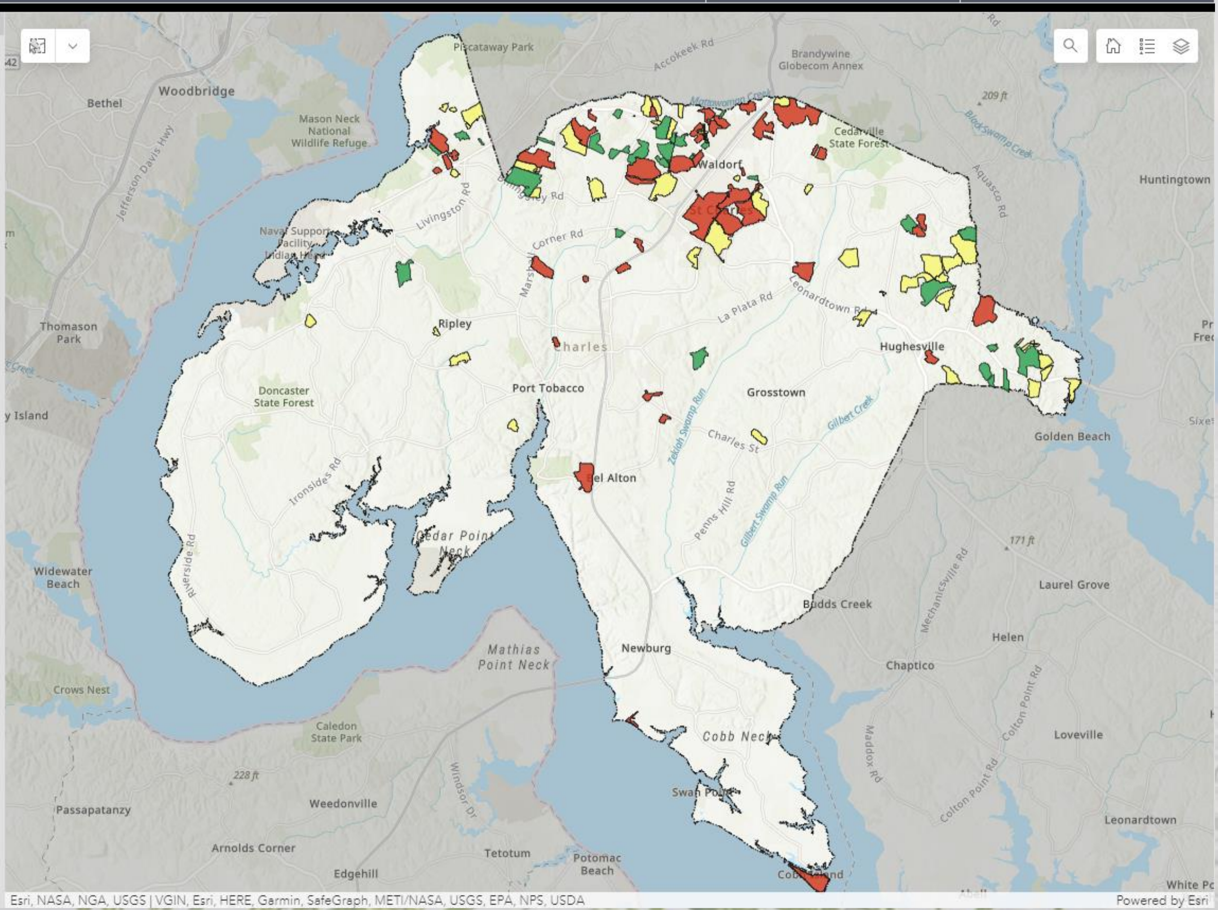
Green Meadows

Category	Score	Max Score	Classification
1	35	40	Drainage System: Failed
2	22	30	
3	15	20	Medium to High Social Vulnerability
4	10	10	
Total	82	100	

Prioritization: High

Zekiah Valley

Category	Score	Max Score	Classification
1	31	40	Drainage System: Failed
2	25	30	
3	15	20	Medium to High Social Vulnerability
4	10	10	
Total	81	100	



Residential Stormwater Drainage Improvement Program

- Cost and Funding
  - Total cost unknown at this time
  - Approximately 51% of Charles County's American Rescue Plan Act (ARPA) Funds will be used for this effort: $16.2 million
  - ARPA funds will also be used for:
    - Rural Broadband Initiative
    - Mattawoman Waste Water Treatment Plant Upgrades
    - Public Safety and Public Health
    - Grants to Support Local Businesses and Non-Profits

Meeting the Climate Challenge

- Whole of Government Approach
  - Support from the top down to prioritize climate resiliency and sustainability
  - Climate Resilience and Sustainability Officer Position
  - Climate competency requirement added to 83 of 822 full-time permanent positions
  - Climate Leadership Academy participation
  - Embarking on a Climate Action Planning process
  - Integrating climate change mitigation, adaptation and resilience into decision-making processes
  - Positive response from bond rating agencies
  - Creation of the Resilience Authority of Charles County

Maryland Climate Leadership Academy

Administered by:

MARYLAND

MARYLAND DEPARTMENT OF NATURAL RESOURCES

Powered by:

ACCO

ASSOCIATION OF CLIMATE CHANGE OFFICERS

Resilience Authority of Charles County

- The Process of Establishing a Resilience Authority (RA)
  - SB457 - 2020 Maryland legislative session
  - Bill 2020-07 adopted by the County Commissioners on 12/08/2020
  - Separate non-profit entity, yet an instrumentality of the incorporating local government
  - Independent Board of Directors appointed February 2021
  - Executive Director, Stacy Schaefer, hired February 2023
- Project Focus
  - Initial focus on stormwater drainage improvement projects
  - High priority projects identified in the Nuisance and Urban Flood Plan
  - Projects that address climate change

Resilience Authority of Charles County

- Advantages
  - Outside the county government procurement process
  - Range of financing structures and funding techniques to leverage public and private investment
  - Eligible to receive grant funding for which county governments may not be eligible or competitive
  - Any debt service incurred by the Authority, as a separate entity, does not accrue to the county's debt ceiling policy
  - Decisions can be made outside of the political process
  - Embrace innovative solutions
  - Scalable to manage larger projects as the county grows

Contact Information

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RESILIENT STORMWATER DESIGN GUIDELINES FOR HAMPTON ROADS

"Climate Change and Stormwater:
Dealing with the Challenges of Coastal Stormwater Management"
11th Biennial Bay-Wide Stormwater Partners' Retreat
National Conservation Training Center
April 14, 2023

Benjamin J. McFarlane, AICP, CFM
Chief Resilience Officer
Hampton Roads Planning District Commission

HAMPTON ROADS PLANNING DISTRICT COMMISSION

The Region:

17 member jurisdictions in southeastern Virginia with a total population of 1.7 million residents

The Commission:

Forum for local and elected officials to discuss issues of regional importance

The Staff:

Provide technical assistance, support policy development, and lead Committees of local staff

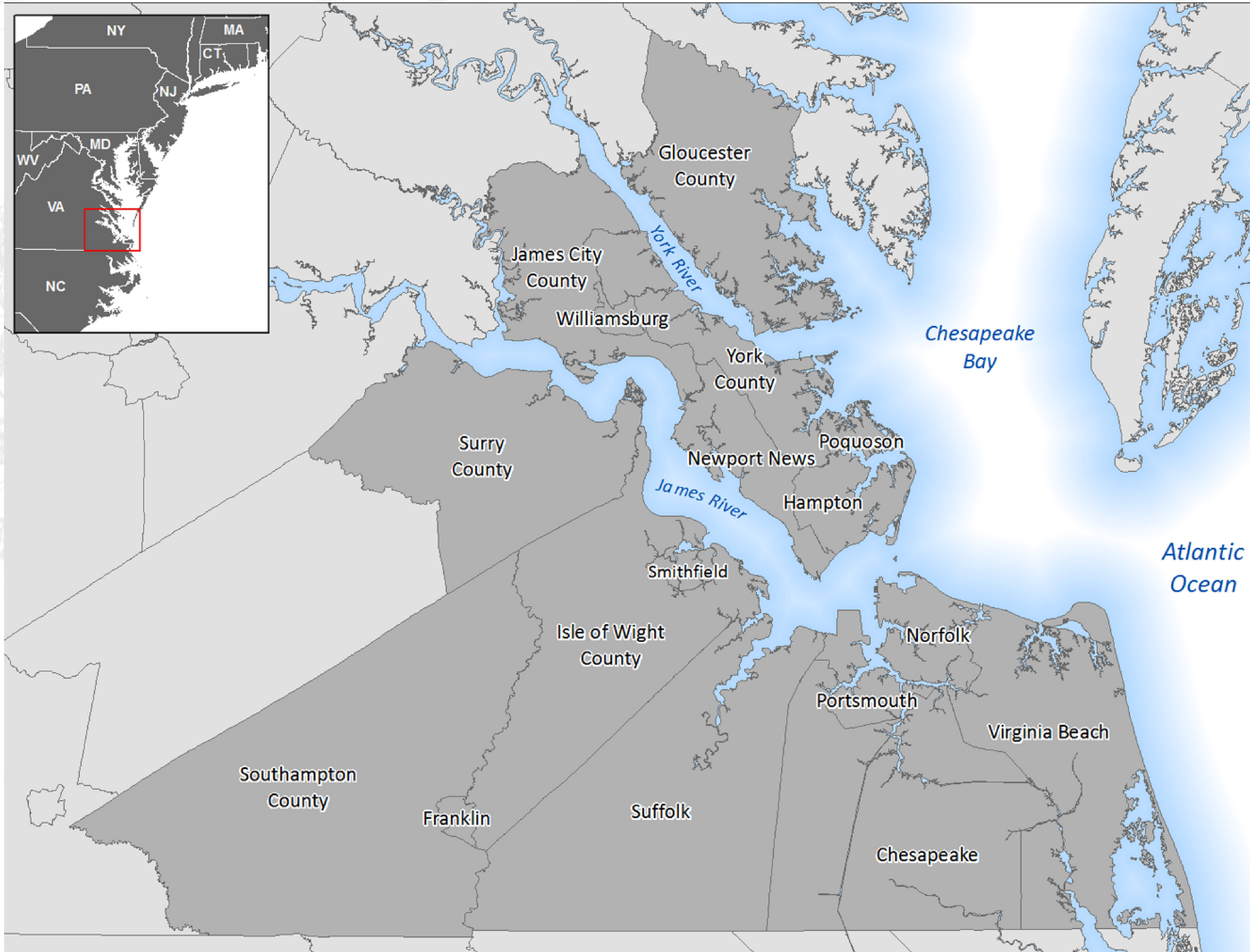


Image Source: City of Norfolk

Image Source: David Powell

Image Source: City of Norfolk

Image Source: Ben McFarlane

THE PROBLEM

Design standards are based on risk - what level of risk are willing to tolerate?

What are we willing to pay to reduce the expected costs or consequences of something happening?

What are the actual options we have to reduce our risk?

What does risk look like in terms of design standards?

THE PROBLEM

Our design standards and regulations are generally based on historic observations.

For public policies to work, it's important for expectations to align with reality.

If we expect the future to look different from the past or the present, we should design for those expected conditions.

A WAY FORWARD

Using available information, amend ordinances, policies, and regulations to account for future conditions under climate change.

These policies should reflect the best available science and be subject to regular review and updates.

Making these changes will help communities make better decisions about where, what, and how to build.

Building on Prior Efforts

CBP/RAND/MARISA

High-Resolution Land Cover Data

FEMA

Flood Insurance Studies

U.S. Army Corps of Engineers

North Atlantic Coast Comprehensive Study

Virginia Beach

Public Works Design Standards Manual

VDOT

Considerations of Climate Change and Coastal Storms

VTRC

Incorporating Potential Climate Change Impacts in Bridge and Culvert Design

Principles

Resilient design guidelines should be scientifically-based, appropriate, and implementable.

Scientifically-Based

Guidelines should be developed using sound data, models, and methods.

Appropriate

Guidelines for specific uses should be based on agreed-upon level of risk tolerance.

Implementable

Guidelines should be practicable and not considered impossible or overly difficult to achieve.

Resilient Design Guidelines: Projections

SEA LEVEL RISE

Regional sea level rise planning scenarios

PRECIPITATION

Future precipitation values based on climate models

Resilient Design Guidelines: Applications

FLOODPLAIN MAPPING

Projections of future floodplains incorporating sea level rise and riverine flooding

TAILWATER ELEVATIONS

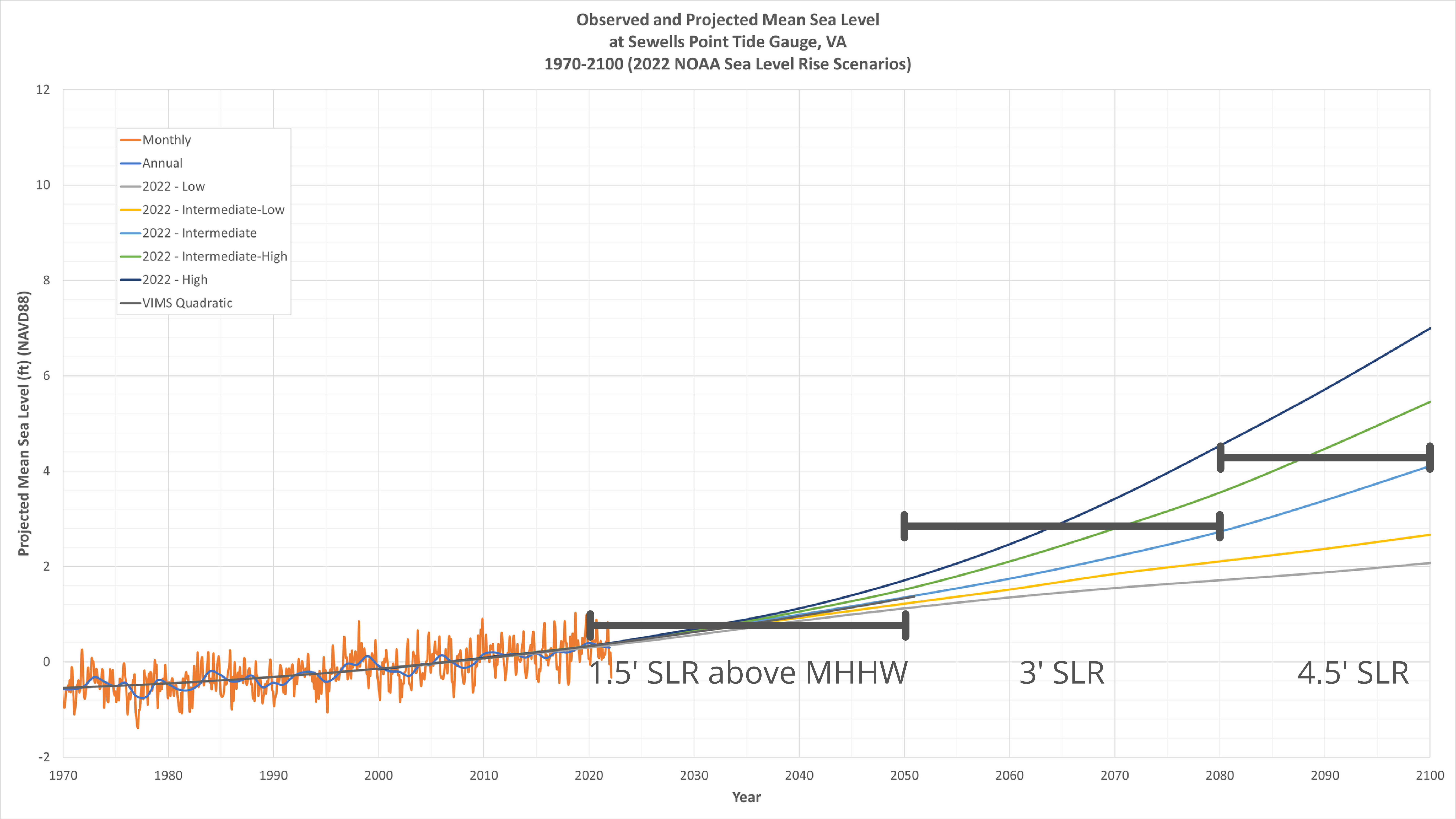
Boundary conditions based on watershed tidal elevations with sea level rise

DESIGN STORMS

Rainfall levels corresponding to various return periods

JOINT PROBABILITY EVENTS

Design storms that pair tidal and rainfall events



Observed and Projected Mean Sea Level
at Sewells Point Tide Gauge, VA
1970-2100 (2022 NOAA Sea Level Rise Scenarios)
Monthly
Annual
2022 - Low
2022 - Intermediate-Low
2022 - Intermediate
2022 - Intermediate-High
2022 - High
VIMS Quadratic
Projected Mean Sea Level (ft) (NAVD88)
Year
1.5' SLR above MHHW
3' SLR
4.5' SLR
12
10
8
6
4
2
0
-2
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100

TAILWATER ELEVATIONS

Stormwater outfalls are designed to account for a certain amount of "tailwater."

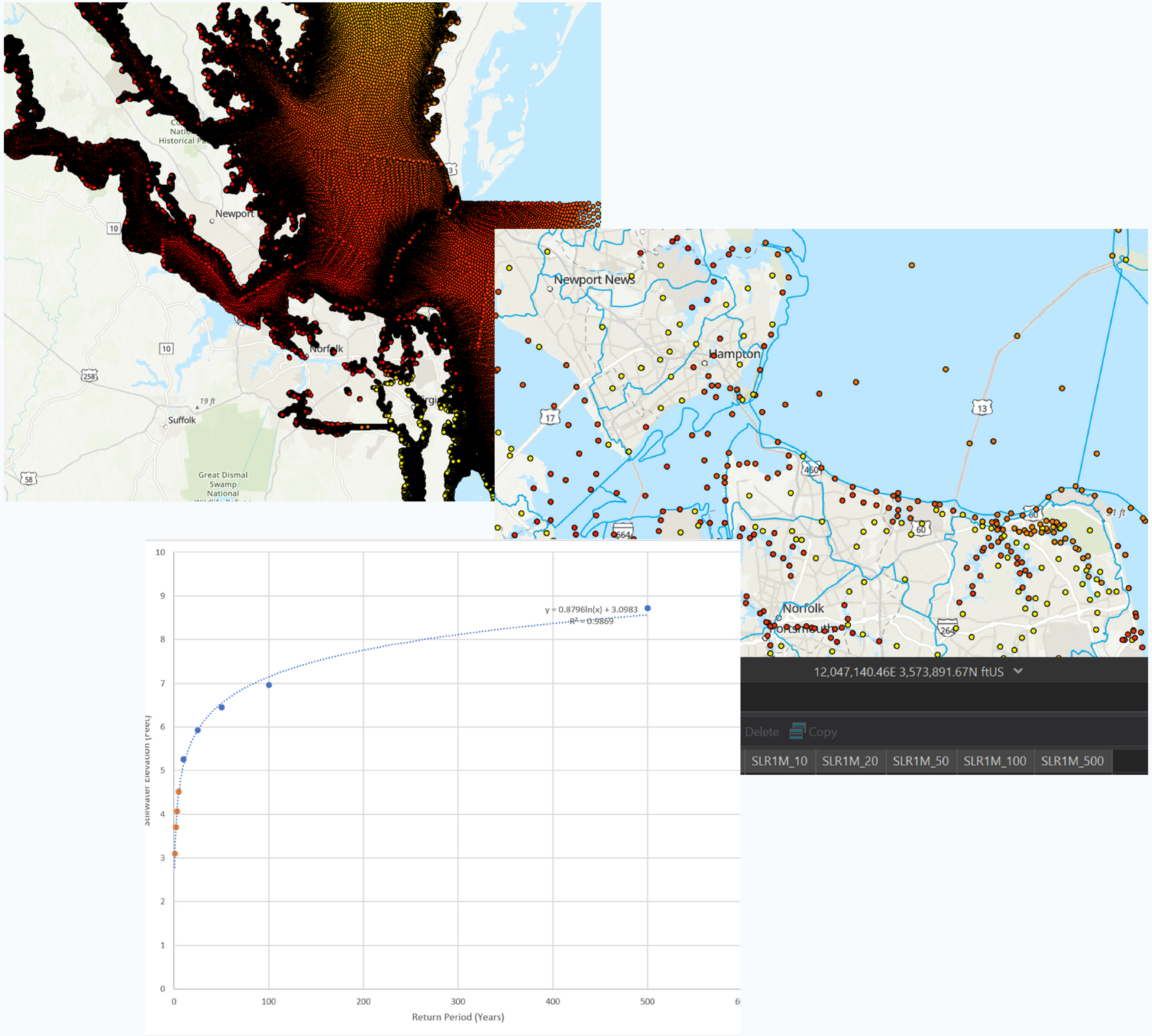
Default tailwater assumptions do not always account for tidal conditions.

Sea level rise will decrease the capacity of stormwater systems that do not take future conditions into account.

Approach

Use FEMA values for 10- to 500-year events to extrapolate values for 1-, 2-, 3-, and 5-year events

Incorporate non-linearity from USACE North Atlantic Coast Comprehensive Study (NACCS).



Tailwater

Calculate tailwater values for each watershed incorporating regional sea level rise scenarios.

These values can be used as inputs for stormwater calculations.

Design Tidal Elevations – Chesapeake

Note: All elevations in feet relative to the North American Vertical Datum (NAVD) of 1988

HUC12	Watershed	Design Level	1-Year	2-Year	3-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
020802080201	New Mill Creek-Southern Branch Elizabeth River	Current	3.9	4.5	4.8	5.2	5.8	6.6	7.2	7.8	9.2
		1.5 ft SLR	5.4	6.0	6.3	6.7	7.3	8.1	8.7	9.3	10.7
		3.0 ft SLR	6.9	7.5	7.8	8.2	8.8	9.6	10.2	10.8	12.2
020802080203	Deep Creek-Southern Branch Elizabeth River	Current	3.4	4.1	4.5	5.1	5.9	6.7	7.3	8.0	10.0
		1.5 ft SLR	4.9	5.6	6.0	6.6	7.4	8.2	8.8	9.5	11.5
		3.0 ft SLR	6.4	7.1	7.5	8.1	8.9	9.7	10.3	11.0	13.0
020802080204	Eastern Branch Elizabeth River	Current	2.9	3.7	4.2	4.8	5.9	6.6	7.3	8.0	10.4
		1.5 ft SLR	4.4	5.2	5.7	6.3	7.4	8.1	8.8	9.5	11.9
		3.0 ft SLR	6.0	6.8	7.3	7.9	9.1	9.8	10.5	11.2	13.6
020802080205	Western Branch Elizabeth River	Current	3.7	4.5	4.9	5.4	6.1	7.0	7.9	8.6	10.3
		1.5 ft SLR	5.2	6.0	6.4	6.9	7.6	8.5	9.4	10.1	11.8
		3.0 ft SLR	6.9	7.7	8.1	8.6	9.3	10.2	11.2	11.9	13.6
030102051104	Indian Creek-Northwest River	Current	-	-	-	-	-	2.0	2.4	2.8	3.8
		1.5 ft SLR	-	-	-	-	-	3.5	3.9	4.3	5.3
		3.0 ft SLR	-	-	-	-	-	5.2	5.6	6.0	7.1
030102051201	Chesapeake Canal	Current	3.0	3.6	4.0	4.4	5.0	5.8	6.4	7.0	8.4
		1.5 ft SLR	4.5	5.1	5.5	5.9	6.5	7.3	7.9	8.5	9.9
		3.0 ft SLR	6.0	6.6	7.0	7.4	8.0	8.8	9.4	10.0	11.4
030102051203 030102051204 030102051205	North Landing River	Current	-	-	-	-	-	2.8	3.4	3.9	4.9
		1.5 ft SLR	-	-	-	-	-	4.3	4.9	5.4	6.4
		3.0 ft SLR	-	-	-	-	-	6.3	6.9	7.5	8.5

Notes:

1. North Landing River watershed includes Upper North Landing River, Pocaty River, and Blackwater Creek-North Landing River watersheds. Sourced from Virginia Beach Public Works Design Standards Manual, June 2020.
2. Due to recurring wind tides, it is recommended to use the 25-year design tidal elevations for 1-year to 10-year return periods for the Indian Creek-Northwest River and North Landing River watersheds.

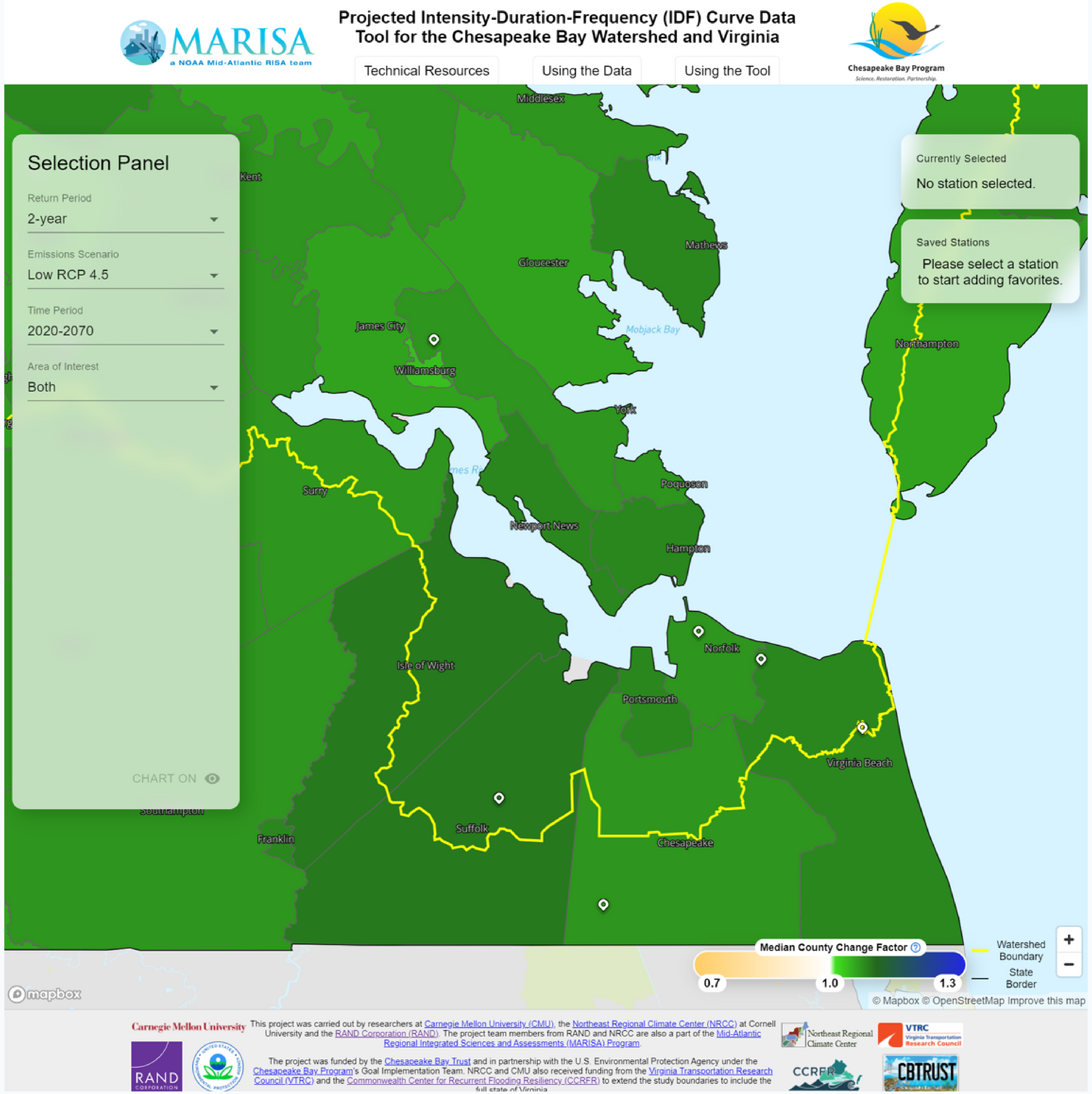
PRECIPITATION

Observations over the last several decades and climate models indicate that precipitation patterns are changing, resulting in both higher overall and increased concentrations of rainfall.

Failure to account for changing precipitation patterns could result in lower levels of service from stormwater management infrastructure.

Future Precipitation

HRPDC is working with its local governments, other regions, and state agencies in Virginia on how to use the RAND/MARISA tool.

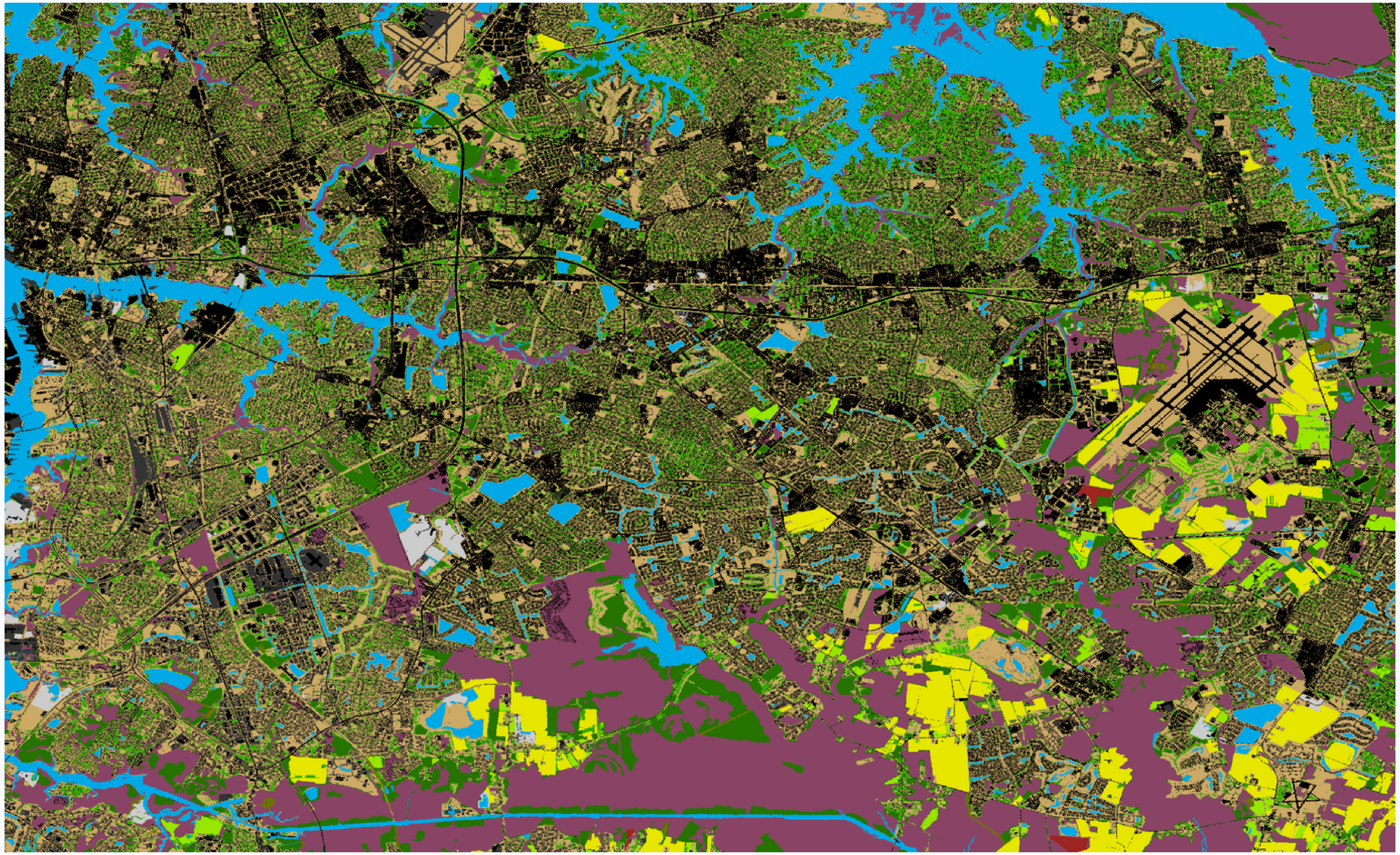


https://midatlantic-idf.rcc-acis.org/

HRPDC Approach

Impervious cover is used as a proxy for watershed capacity to absorb rainfall.

More impervious cover means potentially higher consequences if rainfall is greater than predicted.



Data Source: Chesapeake Bay High-Resolution Landcover

Precipitation

Calculate baseline values using NOAA Atlas 14.

Use RAND/MARISA tool to calculate future precipitation values.

Recommend single multiplier for each locality based on climate projections and existing impervious cover.

Multiplier	Localities
1.1	Gloucester County Isle of Wight County Southampton County Surry County
1.15	James City County Suffolk Williamsburg York County
1.2	Chesapeake Franklin Hampton Newport News Norfolk Poquoson Portsmouth Smithfield Virginia Beach

Precipitation

Calculate precipitation values for each locality based on multipliers.

These values can be used as inputs for stormwater calculations or similar design storm requirements.

Recommended Design Rainfall Depths - Chesapeake

Table 5: NOAA Atlas 14 (Vol. 2) Precipitation Values for Chesapeake, Virginia

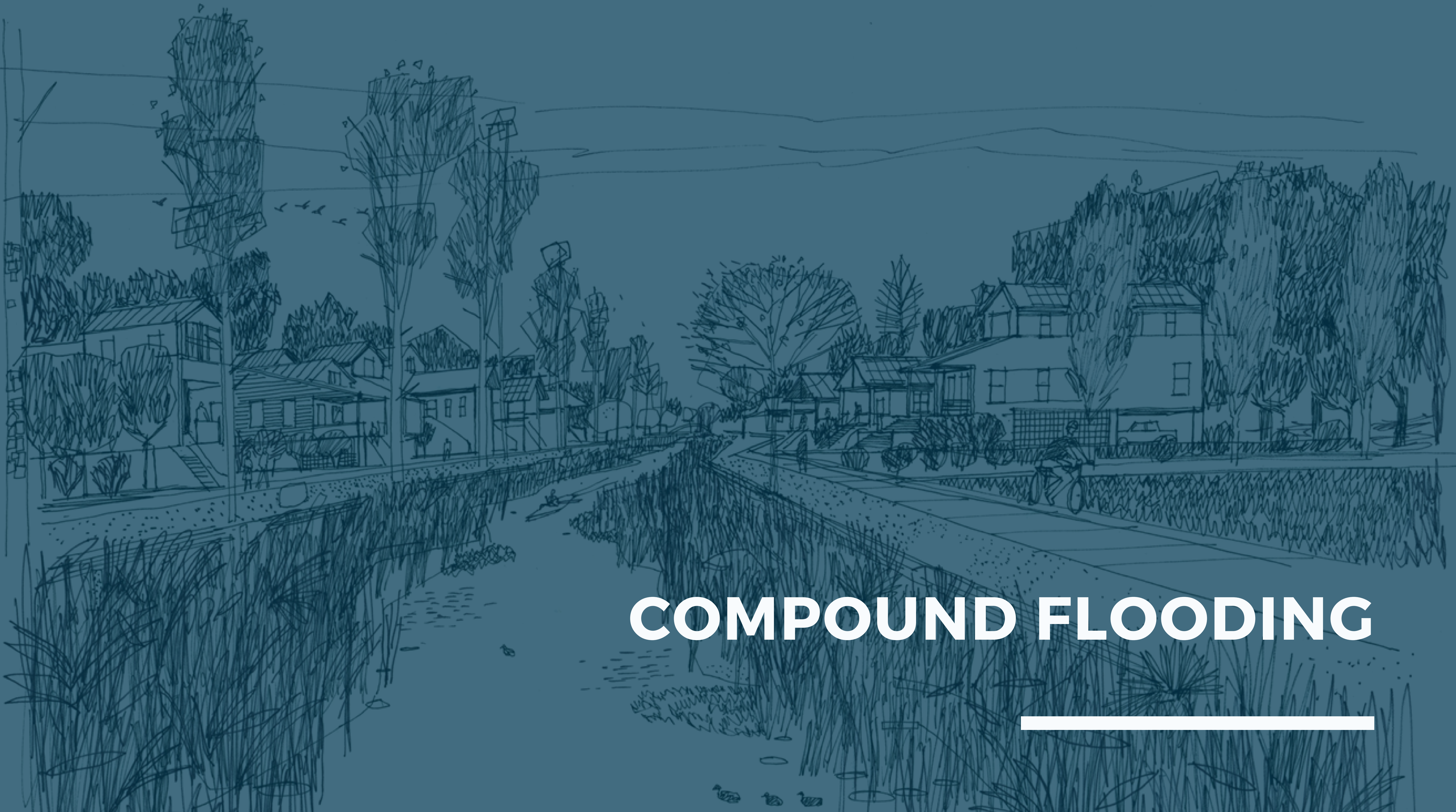
Design Storm	Minimum	Maximum	Mean	Median	90th Percentile	Centroid
1-Year	2.95	3.08	3.03	3.03	3.07	3.04
2-Year	3.59	3.75	3.69	3.69	3.74	3.70
5-Year	4.64	4.84	4.76	4.76	4.82	4.78
10-Year	5.53	5.76	5.67	5.67	5.74	5.69
25-Year	6.85	7.12	7.01	7.01	7.10	7.04
50-Year	7.98	8.29	8.17	8.17	8.26	8.19
100-Year	9.23	9.58	9.44	9.44	9.54	9.47

Table 6: Recommended Design Rainfall Depths for Chesapeake, Virginia

Design Storm Frequency	NOAA Atlas 14 Rainfall (24-Hour Duration)	Design Rainfall (NOAA Atlas 14 * Multiplier)	CBP Median Rainfall Depth (RCP 4.5)	CBP Median Rainfall Depth (RCP 8.5)
1-Year	3.04	**3.65**	-	-
2-Year	3.70	**4.44**	3.96	4.11
5-Year	4.78	**5.73**	5.20	5.25
10-Year	5.69	**6.83**	6.20	6.31
25-Year	7.04	**8.44**	7.67	7.81
50-Year	8.19	**9.83**	8.93	9.26
100-Year	9.47	**11.36**	10.51	10.70

Notes:

1. All values are in inches.
2. All values are for the 24-hour duration event.
3. NOAA Atlas 14 rainfall values for Recommended Design Rainfall Depths are based on the centroid of the city (latitude 36.6793761, longitude -76.3017883).
4. CBP Median Rainfall Depths are not available for the 1-Year event.



COMPOUND FLOODING

Joint Events

Tidal and rainfall events often occur concurrently.

In coastal environments, "design storms" should be defined as pairs of tidal and rainfall events.

Different design storms should be required based on project attributes (scale, type, criticality, etc.).

Design Storm	Tidal Elevation	Rainfall
1-Year	10-Year	1-Year
2-Year	5-Year	2-Year
10-Year	1-Year	10-Year
25-Year	2-Year	25-Year
50-Year	2-Year	50-Year
100-Year	3-Year	100-Year

MOVING FORWARD

What will development look like?

Where we (don't) build

- Avoid sea level rise inundation areas
- Restrict and regulate development in future/projected floodplains
- Intensify development on higher ground

What we build

- Less pavement
- Fewer pipes
- More onsite detention and retention
- Temporary storage (both hidden and visible)

How we build

- Structures built/floodproofed higher
- Salt/water tolerant materials
- Building for un-building

Adopting higher standards will be more expensive, but keeping the same standards will increase risk. Either way, there is a cost.

We do not need to wait for new data, models, or state/federal guidance to start improving local policies.

Contact

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This work was produced, in part, through financial assistance from the Virginia Coastal Zone Management Program in the Virginia Department of Environmental Quality through Grant Nos. NA18NOS4190152, NA19NOS4190163, NA20NOS4190207, and NA21NOS4190152 from the National Oceanic and Atmospheric Administration. It does not necessarily reflect the views of NOAA or any of its sub-agencies.