MONMOUTH UNIVERSITY | URBAN COAST INSTITUTE

Sea Grant
NJ Sea Grant Consortium

Beyond Nuisance Flooding in NJ

Dr. Tom Herrington
Associate Director
Urban Coast Institute
NJSC Coastal Community Resilience

Ocean City, NJ
June 6, 2018

Flooding Terminology

-*What are we really talking about?*

Nuisance Flooding - flooding that causes public inconveniences such as frequent road closures (NOAA)

Chronic Flooding - flooding that occurs more than 24 times per year or every 2 weeks on average (Union of Concerned Scientists)

King Tide – a colloquial term for Especially high astronomical tides Such as a perigean spring tide (e.g., Night in Venice High Tide) Note: Not a scientific term

Introduction

My Background:

Graduate of Ocean City HS
Ph.D. in Ocean Engineering
NJ Coastal Research Program Director
OE Program Director at Stevens

Urban Coast Institute Assoc. Director
NJ Sea Grant Community Resilience Specialist

Introduction

- Work with OCFLooding
  - Science Partnership
    - AGU Thriving Earth Exchange
    - Flood Forum USA
    - Volunteer Scientist
    - NJ Sea Grant
  - Objective
    - Transfer of knowledge to inform science-based decisions on local issues

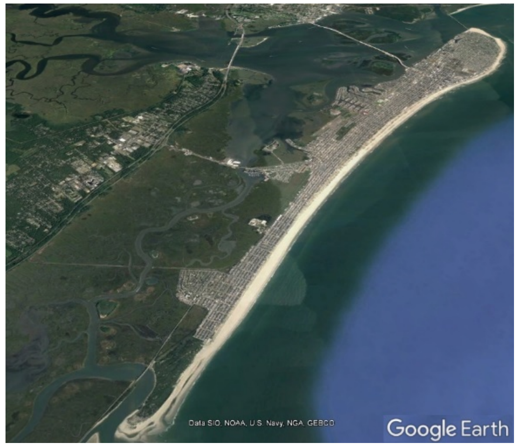
THRIVING EARTH EXCHANGE
Communities & Scientists Working Together

Sea Grant
NJ Sea Grant Consortium

THRIVING EARTH EXCHANGE

Ocean City, NJ, USA

Assessing Flooding & Hydrodynamics for Flood Prevention & Mitigation



Challenge: Sea level rise and land subsidence along the Mid-Atlantic coast is increasing the frequency of rainfall, high tide nuisance flood events and the magnitude of storm inundation. Aging infrastructure and low topography require science-based decision making for long term community resilience to flooding.

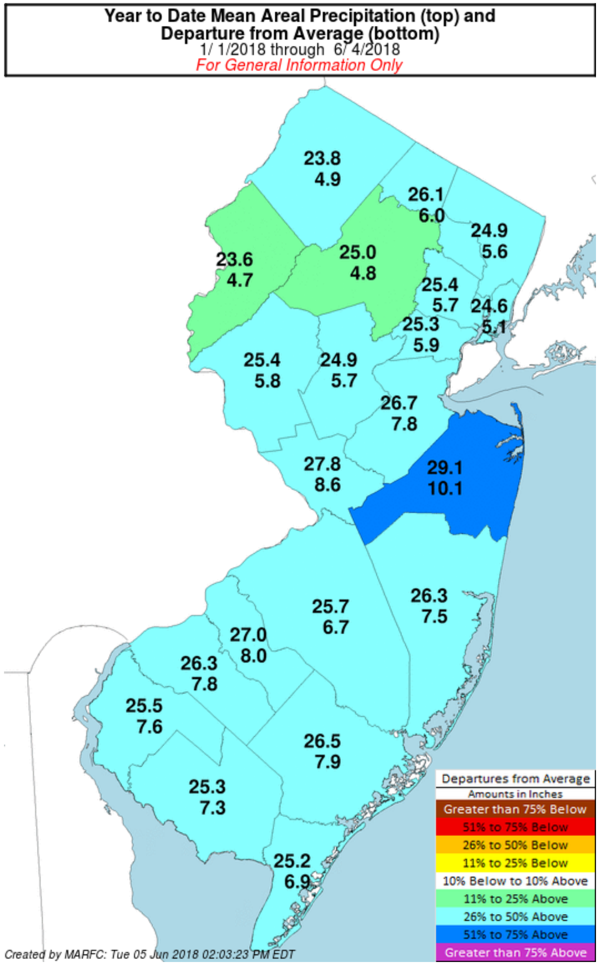
Leads: Suzanne Hornick, Chair, Ocean City Flooding Committee; Dr. Tom Herrington, Associate Director, Urban Coast Institute, Monmouth University.

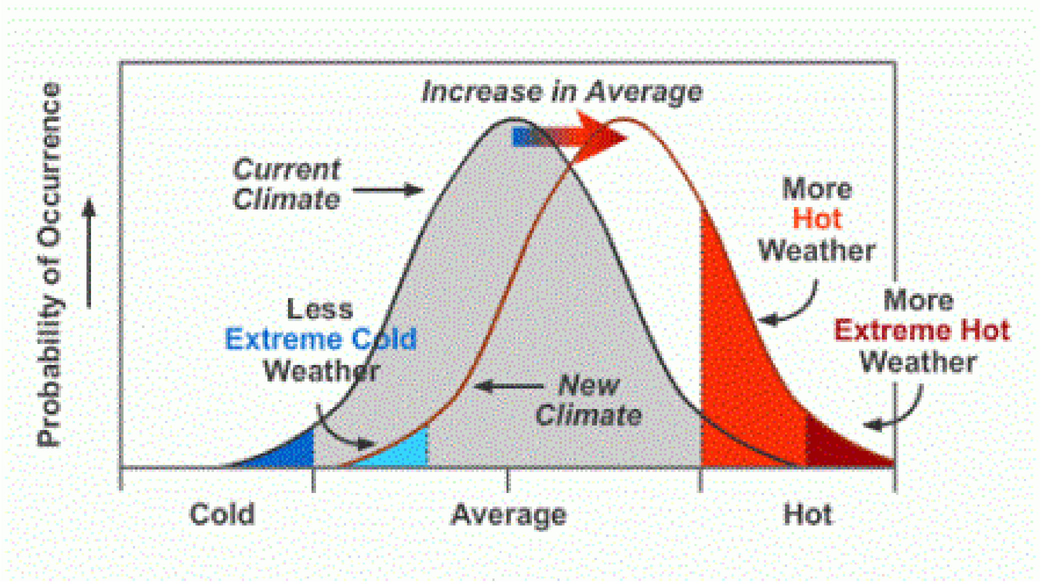
Action: Empower the community to formulate science-based decisions that support long-term flood mitigation and the creation of a resilient coastal community.

Impact: Community engagement in short and long term planning for island-wide flood mitigation.

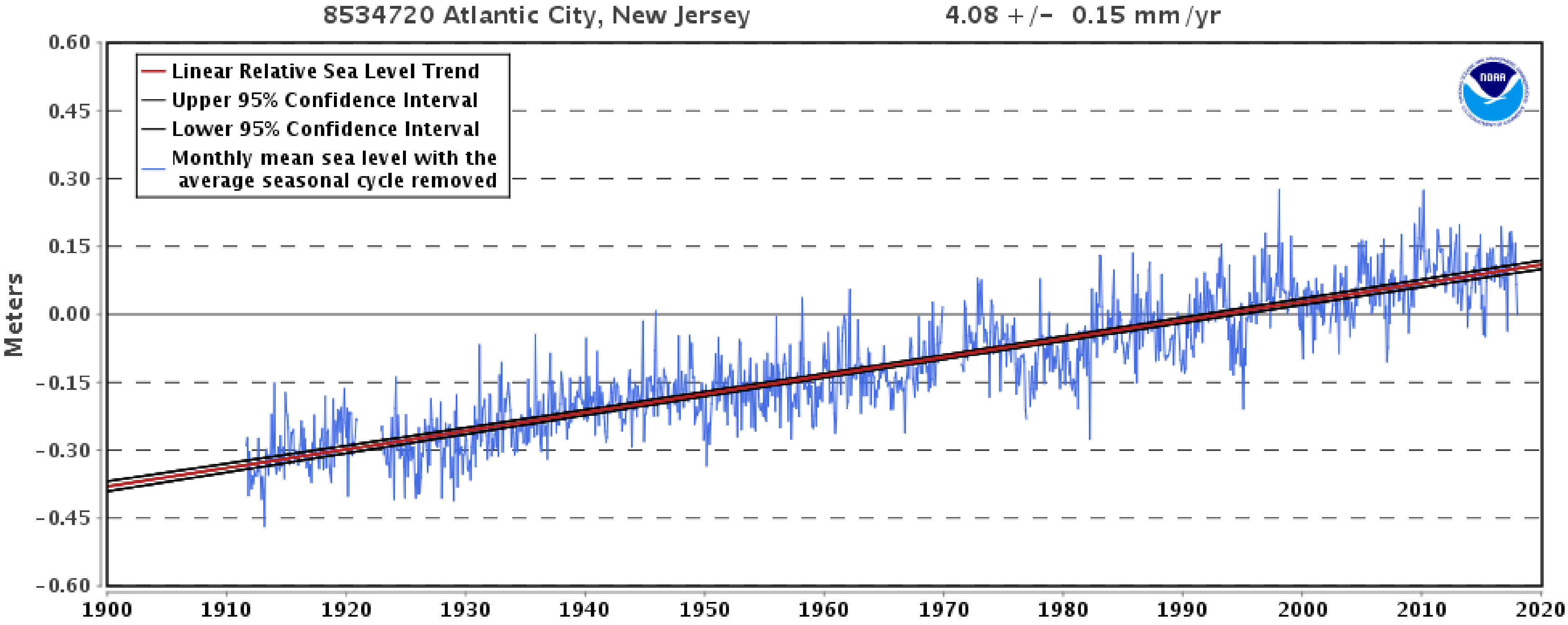
100 RESILIENT CITIES

The Issue: Changes in Rainfall Frequency and Intensity





The Issue: Relative Sea Level Rise



Result: More Days Like This

This Evenings Talk

Stormwater Management

- *Requirements*
- *Challenges*
- *Options*

Tidal Flood Frequency

- *Present Conditions*
- *Future SLR Scenarios*
- *Impacts*

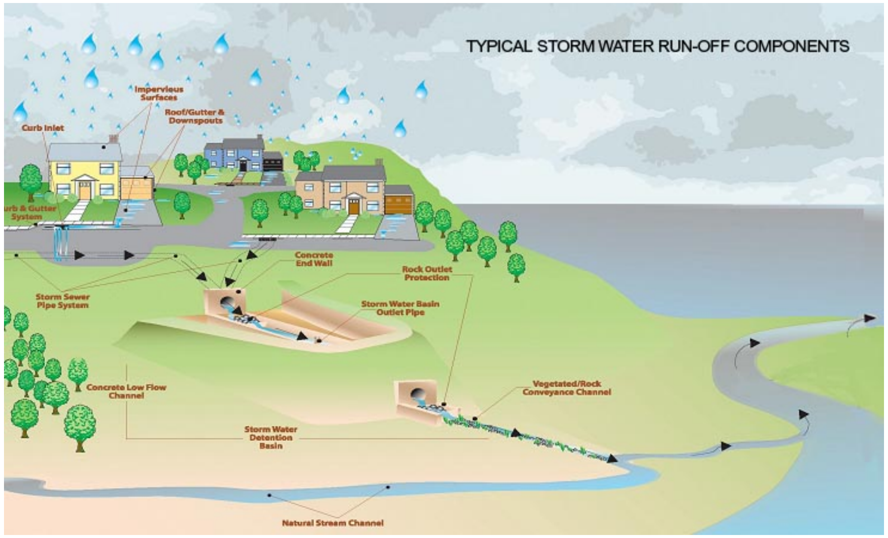
↔

Combined Impacts

MITIGATION OPTIONS

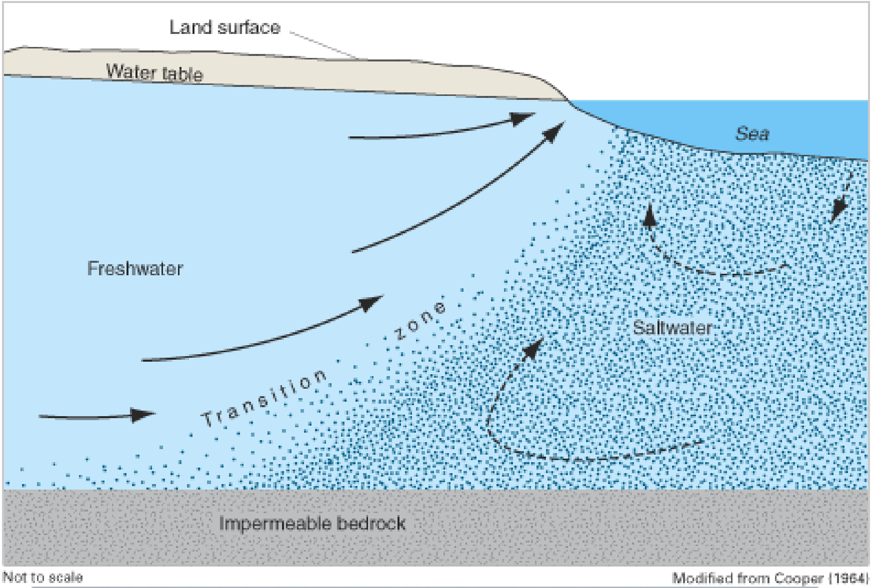
Stormwater Management

- Objective
  - Convey stormwater through drainage system to bay or ocean
  - Storage of stormwater in detention basins to reduce runoff
  - Percolation of stormwater into ground through detention basins/rain gardens

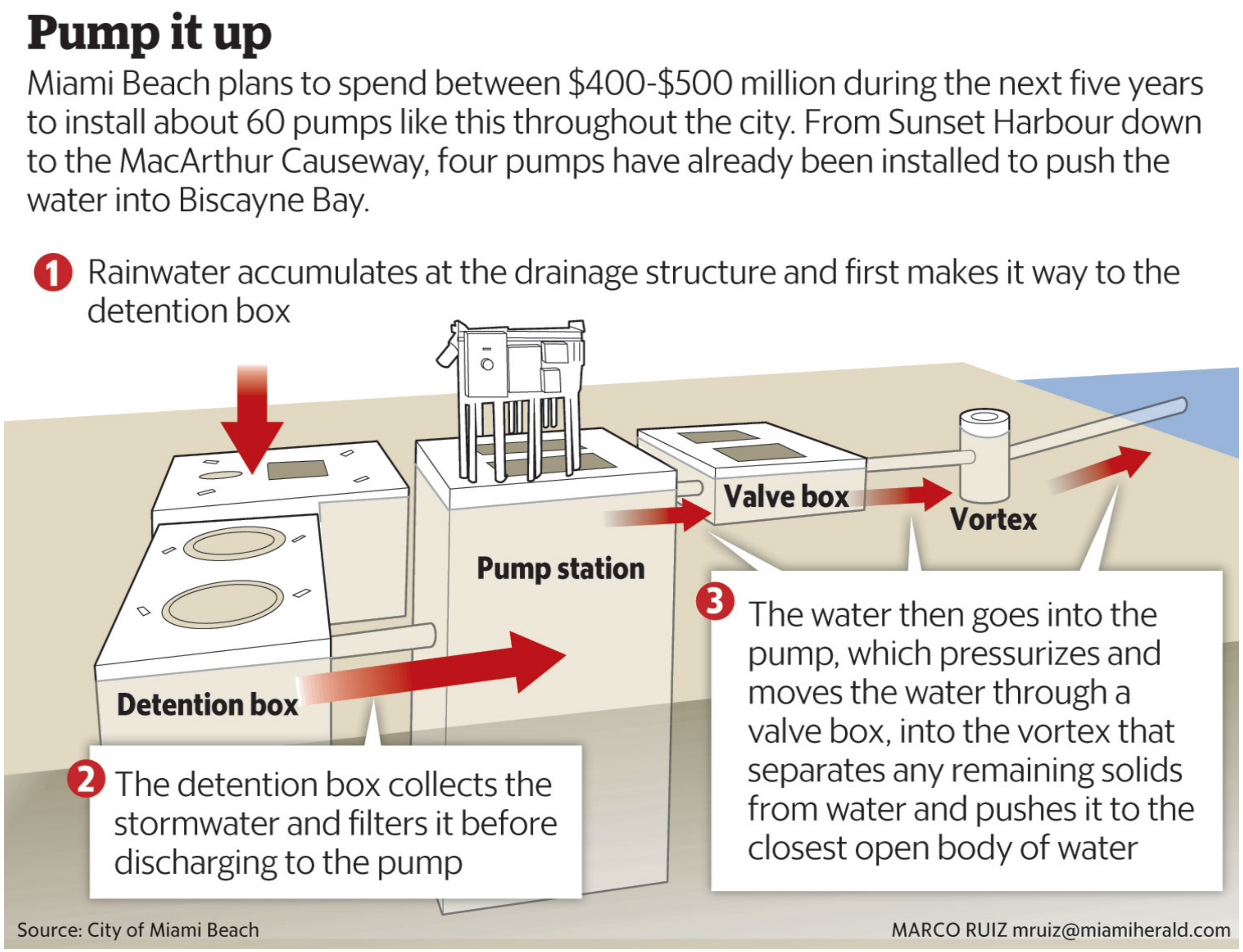


Challenges on Barrier Islands

- Low topographic elevations
- High water table
- Limited location for underground utilities and piping
- Lack of storage areas



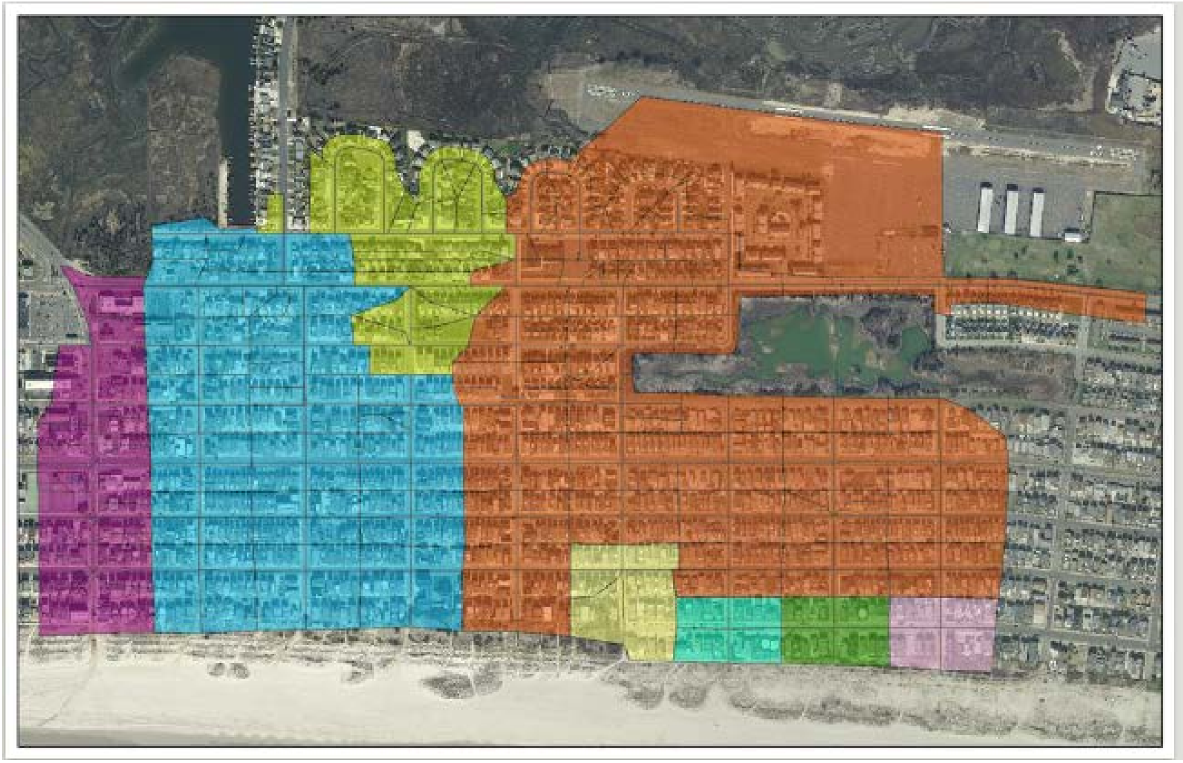
Solution: Storage and Pumping



Ocean City is Leader in NJ

- Michael Baker Flood mitigation study for 250 acres between 26th and 34th Streets and West and Bay Avenues
- Focus: mitigate the more common rainfall events that cause routine or nuisance flooding throughout the study area.
- Goals
  - quantify the amount of rainfall throughout the study area
  - determine the amount of rainfall entering the storm sewers
  - understand the performance of the existing system

Drainage Areas Modeled

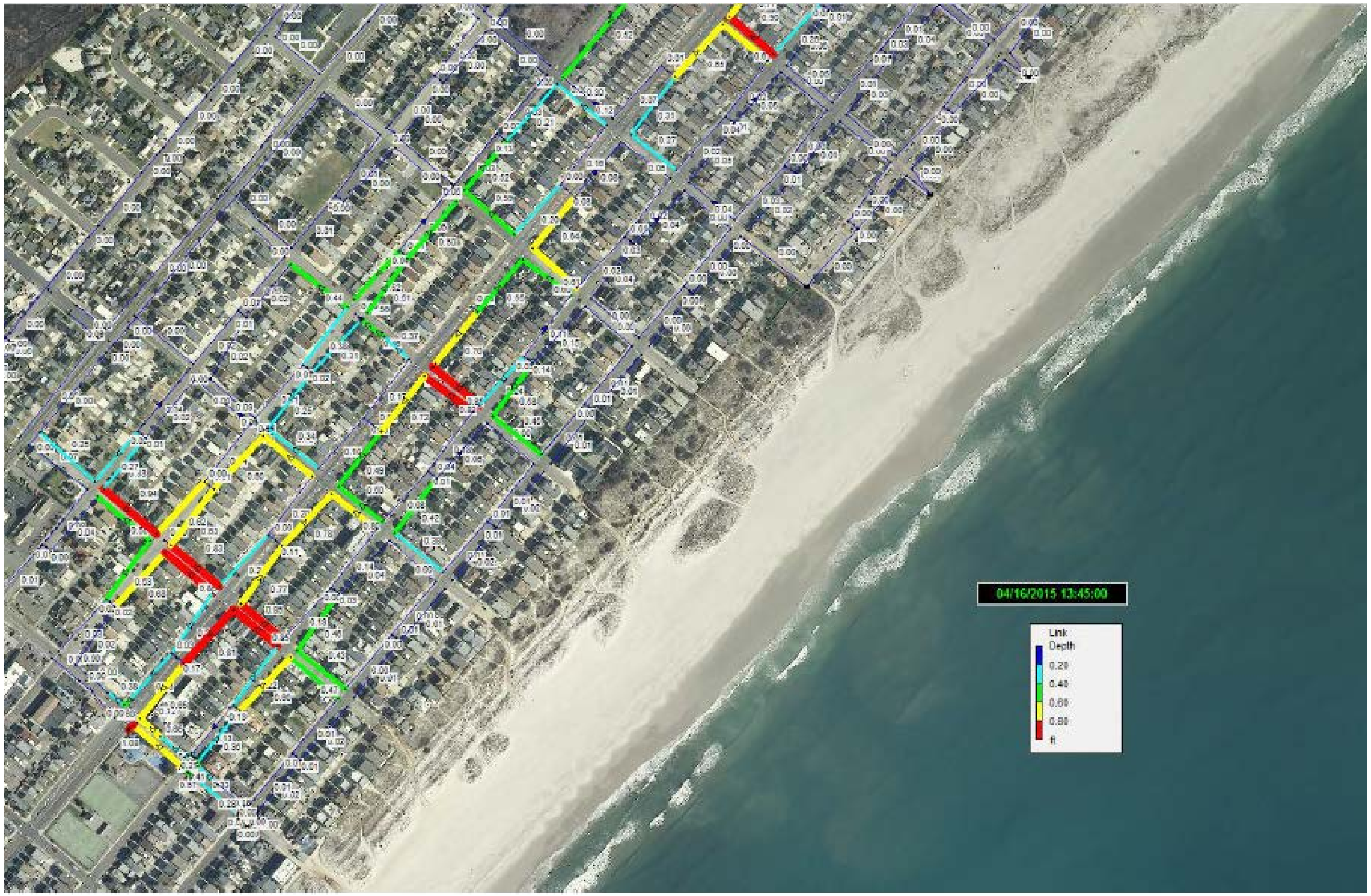


Model

MB Simulated Rainfall Events

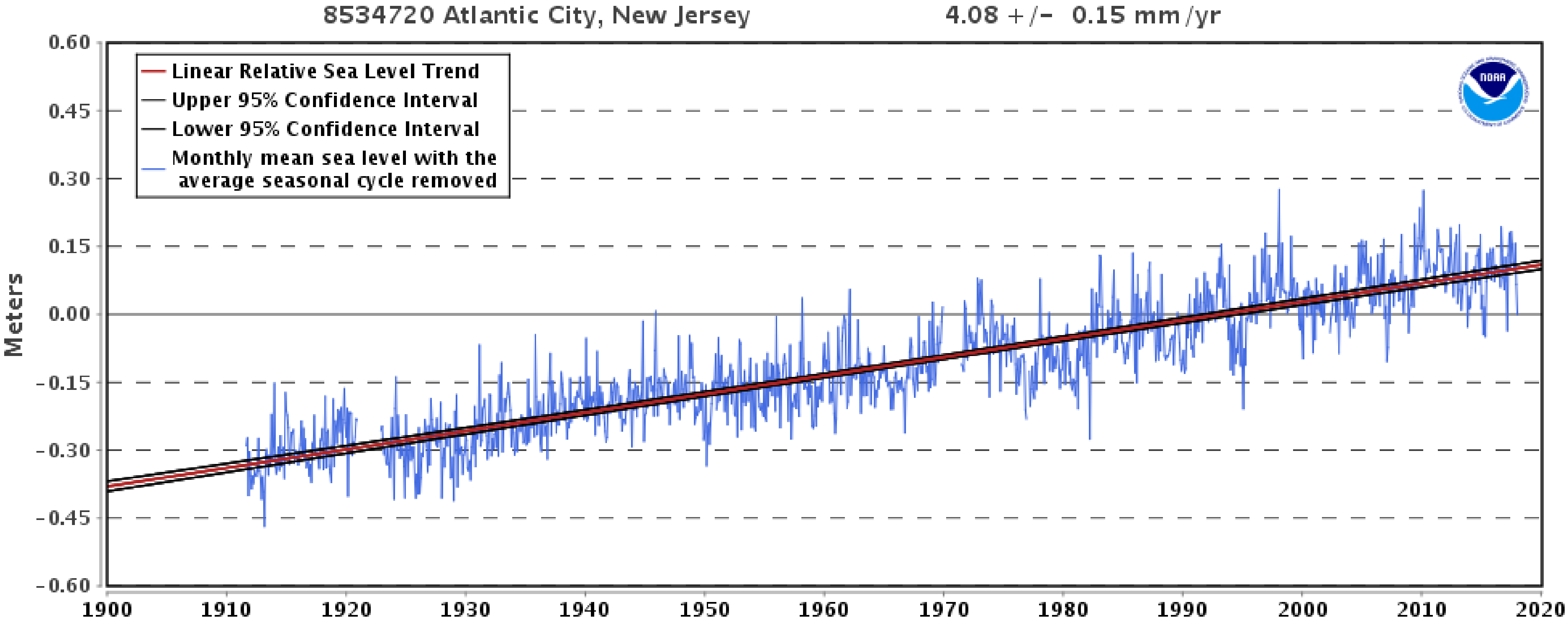
1 Year Event -	2.68 Inches of Rain -	14.67 Million Gallons of Runoff
2 Year Event -	3.27 Inches of Rain -	18.04 Million Gallons of Runoff
5 Year Event -	4.24 Inches of Rain -	23.53 Million Gallons of Runoff
10 Year Event -	5.08 Inches of Rain -	33.79 Million Gallons of Runoff

Model Simulation Output



Tidal Flooding

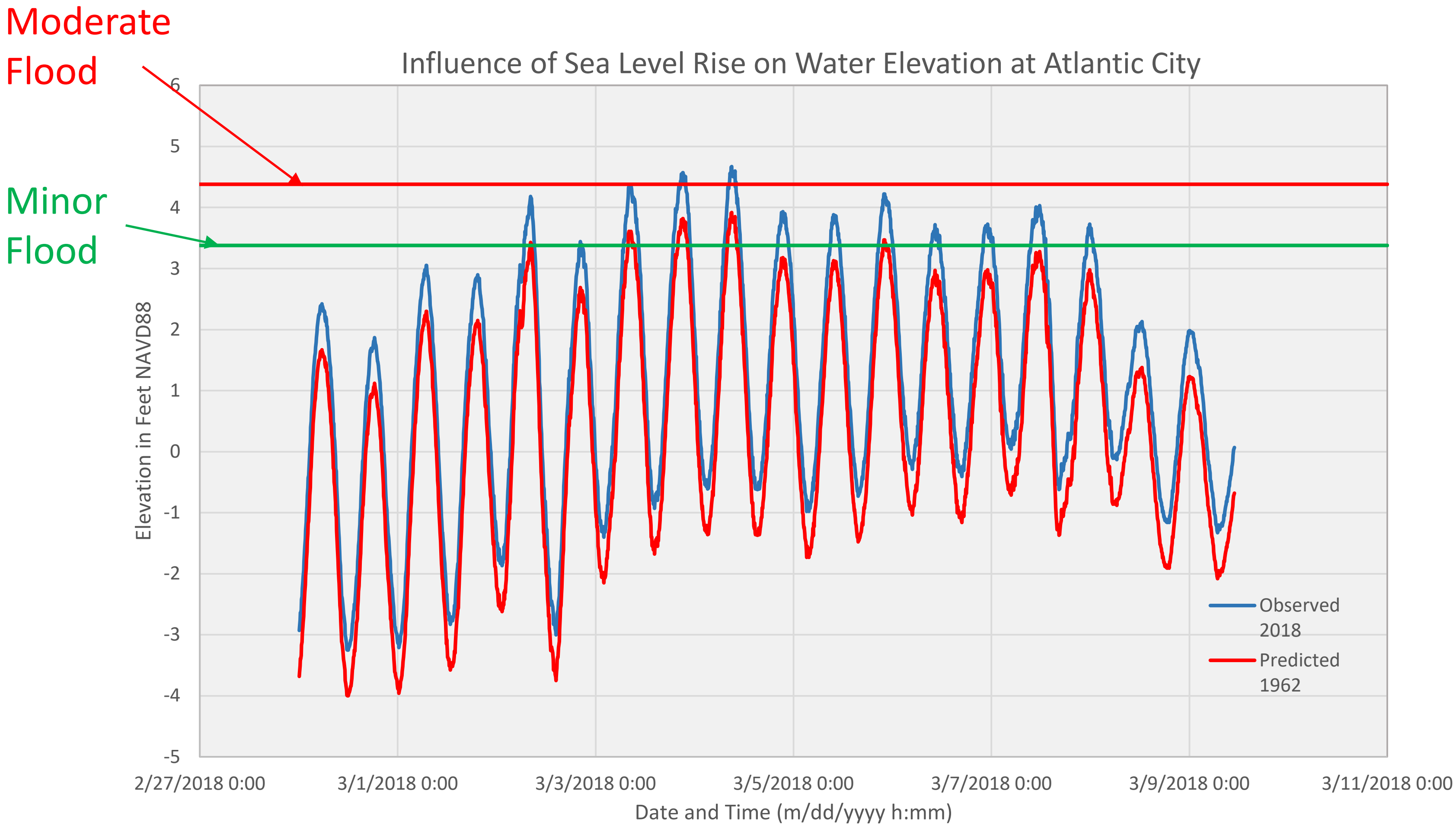
The Issue: Relative Sea Level Rise



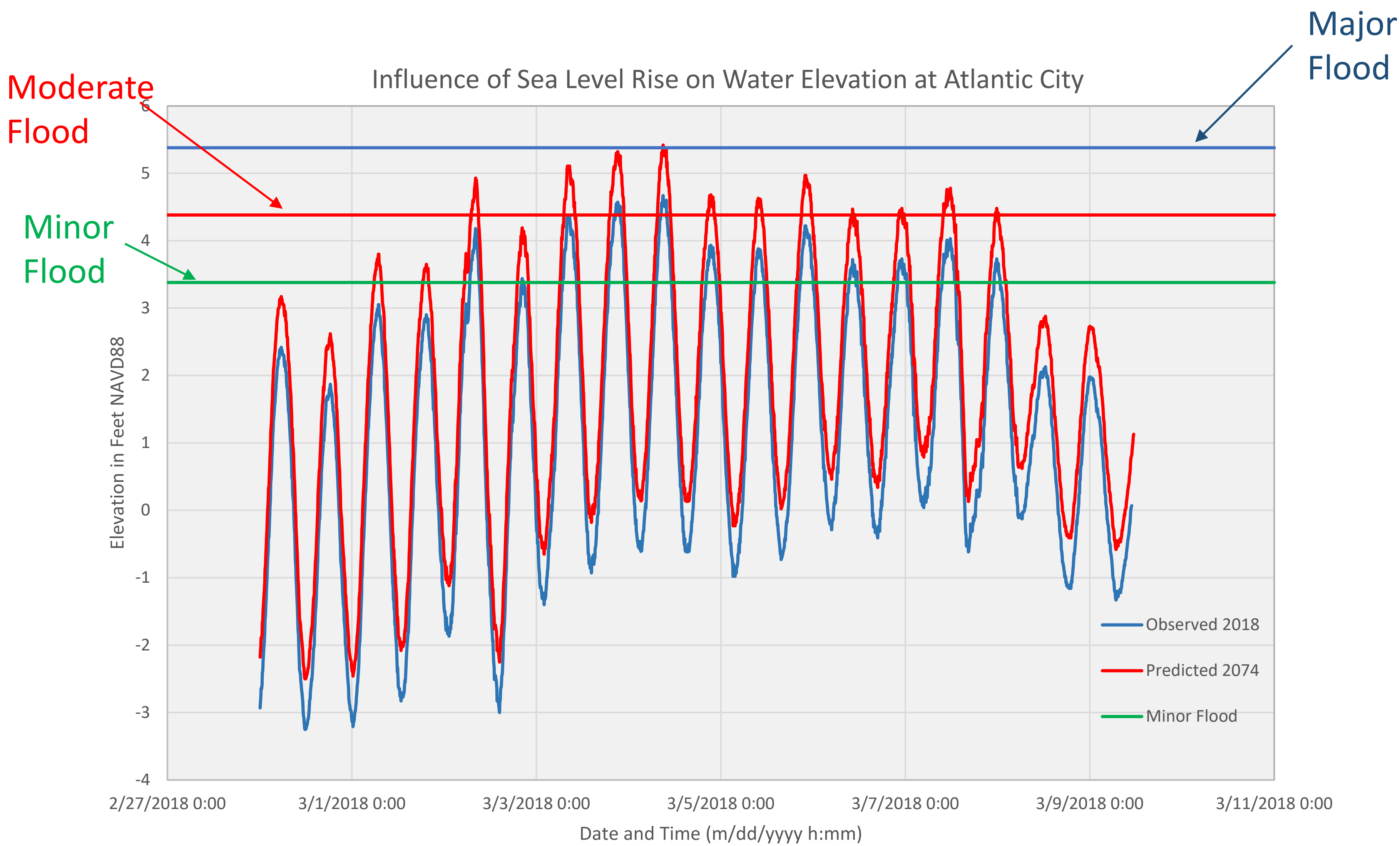
How do we know this?

Tide Gauge Data. Atlantic City, NJ Station operating from 1912 – 2018!

Impacts: March 2018 Nor'Easters



Future Impact: 2074

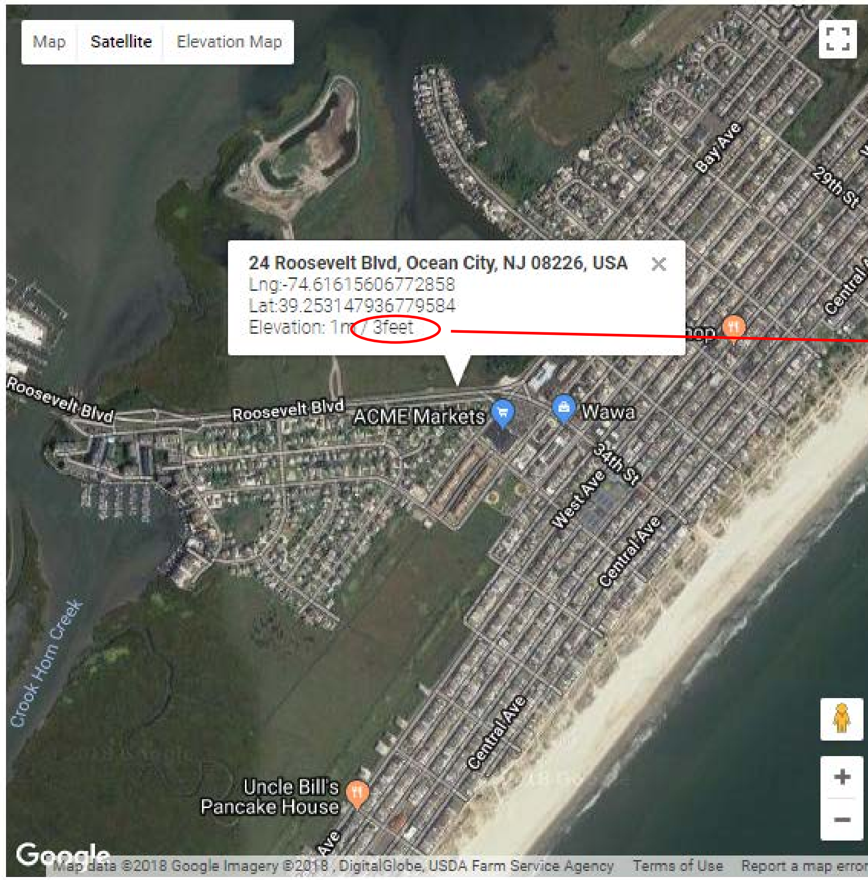


Concerns/Questions

1. How frequently will low-lying roadways and infrastructure experience flooding in the future?
2. Is Sea Level continuing to rise linearly or is the rate of rise increasing?

Ocean City Case Study

Elevation Map of New Jersey, USA



Roosevelt Bld.
has an elevation of
approx. 3 ft NAVD88

http://elevation.maplogs.com/poi/new_jersey_usa.14971.html

NOS Tide Datum at Atlantic City

Elevations on Station Datum

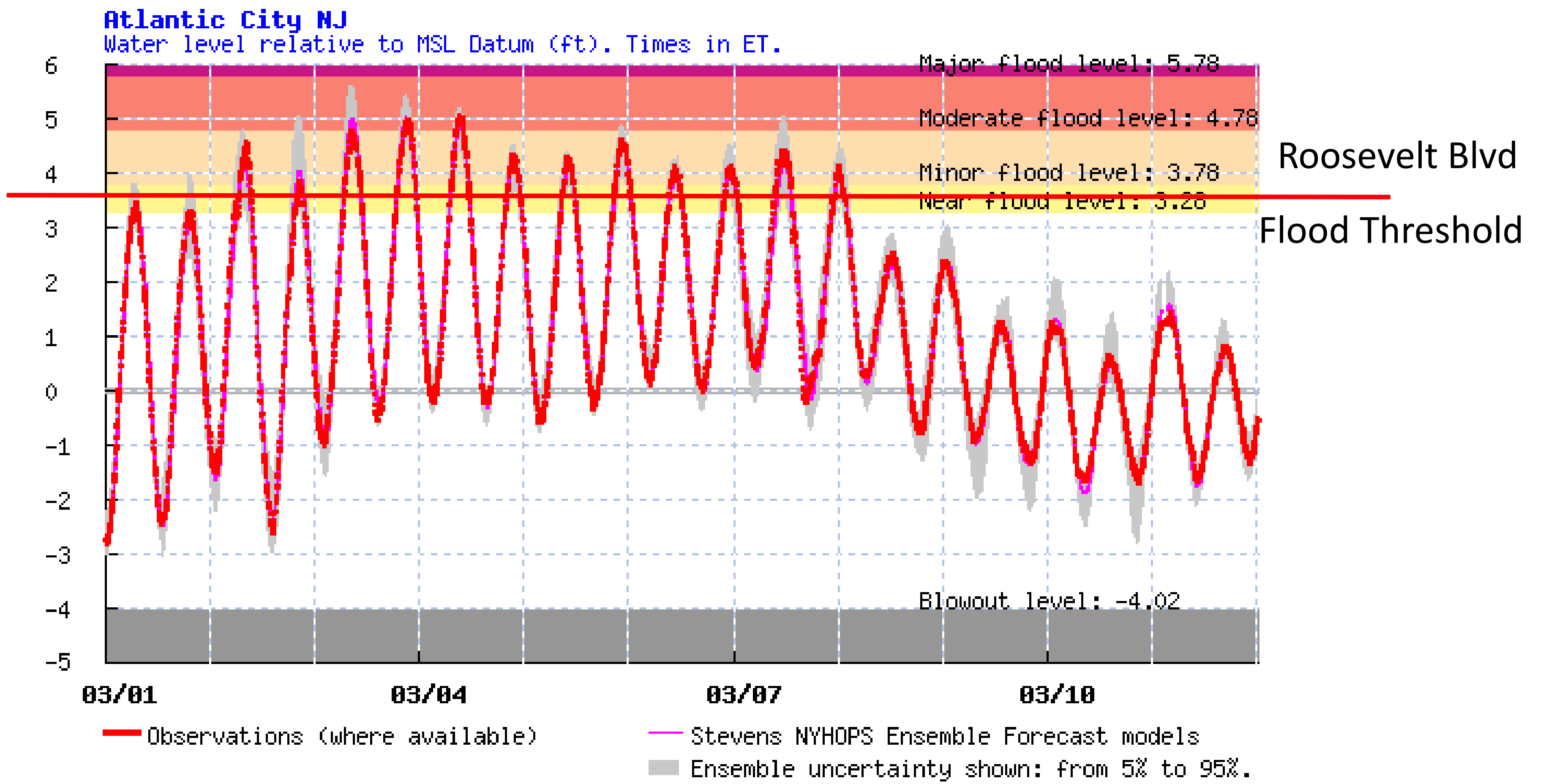
Station: 8534720, Atlantic City, NJ
Status: Accepted (Apr 17 2003)
Units: Feet
T.M.: 75
Epoch: 1983-2001
Datum: STND

Datum	Value	Description
MHHW	9.56	Mean Higher-High Water
MHW	9.14	Mean High Water
MTL	7.14	Mean Tide Level
MSL	7.17	Mean Sea Level
DTL	7.26	Mean Diurnal Tide Level
MLW	5.13	Mean Low Water
MLLW	4.96	Mean Lower-Low Water
NAVD88	7.57	North American Vertical Datum of 1988
STND	0.00	Station Datum

MSL is 0.4 ft below NAVD88

Roosevelt Blvd. is 3.4 ft above Mean Sea Level

Roosevelt Blvd. Flood Threshold



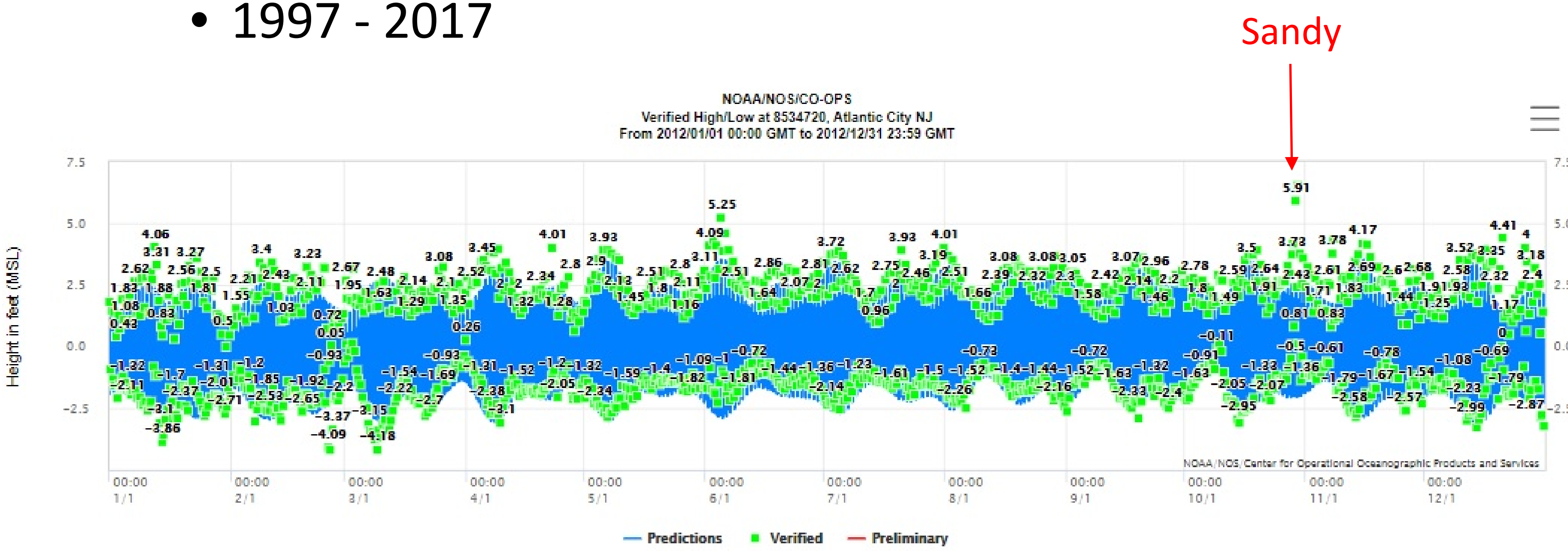
Roosevelt Blvd was flooded on 12 consecutive high tides between March 2-8, 2018

What about the Future?

https://tidesandcurrents.noaa.gov/waterlevels.html?id=8534720

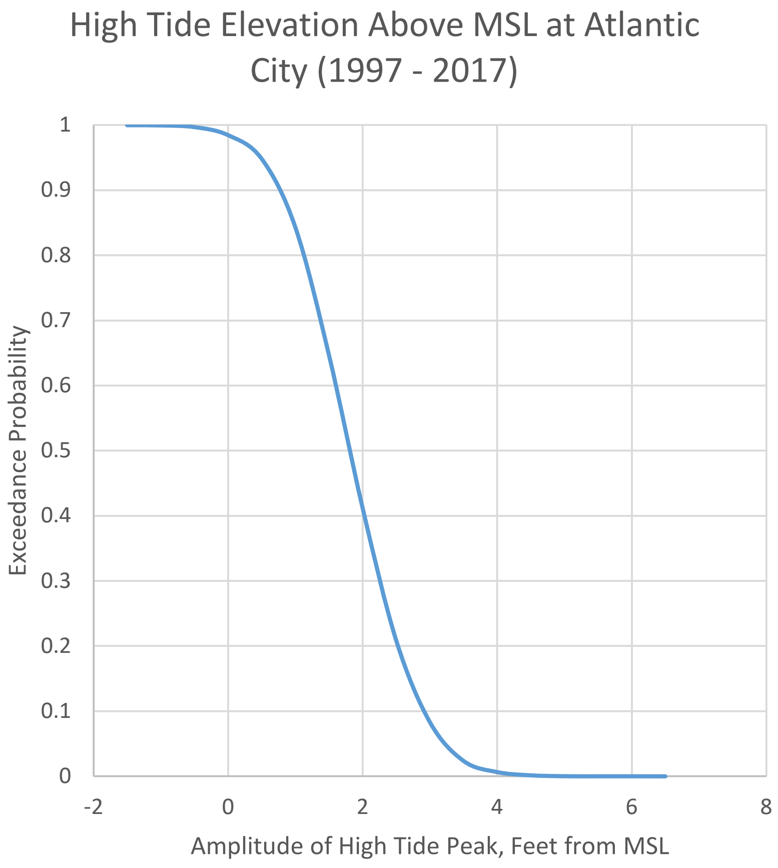
Processing

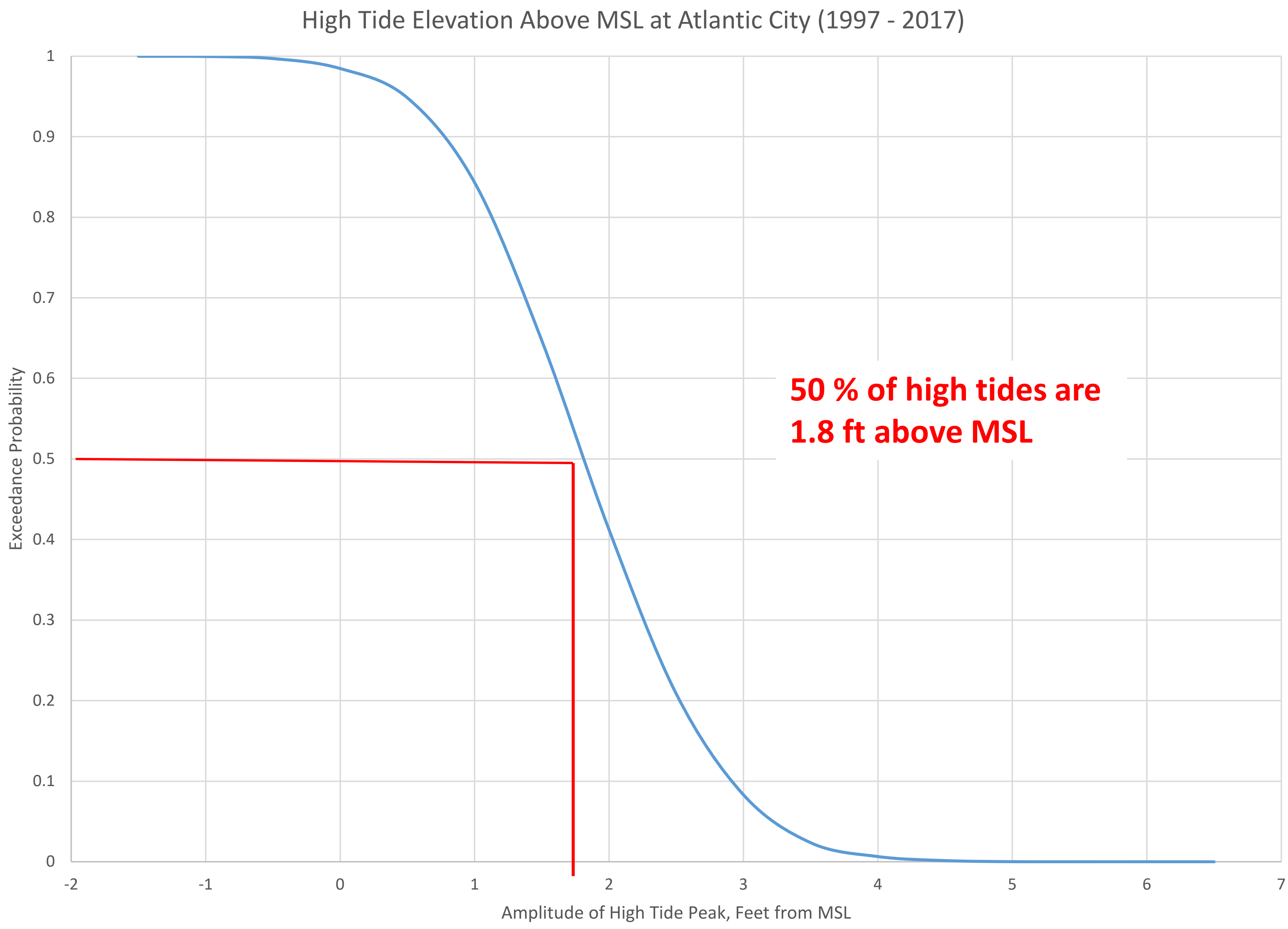
- Start with hourly water levels from Atlantic City
  - Use 20 years of observations to Identify high tide peaks and elevations in data set
  - 1997 - 2017

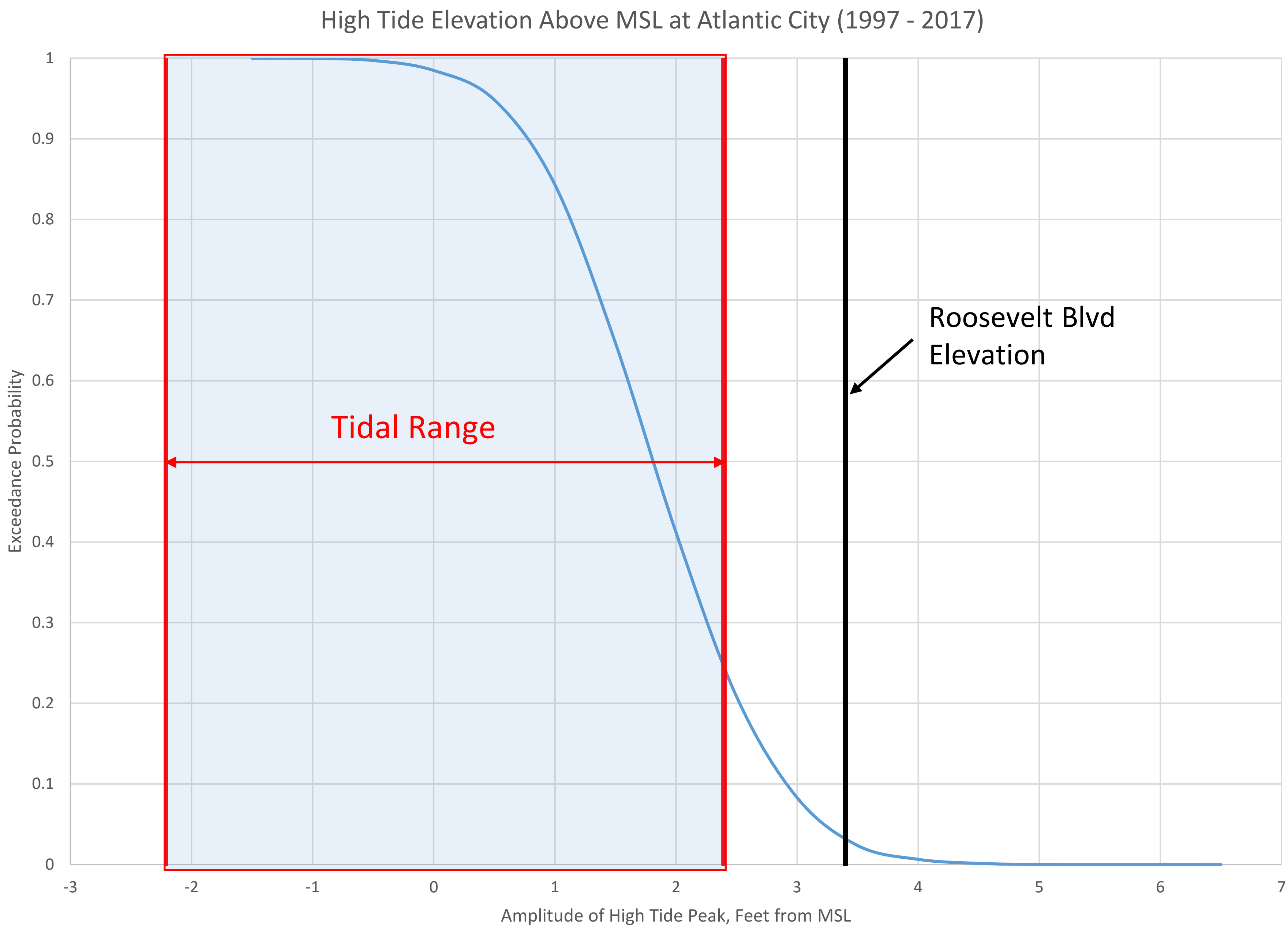


Processing

- Develop probability distribution of high tide amplitudes relative to Mean Sea Level
    - Analyze data for exceedance probability of High Tides relative to Mean Sea Level
    - Provides % time that High Tides were at or above specific elevations
    - Assume same distribution will occur with sea level rise



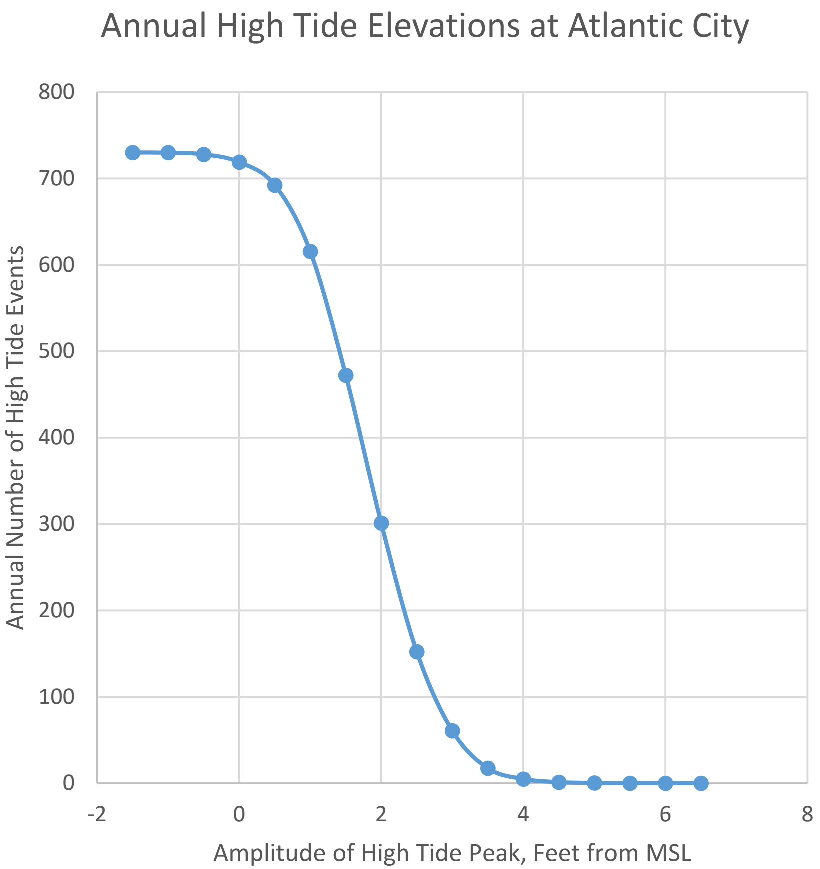

High Tide Elevation Above MSL at Atlantic City (1997 - 2017)
Exceedance Probability
Amplitude of High Tide Peak, Feet from MSL
50 % of high tides are
1.8 ft above MSL
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-2
-1
0
1
2
3
4
5
6
7

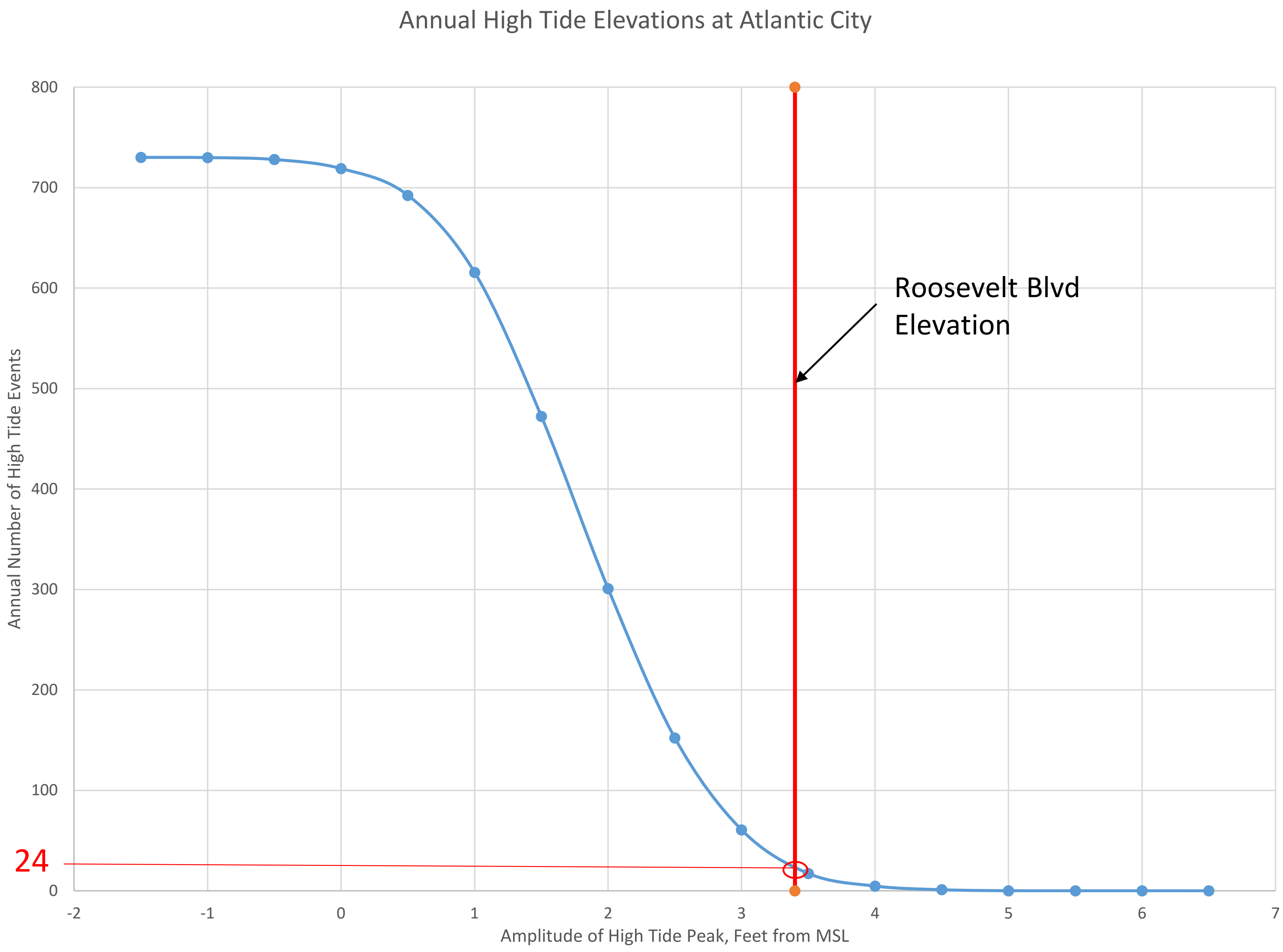


High Tide Elevation Above MSL at Atlantic City (1997 - 2017)
Exceedance Probability
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
-3
-2
-1
0
1
2
3
4
5
6
7
Amplitude of High Tide Peak, Feet from MSL
Tidal Range
Roosevelt Blvd
Elevation

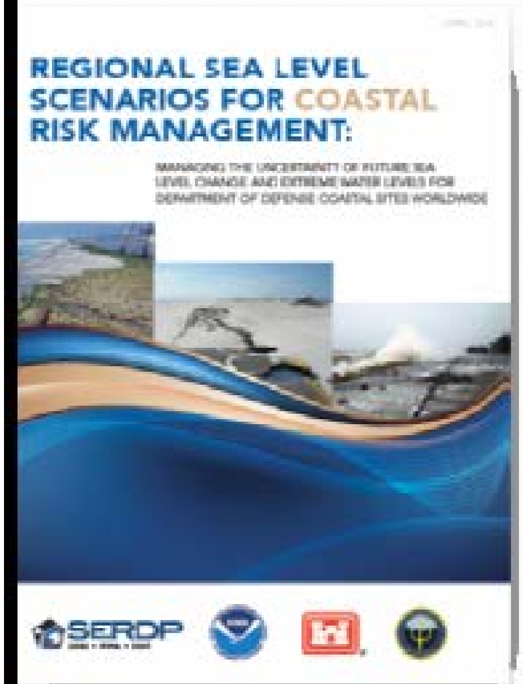
Convert to # of High Tides per year

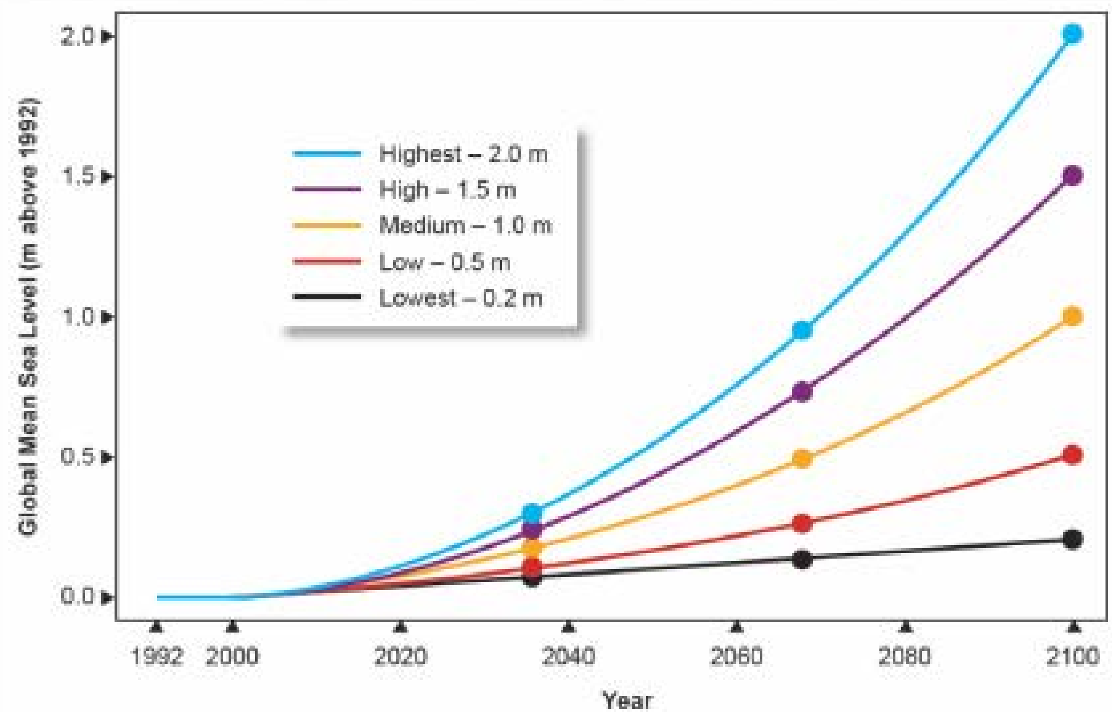
- Easier to think in terms of how many high tides per year exceed a specific elevation
  - Assume the high tides will continue to follow the 20-year distribution of high tides
  - Two high tides per day
  - 730 total high tides per year




Annual High Tide Elevations at Atlantic City
Annual Number of High Tide Events
800
700
600
500
400
300
200
100
0
24
Roosevelt Blvd
Elevation
-2
-1
0
1
2
3
4
5
6
7
Amplitude of High Tide Peak, Feet from MSL

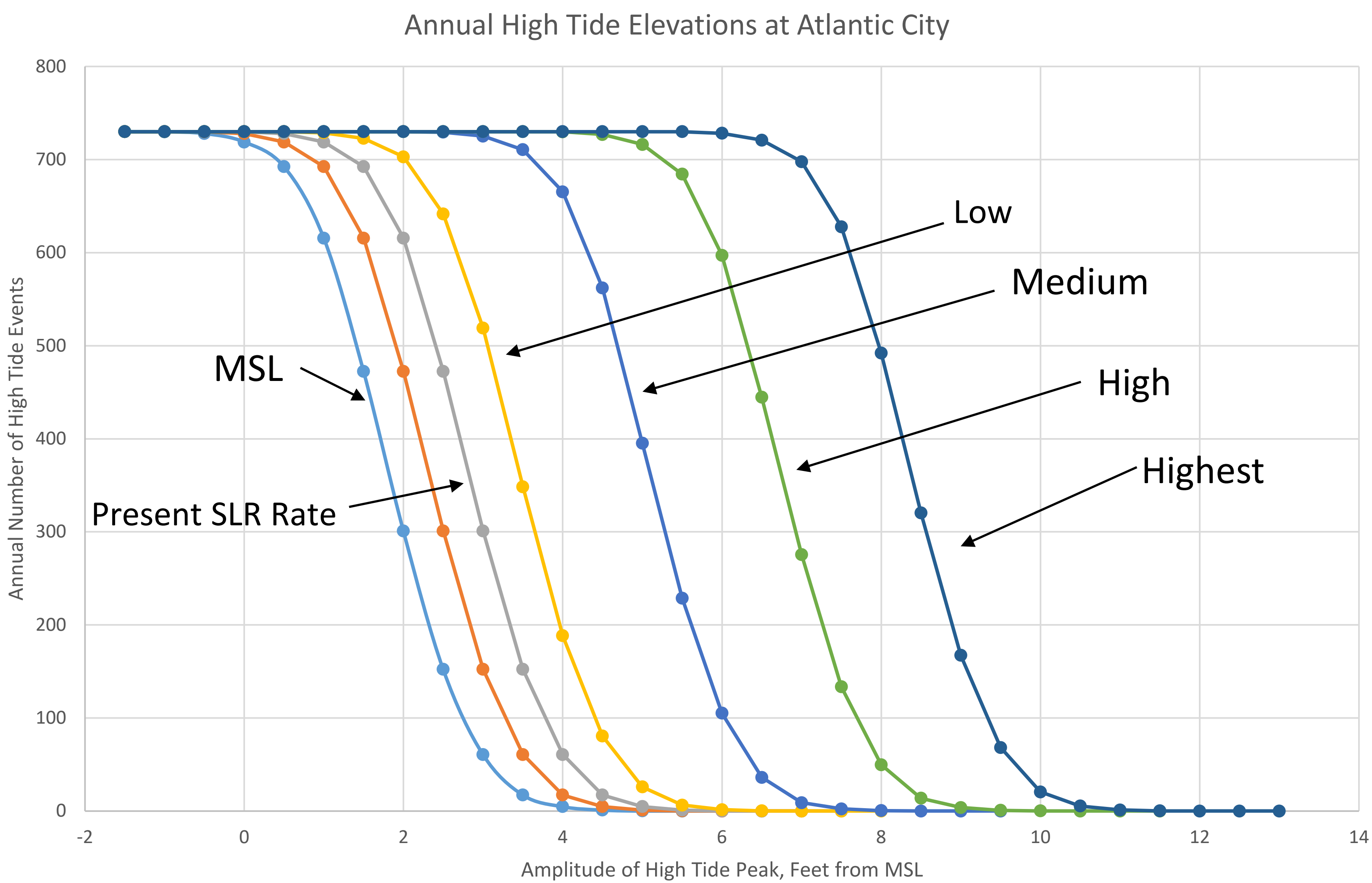
Global Mean Sea Level Projections

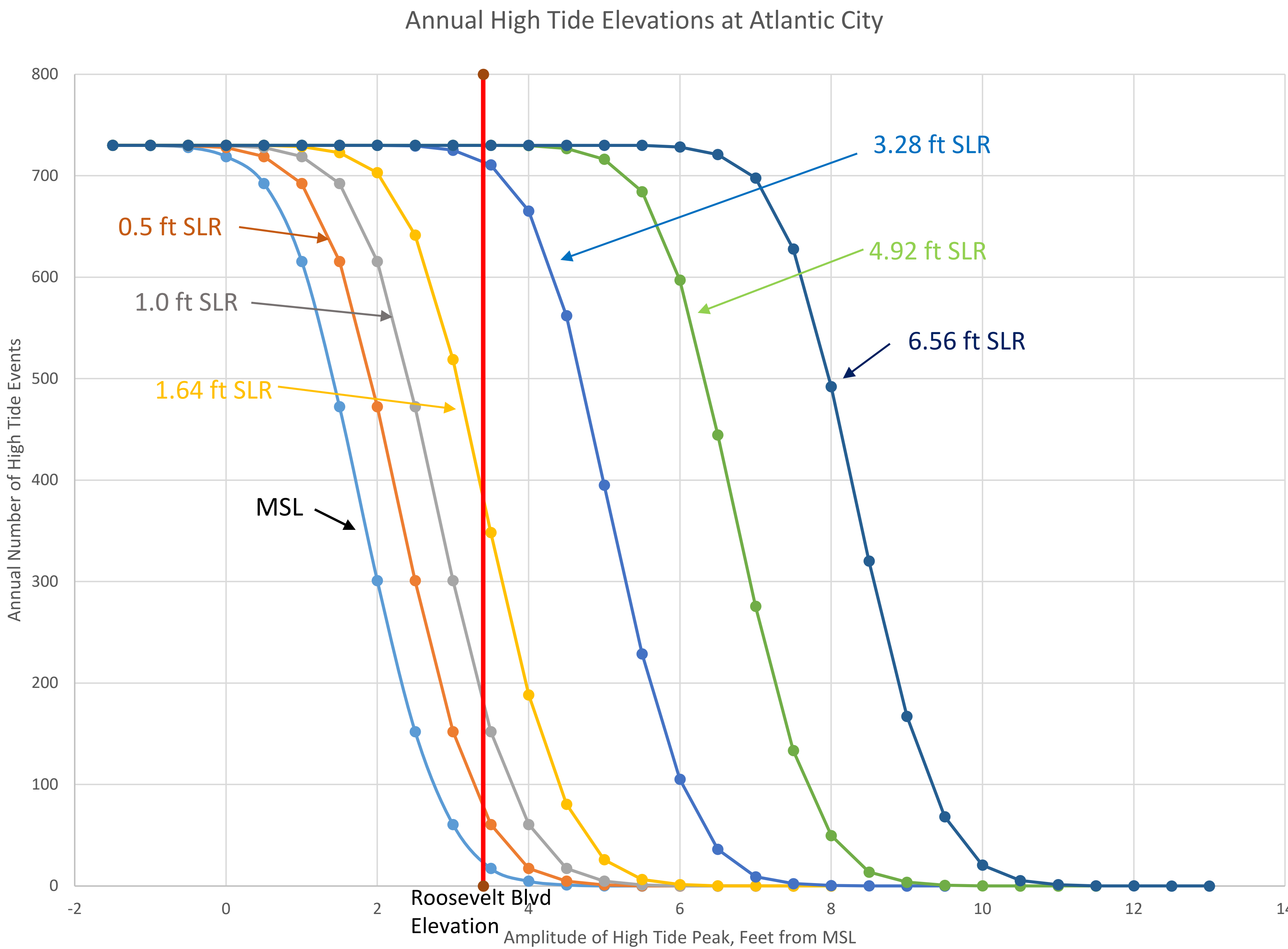




From Kriebel 2017

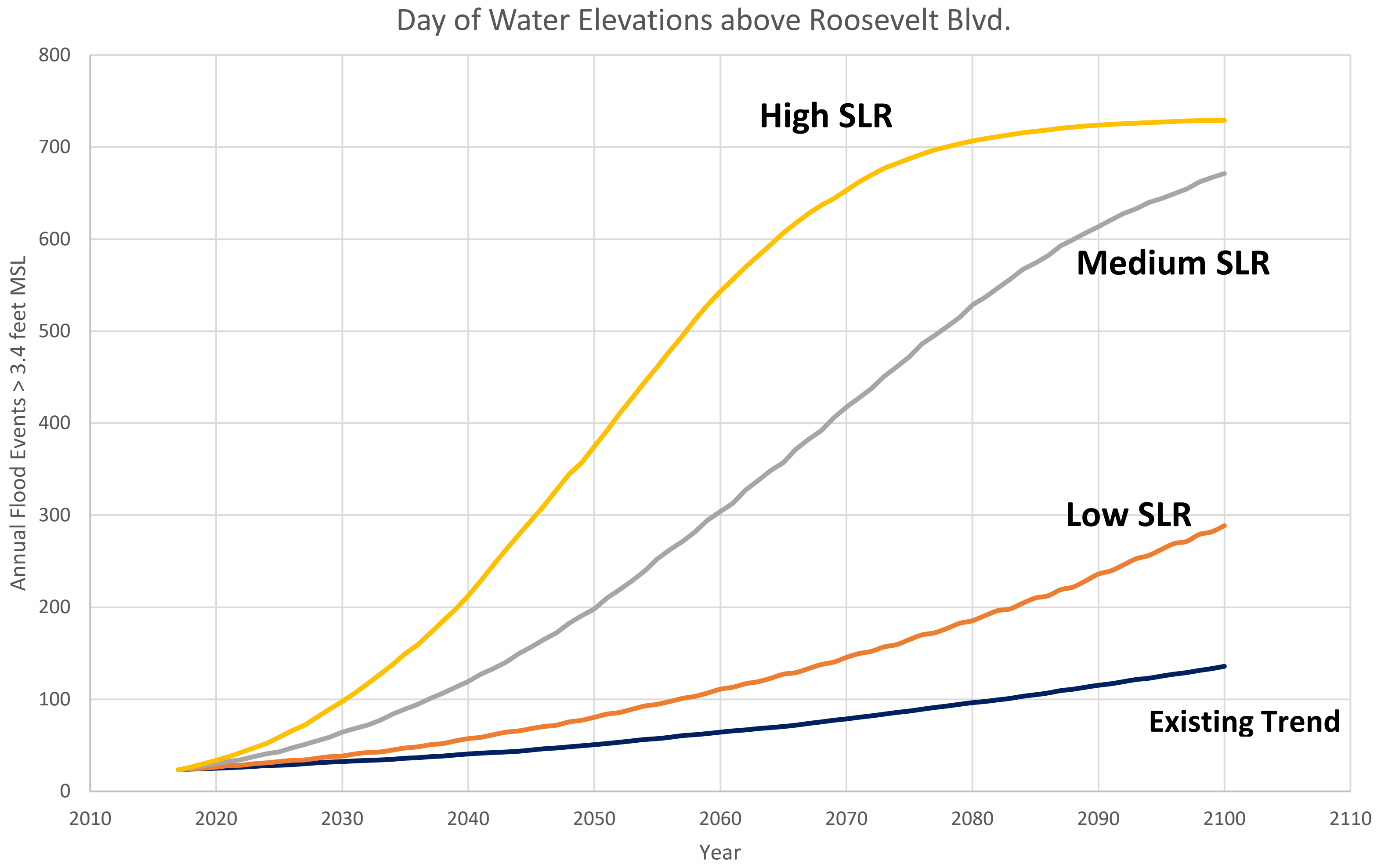
Future Sea Level Rise Projections for the year 2100



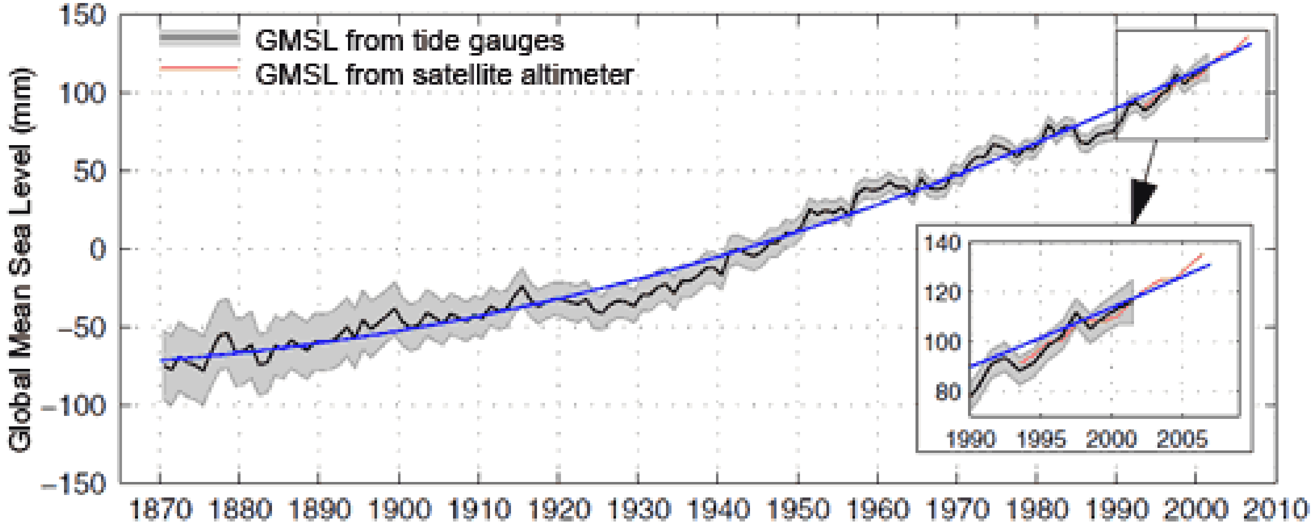


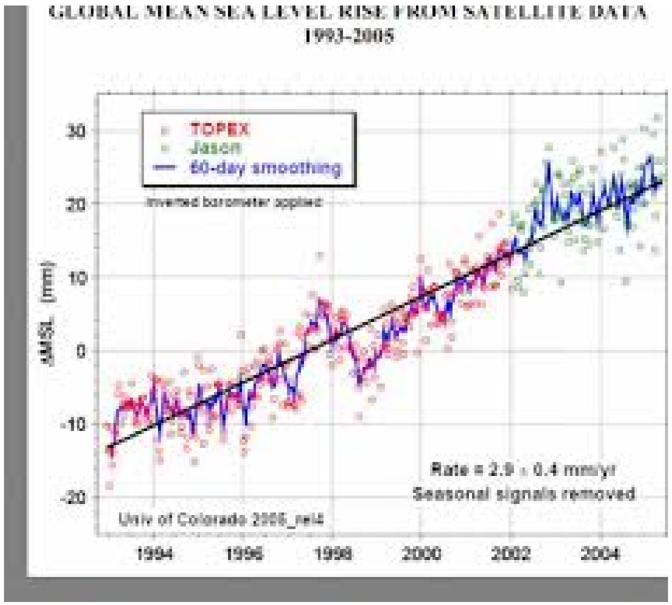
Annual High Tide Elevations at Atlantic City
Annual Number of High Tide Events
Amplitude of High Tide Peak, Feet from MSL
800
700
600
500
400
300
200
100
0
-2
0
2
4
6
8
10
12
14
3.28 ft SLR
0.5 ft SLR
4.92 ft SLR
1.0 ft SLR
6.56 ft SLR
1.64 ft SLR
MSL
Roosevelt Blvd
Elevation

Future Number of Floods by Year

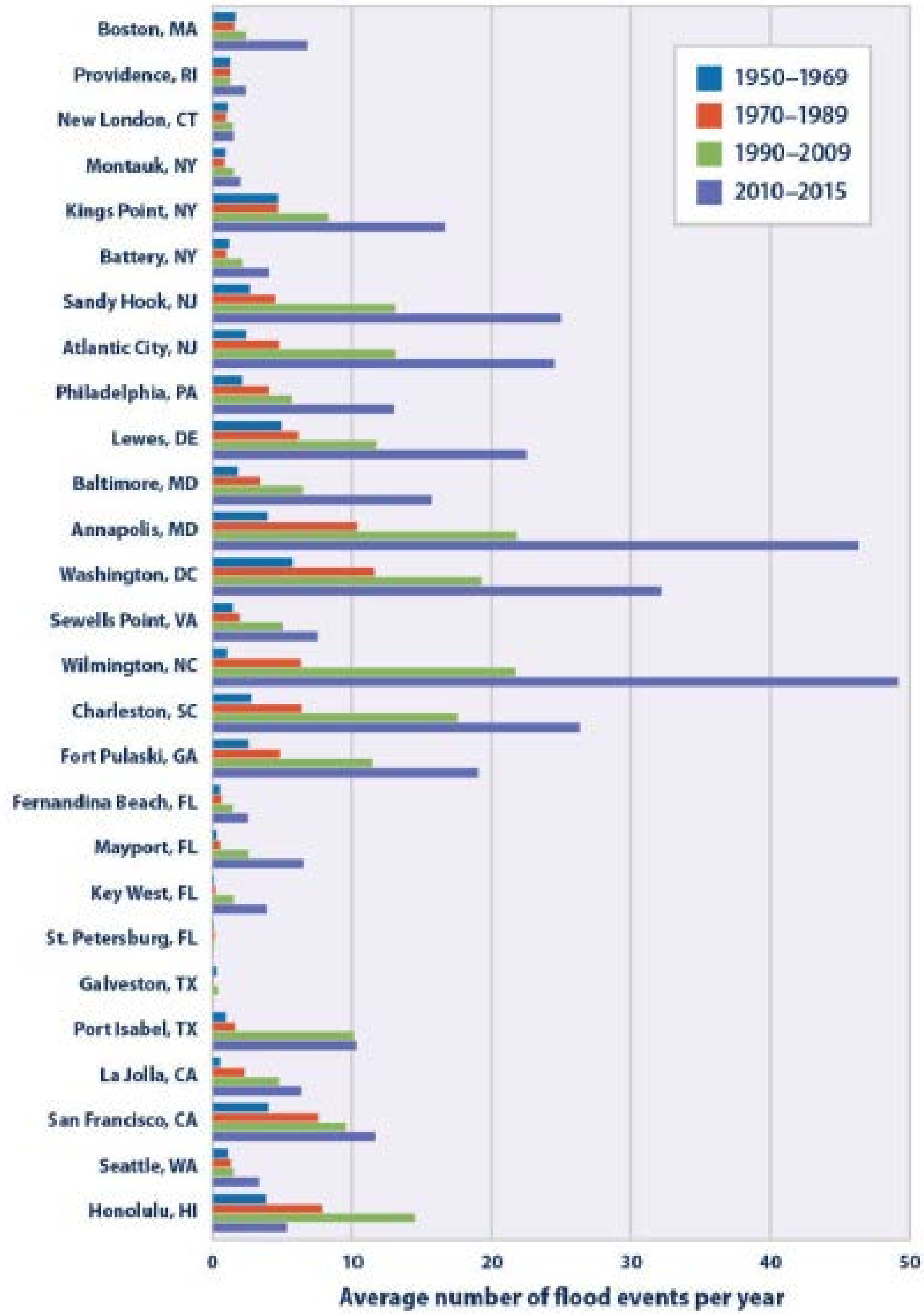


Is Sea Level Rising Linearly?





Sea Level is not Rising Equally Everywhere



Rain and Tidal Flooding

Real Issue moving forward:

plos.org

PLOS | ONE

Publish | About | Browse

OPEN ACCESS PEER-REVIEWED

RESEARCH ARTICLE

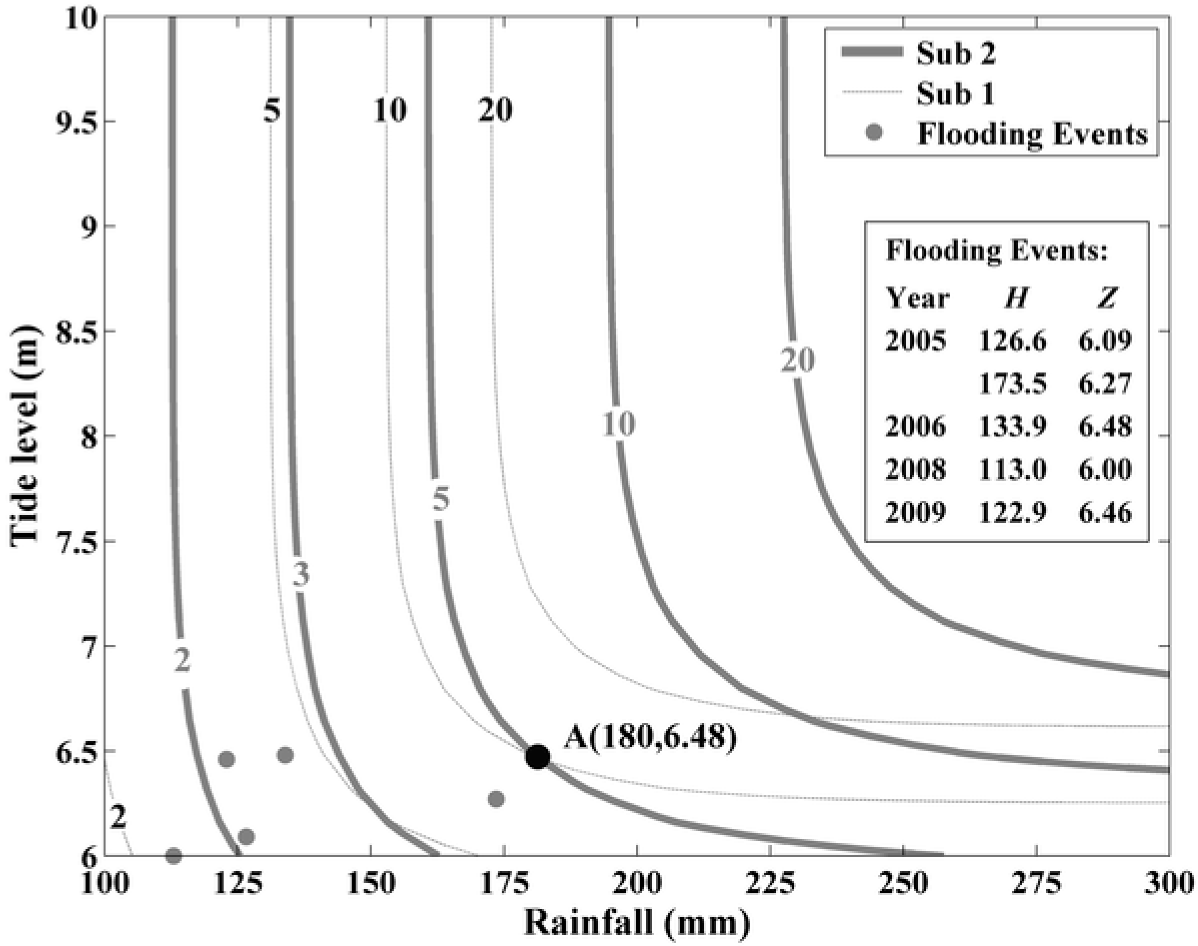
Joint Probability Analysis of Extreme Precipitation and Storm Tide in a Coastal City under Changing Environment

Kui Xu, Chao Ma, Jijian Lian, Lingling Bin

Published: October 13, 2014 • https://doi.org/10.1371/journal.pone.0109341

Article	Authors	Metrics	Comments	Related Content

Future Joint Probabilities are Difficult to Determine



Conclusions

- Number of flood events changes significantly with small changes in sea level
- There will be a large increase in future flood events with current sea level rise trend
- Daily flooding is likely if sea level rise accelerates over the next few decades
- Joint probability of increased rainfall and high tide flood events is not well understood at this time
  - Increased frequency and intensity of rain events will increase frequency of high tide flood events

What can we do about this?

"It's not going to be a slow, gradual change. It's already on an accelerating, upward sloping trajectory"

- **WILLIAM V. SWEET, NOAA OCEANOGRAPHER**

Tidal Flood Mitigation

Structural

- Levees
- Berms
- Dikes
- Floodwalls
- Bulkheads

Non-Structural

- Elevation
- Beach Nourishment
- Living Shorelines
- Reefs
- Wetlands

MANAGEMENT MEASURES
STRUCTURAL - LEVEES

MANAGEMENT MEASURES

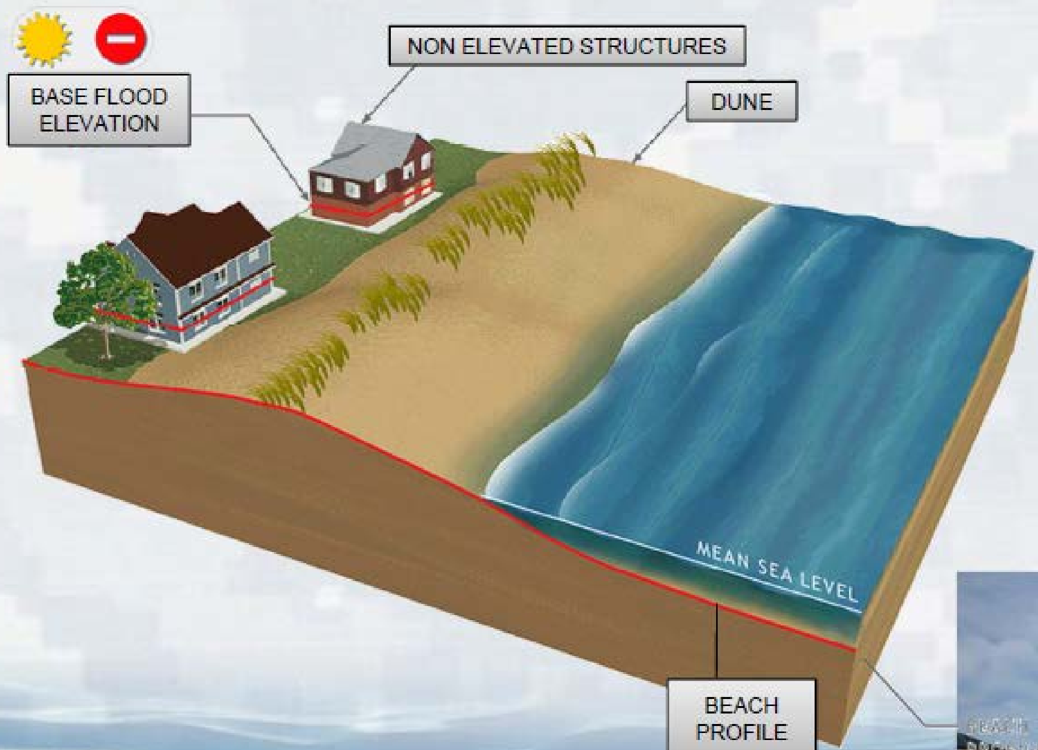
STRUCTURAL– BULKHEADS

Floodwall

Port Monmouth, NJ

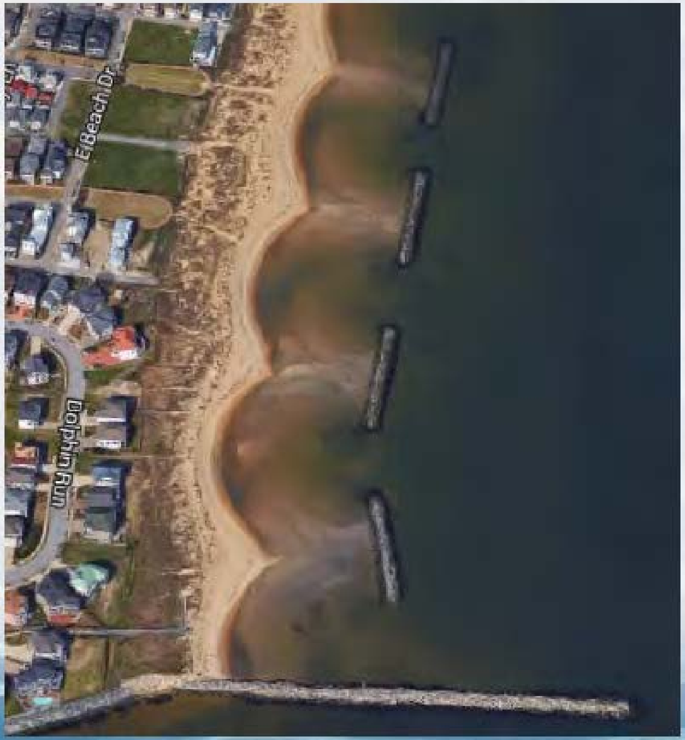
MANAGEMENT MEASURES

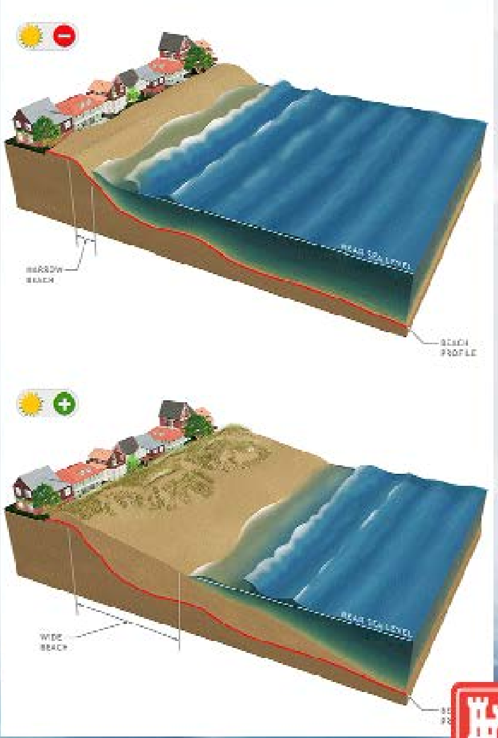
NON-STRUCTURAL - ELEVATION



MANAGEMENT MEASURES

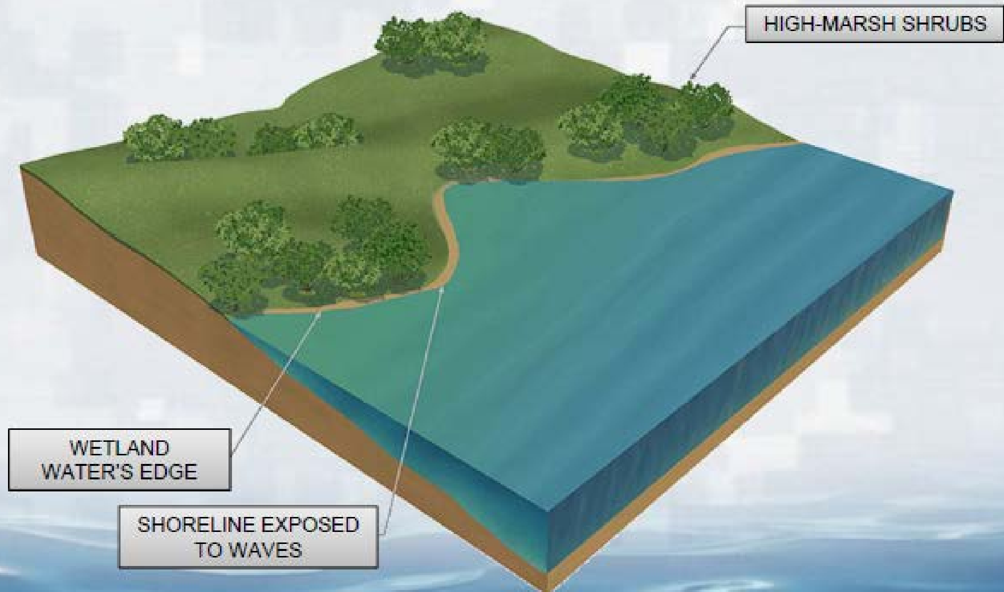
NATURAL AND NATURE-BASED – BEACH NOURISHMENT





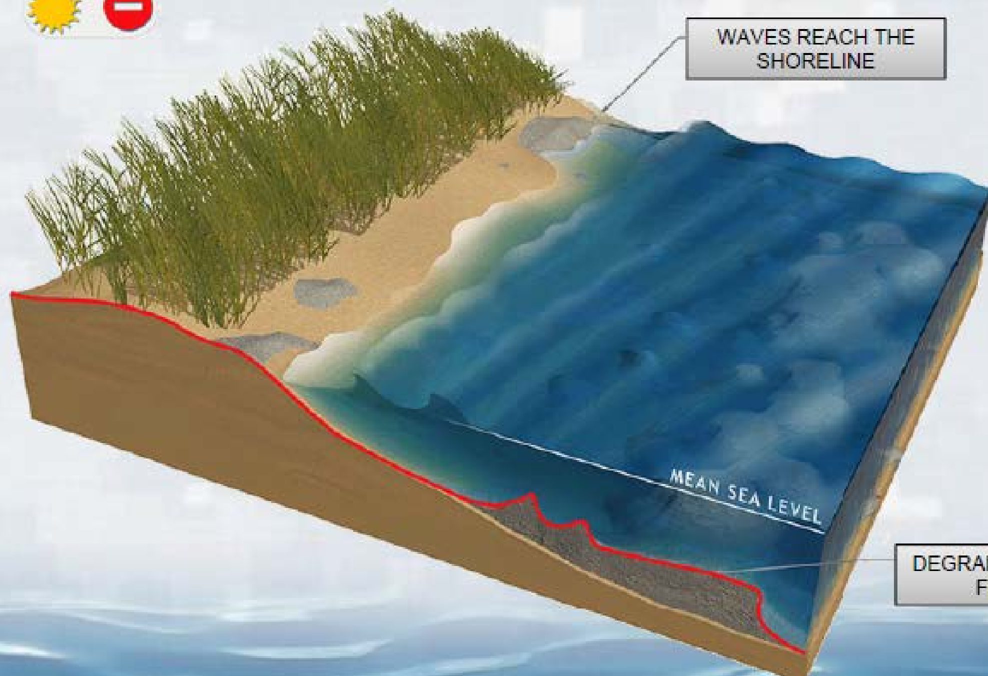
MANAGEMENT MEASURES

NATURAL AND NATURE-BASED – LIVING SHORELINES



MANAGEMENT MEASURES

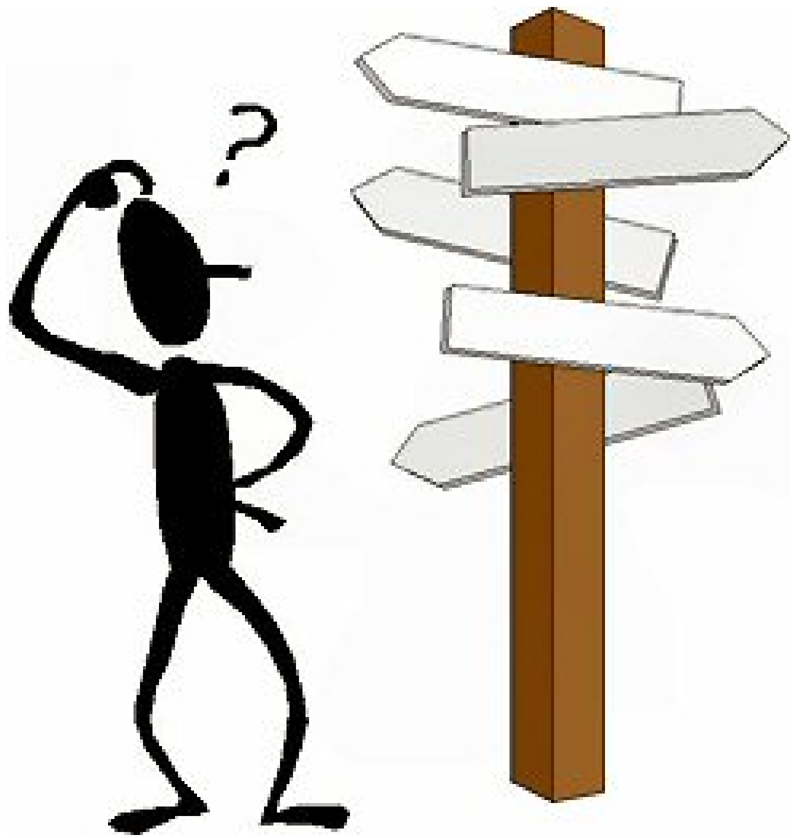
NATURAL AND NATURE-BASED – REEFS



MANAGEMENT MEASURES

NATURAL AND NATURE-BASED – WETLANDS

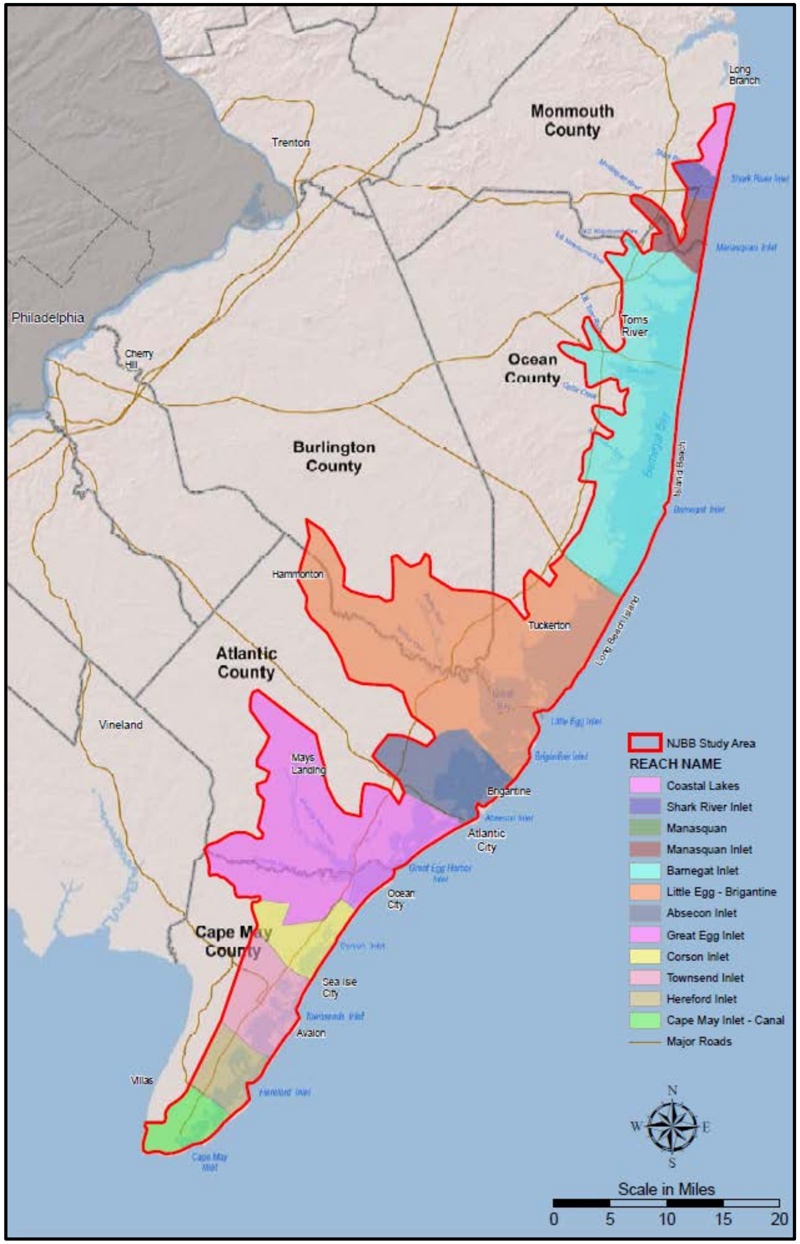
Who is going to do all this Planning & Construction and who is going to pay?



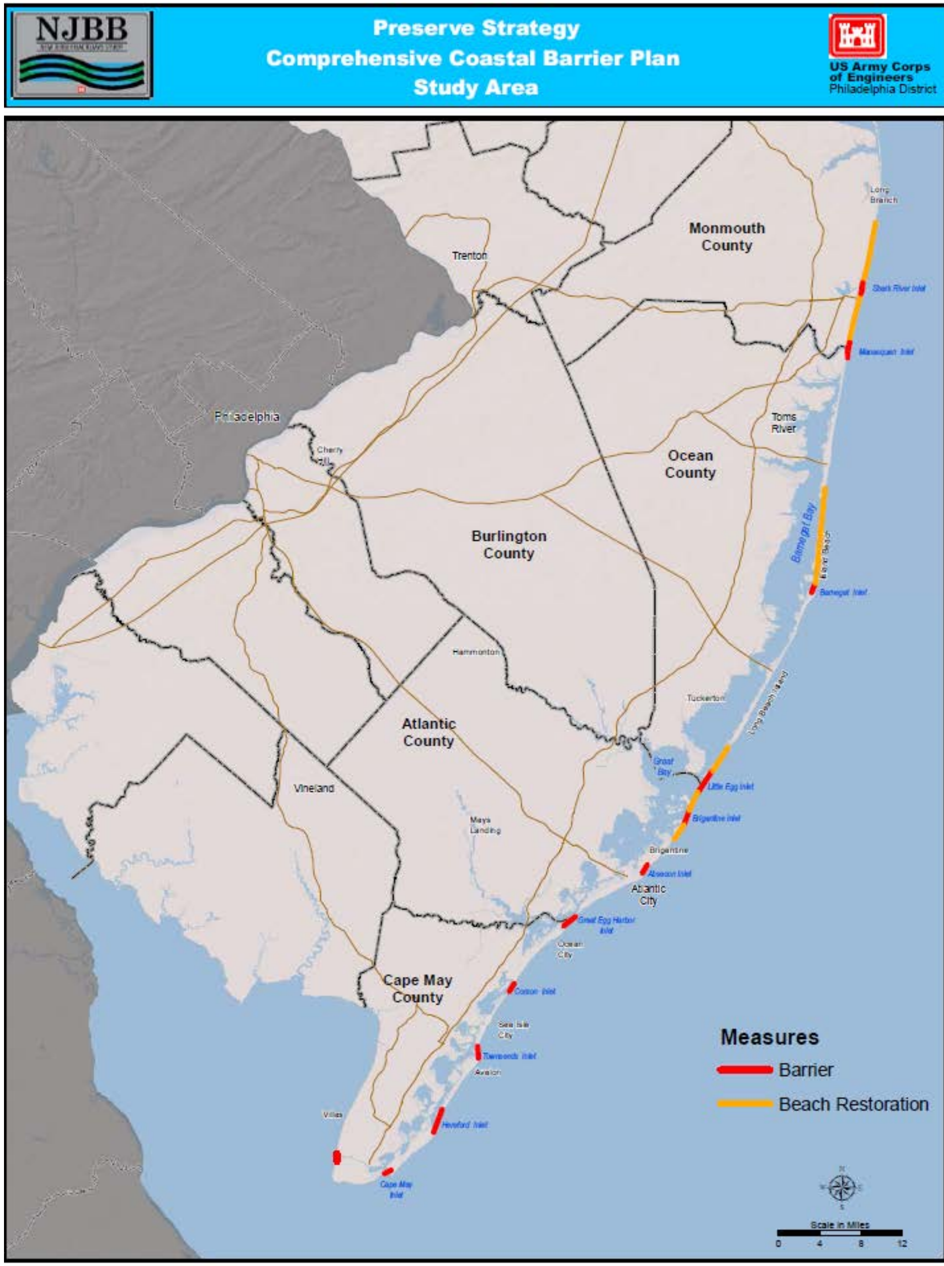
USACE New Jersey Back Bays Study

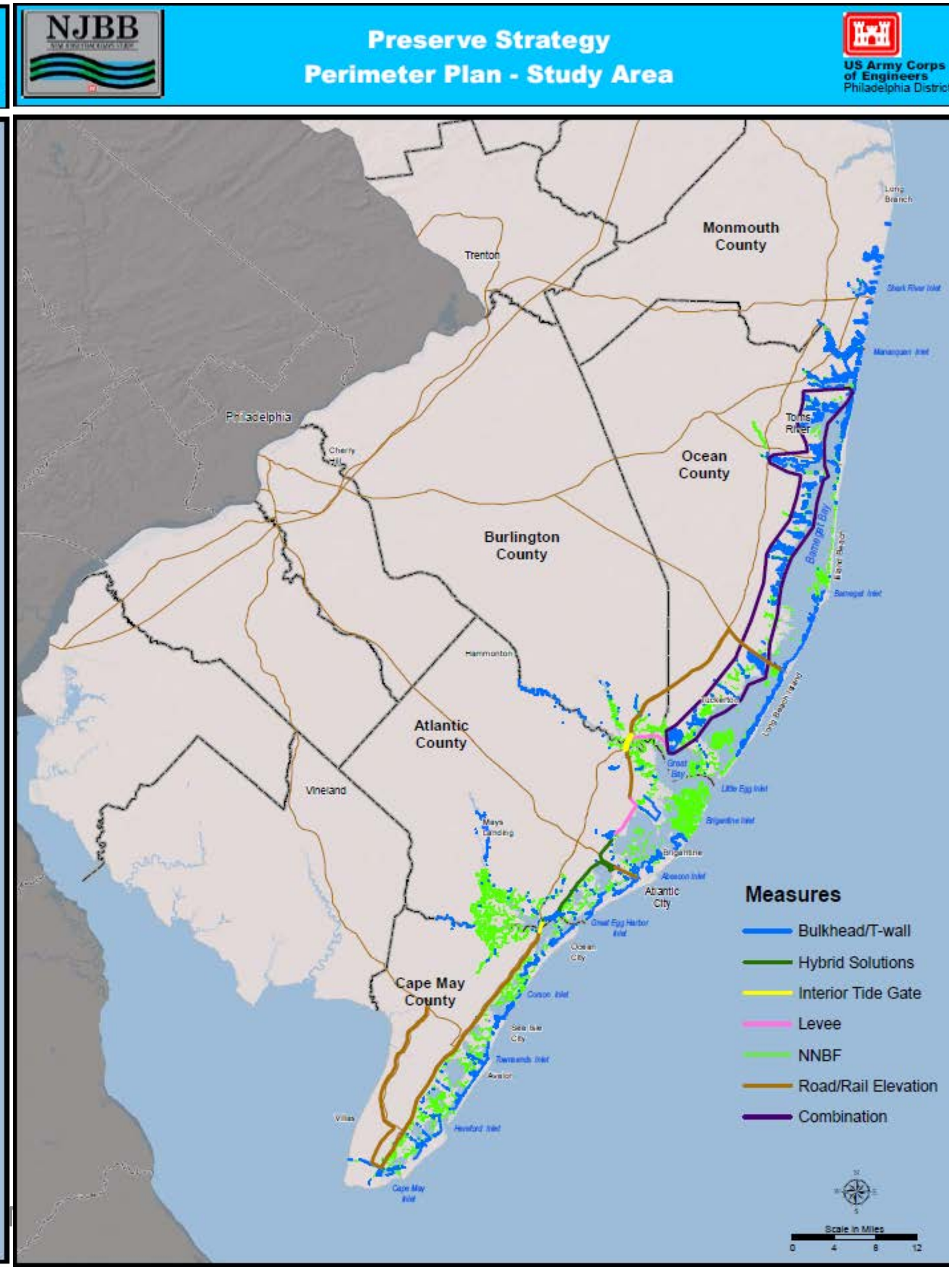
Overview

- NACCS Focus Area
- NJ Shore Protection Study Authority (December 1987 House Resolution)
- Single purpose CSRM Feasibility Study
- Initiated as 3-year study (3X3 model)
- Coastal flooding and sea level rise risk management
- FCSA Executed April 2016
- Public Release Spring 2019



EXAMPLE PLANS (AMM)





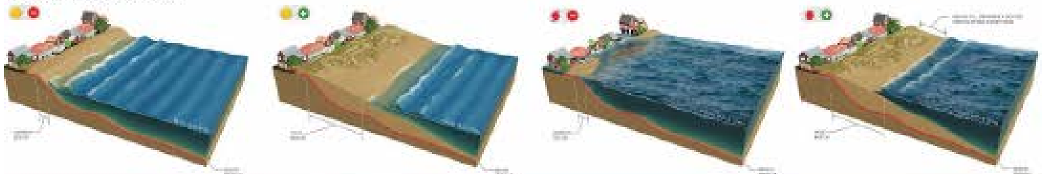
Natural and Nature Based Features (NNBF)

NNBF are defined in the North Atlantic Coastal Comprehensive Study (NACCS) to include elements that are created and evolve over time through the actions of physical, biological, geologic, and chemical properties operating in nature and elements that mimic characteristics of natural features but are created by human design, engineering, and construction to provide specific services such as coastal storm risk management. NNBF measures considered in the NJBB study include Living Shorelines, Reefs, Wetland Restoration, Submerged Aquatic Vegetation (SAV) restoration, and Green Stormwater Management. Improved implemented of NNBF throughout the NJBB CSRM Feasibility Study area presents a significant opportunity to increase resilience and manage coastal storm flooding risk.

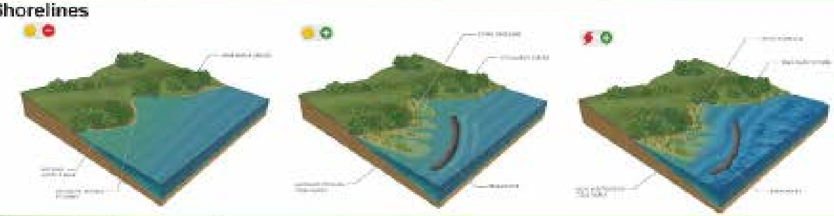
Key to Figures:

- Normal conditions, no measure
- Normal conditions, with measure
- Storm conditions, no measure
- Storm conditions, with measure

Beach Restoration

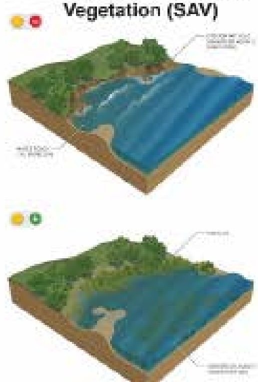


Living Shorelines

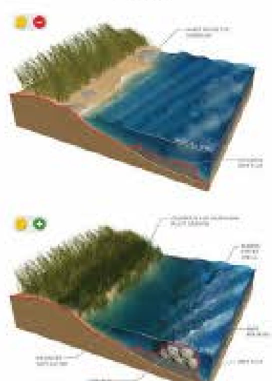


Green Stormwater Management

Submerged Aquatic Vegetation (SAV)

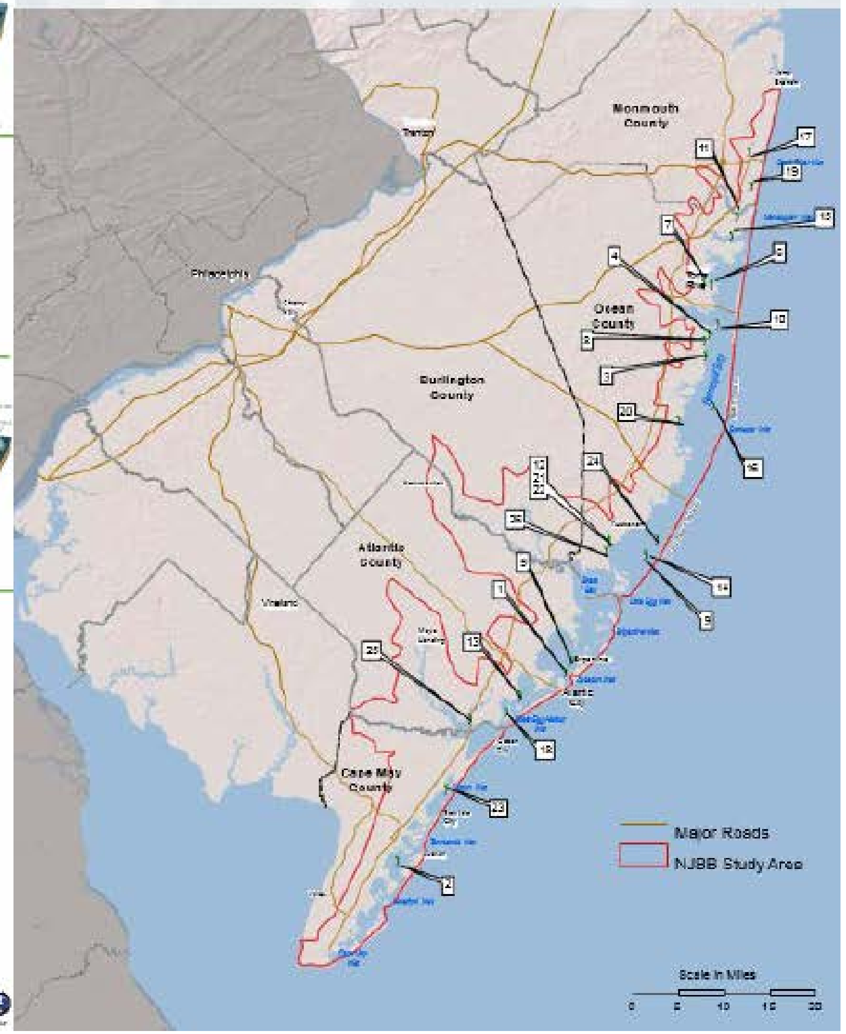


Reefs



Wetland Restoration

Natural and Nature-Based Features



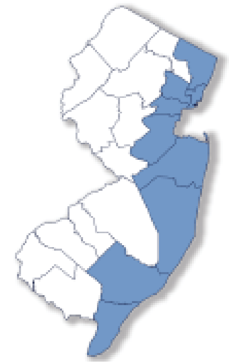
Resilient NJ

Regional Planning
for a Stronger New Jersey

State of New Jersey
Department of Environmental Protection
Office of Coastal and Land Use Planning

WHAT IS THE PROGRAM?

New Jersey was awarded $10 million from HUD through the National Disaster Resilience competition. Administered by NJDEP, ***Resilient NJ*** will fund the development and implementation of up to 5 regional resilience and adaptation action plans to address coastal and riverine flood events. NJDEP will provide qualified consultants to lead the planning process and provide technical support to develop community-driven action plans.



WHO QUALIFIES?

Funding will be awarded on a competitive basis to regional teams. Eligible entities include counties, municipalities, regional planning commissions, utility authorities, and community based organizations (CBO) within Atlantic, Bergen, Cape May, Essex, Hudson, Middlesex, Monmouth, Ocean, and Union Counties. Each team must include at least 3 contiguous municipalities and 1 CBO. This program is open to all communities within these counties.

HOW WILL YOU BENEFIT?

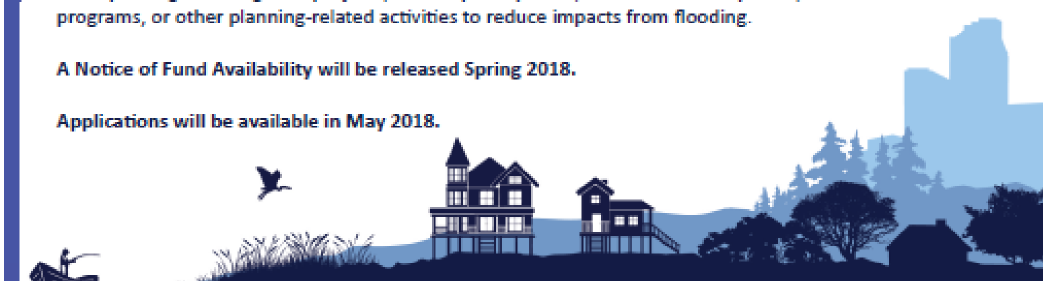
The program will provide grant funding for neighboring communities to develop and implement regional action plans that:

- Assess vulnerability to current and projected flooding, including permanent inundation, chronic and nuisance flooding, riverine and coastal flooding, and coastal storms and storm surge
- Identify locally-significant and regionally-shared critical assets
- Develop strategic and actionable mitigation actions to reduce flooding risk
- Understand and weigh the costs and benefits of specific actions
- Develop a strategic plan that reduces risk and provides a roadmap for implementation

Resilient NJ will also provide funding to implement these actions. Potential actions include planning and concept design of mitigation projects, master plan updates, ordinance development, outreach and education programs, or other planning-related activities to reduce impacts from flooding.

A Notice of Fund Availability will be released Spring 2018.

Applications will be available in May 2018.



Questions? Contact the NJDEP Office of Coastal and Land Use Planning for more details at ResilientNJ@dep.nj.gov

It’s not going to be quick or easy….

Thank you