

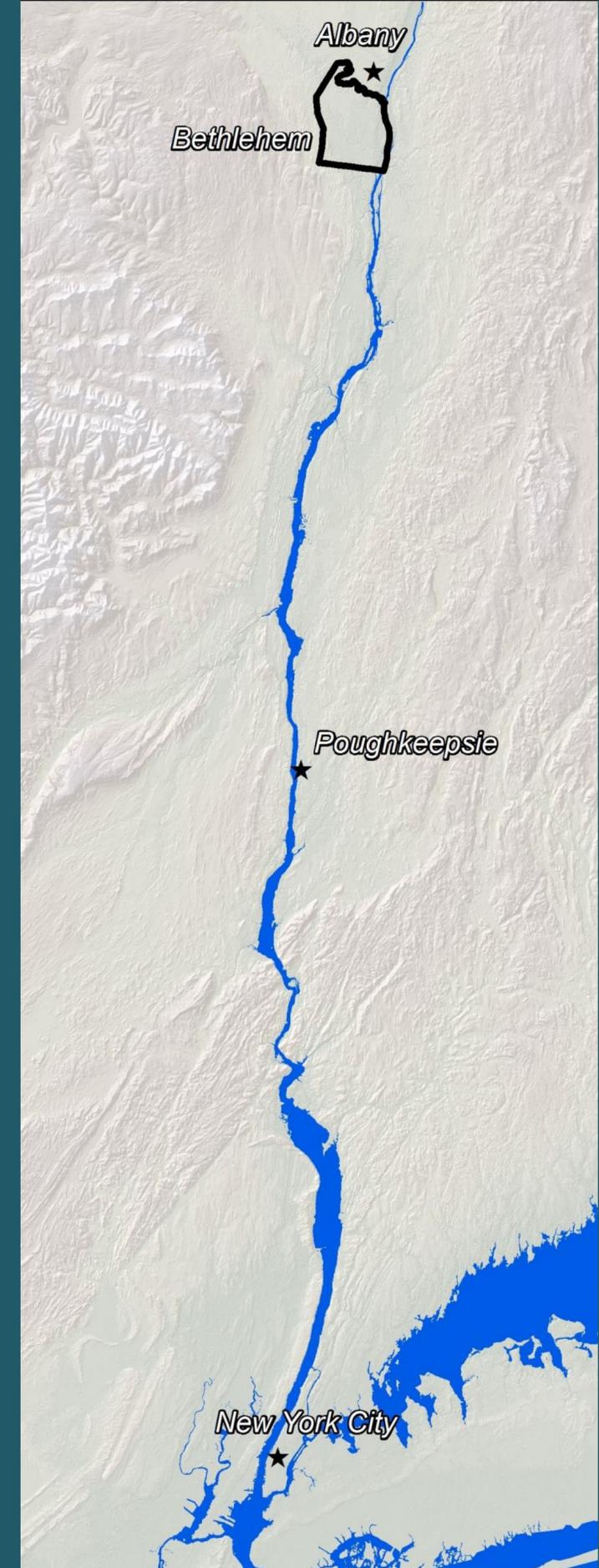
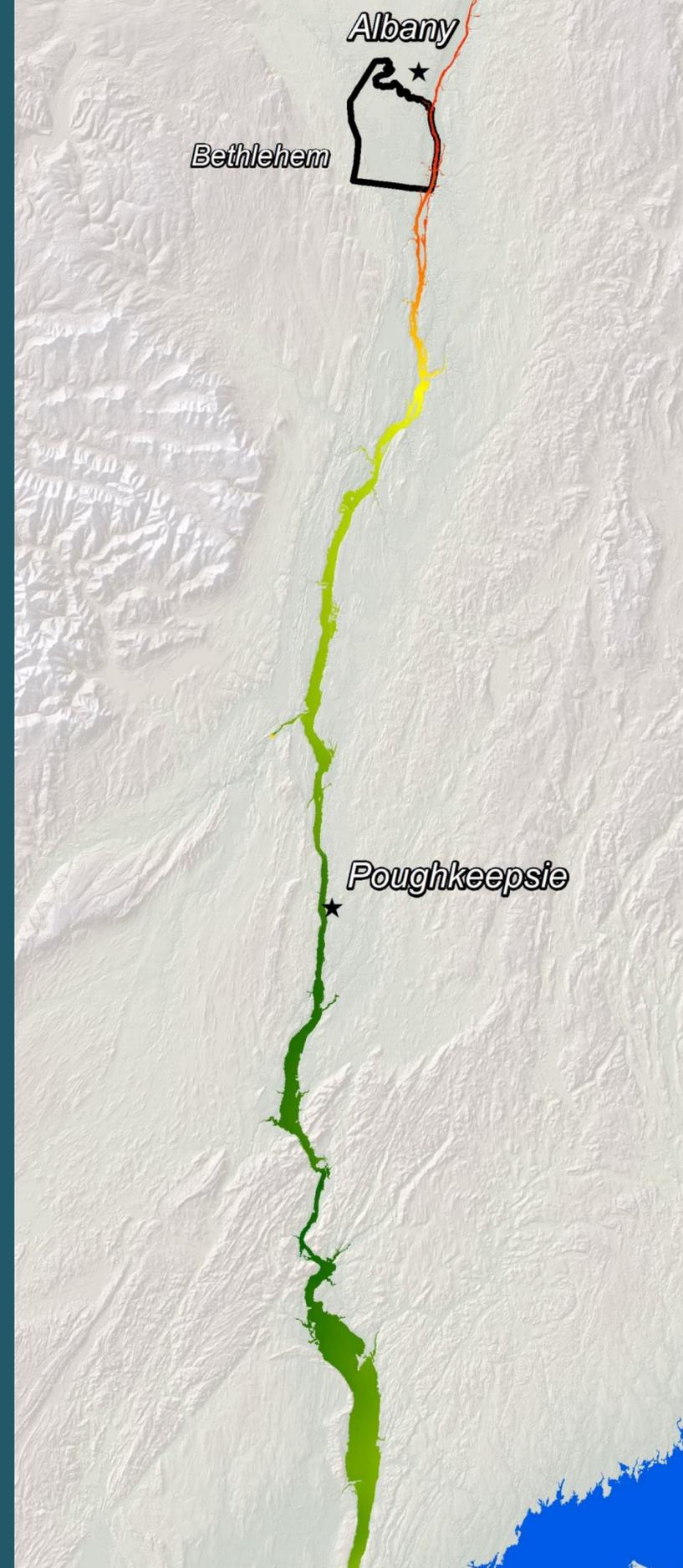
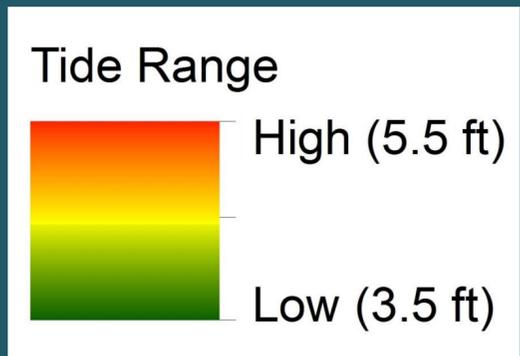
# PLANNING FOR COASTAL RESILIENCE



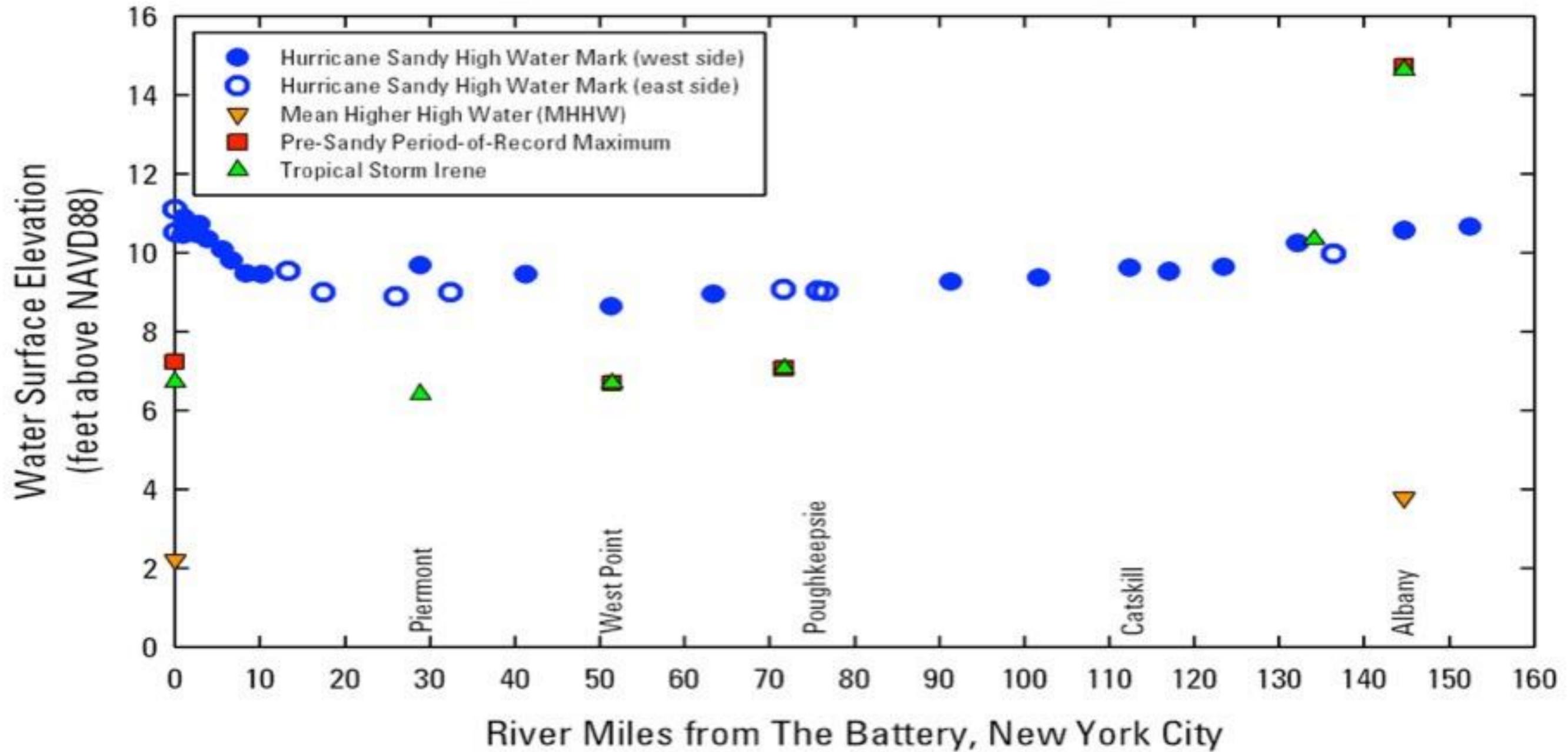
# PLANNING FOR COASTAL RESILIENCE . . . *IN BETHLEHEM?!*



# THE HUDSON RIVER ESTUARY



# Hudson River Hurricane Sandy Storm Surge



## DATA SOURCES:

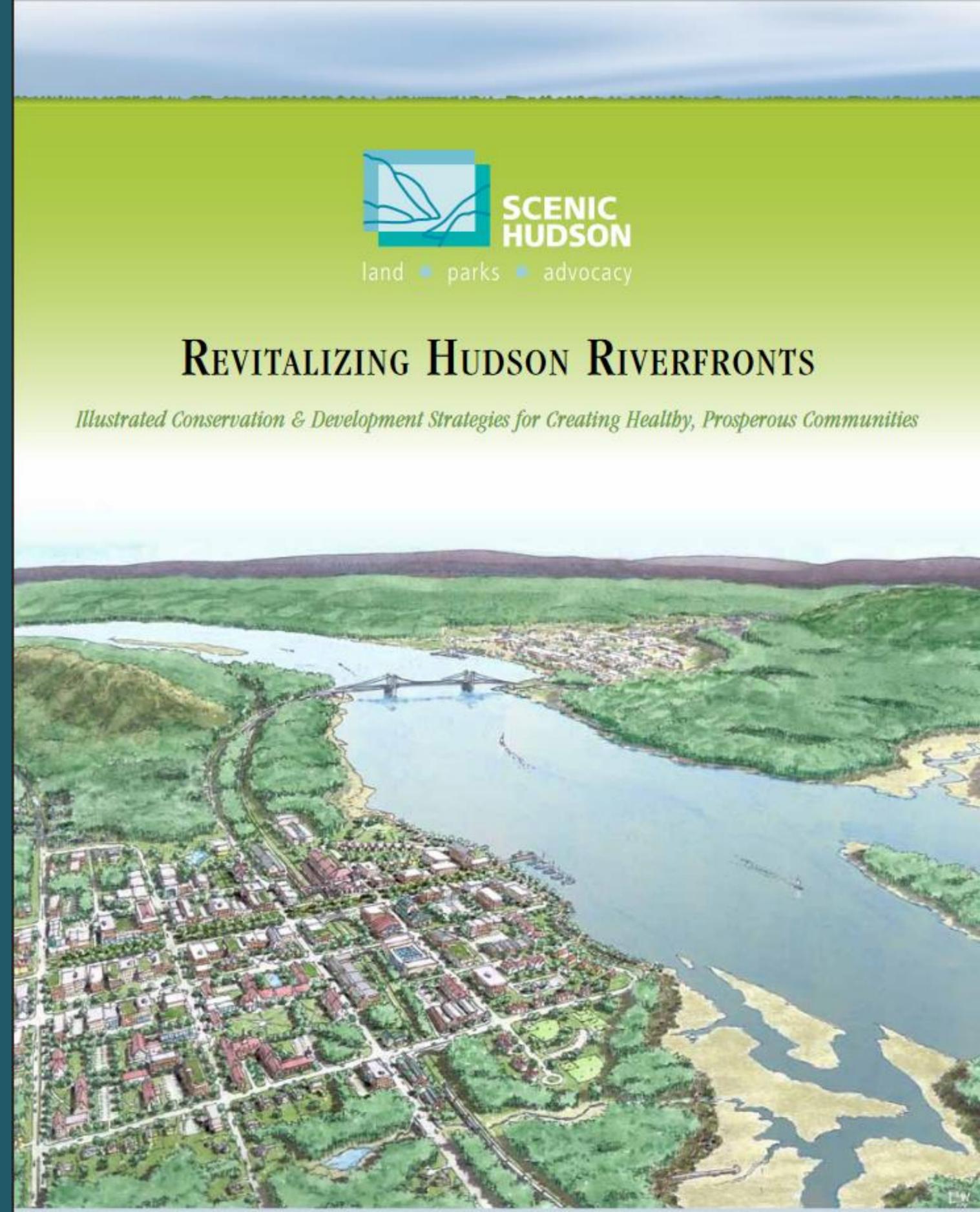
USGS Hurricane Sandy Storm Tide mapper  
USGS National Water Information System  
National Oceanic and Atmospheric Administration  
Hudson River Environmental Conditions Observing System



DATA IS PROVISIONAL AND SUBJECT TO REVISION

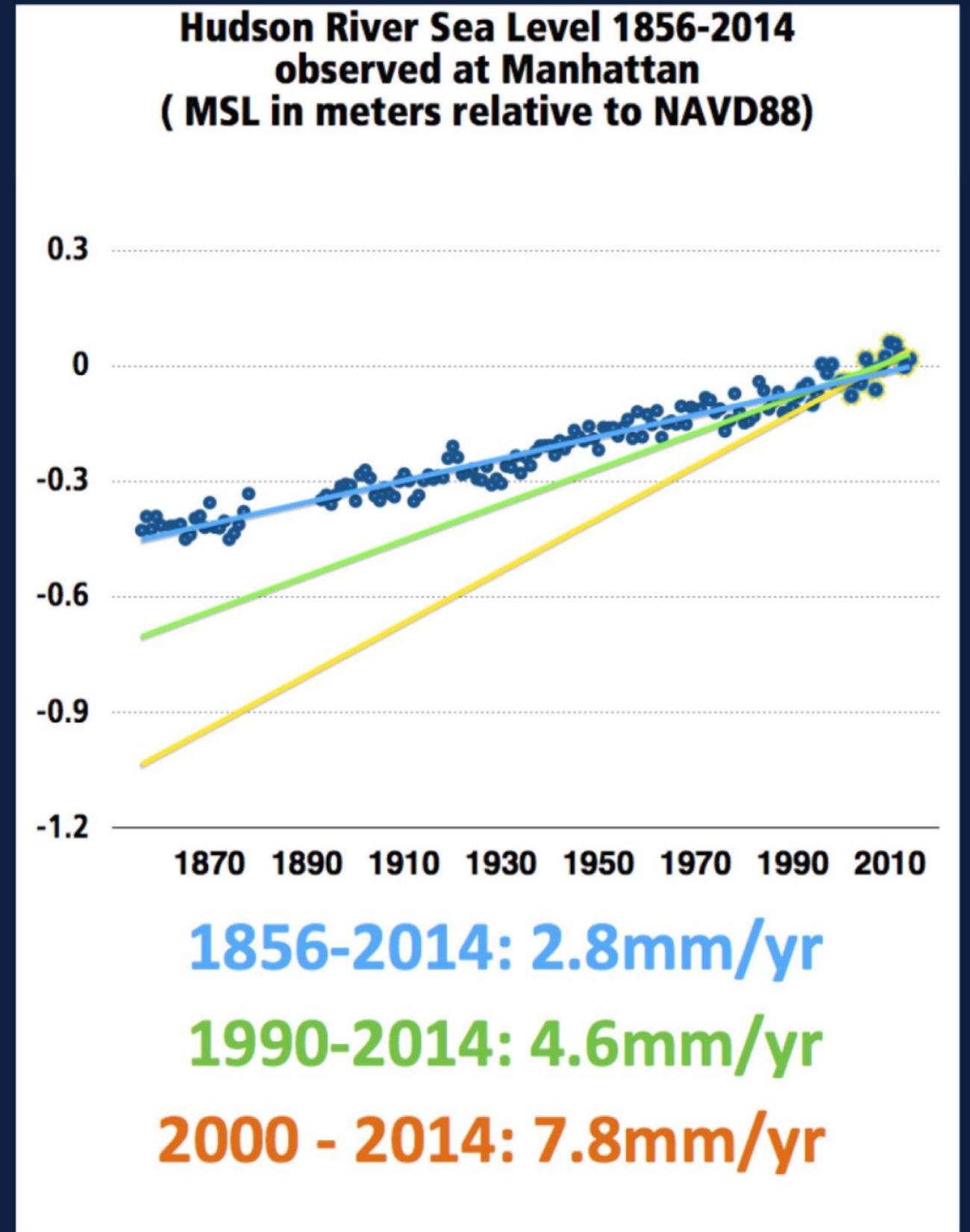
# REVITALIZING HUDSON RIVERFRONTS

- I. Promote riverfront development in areas with existing infrastructure
- II. Encourage water-dependent & water enhanced uses
- III. Connect people to the river
- IV. Protect natural resources
- V. Protect scenic resources
- VI. Promote good urban planning & sustainable design



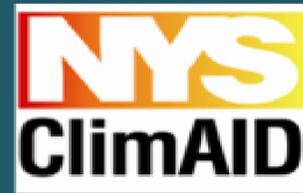
# SEA LEVEL RISE (SLR): A RISING RIVER

- The Hudson River is over 12" higher than a century ago
- 21<sup>st</sup> Century SLR rate is higher and projected to continue accelerating

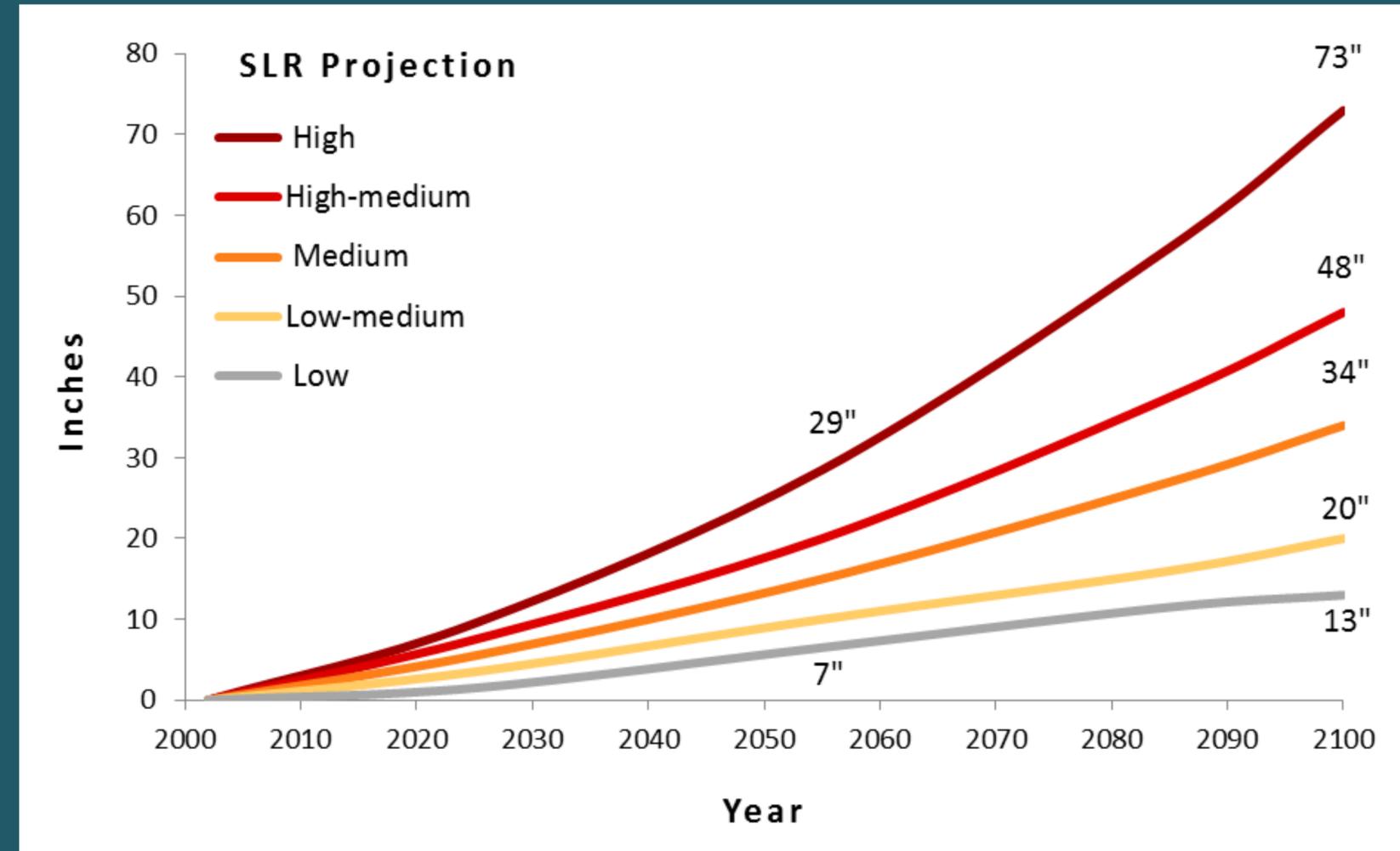


Observation Data from NOAA

# SEA LEVEL RISE (SLR): A RISING RIVER



	Low	Low-Medium	Medium	High-Medium	High
2020s	1.5	3.5	5.5	7.5	9.5
2050s	6.5	10	15	20	28.5
2080s	11.5	16	27	37.5	56
2100	13	20	34	48	73



# SEA LEVEL RISE MAPPER



## Hudson River Sea Level Rise City of Beacon

**Planning for Resilience:** With significant challenges ahead, communities have an opportunity to begin planning and implementing long-range solutions that will increase resilience and maintain the vitality of Hudson River waterfronts. A range of innovative approaches to planning, architecture, infrastructure, and natural resource conservation are available to create locally-appropriate solutions that reduce risk to people, property and nature while opening up new possibilities for taking advantage of our region's greatest asset - the Hudson River.

**City of Beacon**

At risk of flooding (light blue) At risk of inundation (dark blue)

**Households at Risk**

**People at Risk**

**Land at risk (acres)**

**Adaptation Options:** We must find solutions that protect critical infrastructure and ensure the viability of important natural resources. The best plans will provide locally specific tactics that balance options for coastal defense, strategic accommodation and managed relocation.

**Coastal defense:** Solutions that protect existing critical infrastructure - including sea walls, rip rap, levees and hardened shorelines

**Strategic accommodation:** Solutions that permit flooding - including raised infrastructure, adaptive design strategies and compatible land uses

**Managed relocation:** Solutions that allow for inundation and flooding while promoting the migration of tidal wetlands and other important natural resources

**Adaptation: Defense**

**Adaptation: Accommodate**

**Adaptation: Relocate**

**Acknowledgements:** Grant funding provided by the DeCoizart Foundation, the Whitney Foundation, Sean Eldridge and the Wildlife Conservation Society. Project data or technical assistance provided by the NYS Department of Environmental Conservation Hudson River Estuary Program, Dr. Roger Flood of Stony Brook University and the NOAA Coastal Services Center.

FOR MORE INFORMATION, VISIT [WWW.SCENICHUDSON.ORG/SLR](http://WWW.SCENICHUDSON.ORG/SLR)

**The Hudson Is Rising**  
The Hudson River Estuary is an arm of the Atlantic Ocean. Its water levels reflect tidal action and global sea-level increases. Over the past century, local river elevations have risen about 12", a rate of increase greater than the global average. The best data available indicates Hudson River water levels may rise as much as six additional feet by 2100.

**Sea Level Rise Time Frame**  
Sea level projection data are based on figures from the New York State 2100 Commission Report.

Hudson River Sea Level Rise Projections (in.)	2020's	2050's	2080's	2100
Central Range:	2-5	7-12	12-23	15-30
Rapid Ice Melt:	5-10	19-29	41-55	56-72

**How Will It Impact Your Community?  
City of Beacon:**  
At risk if sea level rises 72":

	Inundation	Flooding*
Households:	12	29
People:	31	70
Tidal Wetlands (acres):	240.87	N/A
Railroad (miles):	0.49	6.5
Treatment Plants:	0	0
Hazardous Facilities:	0	0
Brownfields:	1	2
Schools:	0	0

\*Inundation refers to areas underwater at high tide. Flooding refers to 1% risk coastal flood zones; flood statistics include only areas outside of inundation zones.

**Inundation Modeling**  
Sea-level rise will create a "new normal" in the elevation and extent of the river. Scenic Hudson has used GIS to model future high tide lines and floodplains under various sea level rise scenarios, then used those areas to identify resources, infrastructure and people at risk.

INFORMATION, VISIT [WWW.SCENICHUDSON.ORG/SLR](http://WWW.SCENICHUDSON.ORG/SLR)



**LEGEND**

- Current river
- Tidal wetlands and sub-aquatic vegetation
- 100 year floodplains and low-lying areas
- Hard Shoreline
- Natural Shoreline
- Railroad
- Libraries
- Schools
- Wastewater Treatment Facilities
- Brownfields & EPA Hazardous Sites

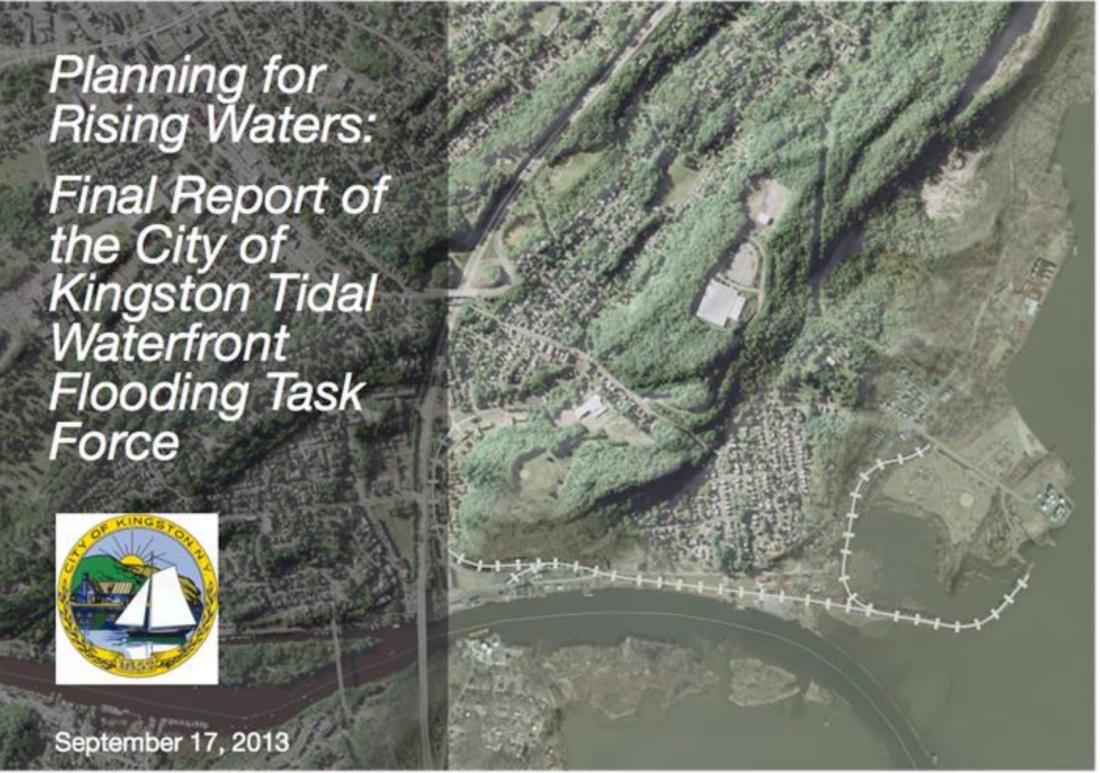
**INUNDATION DEPTH**

6" 12" 18" 24" 30" 36" 42" 48" 54" 60" 66" 72"

# WATERFRONT COMMUNITY RESILIENCE



*Planning for Rising Waters:  
Final Report of the City of Kingston Tidal Waterfront Flooding Task Force*



September 17, 2013

The image shows an aerial view of a waterfront area with a white dashed line tracing a path along the water's edge. The text and logo are overlaid on the left side of the image.

**RESILIENT CATSKILL**

*Report of the Catskill Waterfront Resilience Task Force*

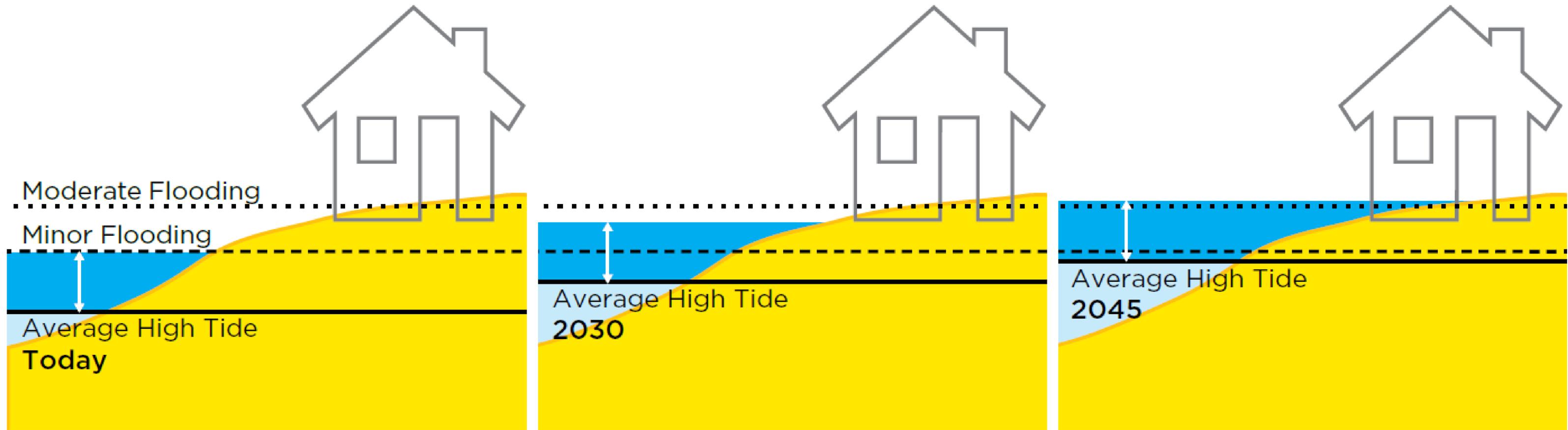
An aerial photograph showing a town built along a wide river. The town includes residential houses, a school, and industrial buildings with large storage tanks. The surrounding area is lush with green trees.

**RESILIENCE ROADMAP:  
PLANNING FOR PIERMONT'S FUTURE**

*Report of the Piermont Waterfront Resilience Task Force*

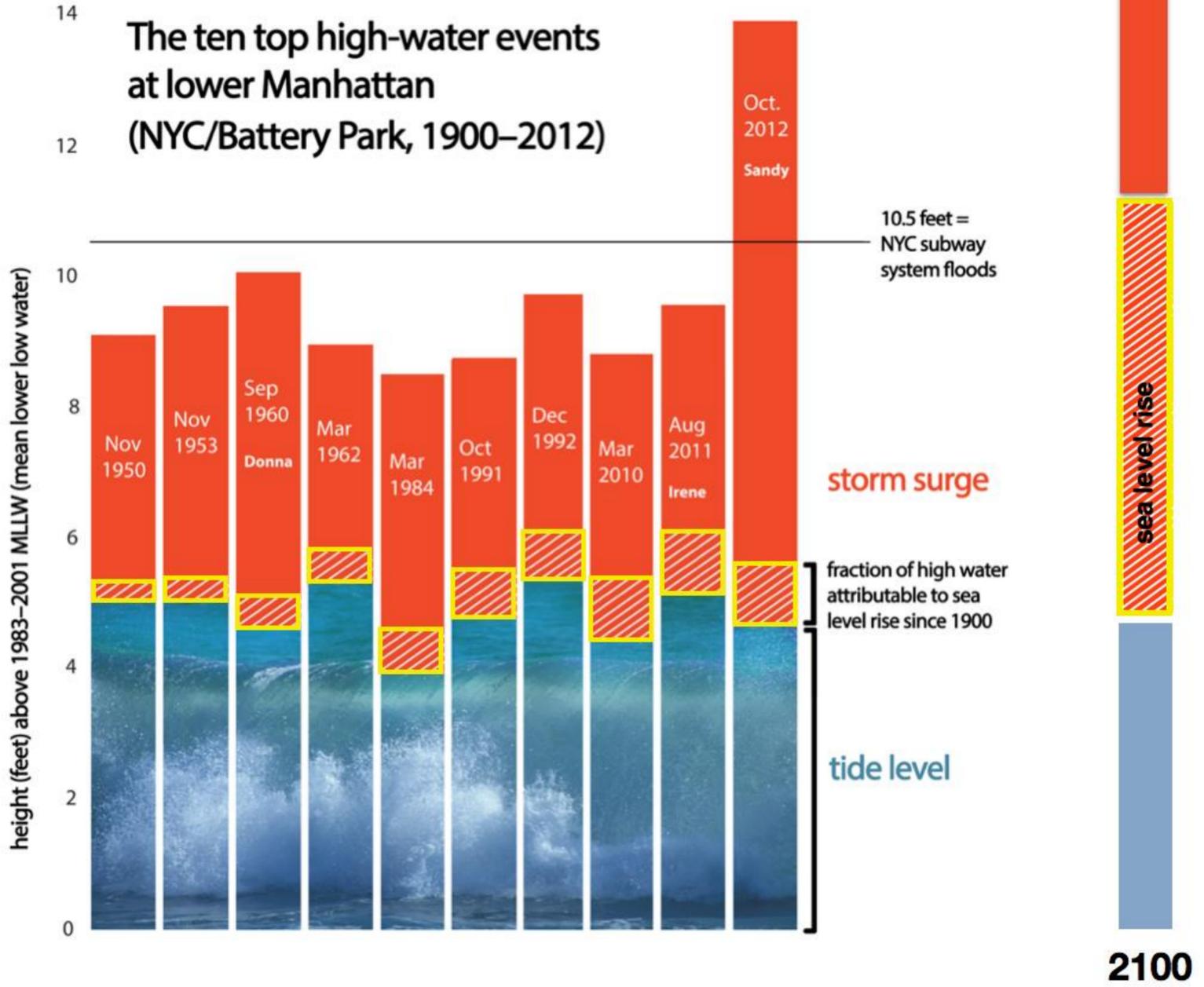
An aerial view of a coastal town built on a narrow strip of land. A large marina with many boats is visible on the right. The town features a mix of residential and commercial buildings along the waterfront.

# FLOODING AND SEA LEVEL RISE

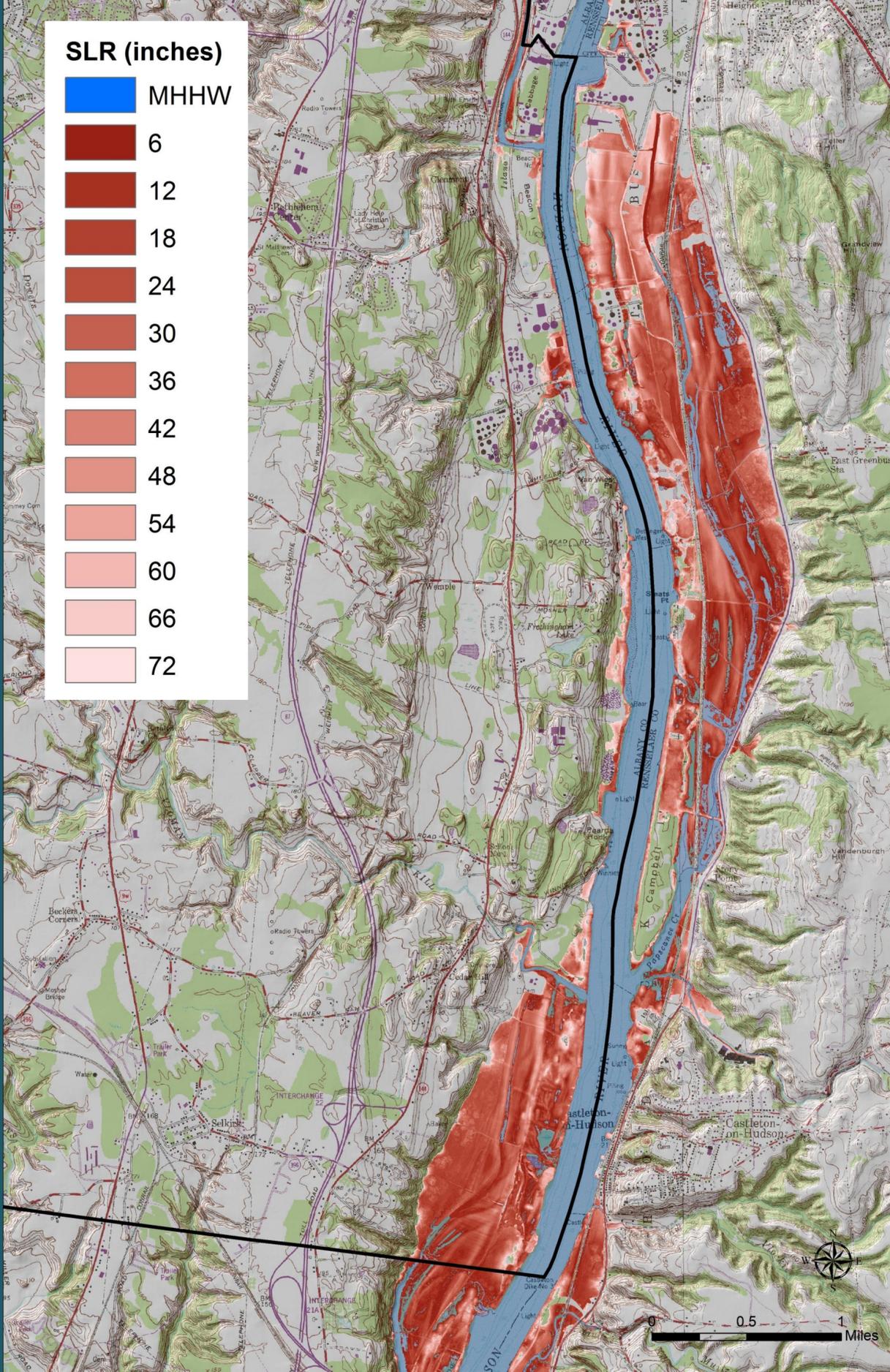
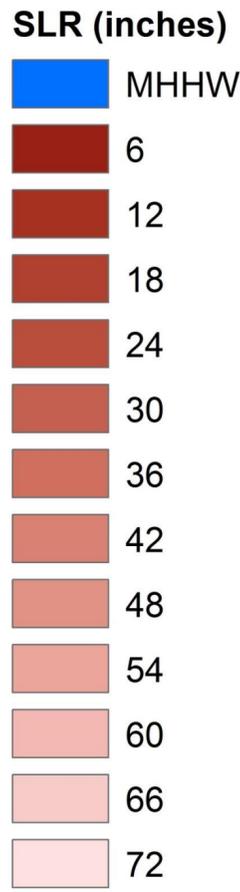


*A tide that causes a minor flood today is a nuisance (white arrow). In the future, higher sea levels will allow high tides to push water deeper into coastal communities, affecting more homes, businesses, and infrastructure. Extensive moderate flooding—now usually associated with storms and high winds—is expected to become more common, simply from high tides.*

# FLOODING AND SEA LEVEL RISE



# SEA LEVEL RISE IN BETHLEHEM

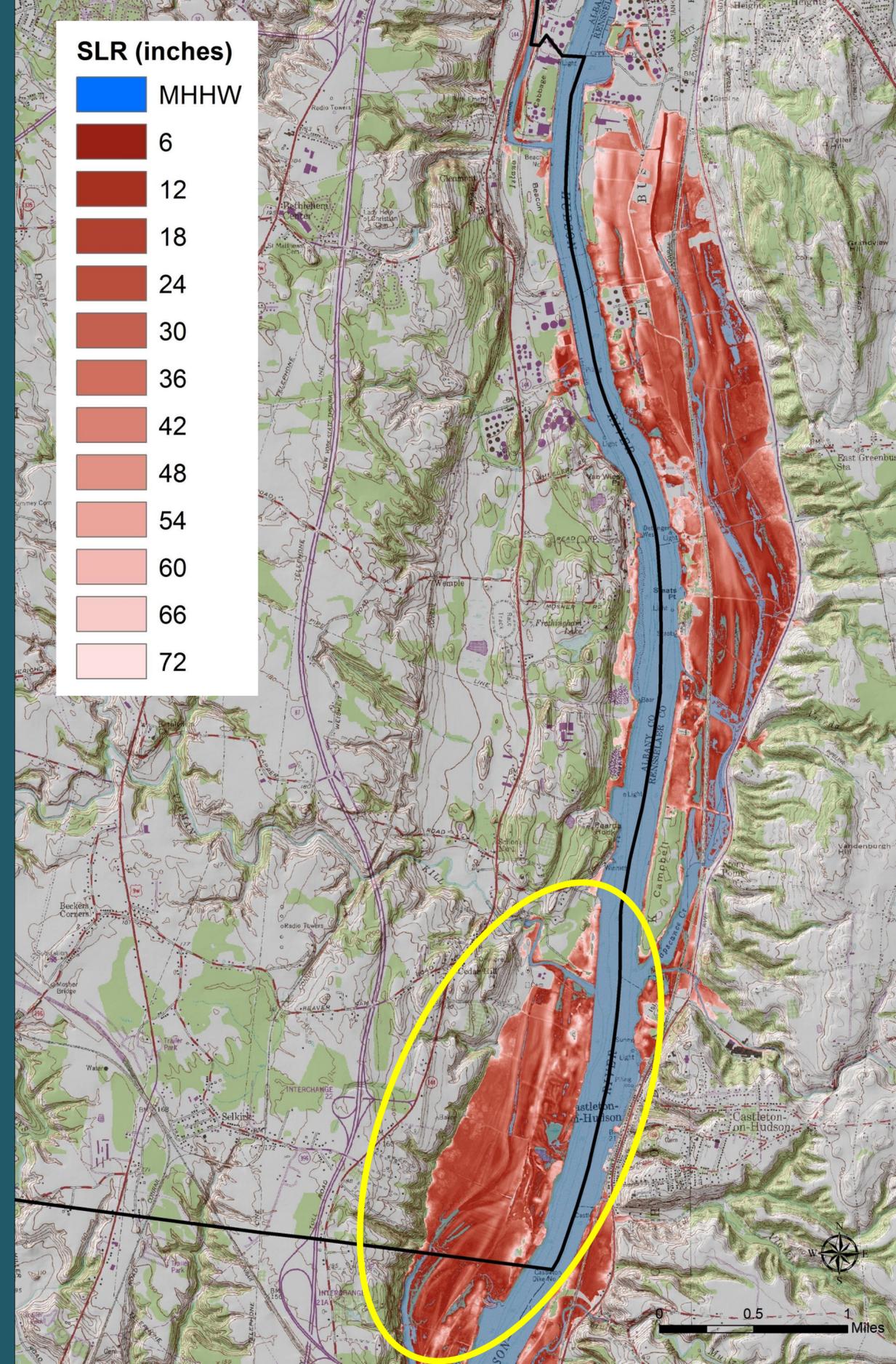
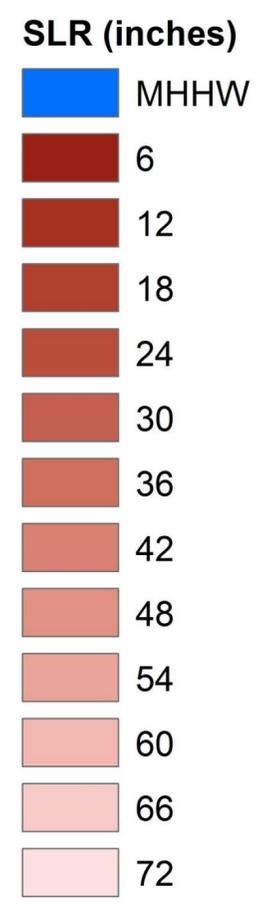
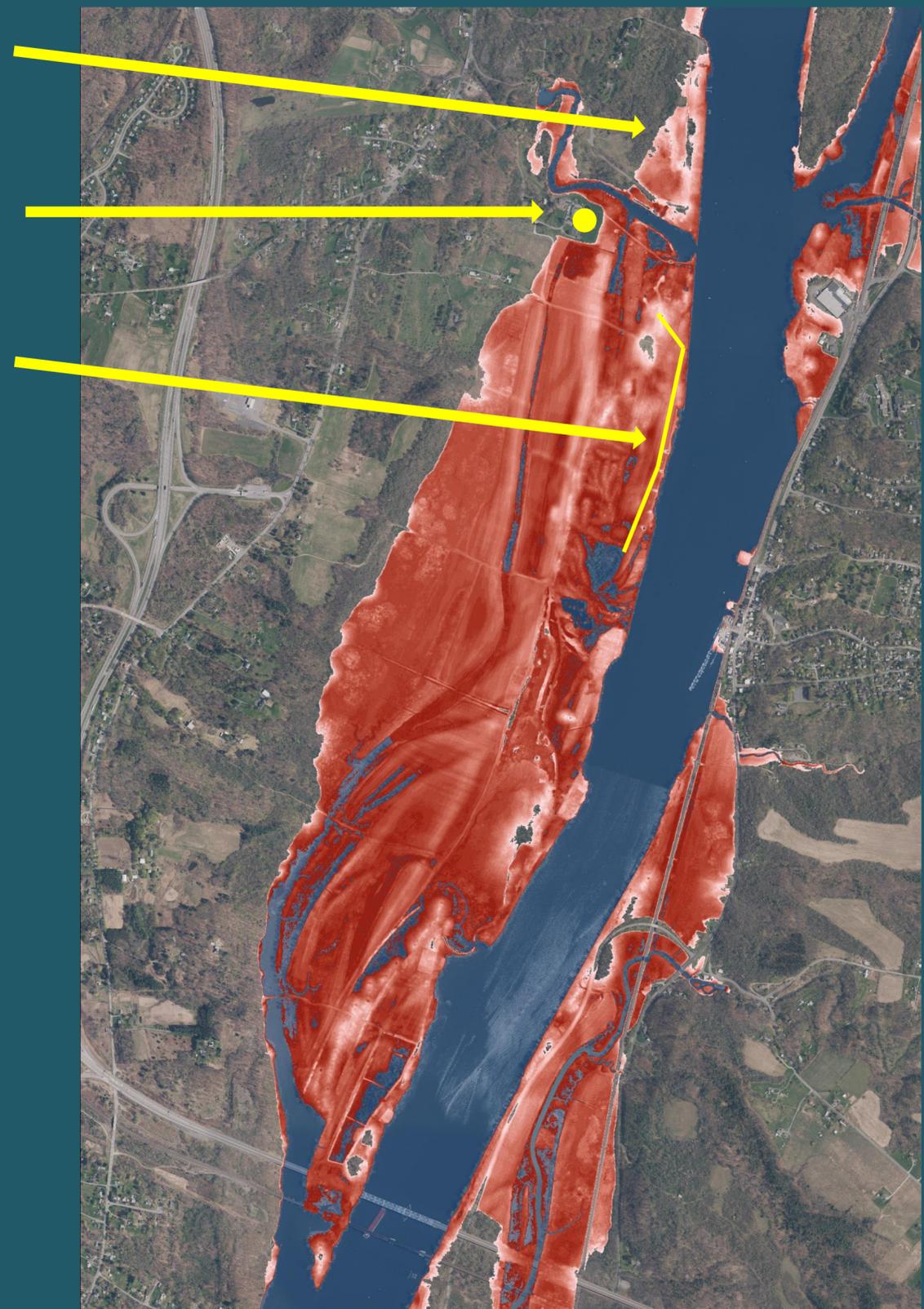


# SEA LEVEL RISE IN BETHLEHEM

Henry Hudson Park

Wastwater treatment plant

Production wells

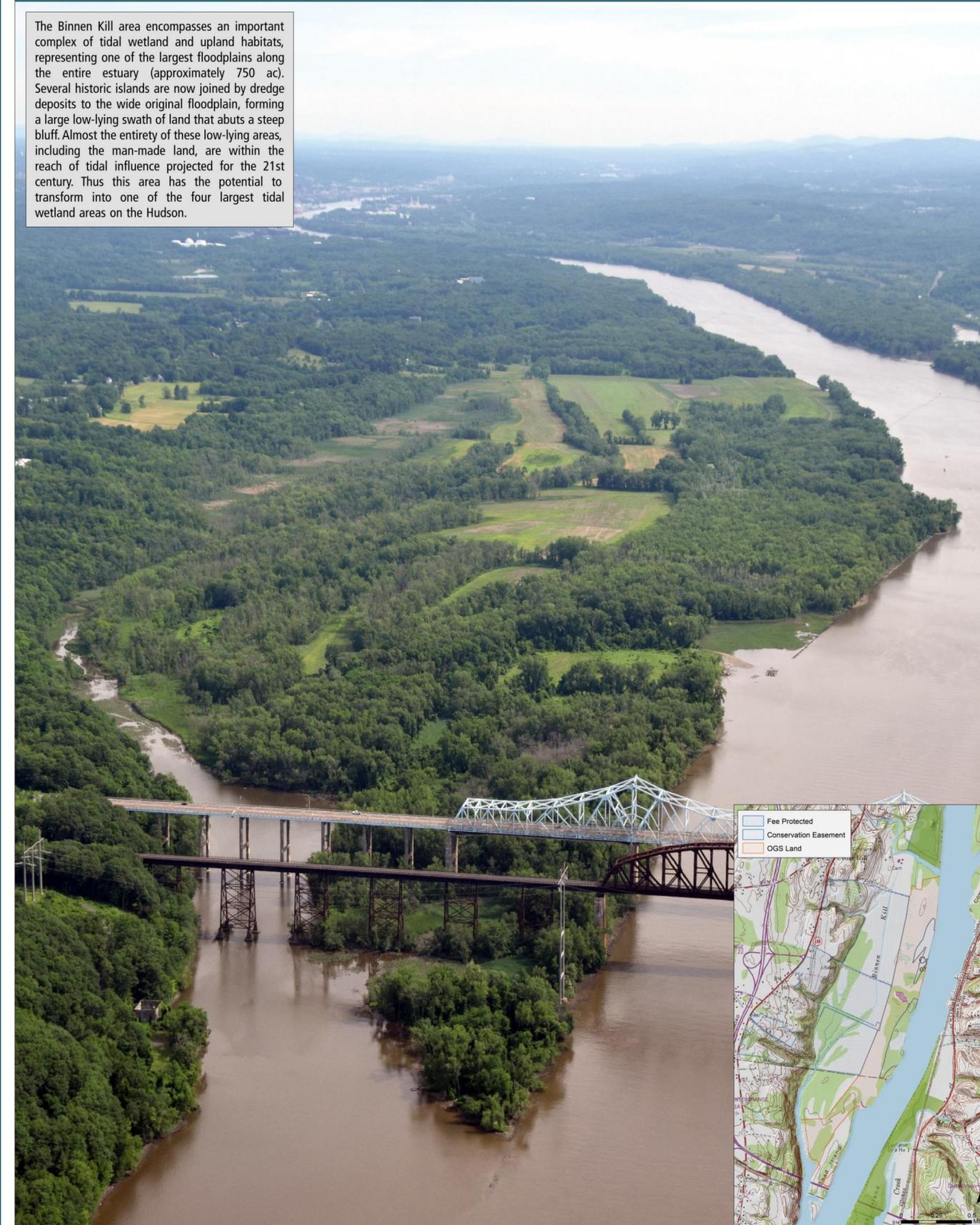


# TIDAL WETLAND EXPANSION IN THE HUDSON RIVER ESTUARY

The Binnen Kill area encompasses an important complex of tidal wetland and upland habitats, representing one of the largest floodplains along the entire estuary (approximately 750 ac). Several historic islands are now joined by dredge deposits to the wide original floodplain, forming a large low-lying swath of land that abuts a steep bluff. Almost the entirety of these low-lying areas, including the man-made land, are within the reach of tidal influence projected for the 21st century. Thus this area has the potential to transform into one of the four largest tidal wetland areas on the Hudson.

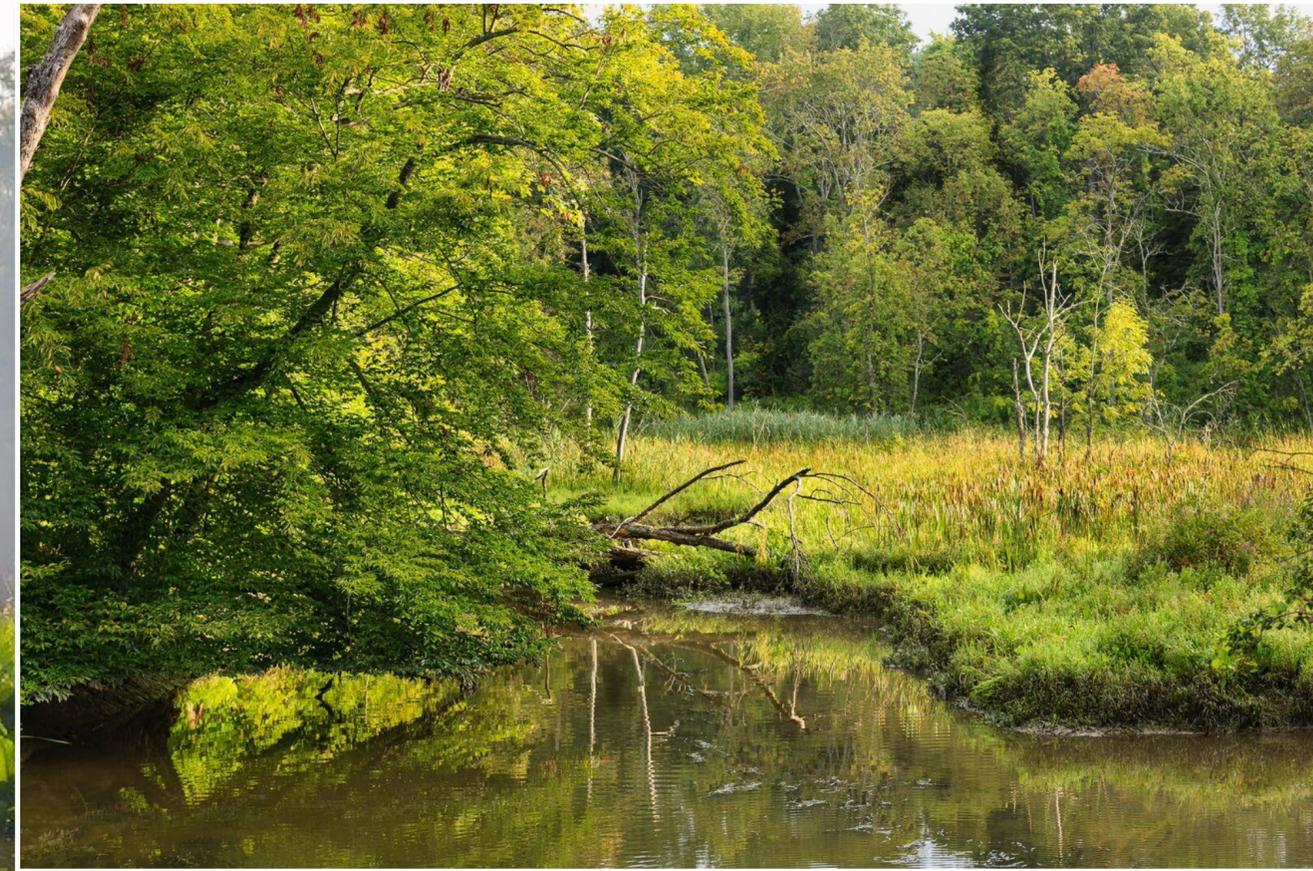


The Binnen Kill area encompasses an important complex of tidal wetland and upland habitats, representing one of the largest floodplains along the entire estuary (approximately 750 ac). Several historic islands are now joined by dredge deposits to the wide original floodplain, forming a large low-lying swath of land that abuts a steep bluff. Almost the entirety of these low-lying areas, including the man-made land, are within the reach of tidal influence projected for the 21st century. Thus this area has the potential to transform into one of the four largest tidal wetland areas on the Hudson.



# TIDAL WETLANDS: VALUES AND FUNCTIONS

- Highly productive
- Biologically diverse
- Fish and Wildlife habitat
- Ecosystem services
- Recreational & economic resource



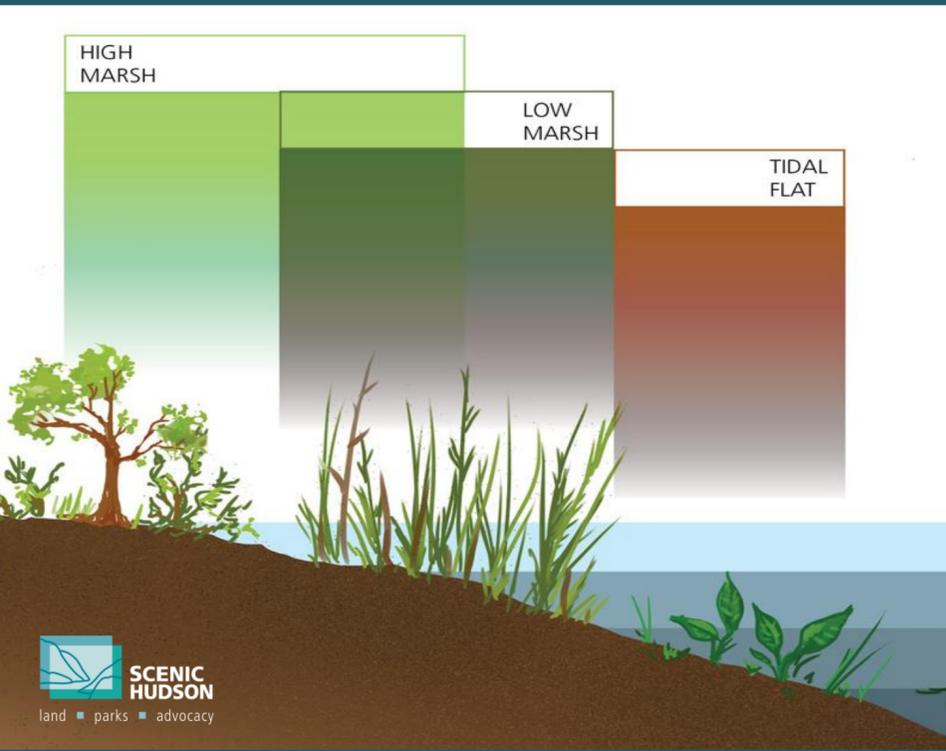
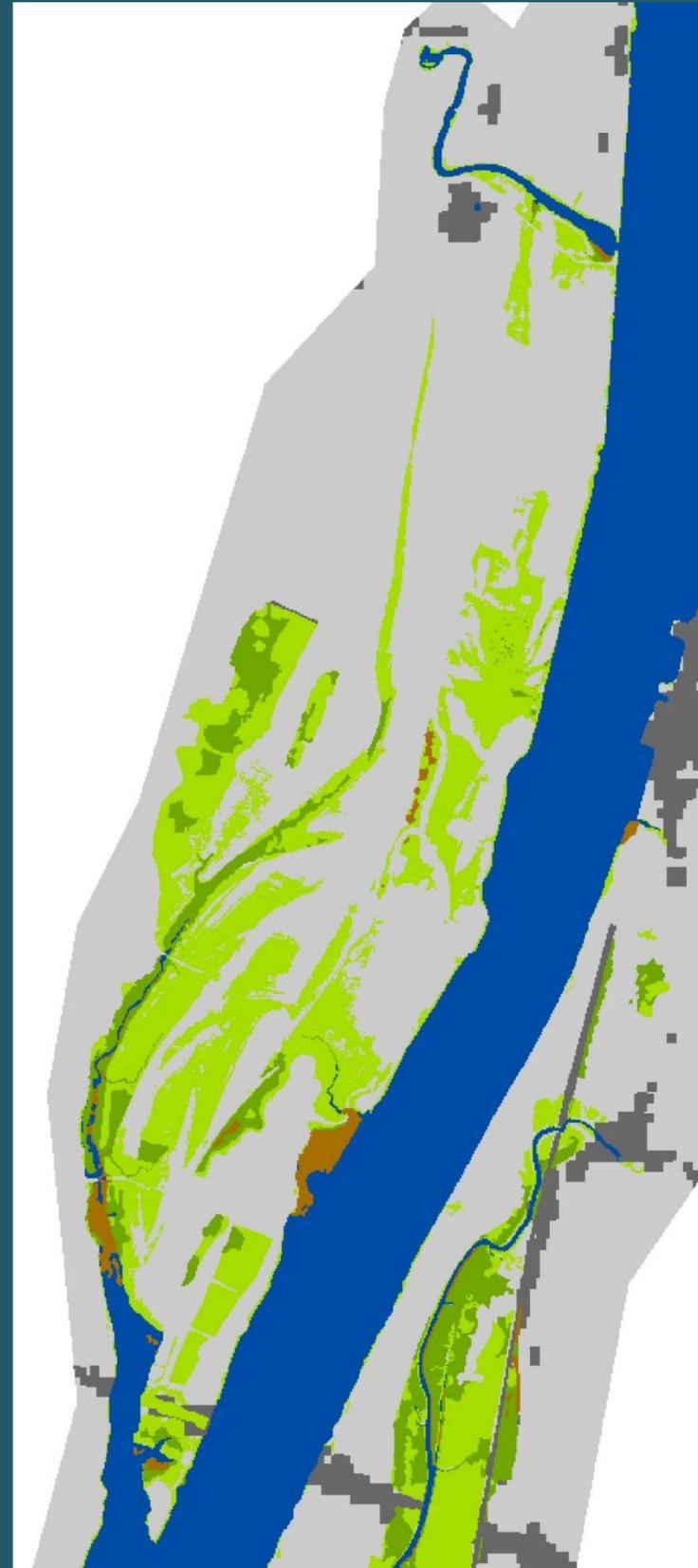
# TIDAL WETLAND PROJECTIONS AT BINNEN KILL

- High Marsh
- Low Marsh
- Tidal Flat
- Open Water

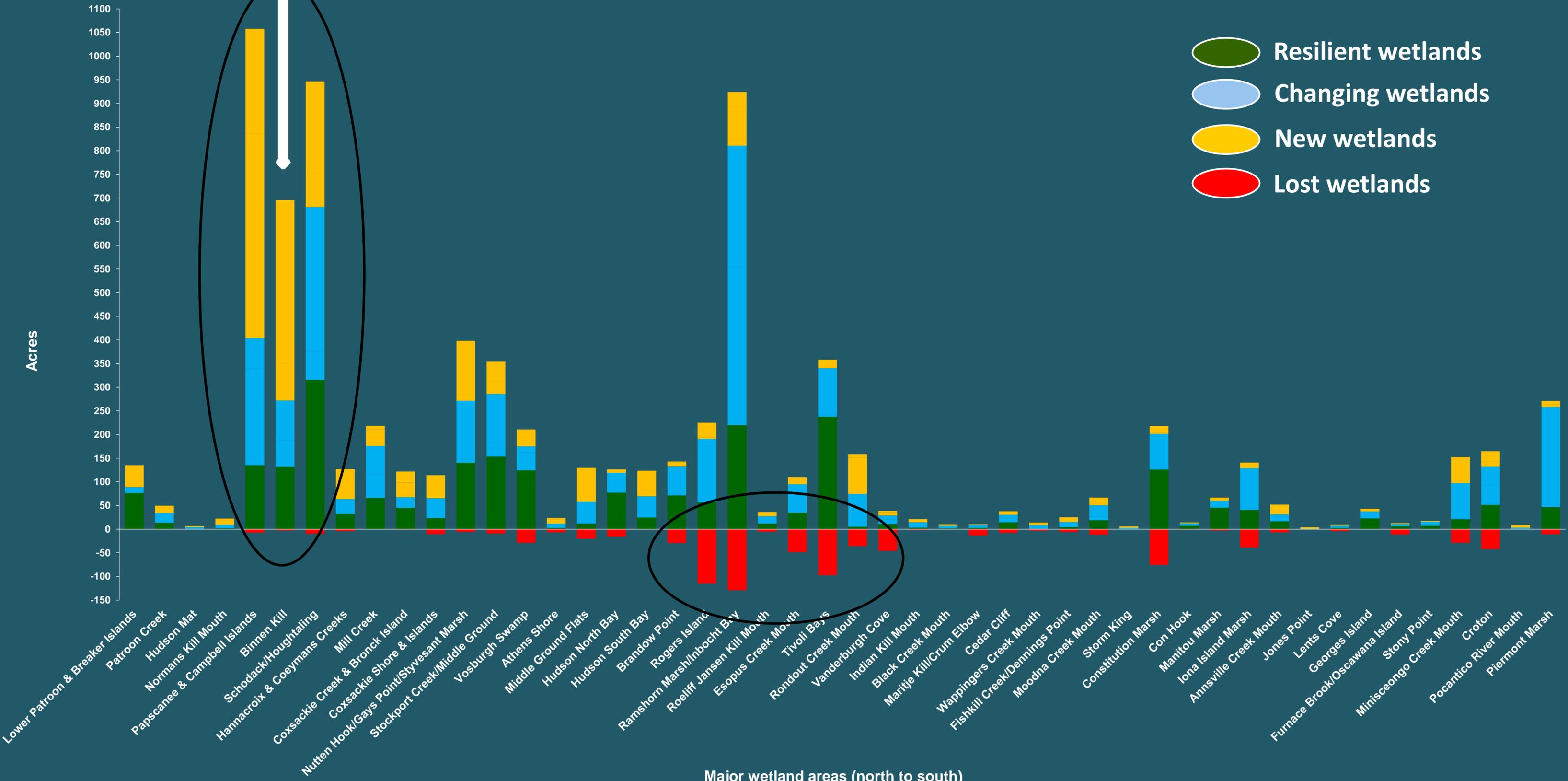
2007

2060

2100

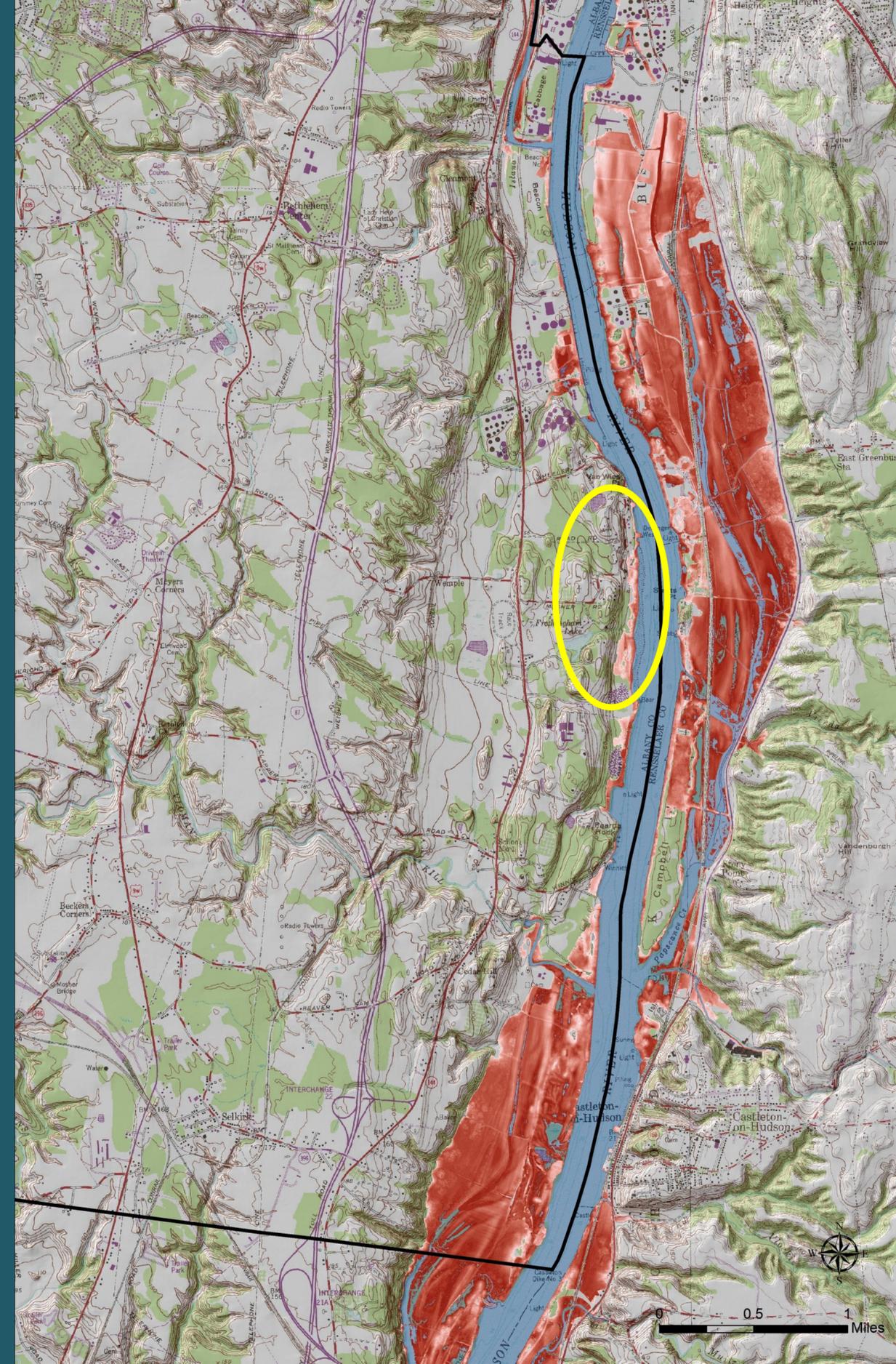
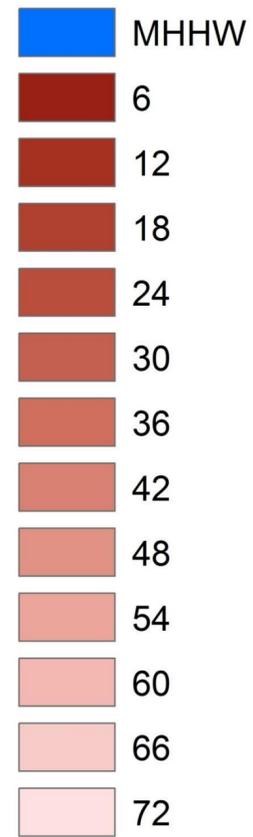


# PROJECTED WETLAND CHANGES

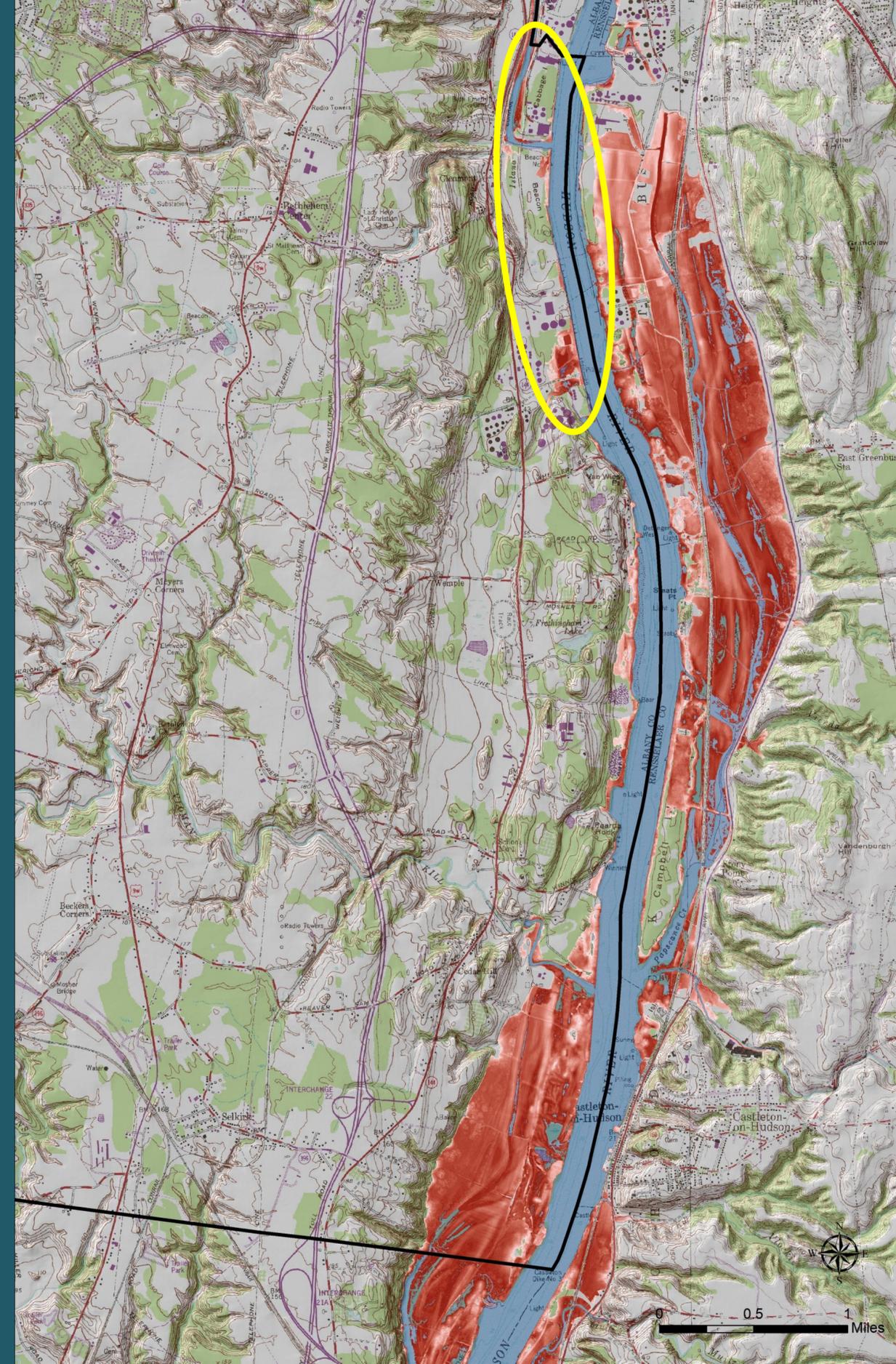
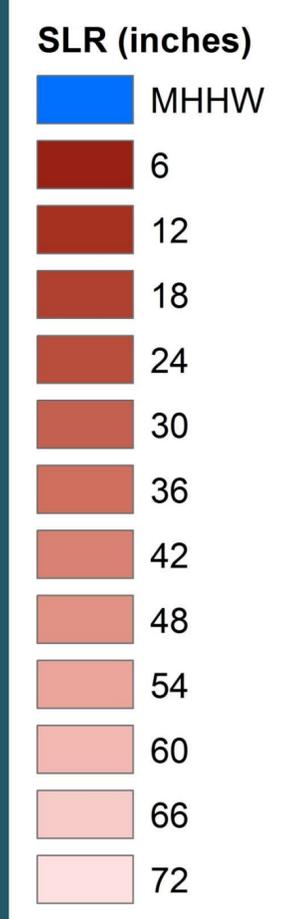


# SEA LEVEL RISE IN BETHLEHEM

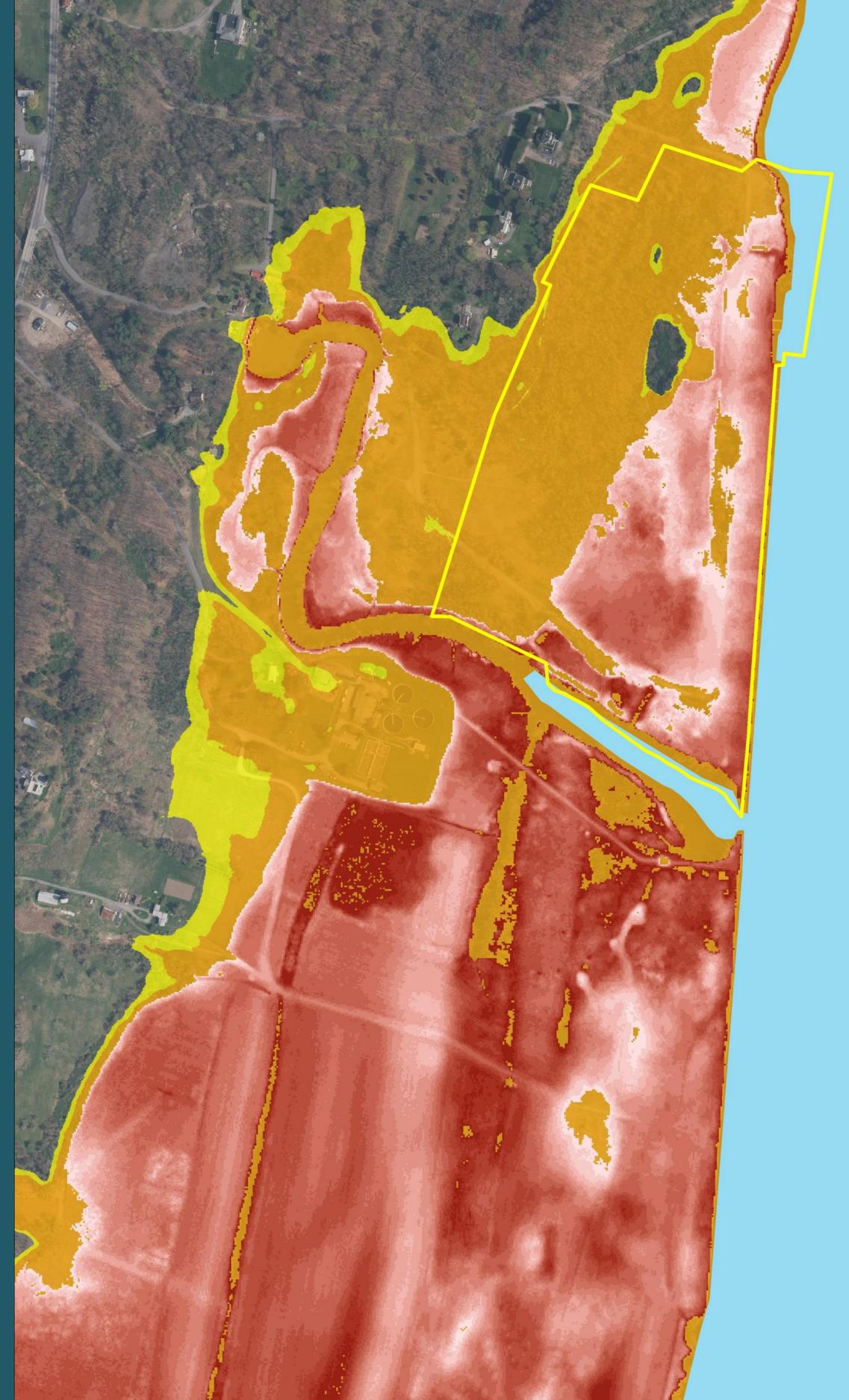
SLR (inches)



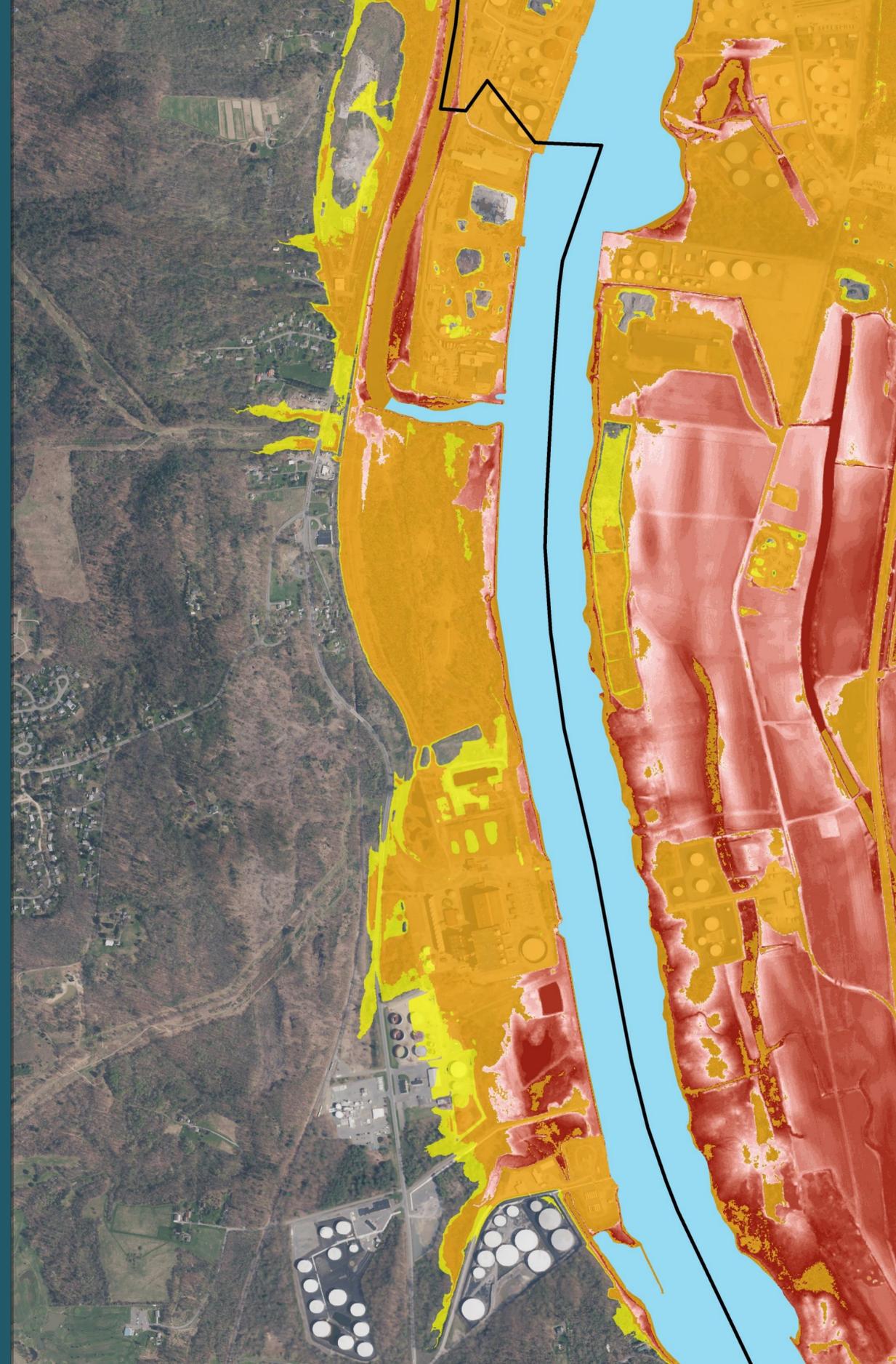
# SEA LEVEL RISE IN BETHLEHEM



# HENRY HUDSON PARK: EXAMPLE OF FLOODPLAIN VS INUNDATION



# INDUSTRIAL ZONE: EXAMPLE OF FLOODPLAIN VS INUNDATION



# PLANNING FOR COASTAL RESILIENCE



# PROTECT

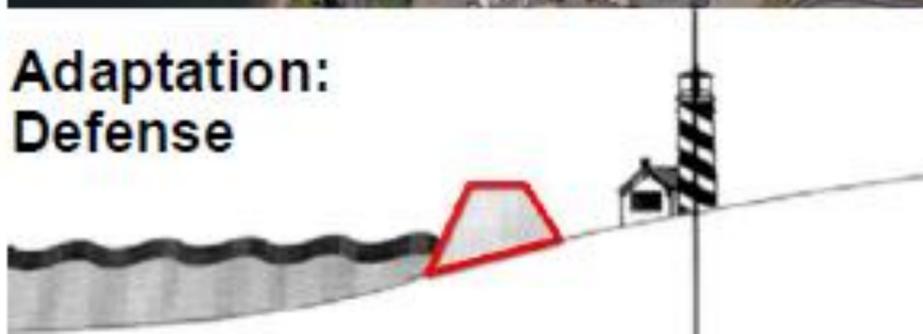
# ACCOMMODATE

# RELOCATE

Coastal defense: Solutions that protect existing critical infrastructure - including sea walls, rip rap, levies and hardened shorelines



Adaptation:  
Defense



Strategic accommodation: Solutions that permit flooding - including raised infrastructure, adaptive design strategies and compatible land uses



Adaptation:  
Accommodate



Managed relocation: Solutions that allow for inundation and flooding while promoting the migration of tidal wetlands and other important natural resources



Adaptation:  
Relocate



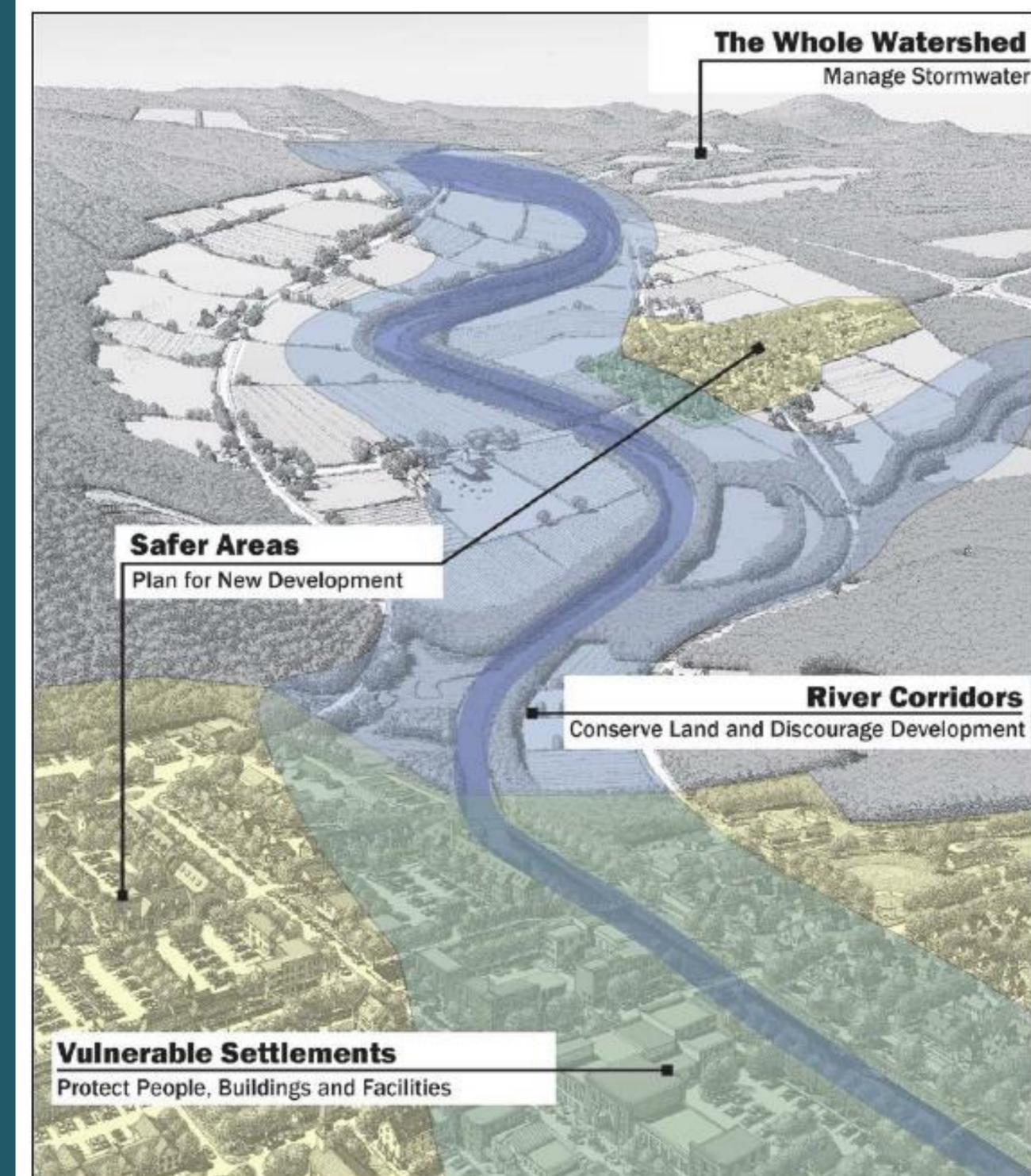
# INCREASING COASTAL RESILIENCE: PLANNING APPROACHES

## Categories of Approaches

Approaches are categorized based on the six management measures identified by the State with an additional category for approaches that increase overall systemic resilience

Management measure	Description	Sub-category within management measure	Impact
1. <b>Conserve, enhance, restore natural protective features</b>	Use the landscape to promote safety and livability by preserving and expanding natural protective features for their capacity to reduce hazardous impacts and increase capacity to absorb impacts	<ul style="list-style-type: none"> <li>Beach protection</li> <li>Wetland restoration</li> <li>Vegetation use and management</li> <li>River protection</li> </ul>	↑ ↓
2. <b>Resilient construction</b>	Use construction techniques and technologies to provide an enhanced level of safety for structures and occupants	<ul style="list-style-type: none"> <li>Elevation, change in design, inputs, etc., for:                             <ul style="list-style-type: none"> <li>Homes</li> <li>Infrastructure</li> </ul> </li> <li>Use of standards to regulate construction</li> </ul>	↑
3. <b>Structural defenses</b>	Use structural defenses (engineered or non-engineered) to resist hazardous impacts by reducing or eliminating exposure to the hazard	<ul style="list-style-type: none"> <li>Engineered defenses (e.g., levees, storm surge barriers, sea gates, floodwalls, revetments)</li> <li>Natural defenses (e.g., barrier islands and reefs, dunes)</li> </ul>	↓
4. <b>Land use planning and regulation</b>	Use land use management approaches to reduce exposure to hazards by removing assets and increase resilience through regulatory requirements	<ul style="list-style-type: none"> <li>Development rights</li> <li>Zoning</li> <li>Development activities (e.g., Greenbelts)</li> <li>Relocation of assets and infrastructure</li> </ul>	↑ ↓
5. <b>Market-based methods</b>	Use market-based methods (e.g., taxes, subsidies) as incentives to promote and encourage activities that increase resilience and reduce vulnerability	<ul style="list-style-type: none"> <li>Incentives – taxes, fees, subsidies</li> <li>Buyout of assets or infrastructure in exposed areas</li> <li>Insurance programs</li> </ul>	↑ ↓
6. <b>Awareness, information and preparedness</b>	Use education and outreach to better prepare citizens and businesses on potential risks, emergency responses, community preparedness, etc.	<ul style="list-style-type: none"> <li>Education and training</li> <li>Community preparedness</li> <li>Emergency-response systems and capabilities</li> <li>Vulnerable populations</li> </ul>	↑ ↓
7. <b>Systemic resilience</b>	Use methods that increase the overall strength of the community and supporting systems by lowering the extent of damage a single event has and increasing the ability to respond	<ul style="list-style-type: none"> <li>Redundancies and backups</li> <li>Information to enable learning and foresight</li> </ul>	↑ ↓

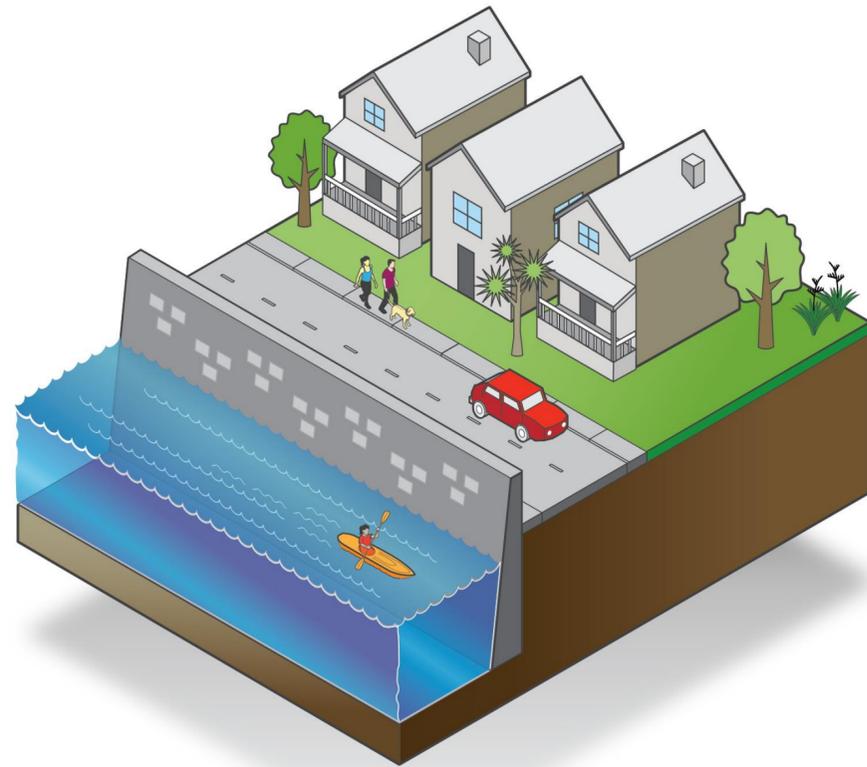
↑ Increase resilience ↓ Reduce vulnerability



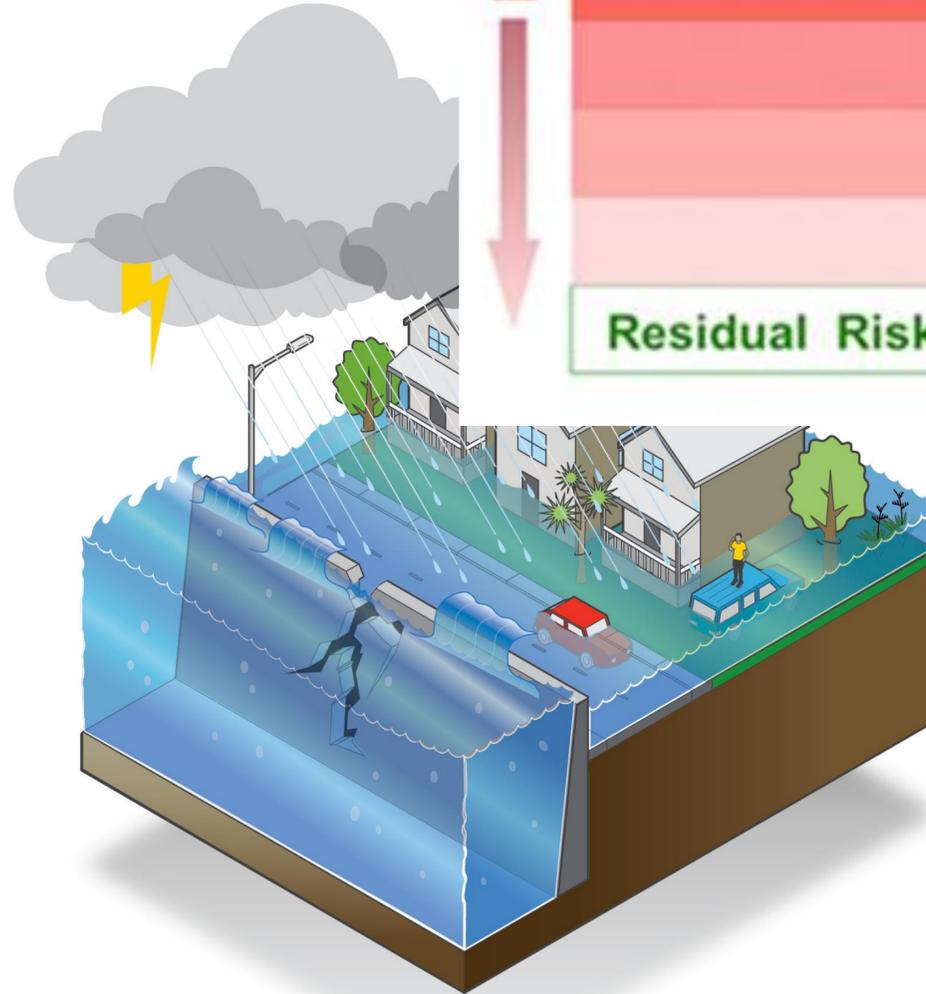
# RESIDUAL RISK

## Residual risk

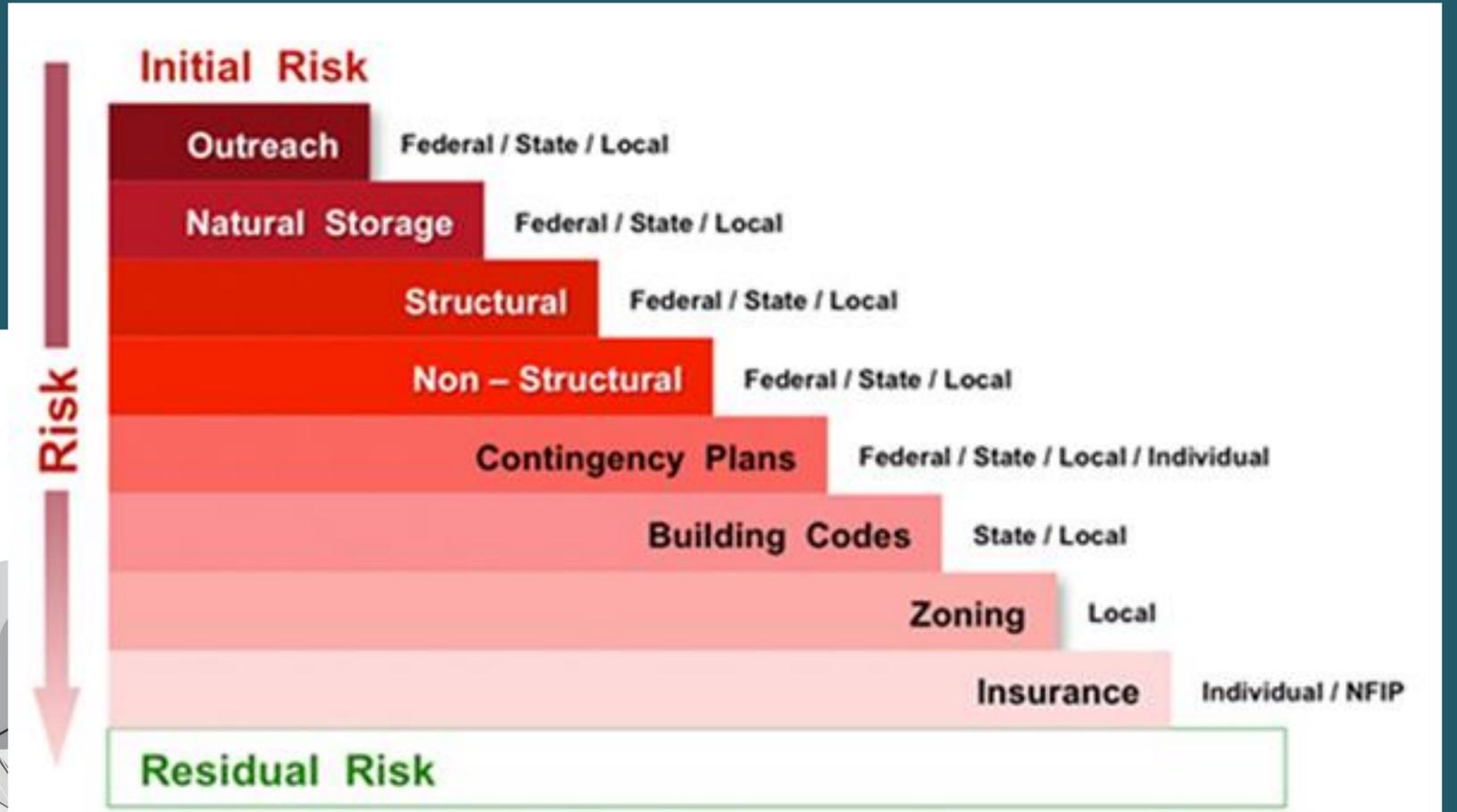
Residual risk is the risk that remains after risk treatment has been applied to reduce the potential consequences.



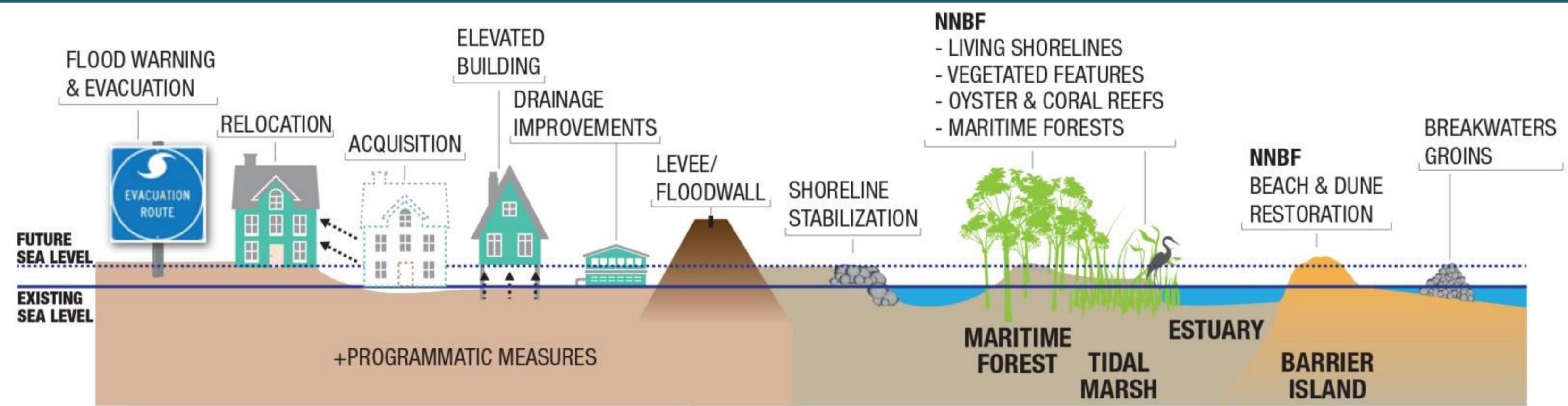
**A** Seawall typically provides protection against a 1:50 year storm event for which it was designed for.



**B** Seawall cannot protect against a less frequent but higher magnitude 1:100 year storm event.



# REDUCING RISK: REDUNDANT MEASURES



# RISK TOLERANCE: SELECTING PLANNING APPROACH



	Low	Low-Medium	Medium	High-Medium	High
2020s	1	3	5	7	9
2050s	5	9	14	19	27
2080s	10	14	25	36	54
2100	11	18	32	46	71



	Conditions Better	Conditions Worse
Plan for Better	SAFE	UNSAFE
Plan for Worse	SAFE But overinvest	SAFE

# COMMUNITY RISK & RESILIENCY ACT (CRRA):

Sea level rise, storm surge, & flooding

- State SLR projections
- Facility siting, permitting, funding
- Smart Growth Public Infrastructure Policy Act criteria
- Model local laws
- Guidance on natural resiliency measures

**LWRP**



# COMMUNITY RISK & RESILIENCY ACT (CRRA): Sea level rise, storm surge, & flooding

## Guidance on Natural Resiliency Measures

- Wetlands (tidal and non-tidal)
- Floodplains
- Shorelines/Banks
- Channels and inlets
- Nearshore area/riparian buffer
- Forests
- Stormwater green infrastructure



# COMMUNITY RISK & RESILIENCY ACT (CRRA)

- Conserve and restore natural features
- Use nature-based features in built environments

## Hudson River Sustainable Shorelines



*The Hudson River Sustainable Shorelines Project aims to develop science-based recommendations for shore zone management to enhance natural benefits while meeting protection needs.*

# COMMUNITY RISK & RESILIENCY ACT (CRRA)

- Conserve and restore natural features
- Use nature-based features in built environments

## case study: Esopus Meadows



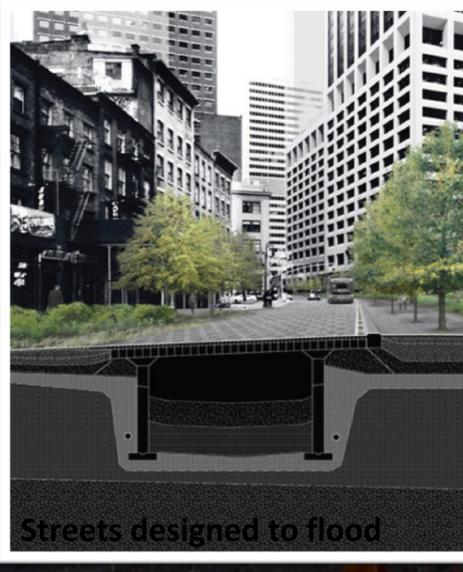
*before*



*after*

A degrading bulkhead was replaced with softer stabilizing alternatives that still provide shoreline protection. A stone toe was placed at the high tide line and soft gabions positioned above it help hold the soil in place.

# RESILIENT WATERFRONT DESIGN



# PLANNING FOR COASTAL RESILIENCE

## Bethlehem LWRP

- Inventory/analysis
- Promoting specific uses
- Reviewing policies
- Proposing projects
- Public engagement

# PLANNING FOR COASTAL RESILIENCE



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