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Leveraging nature and understanding potential threats to water quality and migrating organisms

Philip Orton

Research Associate Professor

Stevens Institute of Technology

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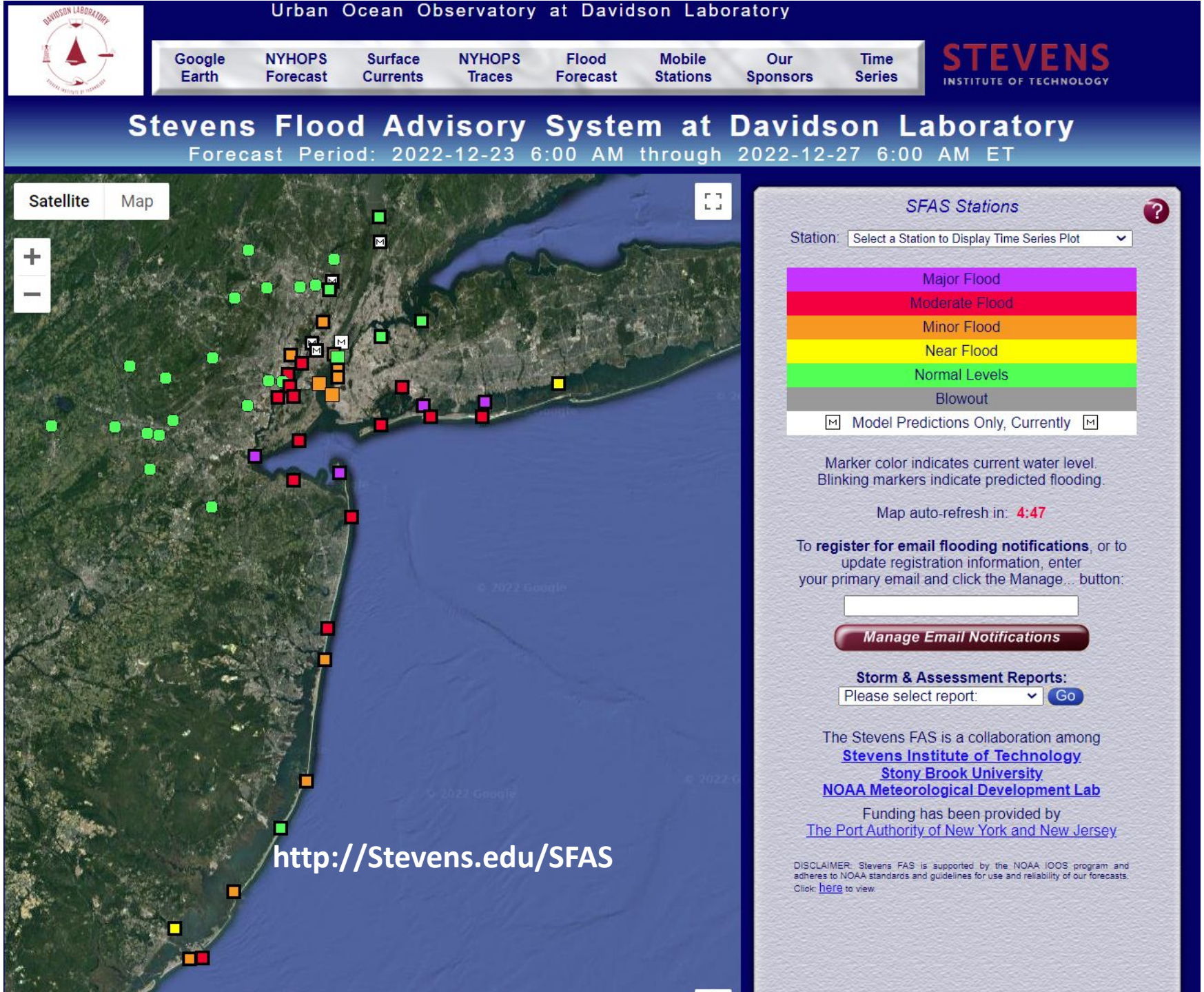
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Stevens Flood Advisory System at Davidson Laboratory
Forecast Period: 2022-12-23 6:00 AM through 2022-12-27 6:00 AM ET
Satellite
Map
http://Stevens.edu/SFAS
SFAS Stations
Station: Select a Station to Display Time Series Plot
Major Flood
Moderate Flood
Minor Flood
Near Flood
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Marker color indicates current water level.
Blinking markers indicate predicted flooding.
Map auto-refresh in: 4:47
To register for email flooding notifications, or to update registration information, enter your primary email and click the Manage... button:
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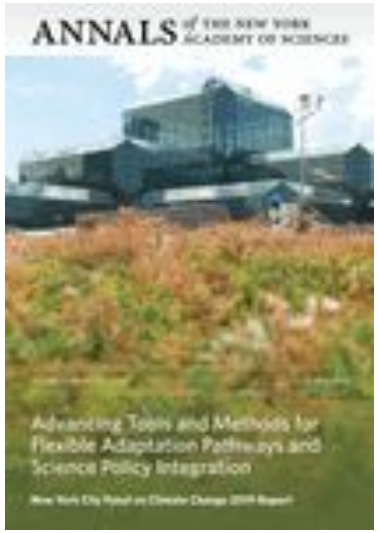


Advancing Tools and Methods for Flexible Adaptation Pathways and Science Policy Integration:
New York City Panel on Climate Change 2019 Report

Member for 2013, 2015, 2019, and upcoming 2023/2024 Reports

Topics: Understanding and Assessing HATS

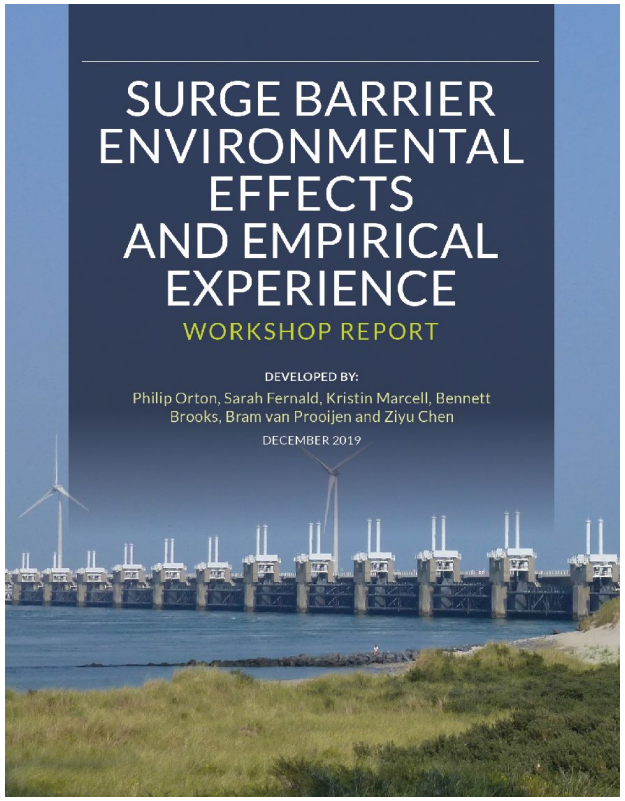
- Water quality effects
- Migrating organism effects
- Opportunities for leveraging nature to reduce coastal flooding

Community and Scientist Engagement

1) **Project scoping workshop and final future scoping workshop included 30-40 attendees**

2) **Surge Barrier Environmental Effects and Empirical Experience Workshop**

- The workshop was attended by 30+ researchers (US, UK, Netherlands) and PAC members
- These topics were
  - (1) empirical experience from constructed gated storm surge barriers,
  - (2) potential surge barrier effects on migrating organisms, and
  - (3) potential surge barrier effects on tidal wetlands.



Consensus Science – Setting a Research Agenda

Increased Utilization of Storm Surge Barriers:
A Research Agenda on Estuary Impacts

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Invite pe
response

Water Quality
e.g. oxygenation, algal blooms, pathogens

What are the water quality risks?

How will CSOs be dealt with?

- 2022 Report section “6. EFFECTS AND CONSEQUENCES OF THE ALTERNATIVE PLANS”
  - Impacts to dissolved oxygen (DO) are anticipated to have an impact rating of low to moderate impact
  - Impacts to turbidity are anticipated to have an impact rating of low to moderate impact
- Physical obstruction to flows when barriers are open is being minimized through plentiful gated areas
- Closures cause temporary prevention of flushing of pollutants
  - Accompanying storm-driven rainfall can lead to CSOs and high pathogen concentrations
  - Assessment of water levels trapped behind closed barriers suggests no increase in flooding (e.g. Chen et al. 2020)
- More detailed modeling of these topics by USACE is likely planned for next phase of study

Pollution and Public Health

… public health effects of closing gates in areas that have contaminated fill and adjacent superfund sites?

Clarify public health risks of flooding by polluted waters

- All potential pollution risks from surge barriers or seawalls must be contrasted against risk from flooding
  - Sandy flooding demonstrated how these contaminants can be introduced into homes and neighborhoods
- Small-scale surge barriers on Newtown Creek or Gowanus may need pumps behind them to handle polluted rainfall run off
- One important concern with the surge barriers is erosion in areas near the barriers, which could lead to remobilization of contaminated sediments

Ecological Impacts

How will ecological biodiversity and habitat connectivity be addressed through this project?

Open gate areas have up to 2x stronger currents – effects on migrating organisms are an important concern

Preliminary Illustration of Jamaica Bay Surge Barrier

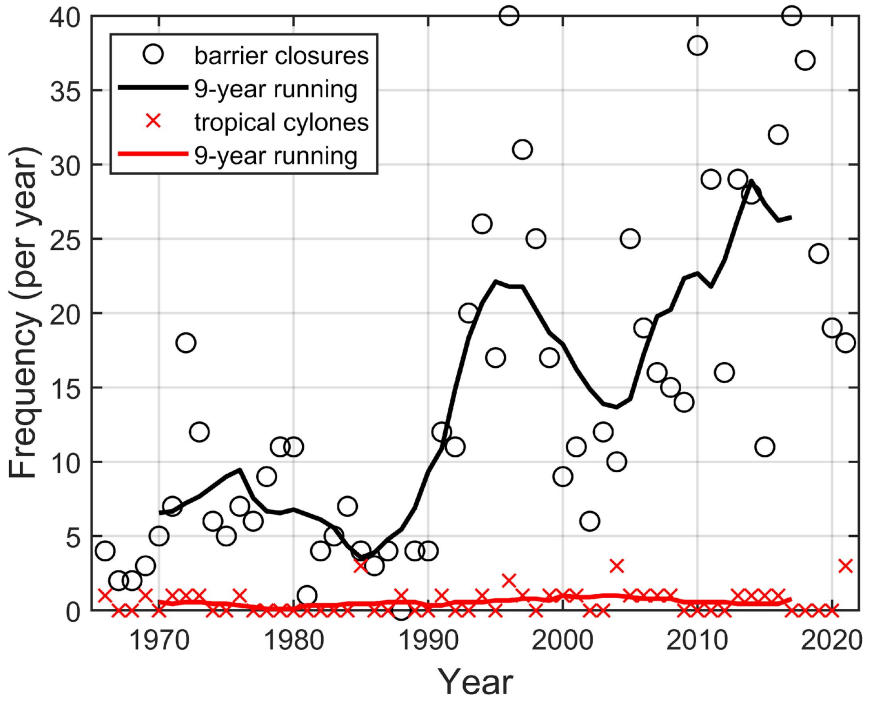
HATS 2022 Report: "Modeling of the potential impacts to migratory patterns from storm surge barriers and other structures may occur during the Tier 2 EIS(s)."

Fundamental Problem – Barriers may be Overused

- Impacts on the physical environment, water quality and ecology all grow with increasing closure frequency
- Where a barrier is built, there will be future decisions between
  - Protecting property by closing the barrier frequently (e.g. monthly)
  - Raising neighborhoods or using non-structural measures to address chronic flooding

New Bedford Hurricane Barrier, Massachusetts

Orton et al. submitted to *Earth's Future*



Leveraging Nature

“Multi-benefit solutions with natural or nature-based features are preferred.” – Government agency workshops from 2017 (HATS 2019 report)

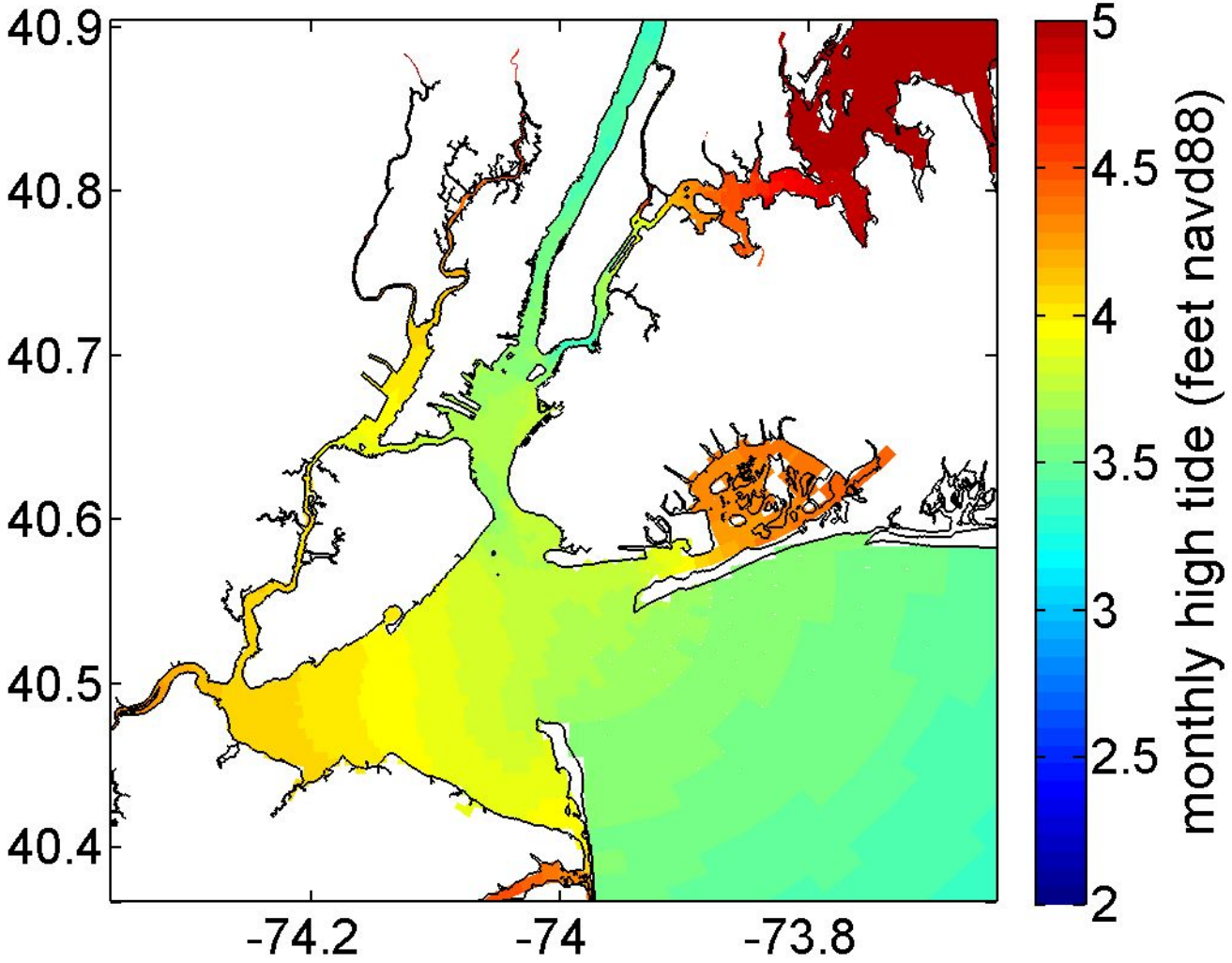
"Can we use nature-based infrastructure in dense areas like Manhattan to withstand storm surge?"

Can we use nature-based solutions (NBS) in dense areas like Manhattan to withstand storm surge?

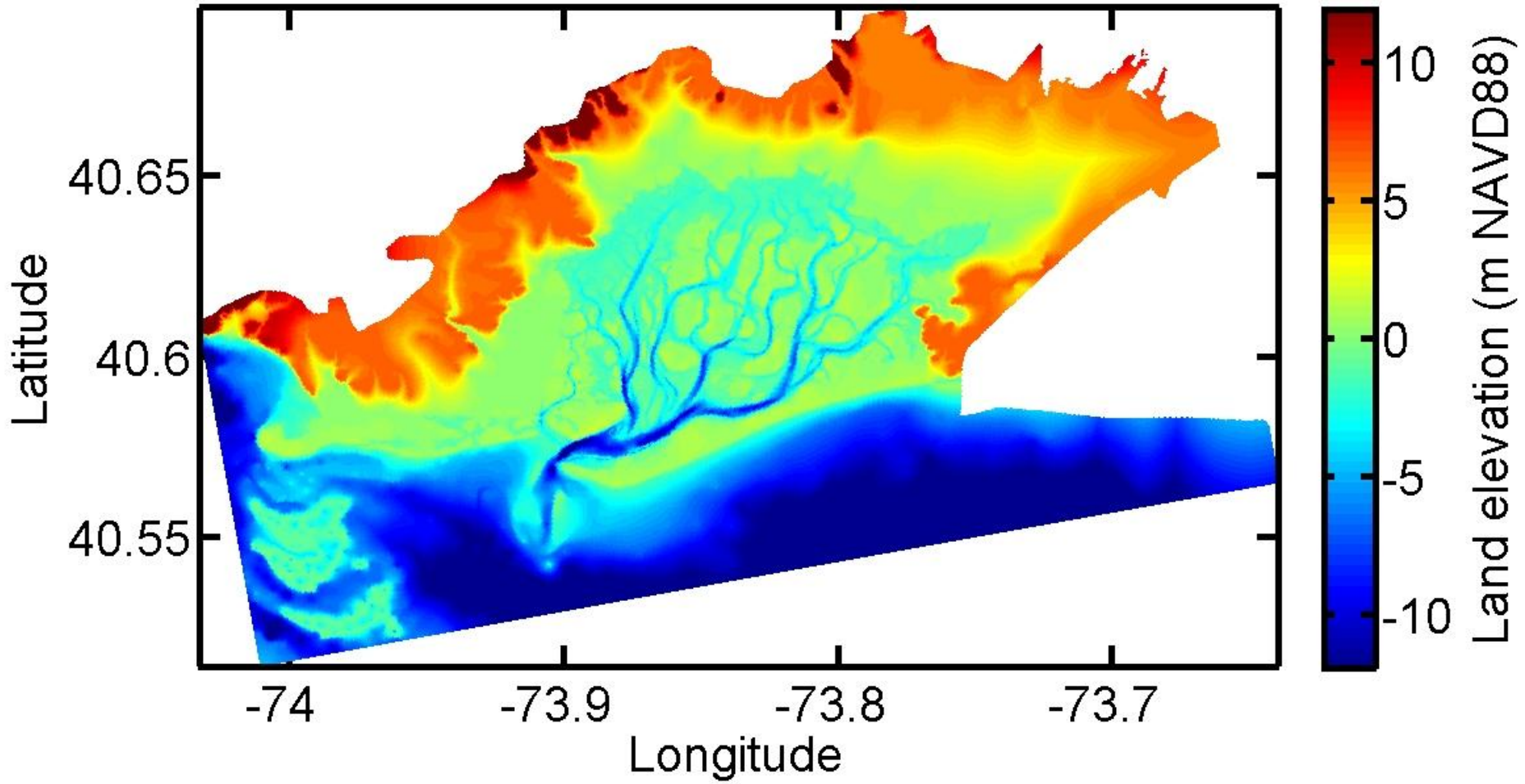
- A limited set of widely-known nature-based features was considered by the USACE and none were expected significantly reduce storm surge
- Features like vegetation and oysters cause frictional drag to reduce storm surge, requiring large swaths of area – tens of kilometers
- The two areas where this may be feasible are Jamaica Bay and the Meadowlands (both gated in TSP)
- A novel estuary-scale NBS of sedimentary restoration is gaining attention as a possible solution for urbanized estuaries like Jamaica Bay
  - SIRR Study modeling (A Stronger More Resilient New York, 2013) by Arcadis, Orton et al.
  - Rebuild By Design modeling
  - Orton et al. (2015) paper on channel shallowing as mitigation of storm tides
  - National Science Foundation – funded collaborative work (2019-2023)
  - Orton et al. (2020), Pareja-Roman et al. (2023)

Why Do Areas Around Jamaica Bay Flood So Often?

- Low-lying neighborhoods
- Sea level rise
- Tide/flood amplification

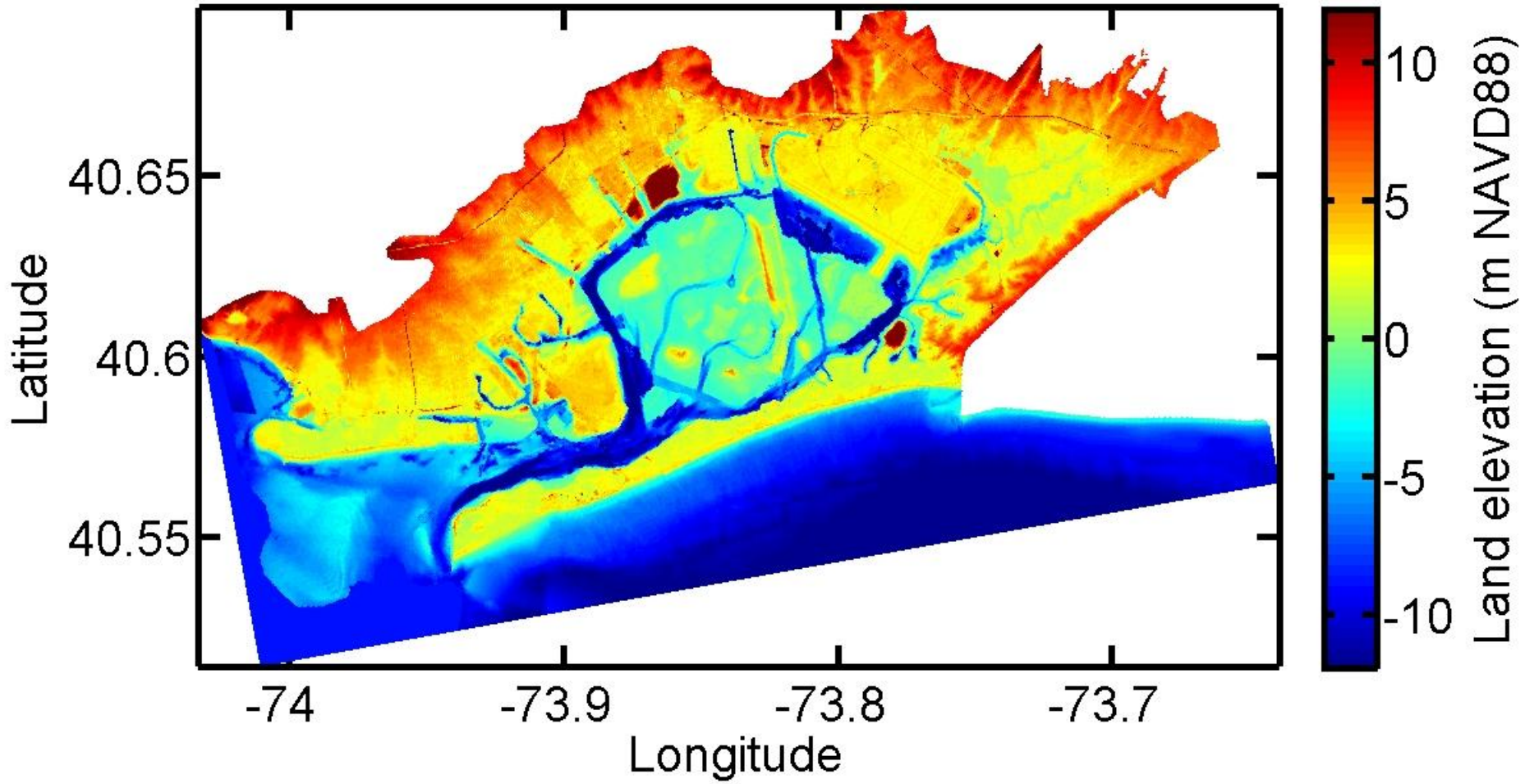


Jamaica Bay 1870s Land Elevation



Orton et al. 2020, *Natural Hazards and Earth System Science*

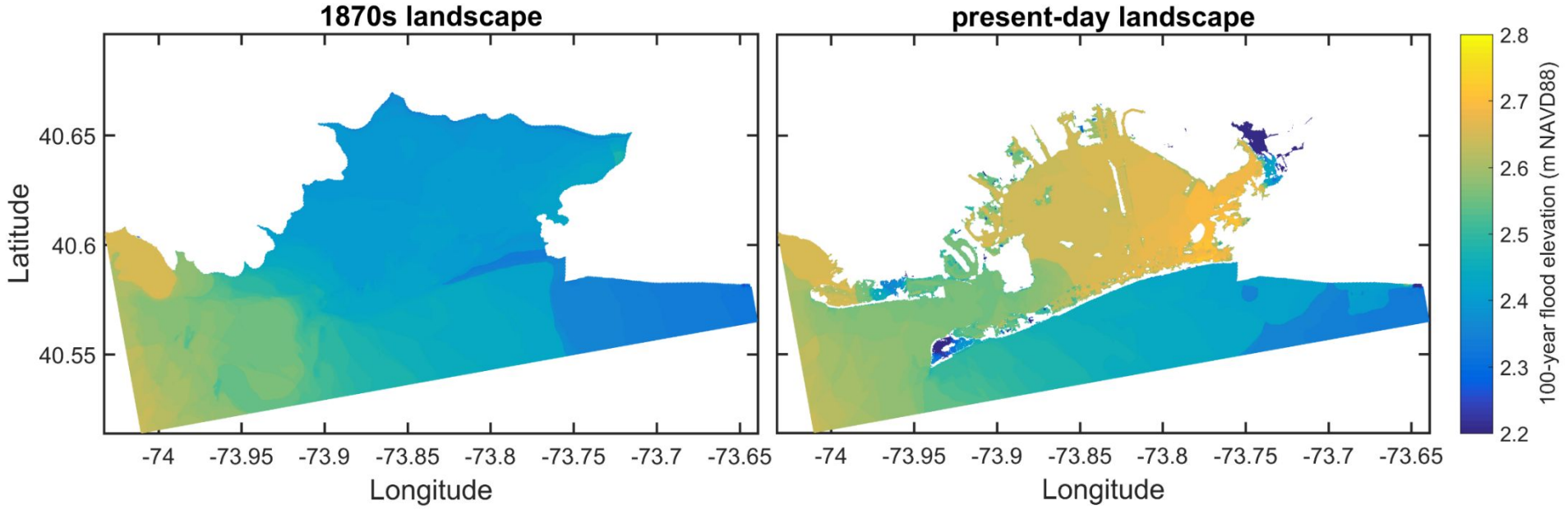
Jamaica Bay 2015 Land Elevation



Orton et al. 2020, *Natural Hazards and Earth System Science*

Extreme event flood risk has risen more due to landscape change than due to global sea level rise

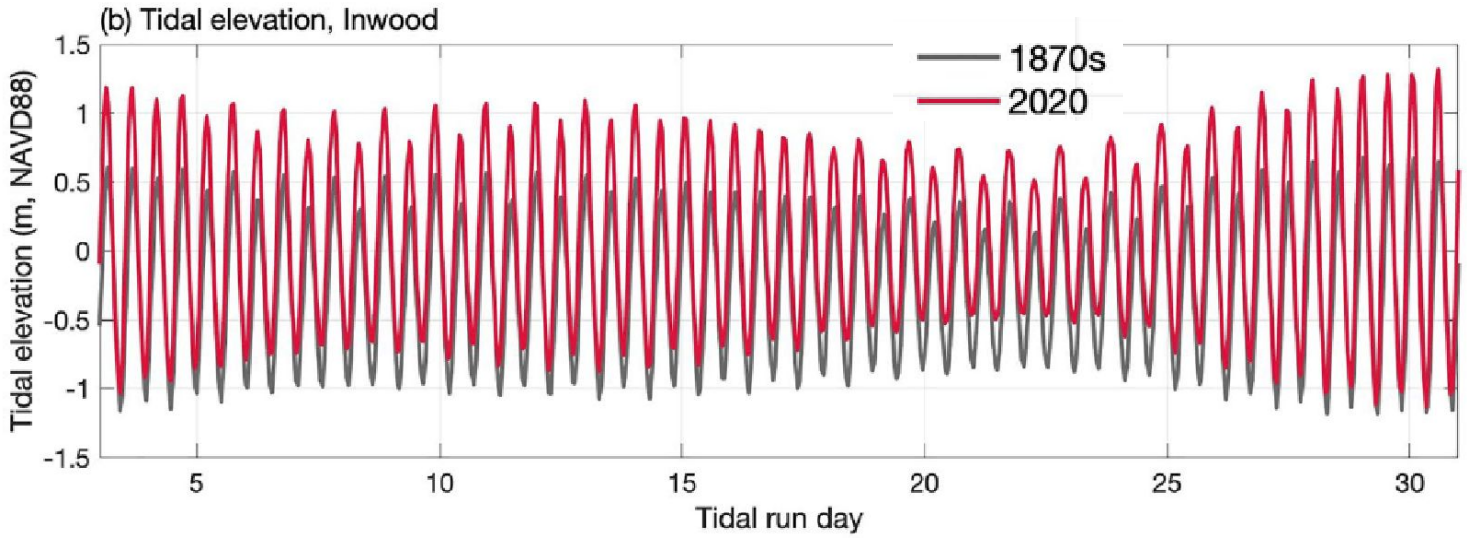
100-year storm tide (m) on present-day mean sea level



Orton et al., 2020, *Natural Hazards and Earth System Sciences,* Key Points:

- Total marsh habitat declined from 61 to 15 km^2 and intertidal unvegetated habitat area from 17 to 4.6 km^2.
- The landscape changes caused an increase of 0.28m (12%) in the 100-year storm tide, even larger than the influence of global sea level rise of about 0.23m since the 1870s.

High-tide flooding in Jamaica Bay is as much a result of landscape change as sea level rise



Li et al. 2021, *Science Advances*:

Changing tides, usually due to estuary urbanization practices such as dredging and landfill, have increased US nuisance flooding by about 20% (the net increase for 40 stations).

Pareja-Roman et al. (2023) *Journal of Geophysical Research*:

- Landscape change since 1870s (e.g. dredging, land filling) increased tidal range by 20%
- Of 15 minor floods in 2020, there would only have been without historical landscape change, or 1 without historical local sea level rise”

Adaptations Developed Collaboratively in 2015 Have Never been Studied by the USACE

Introduction to AdaptMap - Flood, sea level rise, and adaptation mapper for Jamaica Bay, NYC

Launch AdaptMap

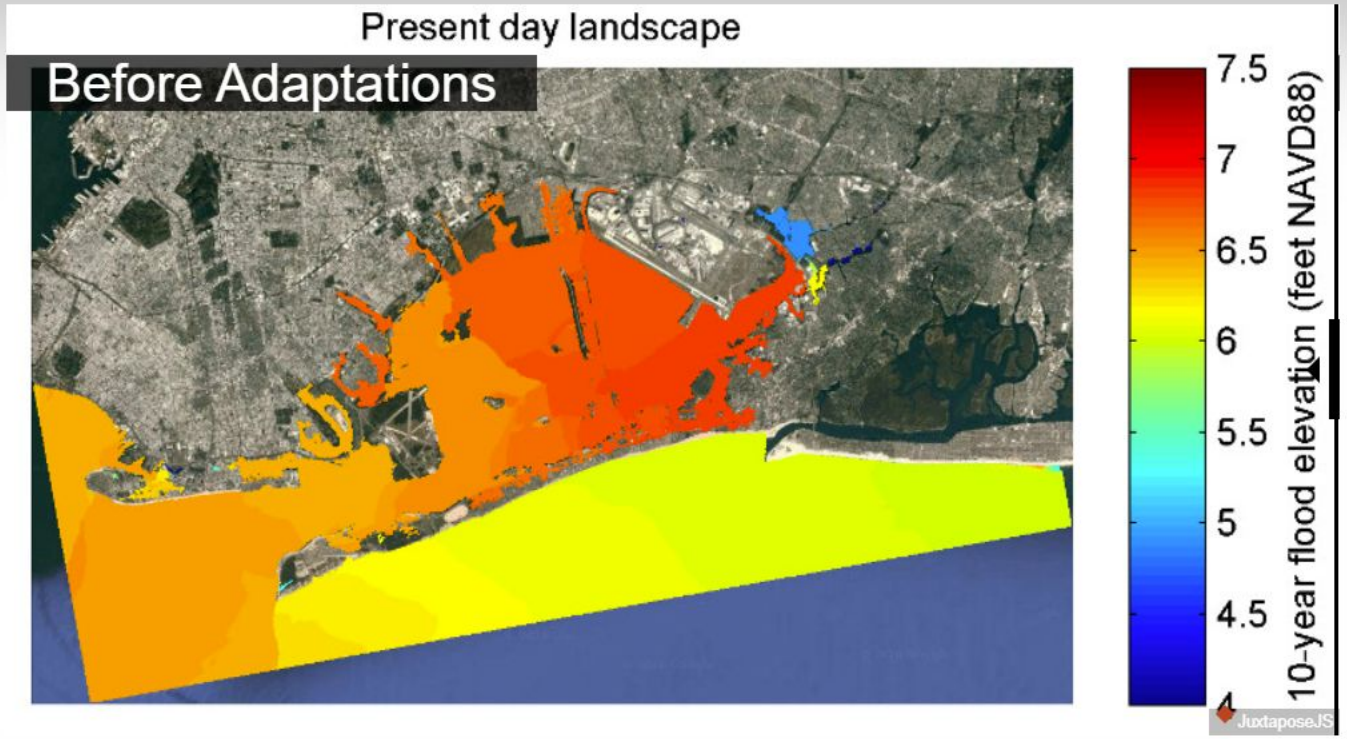
About AdaptMap | The Bay - Then and Now | Flooding - Then and Now | Nature Based Adaptation | History of Jamaica Bay | How to use AdaptMap

Our flood adaptation scenarios aim to reverse the extreme historical over-dredging and widening of channels in the bay by slightly shallowing the bay and narrowing the inlet.

The narrowed and/or shallower channels constrict the flow of water entering Jamaica Bay during a coastal storm.

This map and slider bar shows a demonstration of the influence of our adaptation scenario #2 on the 10-year flood elevation. On the left is a map of the flood area, shaded to represent flood elevation. On the right is a map of the smaller flood area and elevation with the bay shallowing and narrowing.

The new maximum bay depth with the shallowing is 20 feet below low tide, so would not interfere with shipping. Also, addition of sand to the bay may help ecosystems and wetlands (See our project's Technical Report for more details).



"Channel Repair" Bay Modifications

- Deep inlet and channels shallowed to 20 ft depth
- Narrowed inlet

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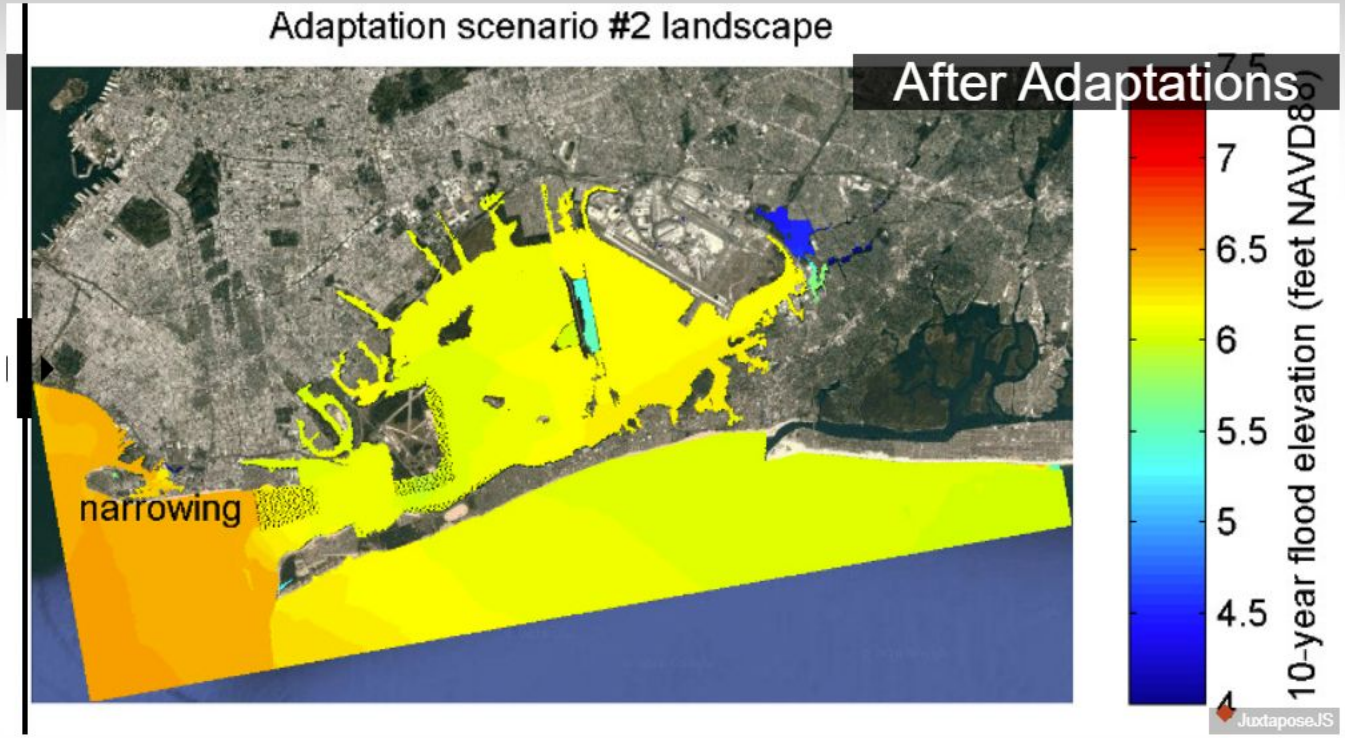
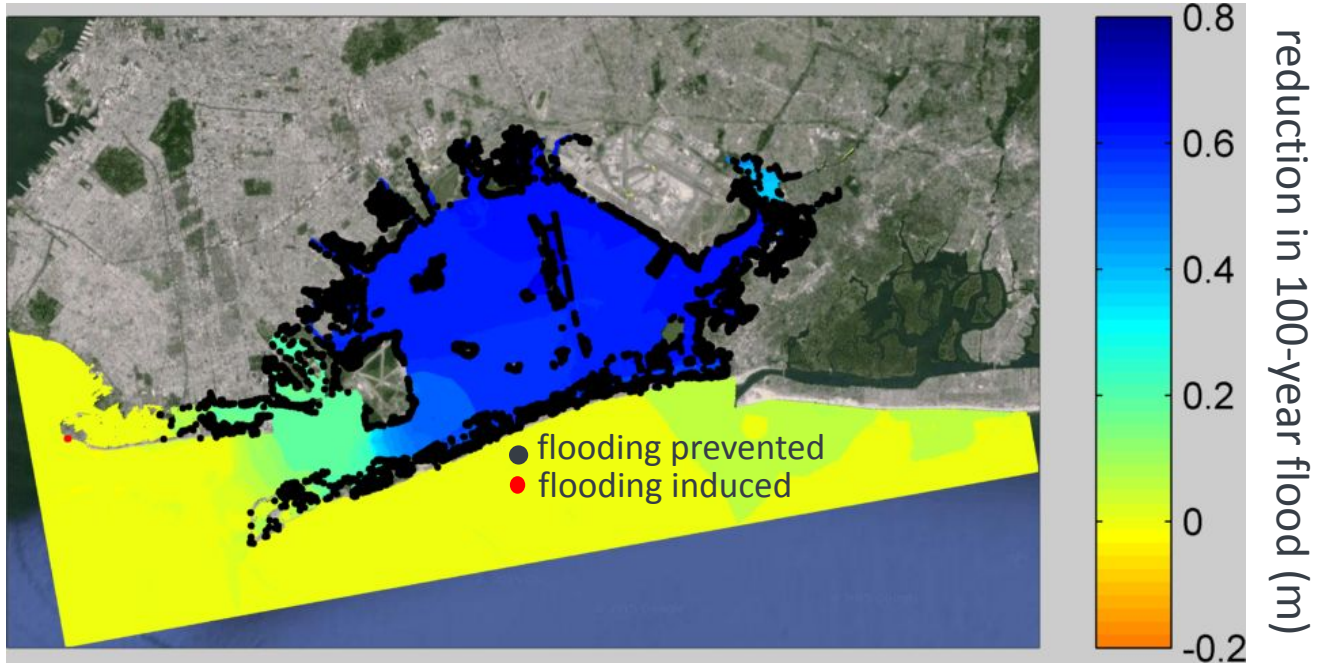


"Channel Repair" Bay Modifications

- Deep inlet and channels shallowed to 20 ft depth
- Narrowed inlet

Results: "Shallows Restoration" (6-12 foot deep channels)

- Relative to a future without action, the upland flood area for a 100-year storm at 2055 is reduced by 49%
- Reduces flood levels in the bay by 50-65 cm (~2 feet)
- Causes **no flood reflection nor induced flooding** (sharp contrast with surge barriers)



Challenges and Benefits of Sedimentary Restoration

- Challenges to estuary-scale nature-based solutions in Jamaica Bay
  - Concerns about polluted sediments being dumped, or borrow pit pollutants reintroduced
  - Any reduction in deepwater habitat (potentially important to striped bass)
  - The speed of modification of benthic habitat, harming benthic organisms
  - Availability of clean sediments of the volume needed (10s of millions of cubic yards)
- Potential benefits (apart from flood risk reduction)
  - Flood risk reduction that doesn't reflect floods out to other locations
  - A self-sustaining natural sediment-marsh system
  - Water quality improvement – our preliminary research showed large reduction in hypoxic area
  - Increased intertidal habitat, which has mostly disappeared from NY/NJ Harbor
  - Avoidance of temporary solutions to long-term problems like sea level rise

Conclusions

- **Water quality impacts** of the HATS TSP are predicted to be low to moderate, but will be further studied
- **Impacts on marine organisms** are poorly understood and are still being quantified
- Impacts of surge barriers generally scale with the frequency of closure
  - Sea level rise will eventually cause rising chronic flooding, which will need to be addressed and could cause overuse of barrier closures
- **Nature-Based Solutions** under HATS:
  - A limited set of widely-known NBS was considered and none were expected to significantly reduce storm surge
  - NBS will later be planned and evaluated for reducing small chronic floods (residual risk) and other co-benefits
- Many stakeholders and residents prefer to see an exhaustive evaluation of NBS to flooding
- However, the new estuary-scale NBS approach of sedimentary restoration has not been studied by the USACE

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References

Chen, Z., P. M. Orton, and T. Wahl, 2020. Storm Surge Barrier Protection in an Era of Accelerating Sea Level Rise: Quantifying Closure Frequency, Duration and Trapped River Flooding, *Journal of Marine Science and Engineering*, 8(9), 725.

Li, S., T. Wahl, S. A. Talke, D. A. Jay, P. M. Orton, X. Liang, G. Wang, and L. Liu, 2021. Evolving tides aggravate nuisance flooding along the U.S. coastline, *Science Advances*, 7(10), eabe2412.

Orton, P. M., S. A. Talke, D. A. Jay, L. Yin, A. F. Blumberg, N. Georgas, H. Zhao, H. J. Roberts, and K. MacManus, 2015. Channel Shallowing as Mitigation of Coastal Flooding, *Journal of Marine Science and Engineering*, 3(3), 654-673

Orton, P. M., E. W. Sanderson, S. A. Talke, M. Giampieri, and K. MacManus, 2020. Storm tide amplification and habitat changes due to urbanization of a lagoonal estuary, *Natural Hazards and Earth System Science*, 20(9), 2415-2432.

Orton, P. M., D. Ralston, B. van Prooijen, D. Secor, N. K. Ganju, Z. Chen, S. Fernald, B. Brooks, and K. Marcell (submitted, pending minor revision), Increased utilization of storm surge barriers: A research agenda on estuary effects, *Earth's Future*.

Pareja-Roman, L. F., Orton, P. M., & Talke, S. A. (2023). Effect of estuary urbanization on tidal dynamics and high tide flooding in a coastal lagoon. *Journal of Geophysical Research: Oceans*, 128.

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Extra Slides
In case needed

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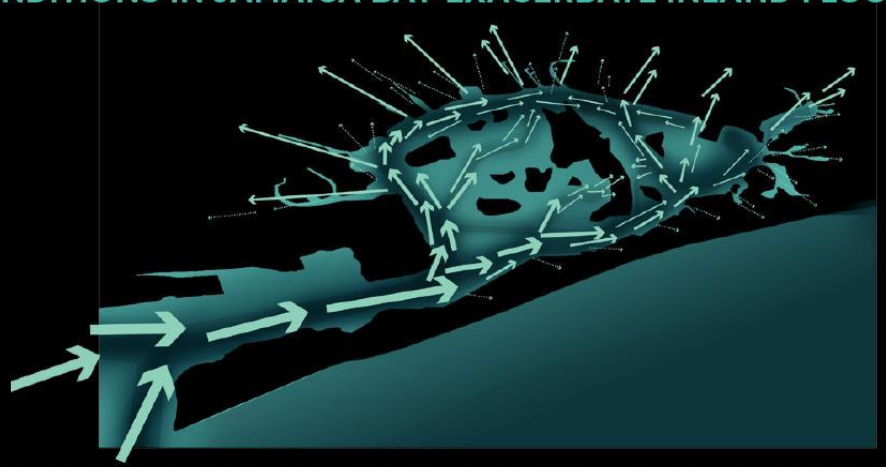
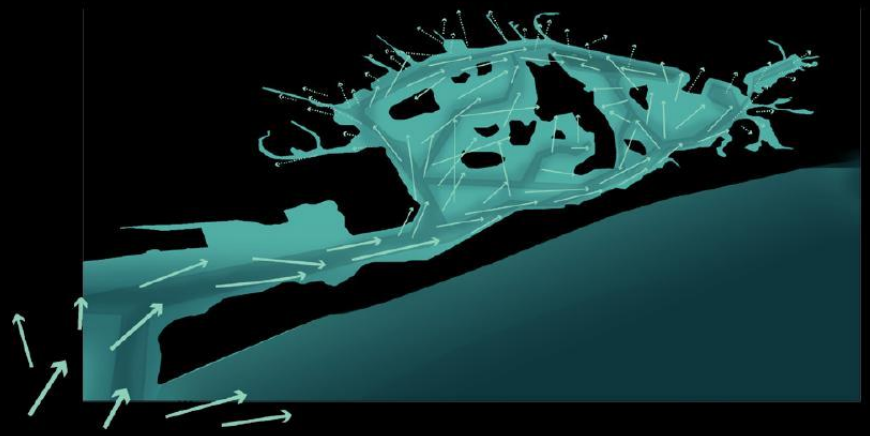
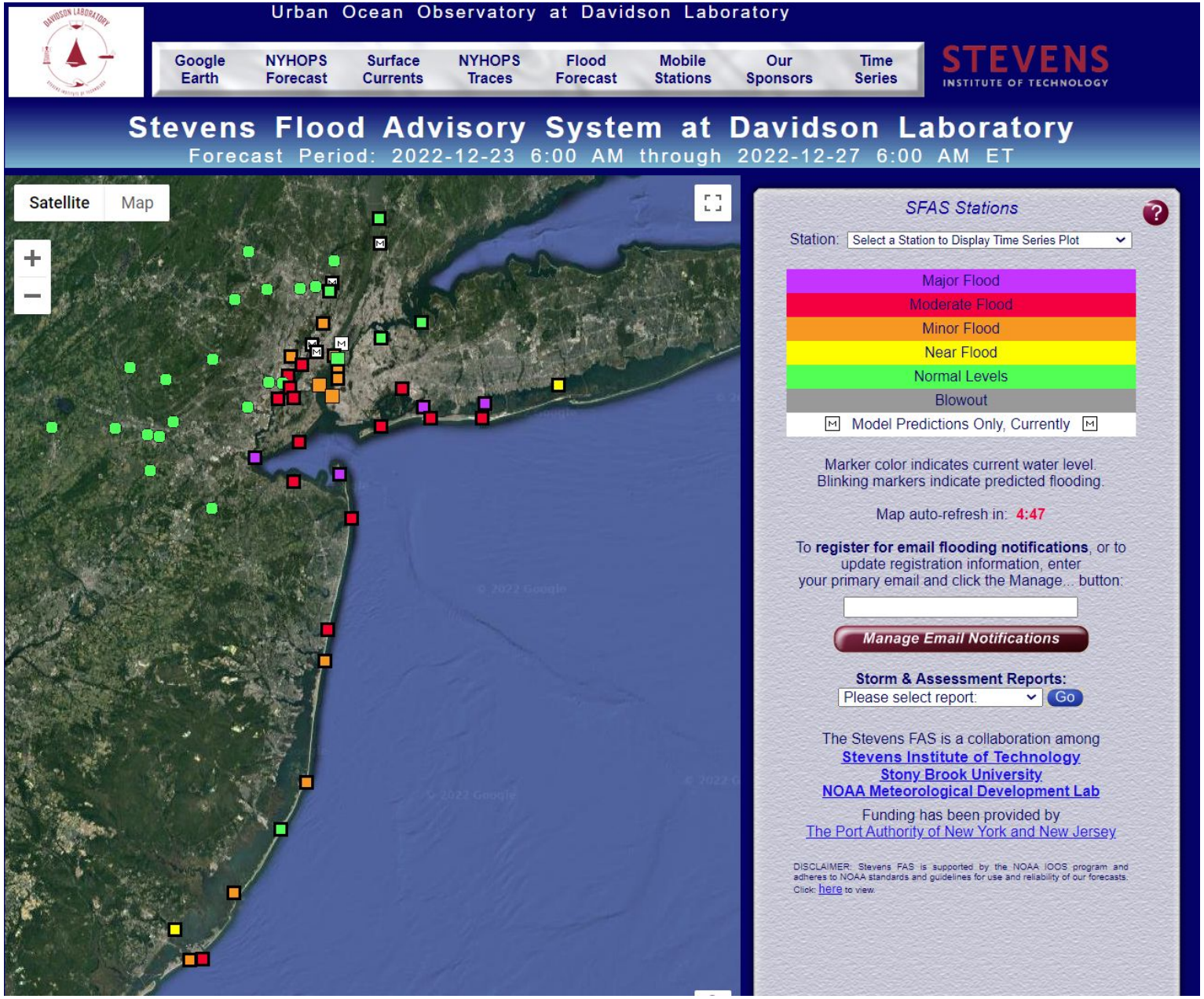
2022

CURRENT CONDITIONS IN JAMAICA BAY EXACERBATE INLAND FLOODING



PROPOSED SHALLOWING REDUCES INFLOW TO BAY SUBSTANTIALLY

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Model Predictions Only, Currently
Marker color indicates current water level.
Blinking markers indicate predicted flooding.
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Storm Surge Barriers and Sea Level Rise

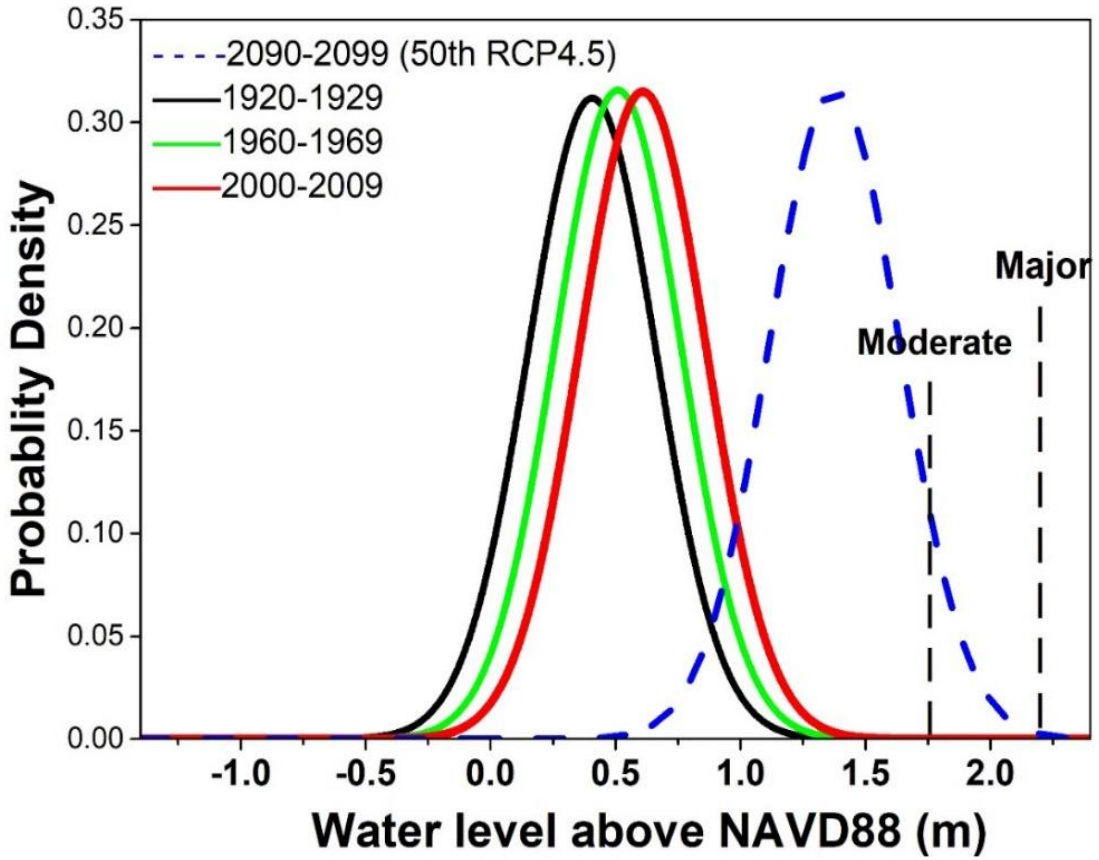
Gate closure “trigger” water level

NWS “**moderate flood**” level of 1.74 m: some inundation of structures and roads near the stream.
NWS “**major flood**” level of 2.20 m: extensive inundation; significant threats to life and property.

Closure frequency

Sea level rise will **increase the frequency** of trigger water level exceedances (barrier closures)

Impacts on the physical environment, water quality and ecology all grow with increasing closure frequency.



HATS addresses having possible limits on closures

HATS Report raises the possibility of a changing trigger water level

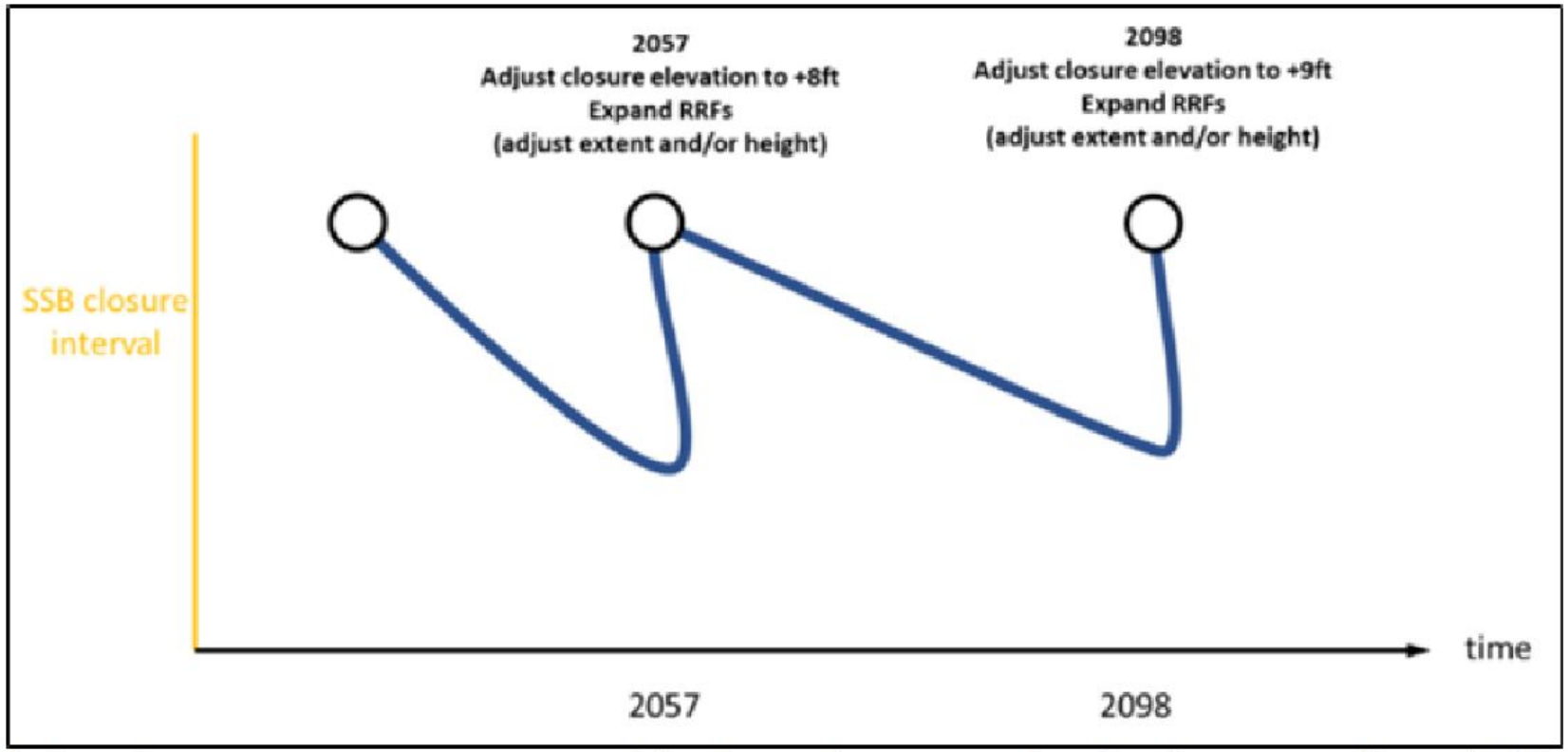


Figure 57: Adaptive management considering closure criteria (intermediate RSLC

HATS Report: Possibility of a Changing Trigger

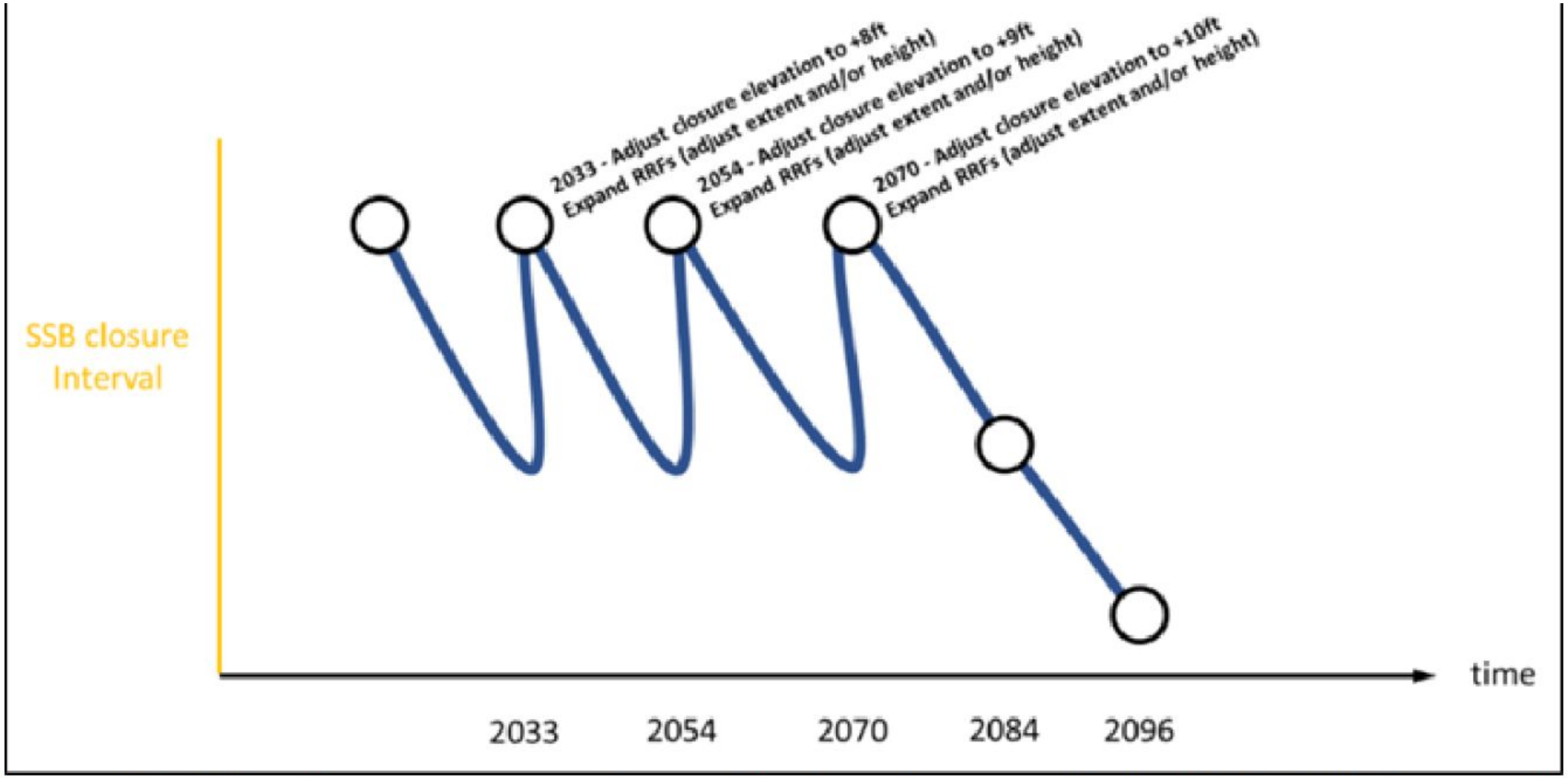


Figure 58: Adaptive management considering closure criteria (high RSLC scenario).