Projected Climate Change Impacts in New York City

Bernice R. Rosenzweig, Sarah Lawrence College, 1.25.2023

Outline

- New York City’s weather hazards landscape
  - Heat
  - Storm Hazards
    - Flooding Types
- Projected impacts of climate change

Rockaway, 12/23/2022 (Photo: PJ Marcell)

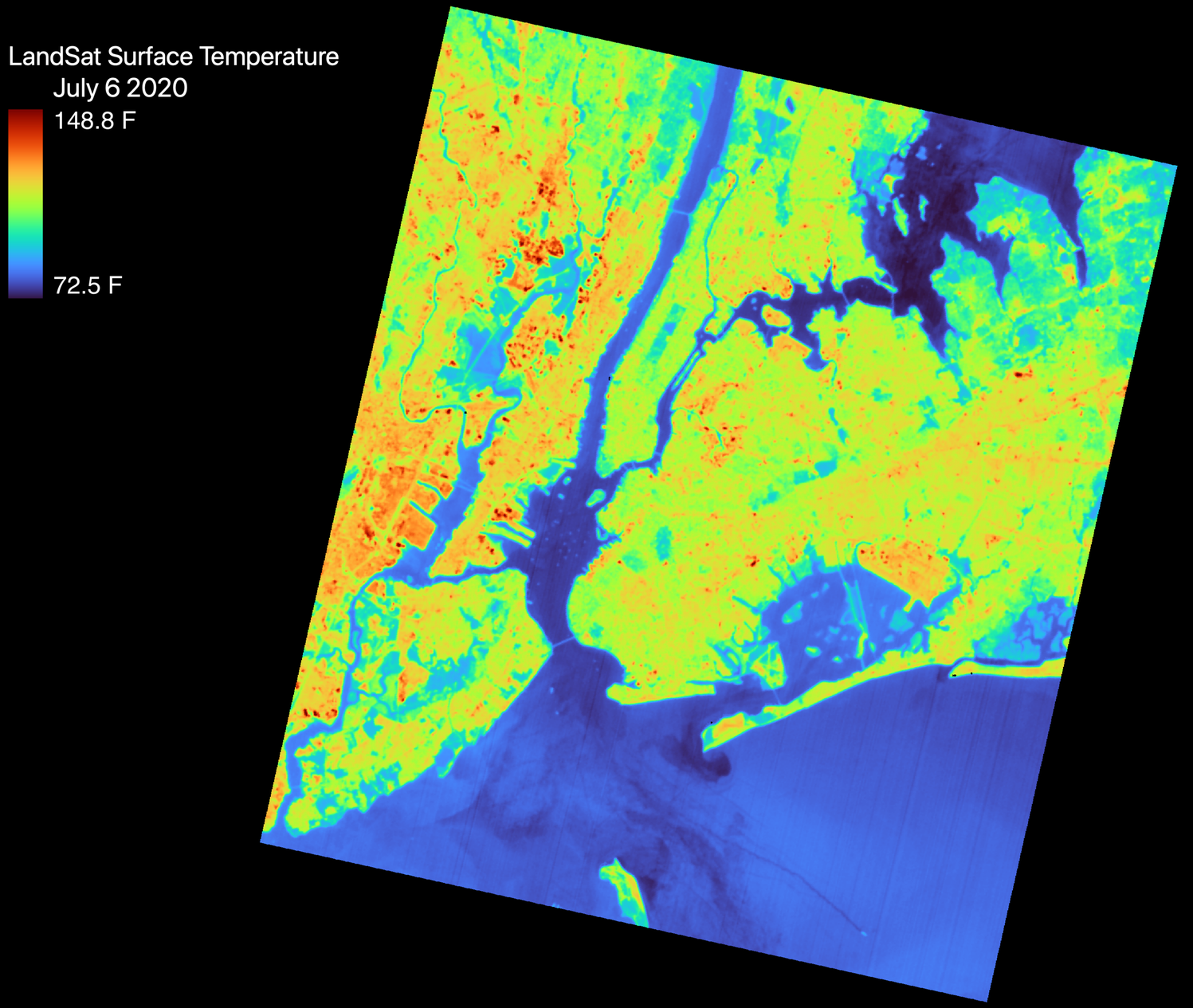
Heat

- Extreme heat is associated with increased mortality
- Heat wave:
  - 3 or more consecutive days with temperatures greater than 90° F *(US National Weather Service)*

Photo: Spencer Green

Urban Heat Island

- Conventional road and building materials generally reflect less sunlight and absorb and reemit more heat energy than natural surfaces
- Cooler surface temperatures with increased vegetation
- Water bodies can moderate temperature



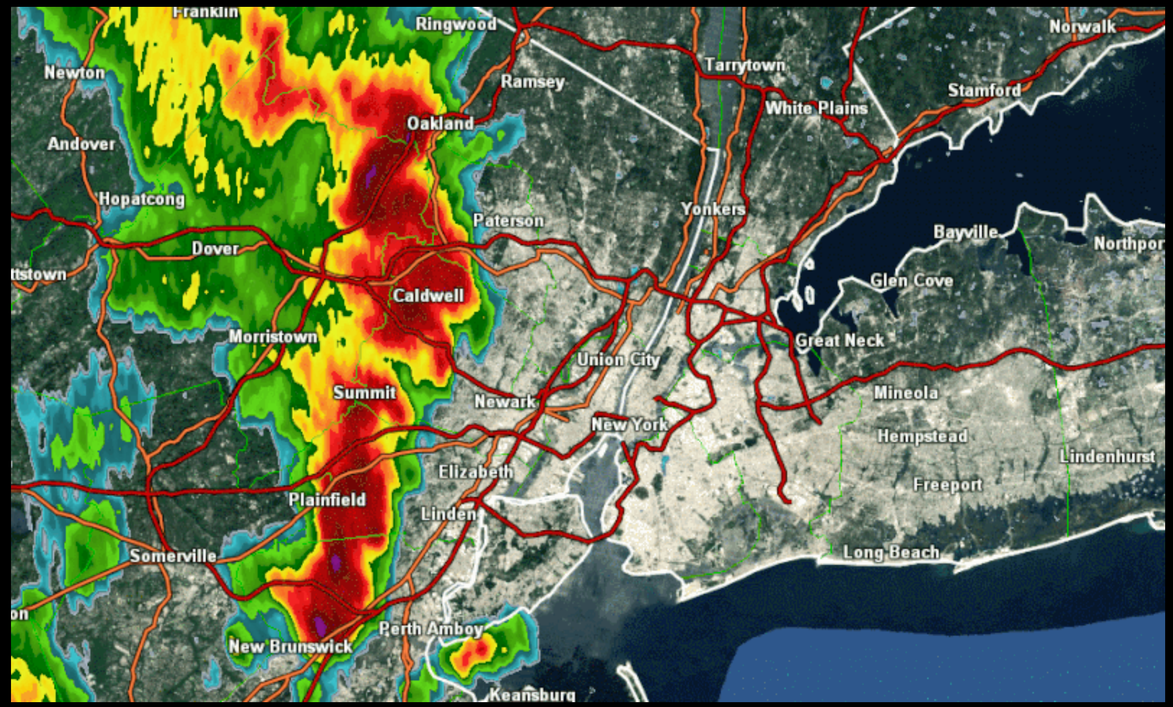
Tropical cyclones

- ‘Powered’ by warm ocean waters
- Examples:
  - Hurricanes
  - Tropical Storms
  - Tropical Depressions

Track of Hurricane Irene (2011) , which made landfall in Brooklyn as a Tropical Storm

Other storms

- ‘Powered’ by differences in air-temperature (baroclinic processes)
  - Warmer land surfaces than air aloft
  - Fronts where warm and cold air masses meet



Other Storms

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  - Warmer land surfaces than air aloft
  - Fronts where warm and cold air masses meet

Examples associated with hazardous weather:

- Thunderstorms
- Clippers
- Squalls
- Nor’Easters
- Post-tropical ‘remnants’ of hurricanes

Storm Hazards

Any given storm event can be associated with one or more

- Rain
- Storm surge
- Lightning
- Wind
- Tornadoes
- Hail *(except tropical cyclones)*
- Snow/Ice *(except tropical cyclones)*

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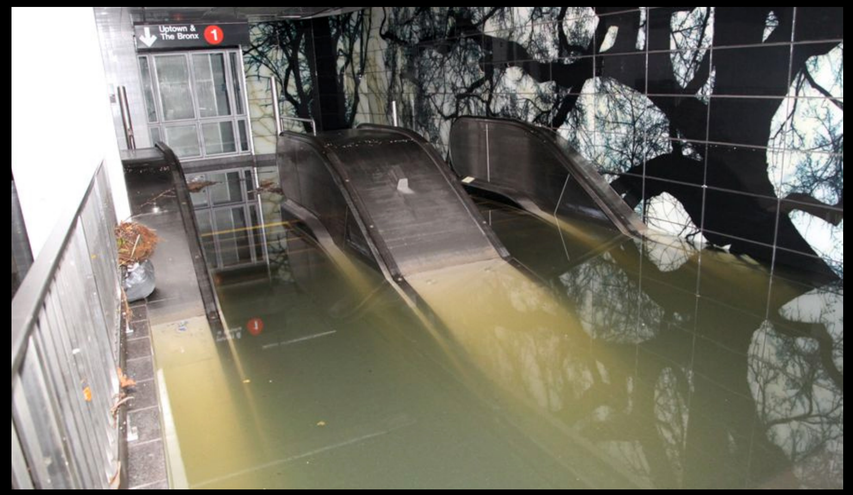
Associated with flooding

Tropical Storm Irene (2011)

Combined storm surge and rain



Post-tropical Storm Sandy (2012)

Storm surge, minimal rain

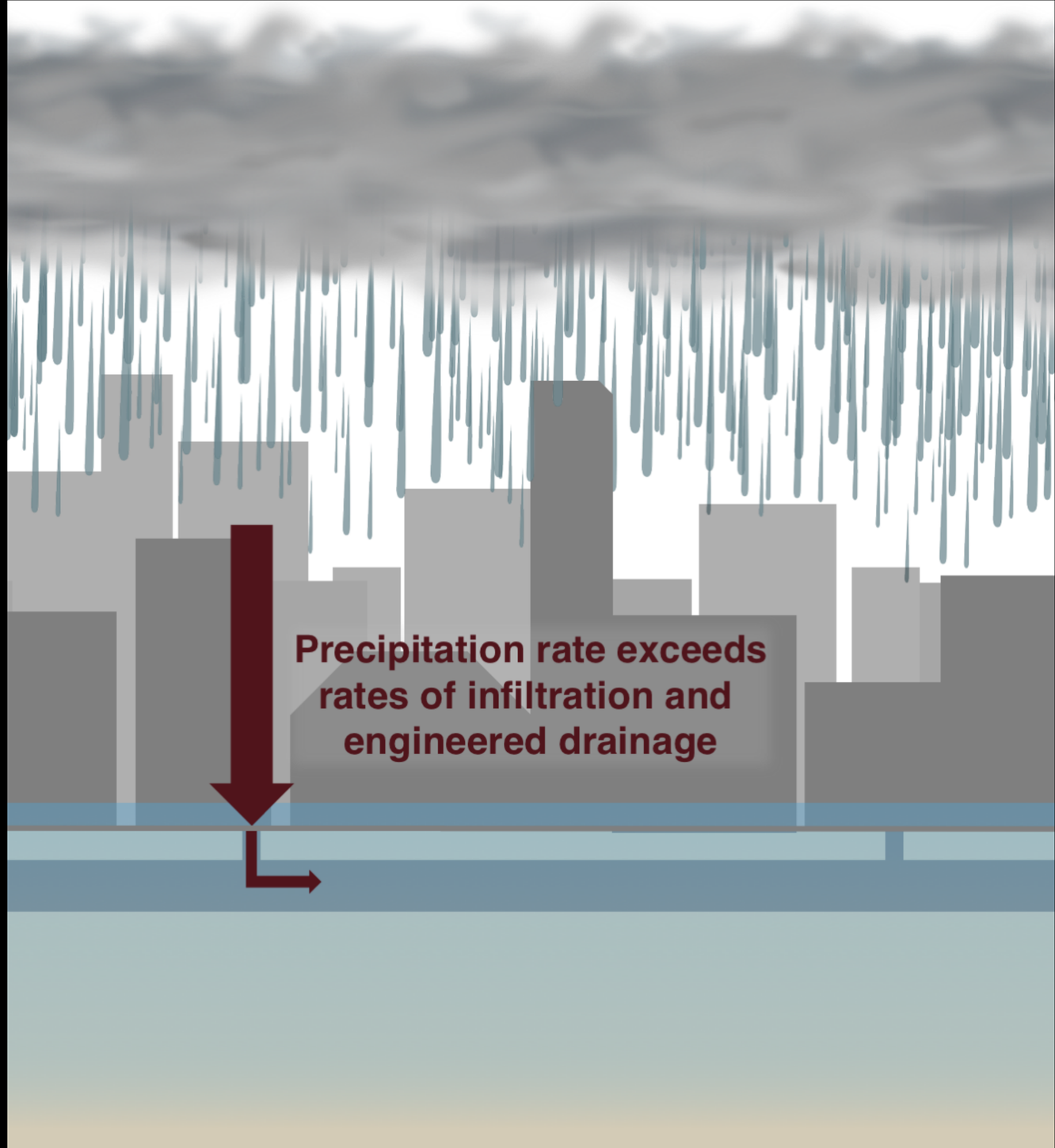
Cloudburst associated with Hurricane Ida remnants (2021

Extreme rain, no storm surge

Flooding from rain

Pluvial flooding

- Most of New York City's natural streams have been filled and replaced with storm sewers
- Pluvial flooding occurs when rainfall rates are greater than the rate of sewer drainage and soil infiltration



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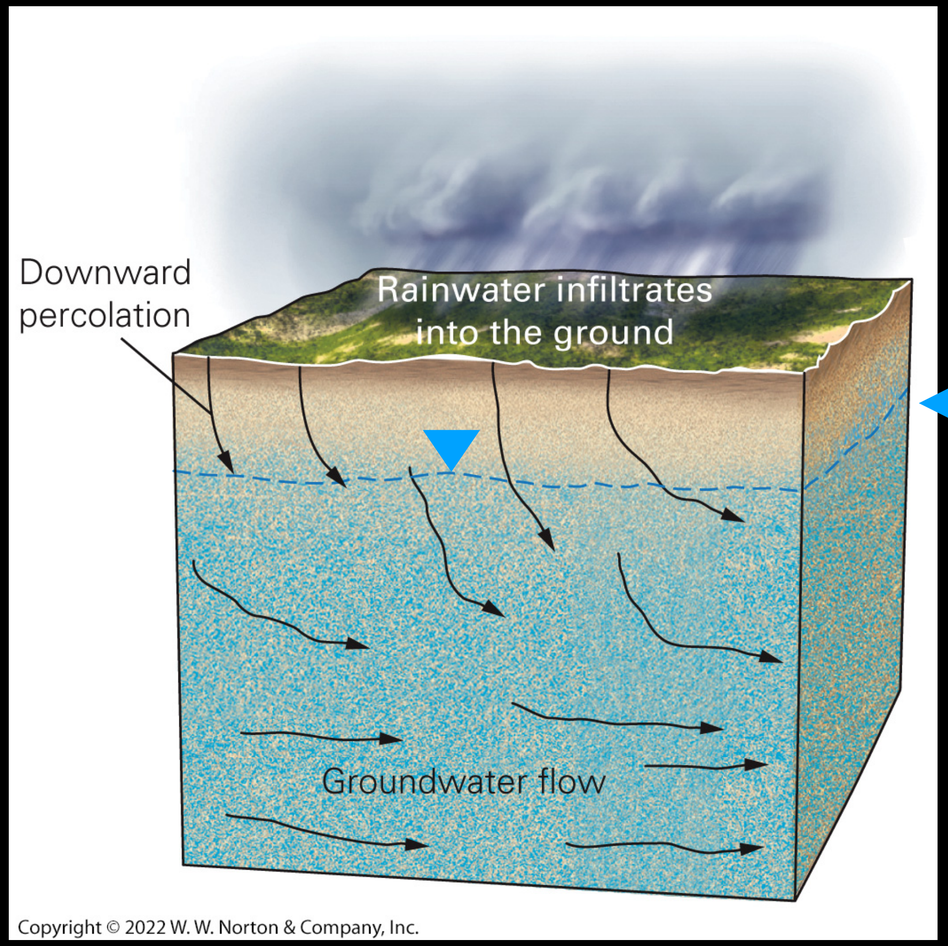
Flooding from below

Groundwater flooding



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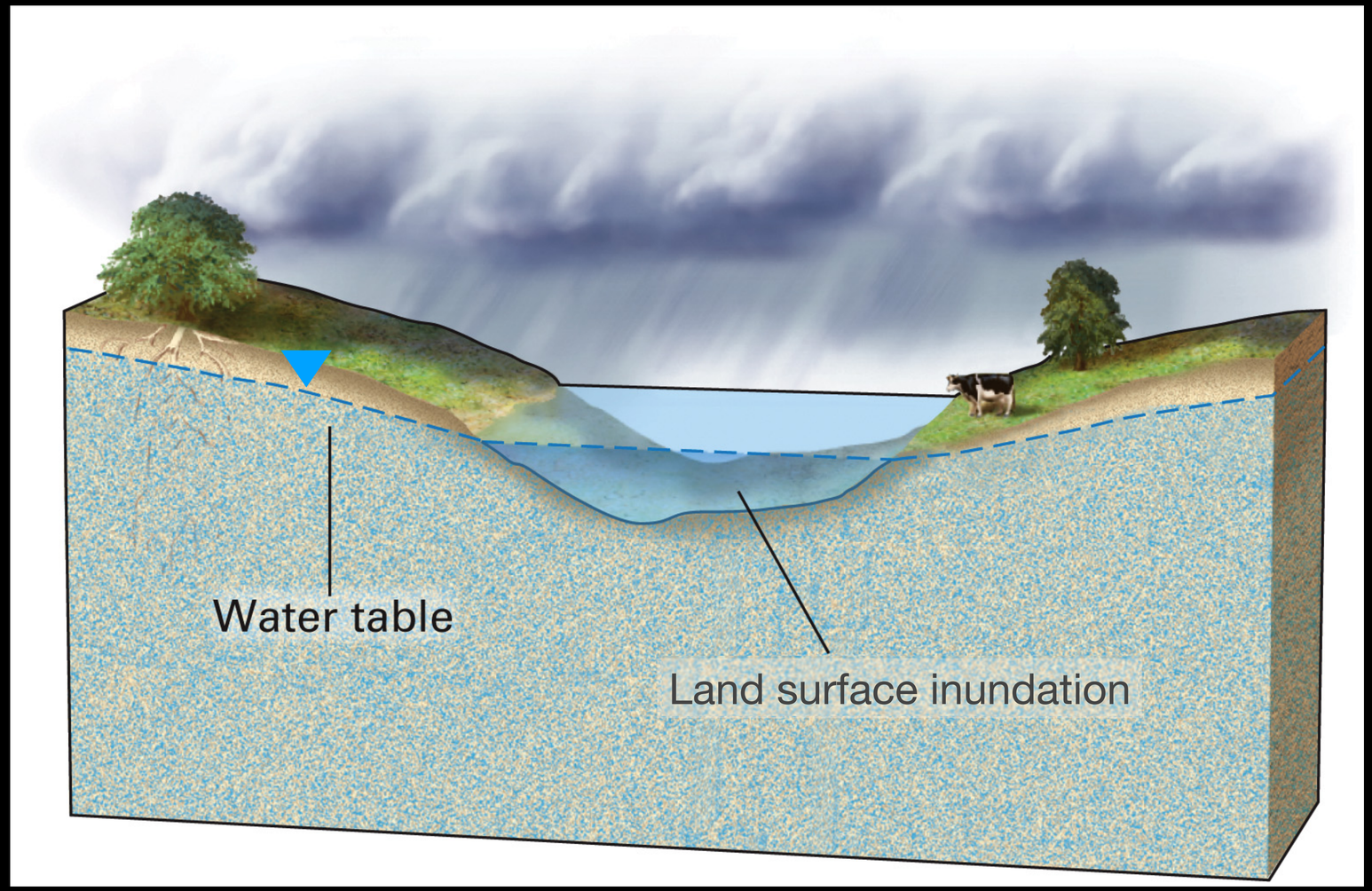
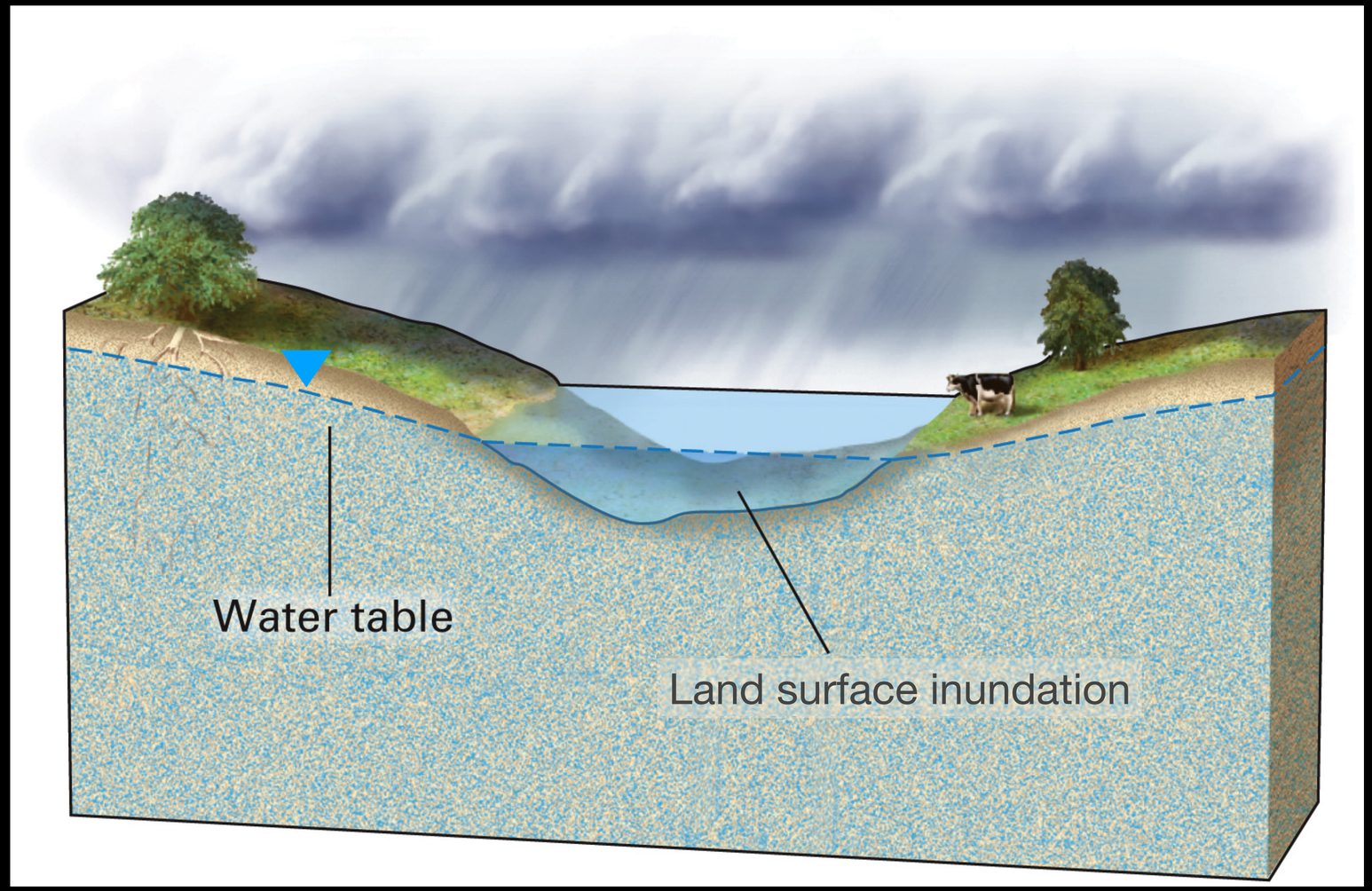


During wet seasons, the water table can rise above the land surface of low-lying areas

Modified from W.W. Norton Inc.

Flooding from below

Groundwater flooding



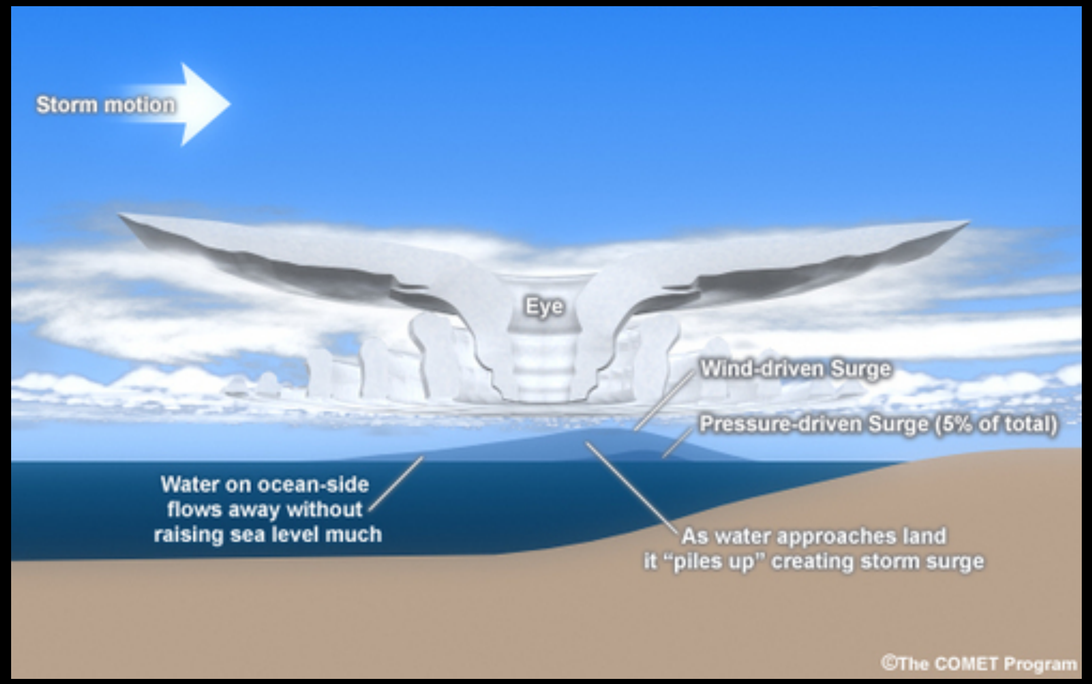
Modified from W.W. Norton Inc.

Lindenwood, Brooklyn/Queens (Photo: Samantha Maldonado)

Flooding from the sea

Storm Surge

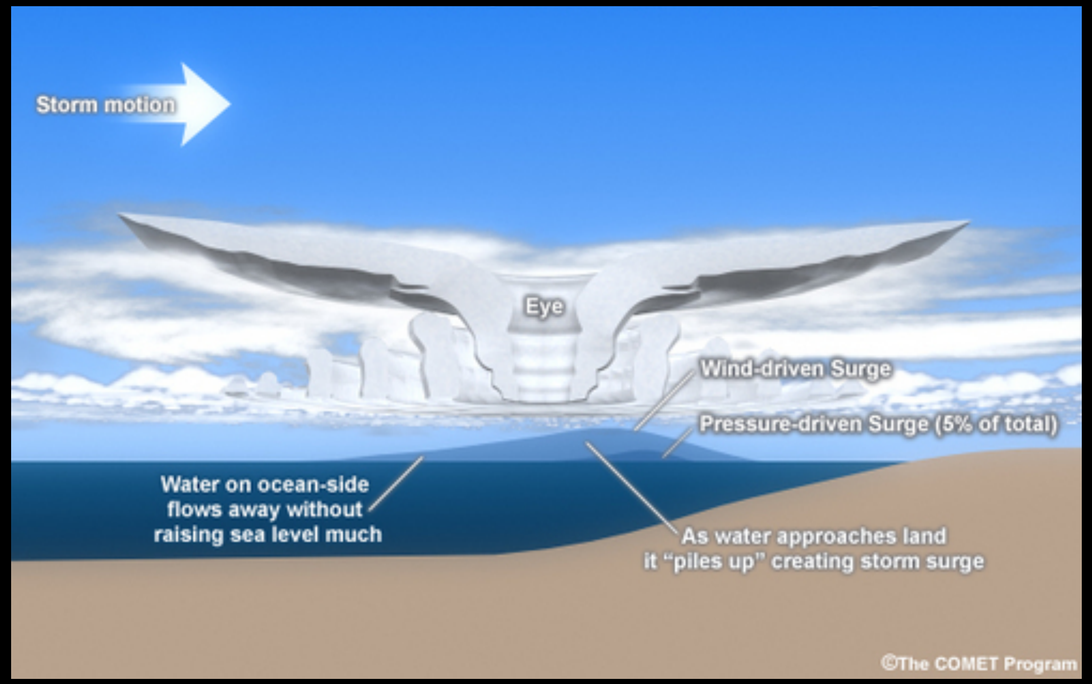
- Caused by wind and, to a lesser extent, the low pressure of coastal storms
- Coastal storms
  - Tropical cyclones *(Tropical Depressions, Tropical Storms, Hurricanes)*
  - Extratropical cyclones *(Nor'Easters)*



Flooding from the sea

Storm Surge

- Storm surge magnitude determined by coastal storm:
  - Size
  - Wind speed
  - Track (and the shape of the coast it affects)
  - Translational (travel) speed



Flooding from the sea

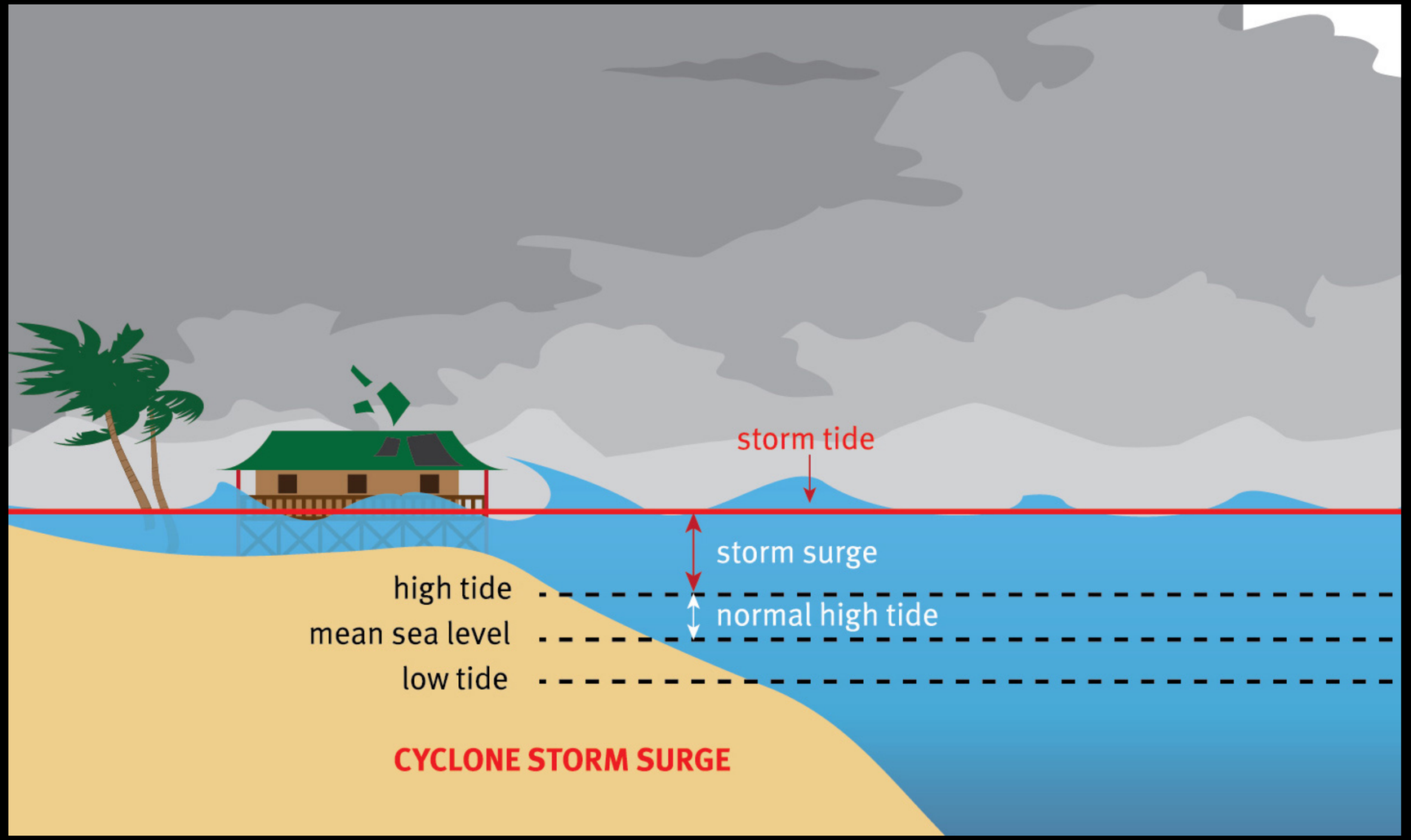
Storm Surge

Flooding is determined by the storm tide, which is storm surge + tide level

Cross Bay Boulevard, 10.29.2012 (Photo: Richard York)

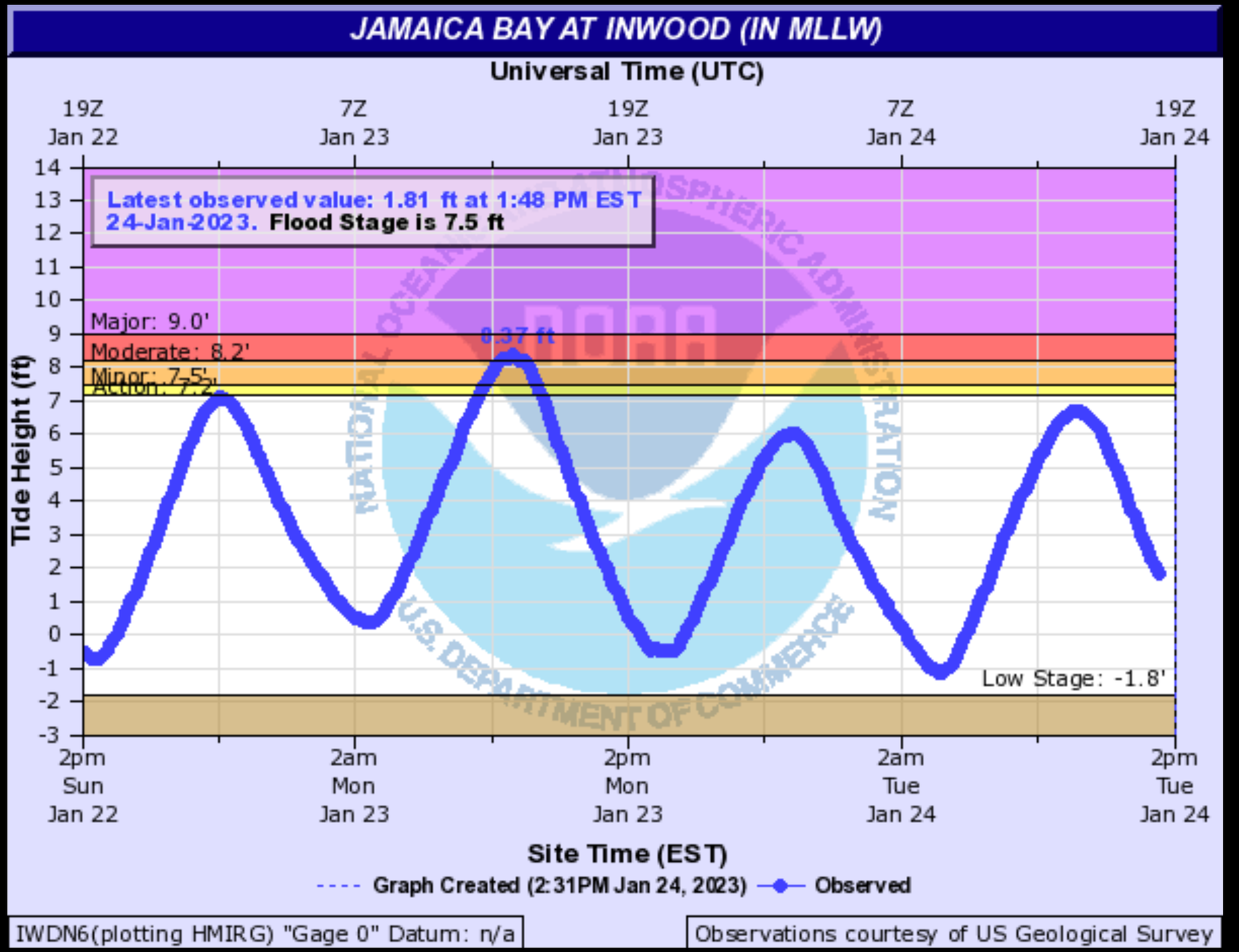
Storm tide

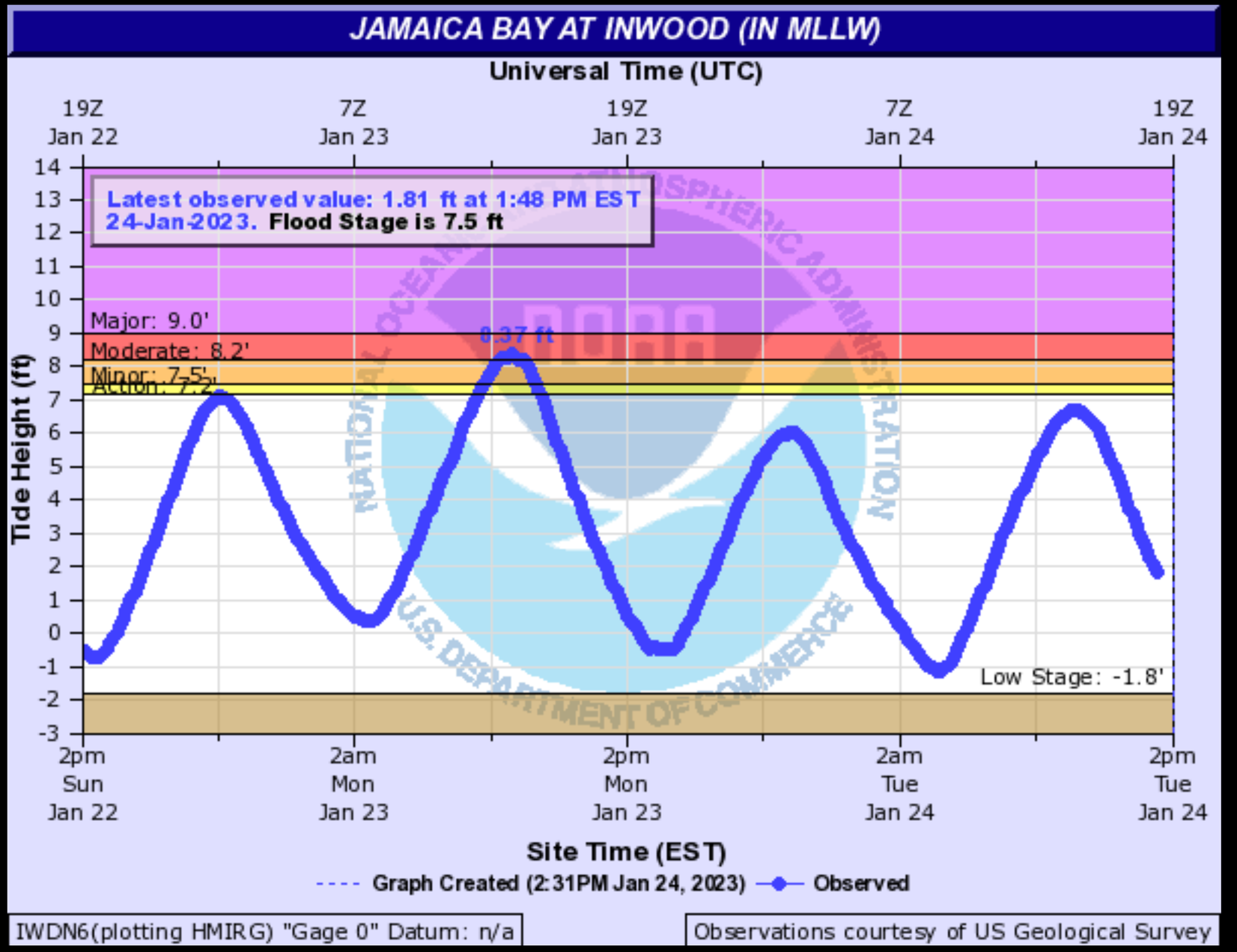
Determines coastal flooding



Coastal Flood Stages

Harbor water levels that will result in flooding




JAMAICA BAY AT INWOOD (IN MLLW)
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14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
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-3
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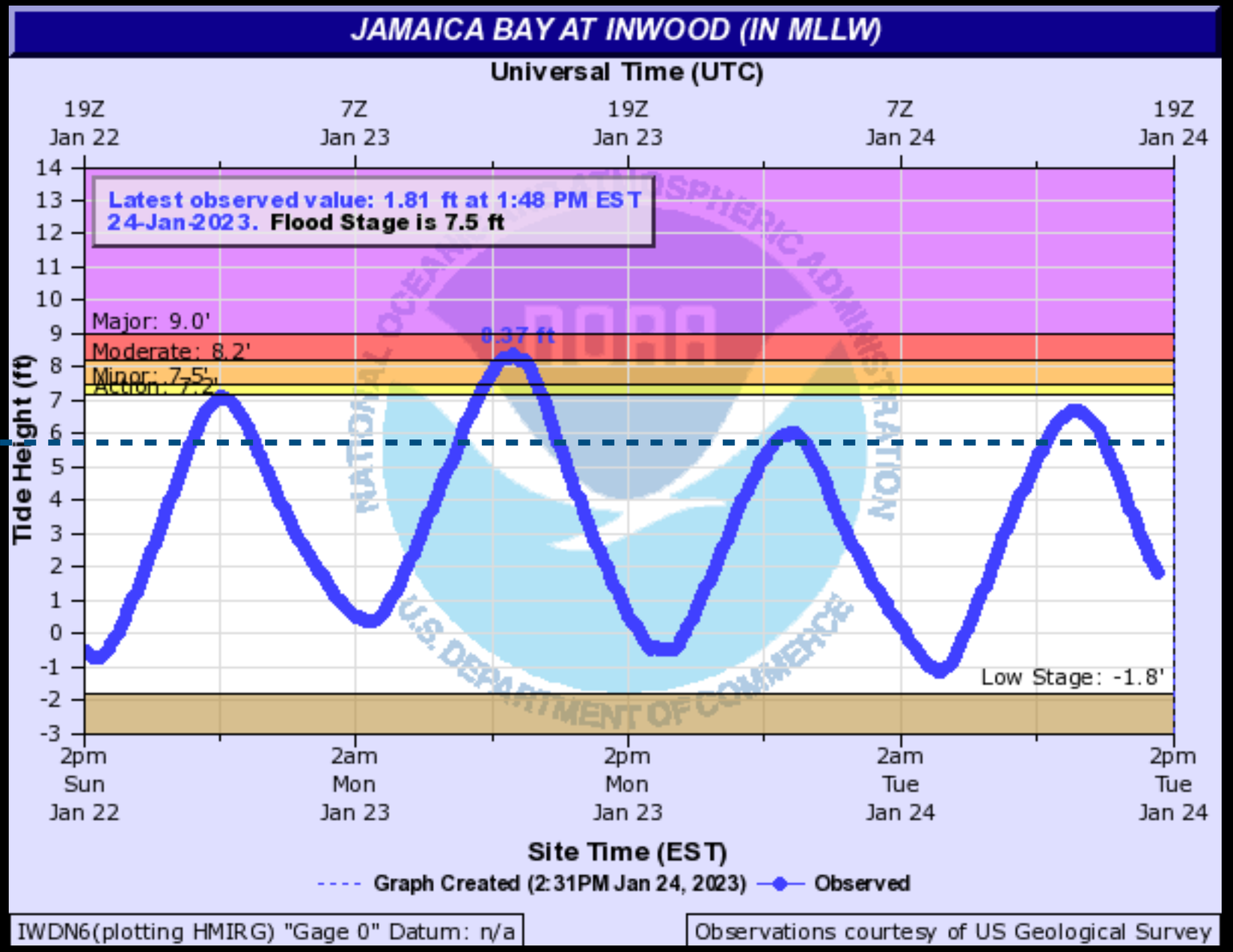
Observations courtesy of US Geological Survey

Mean Higher High Water (MHHW)

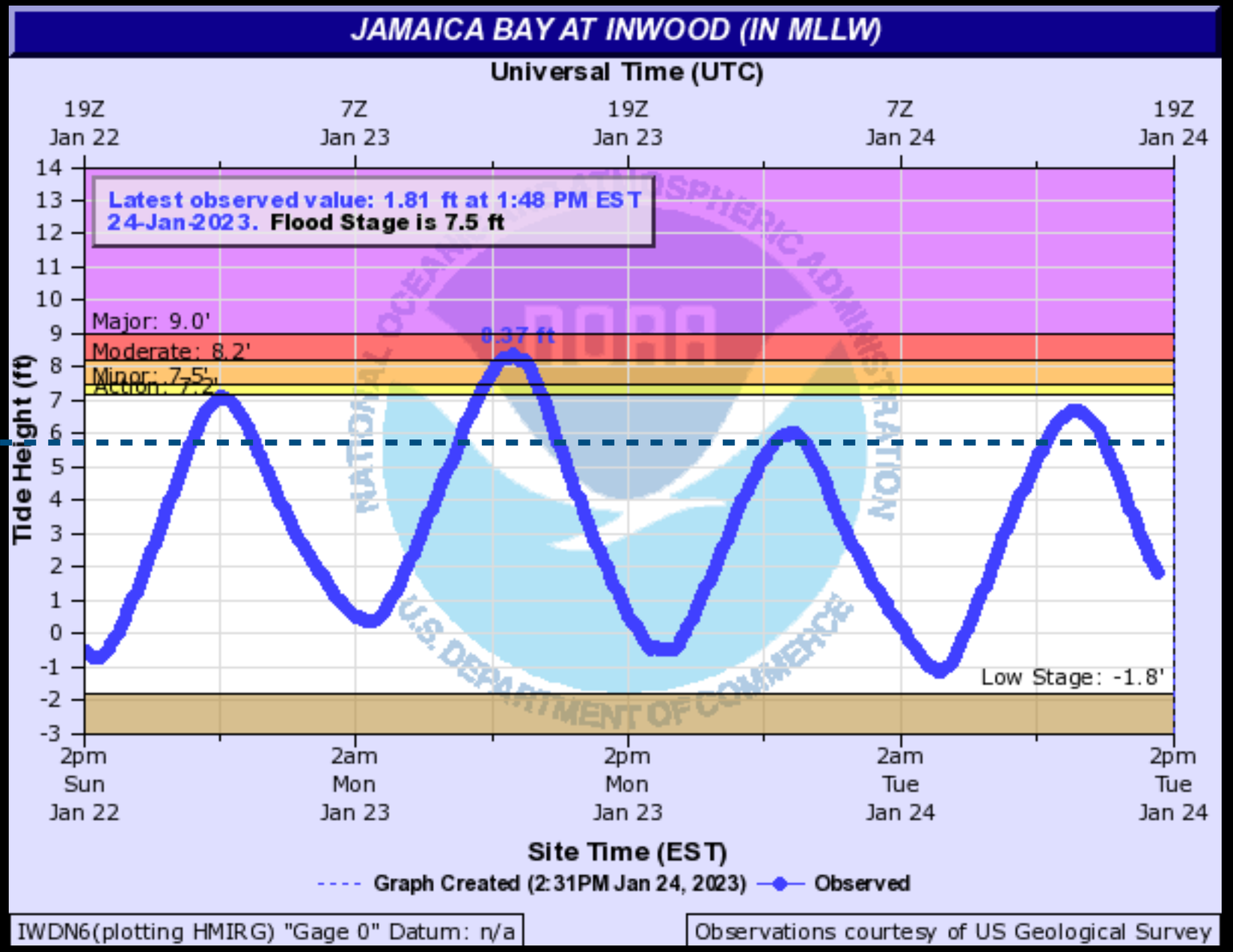
5.9 ft



Minor Flooding 1.6 ft. Above MHHW

Mean Higher High Water (MHHW)

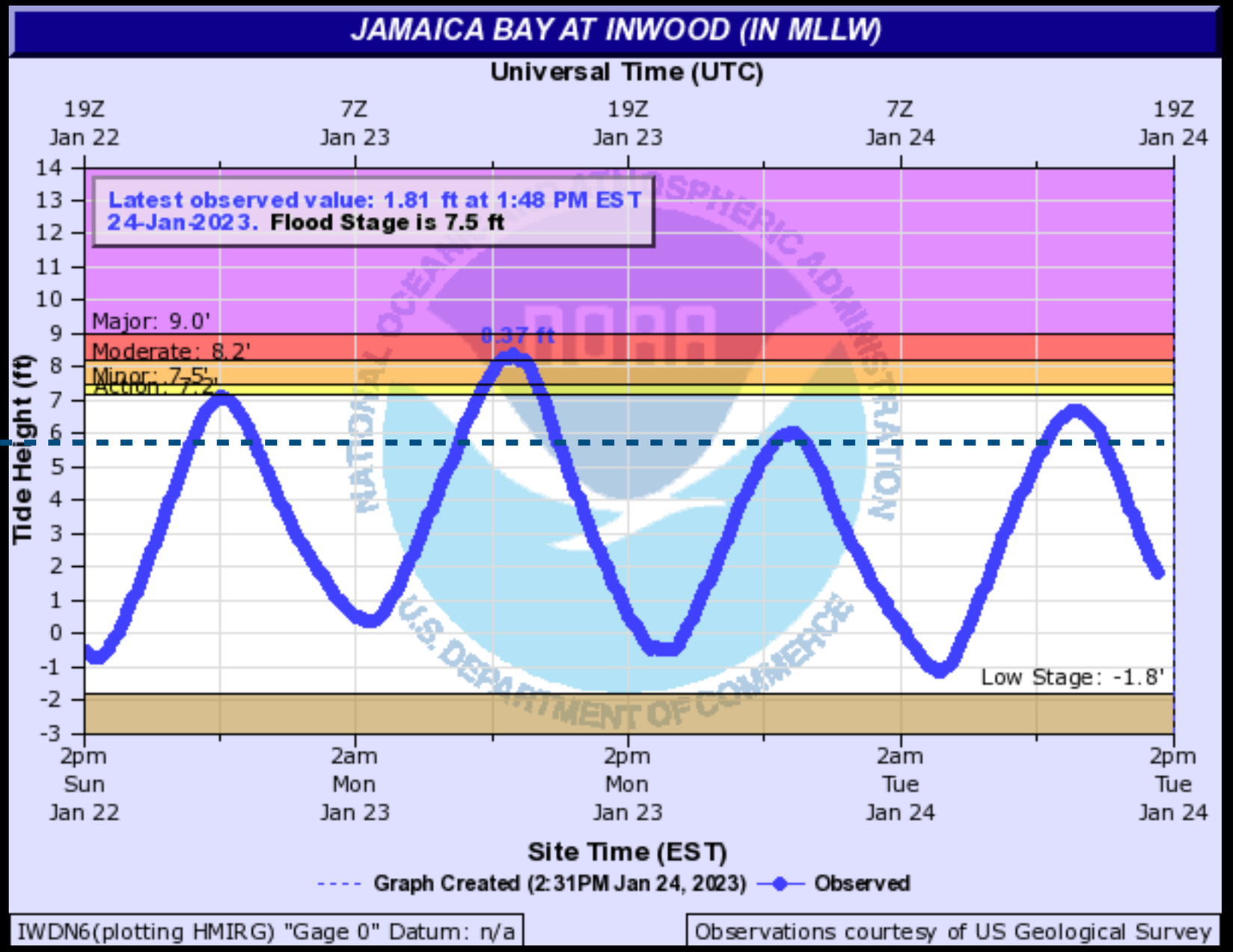
5.9 ft



Moderate Flooding 2.34 ft. Above MHHW

Mean Higher High Water (MHHW)

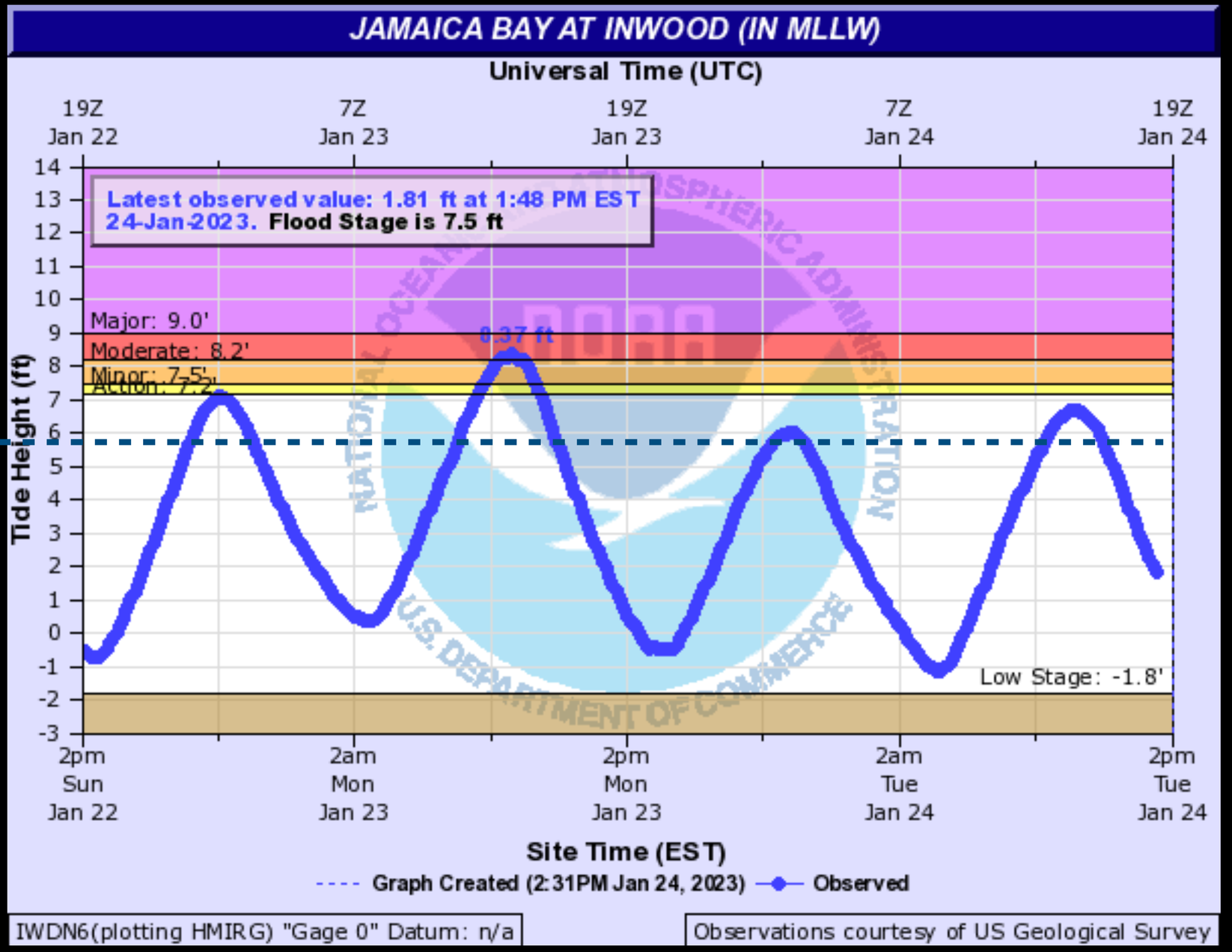
5.9 ft



Major Flooding 3.1 ft. Above MHHW

Mean Higher High Water (MHHW)

5.9 ft

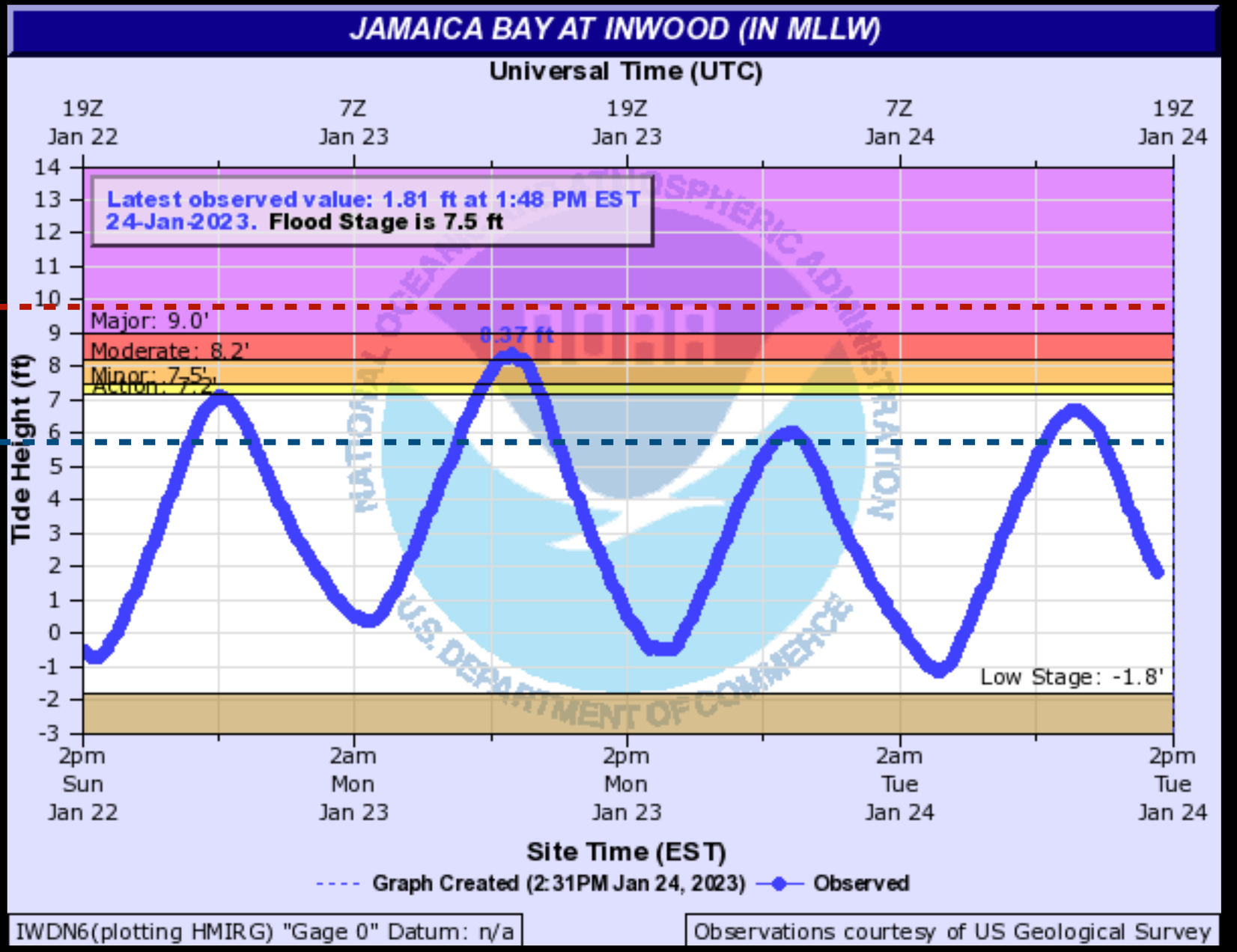


9.81ft above MLLW on December 23, 2022

3.91ft

Mean Higher High Water (MHHW)

5.9 ft



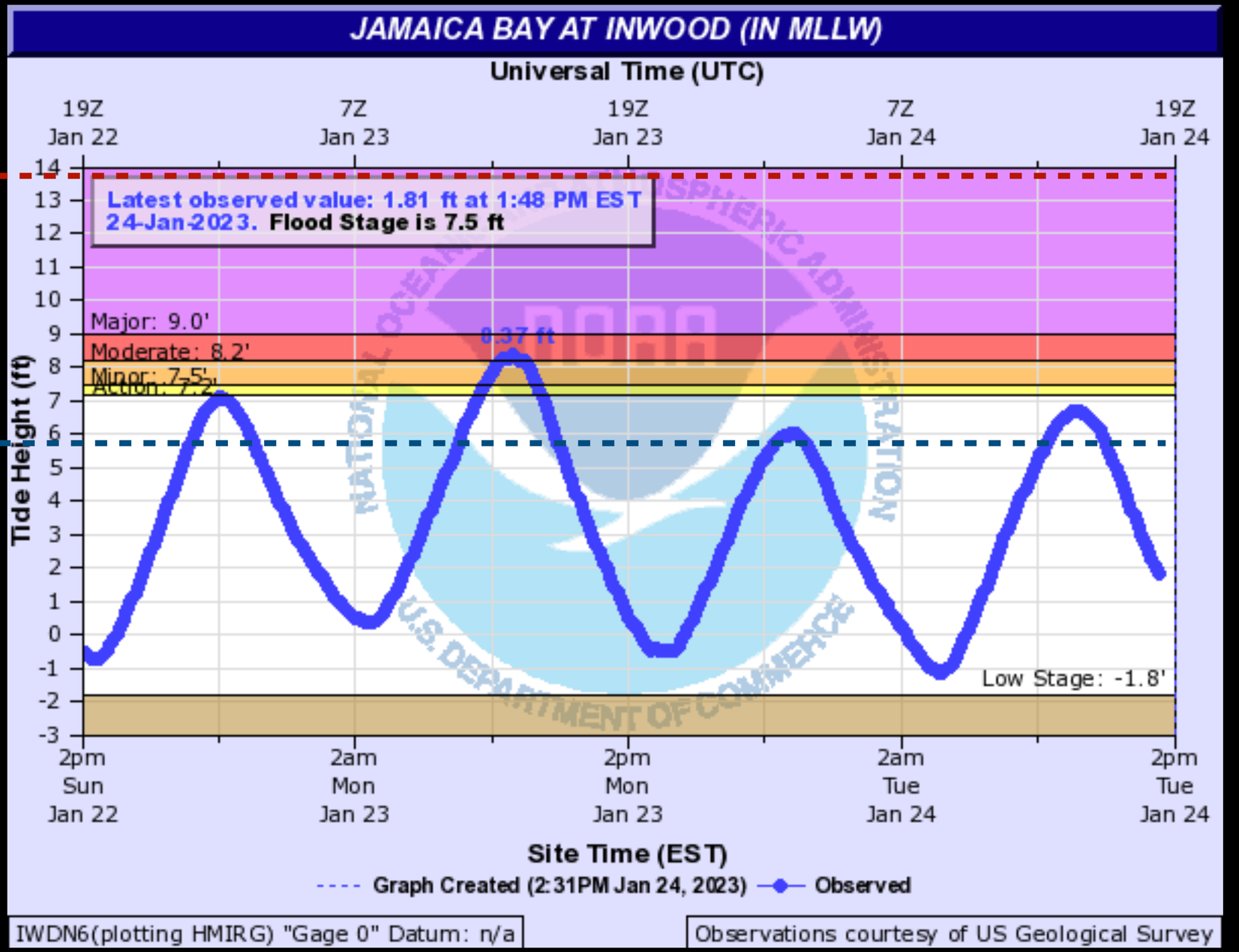
13.7ft above MLLW on October 29, 2012 (Sandy)

7.8ft

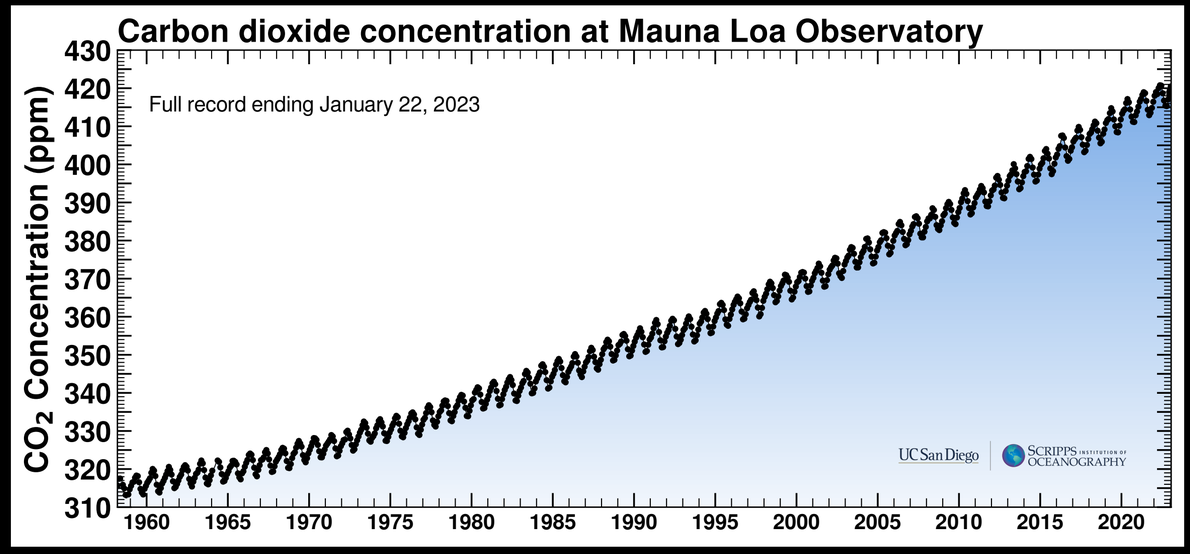
Mean Higher High Water (MHHW)

5.9 ft

Photo: Nathan Kensinger

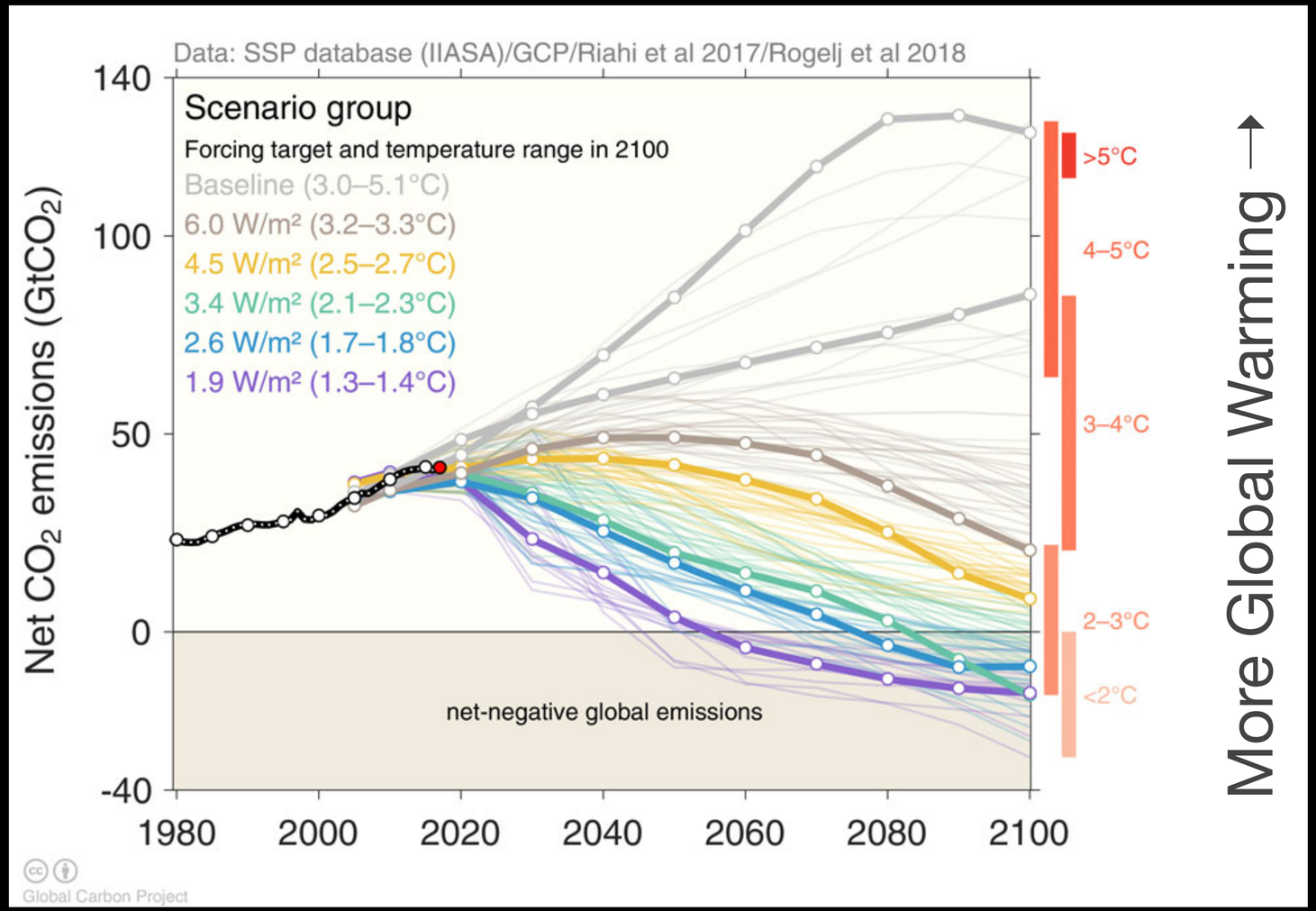


Climate change and weather hazards in New York City



Climate change pathways

Global emissions of heat-trapping gases



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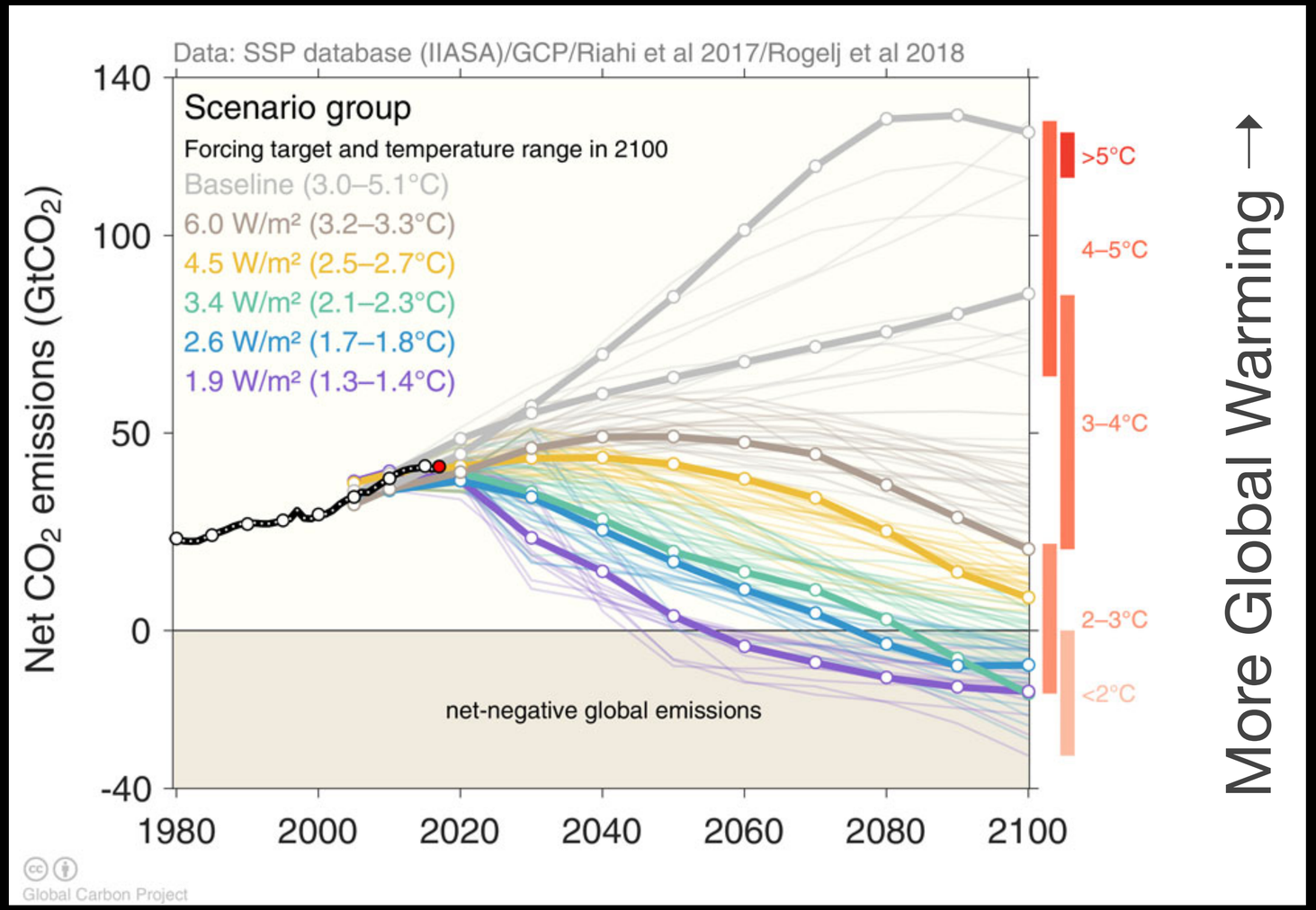


More Global Warming →

5.0°C

2.0°C

1.5°C

Climate Change

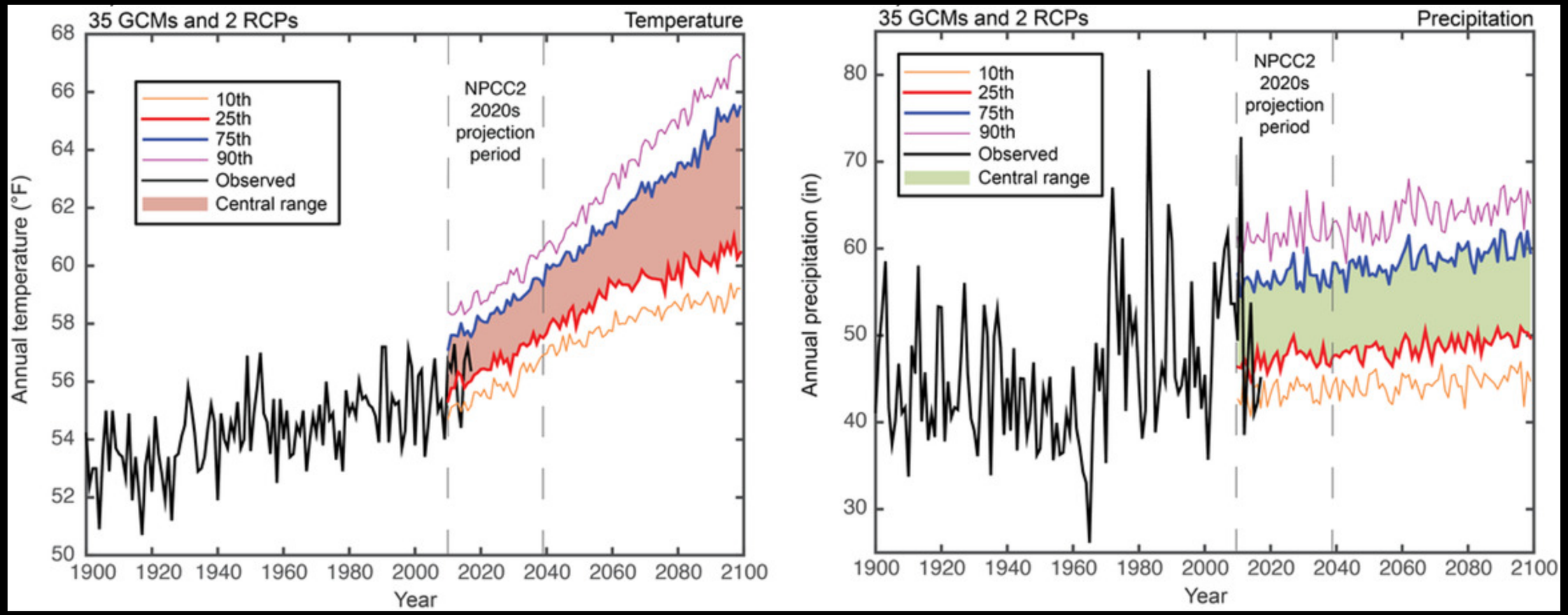
Mitigation and Adaptation

- Climate Change Mitigation:
  - Preventing global warming and associated changes to climate, primarily through the global reduction of emissions of greenhouse (heat-trapping) gases

- Climate Change Adaptation:
  - Societal changes (including infrastructure and policy changes) to better manage the impacts of climate change

Climate Change and New York City

Warmer and wetter

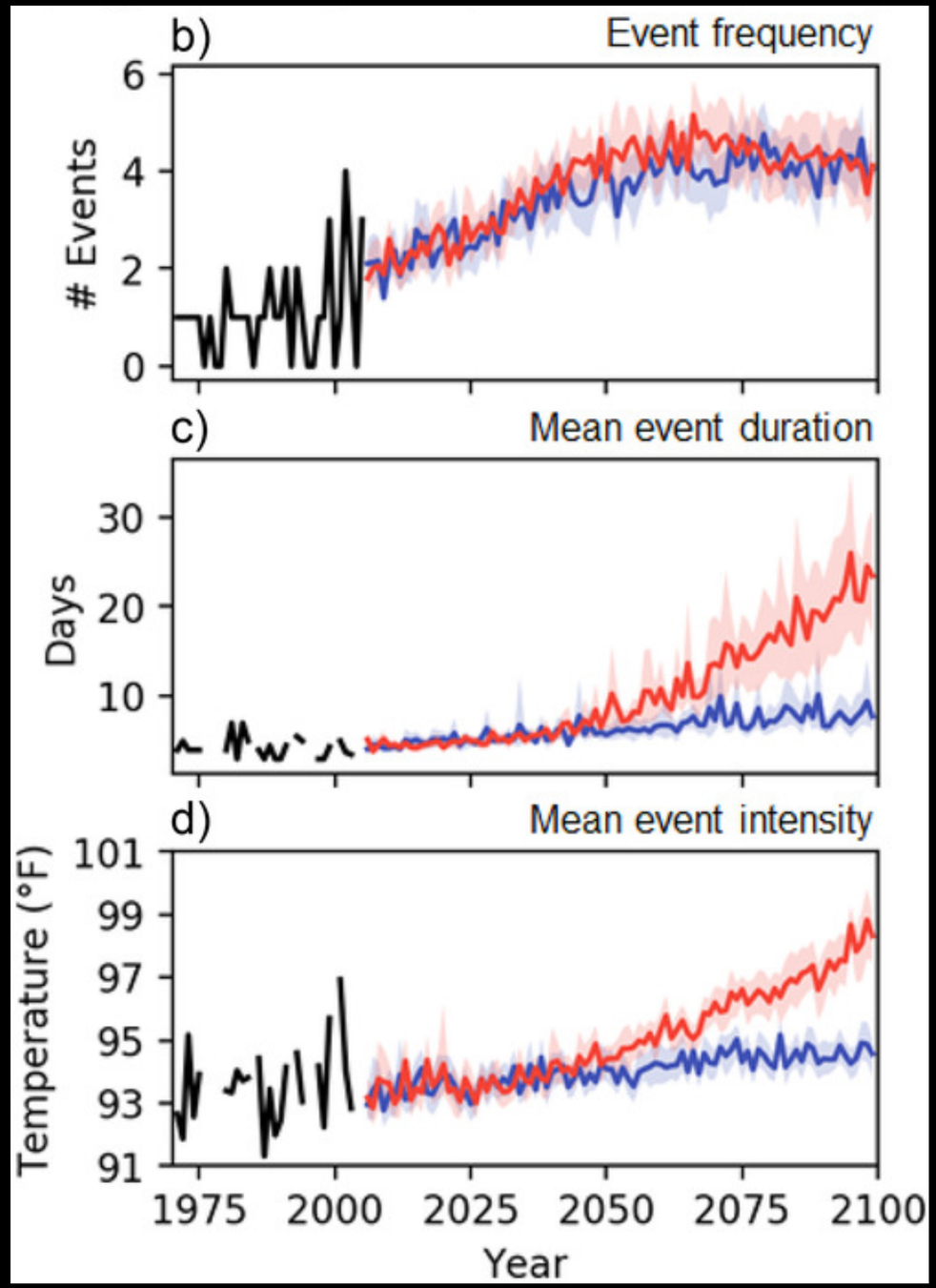


González, J.E. et al. , 2019. New York City Panel on Climate Change 2019 Report Chapter 2: New methods for assessing extreme temperatures, heavy downpours, and drought. *Annals of the New York Academy of Sciences*, *1439*)

Climate Change and Heat

More extremely hot days

- Event frequency: Number of heat waves each year
- Mean event duration: Average length of heat waves
- Mean event intensity: Average maximum temperatures during heat waves



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Climate change and rain

More intense rain

- When conditions are favorable for rain, rainfall can potentially fall at higher rates
- Warmer temperatures can amplify the dynamics of thunderstorms
- Uncertainty about how much
  - Challenge for planning

Rain during the Ida Remnants Cloudburst on 9.1.2021 (Photo: Anthony Behar)

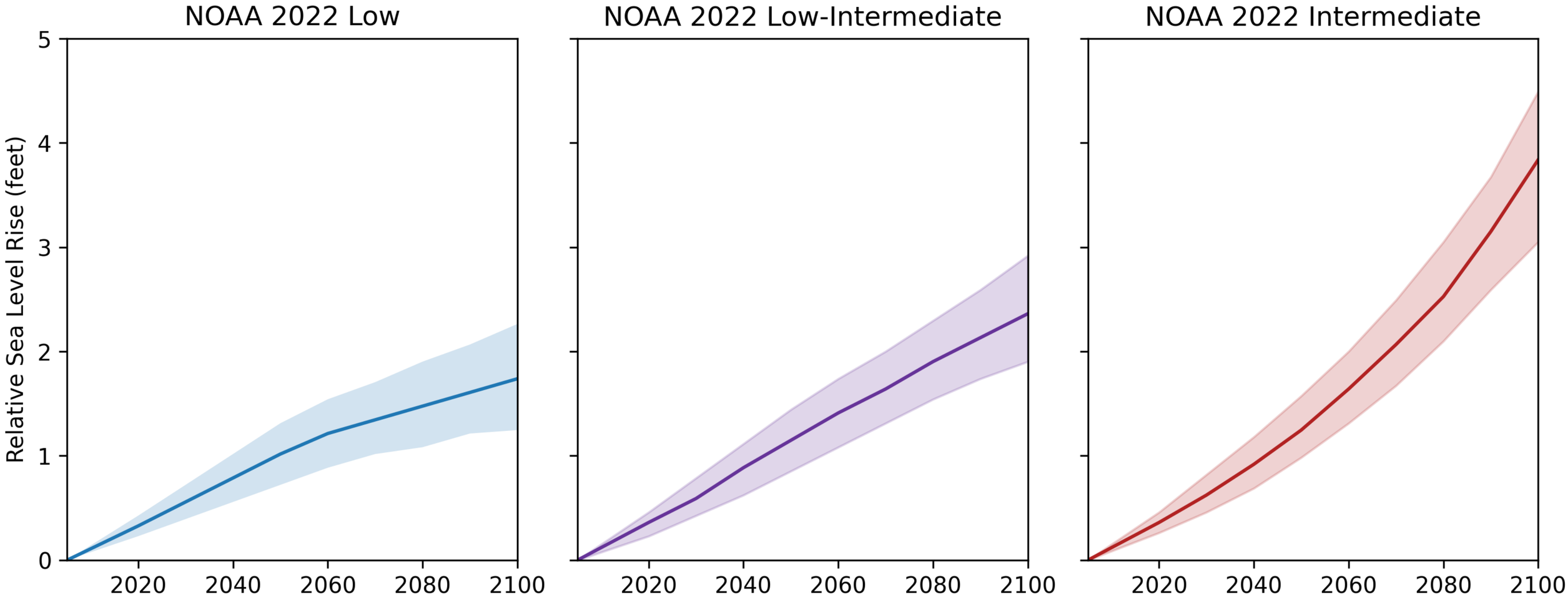
Climate change and sea level rise

- Global sea levels will rise as the ocean expands and land ice melts
- New York City is part of the mid-Atlantic sea level rise hot spot
    - Local relative sea level rise is much higher than the global average

Sunny day flooding on 1.4.2022 (Photo: Giles Ashford)

Sea Level Rise Projections

Sweet et. al (2022) Global and Regional Sea Level Rise Scenarios for the United States: Updated Mean Projections and Extreme Water Level Probabilities Along U.S. Coastlines. NOAATechnical Report NOS 01.



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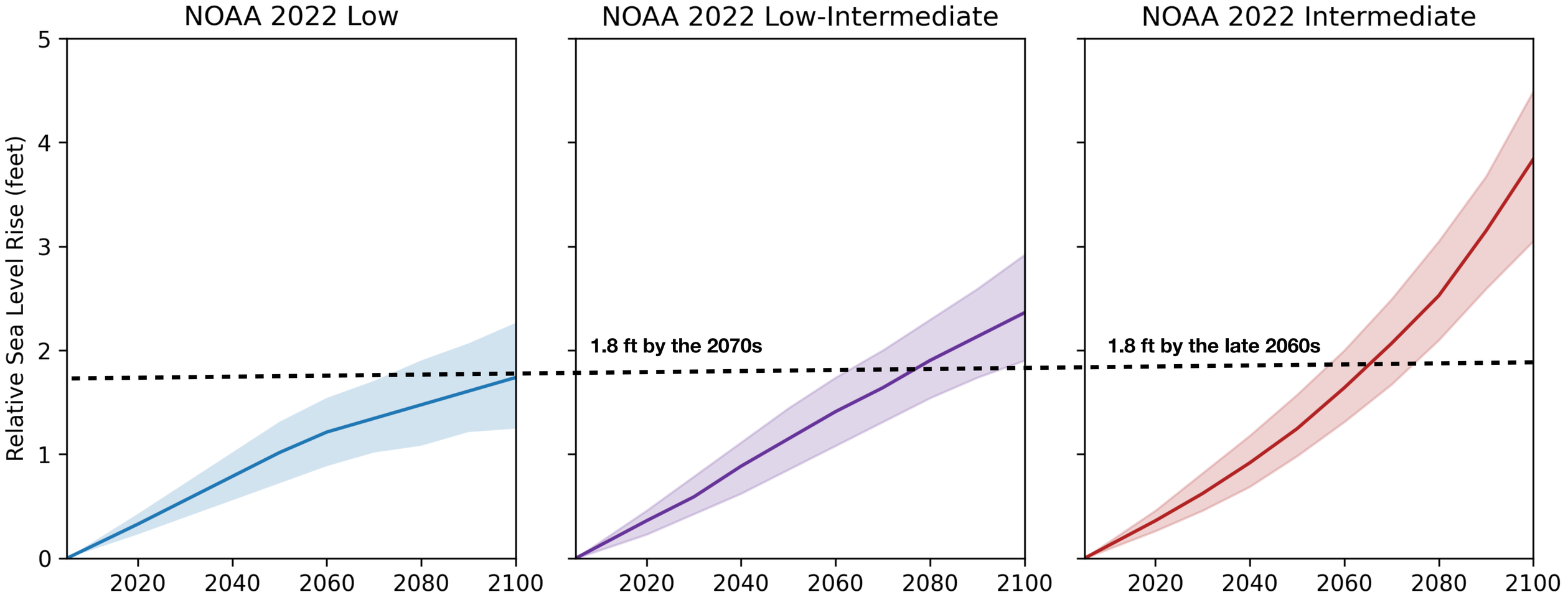

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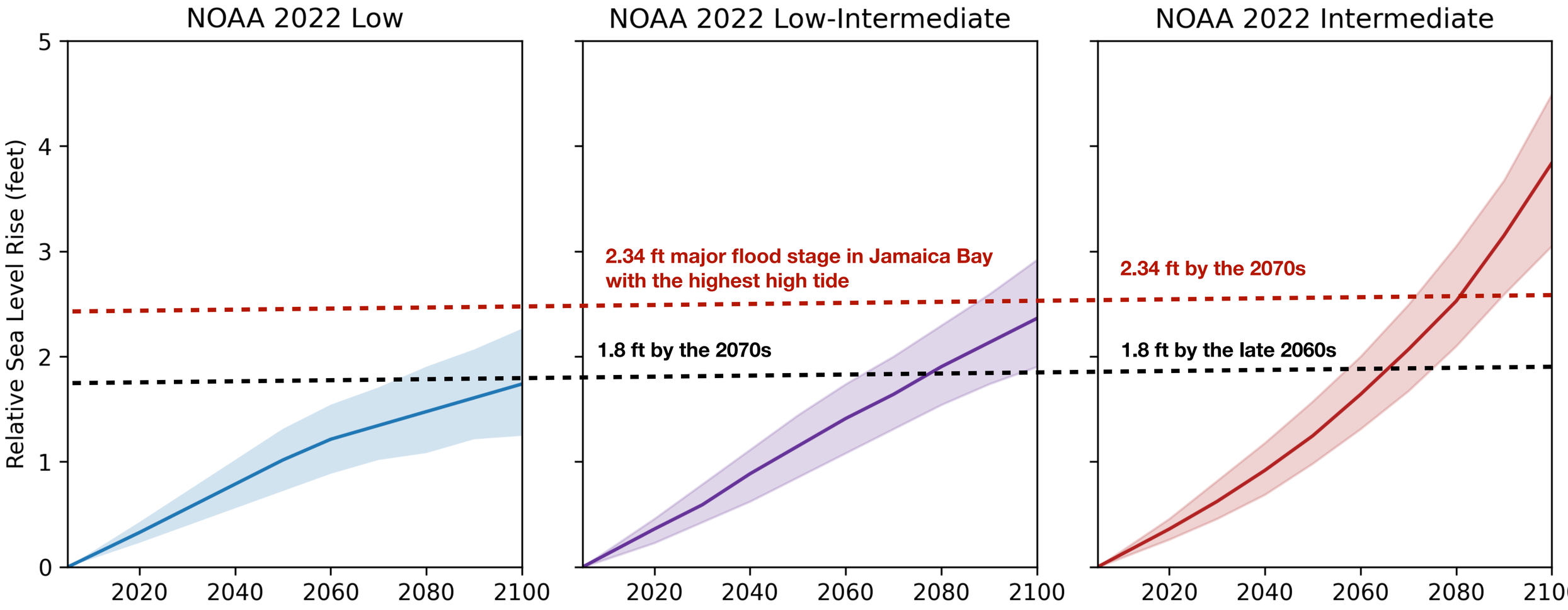

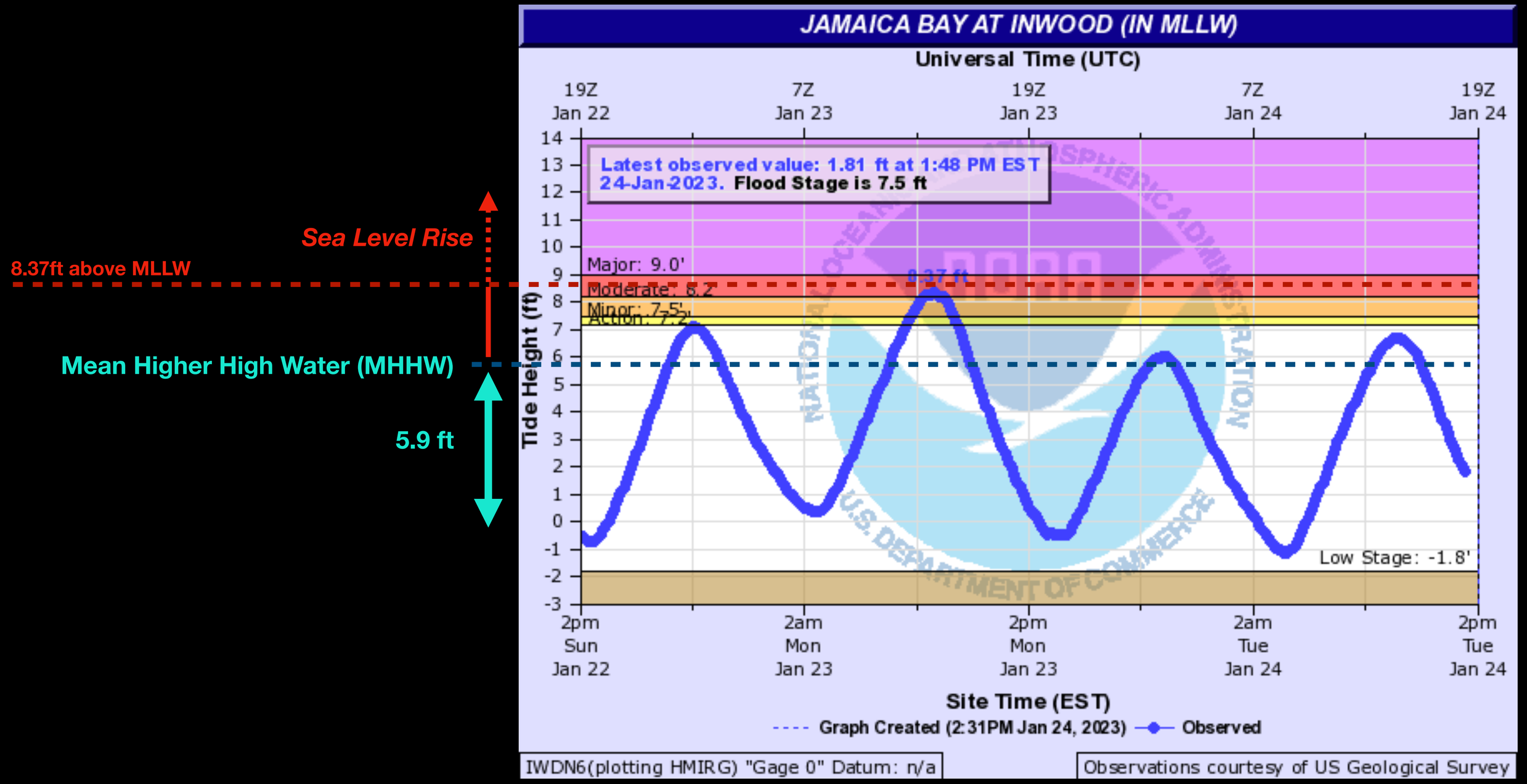
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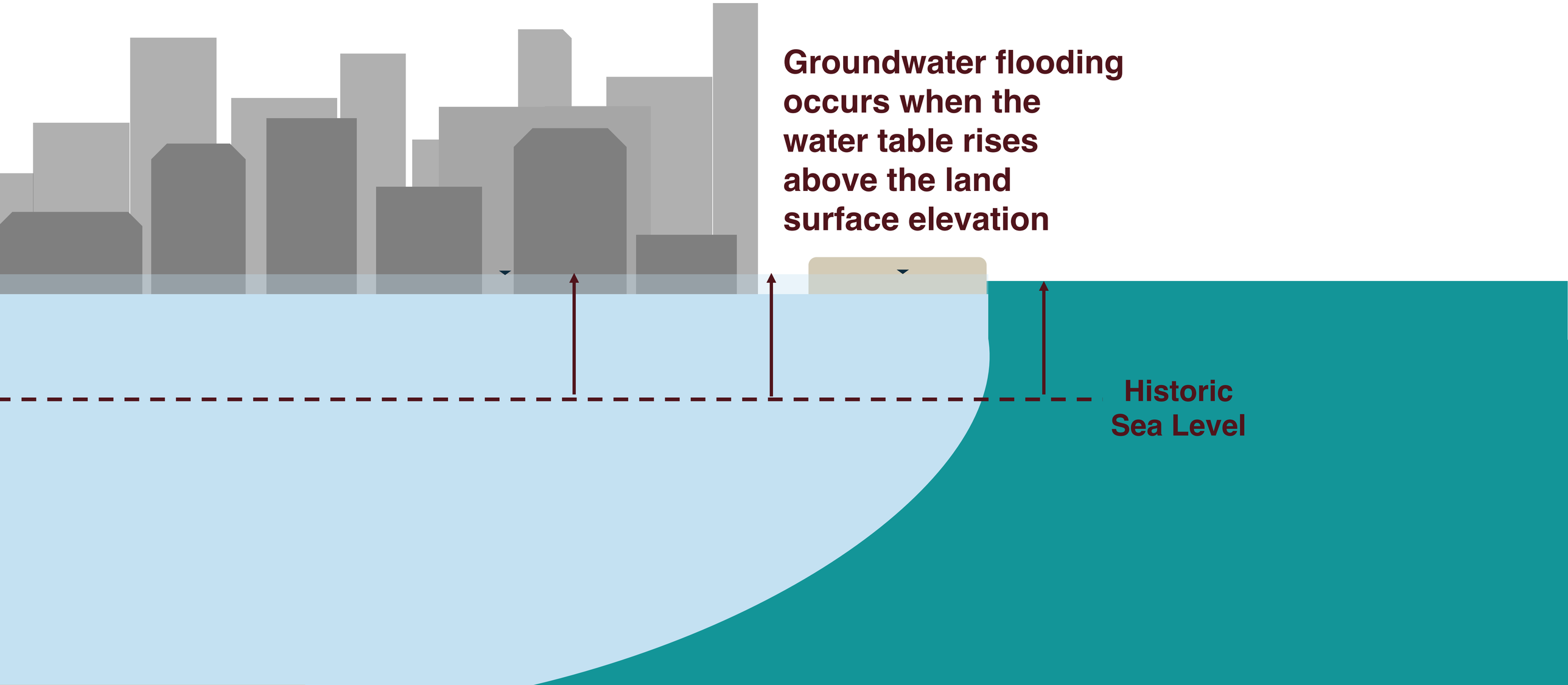
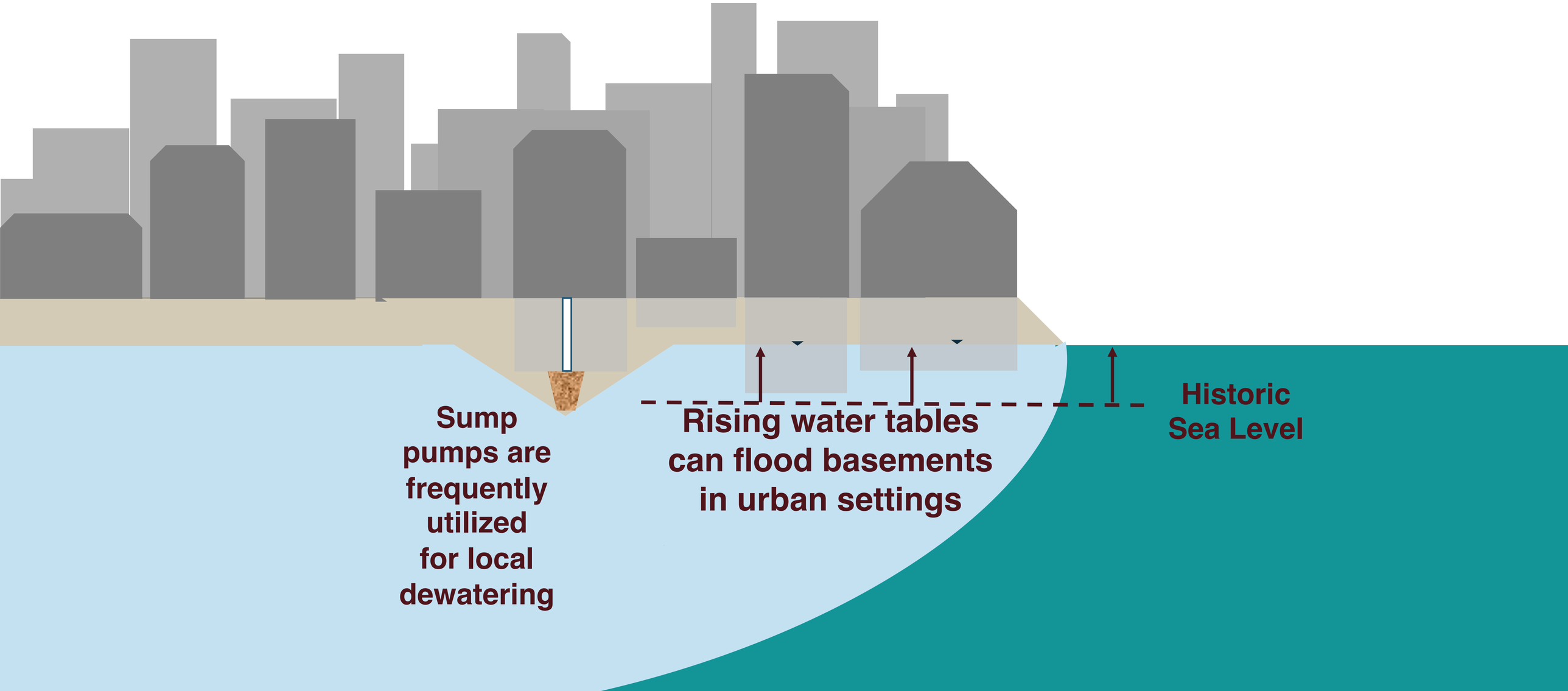
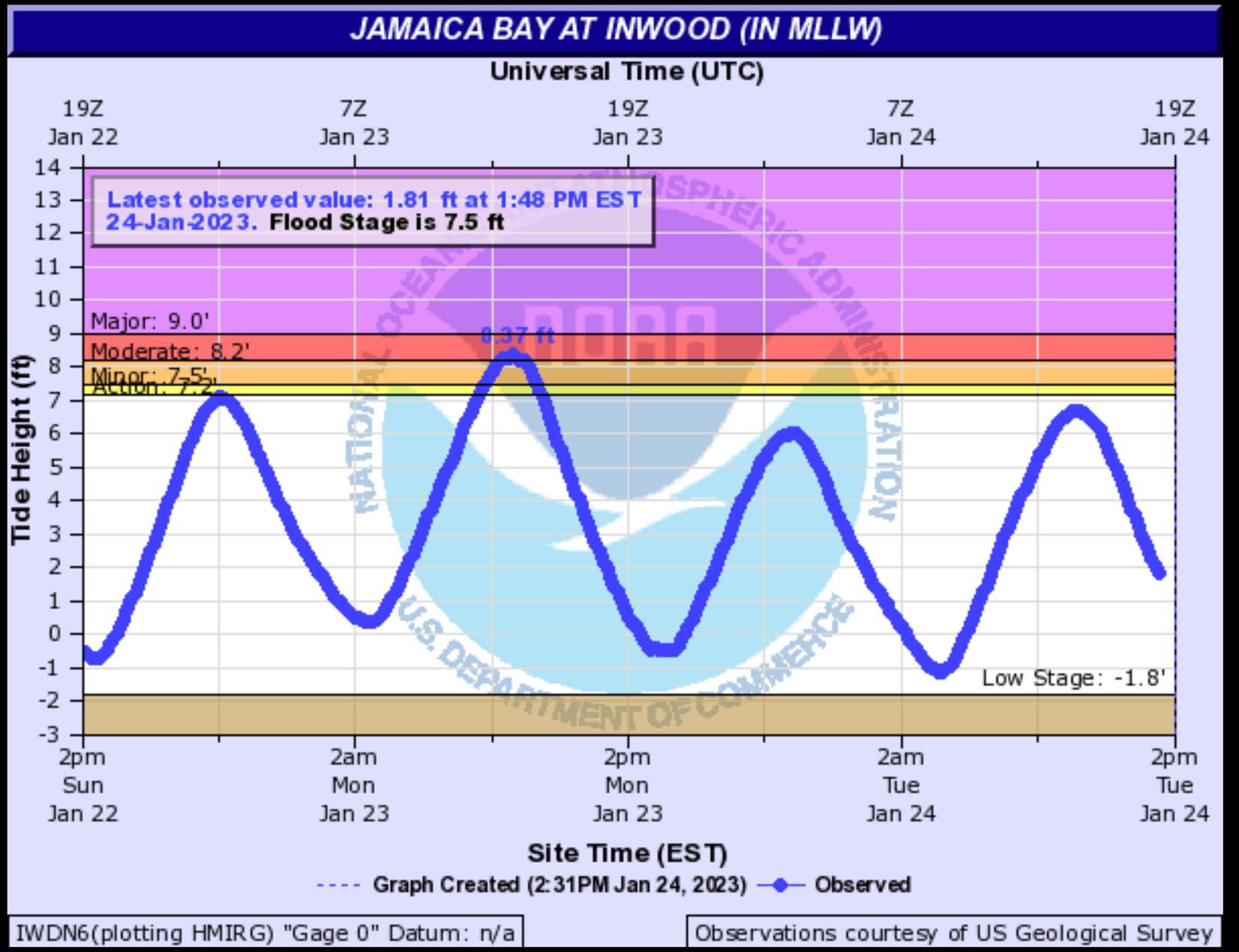
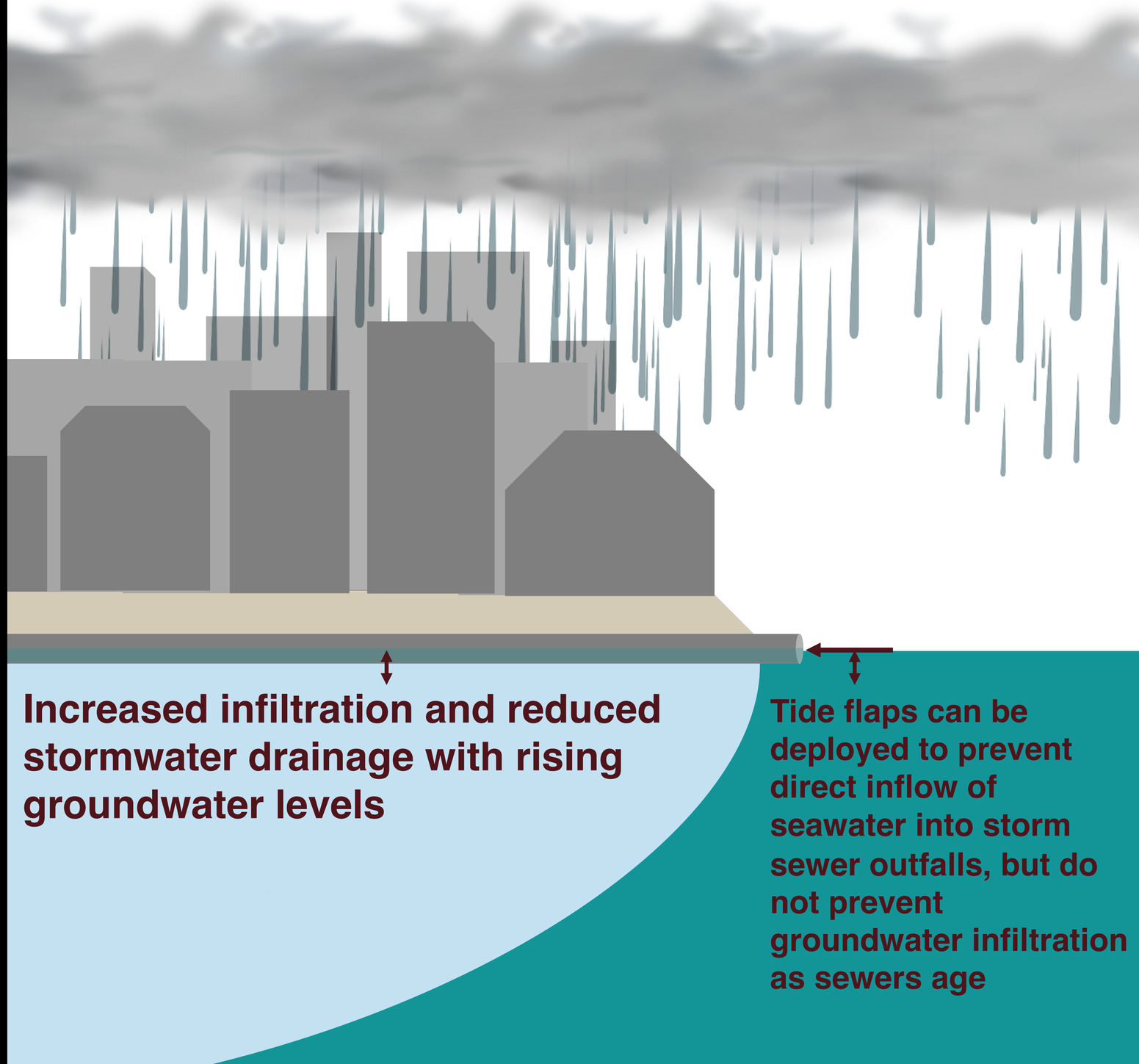

Groundwater flooding occurs when the water table rises above the land surface elevation
Historic Sea Level


Sump pumps are frequently utilized for local dewatering
Rising water tables can flood basements in urban settings
Historic Sea Level

Coastal Flood Stages

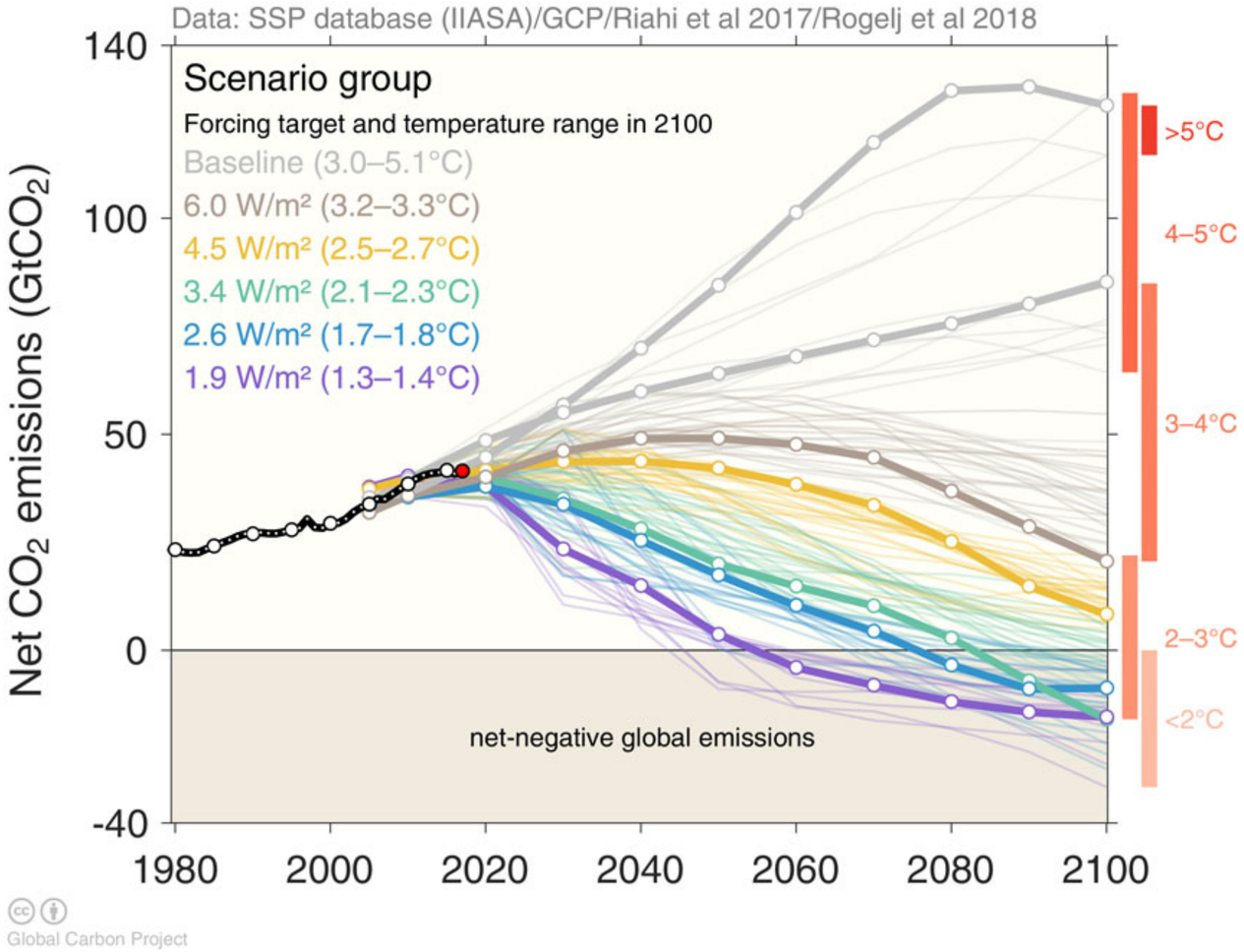
Harbor water levels that will result in flooding…. But are not set in stone. These can be changed through local adaptation measures.

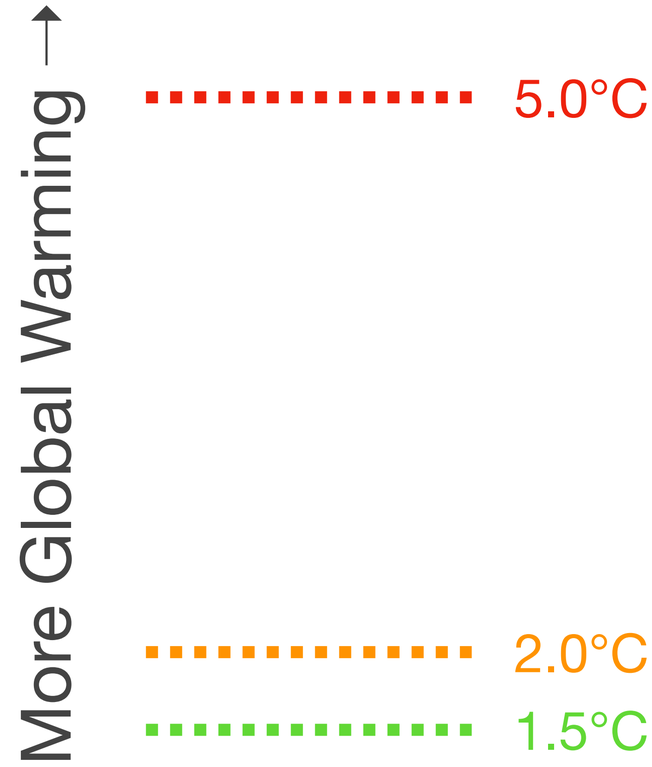



Increased infiltration and reduced stormwater drainage with rising groundwater levels
Tide flaps can be deployed to prevent direct inflow of seawater into storm sewer outfalls, but do not prevent groundwater infiltration as sewers age

Sea Level Rise Projections

Are dependent on global emissions of greenhouse gases. Climate change mitigation can reduce the likelihood of higher sea level rise scenarios.





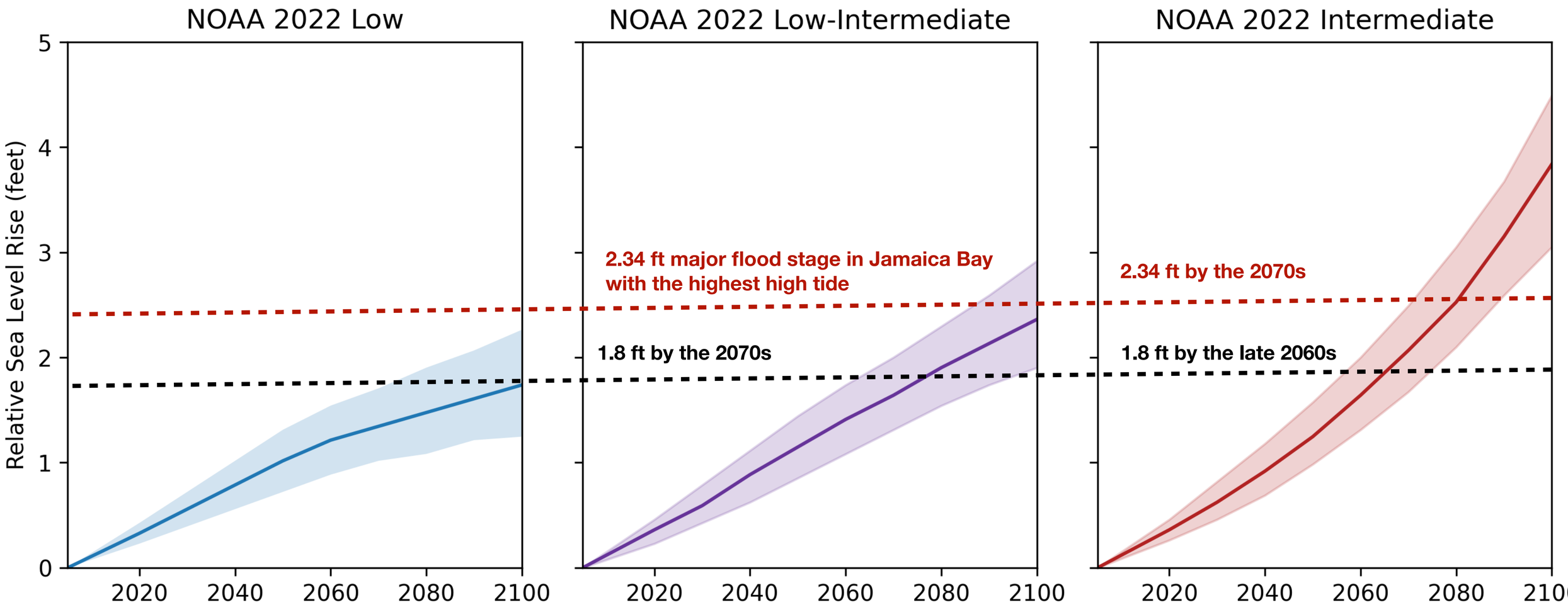
Sea Level Rise Exceedance Probability

1.5°C end-century warming *(SSP1-2.6 immediate, rapid energy transition)*

92%

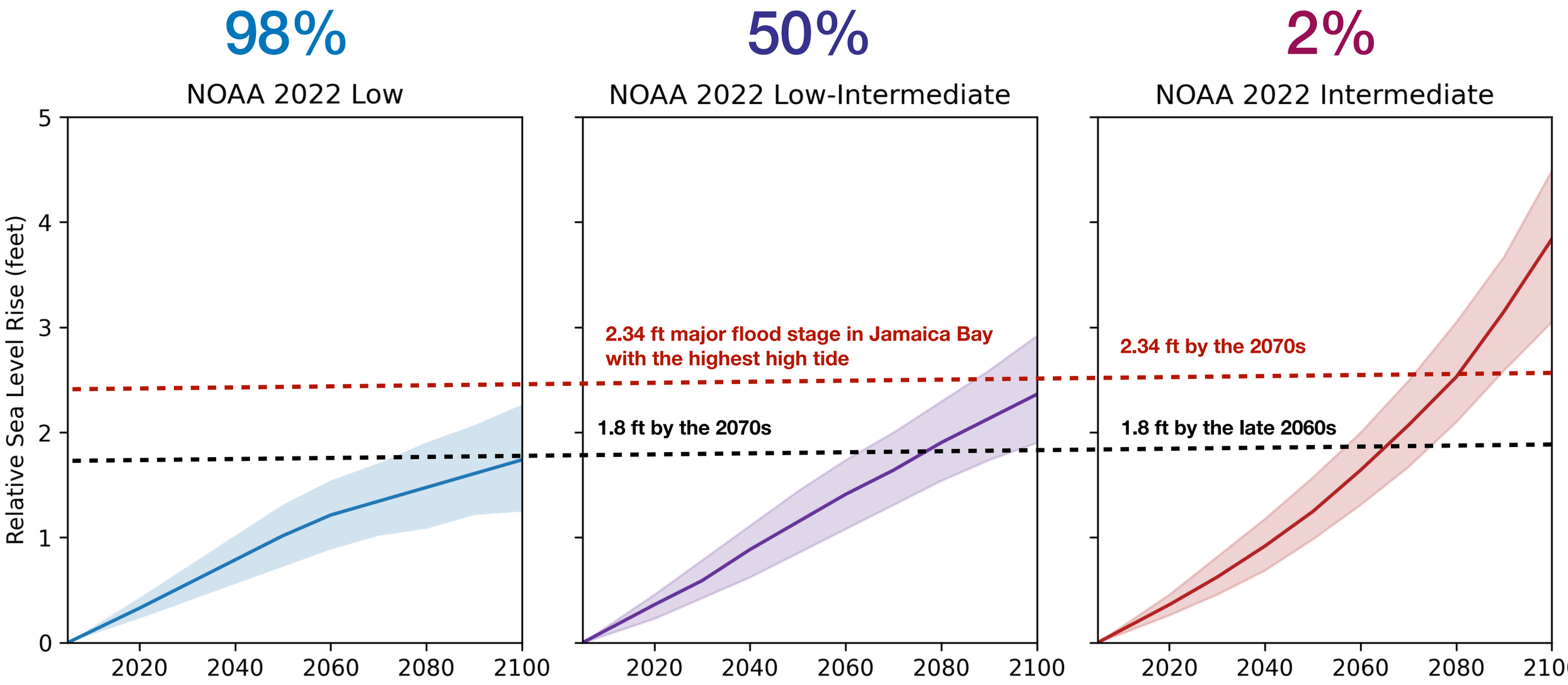
37%

<1%



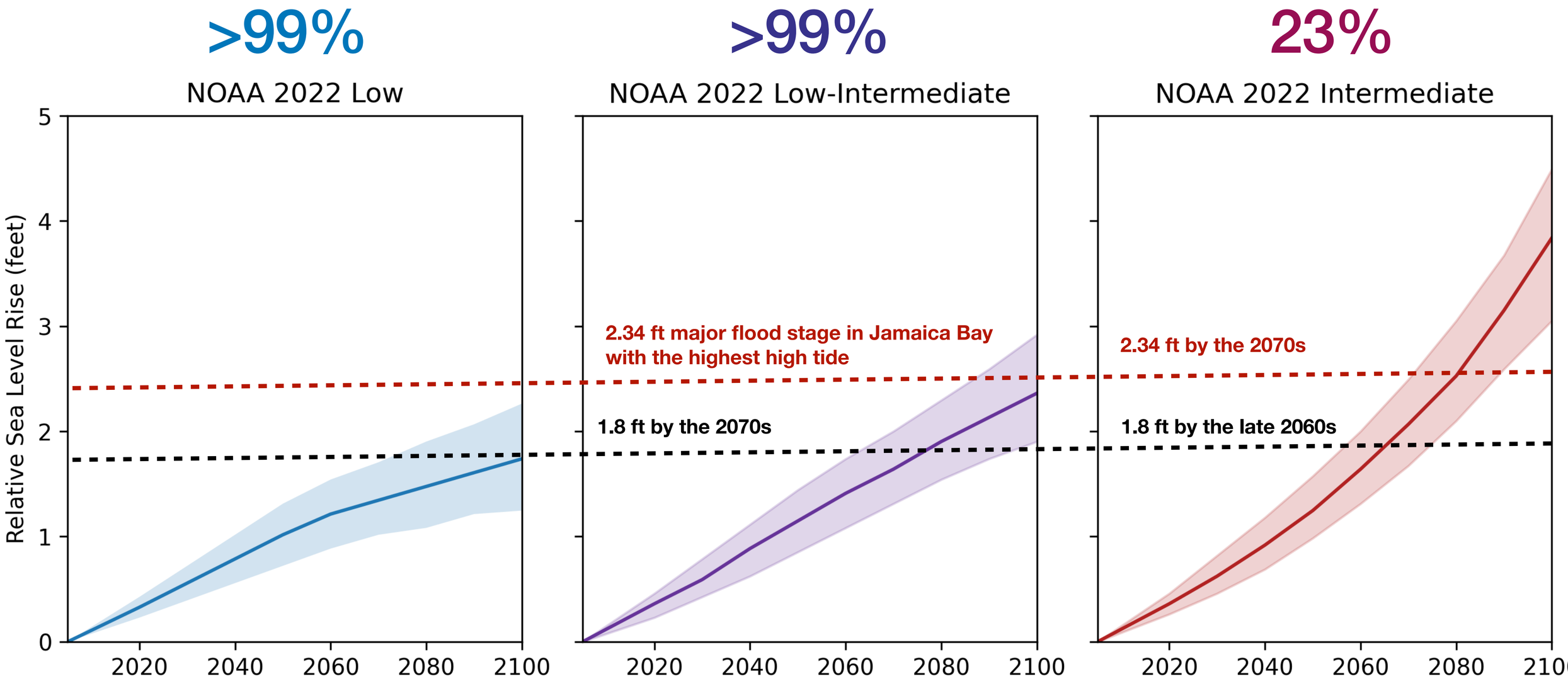
Sea Level Rise Exceedance Probability

2.0°C end-century warming *(SSP1-2.6 to SSP2.6-4.5 - near-term energy transition)*



Sea Level Rise Exceedance Probability

5.0°C end-century warming *(SSP8.5 high emissions + feedbacks)*



Summary

- In New York City, climate change will result in:
  - More hot days
  - More intense precipitation
  - Sea level rise
- Adaptation will be necessarily to manage the impacts of these amplified hazards
- Global warming mitigation is critical for avoiding more severe climate change pathways

Long Island City, NY, August 2022