Indicator Reference Sheet – March 6, 2022

Hurricane Storm Surge Zone

U.S. Environmental Protection Agency

Indicator Names in RPS Tool

- *% Hurricane Storm Surge Zone (Category 2) in Watershed*
- *% Hurricane Storm Surge Zone (Category 4) in Watershed*

Indicator Category | **Stressor**

Subcategory | *Flood Inundation Risk*

Available in RPS Tool files for all lower 48 states

Indicator Description

Background

Hurricane storm surge refers to the rise in ocean levels that occurs as hurricanes approach the coast. The storm surge is primarily driven by high winds that blow along the ocean surface and cause water to collect and swell at the storm front. When a hurricane reaches the shore, the storm surge washes over the land, resulting in flooding and inundation of areas that are otherwise typically above water. Areas that become inundated due to the storm surge make up the *hurricane storm surge zone*.

What the Indicators Measure

These indicators measure the extent of the hurricane storm surge zone for Category 2 and Category 4 hurricanes in a HUC12 subwatershed:[*]

- ***% Hurricane Storm Surge Zone (Category 2) in Watershed*** – area of the hurricane storm surge zone in the HUC12 for a Category 2 hurricane, expressed as a percentage of the total HUC12 area (Figure 1). Category 2 hurricanes are storms with windspeeds between 96 to 110 miles per hour.
- ***% Hurricane Storm Surge Zone (Category 4) in Watershed*** – area of the hurricane storm surge zone in the HUC12 for a Category 4 hurricane, expressed as a percentage of the total HUC12 area. Category 4 hurricanes have winds between 130 to 156 miles per hour.

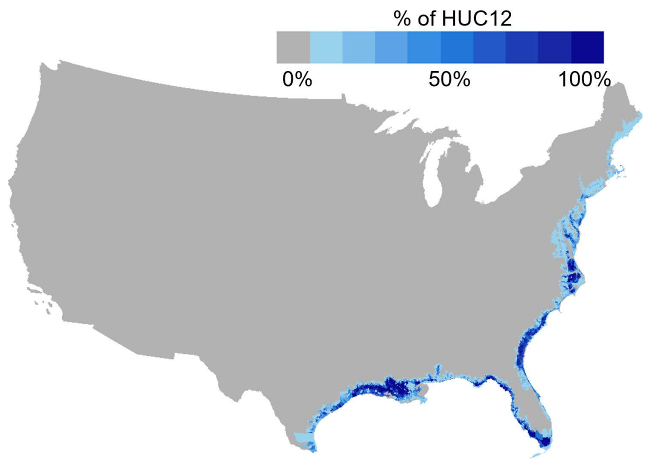

*Figure 1. Map of **% Hurricane Storm Surge Zone (Category 4) in Watershed** for HUC12s across the contiguous US.*

Relevance to Water Quality Restoration and Protection

A storm surge can be the most destructive[1] aspect of a hurricane, significantly affecting the flooded areas. Flooding from storm surges can degrade water quality by eroding soils and washing pollutants that have accumulated on the land surface into nearby streams, rivers, and other waterbodies. Like other types of flooding, storm surges can disrupt operations at sewage treatment plants and related facilities, leading to the discharge of inadequately treated wastewater into surface waters.[2]

Studies have found that excessive nutrient loading, algal blooms, depleted dissolved oxygen levels, animal displacements, chemical and debris pollution, and elevated pathogens can occur in coastal and inland waters following the passage of hurricanes.[3] The specific effects on a given location depend on the characteristics of the hurricane and human development in the area.[4-5]

Hurricane activity in the Atlantic Ocean has increased since 1970 in association with rising greenhouse gas emissions and temperatures.[5] Storm surge flooding may therefore become more common and widespread under a changing climate. Further, anticipated sea level rise along the Atlantic and Gulf Coast during the 21st century may intensify hurricane storm surges.[6,7] Other hurricane impacts such as heavier rains, combined with sea level rise may magnify the risk of storm surge impacts on current vulnerable areas.[8]

These indicators can be used to identify HUC12s that may be at greater risk for severe flooding and could be considered priorities for follow-up resilience planning and management. Additional indicators, such as the percentage of impervious cover or recent trends in developed land uses, can also be included in an evaluation of priority HUC12s to gain a more complete picture of the vulnerability of watersheds to flooding impacts.

Processing Method

These indicators are derived from storm surge projections developed by the National Oceanic and Atmospheric Administration (NOAA) National Hurricane Center using the Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model. The SLOSH model simulates representative storms for each hurricane category and maps the resulting

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[*] HUC12s are subwatershed delineations in the National Watershed Boundary Dataset. HUC12s are referenced by their 12-digit Hydrologic Unit Code.

depth and extent of storm surge inundation. The SLOSH map layers acquired from NOAA for HUC12 indicator analysis were published December 2016.

NOAA researchers have run several thousand simulated storms through SLOSH with varying characteristics like forward speed, landfall location, tide level, and trajectory. The results are aggregated to map the maximum extent of storm surge inundation for a given hurricane category, termed the Maximum of the Maximum Envelope of High Water (MOM). The MOMs are not storm specific (i.e., no single hurricane will produce the flooding depicted in the MOMs) but are instead intended to reflect the extent of the area that is subject to storm surge flooding over time.

To determine the extent of storm surge inundation in HUC12s, the SLOSH map layers of inundation extent for Category 2 and Category 4 hurricanes were overlayed with HUC12 boundaries. The inundated area was tabulated for each HUC12 and then converted to a percentage of total HUC12 area. An example overlay map of HUC12 boundaries and storm surge zones is provided in Figure 2.

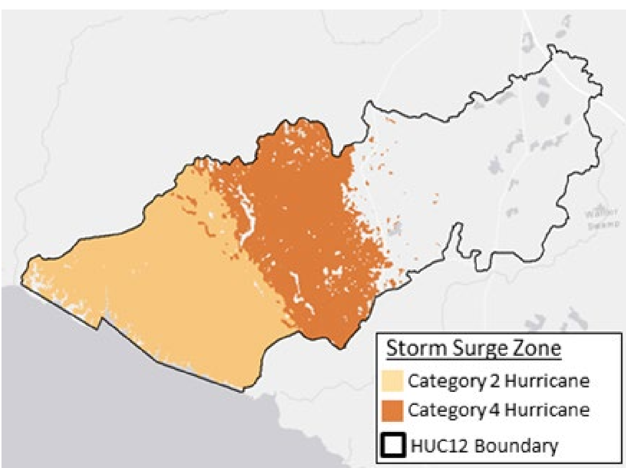

Figure 2. Overlay of storm surge inundation map layers and HUC12 boundaries for an example coastal HUC12.

Limitations

- These indicators measure the extent of areas with any hurricane storm surge inundation. They do not differentiate between the depth of inundation in flooded areas, which ranges from 1 to over 20 feet above ground in SLOSH model map layers.
- The SLOSH model does not account for future sea-level change or future shoreline changes that can occur with rising sea levels, which may affect inundation patterns.
- The map layers used to calculate these indicators are constrained by the geographic extent of SLOSH model simulations, and storm surge flooding could extend into areas not covered by the model extent.
- Readers should be aware that these indicators are only relevant to regions of the US where hurricanes occur (Atlantic and Gulf coasts).
- These indicators only reflect flood risk due to hurricane storm surge. Flooding and associated impacts can also result from heavy precipitation during hurricanes or during other storm events.

Links to Access Data and Additional Information

HUC12 indicator data can be accessed within the EPA Restoration and Protection Screening (RPS) Tool, in downloadable data files, or as a web service. Visit the EPA RPS website for links to access the RPS Tool, HUC12 indicator database, and web service.

The SLOSH model storm surge map layers used to calculate these indicators can be accessed from the NOAA National Storm Surge Hazard Maps website.

References

[1]NOAA. 2021. Storm Surges Can Be Deadly.

[2]Swanson, R., et al. 2017. Environmental consequences of the flooding of the Bay Park Sewage Treatment Plant during Superstorm Sandy. *Marine Pollution Bulletin*. 121(1-2): 120-134.

[3]Greening, H., et al. 2006. Hurricane impacts on coastal ecosystems. *Estuaries and Coasts*. 29(6): 877-879.

[4]Mallin, M., et al. 2006. How hurricane attributes determine the extent of environmental effects: Multiple hurricanes and different coastal systems. *Estuaries and Coasts*. 29(6): 1046–1061.

[5]Kiaghadi, A., et al. 2017. Development of a storm surge driven water quality model to simulate spills during hurricanes. *Marine Pollution Bulletin*. 129(2): 714-728.

[6]USGCRP. 2018. Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.

[7]Neumann, J., et al. 2015. Joint effects of storm surge and sea-level rise on US Coasts: new economic estimates of impacts, adaptation, and benefits of mitigation policy. *Climatic Change*. 129(1): 337-349.

[8]Lin, N., et al. 2012. Physically based assessment of hurricane surge threat under climate change. *Nature Climate Change*. 2(6): 462-467.