Planning for Sea Level Rise in the Matanzas Basin

Appendix B:

Storm Surge Hazus Modeling for the Matanzas Basin

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METHODS

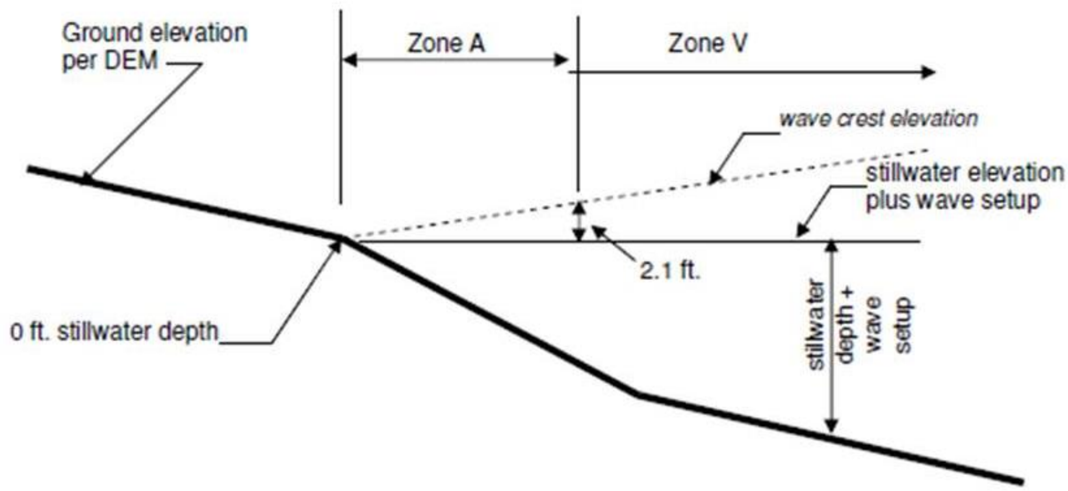
As a complimentary analysis to the sea level rise vulnerability, conservation, and future development scenario analyses conducted in the Matanzas basin, storm surge modeling was completed for Flagler and St Johns Counties. HAZUS software was used to generate models depicting a 100 year storm surge based on current sea levels (base storm surge), 100 year storm surge with a 0.5m rise in sea levels, and 100 year storm surge with a 1m sea level rise.

According to NOAA, factors determining storm surge height include: 1) central pressure, 2) intensity, 3) forward speed, 4) size of the storm, 5) the angle of the storm's approach with the coastline, 6) the shape of the coastline, 7) the width and slope of the ocean bottom, and 8) local features on or along the coastline. The following bulleted summarizes the 8 storm surge factors:

- **"The central pressure of the storm** – the lower the storm's central pressure the higher the storm surge because the ocean water level rises as a result of decrease atmospheric pressure on the water. However, NOAA indicates that the impact of central pressure on the storm surge height is minimal.
- **The storm's intensity**, other factors held constant, increases the height of the storm surge. Generally, the larger storms result in increased storm surge because a larger storm affects the ocean's water surface over a larger area. For example Katrina was a much larger storm at landfall than Charley.
- **Faster storms**, making landfall on open coastline, will produce a higher surge. However, a higher surge is produced in bays, sounds, and other enclosed bodies of water with a slower storm.
- **The angle of the storm**; as the storm approaches the coastline the angle of the storm with the coastline has an impact on the storm surge height. Storms that form a perpendicular angle with the coastline produce a higher storm surge than a storm that approaches parallel to the coastline.
- **The shape of the coastline** has an impact on the height of the storm surge. A coastline that curves inward produces a higher storm surge than a coastline that curves outward.
- **The width and shape of the ocean bottom** impacts the height of the storm surge. Higher storm surge occurs with wide, gently sloping continental shelves, while lower storm surge occurs with narrow, steeply sloping shelves. Areas along the Gulf Coast, especially Louisiana and Mississippi, are particularly vulnerable to storm surge because the ocean floor gradually deepens offshore. Conversely, areas such as the east coast of Florida have a steeper shelf, and storm surge is not as high.
- **The local features of the coastline** highly influence storm surge. Local features influence the flow of water with the storm surge and the distance the surge propagates inland. Features such as manmade barriers, dunes and coastal islands significantly impact storm surge."

HAZUS implements the previous factors within its modeling but requires only the Flood Insurance Study (FIS) Stillwater Elevation Level (SWEL) to accomplish basic modeling. Figure 1 shows the HAZUS concept for modeling coastal inundation commonly referred to as storm surge. There are many terms included in the SWEL for HAZUS including tide, storm pressure, direction, size, and wave set-up. The wave set-up is an elevation identifying a portion of the wave's height created by the storm but lower than the wave crest elevation and its value is part of the SWEL unless stated in the FIS. HAZUS also calculates the wave crest elevation once the FIS SWEL is provided for the model.

Two important areas associated with a storm surge are the FEMA Zones "A" and "V". Zone "V" areas are areas along coasts subject to inundation by the 1-percent-annual-chance flood event with additional hazards associated with storm-induced waves. Mandatory flood insurance purchase requirements and floodplain management standards apply (FEMA). Zone "A" areas are areas along coasts subject to inundation by the 1-percent-annual-chance flood event with no additional hazards associated with storm-induced waves. Mandatory flood insurance purchase requirements and floodplain management standards also apply in these areas (FEMA).



HAZUS Wave Height Model – Relationship between Wave Crest, Stillwater Flood Depth and Wave Setup

Figure 1: The HAZUS concept for modeling coastal inundation commonly referred to a storm surge.

The base HAZUS coastal flood model generates a flood depth surface, a SWEL surface, and a wave crest surface to assist in identifying the boundary location for the overall inundation area, and the boundary for Zones "A" and "V". The model accomplishes this task by identifying the difference between SWEL and the ground elevation DEM (Figure 2) using sample transects perpendicular to the coastline (Figure 3). The sample transect locations are also used to determine wave height and wave crest height at locations along the coastline (Figure 4).

Finally, the model uses census storm surge depth and extent (Figure 5) data to estimate some critical impacts for the storm; such as building related loss estimates, debris generation estimates, shelter requirements for displaced households, essential facilities impacts, and economic loss including business interruption. *Figures 2-5 are not from locations within the Matanzas study area, and are only included for illustrative purposes.*

Figure 2: Digital Elevation Model (DEM) showing ground elevations. The ground elevations are shown from dark green to dark brown. The lowest ground elevations are shown in dark green and the highest ground elevations are in dark brown.

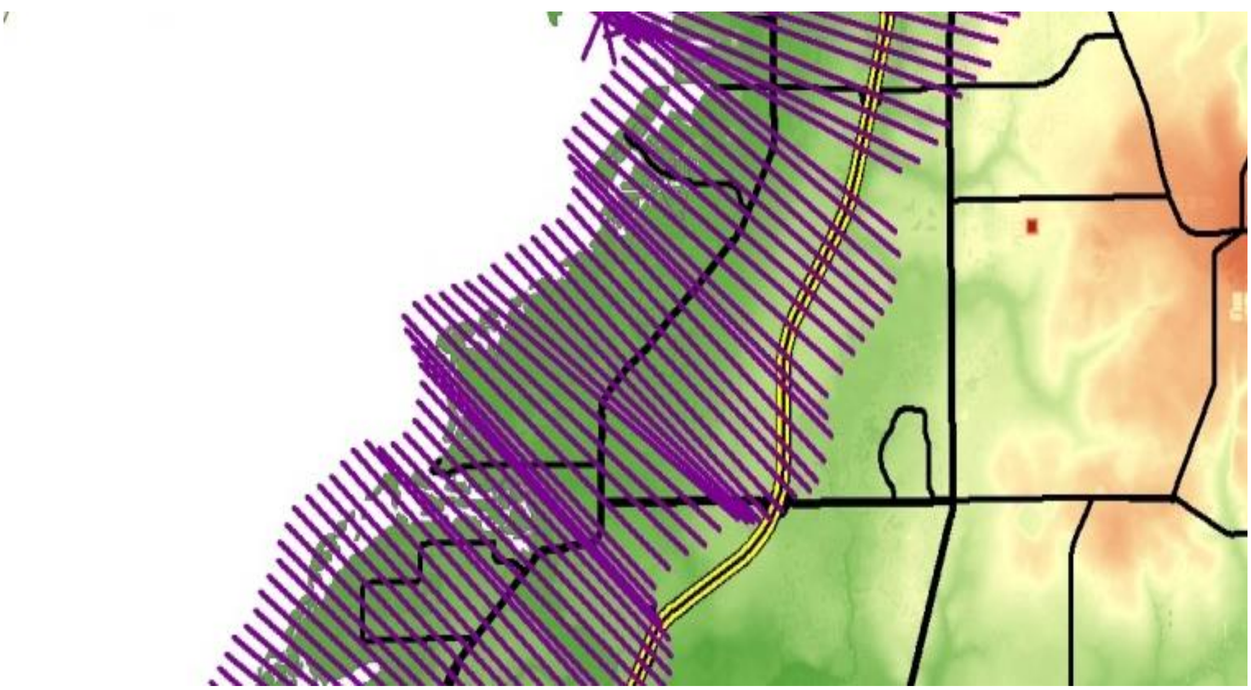


Figure 3: Sample transect locations in the same area as Figure 2. The purple transects are employed to select elevation samples from the DEM for HAZUS storm surge modeling.

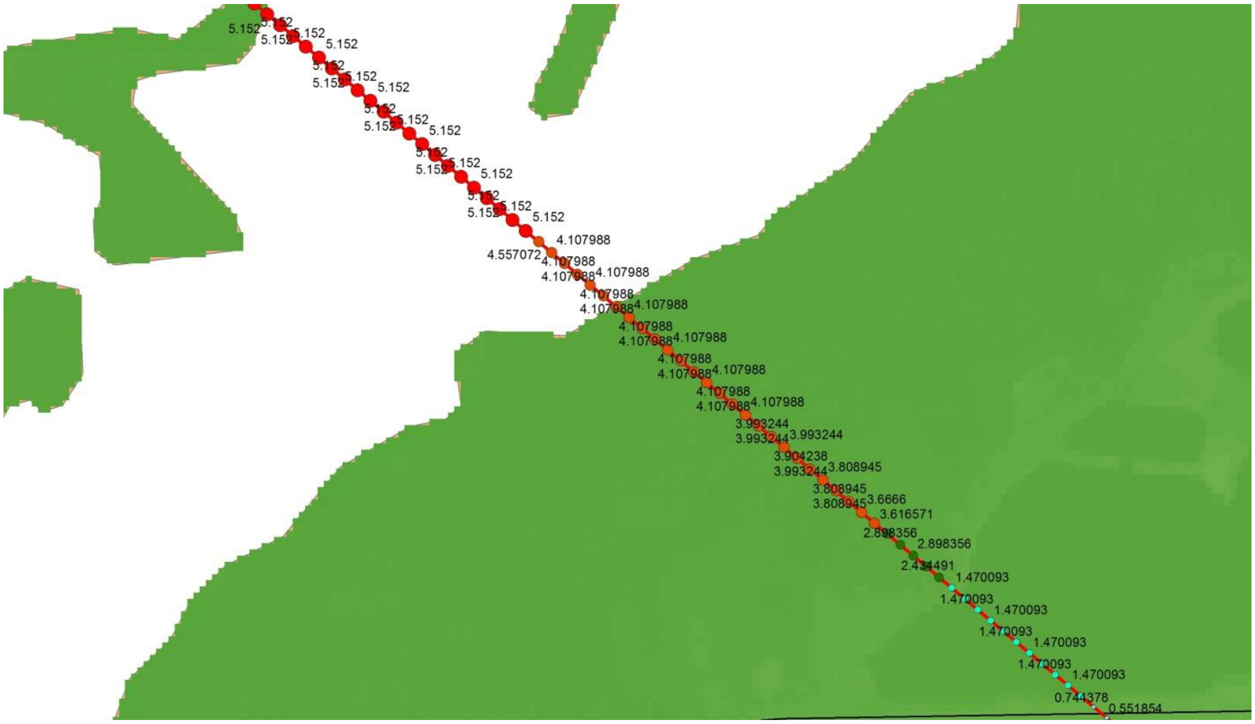


Figure 4: Transect wave crest heights along a selected transect example. The highest wave crest heights are shown at the furthest seaward locations in red while the lowest wave crest heights are shown in light blue at the furthest inland locations.

Figure 5: Storm surge depth surface with largest depth shown in darker blue and lowest depth shown in light blue.

RESULTS

Impacts from base storm surge, as well as storm surge after 0.5m and 1m sea level rise are summarized in Table 1 and Figures 6-7 below. A base 100 year storm surge will have significant impacts within both counties in terms of the total terrestrial acreage inundated. Sea level rise causes a significant increase in impacted acreage, particularly in inland areas adjacent to the St Johns River, potentially impacting extensive areas of agricultural and conservation land. In coastal areas, even a base storm surge will have significant impacts to the population centers of Palm Coast and St Augustine, including the historically and culturally significant core of St Augustine. In coastal areas, the total acreage of areas impacted by storm surge does not increase significantly as sea level rises, most likely due to the coastal geomorphology and inland dune structure. However water depth will increase, potentially causing more severe impacts in the areas that are inundated.

Within the GTM NERR and contiguous conservation lands, results are similar in that the number of acres impacted by storm surge does not increase significantly with sea level rise. However a significant percentage of the GTM is impacted by storm surge relative to current acreage (see Table 1 and Figure 7).

Table 1. Cumulative storm surge impacts (acres) for base 100yr storm surge, and storm surge with 0.5m and 1m sea level rise.

	Existing Acres	Base Storm Surge	0.5m SLR Storm Surge	1m SLR Storm Surge	Percent Existing Acres Inundated by 1m SLR Storm Surge
Flagler County	310,694 (land only)	35,665	48,015	60,087	19%
St Johns County	384,422 (land only)	67,461	80,123	90,732	24%
Existing Developed Lands*	69,007	13,376	16,741	19,366	28%
GTM NERR	29,457	11,953	12,537	13,052	44%

*Based on 2010 parcel data including residential, commercial, industrial, institutional, and related developed land uses. Total acreage is an estimate based on this classification, and does not reflect the most current land use as of 2015.

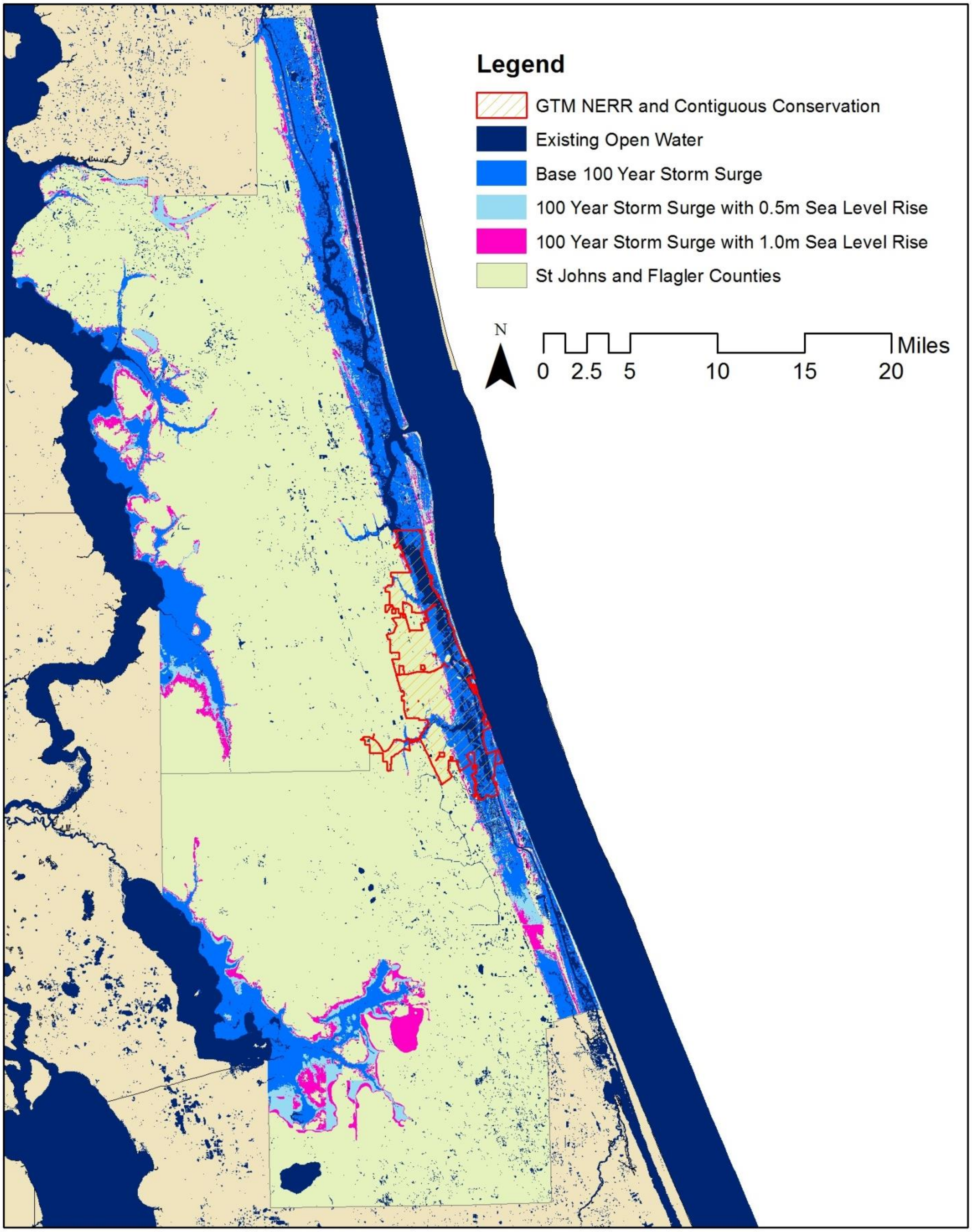


Figure 6. Storm surge impacts at current sea levels, 0.5m, and 1.0m sea level rise in St Johns and Flagler Counties

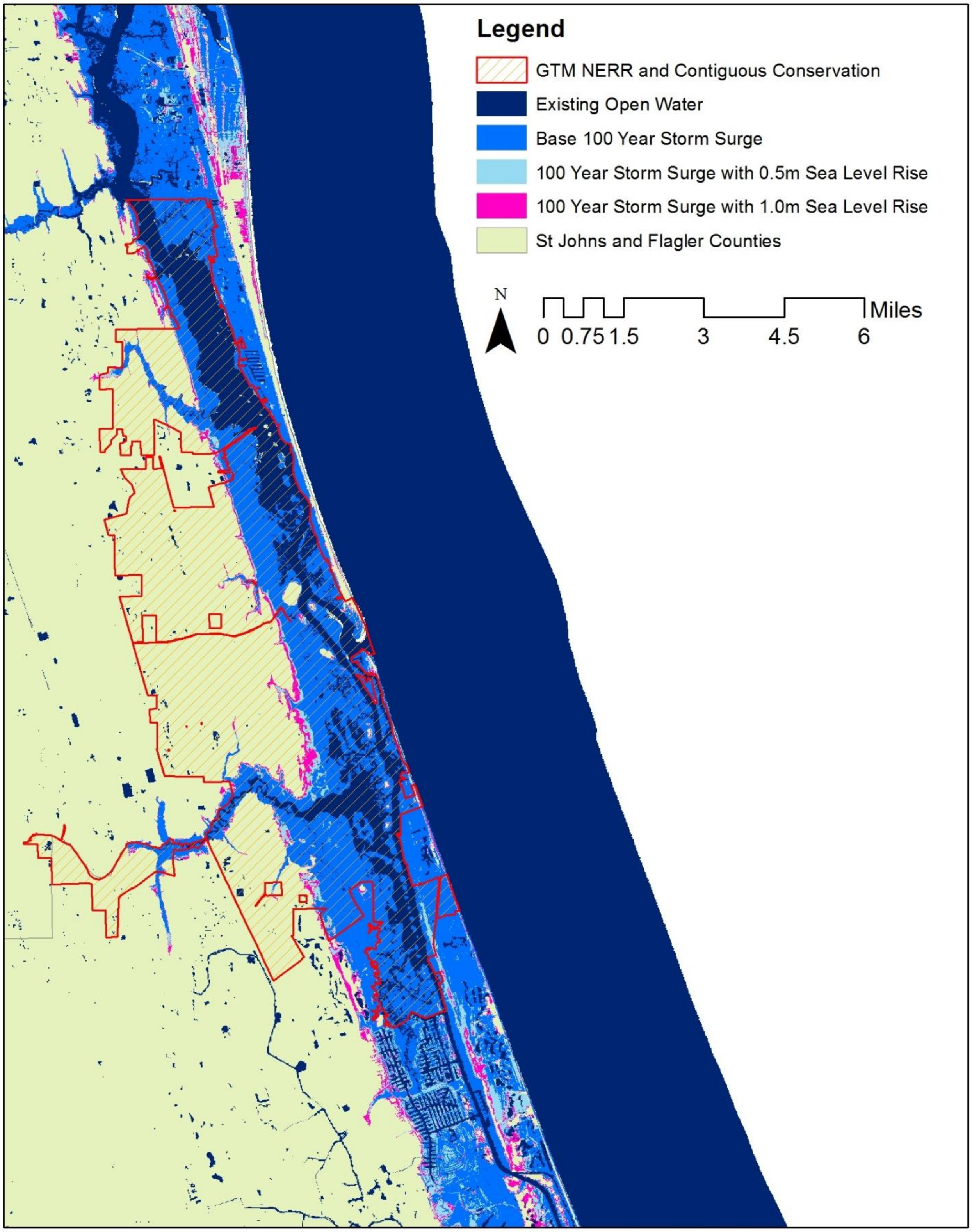


Figure 7. Storm surge impacts at current sea levels, 0.5m, and 1.0m sea level rise within the GTM NERR and contiguous conservation lands.