



# Coastal Hazards & Sea-Level Rise Asset Vulnerability Assessment for Fort Frederica National Monument

## *Summary of Results*

NPS 369/186747, November 2022



PROGRAM FOR  
THE STUDY OF  
DEVELOPED  
SHORELINES

Western  
Carolina  
UNIVERSITY

**ON THE COVER**

Fortification ruins at Fort Frederica National Monument

Photo credit: Program for the Study of Developed Shorelines at Western Carolina University

---

# Coastal Hazards & Sea-Level Rise Asset Vulnerability Assessment for Fort Frederica National Monument

## *Summary of Results*

NPS 369/186747, November 2022

Program for the Study of Developed Shorelines  
Western Carolina University  
Cullowhee, North Carolina 28723

*This document has been developed by the NPS Climate Change Response Program and Park Facilities Management Division in partnership with Western Carolina University through a Task Agreement with the Southern Appalachian Cooperative Ecosystems Studies Unit.*

Please cite this publication as:

Peek, K.M., H.L. Thompson, B.R. Tormey, and R.S. Young. 2022. Coastal Hazards & Sea-Level Rise Asset Vulnerability Assessment for Fort Frederica National Monument: Summary of Results. NPS 369/186747. Program for the Study of Developed Shorelines, Western Carolina University, Cullowhee, N.C.

# Executive Summary

This document presents the results of the **Coastal Hazards & Sea-Level Rise (SLR) Asset Vulnerability Assessment (VA)** completed by Western Carolina University at Fort Frederica National Monument (FOFR) in 2021. In this VA, we evaluate the vulnerability (as a combination of exposure and sensitivity) of NPS buildings and transportation assets<sup>1</sup> to identified coastal hazards and climate change factors, approximately to the year 2050 (for full methodology, see Peek et al. 2022).

We assessed 19 buildings (including barns, storage/maintenance, ruins, and other fortification-related structures) and 9 transportation assets (roads, parking lots, and a waterfront) at FOFR. Approximately one-third (32%) of assets analyzed have high or moderate vulnerability to the evaluated coastal hazards and SLR, while the majority (68%) of assets have low vulnerability. Scoring details and results for all assets evaluated at FOFR are reported in the provided Excel sheets.

## Exposure Results

Exposure is a measure of the character, magnitude, and rate of changes a target may experience (e.g., from the impacts of climate change or a natural hazard influenced by climate change; NPS 2021). In this VA, we evaluate the exposure of each asset to the following coastal hazard indicators: flooding potential, shoreline change, SLR inundation, extreme event flooding, and reported coastal hazards (Table 1).

**Table 1.** Exposure indicators and hazard data sources used.

<b>Exposure Indicator (Description)</b>	<b>FOFR Data (Citation)</b>
Flooding potential (1% annual-chance)	Effective FEMA VE & A zones (FEMA 2018)
Shoreline change (coastal proximity)	35-m shoreline proximity buffer (Peek et al. 2022)
SLR inundation (2050 proxy) *	NPS 2100 4.5 RCP SLR model; 0.56 m rise (Caffrey et al. 2018)
Extreme event flooding (category 3 surge)	NPS storm surge inundation model (Caffrey et al. 2018)
Reported coastal hazards (historic flooding)	Questionnaire results & discussions (Peek et al. 2022)

\*See Unique Considerations

Assets with high exposure are within at least four exposure indicator hazard zones. Assets with moderate exposure are within two or three exposure indicator hazard zones. Assets with low

---

<sup>1</sup> The NPS Facility Management Software System (FMSS) database defines assets as “...a physical structure or grouping of structures, land features, or other tangible property that has a specific service or function, such as a farm, cemetery, campground, marina, or sewage treatment plant. The term ‘asset’ shall also be applied to movable items, such as vehicles and equipment.”

exposure are within only one exposure indicator hazard zone. The asset could still be seriously impacted by this hazard. Assets with minimal exposure are not in any exposure indicator hazard zone. This does not mean that the asset has no exposure to coastal hazards, but it is not within the exposure hazard data used in this study.

Approximately one-third (32%) of assets analyzed at FOFR have either high or moderate exposure to the evaluated coastal hazards (Table 2). Two assets, the Fort Ruins and Frederica River Waterfront, are within all evaluated exposure zones. Most assets (68%) have low exposure; these results are because most assets are outside all exposure hazards zones (except Category 3 storm surge).

**Table 2.** FOFR exposure results. Sum of percentages may not equal 100 due to rounding.

Assets	High Exposure		Moderate Exposure		Low Exposure		Minimal Exposure		Total
	#	%	#	%	#	%	#	%	#
Buildings	2	11%	2	11%	15	79%	0	0%	19
Transportation	1	11%	4	44%	4	44%	0	0%	9
All Assets	3	11%	6	21%	19	68%	0	0%	28

## Sensitivity Results

Sensitivity reflects the degree to which a resource is affected by exposure (NPS 2021). In this VA, we assess the following sensitivity indicators: flood damage potential/elevated, storm resistance and condition, historic damage, and protective engineering. In general, assets with high sensitivity have unfavorable determinations for 3 or 4 of these indicators, moderate-sensitivity assets have unfavorable determinations for 2 indicators, and low-sensitivity assets have unfavorable determinations for 0 or 1 indicator. Assets with minimal exposure are not analyzed for sensitivity.

No assets have high sensitivity to coastal hazards and SLR at FOFR (Table 3). Most assets analyzed (96%) have moderate sensitivity; only one asset, the Powder Magazine, has low sensitivity. In most cases, assets are not significantly elevated above local ground level, have not been damaged in the past by coastal floods, and are in good condition.

**Table 3.** FOFR sensitivity results. Sum of percentages may not equal 100 due to rounding.

Assets	High Sensitivity		Moderate Sensitivity		Low Sensitivity		Total Analyzed	Excluded
	#	%	#	%	#	%	#	#
Buildings	0	0%	18	95%	1	5%	19	0
Transportation	0	0%	9	100%	0	0%	9	0
All Assets	0	0%	27	96%	1	4%	28	0

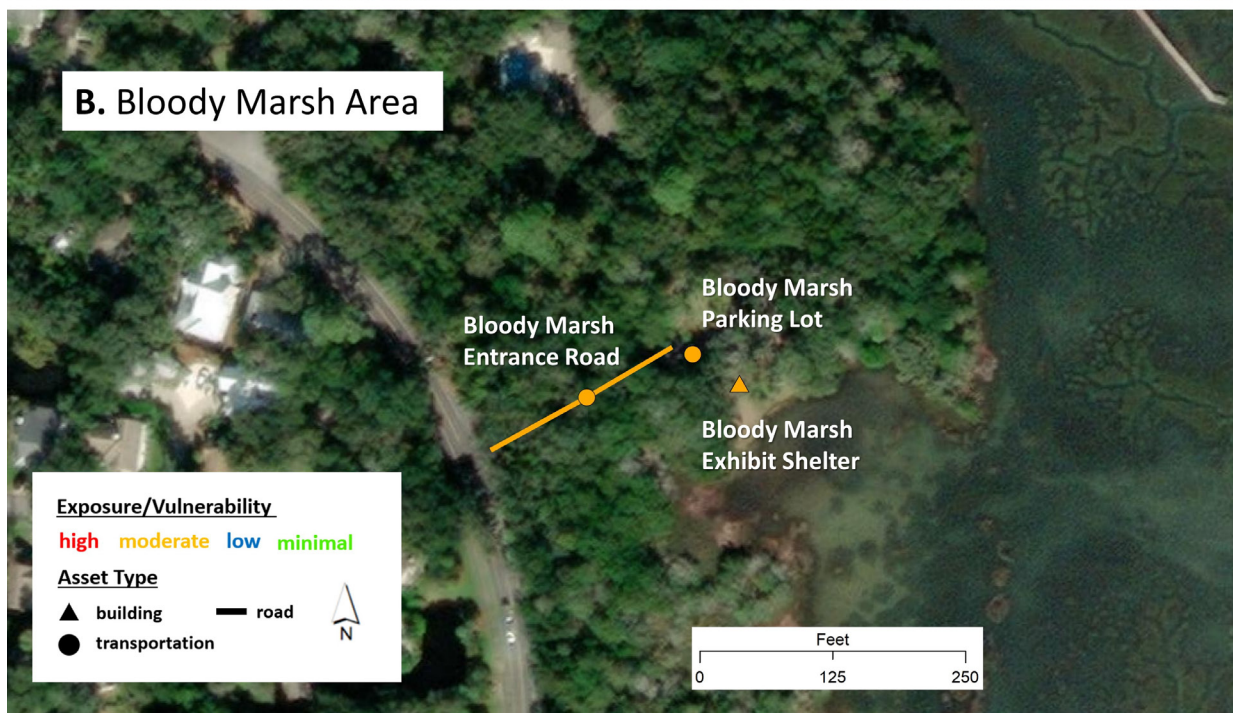
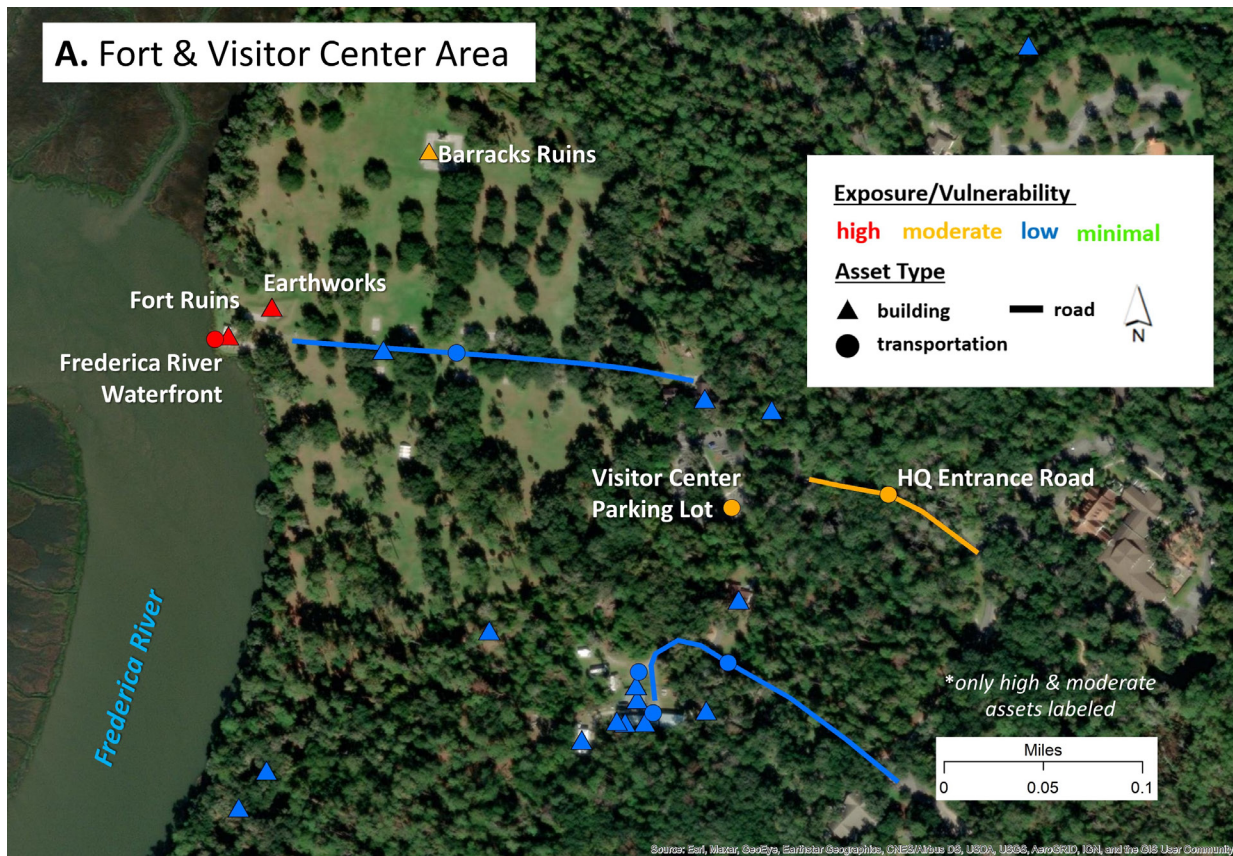
# Vulnerability Results

Vulnerability is a measure of the degree to which park resources and assets are “susceptible to harm from direct and indirect effects of climate change, including variability and extremes” (NPS 2021). In this VA, we evaluate the vulnerability of infrastructure assets as a simple combination of exposure and sensitivity ratings. It should be noted that the vulnerability of any asset can change with time (e.g., due to adaptation actions or the result of geomorphic change).

The vulnerability results at FOFR are identical to the exposure results, as all assets but one have moderate sensitivity (Table 4, Figure 1). This lack of variability in sensitivity means that the vulnerability of assets at FOFR is primarily controlled by exposure. Only the Fort Ruins, Earthworks, and Frederica River Waterfront have high vulnerability to the evaluated coastal hazards; these assets also have a high asset priority index (API > 80, as reported in FMSS). Six assets (21%) assets have moderate vulnerability, five of which have the highest possible API (100): Barracks Ruins, Visitor Center Parking Lot, HQ Entrance Road, Bloody Marsh Parking Lot, and Bloody Marsh Entrance Road. Most assets (68%) at FOFR have low vulnerability to the evaluated coastal hazards.

**Table 4.** FOFR vulnerability results. Sum of percentages may not equal 100 due to rounding.

Assets	High Vulnerability		Moderate Vulnerability		Low Vulnerability		Minimal Vulnerability		Total #
	#	%	#	%	#	%	#	%	
Buildings	2	11%	2	11%	15	79%	0	0%	19
Transportation	1	11%	4	44%	4	44%	0	0%	9
All Assets	3	11%	6	21%	19	68%	0	0%	28



**Figure 1.** FOFR exposure and vulnerability results. A) Results for the fortification and visitor center area; only high and moderate assets are labeled. B) Results for the Bloody Marsh area. Background is ESRI streaming imagery.

## FOFR Unique Considerations

**Shoreline change:** USGS (or other) shoreline erosion rate data are not available for FOFR, which has non-oceanfront coastlines. As a result, we used a simple coastal proximity buffer of 35 meters, which accommodates an erosion rate up to 1m/year and assumes that infrastructure near the coast is likely to experience multiple coastal hazards within the 35-year (approximately 2050) timeframe of this analysis (see Peek et al. 2022).

**SLR data:** We used the 2100 4.5 RCP SLR projection (0.56 m rise) and inundation model from Caffrey et al. (2018) developed specifically for NPS units to score exposure for this indicator. These data are used as a proxy for 2050 SLR to accommodate higher SLR projections recently released by NOAA (see Peek et al. 2022).

**Linear Features:** NPS-owned roads at FOFR were not segmented, as all are already short features (< 0.25 miles in length). Therefore, each road has only one score for exposure, sensitivity, and vulnerability. Any statistics or estimates of value represent the entire road, even if only a small portion has high exposure or vulnerability.

## References

- Caffrey, M., R.L. Beavers, and C. Hawkins Hoffman. 2018. Sea level rise and storm surge projections for the National Park Service. Natural Resource Report. NPS/NRSS/NRR—2018/1648. National Park Service. Fort Collins, Colorado. Available at: <https://irma.nps.gov/DataStore/Reference/Profile/2253283>.
- Federal Emergency Management Agency (FEMA). 2018. National Flood Hazard Layer. <https://www.fema.gov/flood-maps/national-flood-hazard-layer>. Accessed September 2020
- National Park Service (NPS). 2021. Coming to terms with climate change: Working definitions. National Park Service Climate Change Response Program, Fort Collins, Colorado.
- Peek, K.M., B.R. Tormey, H.L. Thompson, and R.S. Young. 2022. Coastal hazards & sea-level rise asset vulnerability assessment protocol: Updated project description & methodology. Natural Resource Report. NPS/NRSS/CCRP/NRR—2022/2427. National Park Service. Fort Collins, Colorado. Available at: <https://doi.org/10.36967/2293653>.





**EXPERIENCE YOUR AMERICA™**

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 369/186747, November 2022