Coastal Hazards & Sea-Level Rise Asset Vulnerability Assessment for Fort McHenry National Monument & Historic Shrine

Summary of Results

NPS 346/187361, January 2023

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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 McHenry National Monument and Historic Shrine (FOMC) in 2022. In this VA, we evaluate the vulnerability (as a combination of exposure and sensitivity) of NPS buildings and transportation assets[1] to identified coastal hazards and climate change factors, approximately to the year 2050 (for full methodology, see Peek et al. 2022).

We assessed 31 buildings (including a visitor center, maintenance buildings, magazines, barracks, quarters, batteries, walls, and other fortification-related structures), and 10 transportation assets (roads, parking lots, a trail, a boat ramp, and a dock) at FOMC. Only 12% of assets have high or moderate vulnerability to the evaluated coastal hazards and SLR, while the majority (78%) of assets have minimal vulnerability. Scoring details and results for all assets evaluated at FOMC 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.

Exposure Indicator (Description)	FOMC Data (Citation)
Flooding potential (1% annual-chance)	Effective FEMA VE & A zones (FEMA 2014)
Shoreline change (coastal proximity)	30-m shoreline proximity buffer (Peek et al. 2022)
SLR inundation (2050 proxy) *	NPS 2100 4.5 RCP SLR model; 0.62 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

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[1] 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."

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 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.

Four assets at FOMC have either high or moderate exposure to the evaluated coastal hazards (Table 2, and Figure 1). Two assets, the Seawall and the Water Taxi Dock (City of Baltimore), are the only assets within all evaluated exposure zones. Only five assets have low exposure, while 32 assets have minimal exposure.

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

Assets	High Exposure		Moderate Exposure		Low Exposure		Minimal Exposure		Total
	#	%	#	%	#	%	#	%	#
Buildings	1	3%	0	0%	3	10%	27	87%	31
Transportation	2	20%	1	10%	2	20%	5	50%	10
All Assets	3	7%	1	2%	5	12%	32	78%	41
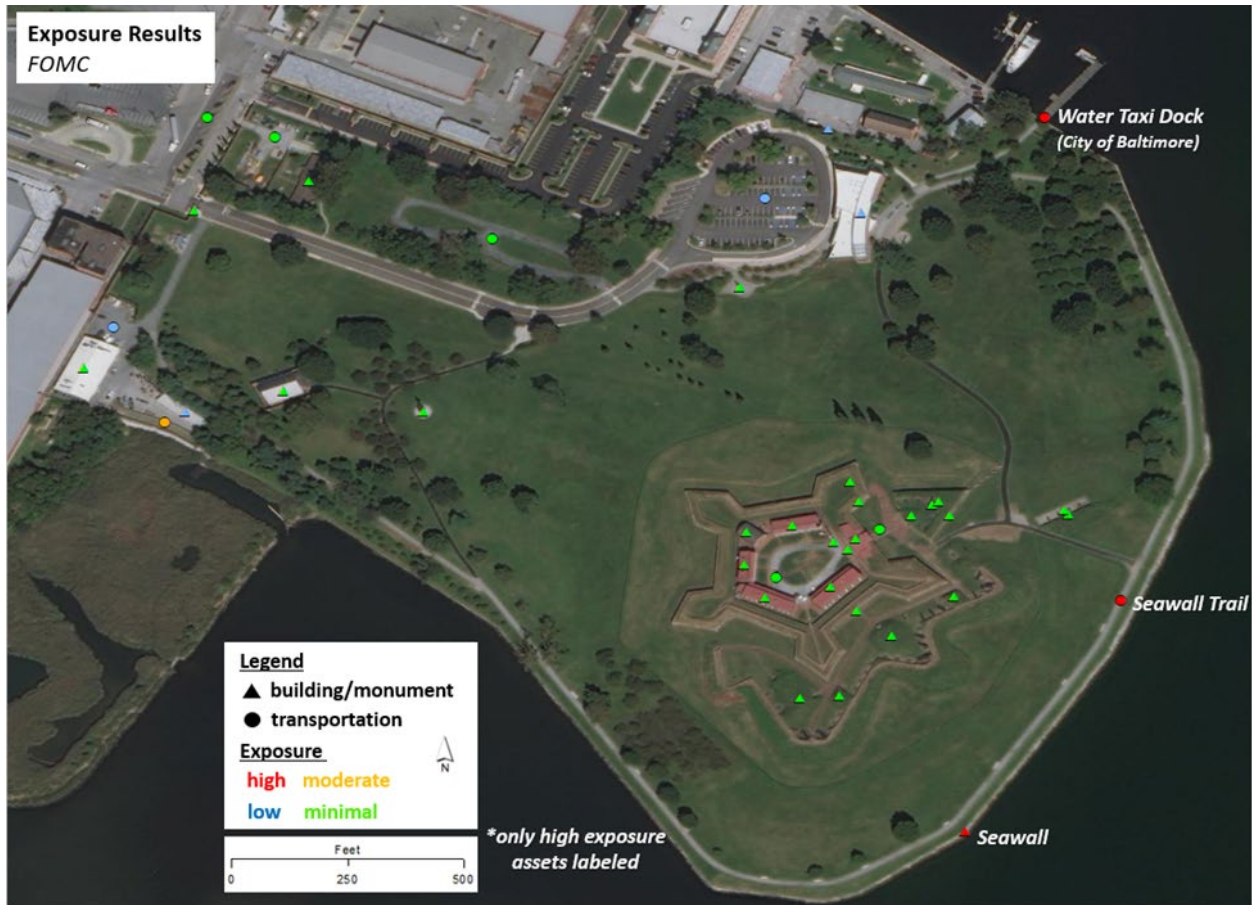
Figure 1. FOMC exposure results. Only high exposure assets are labeled. Background map is ESRI streaming imagery.

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 (this is the case for 32 assets at FOMC).

Three of the assets analyzed at FOMC have high sensitivity to coastal hazards and SLR, while six assets have moderate sensitivity (Table 3). In general, most assets are not significantly elevated above local ground level and not storm resistant, but most are in good condition.

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

Assets	High Sensitivity		Moderate Sensitivity		Low Sensitivity		Total Analyzed	Excluded*
	#	%	#	%	#	%	#	#
Buildings	2	50%	2	50%	0	0%	4	27
Transportation	1	20%	4	80%	0	0%	5	5
All Assets	3	33%	6	67%	0	0%	9	32

*Minimal exposure assets were excluded from the sensitivity analysis; total number analyzed is different for sensitivity.
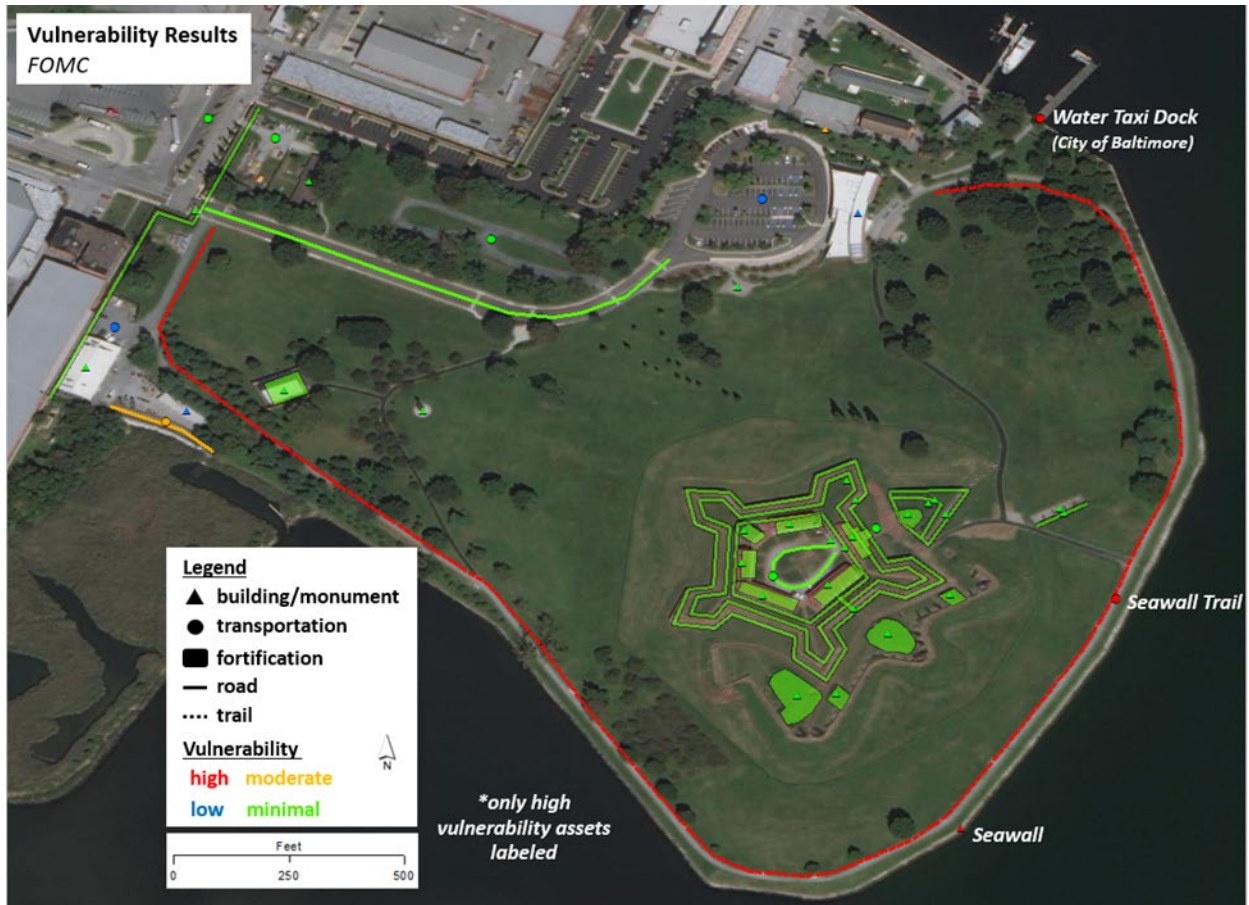
Vulnerability Results

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 FOMC are nearly identical to the exposure results, which indicates that the vulnerability is primarily controlled by exposure. Only the Seawall, Seawall Trail, and Water Taxi Dock (City of Baltimore) have high vulnerability to the evaluated coastal hazards (Table 4, and Figure 2). The Seawall has a high asset priority index (API = 92, as reported in FMSS). Two assets (5%) have moderate vulnerability, and of those only the Boundary Iron Fence has a high API (92). Four assets (10%) have low vulnerability, while most assets (78%) have minimal vulnerability.

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

Assets	High Vulnerability		Moderate Vulnerability		Low Vulnerability		Minimal Vulnerability		Total
	#	%	#	%	#	%	#	%	#
Buildings	1	3%	1	3%	2	6%	27	87%	31
Transportation	2	20%	1	10%	2	20%	5	50%	10
All Assets	3	7%	2	5%	4	10%	32	78%	41

Figure 2. FOMC vulnerability results. Only high vulnerability assets are labeled. Background is Google Earth streaming imagery.

FOMC Unique Considerations

Non-FMSS assets: At the request of the park, we evaluated one non-FMSS listed asset at FOMC, the Water Taxi Dock. This dock is owned by the City of Baltimore but is imperative to the park as it delivers frequent visitors to the park. All statistics in the results and within this report include this asset.

Shoreline change: United States Geological Survey (USGS) or other shoreline erosion rate data are not available for FOMC, which has non-oceanfront coastlines. As a result, we used a simple coastal proximity buffer of 30 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 30-year (approximately 2050) timeframe of this analysis (see Peek et al. 2022).

SLR data: We used the 2100 4.5 Representative Concentration Pathway (RCP) SLR projections and inundation model from Caffrey et al. (2018) developed specifically for NPS units to score exposure for this indicator (0.62 m rise for FOMC). These data are used as a proxy for 2050 SLR to

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accommodate higher SLR projections recently released by the National Oceanic and Atmospheric Administration (NOAA; see Peek et al. 2022).

Linear assets: Roads and trails at FOMC were not segmented, as all are relatively short features (< 1 mile in length). Therefore, each road and trail has only one score for exposure, sensitivity, and vulnerability. Any statistics or estimates of value represent the entire asset, even if only a small portion has high exposure or vulnerability.

References

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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.

National Park Service
U.S. Department of the Interior