



Coastal Hazards & Sea-Level Rise Asset Vulnerability Assessment for Buck Island Reef National Monument, Christiansted National Historic Site, and Salt River Bay National Historical Park & Ecological Preserve

Summary of Results

NPS 163/187360, NPS 399/187360, NPS 141/187360, January 2023



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Fort Christiansvaern at Christiansted National Historic Site

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Program for the Study of Developed Shorelines
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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 Buck Island Reef National Monument (BUIS), Christiansted National Historic Site (CHRI), and Salt River Bay National Historical Park & Ecological Preserve (SARI; together referred to as the St. Croix Parks) in 2021. In this VA, we evaluate the vulnerability (as a combination of exposure and sensitivity) of NPS buildings and transportation assets¹ to identified coastal hazards and climate change factors, approximately to the year 2050 (for full methodology, see Peek et al. 2022).

We assessed 20 buildings/structures (including a visitor contact station, fort, picnic shelter, warehouse, comfort stations, and historical buildings) and 24 transportation assets (including roads, parking lots, trails, and a pier) at the St. Croix Parks. Forty-one percent of assets analyzed have high vulnerability to the evaluated coastal hazards and SLR, while over one-third (36%) have minimal vulnerability (are not in any of the evaluated hazard zones). Scoring details and results for all assets evaluated at the St. Croix Parks are reported in the provided Excel sheets (BUIS_Buildings_Transportation_Results.xlsx; CHRI_Buildings_Results.xlsx; CHRI_Transportation_Results.xlsx; and SARI_Buildings_Transportation_Results.xlsx)

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). 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)	St. Croix Parks Data (Citation)
Flooding potential (1% annual-chance)	Effective FEMA VE & A zones (FEMA 2007)
Shoreline change (coastal proximity)	35-m shoreline proximity buffer (Peek et al. 2022)
SLR inundation (2050)	NPS 8.5 RCP SLR model, 0.23 m rise (Caffrey et al. 2018)
Extreme event flooding (category 3 surge & tsunami inundation)	NOAA national storm surge hazard maps (Zachry et al. 2015), USVI tsunami modeling (NOAA 2018), NOAA 10 ft SLR (NOAA 2022)
Reported coastal hazards (historic flooding)	Questionnaire results & discussions (Peek et al. 2022)

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.

Forty-one percent of assets evaluated at the St. Croix Parks have high exposure to the assessed coastal hazards (Table 2, and Figures 1-3). This includes four assets at BUIS (three buildings, one transportation), nine at CHRI (five buildings, four transportation), and five at SARI (one buildings, four transportation). All these assets are in the Federal Emergency Management Agency (FEMA) VE flood zone (1% annual chance flood + wave velocity) and the extreme event flooding zone. Most are also in the coastal proximity zone and have been flooded in the past.

Table 2. St. Croix Parks exposure results. Sum of percentages may not equal 100 due to rounding.

Assets	High Exposure		Moderate Exposure		Low Exposure		Minimal Exposure		Total
	#	%	#	%	#	%	#	%	#
Buildings	9	45%	3	15%	0	0%	8	40%	20
Transportation	9	38%	5	21%	2	8%	8	33%	24
All Assets	18	41%	8	18%	2	5%	16	36%	44

Eight assets at CHRI and SARI have moderate exposure. These assets are all in the FEMA A zone (1% annual flood chance), and most are also in the extreme event flooding zone. Only two assets at the St. Croix Parks have low exposure. Over one-third (36%) of assets have minimal exposure. These assets are in located in the higher elevation and inland areas of the three parks (e.g., Sion Ridge assets at CHRI). The following assets have minimal exposure using this protocol: Signal Station, USCG Tower Trail, and Hiking Trail System at BUIS; Steeple Building, Sion Ridge Warehouse, Housing Unit 00001, Housing Unit 00002, Housing Unit 00003, Sion Ridge Generator Building, Sion Farm Parking Lot Rt. 0903, and Sion Ridge Road at CHRI; and Salt River Visitor Contact Station, Salt River Visitor Contact Station Parking Lot Rt., Salt River Park Access Road-East Rt. 0400, Salt River Visitor Contact Station Overflow Parking RT0901, and Salt River Visitor Contact Station Road at SARI.

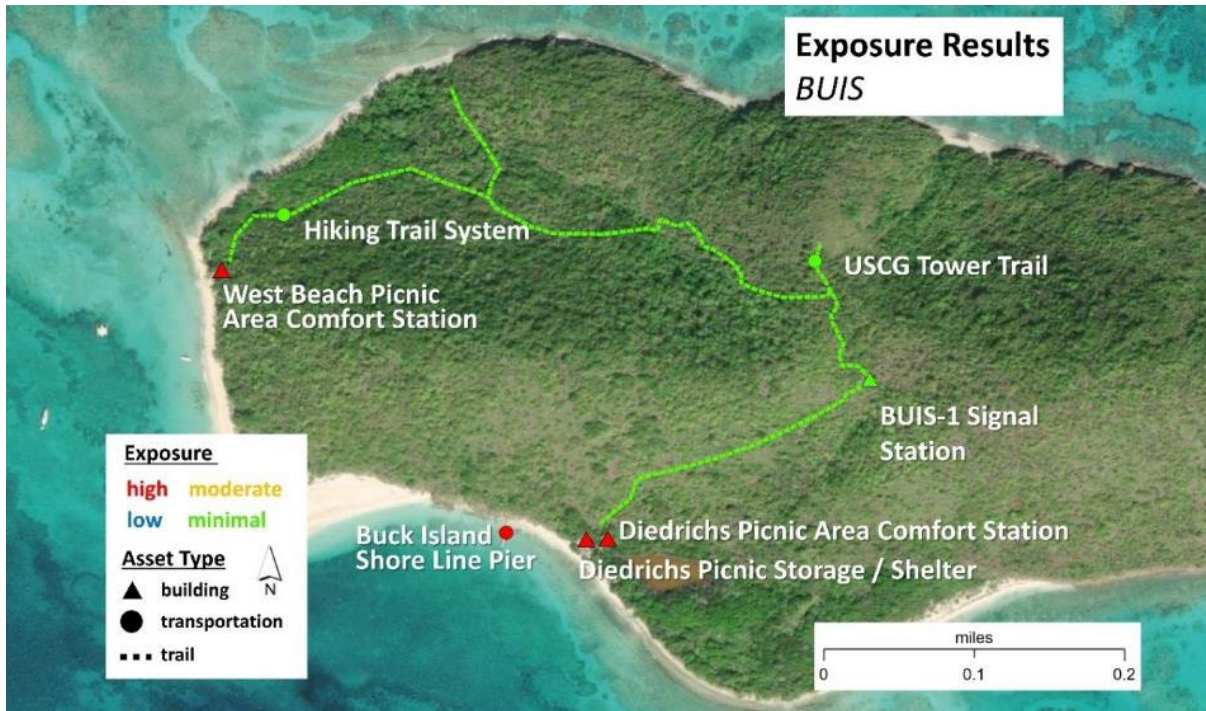


Figure 1. BUIS exposure results summary. Background map is ESRI streaming imagery.

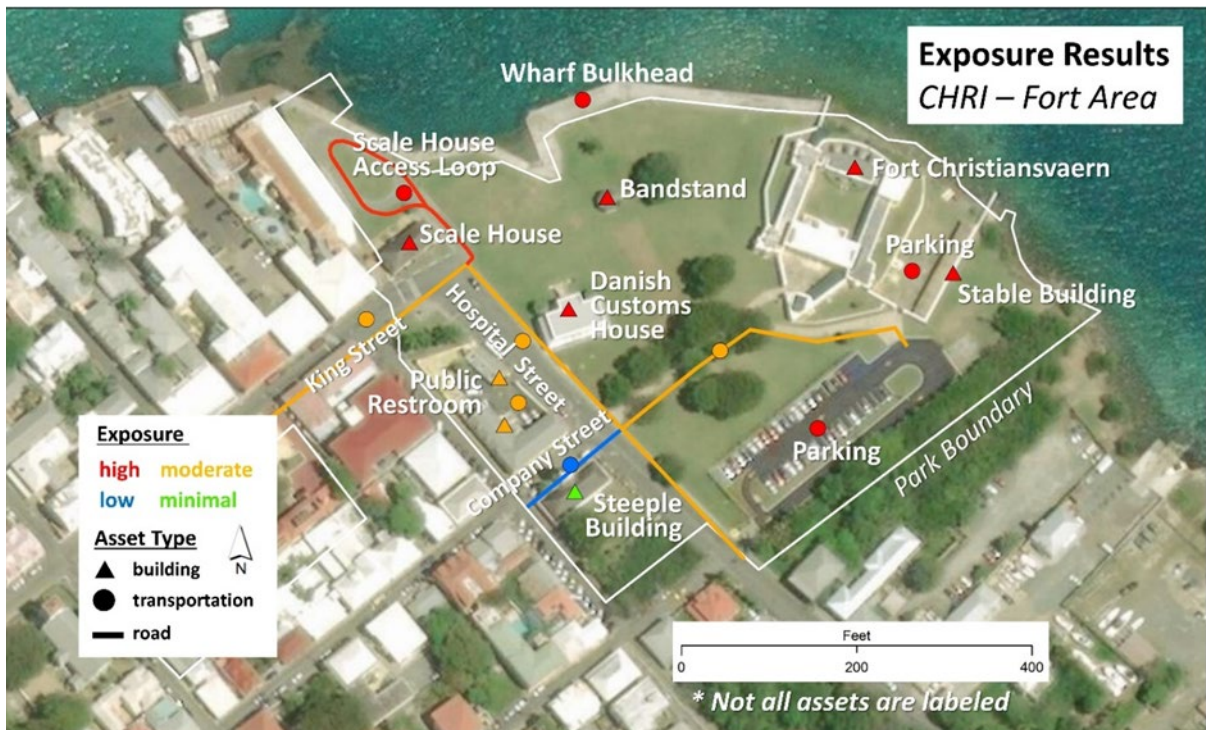


Figure 2. CHRI exposure results summary. Only select assets are labeled. Background map is ESRI streaming imagery.

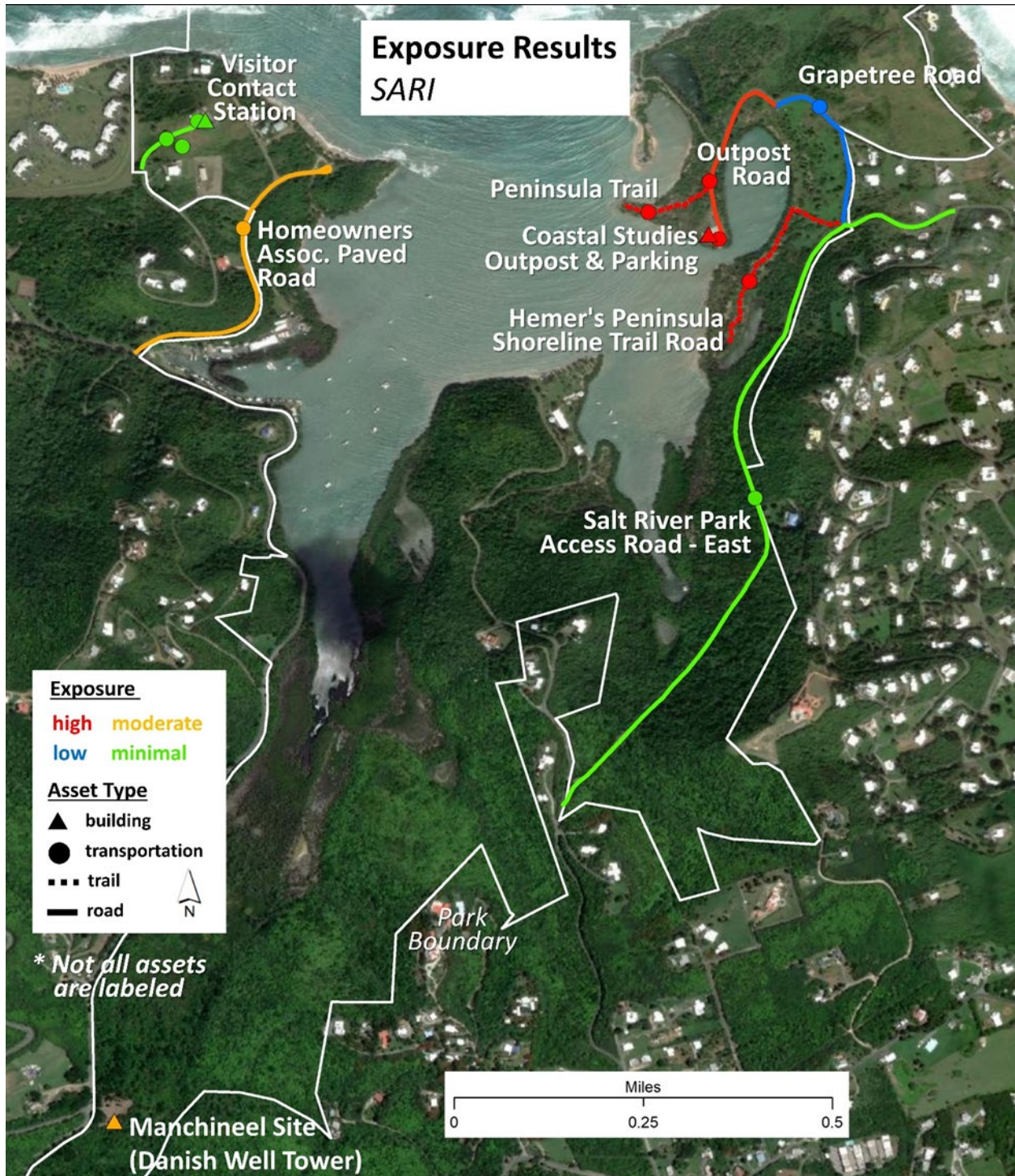


Figure 3. SARI exposure results summary. Only select assets are labeled. Background map is ESRI streaming imagery.

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 16 assets at the St. Croix Parks, see list in Exposure Results).

All but two assets at the St. Croix Parks have high or moderate sensitivity to coastal hazards and SLR (Table 3). The high sensitivity assets are not elevated or storm resistant, and do not have protective engineering. In most cases, the assets with moderate sensitivity (as opposed to high) are in good condition and have not been significantly damaged by coastal flooding in the past.

Table 3. St. Croix Parks sensitivity results. Sum of percentages may not equal 100 due to rounding.

Assets	High Sensitivity		Moderate Sensitivity		Low Sensitivity		Total Analyzed	Excluded*
	#	%	#	%	#	%	#	#
Buildings	4	33%	6	50%	2	17%	12	8
Transportation	2	13%	14	88%	0	0%	16	8
All Assets	6	21%	20	71%	2	7%	28	16

*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).

Forty-one percent of assets at the St. Croix Parks have high vulnerability to the assessed coastal hazards and SLR (Table 4, and Figures 4-6). This is identical to exposure because most assets have a moderate sensitivity. Nine assets have moderate vulnerability and only one has low vulnerability. Over one-third (36%) of assets have minimal vulnerability. Seven of the assets evaluated (all at CHRI) have high vulnerability and a high asset priority index ($API \geq 70$, as reported in FMSS). This includes Fort Christiansvaern, Stable Building, Scale House, Scale House Access Loop, Maintenance Area Parking, Parking Lot Hospital, and Wharf Bulkhead. The West Beach Picnic Area Comfort Station, Deidrichs Picnic Storage/Shelter, and Buck Island Shore Line Pier (all at BUIS) have both high exposure and high sensitivity.

Table 4. St. Croix Parks vulnerability results. Sum of percentages may not equal 100 due to rounding.

Assets	High Vulnerability		Moderate Vulnerability		Low Vulnerability		Minimal Vulnerability		Total #
	#	%	#	%	#	%	#	%	
Buildings	9	45%	3	15%	0	0%	8	40%	20
Transportation	9	38%	6	25%	1	4%	8	33%	24
All Assets	18	41%	9	20%	1	2%	16	36%	44

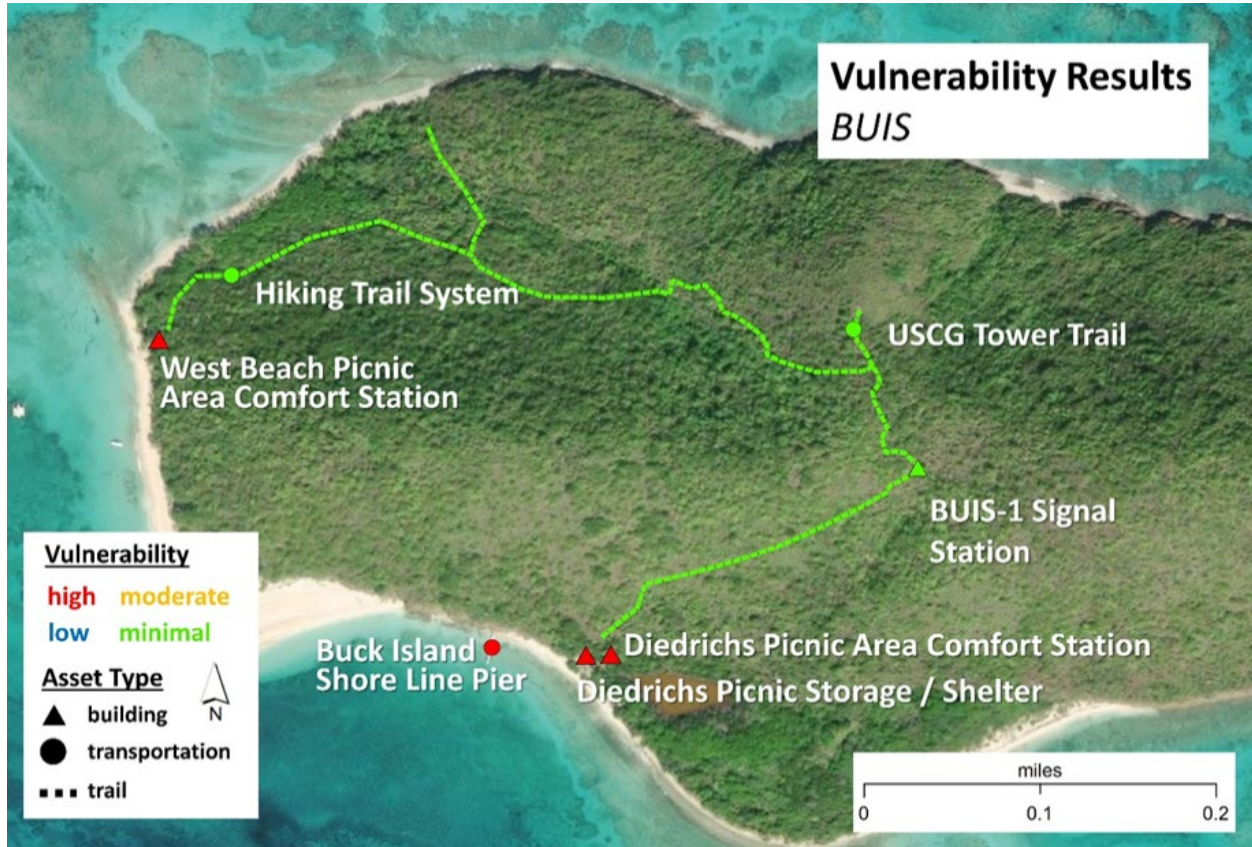


Figure 4. BUIS vulnerability results summary. Background is ESRI streaming imagery.

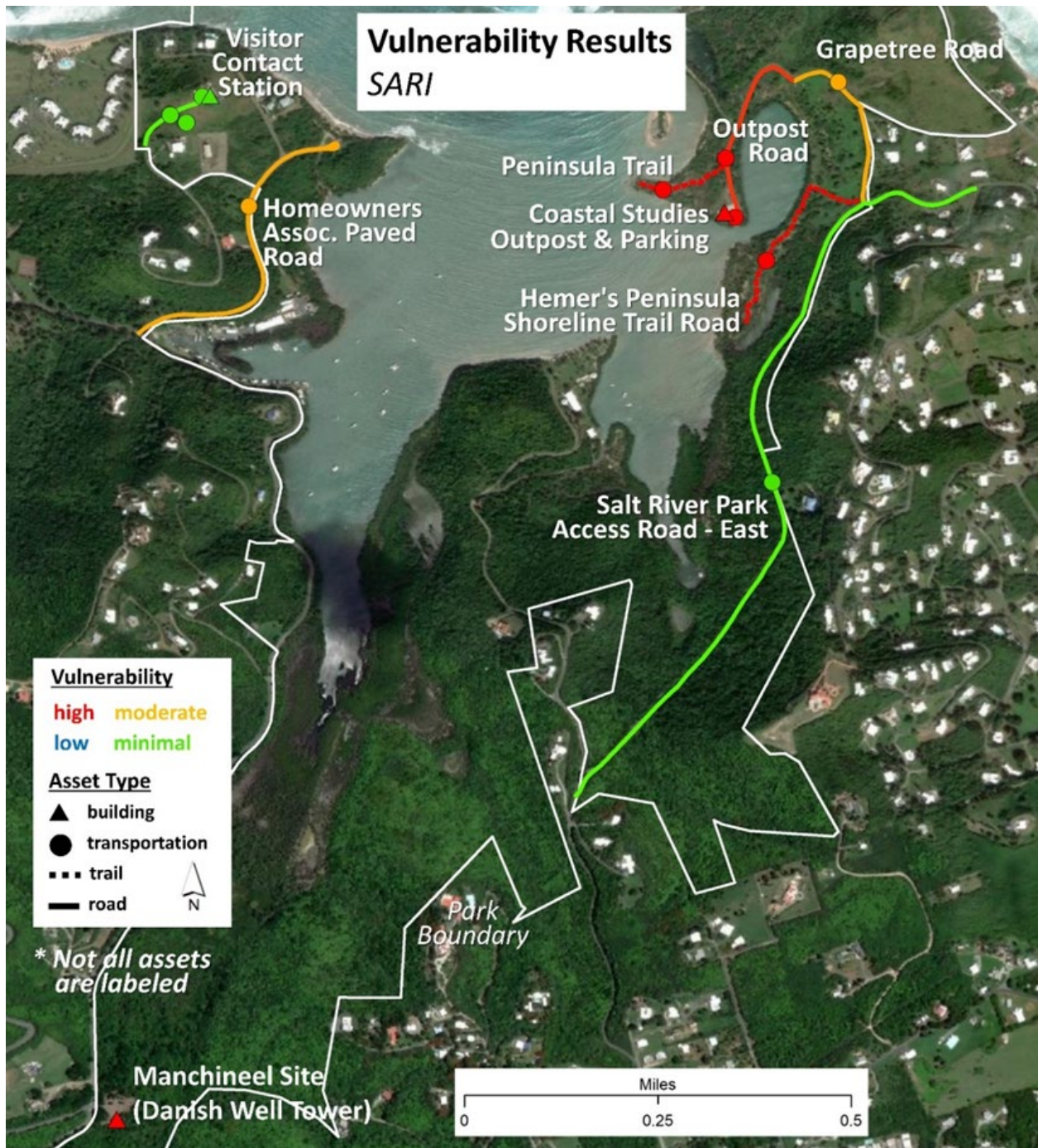


Figure 5. SARI vulnerability results summary. Only select assets are labeled. Background is ESRI streaming imagery.

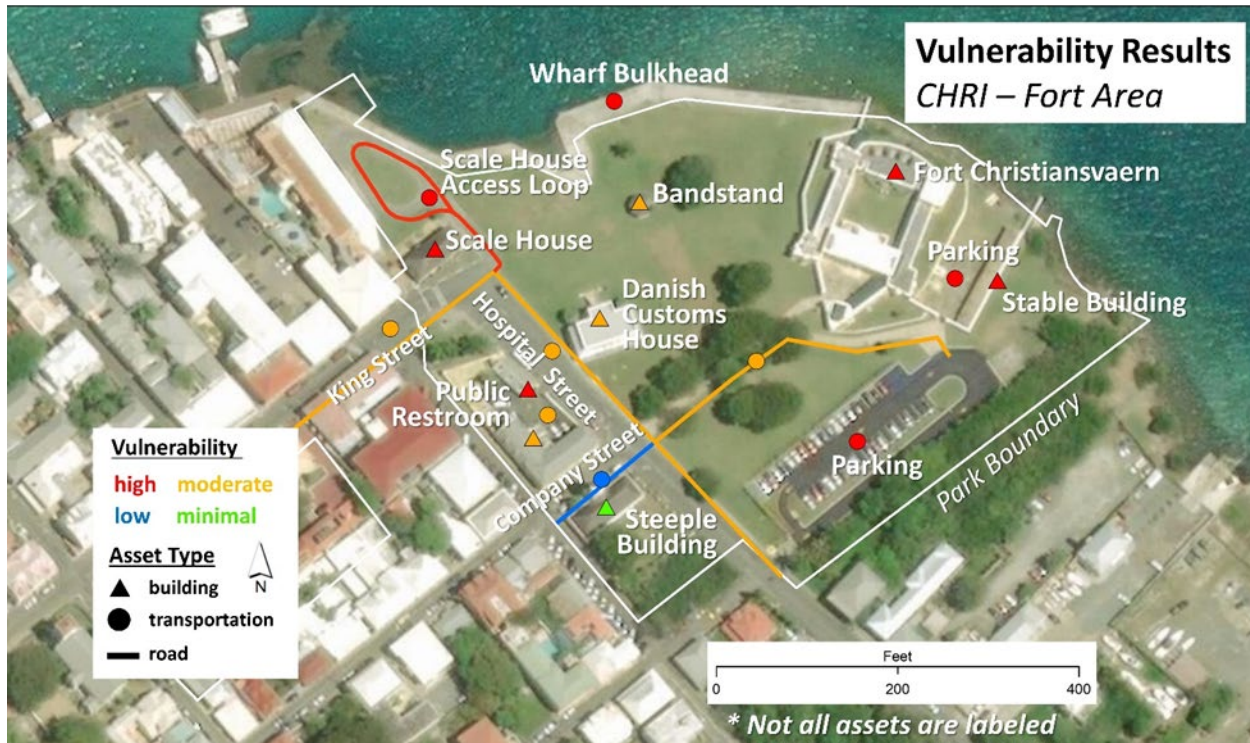


Figure 6. CHRI vulnerability results summary. Only select assets are labeled. Background is ESRI streaming imagery.

St. Croix Parks Unique Considerations

FEMA Data: FEMA data are not accurately mapped for BUIS. The entire island is shown in the VE zone, even areas with 200 meters of elevation. We used elevation and distance from the coast to determine which assets should be in the VE zone.

Shoreline change: United States Geological Survey (USGS) or others shoreline erosion rate data are not available for the coastlines within the St. Croix Parks. 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 (2050) timeframe of this analysis (see Peek et al. 2022).

SLR data: We used the 2050 8.5 Representative Concentration Pathway (RCP) SLR projection and inundation model (0.23 m rise; Caffrey et al. 2018) developed specifically for NPS units to score exposure for this indicator. However, we also provided alternate scores using the 2100 4.5 SLR projection (0.5 m rise) for comparison (see Peek et al. 2022).

Extreme event flooding data: In most cases, we use storm surge models produced by NPS (Caffrey et al. 2018) within this protocol; however, these data are not available for the St. Croix Parks. To evaluate exposure to extreme event flooding (including tsunami and storm surge) we used the National Oceanic and Atmospheric Administration (NOAA) Category 3 high tide inundation model

(National Storm Surge Hazard Maps - Version 2; Zachry et al. 2015), United States Virgin Islands (USVI) tsunami hazard zone (NOAA 2018), and NOAA SLR 10-ft inundation zone (NOAA 2020).

Linear assets: NPS-owned roads and trails within the St. Croix Parks were not segmented, as most are already relatively short features (only one trail system and four roads are > 1 mile in length). Therefore, each road or trail has only one score for exposure, sensitivity, and vulnerability. Any statistics or estimates of value represent the entire road or trail, even if only a small portion has high exposure or vulnerability.

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