Natural Hazards, Climate, and Resilience

Contents

Overview

Natural hazards and climate change represent acute and chronic challenges that require the U.S. Virgin Islands to strengthen and coordinate its social, economic, infrastructural, and environmental sectors. Climate change affects the conditions that drive many of the natural hazards that commonly affect the Territory, meaning that future hazards have the potential for more expansive negative impacts to communities and the natural environment. The Territory is still recovering from the devastating impacts of Hurricanes Irma and Maria, two back-to-back Category 5 events that hit the islands in 2017. The Territory's recent planning documents lay out initiatives to "build back better," resulting in communities that proactively mitigate hazard risk and have increased capacity to prepare for, respond to, and recover from the stressors of natural hazards and climate change.

This chapter presents an overview of the Territory's baseline conditions with a focus on impacts to human systems. See the **Environmental and Natural Resources** chapter for a discussion of impacts to the natural environment.

What do we mean when we talk about responding to natural hazards and climate change? For consistency, the following terms are taken from the U.S. Virgin Islands Hurricane Recovery and Resilience Task Force Report (2018) and Climate Change Adaptation Planning Assessment and Implementation: Final Vulnerability and Risk Assessment Report (2019)

Hardening: preparing existing assets for the impacts of natural disasters by strengthening the structure or adding physical barriers (e.g., elevating a transformer substation).

Mitigation: lessening the impact of disasters on systems by hardening existing assets, by ensuring those assets are not damaged in the first place (e.g., by moving them), or, if they are damaged, ensuring the systems have enough redundancy to keep working (e.g., by making sure a segment of a power system does not have a single point of failure).

Resilience: engaging in mitigation, while also ensuring systems can recover quickly even if they are disrupted and minimizing the impact of a disruption so the impact on the communities they serve is as small as possible. Another, still broader, definition of resilience is the capacity of individuals, communities, institutions, businesses, and systems to survive, adapt, and thrive no matter what kinds of chronic stresses and acute shocks they experience.

Adaptive capacity: the ability of natural and built systems and individuals to adjust to changing environments and respond to the opportunities and impacts that result from change.

Natural Hazard Risk and Land Use Patterns

The U.S. Virgin Islands Hazard Mitigation Plan Update (2019) (HMP) profiles eight natural hazards that are most salient to the Territory. These natural hazards are interrelated and may occur simultaneously, worsen the severity of another hazard, and/or can initiate a secondary hazard. The eight profiled natural hazards are listed below:

1. **Drought:** Drier than normal conditions caused by reduced precipitation that lasts over an extended period.
2. **Earthquake:** Shaking, displacement, or other movement of the earth's surface caused by movement of the earth's tectonic plates.
3. **Riverine flooding:** Inundation of low-lying areas adjacent to waterways resulting from a lack of capacity of rivers and streams to accommodate water flows.
4. **Coastal flooding and erosion:** Coastal flooding refers to the periodic inundation of coastal areas caused by high tides, as well as inundation from storm-driven waves (i.e., storm surge). Coastal erosion is the wearing away and transport of coastal sediments resulting from wave action, coastal flooding and storms, and sea level rise.

5. **Hurricane winds:** Extreme winds capable of damage to the natural and built environment associated with hurricanes and tropical storms, with hurricanes characterized by winds over 74 miles per hour (mph).
6. **Rain-induced landslide:** Landslides, or the movement of materials (e.g., rock and debris) downhill under the force of gravity, trigged by prolonged or extreme precipitation.
7. **Tsunami:** A series of long waves generated in the ocean by a sudden displacement of a large volume of water (e.g., underwater earthquake) that can result in destructive and high-impact waves inundating coastal areas.
8. **Wildfire:** An unplanned and uncontrolled fire in natural grasslands, brush, or woodlands often caused by humans or lightning strikes.

All natural hazards have the potential to impact human systems. Choices in where and how people settle determine *exposure*—the population and property in harm's way—and *vulnerability*—the extent to which the population and property is susceptible to harmful effects. The interaction between a hazard and a community's exposure and vulnerability describes *risk*, or the potential for harm to or loss of life and property.

Land use patterns in the U.S. Virgin Islands increase both exposure and vulnerability to natural hazards, heightening overall risk (see next page). Historical settlement patterns and the economic and population boom of the 1960s and 1970s led to development in environmentally sensitive areas such as floodplains and steep slopes. In the context of natural hazards, these land use patterns place people in areas where natural hazards are likely to occur and diminish the mitigating benefits environmental sensitive areas would otherwise confer (e.g., flood storage, soil stabilization).

During public outreach conducted as part of the HMP, residents of St. Thomas and St. Croix expressed the most concern about impacts from hurricanes, earthquakes, and riverine flooding. Residents of St. John were most concerned about hurricanes, earthquakes, and landslides. Across the islands, major population centers are within areas most exposed to coastal flooding and hurricane impacts. These exposed coastal areas include:

- St. Thomas: Charlotte Amalie and the Bovoni, Smith Bay, and Magens Bay area
- St. John: Christiansted, Fredericksted, Sandy Point, the Limetree Bay area, and the south coast
- St. Croix: Cruz Bay, Coral Bay, and the southwest coast

Past severe riverine flooding events across all islands have resulted in flash flooding, roadway flooding, overwhelmed stormwater drainage infrastructure, and property damage. Heavy precipitation and severe flooding events have also led to collapsed roadways and landslides, threatening access and egress routes. While intense, harmful earthquake events have not occurred in recent history, the U.S. Virgin Islands can expect to experience strong to very strong shaking during earthquake events that may result in slight to considerable damage in buildings not constructed to the appropriate seismic design category.[1] In addition to hillside development, many coastal developed areas are built on alluvial soils and fill that are prone to liquification during earthquakes. Vulnerable areas include the Charlotte Amalie, Christiansted, and Fredericksted waterfronts. For coastal areas, concern about earthquakes pair with concern about tsunamis. The tsunami evacuation zone encompasses all areas in the Territory below 82

[1] U.S. Virgin Islands Hazard Mitigation Plan Update (2019), 96.

feet above mean sea level and within 2 miles of the coast. Major population centers on St. Thomas, St. John, and St. Croix are located within the tsunami evacuation zone.

St. Thomas (Unsplash).

Development in flood prone and high run off areas puts residents in areas of known flood risk. Increased impervious surfaces, stream flow alternation, vegetation removal, and the use of fill degrades watersheds' capacity to manage stormwater and can increase the magnitude, frequency, and extent of flooding.


Charlotte Amalie, St. Thomas (Unsplash).

Development in low-lying coastal areas is exposed to coastal flooding, storm surge, and sea level rise. Development on fill and alluvial soils is vulnerable to damage caused by soil settlement and liquefaction during earthquakes. Earthquakes also carry the risk of tsunamis for low-lying coastal areas.


Charlotte Amalie, St. Thomas (Unsplash).

Development on steep slopes removes vegetation that acts as a natural soil stabilizer and increases stormwater and sediment runoff. The landscape is more susceptible to erosion and landslides, including landslides triggered by earthquakes, and contributes to downstream flooding and reduced water quality caused by sedimentation.

Climate Change and Natural Hazards

Global warming, the rise in global temperatures caused by human-activities that increase the concentration of greenhouse gases in the atmosphere, is changing the climate. Climate change is shifting temperature and weather patterns that affect the frequency, intensity, duration, and geography of natural hazards, with the effect that future hazard occurrences may be more impactful, costly, and dangerous to our communities. As noted in the U.S. Virgin Islands Hurricane Recovery and Resilience Task Force Report (2018),[2] the Territory is frequently impacted by several climate-induced natural hazards, including hurricanes, rainstorms, and droughts, that can subsequently lead to additional impacts from coastal and riverine flooding, destructive winds, and other events.[3] For an economy heavily dependent on attracting tourism to the Territory, natural hazards are disruptive and can pose immediate physical barriers (e.g., damage to transportation infrastructure and lodging) and depress long-term tourism trends that affect local economy activity.

Incorporating Climate Change Projections into Flood Hazard Modeling

Federal Emergency Management Agency (FEMA) flood hazard maps do not yet account for climate change projections, meaning the Territory's flood hazard maps present an incomplete view of flood risks under changing climate conditions. Several recent studies have focused on modeling future flood hazards to better understand future risks to infrastructure (e.g., drainage system) and critical structures and buildings based on climate projections for 2050 and inform hazard mitigation planning. In 2021, flood hazard modeling under increased rainfall intensity scenarios were released; modeling for future flood risks that incorporate sea level rise projections is ongoing.

For coastal areas in the Territory, sea level rise will have varied impacts. Under an Intermediate climate scenario, the Caribbean region is expected to experience 1.2 feet and 3.6 feet of sea level rise by 2050 and 2100, respectively (

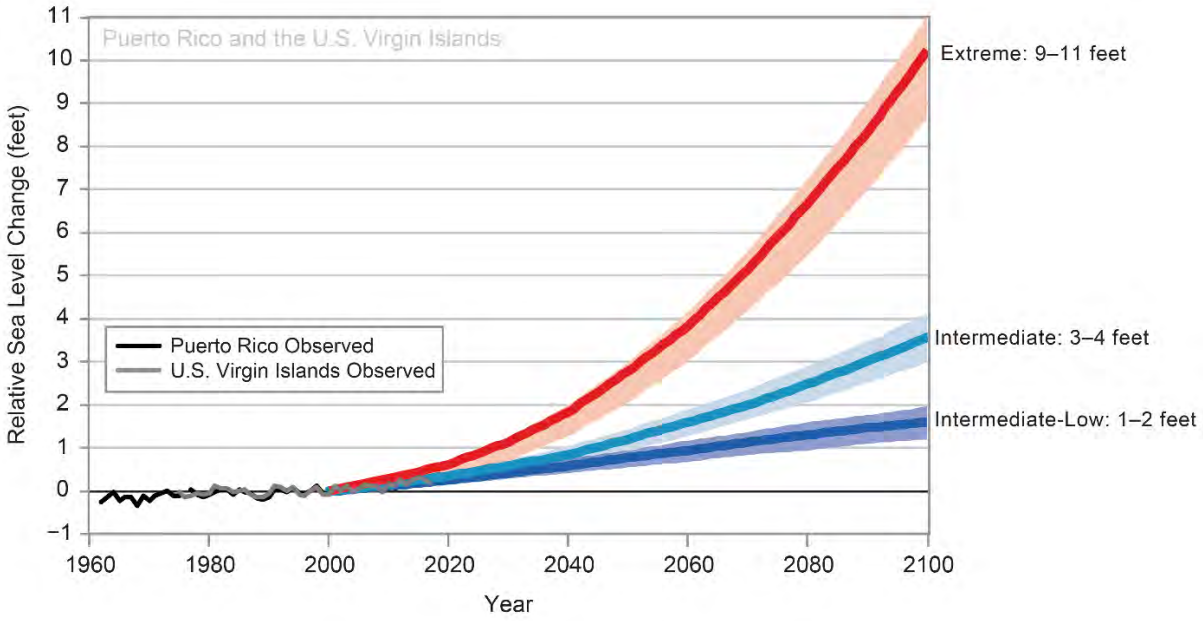
[2] Hereafter, the "Hurricane Task Force Report."
[3] U.S. Virgin Islands Hurricane Recovery and Resilience Task Force Report (2018), 32.

Figure 1).4 Several low-lying coastal areas will experience inundation much earlier than other areas, with the islands' topography mitigating widespread inundation from sea level rise.

More extensive studies and modeling of how flooding, including coastal flooding from storm surge, will interact with sea level rise will lead to a better understanding of future flood risks.

[4] U.S. Global Change Research Program, Chapter 20 in Impacts, Risks, and Adaptation in the U.S.: Fourth National Climate Assessment, Volume II (2018).

Figure 1. Observed and Projected Sea Level Rise



Source: U.S. Global Change Research Program, Chapter 20 in Impacts, Risks, and Adaptation in the U.S.: Fourth National Climate Assessment, Volume II (2018)

Table 1 summarizes climate change trends observed in the Territory, future projections on how these trends will develop over time, and impacts related to these trends.

Table 1. Climate Projections and Local Impacts

Climate Change Trend	Future Projections	Local Impacts
Rising temperature *Air temperature has increased by about 1.5° F since 1950.*	• Increase of 1.5-4° F in average temperatures by 2050. • Annually, more days over 95° F and more nights over 85° F.	• Increased incidence of heat-related illnesses. • Increased risk of wildfire and drought. • Increased demand on drinking water supplies. • Potential for increased incidence of coral bleaching events. • Potential for increased incidence of disease outbreaks.
Changes in precipitation patterns *Average rainfall is around 39 inches per year, but annual patterns can vary significantly.*	• Greater annual variability in precipitation patterns. • Uncertainty remains, but projections indicate both wet and dry seasons will become drier on average.	• Potential for inland flooding if extreme events become frequent and intense. • Extreme events may lead to rainfall-induced landslides and increased erosion. • Potential for negative impacts to local agricultural production due to changes in growing season and rainfall. • Potential for negative impacts to availability of rainwater for drinking water supplies.
Sea surface temperature *Sea surface temperature has increased nearly 2° F since 1901, with the rate of warming increasing since 2016.*	• Continued increase in sea surface temperatures at a rate of 0.43° F per decade.	• Warmer waters may increase the strength of hurricanes and tropical storms. • Potential for negative impacts to fish populations due to alterations to migration and breeding patterns, reef habitat, and nutrient supply.

Climate Change Trend	Future Projections	Local Impacts
Ocean acidification *Ocean acidity in the Caribbean Sea has increased by about 25% in the last three centuries.*	• Additional increase in ocean acidity by 40-50% by 2100.	• Potential for increased incidence of coral bleaching events and disease outbreaks. • Negative impacts to dependent fish and marine species resulting from coral reef habitat degradation. • Degradation of coral reef habitats reduces shoreline protection from storm surge.
Sea level rise *Sea levels have already risen 4 inches on St. Croix and approximately 3.3 inches on St. Thomas over the past 40 years.*	• Under an Intermediate climate scenario, 1.2 feet and 3.6 feet of rise are expected by 2050 and 2100, respectively, across the Caribbean region.	• Increased extent of storm surge inundation. • Increased daily tidal flooding in low-lying areas. • Increased coastal erosion. • Increased potential for saltwater intrusion into coastal wells and drinking water supplies. • Loss of mangroves and associated shoreline protection due to permanent inundation.

Source: U.S. Global Change Research Program, Chapter 20 in Impacts, Risks, and Adaptation in the U.S.: Fourth National Climate Assessment, Volume II (2018); U.S. Virgin Islands Hurricane Recovery and Resilience Task Force Report (2018); Climate Change and Adaptation Planning Assessment and Implementation: Final Vulnerability and Risk Assessment Report (2019)

Planning for Resilience

Planning for resilience means increasing the Territory's capacity to mitigate, prepare for, respond to, and recover from natural hazards. These are interrelated capacities that support each other; for example, increasing capacity to mitigate a natural hazard may reduce its impacts, reducing the extent of necessary recovery actions.

Today, much of the discussion around planning for resilience references Hurricanes Irma and Maria, which made landfall in 2017 as Category 5 storms within two weeks of one another on St. Thomas/St. John and St. Croix, respectively, and exposed a number of weaknesses in the Territory's infrastructure, regulations and standards, planning, and pre-storm level of preparedness. Collectively, the two hurricanes caused catastrophic damage across the Territory, resulting in the direct deaths of five individuals and an estimated $10.7 billion in damages. The Virgin Islands Housing Authority estimates total disaster recovery need from the hurricanes at $11.25 billion.[5]

The Hurricane Task Force Report examining the impacts of Hurricanes Irma and Maria identifies 228 initiatives to improve resilience across 14 sectors. These resilience initiatives also support the objectives of the Territory's recently updated HMP and Virgin Islands Territorial Emergency Operations Plan (2022) (TEOP). Specific challenges referenced across different planning documents include:

- Upgrading, hardening, and maintaining public infrastructure, much of which was already subject to underinvestment and a lack of maintenance prior to Hurricanes Irma and Maria. A lack of redundancies and emergency backup generators within public infrastructure systems must also be addressed.
- Improving and enforcing standards for housing and buildings and retrofitting older structures to meet updated codes. Many houses and schools and some medical facilities are built to outdated codes, leaving these structures vulnerable to extreme weather. Hurricanes Irma and Mara inflicted damage to 54% of the housing stock in the Territory, 12% of which was major to severe damage.[6]

[5] U.S. Virgin Islands Disaster Recovery Action Plan, Version 2.0 (2019), 37.
[6] Ibid, 45-46.

- Increasing the resilience of vulnerable residents, who make up a high proportion of Virgin Islanders based on income, age, and other demographic characteristics. An estimated 65,000 Virgin Islanders are considered vulnerable based on income, age, and other demographic indicators.[7] Median household income in 2020 was approximately $40,400, with just under 23% of the population living below the poverty level. Household access to water and telecommunications infrastructure is limited, with 53% of households not connected to the public water supply network and 14% without internet access.[8] Impacts of extreme weather are often disproportionate: during Hurricanes Irma and Maria, 86% of the households with major to severe damage to their homes were low or moderate income.[9]
- Improving pre-storm preparedness and planning activities. In the wake of the Hurricanes Irma and Maria in 2017, the Territory has completed a number of plans and studies to guide resilience actions and planning.

Emergency Operations

Emergency operation responsibilities are defined in the TEOP. During natural disasters, the Virgin Islands Emergency Management Agency (VITEMA) acts as the lead government agency coordinating the response and activates emergency operations centers (EOCs) in accordance with the incident's level of severity. EOCs are maintained on St. Thomas, St. Croix, and St. John, with the St. Thomas EOC serving as the central hub. Local emergency response capacity can be supplemented through the Territorial Mutual Aid Program, which mobilizes additional resources from within the Territory, and public-private mutual aid agreements. The TEOP also establishes mechanisms to request additional state-to-territory and federal support. The TEOP provides additional context for coordinating disaster response to specific hazards including hurricanes and tropical storms and earthquakes.

Hurricanes

Since 1970, 16 hurricanes have resulted in federal disaster declarations in the Territory. All declarations in the 21st century are attributable to the impacts of hurricanes and tropical storms.[10] The hurricane season runs from June to November, with peak activity occurring in September. Storms with maximum sustained winds between 39 – 73 miles per hour (mph) and 74 mph or higher are classified as tropical storms and hurricanes, respectively.[11] As noted in the Territorial Emergency Operations Plan, any storm within 100 miles of the U.S. Virgin Islands has the potential to cause damage. The cascading nature of storm impacts—such as heavy rainfall that leads to landslides or storm surge that leads to coastal flooding and erosion—can lead to extensive damage in communities.

Table 2. Saffir-Simpson Hurricane Wind Scale

Category	Sustained Winds	Types of Damage due to Hurricane Winds
1	74-95 mph	Very dangerous winds will produce some damage: Well-constructed frame homes could have damage to roof, shingles, vinyl siding and gutters. Large branches of trees will snap, and

[7] U.S. Virgin Islands Hurricane Recovery and Resilience Task Force Report (2018), 168-169.
[8] U.S. Virgin Islands Disaster Recovery Action Plan, Version 2.0 (2019), 40.
[9] Ibid, 48.
[10] Virgin Islands Territorial Emergency Operations Plan (2022), HTS-2.
[11] National Hurricane Center, "Tropical Cyclone Climatology," Accessed 10/20/2022. https://www.nhc.noaa.gov/climo/.

Category	Sustained Winds	Types of Damage due to Hurricane Winds
		shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
2	96-110 mph	Extremely dangerous winds will cause extensive damage: Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.
3	111-129 mph	Devastating damage will occur: Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.
4	130-156 mph	Catastrophic damage will occur: Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted, and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
5	157 mph or higher	Catastrophic damage will occur: A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

Source: National Hurricane Center, "Saffir-Simpson Hurricane Wind Scale," accessed October 20, 2022.

Energy

While no sector escaped the impacts of Hurricanes Irma and Maria, the Territory's energy infrastructure was already in "a state of crisis" before their landfall. The Territory's energy infrastructure is largely owned and operated by the U.S Virgin Islands Water and Power Authority (WAPA), a public utility. Following Hurricanes Irma and Maria—which caused extensive damage to WAPA's power generating units, several substations, and aboveground transmission and distribution infrastructure—returning power across the entire Territory took over three months. This sustained loss of electrical power caused emergency backup generators to fail from overuse, kept traffic signals and streetlights dark, and stopped production and treatment functions at reverse osmosis drinking water and sewer plants for varying time periods, among other impacts.

The Hurricane Task Force Report identifies four primary goals to increase resilience in the energy sector to acute impacts from storms and chronic climate change stressors, which will lead to increased future energy demands:

1. WAPA must diversify its energy generation portfolio and add on-island renewable assets to reduce reliance on petroleum product imports, as well as increase the efficiency of its generators.
2. WAPA must modernize its grid to enable better and coordinated management of a diversified energy generation portfolio.
3. WAPA must fortify and harden its infrastructure against climate risks that can directly damage energy assets (e.g., hurricane winds, precipitation, storm surge) and change energy consumption patterns (e.g., rising temperatures).
4. The Territory must strengthen and coordinate its energy planning and regulatory structures to enable it to adapt to future energy challenges and needs.[12]

[12] U.S. Virgin Islands Hurricane Recovery and Resilience Task Force Report (2018), 42-43.

See the **Infrastructure** chapter for a more detailed discussion of energy infrastructure.

Current and Future Challenges of an Island Setting

The Territory has limited availability of natural resources and an economy heavily centered around tourism, with little local agricultural or manufacturing production.[13] The Territory's setting and geography leaves it susceptible to a number of natural hazards, with development patterns and climate change exacerbating that risk. Notable current and future challenges of an island setting include the following:

- Dependence on imports, including imported energy, and high cost of imported goods and services.
- Dependence on rainwater for drinking water, which may be affected by drought and changes in precipitation patterns. Likewise, increasing temperatures may increase demand for potable water.
- Susceptibility to compound risks of natural hazards, in which different hazards occur simultaneously or one after another, further stressing response systems. For example, hurricanes often drive coastal flooding and coastal erosion.
- Sea level rise as a phenomenon by itself can cause damage, but it will also exacerbate the impacts related to hurricanes, coastal flooding, and coastal erosion across the Territory.
- Natural resources such as coral reefs and mangroves, which provide shoreline protection, are negatively affected by coastal erosion and sea level rise and can also be harmed during coastal storm events.
- Operating utility systems on an island without the benefit of interconnections to neighboring utilities that could provide emergency services during disruptions.
- Physical isolation can impede recovery from natural disasters as the ability to access resources and support may become compromised.

Recent Planning

Despite the ongoing challenges that preparing for and recovering from natural hazards and climate change presents, the U.S. Virgin Islands has released a spate of planning documents in recent years that inform its path toward resilience. Recent plans include the following:

- Synthesis of Climate Change Related Knowledge and Information in the U.S. Virgin Islands: An Institutional Analysis (2016)
- U.S. Virgin Islands Hurricane Recovery and Resilience Task Force Report (2018)
- Climate Change Adaptation Planning Assessment and Implementation: Final Vulnerability and Risk Assessment Report (2019)
- U.S. Virgin Islands Hazard Mitigation Plan Update (2019)
- Virgin Islands Housing Finance Authority Disaster Recovery Action Plan (2019)
- South Atlantic Coastal Study (SACS) U.S. Virgin Islands Appendix (2021)
- Virgin Islands Territorial Emergency Operations Plan (2022)

[13] Interdependent Infrastructure Resilience in the U.S. Virgin Islands: Preliminary Assessment (2018), 2.

Timeline

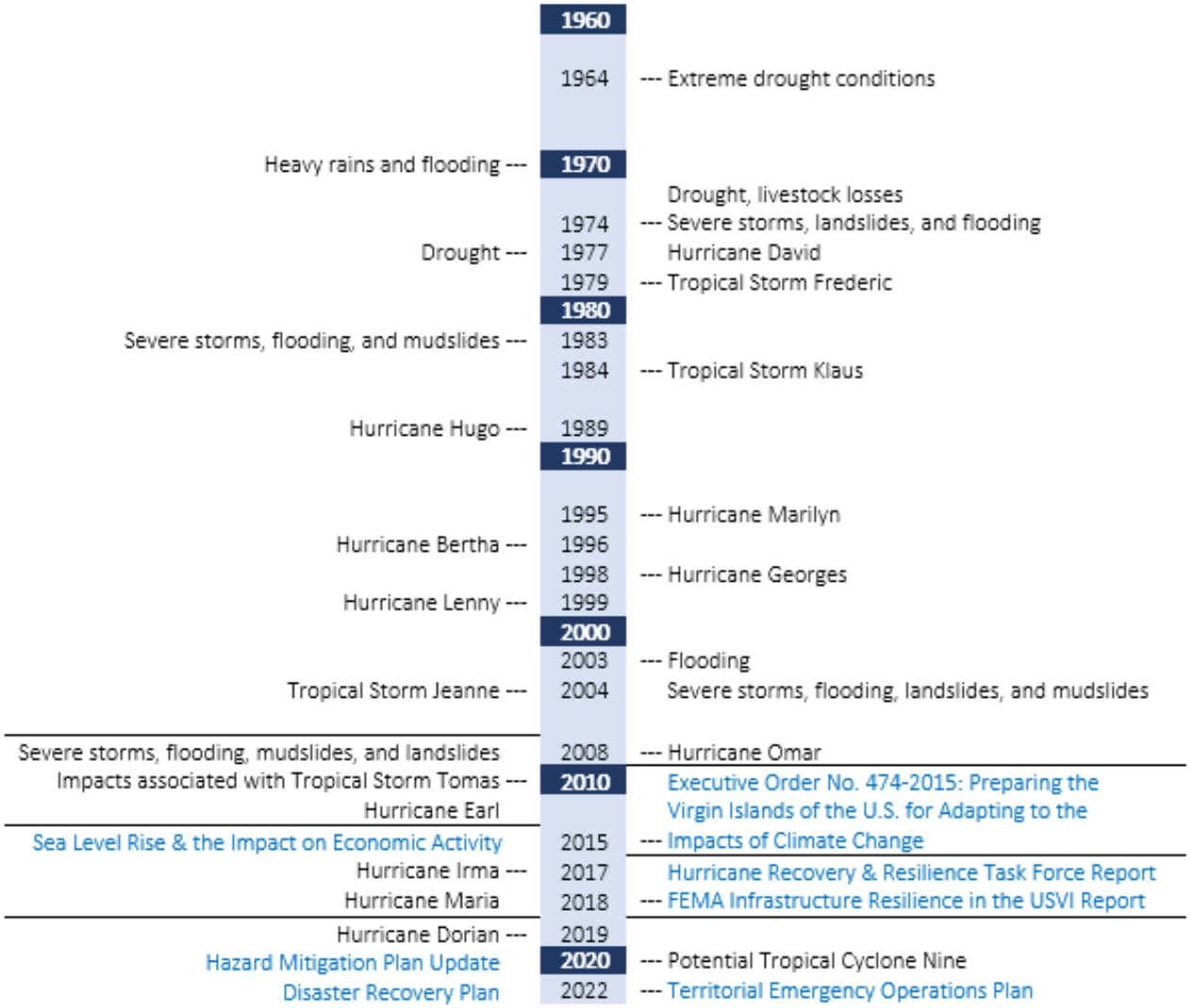
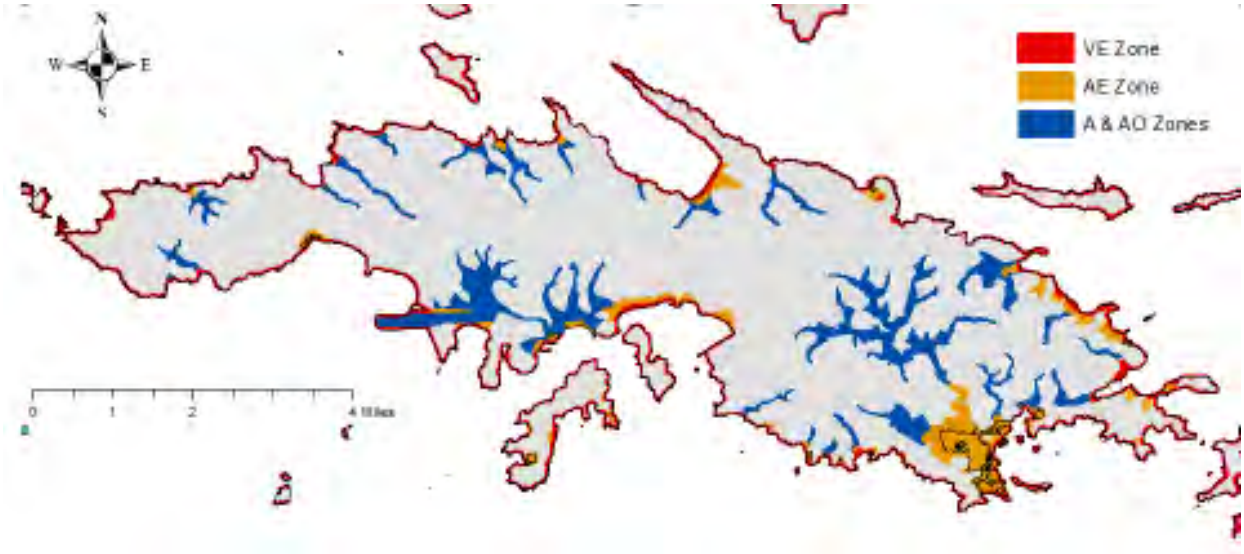

1960
1964
--- Extreme drought conditions
Heavy rains and flooding ---
1970
Drought, livestock losses
1974
--- Severe storms, landslides, and flooding
Drought ---
1977
Hurricane David
1979
--- Tropical Storm Frederic
1980
Severe storms, flooding, and mudslides ---
1983
1984
--- Tropical Storm Klaus
Hurricane Hugo ---
1989
1990
1995
--- Hurricane Marilyn
Hurricane Bertha ---
1996
1998
--- Hurricane Georges
Hurricane Lenny ---
1999
2000
2003
--- Flooding
Tropical Storm Jeanne ---
2004
Severe storms, flooding, landslides, and mudslides
Severe storms, flooding, mudslides, and landslides
2008
--- Hurricane Omar
Impacts associated with Tropical Storm Tomas ---
2010
Executive Order No. 474-2015: Preparing the
Hurricane Earl
Virgin Islands of the U.S. for Adapting to the
Sea Level Rise & the Impact on Economic Activity
2015
--- Impacts of Climate Change
Hurricane Irma ---
2017
Hurricane Recovery & Resilience Task Force Report
Hurricane Maria
2018
--- FEMA Infrastructure Resilience in the USVI Report
Hurricane Dorian ---
2019
Hazard Mitigation Plan Update
2020
--- Potential Tropical Cyclone Nine
Disaster Recovery Plan
2022
--- Territorial Emergency Operations Plan

Figure 2. FEMA Flood Hazard Areas, St. Thomas

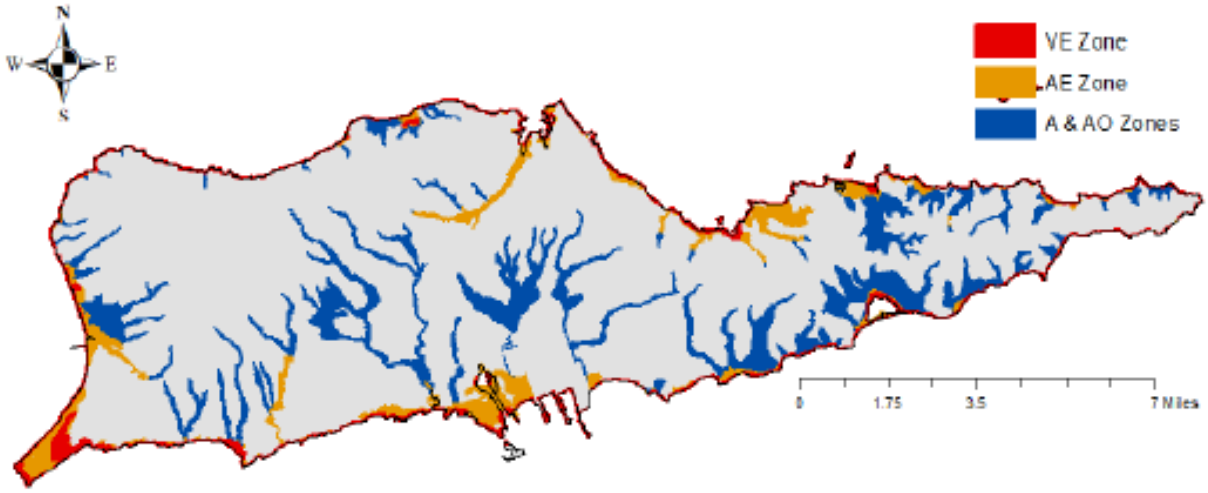


Source: Climate Change and Adaptation Planning Assessment and Implementation: Final Vulnerability and Risk Assessment Report (2019)

Figure 3. FEMA Flood Hazard Areas, St. John

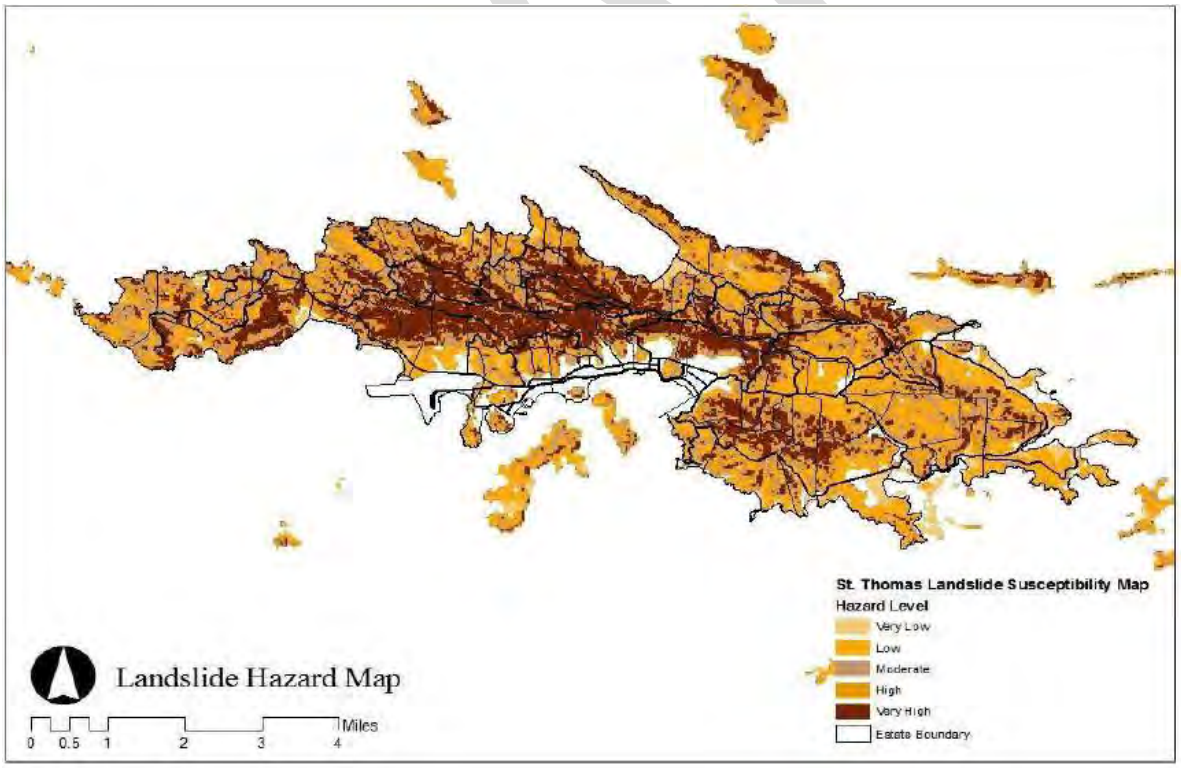
Source: Climate Change and Adaptation Planning Assessment and Implementation: Final Vulnerability and Risk Assessment Report (2019)

Figure 4. FEMA Flood Hazard Areas, St. Croix



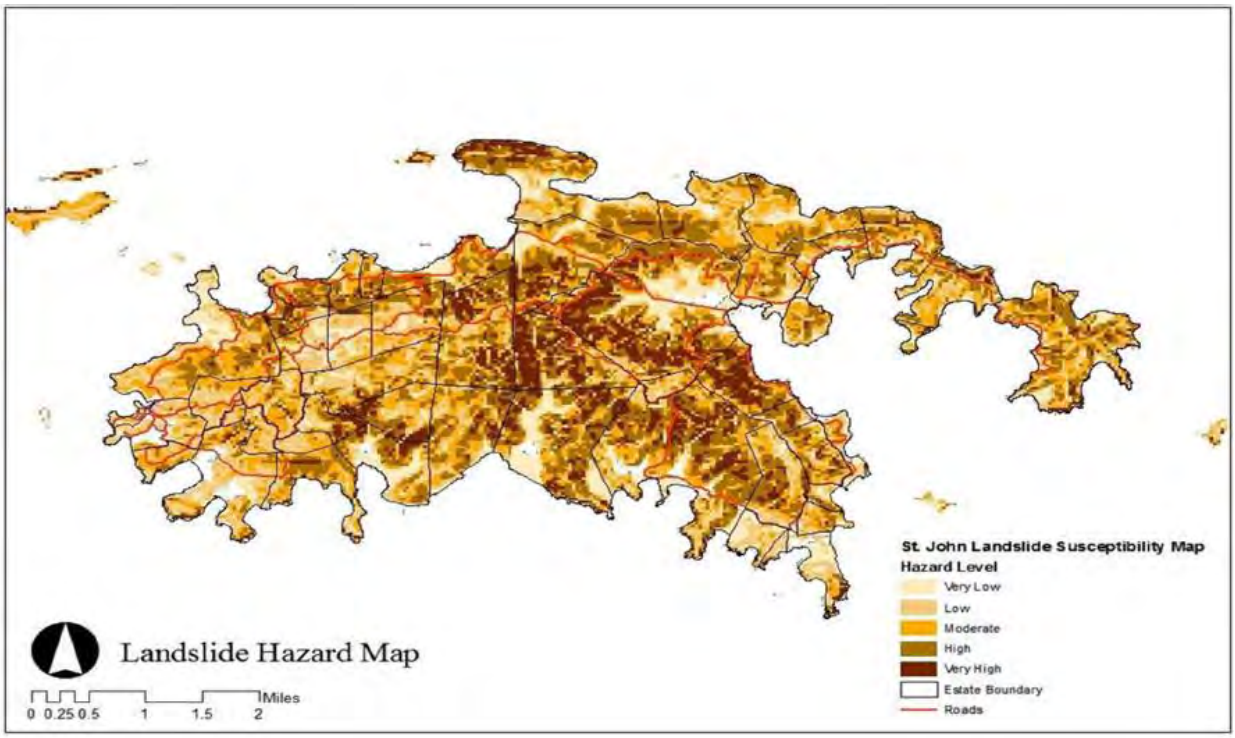
Source: Climate Change and Adaptation Planning Assessment and Implementation: Final Vulnerability and Risk Assessment Report (2019)

Figure 5. Landslide Hazard, St. Thomas



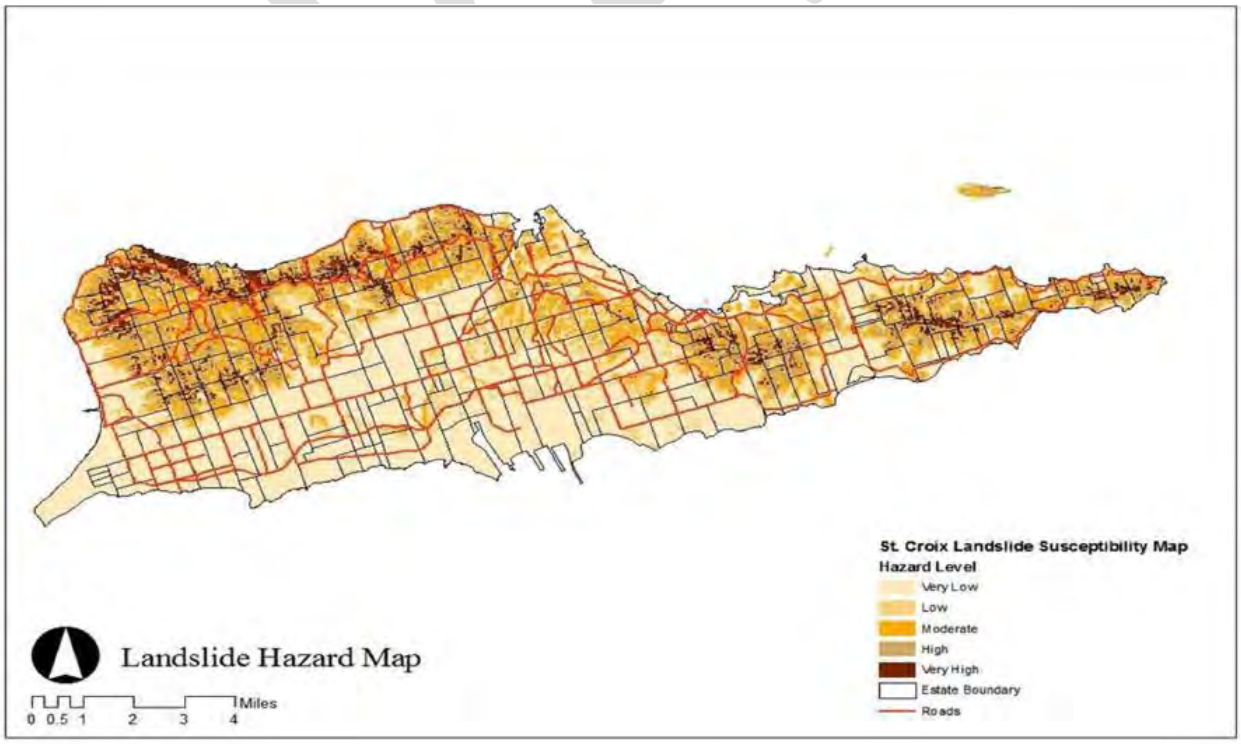
Source: U.S. Virgin Islands Hazard Mitigation Plan Update (2019)

Figure 6. Landslide Hazard, St. John



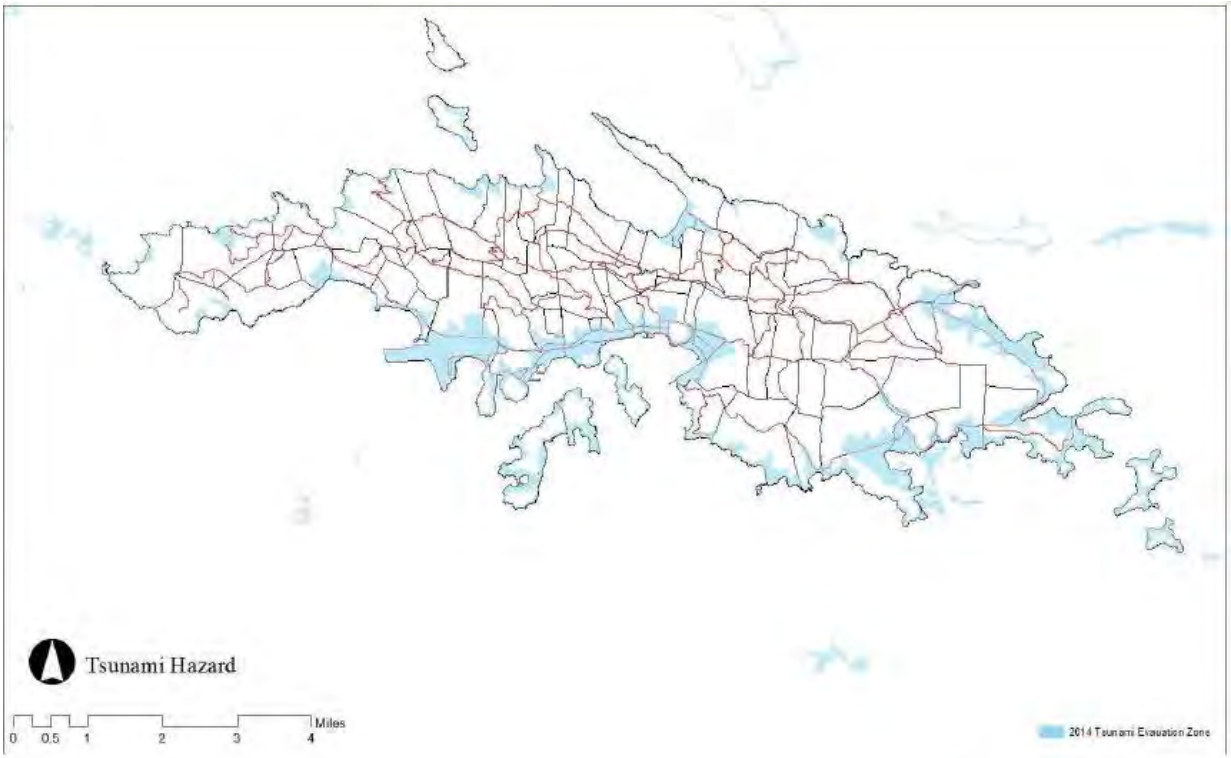
Source: U.S. Virgin Islands Hazard Mitigation Plan Update (2019)

Figure 7. Landslide Hazard, St. Croix



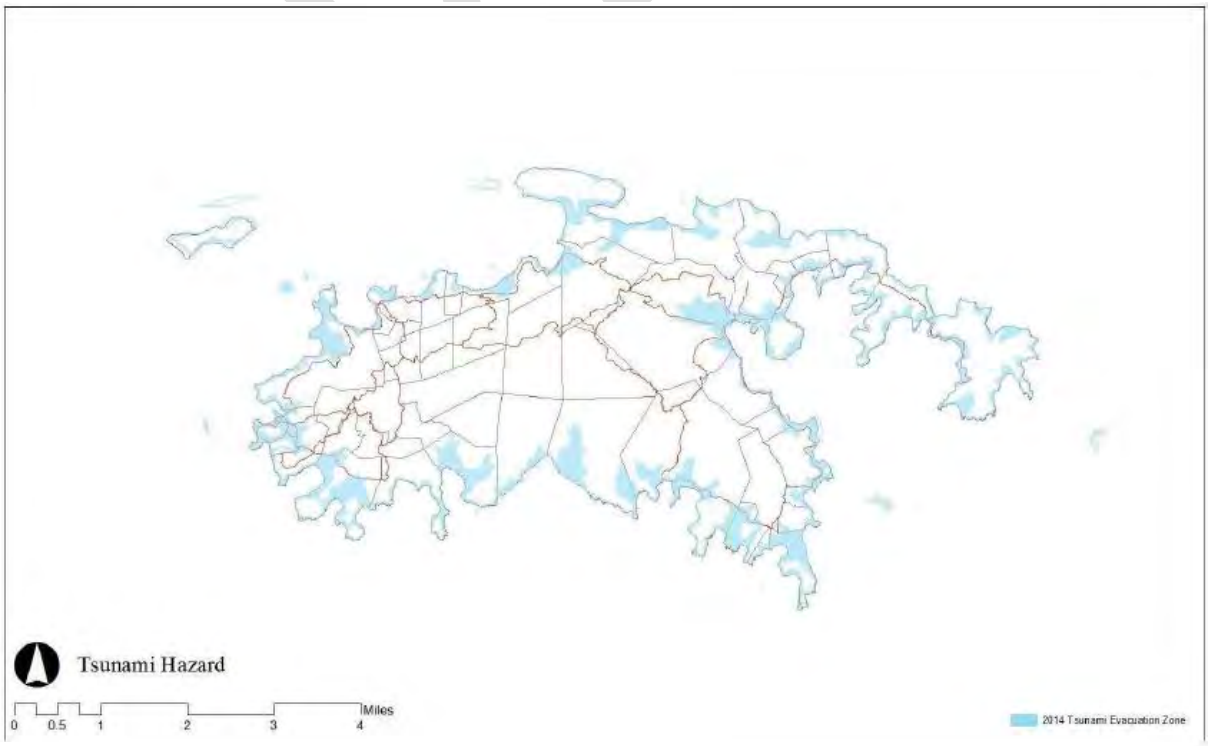
Source: U.S. Virgin Islands Hazard Mitigation Plan Update (2019)

Figure 8. Tsunami Evacuation Area, St. Thomas



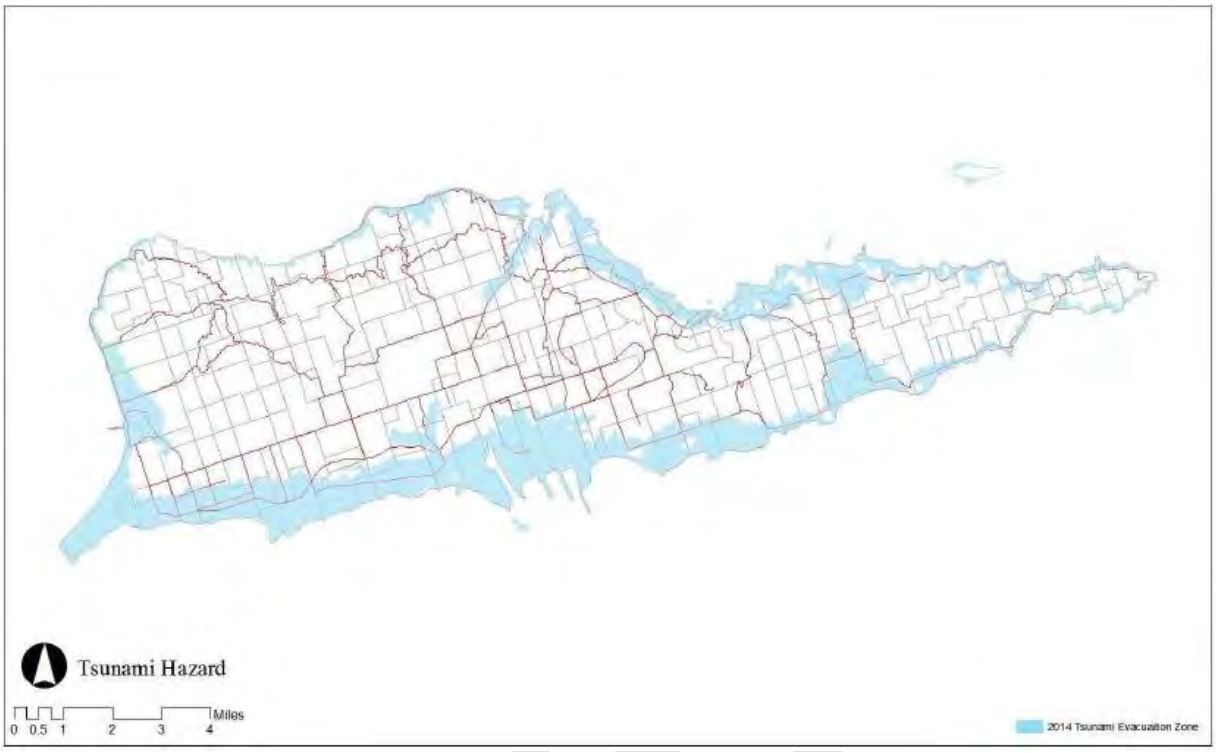
Source: U.S. Virgin Islands Hazard Mitigation Plan Update (2019)

Figure 9. Tsunami Evacuation Area, St. John



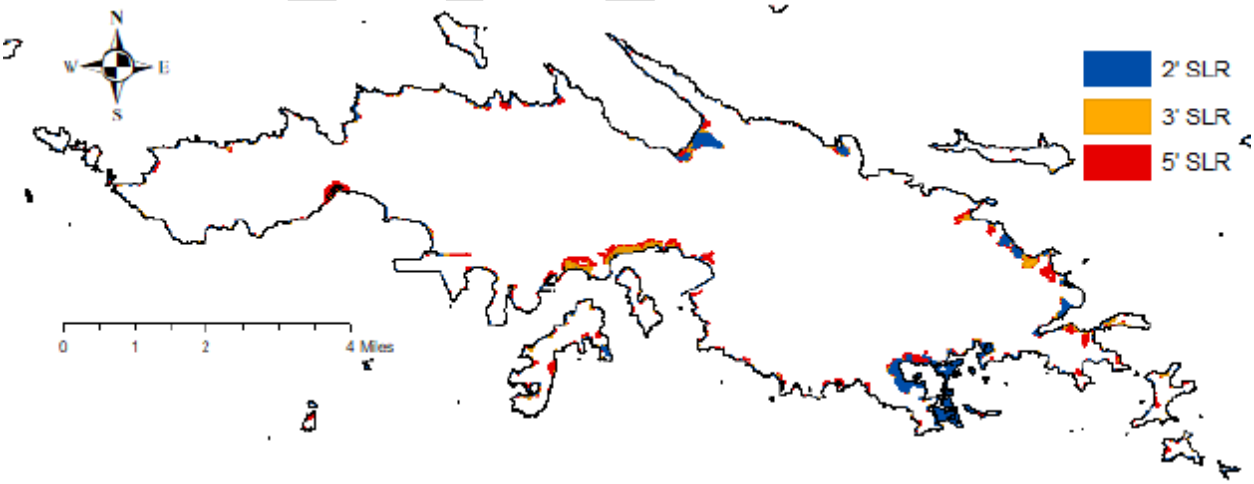
Source: U.S. Virgin Islands Hazard Mitigation Plan Update (2019)

Figure 10. Tsunami Evacuation Area, St. Croix



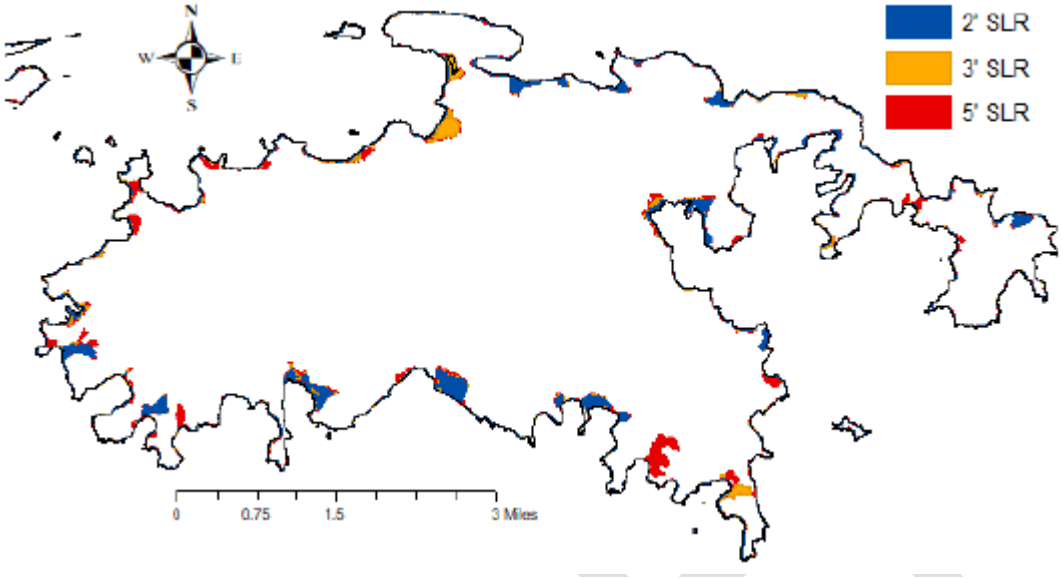
Source: U.S. Virgin Islands Hazard Mitigation Plan Update (2019)

Figure 11. Sea Level Rise Projections, St. Thomas



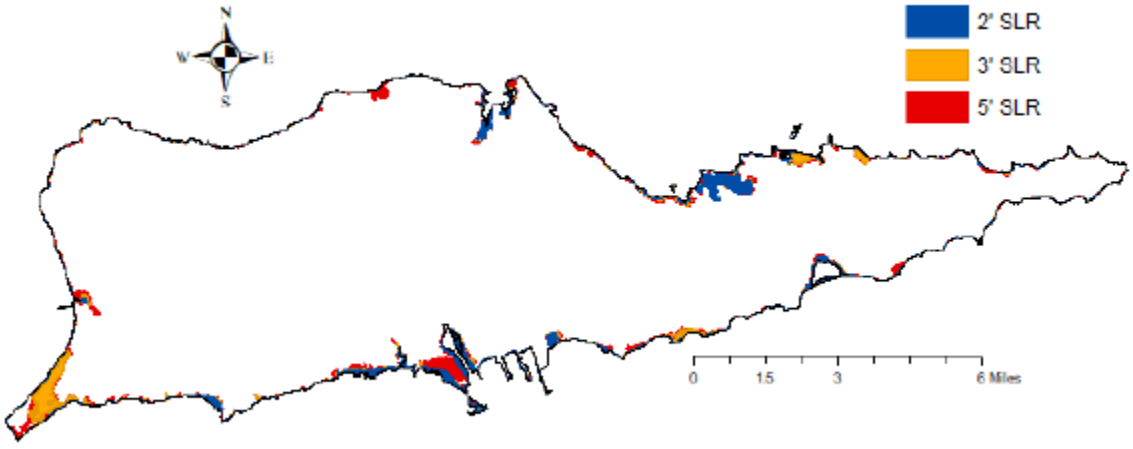
Source: Climate Change and Adaptation Planning Assessment and Implementation: Final Vulnerability and Risk Assessment Report (2019)

Figure 12. Sea Level Rise Projections, St. John



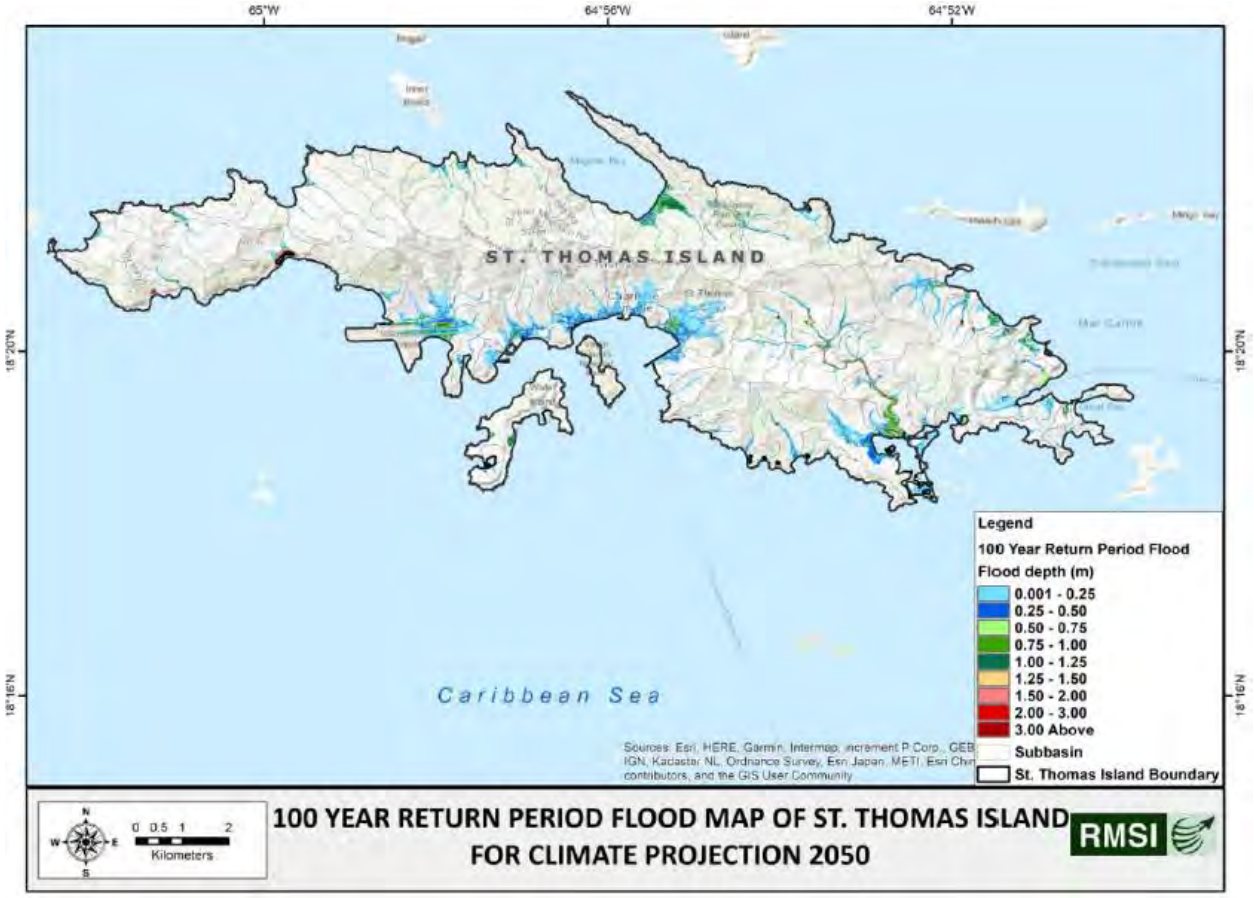
Source: Climate Change and Adaptation Planning Assessment and Implementation: Final Vulnerability and Risk Assessment Report (2019)

Figure 13. Sea Level Rise Projections, St. Croix



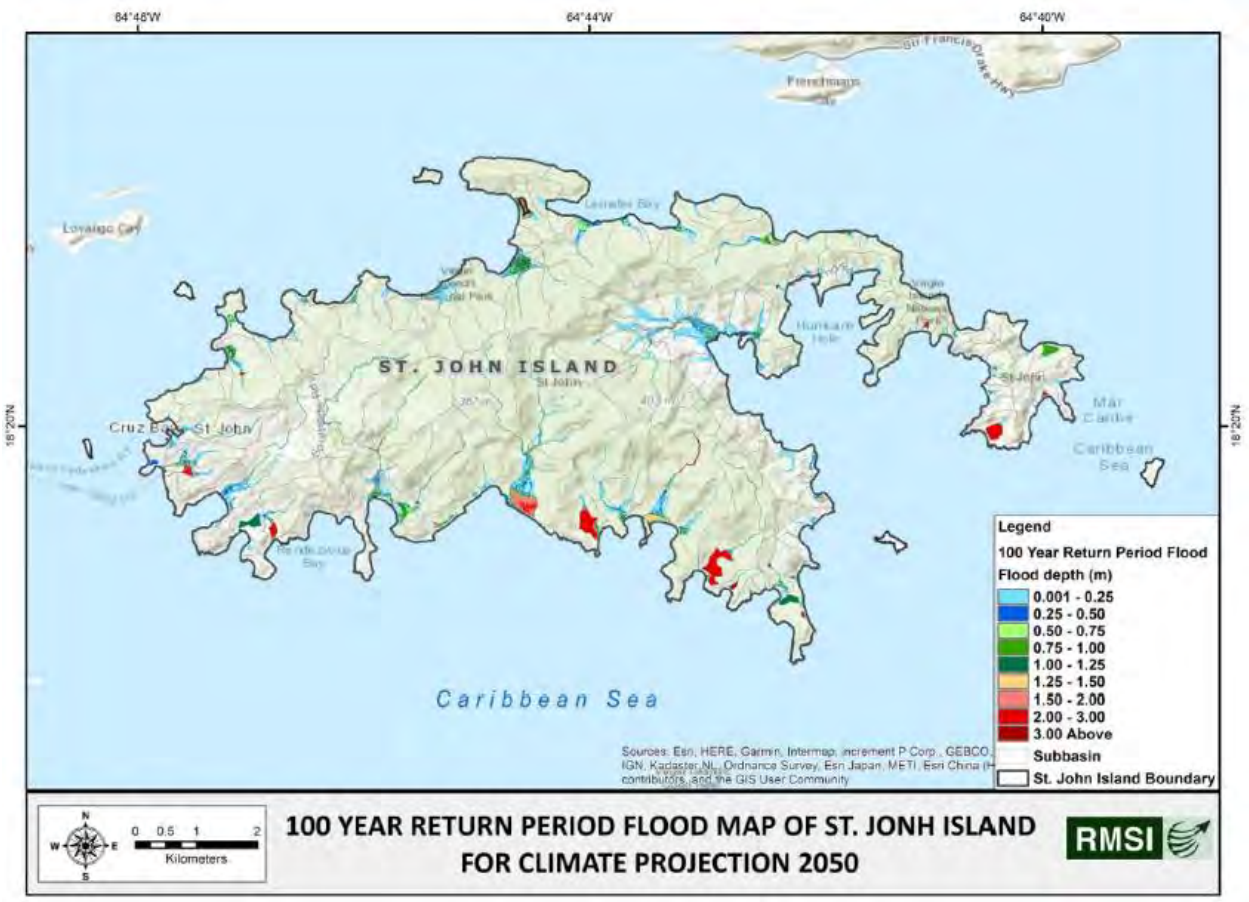
Source: Climate Change and Adaptation Planning Assessment and Implementation: Final Vulnerability and Risk Assessment Report (2019)

Figure 14. Projected 100-Year (1% Annual Chance) Flood for 2050, St. Thomas



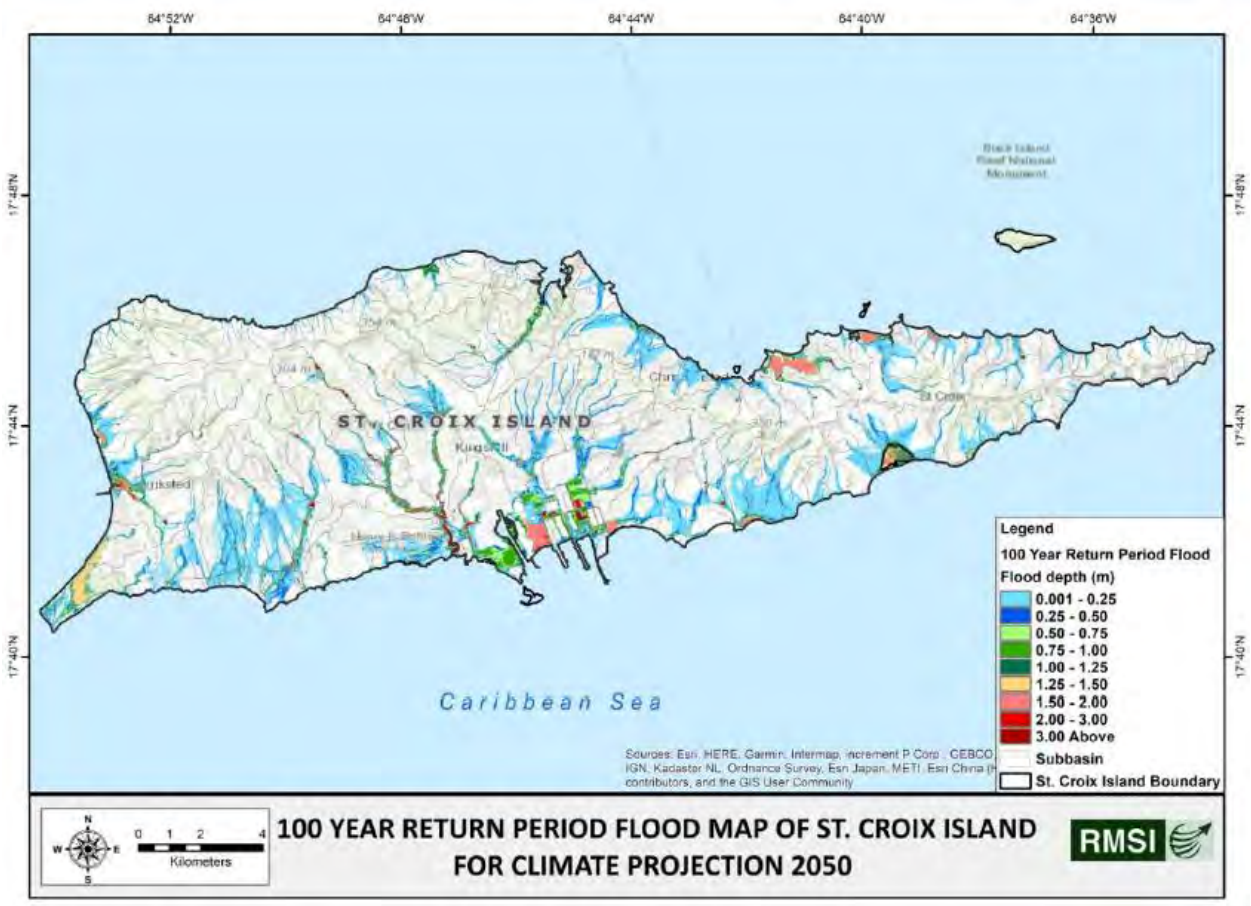
Source: Natural Hazard Risk Analysis for the U.S. Virgin Islands: Report on Flood Hazard Maps and Review of Vulnerability Functions (2021)

Figure 15. Projected 100-Year (1% Annual Chance) Flood for 2050, St. John



Source: Natural Hazard Risk Analysis for the U.S. Virgin Islands: Report on Flood Hazard Maps and Review of Vulnerability Functions (2021)

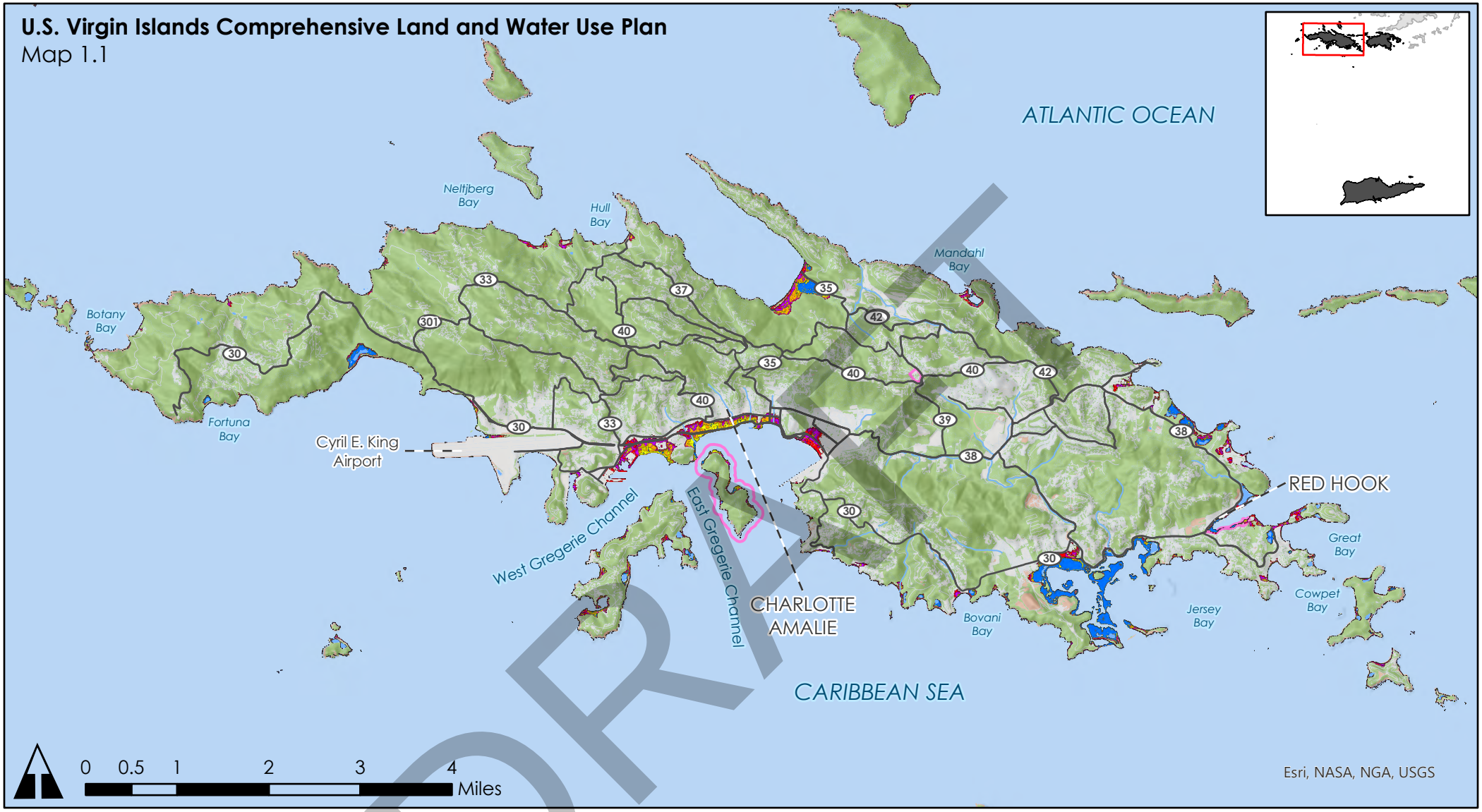
Figure 16. Projected 100-Year (1% Annual Chance) Flood for 2050, St. Croix



Source: Natural Hazard Risk Analysis for the U.S. Virgin Islands: Report on Flood Hazard Maps and Review of Vulnerability Functions (2021)

U.S. Virgin Islands Comprehensive Land and Water Use Plan

Map 1.1



Legend

- Surface Water Bodies
- Guts
- Major Roads
- National Park Service Land

Land Cover (2012)

- Developed Land
- Barren Land
- Undeveloped Land

Potential Hurricane Storm Surge

- Category 1 Hurricane
- Category 2 Hurricane
- Category 3 Hurricane
- Category 4 Hurricane
- Category 5 Hurricane

Potential Hurricane Storm Surge - St. Thomas

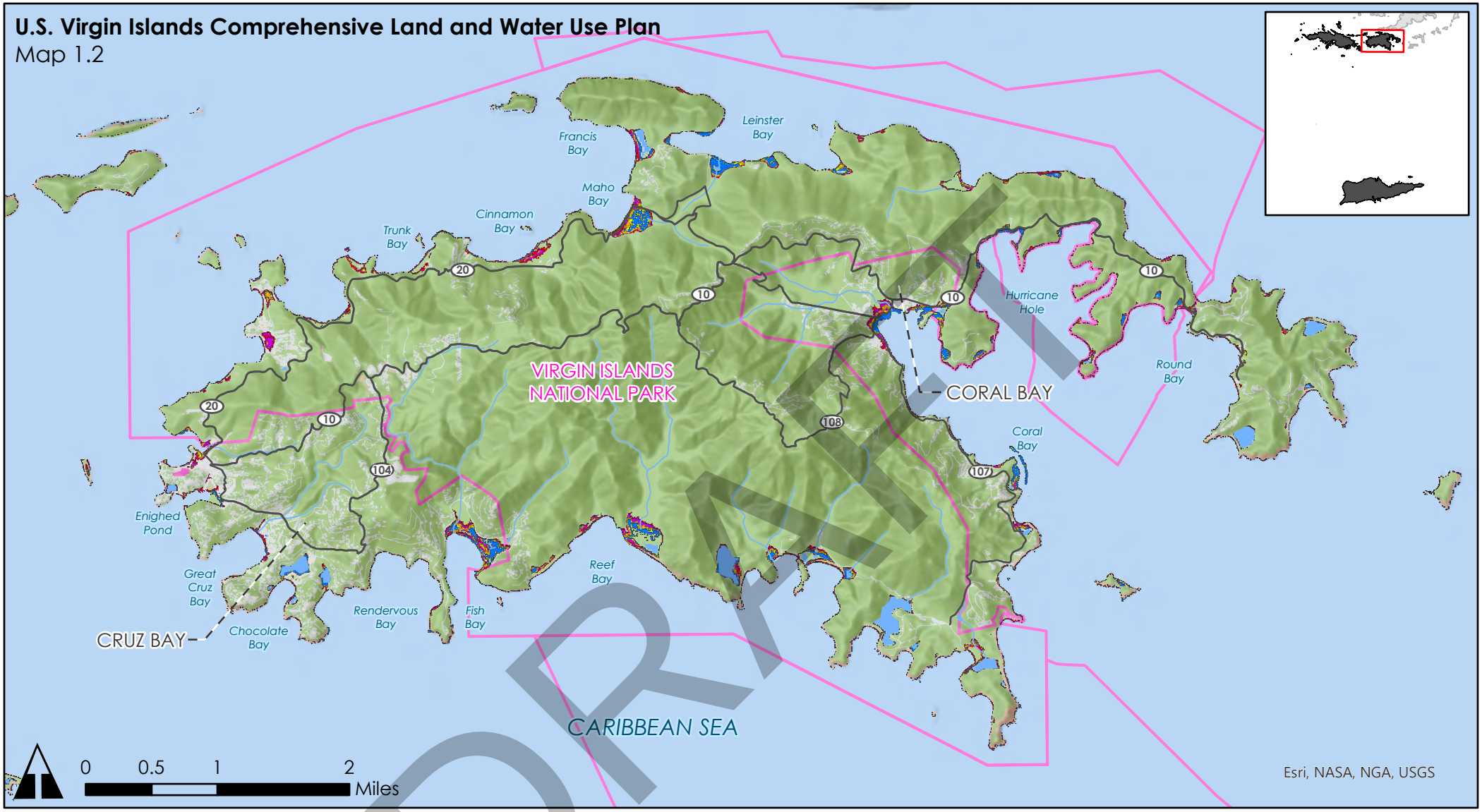
Date: 4/24/2023

Source: U.S. Census Bureau, OCHA Centre for Humanitarian Data, National Park Service, NOAA

Note: This map is for informational purposes only and is not suitable for legal, engineering, or surveying purposes.

U.S. Virgin Islands Comprehensive Land and Water Use Plan

Map 1.2



Legend

- Surface Water Bodies
- Guts
- National Park Service Land
- Major Roads

Land Cover (2012)

- Developed Land
- Barren Land
- Undeveloped Land

Potential Hurricane Storm Surge

- Category 1 Hurricane
- Category 2 Hurricane
- Category 3 Hurricane
- Category 4 Hurricane
- Category 5 Hurricane

Potential Hurricane Storm Surge - St. John

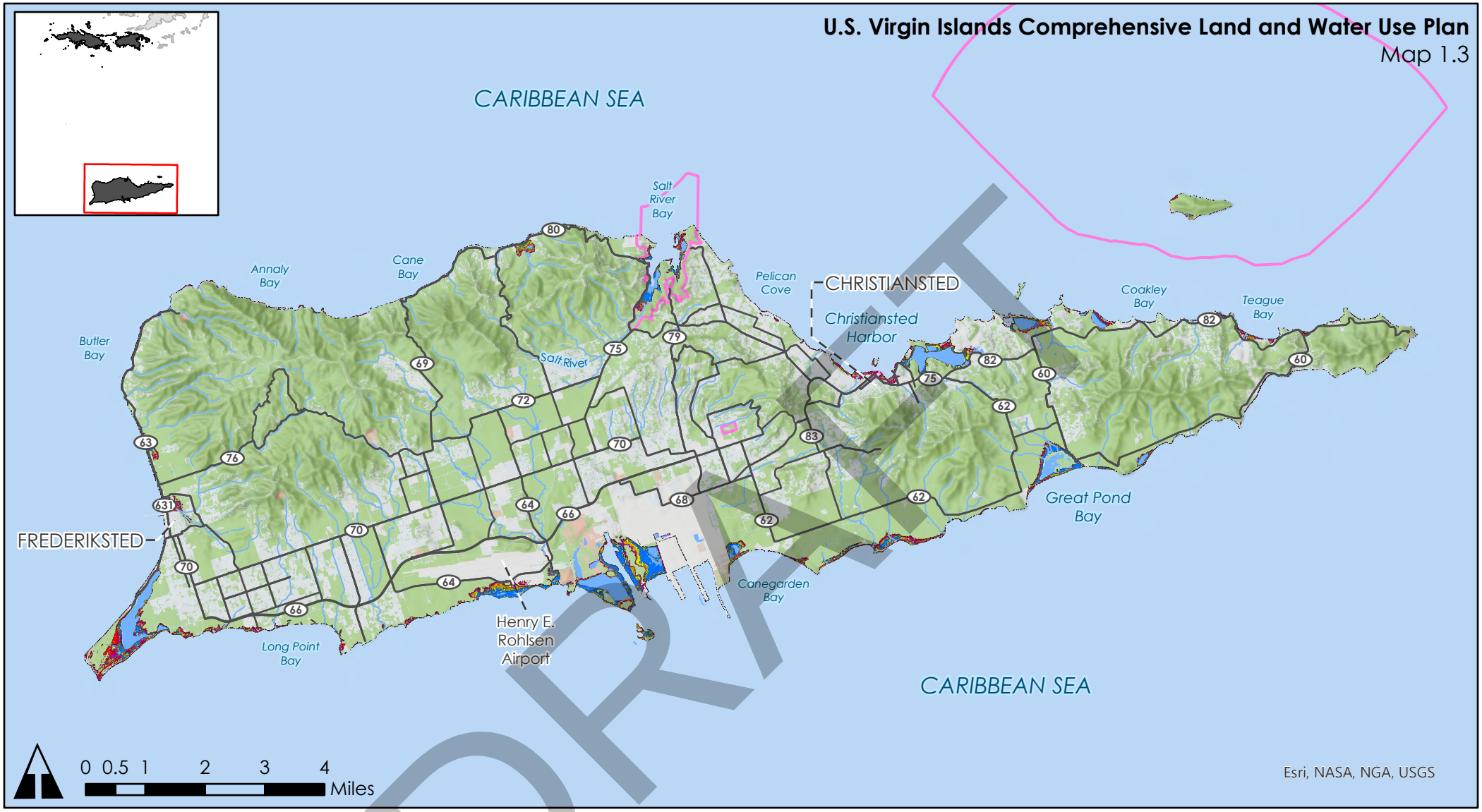
Date: 4/24/2023

Source: U.S. Census Bureau, OCHA Centre for Humanitarian Data, National Park Service, NOAA

Note: This map is for informational purposes only and is not suitable for legal, engineering, or surveying purposes.

U.S. Virgin Islands Comprehensive Land and Water Use Plan

Map 1.3



Legend

- Surface Water Bodies
- Guts
- National Park Service Land
- Major Roads

Land Cover (2012)

- Developed Land
- Barren Land
- Undeveloped Land

Potential Hurricane Storm Surge

- Category 1 Hurricane
- Category 2 Hurricane
- Category 3 Hurricane
- Category 4 Hurricane
- Category 5 Hurricane

Potential Hurricane Storm Surge - St. Croix

Date: 4/24/2023

Source: U.S. Census Bureau, OCHA Centre for Humanitarian Data, National Park Service, NOAA

Note: This map is for informational purposes only and is not suitable for legal, engineering, or surveying purposes.