

SECTION FOUR RISK ASSESSMENT

This section is organized around the risk assessment process that includes the following eight subsections:

- 4.1 Introduction and Methodology
- 4.2. IFR Requirements for Risk Assessment
- 4.3 Hazard Identification
- 4.4 Hazard Profile
- 4.5 Inventory of Assets
- 4.6 Vulnerability Assessment
- 4.7 Loss Estimates
- 4.8 Loss Estimation Summary and Hazard Ranking

4.1 INTRODUCTION & METHODOLOGY

The risk assessment methodology utilized in this Plan Update is the same as was utilized in the 2008 Plan. It is consistent with the process and steps presented in FEMA Publication 386-2, “State and Local Mitigation Planning How-To Guide, Understanding Your Risks—Identifying Hazards and Estimating Losses” (FEMA 2001) and utilizes a risk assessment methodology similar to HAZUS-MH. Figure 4.1 shows the four major steps that comprise the risk assessment process: Hazard Identification, Hazard Profiling, Vulnerability Assessment, and Loss Estimation.

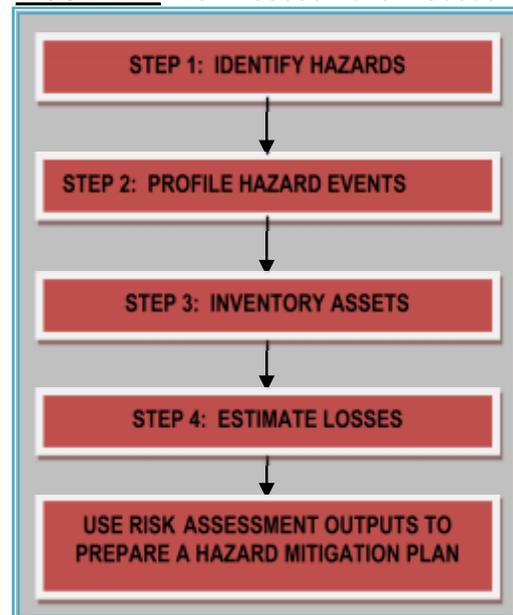
Step 1 – Hazard Identification

The hazard identification was compiled by investigating the various natural hazard occurrences within the Territory.

Because it is assumed that hazards that occurred in the US Virgin Islands in the past may be experienced in the future, the hazard identification process for this Plan Update included extensive discussions with VITEMA, its Hazard Mitigation Steering Committee, island Hazard Mitigation Committees and the general public.

Discussions with these groups focused on the identification of hazards for this Plan Update. Information of past hazards was obtained from historical hazard assessment documents, and hazard specific plans and reports developed by experts over the past two decades.

FIGURE 4.1 Risk Assessment Process



Step 2 – Hazard Profiling

This step involved determining the extent where possible (i.e. maps), the frequency or probability of future events, their severity, and factors that may affect their severity. Each hazard type has unique characteristics that can impact the Territory in different ways. At the hazard identification phase, several important natural hazards that could affect the US Virgin Islands were considered. The following natural hazards have been documented for the US Virgin Islands and have been assessed as risks for the purpose of this Plan Update. They are listed in the order that they will be discussed in the Plan Update:

- Drought,
- Earthquake,
- Riverine Flooding,
- Coastal Flooding and Erosion,
- Hurricane Winds,
- Rain-Induced Landslide,
- Tsunami, and
- Wildfire

The results of the hazard identification process and discussions reveal that the hazards listed above warrant a vulnerability assessment. It is important to note; however, that the consultant team formally indicated to VITEMA, that there was a concern about the availability of data concerning the mapping (extent) and historic data required to understand the frequency and vulnerability of several of the identified hazards, specifically rain-induced landslide, drought and wildfire.

It is necessary to note that several of these hazards were identified as concerns during the last plan update and mitigation actions were included in the Plan (2008) to collect information concerning the location, frequency and history of these events in the Territory. No data has been collected for use in this Plan Update and that data gap will limit the ability to fully profile these hazards – i.e. catalog of events from which to ascertain their frequency of occurrence and/or estimate the magnitude of historical events, let alone to accurately estimate vulnerability and losses (i.e. future impacts).

Step 3 – Inventory of Assets

The inventory of assets quantifies what can be lost when a hazard occurs. Specifically, the people, places, and property that could be injured, damaged, or destroyed are quantified. The following data was collected and calculations were made:

- Estimate or count the total number of buildings, value of buildings, and population in the Territory.
- Determine the proportion of buildings, the value of buildings, and the population in located in hazard prone areas, and
- Calculate the proportion of assets located in hazard areas.

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In order to understand the vulnerability of people, buildings and infrastructure to natural hazards, a comprehensive inventory of assets was conducted. Inventory data was categorized into a number of asset categories, including population, general building stock, and infrastructure.

Population.

2000 U.S. Census information was updated using projected annual population growth rates for the Territory. 2010 U.S. Census data for the US Virgin Islands was unavailable at the time of the Plan Update. A series of calculations were performed to identify the number of people less than 18 years of age and the number of people over 65 years of age. These two demographic subgroups help define the territory's social vulnerability as these two population groups are the most likely to need assistance during and/or after a hazard event.

General Building Stock.

The Virgin Islands Tax Assessors Office (Division of the Office of the Lt. Governor) provided the project team its Computer Aid Mass Appraisal (CAMA) database in 2008 to assist in the classification of the general building stock. The 2008 database was updated to categorize the built environment into two general occupancy categories: commercial and residential. Detailed below are the procedures used to identify the number of buildings and to estimate the exposure values of the general building stock (replacement and content values).

1. Tax lot or parcel information was aggregated for each estate on each island to identify the number of buildings per occupancy class, per estate. Analysis was limited to commercial and residential type buildings. Data limitations within the tax assessment database precluded the consideration of other occupancy classes, i.e., industrial, government, agricultural, and religious institutions.
2. A matrix was developed to relate the number of building and occupancy classes to specific building types, showing the distribution of model building types throughout each island. Distribution information was compiled to determine the number of building types per specific occupancy class. Collected data was aggregated at the estate level for each island.
3. An average replacement cost was developed for each building type. Replacement costs were based on average construction costs per square foot, reflecting labor and material costs for each island. For each occupancy class, content values were determined as a percent of the replacement costs (i.e. multiply building replacement costs by content cost percentage to calculate content value).
4. This analysis facilitated a determination of the number of buildings per occupancy class and an aggregate estimate per estate of exposure costs (i.e. replacement value added content value). To enable an island by island comparison, the number of buildings and aggregate replacement and content values of each island were summed up, identifying exposure values for general building stock.

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The data utilized in this Plan Update was aggregated from 2008 building stock data and contains estimates of residential and commercial values based on price indexes for housing and construction costs. Annual data sets were derived from publicly available data from the Bureau of Economic Analysis (BEA). The value of structures identified as residential and commercial purposes in this Plan Update are considered to be of “fair market value” for the US Virgin Islands.

Critical Facilities and Infrastructure.

A detailed list of critical facilities and infrastructure was developed by VITEMA with the input from the Hazard Mitigation Steering Committee. The list was based on critical facilities included in the 2008 Plan, the Critical Facility Infrastructure Plan and from information collected from Department of Property and Procurement. Detailed procedures used to update exposure values of critical facilities (replacement and content values) are provided below:

1. A thorough evaluation of the critical facilities and infrastructure list revealed that there were no new critical facilities identified since the 2008 Plan. Therefore, site visits were undertaken in the 2008 Plan were not necessary as the general structural characteristics and general conditions of each critical facility identified by VITEMA did not change significantly since the last Plan Update.
2. Facilities/structures were categorized by structural characteristics relevant to the prominent hazards addressed in the vulnerability assessment. The approximate square footage for each facility/structure or group of buildings.
3. Replacement and content values for facilities for the 2008 Plan were provided by the VI Department of Property and Procurement. An evaluation of this data revealed that approximate building areas and construction costs (i.e. exposure) were overstated. Therefore, this Update Plan relied on construction price indices and inflation factors derived from the U.S. Department of Commerce, Bureau of Economic Analysis to update replacement estimates for critical facility classes.

The final step of the inventory process is a **vulnerability assessment**, which facilitates an understanding of the proportion of buildings, the value of buildings, and the population that is located in hazard areas. The results of the hazard identification and profile were used to understand characteristics of hazards (i.e. wind speed, flood depth, etc.) in order to assess the vulnerability parameters (specific damage and loss characteristics) of each asset identified. For instance, a wood frame building will have different damage and loss characteristics for a hurricane than a reinforced concrete structure. A hazard vulnerability assessment level (very low, low, medium, high, and very high) was assigned to each building type or facility to express the vulnerability for the general building stock (model building types) and critical facilities and infrastructure in qualitative terms. It is necessary to note that vulnerability estimates were not conducted for all hazards, especially drought, rain-induced landslides and wildfires. Instead, hazard overlays were performed to identify the number of buildings in hazard susceptibility zones identified on newly created maps for these hazards.

Step 4—Loss Estimation

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Based on the vulnerability assessment for the general building stock, damage functions were developed to translate the hazard intensity data (given in terms of wind speed, ground shaking, depth of flooding, etc.) into its respective economic loss potential. In its simplest form, a damage function estimates the potential economic damage (e.g., cost to repair/replace the damaged components) of a building or group of buildings to a specified level of hazard intensity. For this study, damage functions were developed based on standard damage ratios obtained from HAZUS^{MH} for hurricane wind, earthquake and flooding, various published reports, expert opinion and other propriety information. Data limitations did not allow for the development of damage functions or the newly identified hazards: drought, rain-induced landslide and wildfire. The vulnerability assessment only provides a rough estimate of the built environment that is exposed to these hazards and does not allow for a characterization of how a structure or group of structures would perform at a certain level of hazard intensity.

Below are procedures for a prototypical estate in the US Virgin Islands:

1. Hazard maps (location) and hazard profile information (intensity) were used to identify the natural hazard affecting a particular area. Based on the intersection of hazard areas, each estate was assigned a particular hazard intensity level (i.e. hurricane wind speed).
2. Exposure to a specific hazard (i.e. number of buildings, % of total buildings, and value) was determined for identified buildings (general building stock and critical facilities).
3. A qualitative vulnerability level was assigned to each model building type to understand the vulnerability of buildings. This is expressed as a percentage of damage based on a specific hazard level.
4. Qualitative vulnerability levels were related to specific loss estimation tables to determine a specific percentage of damage to a structure (i.e. replacement and content value).
5. To calculate losses, the expected percentage of damage was multiplied by the structure replacement cost and content value.

The loss estimation process provides the US Virgin Islands with a relative ranking of risk to general building stock and critical facilities and infrastructure from various hazards.

Loss estimates associated with drought, wildfire and rain-induced landslides were not analyzed using a risk assessment methodology based on the same principals as described above. Instead, available historical data for each hazard are used and statistical evaluations are performed using manual calculations. The general steps used in this methodology include: compilation of data from national and local sources; verification of data using statistical analysis; determine the frequency of hazard occurrence; and, estimate damages associated with a specific hazard occurrence.

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It is important to note that loss estimates in this risk assessment used the best available data and methodologies, but should still be considered approximate. These estimates should be used to understand relative risk from hazards and potential losses and are not intended to be predictive of precise results. Uncertainties are inherent in any loss estimation methodology arising in part from incomplete scientific knowledge concerning natural hazards and their effects on the built environment. Uncertainties also result from approximations and simplifications that are necessary for a comprehensive analysis (e.g., incomplete or outdated inventory, demographic, or economic parameter data).

4.2 IFR REQUIREMENTS FOR RISK ASSESSMENT

4.2.1 IFR REQUIREMENTS FOR HAZARD IDENTIFICATION AND PROFILES

§201.4(c)(2) of the IFR states that “[the State plan must include a risk assessment] that provides the factual basis for activities proposed in the strategy portion of the mitigation plan. Statewide risk assessments must characterize and analyze natural hazards and risks to provide a statewide overview. This overview will allow the State to compare potential losses throughout the State and to determine their priorities for implementing mitigation measures under the strategy, and to prioritize jurisdictions for receiving technical and financial support in developing more detailed local risk and vulnerability assessments.”

The IFR includes two specific requirements for the identification and profiling of natural hazards:

- **Hazard Identification** per **Requirement §201.4(c)(2)(i)**: “[The State risk assessment shall include an] overview of the type ... of all natural hazards that can affect the State”
- **Hazard Profiles** per **Requirement §201.4(c)(2)(i)**: “[The State risk assessment shall include an overview of the] location of all natural hazards that can affect the State, including information on previous occurrences of hazard events, as well as the probability of future hazard events, using maps where appropriate ...”

4.2.2 IFR REQUIREMENTS FOR VULNERABILITY ASSESSMENT AND LOSS ESTIMATION

The IFR includes two specific requirements regarding vulnerability assessments and loss estimates:

- **Vulnerability Assessment** per **Requirement §201.4(c)(2)(ii)**: “[The State risk assessment shall include an] overview and analysis of the State’s vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in local risk assessments as well as the State risk assessment. The State shall describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events. State-owned critical or operated facilities located in the identified hazard areas shall also be addressed.”
- **Estimated Losses** per **Requirement §201.4(c)(2)(iii)**: “[The State risk assessment shall include an] overview and analysis of potential losses to the identified vulnerable structures, based on estimates provided in local risk assessments as well as the State risk assessment. The State shall estimate the potential dollar losses to State owned or

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operated buildings, infrastructure and critical facilities located in the identified hazard areas.”

US Virgin Islands local risk assessments were not available. In order to provide risk comparisons among the islands, the Plan Consultant performed, for each island, local risk assessments that meet the IFR **Requirement §201.6(c)(2)** for local mitigation plans. These local risk assessments, while not required by the State IFR guidelines, provide information valuable to the mitigation process.

4.3 HAZARD IDENTIFICATION

Since the completion of the 2008 Plan there have been four (4) Presidential Disaster Declarations involving the UWVI. As a result, the USVI has suffered significant loss of property from natural hazards. Since 1995, the USVI received eleven presidential disaster declarations. As shown in Table 4.1, the main sources of damages in recent years have been hurricanes and flooding.

TABLE 4.1 Presidential Disaster Declarations in the US Virgin Islands, 1994 – 2010

Year	Date	Declaration / Disaster Type
2010	11/24	Severe Storms, Flooding, Rockslides, and Mudslides associated with Tropical Storm Tomas
2010	11/05	Severe Storms, Flooding, Mudslides, and Landslides associated with Tropical Storm Otto
2010	09/28	Hurricane Earl
2008	1/29	Hurricane Omar
2004	10/07	Major Disaster / Tropical Storm (Jeanne)
2003	12/09	Major Disaster / Flooding
1999	11/23	Major Disaster / Hurricane (Lenny)
1999	11/18	Emergency / Hurricane (Lenny)
1998	09/24	Major Disaster / Hurricane (Georges)
1996	07/10	Major Disaster / Hurricane (Hortense)
1995	09/16	Major Disaster / Hurricane (Marilyn)

These hazards have challenged the US Virgin Islands to develop ways to reduce future damages. This subsection describes the process used to identify those hazards addressed in detail in the risk assessment of this Plan Update.

The process included reviewing and identifying a list of natural hazards. The review and evaluation of the hazards included those identified in the 2008 Plan and the following new additions: rain-induced landslide; wildfire; and, drought. It is important to note that the coastal flooding section in this Plan Update was updated to include erosion, related to storm surges. The list of hazards addressed in this Plan Update include:

- Drought,
- Earthquake,

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- Riverine Flooding,
- Coastal Flooding and Erosion,
- Hurricane Winds,
- Rain-Induced Landslide,
- Tsunami, and
- Wildfire

Each hazard was discussed in detail during the Hazard Mitigation Steering Committee and island specific Hazard Mitigation Committee meetings, in addition to summarizing the hazards evaluated and risk assessment process to the general public during public informational workshops. Citizens were given a chance to review this listing and express concerns about hazards on their respective islands.

Citizens on St. John expressed concerns about hurricanes, earthquakes and landslides, while residents on St. Thomas and St. Croix spoke about hurricanes, earthquakes and a greater concern about riverine flooding.

The result of this community input and pursuant discussions with VITEMA allow for an evaluation of each of the hazard with criteria that was set forth in the 2008 Plan Update. The evaluation criteria included the following five major benchmarks:

- Ability to describe the hazard,
- Ability to describe the nature of the hazard in USVI,
- Ability to identify the location and map the extent of the hazard,
- Ability to document previous occurrences and frequency of the hazard, and
- Ability to quantify losses for the hazard

The participants at all of the public informational meetings contributed through a lively discussion of both the reasons for inclusion and conversely the reasons for exclusion of hazards that should be addressed in this Plan Update. The decision for the inclusion for the following hazards was made by the Hazard Mitigation Steering Committee and ratified by the island specific Hazard Mitigation Committees during meeting held at the VITEMA Emergency Operations Center on February 14, 2011. The updated results of the evaluation are provided below in Table 4.2

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TABLE 4.2 Hazard Identification Evaluation Matrix, 1994 – 2010

Hazard/Criteria ¹	Ability to describe the hazard	Ability to describe the nature of the hazard in USVI	Ability to identify the location and map the extent of the hazard	Ability to document previous occurrences and frequency of the hazard	Ability to quantify losses for the hazard.
Drought	3	3	2	1	1
Earthquake	4	4	4	4	4
Riverine Flooding	4	4	4	4	4
Coastal Flooding and Erosion	4	4	4	4	4
Hurricane Winds	4	4	1	4	4
Rain-induced Landslide	3	3	3	1	2
Tsunami	4	4	4	4	4
Wildfire	2	2	2	1	1

Based on the results, the consensus was to endeavor to undertake an assessment of all of the identified hazards. The Hazard Mitigation Steering Committee and island Hazard Mitigation Committees felt that the several key hazards posed the highest threat to the Territory and demanded attention. These hazards are Hurricane, Earthquake, Flooding and Landslides.

Discussion focused on the fact that there were not sufficient credible and historic data for drought, rain-induced landslides and wildfire hazards and that additional research and mapping would be necessary to confirm and profile these hazards, yet alone estimate losses. The profile and risk assessments included in this Plan Update for the rain-induced landslides, wildfires, and drought hazards, while useful for developing strategies designed to mitigate the impact of the hazards, should be considered preliminary. The Territory should include specific actions to collect more reliable information for these and other hazards. Actions to collect more reliable information for these and other hazards were included in the 2008 Plan Update and are once again included in this Plan Update and should be considered to be a priority for VITEMA. These actions are listed in Section Five – Mitigation Strategy in this Plan Update (See Programmatic Actions USVI:6 through 9).

¹ Rating:

- 1 –low ability
- 2- moderate ability
- 3 –high ability
- 4 –very high ability

Nevertheless, VITEMA believes the Territory’s position is justified as per key language included in the IFR, specifically the *IFR Requirement §201.4 (c)(2)(ii)*, which states: “*The State shall describe vulnerability in terms of the jurisdictions ... **most vulnerable** to damage and loss associated with hazard events.*” By identifying the most prevalent hazards, based on the experience of VITEMA, the Territory in effect is pursuing a meaningful evaluation of the *most vulnerable* areas on the three major Islands².

4.4 HAZARD PROFILE

4.4.1 DROUGHT

Hazard Description

Drought is a normal part of virtually all climatic regimes, including areas with high or low average rainfall. Drought is the consequence of a natural reduction in the amount of precipitation expected over an extended period of time, usually a season or more in length.

Droughts can be classified as meteorological, hydrologic, agricultural, and socioeconomic. Table 4.3 below presents definitions for these types of droughts.

TABLE 4.3 Drought Classification Definitions

Term	Definition
Meteorological Drought	The degree of dryness or departure of actual precipitation from an expected average or normal amount based on monthly, seasonal, or annual time scales.
Hydrologic Drought	The effects of precipitation shortfalls on streamflow and reservoir, lake, and groundwater levels.
Agricultural Drought	Soil moisture deficiencies relative to water demands of plant life, usually cropland but can also include rangeland.
Socioeconomic Drought	The effect of demand for water exceeding supply as a result of a weather-related supply shortfall.

Source: *Multi-Hazard Identification and Risk Assessment: A Cornerstone of the National Mitigation Strategy*, FEMA

Nature of the Hazard

In the U.S. Virgin Islands, adequate water supplies are critical for the well being and economic security of the islands. Water resources or access to them are already limited and subject to competing demands (i.e.

² *The US Virgin Islands Territorial Hazard Mitigation Plan, consistent with the intent of the Disaster Mitigation Act of 2000 (DMA 2000) is focused on natural hazards. The plan does not include consideration of any manmade hazards beyond the secondary effects of natural disasters on sites and facilities with technological, hazard materials or other manmade considerations.*

growing population and a growing tourist industry). The US Virgin Islands has extremely limited surface-water resources and limited ground-water resources, receives only moderate rainfall, much of which is lost to evaporation and surface run-off.

Therefore, droughts can exacerbate the problem of ensuring a sustainable yield of potable water. With no year-round streams and only limited ground water resources, 65% of drinking water supplies are provided by desalination (removing the salt from seawater). Groundwater provides 22% of the drinking water supply and the remaining 13% is from rooftop catchments.

Droughts also increase the potential for wildfires, adversely affect farming, and can cause strains on already strained water resources throughout the territory.

Hazard Location, Extent and Distribution

Figure 4.2, 4.3, and 4.4 illustrate the geographic coverage of drought on all three islands. The entire Territory is susceptible to the effects of drought. There are, however, some useful distinctions between islands which should be noted:

- **St. Croix** – drought can have an impact in southern coastal areas on St. Croix, where historically large sections of land were allocated to agriculture, primarily dairy and livestock. Impacts included reduced productivity of rangeland and reduced milk production. Small scale agriculture can also be impacted. Production costs can increase owing to the cost of water supply, transport and/or transfer.
- **St. John** – Coral Bay is at risk to drought as precipitation shortfalls can impact small scale agriculture and impact residential developments because of increased costs for water supply, transport and/or transfer.
- **St. Thomas** – In terms of specific locations, the East End of the island is the most susceptible to the impact of droughts. Although, urban areas of Charlotte Amalie are not immune to drought due to increased costs for water supply and transfer.

Disaster History

The recorded history of droughts is very limited for the US Virgin Islands. There are scant references to droughts in historical reports. For instance, in 1733, when the islands were administered by the Danish, the islands were severely affected by drought, suffered an insect plague, and were affected by two hurricanes.

In the 1920's to 30's, St. Croix experienced a period of drought. During this time the U.S. Government assisted with the construction of Creque Dam (1923) to capture rain water. This program was expanded throughout the islands. Several reservoirs and catchment areas were constructed near the towns to collect rain water. Ponds were created for maintenance of livestock. Windmills were converted to cisterns and wells were sunk in former cane fields to fill water troughs.

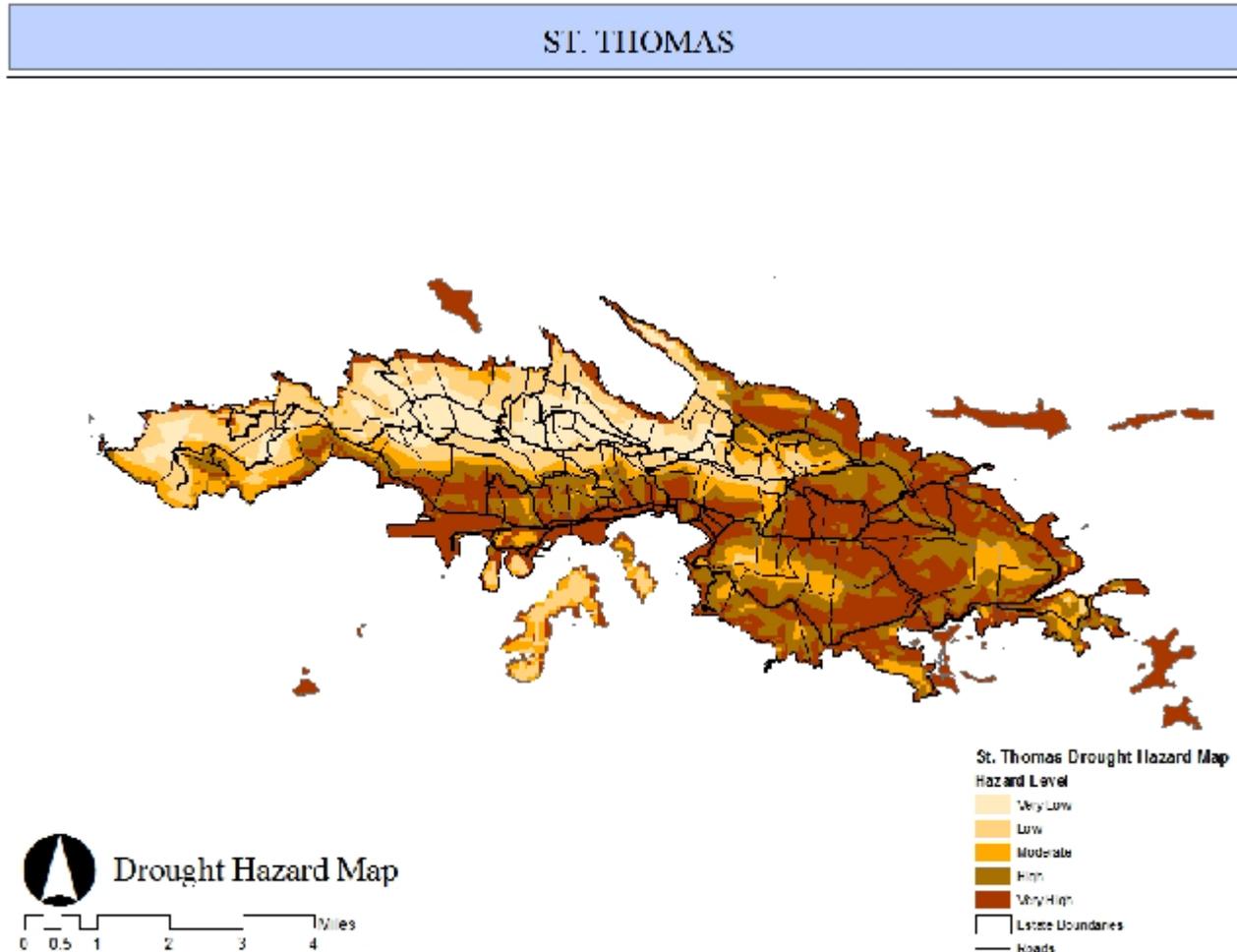
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The first Federal declaration in US Virgin Islands for drought was in June 8, 1964. Although the effects of this event are were not reported, it is listed on FEMA's website as an extreme event.

In recent years, droughts have been more frequent and severe. Minor shortfalls in rainfall have dramatically affected agriculture and have required water rationing. In 2002, the Virgin Islands Daily News reported that East End of St. Croix was suffering a localized severe drought. According to local farmers this drought compares to the drought of the early 1970s. This event predicated the need for organized feeding programs and consequently had a major impact to cattle farmers. The National Weather Service reported that accumulated rainfall for St. Croix through 2002 was deficient. During the last seven months of that year, approximately 55 percent of normal rainfall was received.

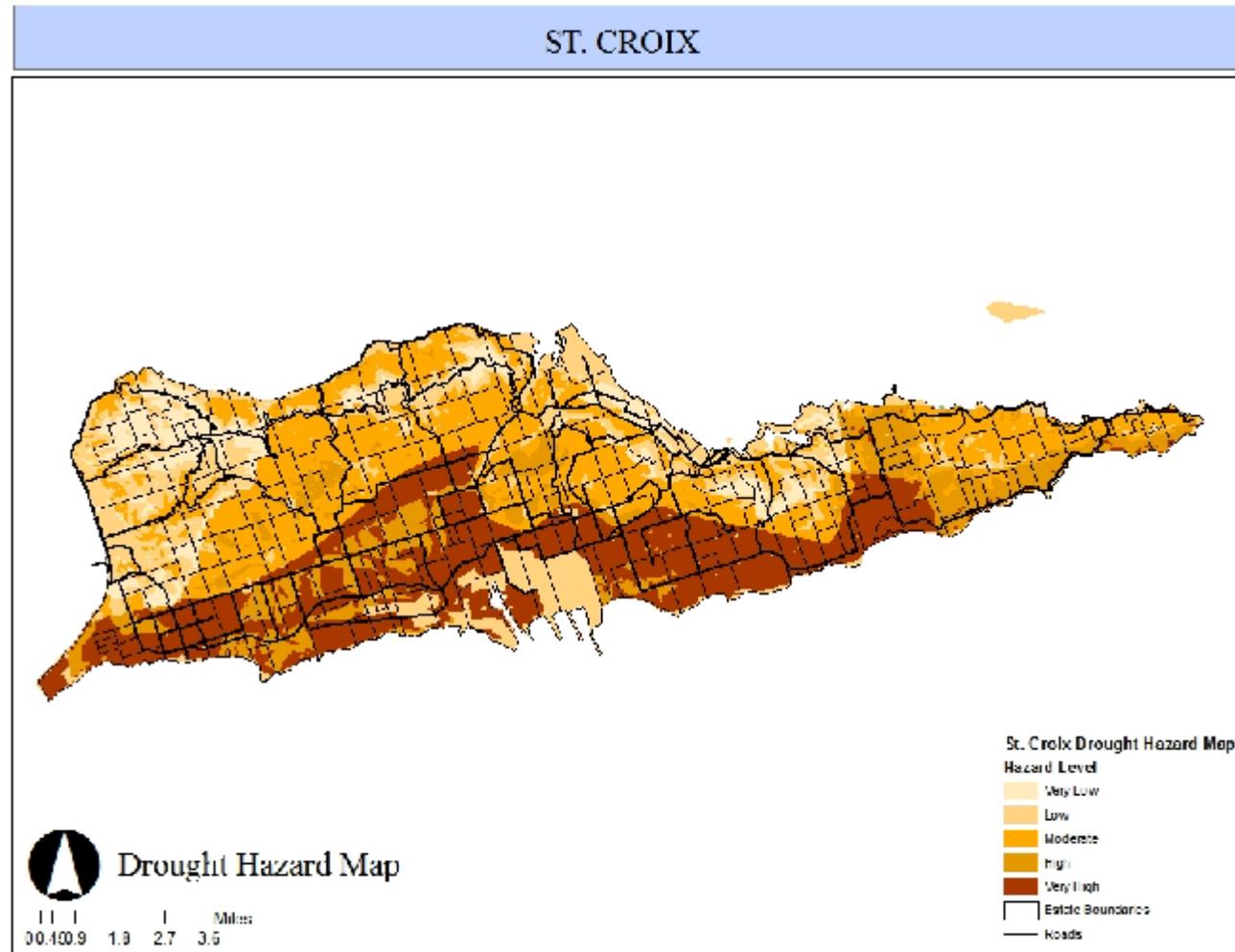
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FIGURE 4.2 *Drought Hazard Map, St. Thomas*



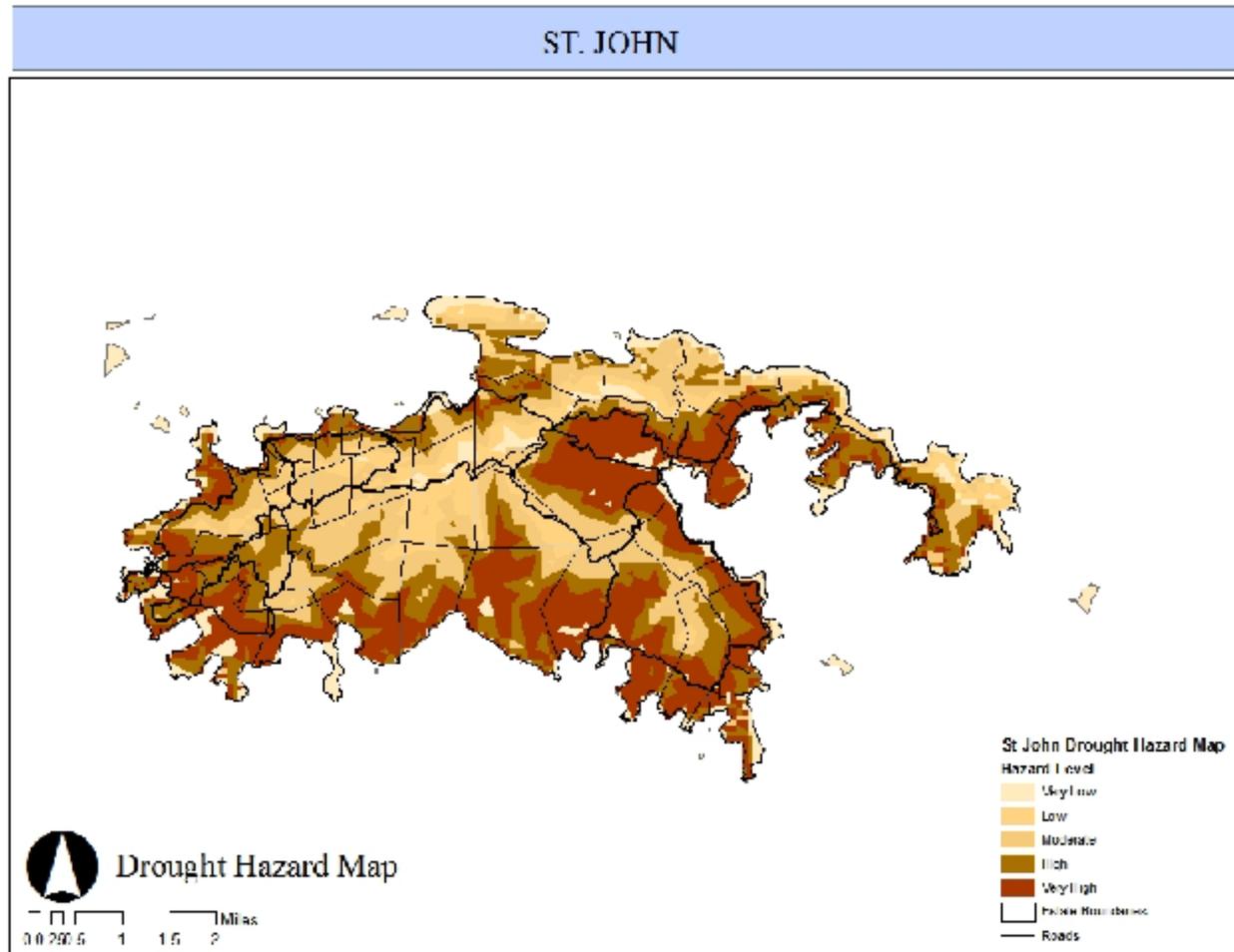
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FIGURE 4.3 *Drought Hazard Map, St. Croix*



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FIGURE 4.4 *Drought Hazard Map, St. John*



Hazard Frequency and Magnitude

There is a general lack of understanding on the definition, on-set, and frequency of drought in the U.S. Virgin Islands. However, based on regional information gathered from the Caribbean Institute for Meteorology and Hydrology and the Brace Centre for Water Resources Management, McGill University, the frequency of drought hazards in the Caribbean will increase.

Temperatures are very likely to rise (90-99% probability). There is greater uncertainty in the rainfall projections. Most models predict a decrease in annual precipitation in the region of 5 to 15% with the greatest change during the months of June to August. Therefore, drought probability, which is tied to annual average precipitation, for Caribbean region which includes the US Virgin Islands is estimated to be 40% below normal³.

Data Sources, Models and Methodologies

Base Data

- (2010): Average Annual Rainfall 1971 -2000, Oregon State University (OSU) Spatial Climate Analysis Service.
- USACE Digital Terrain Model (2008)
- Hydrologic Units for USVI (2002) U.S. Geological Survey in cooperation with the U.S. Department of Agriculture, Natural Resources Conservation Service.
- The United States, Caribbean and Pacific Basin Major Land Resource Areas (MLRA) Geographic Database serves as the geospatial expression of the map products presented and described in Agricultural Handbook 296 (2006).

Drought Hazard Assessment and Determination

- (2009): The Caribbean Drought and Precipitation Monitoring Network: The Concept and its Progress <http://www.wamis.org/agm/meetings/wies09/S3B-Trotman.pdf>
- (2010): Drought Impacts and Early Warning in the Caribbean: The Drought of 2009-2010; Adrian R. Trotman David A. Farrell; <http://www.wmo.int/pages/prog/drr/events/Barbados/Pres/4-CIMH-Drought.pdf>
- UN/ISDR, 2007. Drought Risk Reduction Framework and Practices: Contributing to the Implementation of the Hyogo Framework for Action. United Nations Secretariat of the International Strategy for Disaster Reduction (UN/ISDR), Geneva, Switzerland, 98+vi pp.

Inventory Data (Assets)

- General Building Stock: Office of the Lt. Governor, Office of the Tax Assessor, Computer Mass Appraisal System Database and GIS Parcel Maps
- Critical Facilities and Infrastructure: VI Department of Property and Procurement, VITEMA

³ Drought and Precipitation Monitoring for Enhanced Integrated Water Resources Management in the Caribbean (2008)

4.4.2 EARTHQUAKE

Hazard Description

An earthquake is a sudden motion or trembling of the earth caused by an abrupt release of stored energy in the rocks beneath the earth's surface. The rocks that make up the earth's crust are very brittle. When stresses due to underground tectonic forces exceed the strength of the rocks, they will abruptly break apart or shift along existing faults. The energy released from this process results in vibrations known as seismic waves that are responsible for the trembling and shaking of the ground during an earthquake. Earthquakes are also caused by tremendous rock slides that occur along the ocean floor.

There are several different ways to express the severity of an earthquake. The two most common are *magnitude*, which is the measure of the *amplitude* of the seismic wave and is expressed by the Richter scale, and *intensity*, which is a measure of how strong the shock was felt at a particular location, expressed by the Modified Mercalli Intensity (MMI) scale. The Richter scale represents a logarithmic measurement where an increase in the scale by one whole number represents a tenfold increase in measured amplitude of the earthquake. Table 4.4 shows the rough correlation between the Richter scale, Peak Ground Acceleration (PGA), and MMI. The relationship between PGA, magnitude, and intensity are, at best, approximate, and also depend upon such specifics as the distance from the epicenter and depth of the epicenter.

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TABLE 4.4 Earthquake Magnitude / Intensity Comparison

PGA (in %g)	Magnitude (Richter)	Intensity (MMI)	Description (MMI)
<0.17	1.0 - 3.0	I	I. Not felt except by a very few under especially favorable conditions.
0.17 - 1.4	3.0 - 3.9	II - III	II. Felt only by a few persons at rest, especially on upper floors of buildings. III. Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
1.4 - 9.2	4.0 - 4.9	IV - V	IV. Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rock noticeably. V. Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
9.2 - 34	5.0 - 5.9	VI - VII	VI. Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight. VII. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
34 - 124	6.0 - 6.9	VIII - IX	VIII. Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
>124	7.0 and higher	VIII or higher	X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent. XI. Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly. XII. Damage total. Lines of sight and level are distorted. Objects thrown into the air.

Source: Wald, D., et al., "Relationship between Peak Ground Acceleration, Peak Ground Motion, and Modified Mercalli Intensity in California."

Nature of the Hazard

The US Virgin Islands are located on the northeastern edge of the Caribbean Plate. Although there has been what is referred to as a “seismic gap” where no significant events have been recorded for a long period, the area is still considered very seismically active. The US Virgin Islands is actually considered as earthquake prone as many areas of California. However, the difference of these two areas is that the plate that affects the Virgin Islands is deep compared to the rather shallow fault line in California producing less harmful seismic events.

It also appears from research that the rate of attenuation for earthquakes in this region is lower, i.e., earthquake shocks propagate longer and farther in this region given the same initial earthquake intensity than earthquakes that occur in the northeastern United States (IRF 1984).

The exact configuration of the Caribbean Plate boundary in the vicinity of the Virgin Islands is poorly understood and is also quite complex. The Island of Puerto Rico and all the northern Virgin Islands are considered a “microplate” caught within the plate boundary. Zones of continuing deformation surrounding this microplate pass through the Anegada Passage separating the northern Virgin Islands from St. Croix, as well as along the eastward continuation of the Puerto Rico Trench to the north (EQE International 1994). These two features comprise the principal source of earthquakes that affect the US Virgin Islands.

The Puerto Rico Trench runs E-W about 100 km to the north of Puerto Rico and the northern Virgin Islands. The deepest section of the trench, approximately 8 km, is located to the north of Puerto Rico. The Anegada Passage fault zone extends for approximately 375 km north-east and comprises a series of interconnected basins up to 4.4 km deep. This deep trench separates St. Croix from the Puerto Rico – Virgin Islands platform (EQE International 1994).

Hazard Location, Extent and Distribution

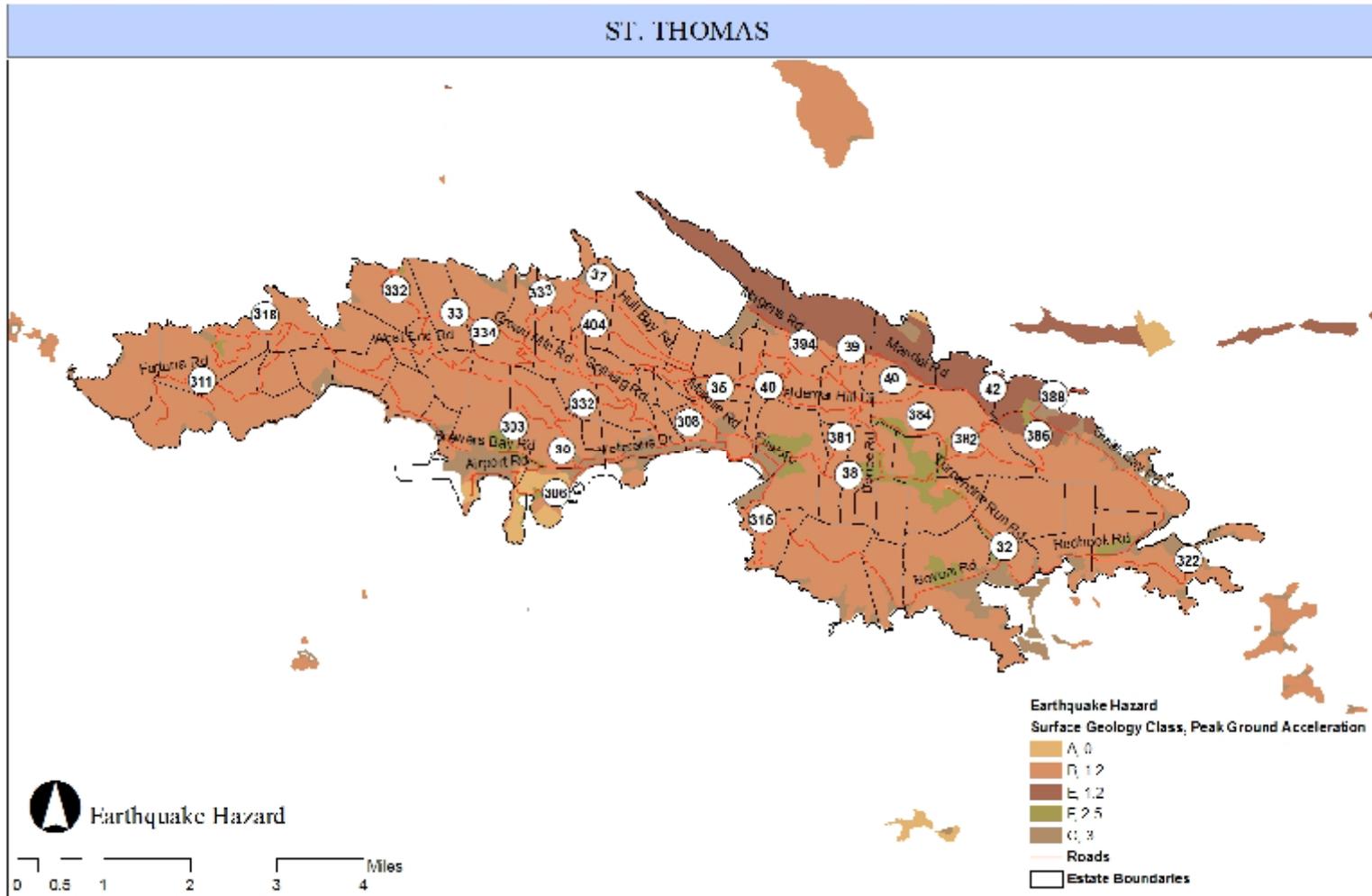
The extent of the earthquake risk is not uniform territory wide. Figure 4.8 illustrates the geographic coverage of earthquake hazard prone areas on the three major islands.

St. Thomas and St. John have been formed as a result of underwater volcanic flows and can be considered to have very similar geology. Both islands have a thin soil cover of sedimentary deposits, limestone, alluvium and recent beach deposits. The Cretaceous-aged Louisehoj and Water Island formations are highly weathered jointed and fractured (Geoscience Associates 1984). From a geologic stand point the islands are essentially the same land mass, separated by a garden, Pillsbury Sound. .

As illustrated in the maps (Figure 4.5, 4.6 and 4.7), the hazard intensity varies throughout St. Thomas and St. John. On both islands, hillsides are susceptible to earthquake induced land sliding. Geoscience Associates, 1984 point to several causes that have increased susceptibility on these islands. They include: increased hillside development; removal of slope vegetation; and steeper man-made slopes. Other critical areas include the waterfront area of Charlotte Amalie that is built upon alluvial soils and various land fill. The performance of such materials is notoriously poor..

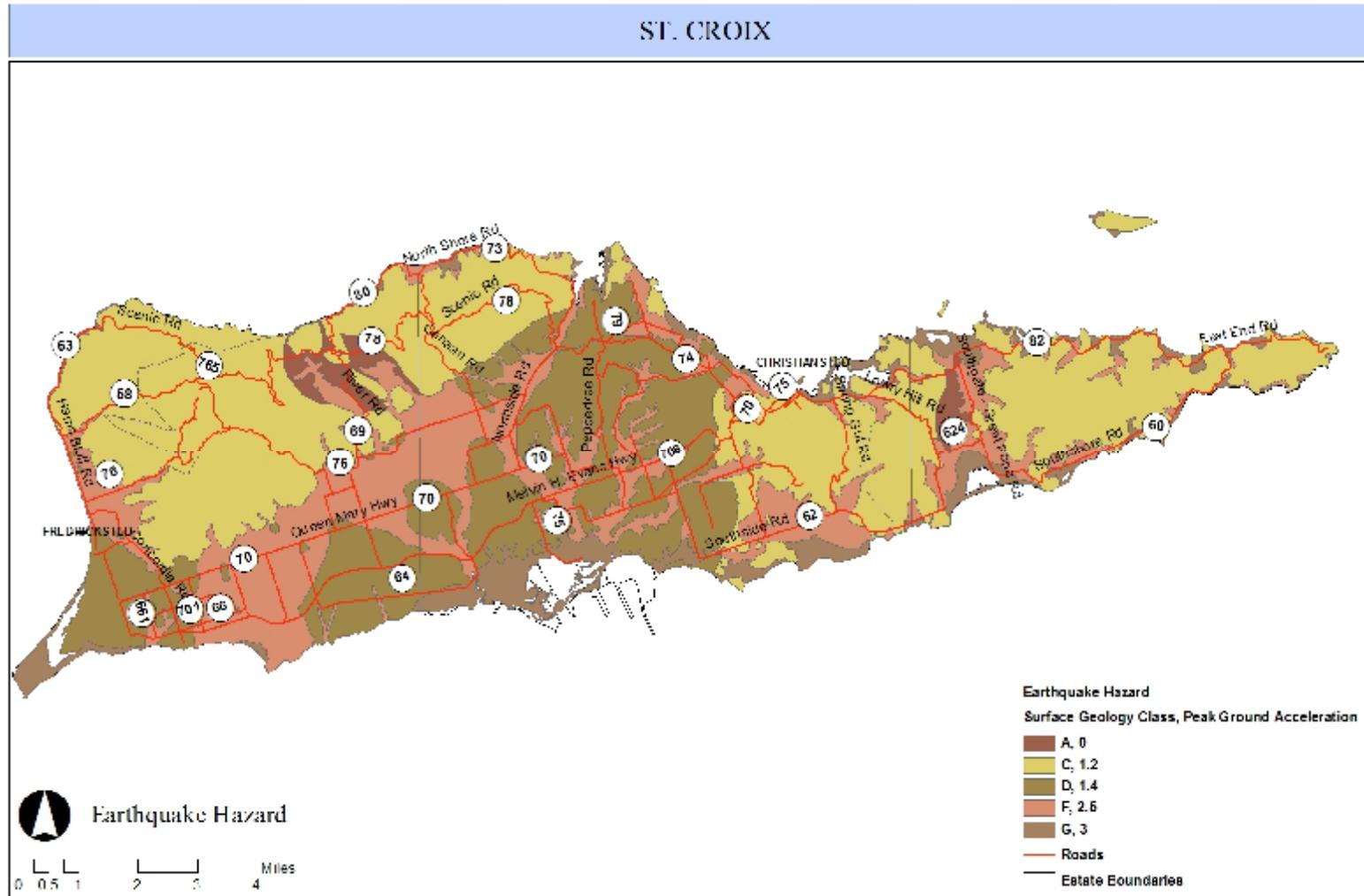
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FIGURE 4.5 Earthquake Hazard Map, St. Thomas



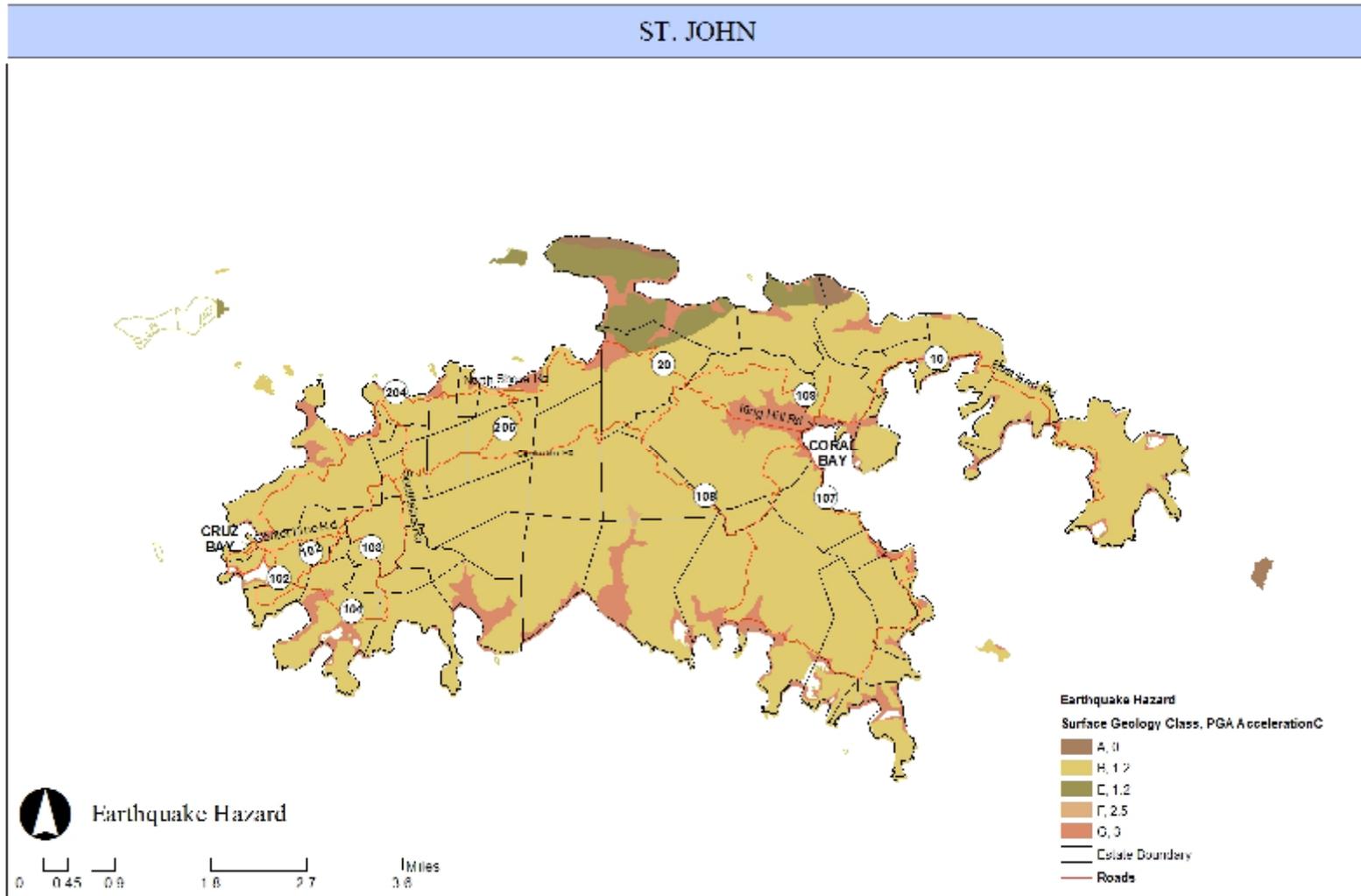
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FIGURE 4.6 Earthquake Hazard Map, St. Croix



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FIGURE 4.7 Earthquake Hazard Map, St. John



St. Croix is not volcanic in origin. Its soils and rock formations have developed from sedimentary processes. The major rock types of St. Croix are siltstones, limestone, sandstones, conglomerates, marls, volcanic ashes, and minor granite intrusives. The rock formations are tilted up to near vertical orientation. The rock formations include Caledonia, Allandale, Cane Valley, and Judith Fancy formations, all of late Cretaceous age (Geoscience Associates 1984).

Much of Christainsted and Fredricksted waterfronts mimic the performance of the waterfront areas on St. Thomas. Much of the town of Fredricksted is supported on residual soils of the Kingshill Marl Formation, the most granular faces of which appeared to be liquefaction prone (Geoscience Associates 1984). Christiansted is built upon alluvial soils and various land fill also making it prone to liquefaction. On St. Croix, there are widespread structural concerns throughout the island. The 1984 Geoscience Associates report points out that hillside construction on St. Croix, especially houses supported on stilts, are quite susceptible to earthquakes.

Disaster History

There is a verifiable record of earthquake occurrences dating back more than 500 years. More than 200 “felt events” have been recorded in the area since the first reliable report on September 1, 1530 near the coast of Venezuela. The first recorded incident directly affecting what is now the US Virgin Islands was in 1777, when a shock with an estimated intensity on the Modified Mercalli scale of IV-V was reported on St. Thomas (see Table 4.4). Over the next two hundred years, as many as 170 individual events were recorded (IRF, 1984) but none have been of great consequence since 1867 when an earthquake estimated at MMI VIII on St. Thomas and VII-VIII on St. Croix as recorded. Since that time there have been no major events with the highest estimated intensity measured at MMI IV-V. Due to the moderate nature of these events and their non-destructive nature there has been no Federal disaster declaration for any of these occurrences

It is worth noting; however, that the Puerto Rico Seismic Network, for its area of responsibility (latitude 17.00 -20.00° N and longitude -63.50 -69.00°), and for the period from January 2008 to March 2011 there have been 57 seismic events with a magnitude of 4.0 or greater on the Richter Scale. The strongest of these was an event that had a magnitude of 6.10 on the Richter Scale and occurred in the Virgin Islands on October 11, 2008.

Clearly the event that stands in our minds is the event in Haiti on January 2010. The 2010 Haiti earthquake was a catastrophic magnitude 7.0 Mw earthquake, with an epicentre near the town of Léogâne, approximately 25 km (16 miles) west of Port-au-Prince, Haiti’s capital. An estimated three million people were affected by the quake; the Haitian government reported that an estimated 316,000 people had died, 300,000 had been injured and 1,000,000 made homeless.⁴

⁴ a b "Red Cross: 3M Haitians Affected by Quake". CBS News. 13 January 2010. Retrieved 13 January 2010.

[^] "Haiti raises earthquake toll to 230,000". AP. The Washington Post. 10 February 2010. Retrieved 30 April 2010.

[^] "Haiti will not die, President Rene Preval insists". BBC News. 12 February 2010. Retrieved 12 February 2010.

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The region from Puerto Rico to the Virgin Islands is seismically active. In 2010, the majority of earthquakes occurred along the Puerto Rican Trench. This is worth noting, as in 2009, most earthquakes had epicenters massed to the north of the Virgin Islands. Earthquakes (above 4.0) averaged nineteen (19) per year.

Hazard Frequency and Magnitude

It has been estimated that an earthquake with the same magnitude as the 1867 earthquake event would have a 300 to 5,000 year recurrence interval (RI). For practical purposes, this is a longer RI than is useful for planning and design purposes. However, there are two useful references for assessing the probability of an earthquake of destructive proportions in the US Virgin Islands, the first of which uses the same value as the 1867 event.

The first is the “design earthquake” recommended by the Natural Hazards Planning Council. The Council selected a “design earthquake”⁵ of level MMI VIII for use by engineers and planners to prevent damage from events that they believed have a reasonable expectation of occurring in the US Virgin Islands (IRF, 1984) given the region’s general seismicity. The second reference is from a study prepared for the US Virgin Islands Water and Power Authority (WAPA, 1994). In this study, the authors determine that the earthquake intensity likely to have a recurrence interval on the scale of 100 years is in the MMI VI-VII range. Based on this estimate (100-yr), the US Virgin Islands has a 1/100 or a 1% annual probability of an event in the MMI VI-VII range.

The Seismic Hazard Map of 1994 (Earth Science Consultants, 1999), which provides ground shaking intensity (expressed in terms of Peak Ground Acceleration (PGA) for 50-, 100-, 250-, and, 1,000-year return periods). This study, utilized the 1000-year ground shaking map. This map was generated using an acceleration variability (σ) of 0.6 at a set of sites across each island. The Peak Ground Acceleration (PGA-%g) ranges from .48 to .91g for a 1000-year return period. Based on this return period (1000-yr), the US Virgin Islands has a 0.1% percent annual probability of observing the losses shown in this risk assessment.

⁵ design earthquake event is used for estimating the demands and predicting the supplies of the real three-dimensional soil-foundation-building system performance during an event.

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Data Sources, Models and Methodologies

Information for the development of the Earthquake Risk Assessment came from a variety of sources, including:

Base Data (Earthquake)

- 1000-year probabilistic ground shaking intensity maps (Earth Scientific Consultants 1999).
- Earthquake vulnerability maps, which classified acceleration factors for local site geology, using NEHRP⁶ provisions to define localized site amplification classification (Earth Scientific Consultants, 1999)

Earthquake Hazard Assessment and Determination

- The hazard assessment was developed using the Seismic Hazard Map of 1994 (Earth Science Consultants, 1999), which provides ground shaking intensity (expressed in terms of Peak Ground Acceleration (PGA) for 50-, 100-, 250-, and, 1,000-year return periods)
- The 1000-year ground shaking map was generated using an acceleration variability (σ) of 0.6 at a set of sites across each island. Acceleration factors were identified based on local soil conditions and the surficial geology.
- Local site geology was classified using NEHRP provisions to define localized site amplification classification.
- GIS overlay techniques were used to assign an earthquake susceptibility factor (PGA) to each estate.

Inventory Data (Assets)

- General Building Stock: Office of the Lt. Governor, Office of the Tax Assessor, Computer Mass Appraisal System Database and GIS Parcel Maps
- Critical Facilities and Infrastructure: VI Department of Property and Procurement, VITEMA

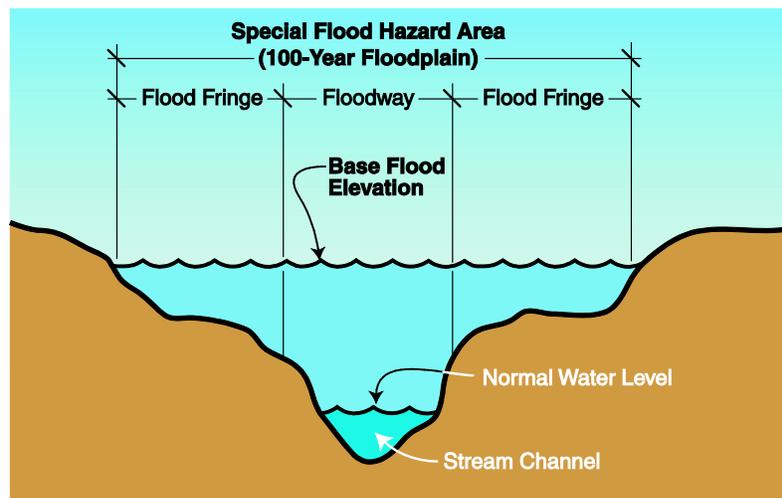
⁶ NEHRP is the National Earthquake Hazards Reduction Program. This program's congressional mandate is "to reduce the risks to life and property from future earthquakes in the United States through the establishment and maintenance of an effective earthquake hazards reduction program".

4.4.3 RIVERINE FLOODING

Hazard Description

Floods are naturally occurring events for rivers and streams. Excess water from rainfall accumulates and overflows onto banks and adjacent floodplains — lowlands adjacent to guts, streams, or rivers that are subject to recurring floods (see Figure 4.8 below).

Figure 4.8 Definition Sketch for Floodplains



Source: *Understanding Your Risks* – FEMA Publication 386-2, Page 2-12

FEMA's National Flood Insurance Program (NFIP) maps many floodplain boundaries. The *Digital Flood Insurance Rate Maps (DFIRMs)* have been updated and reissued in April 2007. They have been provided to the Territory. These maps provide the Territory with a more useful resource for planning and site specific decision making related to flood hazards. The *2007 US Virgin Islands Digital Flood Insurance Rate Maps (DFIRMs)* are used as reference for the National Flood Insurance Program. The Flood Insurance Study; however, provides more detailed information in certain areas where Base Flood Elevations (BFEs) and/or floodways have been determined.

Historically, floods often exceed the mapped floodplains in the Virgin Islands. The 2007 Flood Insurance Study for the US Virgin Islands indicates that the principle causes are associated with storm water run-off. In addition, flooding is caused by encroached upon artificial fills and structures (e.g., filling in floodplain or floodway areas, or increased imperviousness within the watershed from new development) and where guts in many areas are filled with debris (e.g., accretion, erosion, sedimentation, etc.).

Nature of the Hazard

Heavy floods are a common feature of Caribbean islands. This is due to tropical weather patterns that are exacerbated during hurricane season from June to November and to higher seasonal rainfall in the fall months of August, September, October and November. There have been a number of large-scale devastating flooding events through time. Historically, most of these large-scale events have had the greatest impact outside of the island's urban areas. Inland flooding from more frequent, but smaller storm events has caused more cumulative damage over the long run in the more urbanized areas in the US Virgin Islands, although it is less damaging on an event-by-event basis.

The islands' mostly hilly to rugged and mountainous terrain, especially on St. Thomas, is coupled with thin soils and non-porous rock substrata. The steep drainage ditches or "guts" that receive most of the runoff create optimal conditions for over bank flooding problems. Added to this natural tendency to generate flooding conditions are the following:

- Increases in impervious surfaces in the urbanizing areas of the islands as seen in Frenchtown Area in St. Thomas; Sub base Area in St. Thomas; Christiansted Area in St. Croix; Cruz and Coral Bay on St. John
- The placement of undersized culverts where roads cross guts as witnessed in Dorethea in St. Thomas or Gallows Bay in St. Croix;
- A failure to upgrade storm water management facilities to meet the needs of on-going development (i.e. Enigned Pond St. John),
- Lack of consistent maintenance of other storm water management facilities (i.e. Radets Gade St. Thomas, Garden Street on St. Thomas); and
- Encroachments to the floodplain built over many years (i.e. La Grande Princess in St. Croix).

As highlighted above, frequent inundation of property persists. Many of these problems are highlighted in the Mitigation Strategy and Severe Repetitive Loss Strategy of this Plan Update.

Hazard Location, Extent and Distribution

Figure 4.9, 4.10, and 4.11 illustrate the geographic coverage of riverine flooding on the three major islands. The extent and geographic distribution of the regulated 100-year floodplains differ amongst the three islands due to their geology, topography, soils, and rainfall distribution patterns.

The island of St. John overall topographic profile is lower than nearby St. Thomas. However, the average annual rainfall is the greatest of the three major islands of the Territory with 54" compared to 44" on St. Thomas and 40" on St. Croix. The steep terrain of St. John concentrates runoff in natural guts that transverse to the sea. Flooding, like all hazards, is not a problem unless development or infrastructure alters the landscape. This is because the majority of the island is a National Park and remains in its natural state. Coral Bay and the surrounding area have experienced rapid development without regard for effective storm water drainage systems both in the highland areas and lowland environs. The former disregard intensifies the problems of the latter.

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Most of the flooding occurs in Cruz bay or Coral Bay. These areas are prone to flooding as they are both located at the bottom of steep hills. Problems are caused by development without regard for sufficient drainage and inadequate drainage systems or improper engineering for the critical roadways. Although these manifestations cause localized flooding the problem is severe enough to disrupt commerce and emergency access. Particular areas of concern identified by citizens include: Poor or inadequate storm water drainage infrastructure on Centerline and Bordeaux Mt. Roads; need to improve storm water drainage infrastructure to alleviate localized flooding at the Guy Benjamin School in Coral Bay; water drainage system at Guinea (Westin) Gut and localized flooding at Enighed Pond (i.e. WAPA building and treatment plant and areas of Route 102 and Route 104 by the Tennis Court).

St. Thomas, like St. John, is volcanic island, with steep terrain and significant topographical relief. The island is rather heavily developed with two major urban areas, an extensive road network and the accompanying infrastructure. The areas with the most serious flooding problems are in Estate Nadir. This is essentially a continuous drainage system with the drainage channel in Estate Nadir connecting with the natural gut (Turpentine Gut). In the event of heavy rains the Gut and man-made channels have proved to be inadequate to handle the water runoff from the surrounding hillside.

Flooding persists on the East End of the island, particularly in Red Hook, where intensive commercial development has put pressure on drainage infrastructure. The inadequate storm water drainage system in Frydenhoj (next to and across from ball field) has caused localized flooding to commercial and residential structures. The development of many residences in the East End area has either altered the natural flow of runoff or increased the impervious surface area through the construction of the residences and the attending access roads and driveways.

This is witnessed on Bolongo Bay Road from intersection hill going up to Sea view Home to Hotel. Additionally, the flooding problem in the Tutu community is also exacerbated by dense development without regard for natural water runoff and an insufficient drainage system throughout the entire community, but especially along the valley floor. These problems are manifested at the Tutu Fire Station, a critical facility and adjacent to Metro Motors and Gomez school.

Charlotte Amalie is also impacted by flooding. This historic community does not have adequate systems for water runoff causing flooding to the business district and adjacent areas. There are a few guts for runoff but their maintenance is not consistent and of their overflow is frequently due to debris accumulation. The major runoff system is the Frenchtown Gut. This has a shallow pitch that flows into the harbor and in the event of torrential rains tends to backup and flood a rather large surrounding area. The historic business district is prone to shallow flooding that is caused by lack of an ample drainage infrastructure.

Throughout the island there are other areas of localized flooding where development and insufficient drainage systems allow for water accumulation. Severe flooding has taken place on lower Commandant Gade (Garden Street) and Norre Gade (main street) where commercial and residential structures have been flooded. Further to the west of town, existing storm water drainage infrastructure systems on highway from Pueblo to Addelita Cancryn School (sub base) and from Pueblo (sub base) to Crown Bay Port Facility continue to flood and cause traffic disruption, particularly when cruise ships are in port. Inadequate storm

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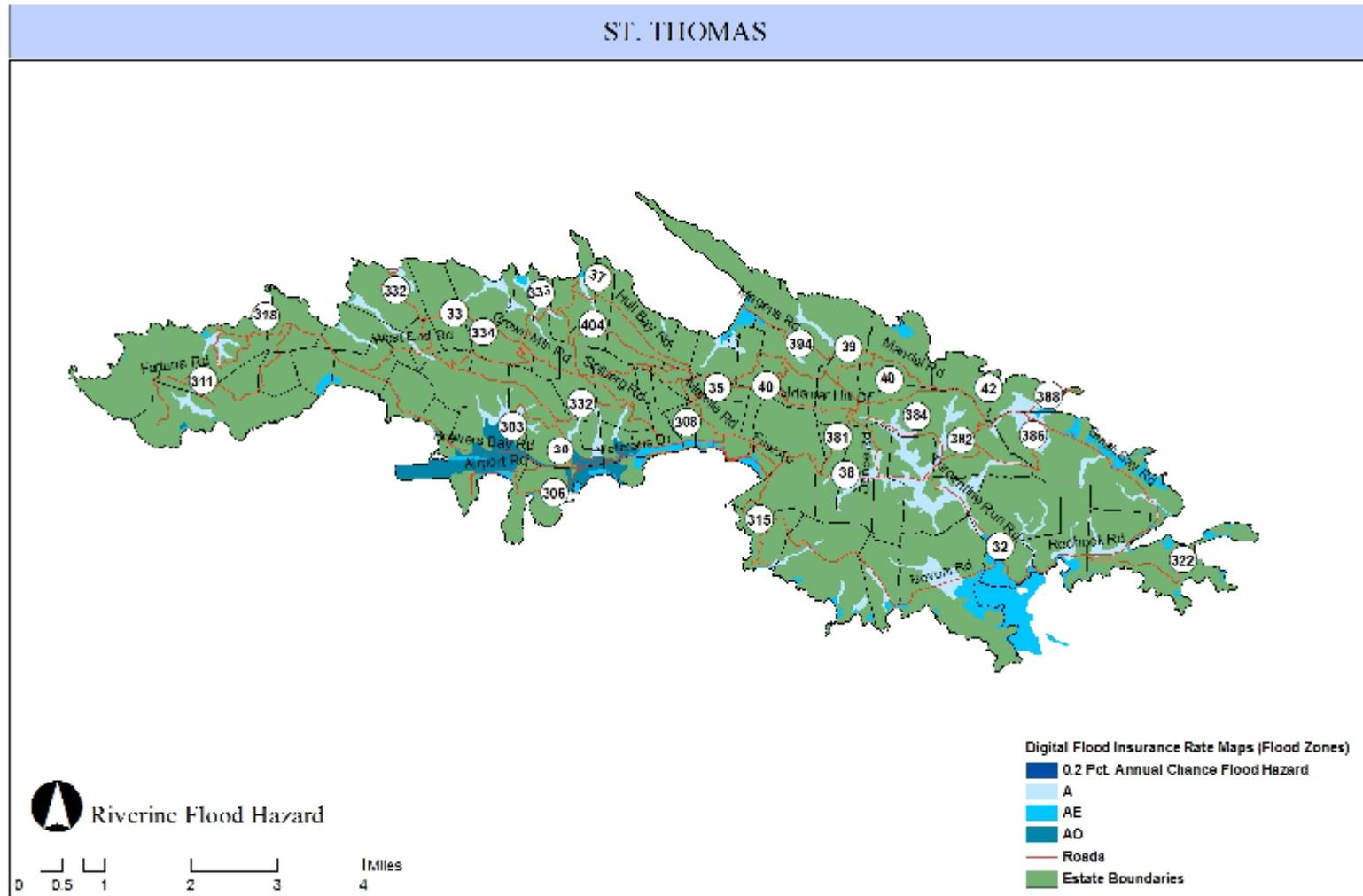
water drainage infrastructure continues to plague residential areas of Bournefield north through Kirwin Terrace Public Housing Units.

The geology of St. Croix is vastly different from either St. John or St. Thomas. The geologic history of the island is of a sedimentary origin and the major rock formations are limestone. The result is a landscape with much less topographic relief than St. Thomas. The center of the island is relatively flat, almost a plateau type of landscape. The steep terrain on the island is found along much of the coastline and in hilly, rolling terrain in the northwest portion of the island. There are extensive areas of riverine floodplains throughout St. Croix. However, due to the generally hilly rather than mountainous terrain, the natural flow of runoff water is less rapid causing for the accumulation of flood waters to dissipate more slowly.

Consequently most natural waterways are subject to shallow flooding with a slow rise in flood depths. This is prevalent in Estate Welcome, Mon Bijou, La Reine, Williams Delight, Hannah's Rest, St. Georges and areas along Center Line Road. Western areas of Christiansted are prone to flooding in which problems are caused principally by poor siting design and/or developments without regard to adequate drainage systems. Improper drainage systems on road ways have exacerbated problems and have increased downstream flooding in areas like Gallows Bay and Spring Gut; in the vicinity of Paul E. Joseph School; the Grove at La Raine; Federiksted Lagoon Area; on Prince Street (Christiansted); on King Cross Street (Christiansted); Fort Federick Beach; East Golden Rock on Rt. 75 (North Shore Road) and the La Grange Gut and associated drainage systems.

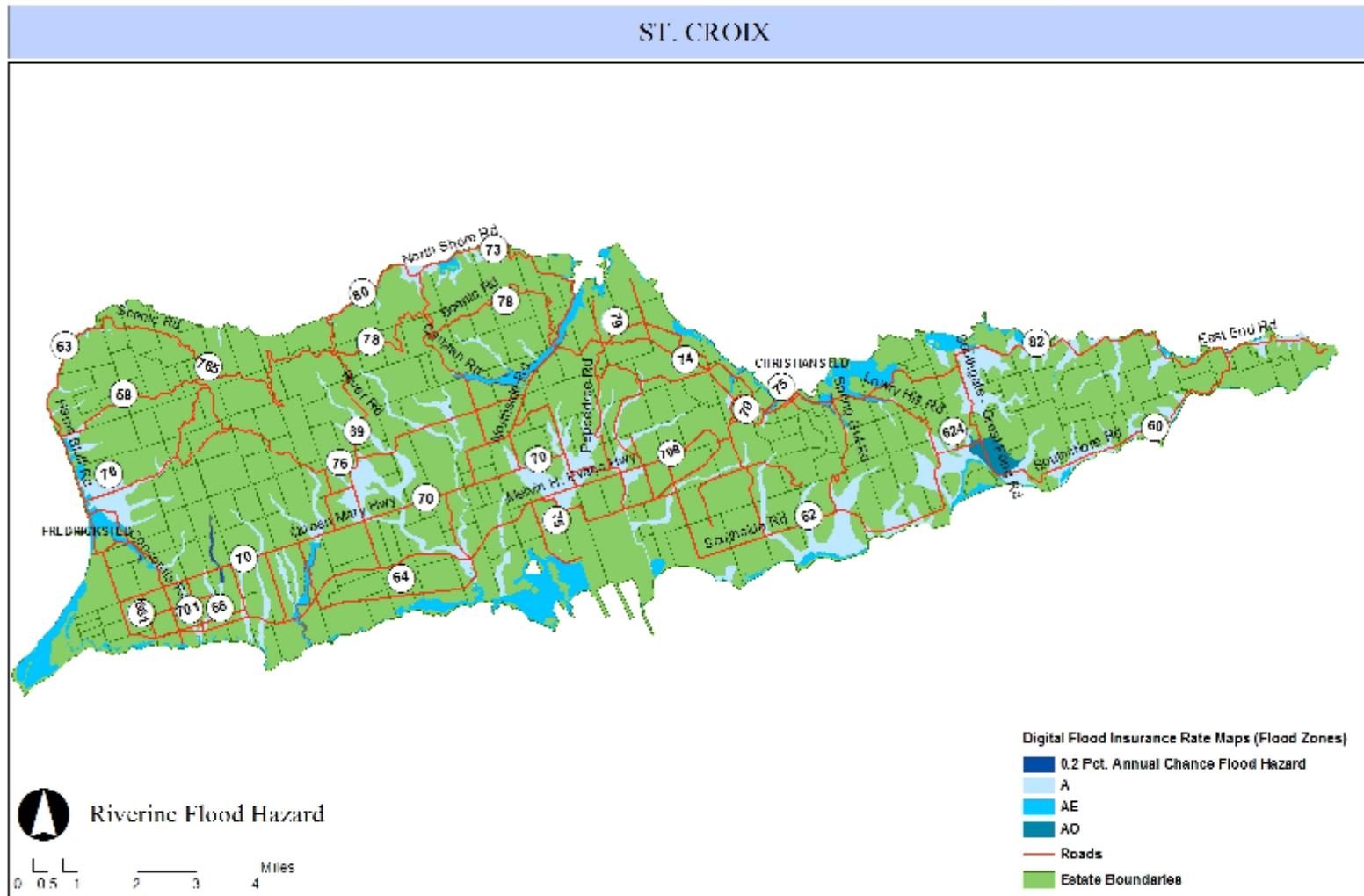
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FIGURE 4.9 Riverine Flooding Hazard, St. Thomas



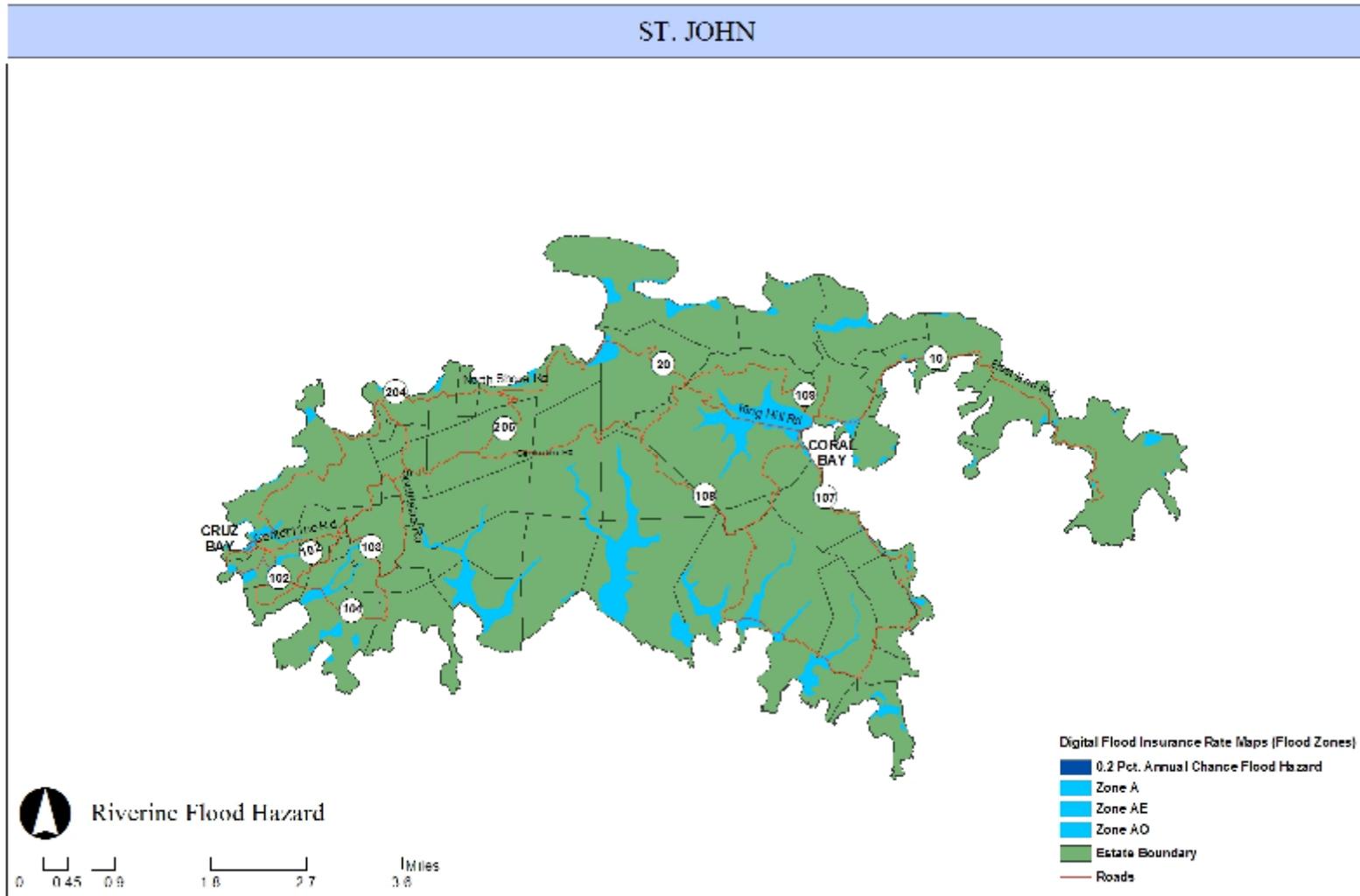
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FIGURE 4.10 Riverine Flooding Hazard, St. Croix



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FIGURE 4.11 Riverine Flooding Hazard, St. John



Disaster History

Since the 2008 Plan development, there have been 4 Federal disaster declarations, of which 2 have been caused by a prolonged period of heavy rainfall. There is a lengthy record of the rainfall amounts that have occurred in the US Virgin Islands. There is also a good understanding of the factors that lead to riverine flooding as it is experienced in the US Virgin Islands as explained above. However, reliable records for specific occurrences of inland flooding are scarce which makes the reconstruction of many past floods and the determination of recurrence intervals difficult if not impossible. There are studies that have attempted to link higher than normal rainfall events with probable flood events but the results are not conclusive. But, there are good records for a few recent events.

In 2003, heavy rains over the US Virgin Islands during the week of November 12th led to widespread flash flooding. The US Virgin Islands was declared a federal disaster area with damages estimated at \$25-30 million. The storm was the result of a two-day period with a stationary area of low pressure, which led to widespread and continuous rainfall across all the US Virgin Islands resulting in generalized flash floods and riverine flooding. This two-day period was followed by a series of showers that lasted for several more days. With the previous heavy rains, the ground was so saturated that most of the subsequent rain became runoff and contributed to additional flooding problems. The four-day accumulation of rain varied from 15 to more than 20 inches across the Islands.

Other significant flooding events have occurred on the island of St. Croix. In November 2004 heavy rains caused severe roadway flooding from Estate Mount Welcome to Gallows Bay depositing large quantities of dirt and debris at the Gallows Bay intersection. There was also general street flooding in Christiansted. In May 2005, severe thunderstorms brought as much as 2 and 3 inches of rain in a one hour period, causing wide spread street and gut flooding in town (Christiansted).

During October 2006, flash flooding caused an accumulation of one foot of water in the Gallows Bay area. This weather system also flooded portions of Mon Bijou, La Reine, Williams Delight, Hannah's Rest, St. Georges and areas along Centerline Road. This system also forced school and business closures. The area on St. Croix most affected by this event were western suburbs of Christiansted. However, excessive flooding was also reported in Frederiksted, along the South Shore Road and the Northside Road.

In November, 2010, the Territory experienced torrential downpours associated with Tropical Storm Otto and Tomas. The flooding caused extensive damages throughout the islands and flooded cars, businesses, homes and streets. Areas of Charlotte Amalie were affected on St. Thomas where several stores in the historic shopping district were flooded. The Diamond Center was flooded with more than 2 feet of water. On Brookman Road, the tremendous volume of water rushing over the asphalt caused it to lift, prompting temporary closure of that road.

The passing of these systems presented major challenges to the Public Works crews, and while all roads on St Thomas and St John were passable, DPW recommended caution given the saturated soil conditions.. On St. John, flooding was particularly bad in the area of Enighed Pond. Sewers were overwhelmed in several locations and manhole covers were carried away and as dirty water flowed down the streets.

On St Croix, roadways flooded and water pooled in several urban areas in Christiansted and Fredricksted,

in places where motorists had not seen water standing before, causing some to stall out in the heavy downpours. The runoff from the rains collapsed a section of roadway leading into Enfield Green on Tuesday night, cutting that southside neighborhood off to vehicle traffic. The rush of rain runoff coming down from the hills and making its way to the sea overwhelmed stormwater drainage infrastructure in William's Delight and Enfield Green. This high velocity flow caused a culvert crossing on the road into Enfield Green to give way.

In La Vallee on the island's North Shore, landslides and localized flooding in low-lying areas created some hazards by pushing debris into the roadways. There were weather-related electrical failures in Orange Grove, LBJ Gardens, Montpellier, Betsy Jewel, Grove Place, La Reine, Castle Coakley, Whim, William's Delight, Two Williams, Mt. Pleasant, Shoys, La Grange, Butler Bay, Spring Garden, Northside, Nicholas, Frederickshaab, Wheel of Fortune, Little Princess Hill, St. John, Grange Hill, Brookshill, Turner Hole, New Works, Bethlehem, and Mon Bijou.

Hazard Frequency and Magnitude

Floods are described in terms of their extent (including the horizontal area affected and the vertical depth of floodwaters) and the related probability of occurrence. Flood studies use historical rainfall records and physical land characteristics to determine the probability of occurrence for different extents of flooding. The probability of occurrence is expressed in percentages as the chance of a flood of a specific extent occurring in any given year.

A specific flood that is used for a number of purposes is called the “base flood” which has a 1% chance of occurring in any particular year. The base flood is often referred to as the “100-year flood” since its probability of occurrence suggests it should only reoccur once every 100 years, although this is not the case in practice. Experiencing a 100-year flood does not mean a similar flood cannot happen for the next 99 years; rather it reflects the probability that over a long period of time, a flood of that magnitude should only occur in 1% of all years.

Smaller floods occur more often than larger (deeper and more widespread) floods. Thus, a “10-year” flood has a much greater likelihood of occurring than a “100-year” flood. Table 4.5 shows a range of flood recurrence intervals and their probabilities of occurrence.

The extent of flooding associated with a 1% probability of occurrence – the base flood - is used as regulatory boundaries by Federal, state and local agencies. Also referred to as the “Special Flood Hazard Area (SFHA)” (see Figures, 4.3, 4.4 and 4.5), this boundary is a convenient tool for assessing vulnerability and risk in flood prone communities since many communities have maps available that show the extent of the estimated base flood event.

TABLE 4.5 Flood Probability Terms

Flood Recurrence Intervals	Chance of occurrence in any given year
10 year	10%
50 year	2%
100 year	1%
500 year	0.2%

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Data Sources, Models and Methodologies

Information for the development of the Riverine Flood Risk Assessment came from a variety of sources, including:

Base Data (Riverine Flooding)

- FEMA Digital FIRM data, which delineate the 100- year floodplain and VE SFHA boundaries
- USACE Digital Terrain Model

Riverine Flood Hazard Assessment and Determination

- FEMA Digital FIRM data were identified as the most comprehensive flood polygon data for the US Virgin Islands. This data was updated in April, 2007. GIS overlay techniques were utilized to identify structures in the flood zone flood polygons. Flood depths were estimated for each estate on each island by overlaying the Q3 flood zone data on a digital elevation model.

Inventory Data (Assets)

- General Building Stock: Office of the Lt. Governor, Office of the Tax Assessor, Computer Mass Appraisal System Database and GIS Parcel Maps
- Critical Facilities and Infrastructure: VI Department of Property and Procurement, VITEMA

4.4.4 COASTAL FLOODING & EROSION

Hazard Description

The most dangerous and damaging feature of a coastal storm is storm surge. Storm surges are large waves of ocean water that sweep across coastlines where a storm makes landfall. The more intense the storm, the greater the height of the storm surge.

Storm surge areas can be mapped by a number of computer-driven models. The coastal hazard mapping was developed for the USACE using the SLOSH (Sea, Lake, and Overland Surges from Hurricanes) computer model (developed by the National Weather Service to forecast surges that occur from wind and pressure forces of hurricanes), Bathymetry and coastline topography. The SLOSH model was developed primarily as an emergency management tool to aid in evacuation planning. In the USVI, hurricane category is the predominant factor in "worst case" hurricane surges. The resulting inundation areas are grouped into Category 1 and Category 3, and Category 5 classifications. The hurricane category refers to the Saffir-Simpson Hurricane Intensity Scale described in Table 4.6.

TABLE 4.6 Saffir-Simpson Hurricane Scale

Category	Storm Surge (feet above normal sea level)
1	4–5 ft.
2	6–8 ft.
3	9–12 ft.
4	13–18 ft.
5	> 18 ft.

Storm surge inundates coastal areas, washes out dunes, causes backwater flooding in rivers, and can flood streets and buildings in coastal communities. The biggest impact coastal flooding has is the wearing away of coastal land, which is commonly described as **coastal erosion**. While erosion is considered a function of larger processes of gradual shoreline change, which includes erosion and accretion, it is tied in the US Virgin Islands to hurricane events. This is particularly true in the short-term, where storms can erode a shoreline that is, over the long-term, may be accreting.

- Erosion results when more sediment is lost along a particular shoreline than is re-deposited by the water body.
- Accretion results when more sediment is deposited along a particular shoreline than is lost.

Over a long-term period (years), a shoreline is considered to be either eroding or accreting or stable. It is very difficult to measure erosion as a rate, with respect to either a linear retreat (i.e., feet of shoreline recession per year) or volumetric loss (i.e., cubic yards of eroded sediment per linear foot of shoreline

frontage per year). This is primarily due to the fact that erosion rates are not uniform, and vary over time at any single location.

The Saffir-Simpson Hurricane Scale indicates that as hurricane increases in strength, the potential storm surge increases in magnitude (Table 4.5). This fact can be used to understand the potential magnitude of coastal storms and the potential associated impacts.

Nature of the Hazard

Coastal flooding in the US Virgin Islands is common and associated with low-pressure systems, including tropical storms and hurricanes. In the limited shoreline areas of the US Virgin Islands coastline that slopes gradually inland, the coastal areas are also vulnerable to large coastal sea swells generated by winter storms over the Atlantic Ocean. Rising storm surge levels are a function of wind, atmospheric pressure, tide, waves, and/or swell. Coastal topography and immediate offshore bathymetry (sea bottom contours) directly affect the extent of coastal flooding.

Shoreline changes, on the other hand, are the result of both natural forces and human activities, such as sand mining and beach construction. Environmental awareness has been slowly growing. Hurricane events, such as Hurricane Hugo, Marilyn and Lenny, have illustrated the vulnerability of the US Virgin Islands' beaches. High waves and tides and ocean currents accompanying these storms, are the most significant forces affecting erosion in the US Virgin Islands. Their turbulent energy stirs up and moves the beach sand, eroding the coastline.

Hazard Location, Extent and Distribution

Figure 4.12, 4.13, and 4.14 illustrate the geographic coverage of coastal flooding on the three major islands. The high winds literally pile the water up to create storm surges. The coastal hazard mapping was developed for the USACE using the SLOSH (Sea, Lake, and Overland Surges from Hurricanes) computer model and indicates that the following areas are most susceptible to storm surge on an island by island basis:

- **St. Croix** – Events like Hurricane Hugo were major disaster events due to high winds. However, historically, storm surge has probably been associated with more fatalities. On St. Croix, Christiansted and Frederiksted are located such that it would take an improbable strike to generate significant water threats. Nevertheless, they are at high risk from storm surge if hurricane forces are aggravated by severe wave conditions. Increased industrial and commercial construction in coastal areas has resulted in the removal of coastal vegetation such as mangroves and grasses which have increased vulnerability to coastal flooding.
- **St. John** – Cruz Bay is at risk to storm surges and any waterfront developments along the coastline that could be affected by a surge up to a maximum of 12 feet in elevation above mean sea level.
- **St. Thomas** – In terms of specific locations, Charlotte Amalie and Red Hook are most vulnerable from increased water heights along with much of the shoreline development between those two

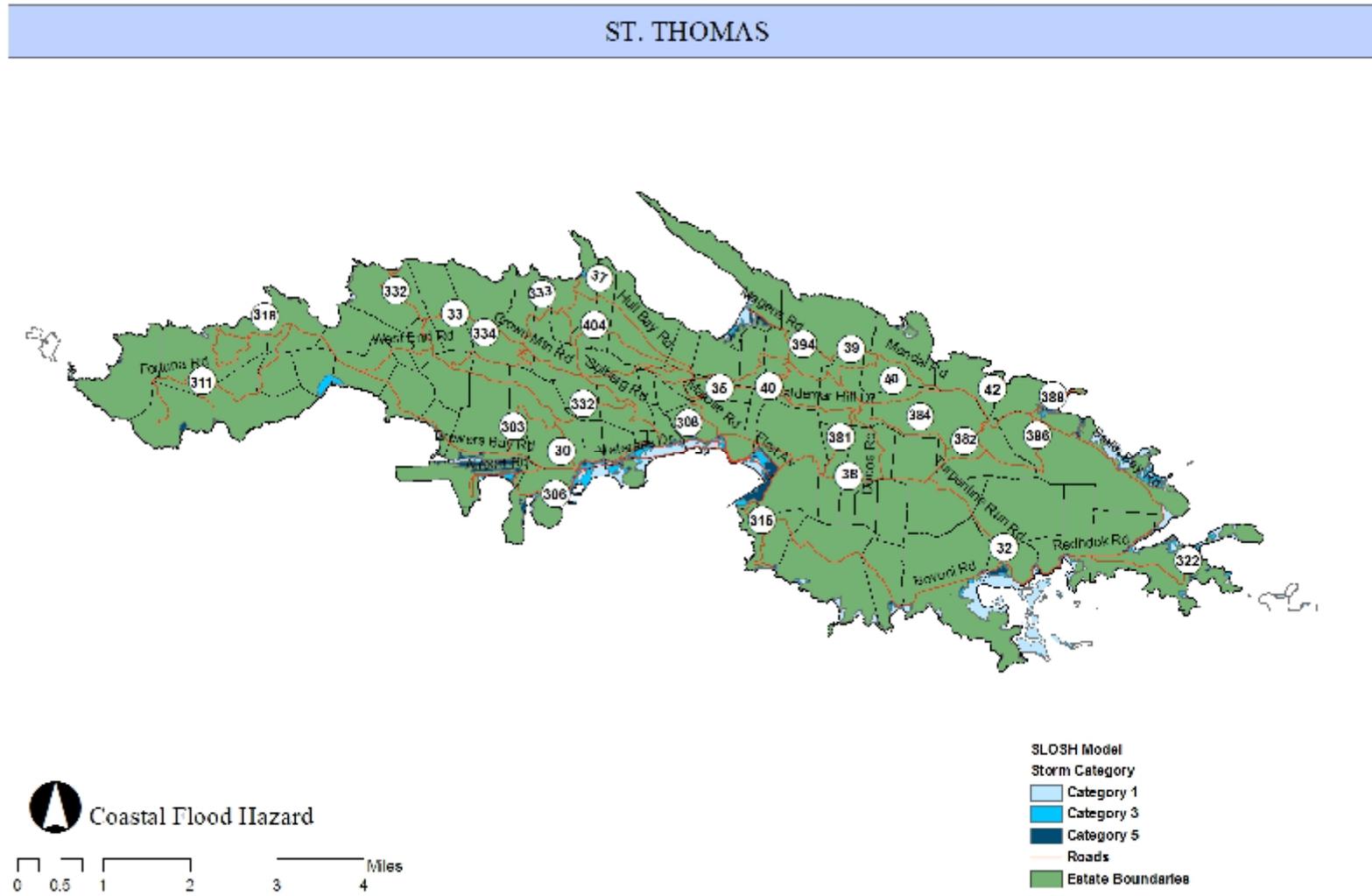
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locations. Although strong storm surges from the south or west are much less frequent, the marinas and large waterfront developments along St. Thomas' south coast would be severely impacted by a large storm from that direction. There are two very large school facilities (Charlotte Amalie High School and Eudora Kean Gymnasium at Red Hook) that offer considerable safe refuge from storm surge. One of their favorable aspects is that they can be accessed by walking.

In addition to Hurricanes, swell waves that are experienced in the US Virgin Islands between the months of October and April may have an impact on USVI shorelines. The storms are caused by intense mid-latitude storms in the North Atlantic and travel thousands of kilometers south to affect the west, north and east coasts of the islands.

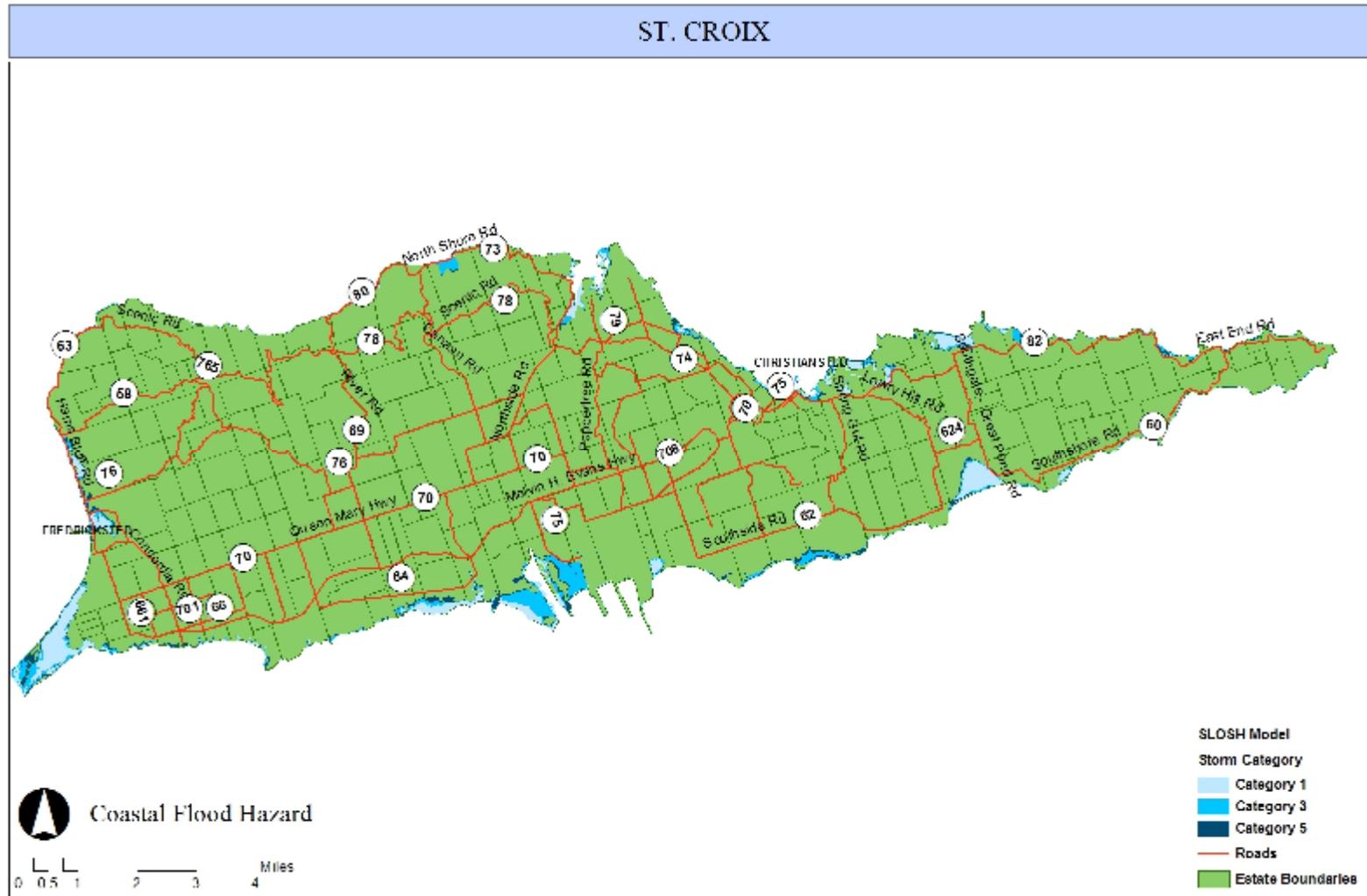
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FIGURE 4.12 Coastal Flooding Hazard Map, St. Thomas



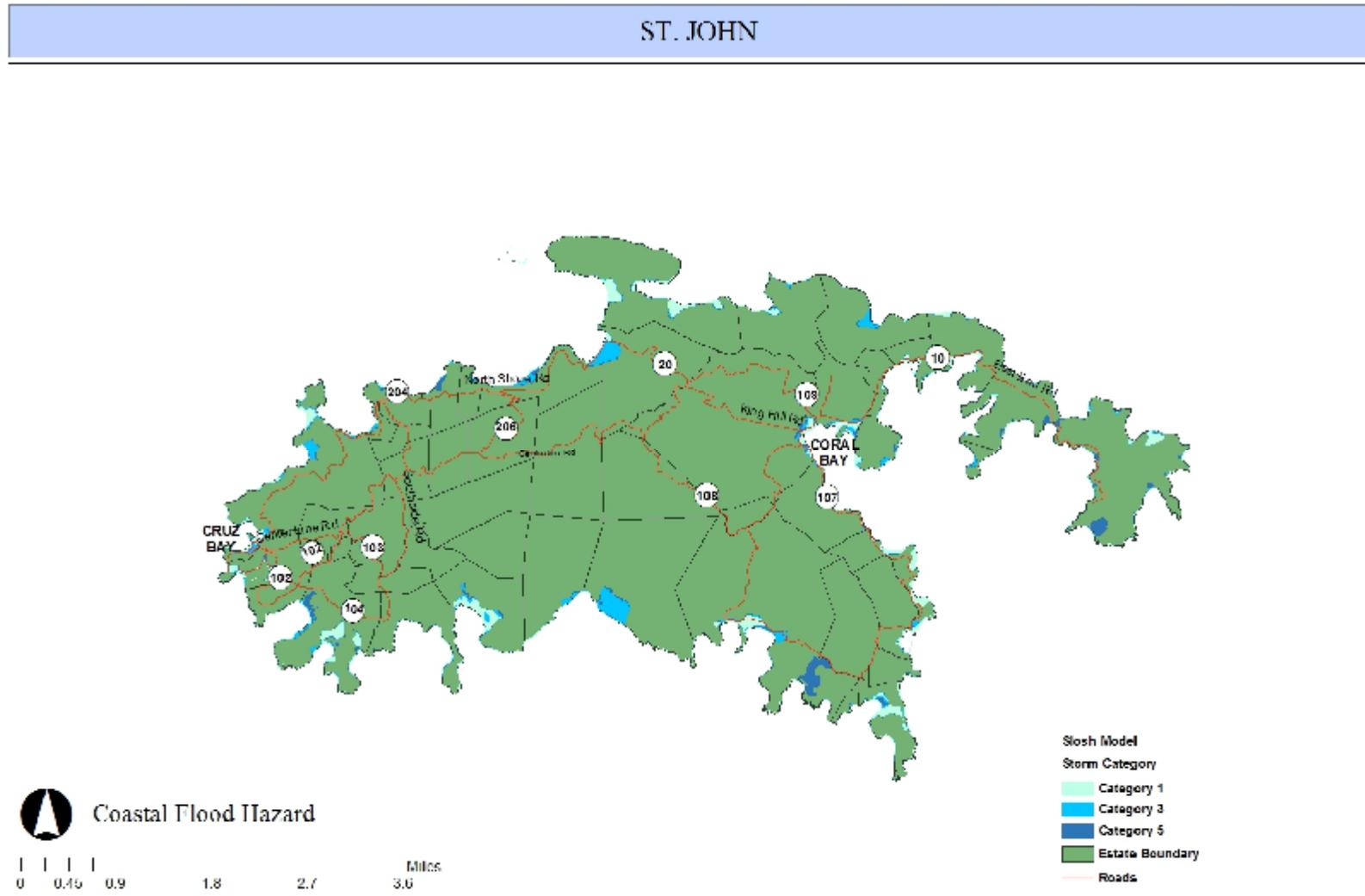
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FIGURE 4.13 Coastal Flooding Hazard Map, St. Croix



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FIGURE 4.14 Coastal Flooding Hazard Map, St. John



Disaster History

Since the last Plan Update (2008), there have not been any major coastal flooding Federal disaster declarations that have caused damage to residential and/or commercial buildings. Hurricane Earl was probably the most the strongest storm to past the islands in this period, did not have much impact on the shorelines besides washing boats ashore.

There is limited available information from the US Virgin Islands that isolates coastal flooding from other hazard impacts. One undocumented source lists 15 recorded accounts of storm surges in the local news records from 1867 to 1960. These ranged in magnitude from as little as 1 foot in elevation to the 12 foot mark in 1867. Nearly one half of the occurrences recorded maximum surge elevations of at least 8 feet with commensurate damage.

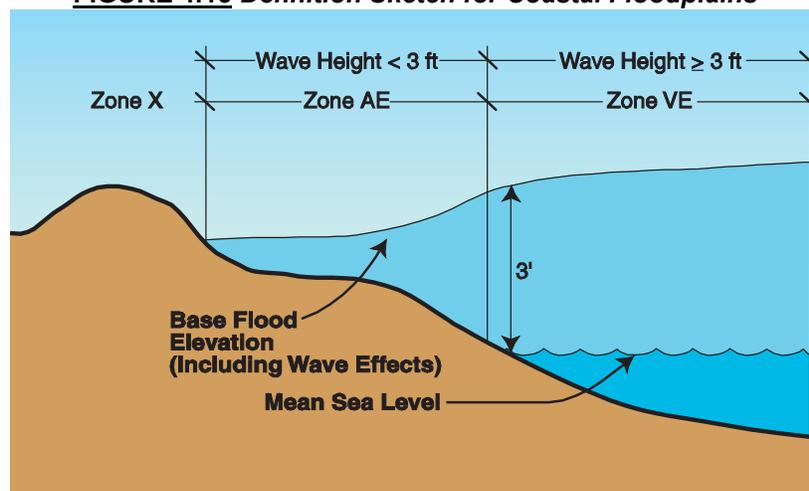
During Hurricane Lenny, tremendous storm surge and wave action affected structures well inland of the coastal high hazard zone (Zone VE) as shown on the FIRMs. The beach and dune systems in the coastal impact areas were destroyed causing increased storm surge inundation levels and wave action in areas previously modeled as being outside the Zone VE.

Between September 16-21, 2010, large, long-period northeast and then north swells of 9 to 13 feet generated by Hurricane Igor began affecting the U.S. Virgin Islands. These long period swells produced very large breaking waves of 15 to 20 feet or higher along local reefs, beaches, and shoals of the local islands. The swells produced minor coastal flooding, beach erosion, and minor structural damage. There was one reported drowning near the Carambola Beach Resort, 2 miles northeast of Christiansted, Saint Croix.

Hazard Frequency and Magnitude

Much like riverine flooding, predictive modeling has been used by FEMA to create NFIP mapping that reflects the 1% recurrence interval events for storm surge or coastal flooding.

FIGURE 4.15 Definition Sketch for Coastal Floodplains



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Source: Understanding Your Risks – FEMA Publication 386-2, Page 2-24

While the “100-year floodplain” for inland and coastal purposes is usually referred to as the “A” zone (see Figure 4.9 above), there is an additional designation in coastal areas, a “V” or “VE” zone that is the area subject to the 1% recurrence interval flood and in areas where the flood waters create waves that are 3 ft or greater in height, are anticipated to be moving with velocity and associated forces. The velocity and force of the water make storm surges even more destructive than riverine flooding.

However, to be consistent with the USACE SLOSH Model that depicts coastal hazard areas for Category 1, 3, and 5 hurricane events. There is an estimated 5% chance for the Territory to experience a Category 3 hurricane each year and the estimated annual probability of experiencing a Category 5 event is less than one percent a year.

Data Sources, Models and Methodologies

Information for the development of the Coastal Flooding Risk Assessment came from a variety of sources, including:

Base Data (Coastal Flooding)

- USACE SLOSH Model for Categories 1, 3, and 5 storms.
- USACE Digital Terrain Model

Coastal Flood Hazard Assessment and Determination

- USACE inundation maps derived from a SLOSH (Sea, Lake, and Overland Surges from Hurricanes) model computes storm surge were identified as the most comprehensive coastal flood polygon data for the US Virgin Islands.
- Surge inundation polygons were developed for three categories of hurricanes as defined by the Saffir-Simpson scale (Categories 1, 3, and 5).
- GIS overlay techniques were utilized to identify structures in the coastal flood polygons.
- Flood depths were estimated for each estate affected by coastal flooding by overlaying the Q3 flood zone data on a digital elevation model.

Inventory Data (Assets)

- General Building Stock: Office of the Lt. Governor, Office of the Tax Assessor, Computer Mass Appraisal System Database and GIS Parcel Maps
- Critical Facilities and Infrastructure: VI Department of Property and Procurement, VITEMA

4.4.5 HURRICANE WINDS

Hazard Description

Hurricanes and tropical storms are large-scale systems of severe thunderstorms that develop over tropical or subtropical waters and have a defined, organized circulation. Hurricanes have a maximum sustained (meaning 1-minute average) surface wind speed of at least 74 mph; tropical storms have wind speeds of 39 mph to 74 mph.

Hurricanes and tropical cyclones get their energy from warm waters and lose strength as the system moves inland. Hurricanes and tropical storms can bring severe winds, inland riverine flooding, flooding in coastal areas, storm surges, coastal erosion, extreme rainfall, thunderstorms, lightning, and tornadoes. Hurricanes and tropical storms typically have enough moisture to cause extensive flooding throughout the Territory, often to the 100- or 500-year flood elevations. However, this subsection is focused on Hurricane Winds; flooding effects of hurricanes and tropical storms are covered in Sections 4.4.4 and 4.4.5 – Riverine and Coastal Flooding, respectively.

Hurricane magnitude is measured on the Saffir-Simpson hurricane scale, shown in Table 4.7, which categorizes hurricane magnitude by wind speeds and storm surge above normal sea levels.

TABLE 4.7 Saffir-Simpson Hurricane Scale

Category	Wind Speed	Expected Damage
1	74–95 mph	Minimal: Damage primarily to shrubbery and trees; unanchored mobile homes damaged; some damaged signs; no real damage to structures.
2	96–110 mph	Moderate: Some trees toppled; some roof coverings damaged; major damage to mobile homes.
3	111–130 mph	Extensive: Large trees toppled; some structural damage to roofs; mobile homes destroyed; structural damage to small homes and utility buildings.
4	131–155 mph	Extreme: Extensive damage to roofs, windows, and doors; roof systems on small buildings completely fail; some curtain walls fail.
5	> 155 mph	Catastrophic: Considerable and widespread roof damage; severe window and door damage; extensive glass failures; entire buildings may fail.

Nature of the Hazard

The US Virgin Islands of the Caribbean are among the most hurricane-prone locations in the world. While the Atlantic Basin hurricane season officially extends from June 1 to November 30, over the last 117 years, the US Virgin Islands has experienced hurricanes no earlier than July 7th (unnamed storm in 1901) and as late as November 23rd (Hurricane Lenny in 1999).

In 2008, Hurricane Omar (2008) passed over the US Virgin Islands and caused damages to critical facilities and infrastructure that was estimated to be \$2.2 million; while Hurricane Earl (2010), a much bigger storm,

passed north of the Territory and caused \$2.1 million in estimated damages. The Territory also experienced severe storms, flooding, rockslides, and mudslides associated with Tropical Storm Tomas in late November 2010.

The peak of activity occurs in September with half of the number of average annual storms occurring in that month.

Hazard Location, Extent and Distribution

One of the most serious components of hurricanes is high winds. Because of the extensive size of a catastrophic hurricane a storm need not pass directly over the Territory to cause severe damage. A hurricane passing within close proximity can also cause major damage to property and even loss of life. Due to the relatively small geographical size of the Territory, any storm passing within a radius of 100 miles is a potential for property loss. Within the past three years four Tropical Storm systems passed within this radius. Accompanying coastal and riverine flooding have a strong spatial context and are addressed in the later sections of this Plan.

Essentially there are no areas of the US Virgin Islands that are free from hurricane force winds. The coastal and low lying areas experience the first effects of damaging winds, but due to the hilly and mountainous nature of the Territory, winds are funneled in gullies and passes between mountainous terrain seeking to traverse the mountains and ridges, and are often compacted and intensified causing damage to structures at higher elevations. While the entire territory is exposed to hurricane winds, there are variations in vulnerability primarily due to the number of properties and type of construction. The newer construction structures that have been built to codes are less vulnerable than the older structures. Another factor is the type of construction – i.e. wood frame structures – that are more susceptible to damages than reinforced concrete. The differences in vulnerability for each island in the Territory are highlighted in Section 4.5 below.

Disaster History

For this Plan Update, there have been no federal disaster declarations. Since the 2005 Plan, Tropical Storm Dean (8/17/07) traversed south of the Virgin Islands. Minimal damage was sustained and limited for the most part to downed trees and coastal road erosion. Between 1887 and 1989, 36 hurricanes passed within 125 miles of the US Virgin Islands (USACE *Hurricane Evacuation Study*, 1994).

Appendix H lists these 36 hurricanes and provides data on wind speed and storm motion (storm track by cardinal points and forward motion of the hurricane in mph). Of the 22 most deadliest, costliest, and most intense hurricanes to strike outlying US territories and the State of Hawaii over the past 100 years, 7 have struck the US Virgin Islands including:

- San Ciprian (1932). US Virgin Islands and Puerto Rico (PR). Damages estimated at \$494 million,
- San Mateo (1949). St Croix. Damages unknown,
- Donna (1960). St. Thomas and PR. Damages unknown,
- Hugo (1989). US Virgin Islands and PR. Damages estimated at \$1.4 billion,

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- Marilyn (1995). US Virgin Islands and PR. Damages estimated at \$1.8 billion,
- Georges (1998). US Virgin Islands and PR. Damages estimated at \$1.9 billion, and
- Lenny (1999). US Virgin Islands and PR. Damages estimated at \$342 million.

Note: Damage estimates include Puerto Rico and were adjusted for inflation (NOAA 2004); damages for Omar and Earl are from Preliminary Damage Assessment Reports.

In 2004 four major storms passed through the Caribbean causing varying levels of damage with one – Tropical Storm Jeanne – resulting in a presidential disaster declaration. Tropical Storm Jeanne affected the Territory with high winds and torrential rains inflicting a total of \$6.4 million in damage, mostly to the infrastructure, with downed power lines and damaged or debris filled roadways. Most damage was caused on St. Croix, but all three islands of the Territory experienced damage and received excessive rainfall and record flood levels. The damages associated with the Omar 2008 (\$2.2 million) and Earl 2010 (\$2.1 million) are minor in comparison.

The majority of presidential declarations in the US Virgin Islands result from hurricanes. A brief description of some recent hurricanes that have impacted the US Virgin Islands follows:

- **Hurricane Klaus** (October 1984). Hurricane Klaus traversed the islands leaving moderate damage to roads and bridges, and heavily damaging the Fredericksted Pier in St. Croix. The most significant hazard event was flooding caused by the heavy rains that accompanied the storm.
- **Hurricane Hugo** (September 1989). Hugo passed directly over the Island of St. Croix on a west northwest track at speeds of 3 - 10 mph. Hugo was a destructive Category 5 hurricane when it St. Croix. As a result, St. Croix suffered damages of catastrophic proportion. The center of the storm passed west of St. Thomas, but still inflicted severe damage. St. Thomas received substantial damage to public and private facilities.
- **Hurricane Marilyn**⁷ (September 1995). This time, St. Thomas bore the brunt of this large hurricane; the eye of the hurricane was more than 20 miles across. Hurricane Marilyn was at Category 1 strength, and intensified to nearly Category 3 strength by the time it reached the U.S. Virgin Islands. Marilyn caused 10 deaths and left thousands homeless. Marilyn damaged or destroyed nearly all 12,000 homes on St. Thomas and another 5,000 on St. Croix. Damage to commercial and residential roofs was extensive. The damages to the WAPA's electric distribution system alone were estimated at \$44 million. The storm also destroyed warehoused food stocks and damaged the only hospital on St. Thomas.
- **Hurricane Lenny** (November 1999). An unusual hurricane that tracked across the Caribbean from the west. Lenny made landfall on the western coast of the St. Croix, causing extensive storm surge damages along it's coastline. Lenny's maximum winds reached 150 mph as it approached the US Virgin Islands.

⁷ Hurricane Marilyn was at Category 1 strength, and intensified to nearly Category 3 strength by the time it reached the U.S. Virgin Islands.

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- **Hurricane Omar** (October 2008). Hurricane Omar weakened from a Category 3 to a Category 1 storm as it quickly moved over the US Virgin Islands. A last minute shift to the east spared St. Croix, the most populated of the U.S. Virgin Islands, which received just a glancing blow from the weaker side of the system. Omar knocked down trees, caused some flooding and minor mudslides.
- **Hurricane Earl** (August 2010). Hurricane Earl, a Category 3 storm, passed near or over the northernmost part of the U.S. Virgin Islands. Hurricane conditions spread across the northern U.S. Virgin Islands to Culebra and Puerto Rico. The eye of Earl passed just north of the British Virgin Islands, and its closest point of approach to the U.S. Virgin islands was around 3 pm on the 30th when it was located about 60 miles northeast of St. Thomas. By 5 pm Earl strengthened into a category 4 hurricane, with maximum winds of around 135 mph while it was moving away from the Virgin Islands.

It is important to note that prior to Hurricane Hugo, the last hurricane with winds of Category 3 or greater occurred 73 years earlier in 1916. During the period from 1916 to 1989, dozens of milder tropical storms and hurricanes came in close proximity or made landfall but none caused the damages associated with Hugo and Marilyn.

Hazard Frequency and Magnitude

A 1994 study produced for the US Virgin Islands Water and Authority (WAPA)⁸ used the available historical record to determine approximate return periods (probability of frequency) for hurricanes of different categories (see Table 4.7: Saffir-Simpson Hurricane Scale). For example, the Territory could expect a Category 3 hurricane once every 20 years as shown on the matrix below. The results are shown in Table 4.8

TABLE 4.8 Frequency of Hurricanes Passing By or Through the US Virgin Islands

Intensity	Average Return Period
Category 3	20 years
Category 4	50 years
Category 5	120 years

Source: US Virgin Islands WAPA 1994

The Atlantic Oceanographic and Meteorological Laboratory's FAQ (Frequently Asked Questions) web site⁹ indicates that there is an estimated 42% chance each year of experiencing a strike by a tropical storm or

⁸ The study went on to note: "that the above estimated return periods are for hurricanes with the corresponding intensity level passing by or through the islands and are not the return periods for a direct hit on the islands. Moreover, because the prevailing hurricane direction in this region is from east to west, the chance of a hurricane traveling north and hitting St. Croix first and then St. Thomas and St. John is very small. Thus, the worst possible realistic scenario is for a hurricane track to be located between St. Croix and St. Thomas/St. John having an east/southeast to west/northwest direction."

⁹ <http://www.aoml.noaa.gov/hrd/tcfaq/G11.html>

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hurricane in the US Virgin Islands. These probabilities were developed from recorded data for the years 1944 to 1999 when a storm or hurricane was within about 100 miles (165 km) of a particular location.

The design wind speed for the USVI in ASCE 7-05 is 145 mph (3-second peak gust). This is equivalent to a Category 3 hurricane on the Saffir Simpson scale. There is an estimated 5% chance of experiencing a Category 3 hurricane each year.

Data Sources, Models and Methodologies

Information for the development of the Hurricane Risk Assessment came from a variety of sources, including:

Base Data

- NOAA National Climatic Data Center.
- American Society of Civil Engineers (ASCE) 7-05 Design Wind Speeds.
- “*Estimation of Potential Hurricane and Earthquake Losses to Water and Power Facilities*” (EQE international, 1994.)

Hurricane Hazard Assessment and Determination

- The American Society of Civil Engineers (ASCE) 7-05 Design Wind Speed maps were the primary data input for the wind hazard model as probabilistic data were not readily available. The ASCE Design Wind Speeds take into account historical events such as hurricanes and tropical storms. The design wind speed in ASCE 7-05¹⁰ for the US Virgin Islands is 145 Mph. In this study design wind speed refers to the sustained wind velocity that structures should be constructed to withstand without suffering catastrophic or total damage. The maps developed show the frequency and paths of hurricanes with winds of Category 4 or above.

Inventory Data (Assets)

- General Building Stock: Office of the Lt. Governor, Office of the Tax Assessor, Computer Mass Appraisal System Database and GIS Parcel Maps
- Critical Facilities and Infrastructure: VI Department of Property and Procurement, VITEMA

¹⁰Note that ASCE wind speeds are 3-second peak gusts

4.4.6 RAIN-INDUCED LANDSLIDE

Hazard Description

Landslides are described as downward movement of a slope and materials under the force of gravity. The term landslide includes a wide range of ground movement, such as rock falls, deep failure of slopes, and shallow debris flows. Landslides are influenced by human activity (construction of buildings and highways) and natural factors (soils, precipitation, and topography).

Landslides occur when masses of rock, earth, or debris move down a slope. Therefore, gravity acting on an overly steep slope is the primary cause of a landslide. They are triggered by storms, earthquakes (not addressed in this analysis), and by human modifications to the landscape. Wildfires can increase the probability of rain-induced landslides occurring.

Mudflows (or debris flows) are flows of rock, earth, and other debris saturated with water. They develop when water rapidly accumulates in the ground, such as during periods of prolonged heavy rainfall, changing the earth into a flowing river of mud. Mudslides can flow rapidly down slopes or through channels and can strike with little or no warning at tremendous speeds. Other types of landslides include: rock slides, slumps, mudslides, and earthflows. All of these differ in terms of content and flow. In the USVI, hydrologic factors (rain, high water table, little or no ground cover) and human factors (development activities such as cutting and filling along roads and removal of forest vegetation) exacerbate the effects of landslides.

Nature of the Hazard

It is very hard to evaluate the location or geographic distribution of landslides across the U.S. Virgin Islands as there is not a historical record from which to reference the incidences of landslides in the Territory. Landslides occur because of a variety of factors in the Virgin Islands and are due to such factors as topography, slope, climate, and soils. Locations at risk from landslides include areas with one or more of the following conditions:

- On or close to steep hills;
- Steep road-cuts or excavations;
- Existing landslides or places of known historic landslides (such sites often have tilted power lines, trees tilted in various directions, cracks in the ground, and irregular-surfaced ground);
- Steep areas where surface runoff is channeled, such as below culverts, V-shaped valleys, and steep intermittent stream channels; and
- Areas where slopes are not maintained or are altered by the property owners (clear-cutting).

Although spatial extent of landslides is hard to determine, human impacts have substantial affect on the potential for landslide failures. Proper planning and geotechnical engineering can be exercised to reduce the threat to people, property, and infrastructure.

Hazard Location, Extent and Distribution

Figure 4.16, 4.17, and 4.18 illustrate the geographic coverage of areas susceptible to rain-induced landslides on the three major islands. The landslide susceptibility maps were developed as part of this project through a constraint mapping methodology that combined elevation, slope, soils and hydrologic units in a Geographic Information System computer model. The following areas are most susceptible to rain-induced landslides on an island by island basis:

- St. John - Events like the severe rainfall experience in November 2010 triggered landslides along portions Centerline road between Cruz Bay and Coral Bay. Nine areas along Centerline Road were blocked and another major landslide in the Bordeaux Mountain area also blocked a major road.
- St. Thomas. The mountain areas, particularly northern facing slopes of the island are the most susceptible to the landslides. Areas in Dorothea and St. Peter Mountain road are especially prone to this hazard. These areas experienced washouts during the recent heavy rainfall events (November/December, 2010). Higher elevations on southern facing slopes, particularly in the area of Crown Mountain are also susceptible to landslides. On Crown Mountain road, a deluge of water shut down the road. A major landslide just beyond the intersection of Crown Mountain and Scott Free roads occurred, along with other smaller landslides. This left Crown Mountain Road impassable at one point.
- St. Croix. The greater variations of rainfall on St. Croix make the landslide hazard more dispersed. The northwestern part of the island receives the greatest amount of rainfall, and as a result, the northern slopes of the mountainous area are highly susceptible to landslides. There are some central areas with steep slopes in the south central area of the island (outside Christiansted) that are also susceptible to landslides. Eastern portions of the island are less susceptible to landslides, particularly lower portions of watershed basins.

Disaster History

Almost no published literature on the occurrence of landslides exists for the Virgin Islands¹¹. A reconnaissance of landslide potential on St. Thomas (Brabb, 1984) indicates that earthflows, debris slides, and individual boulders are recognized landslide types on St. Thomas. Debris flows are not documented or reported as occurring on this island.

¹¹ http://isis.uwimona.edu.jm/uds/Land_US_Virgin_Islands.html

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- The largest landslide documented on St. Thomas is 60 meters long and 60 meters wide. It was mapped in an area about 1.5 kilometers north of Charlotte Amalie in 1979.
- On April 18, 1983, a storm drenched Dorothea Bay with nearly 400 millimeters in 14 hours. In addition to extensive flooding, this storm event produced a number of landslides. Two earthflows developed in weathered colluvium (unconsolidated materials of various sizes). These are small features about 30 meters long and 30 meters wide. Very small debris slides occurred in colluvium exposed at the top of some road cuts. Boulders temporarily blocked several roads. One boulder which was 6 meters in maximum diameter traveled 10 meters downslope before stopping next to and above a house (Brabb, 1984).
- St. John (2010) nine (9) landslides occurred along portions Centerline road between Cruz Bay and Coral Bay.
- St. John (2010) another major landslide in the Bordeaux Mountain area also blocked a major road.
- St. Thomas. (2010) a major landslide just beyond the intersection of Crown Mountain and Scott Free roads.

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FIGURE 4.16 *Landslide Hazard Map, St. Thomas*

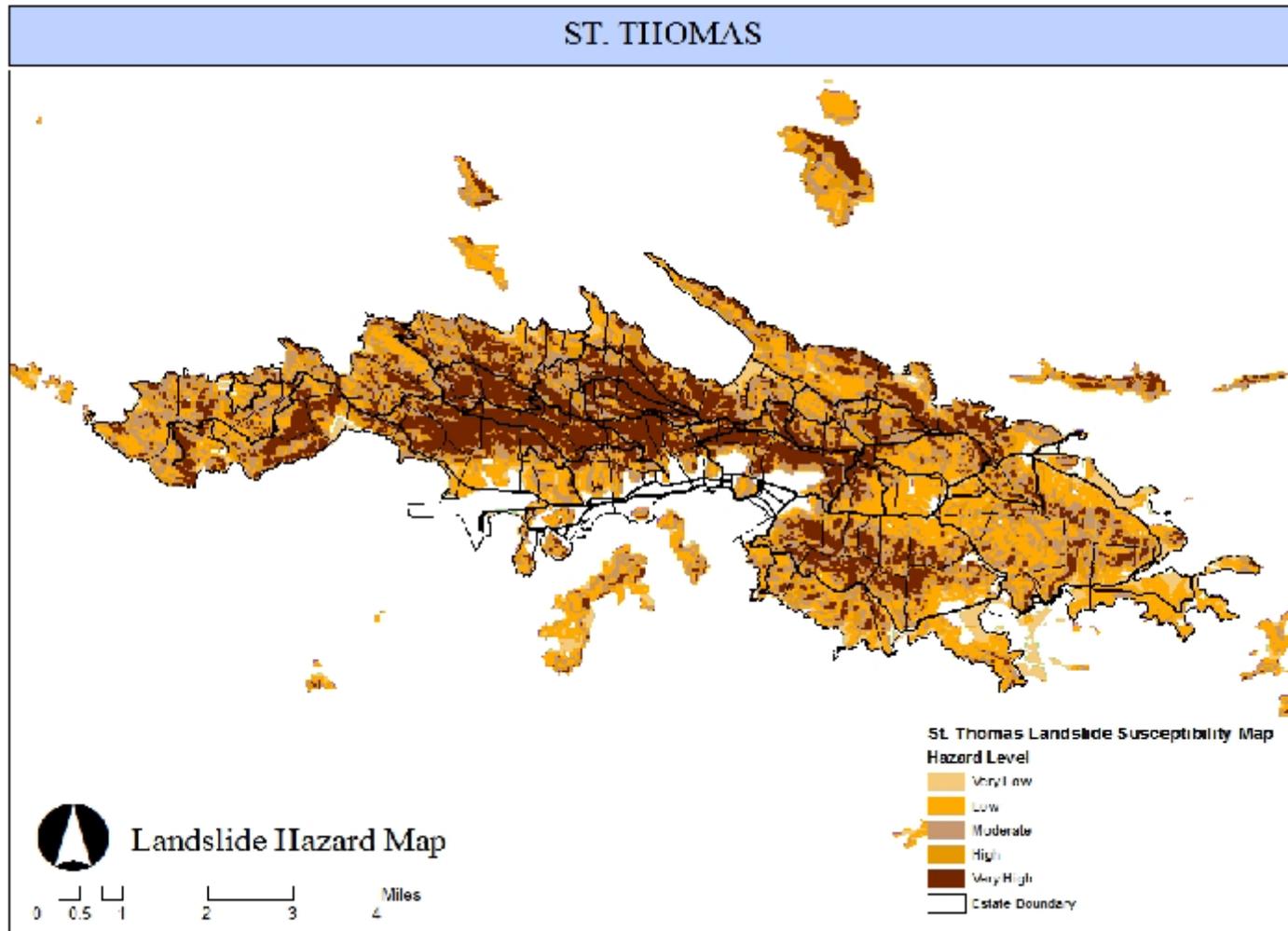


FIGURE 4.17 *Landslide Hazard Map, St. Croix*

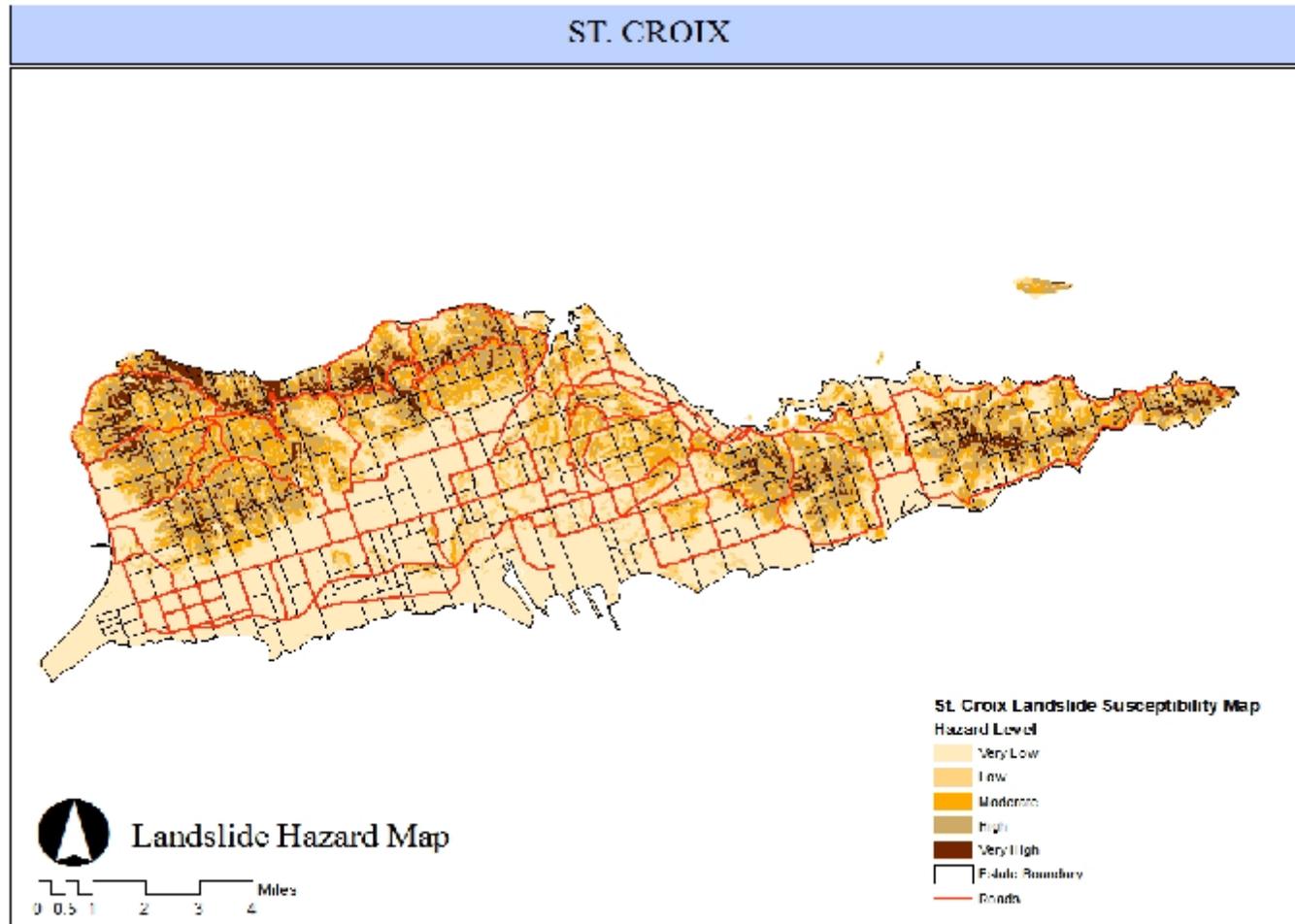
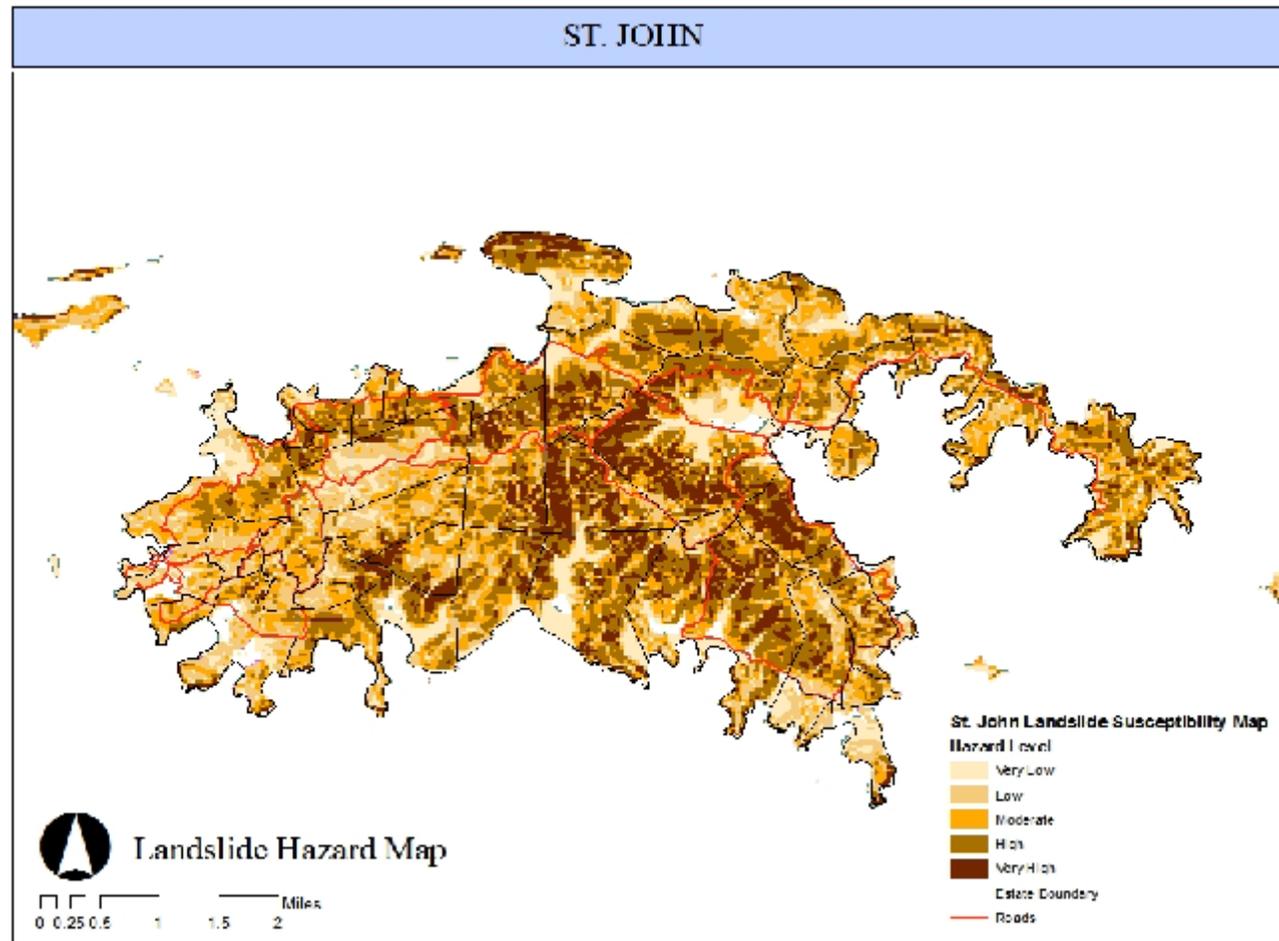


FIGURE 4.18 *Landslide Hazard Map, St. John*



Hazard Frequency and Magnitude

There is a general lack of understanding and information available to determine the frequency and/or magnitude of landslides in the US Virgin Islands. If we tied the incidence of rain-induced landslides to heavy rainfall events, it appears landslide activity is limited in magnitude as the economic data has not been captured for documenting the impact of each landslide. Based on the limited data, US Virgin Islands (territory-wide) can expect at least one (1) landslide event per year.

Data Sources, Models and Methodologies

Base Data

- (2010): Average Annual Rainfall 1971 -2000, Oregon State University (OSU) Spatial Climate Analysis Service.
- USACE Digital Terrain Model (2008)
- Hydrologic Units for USVI (2002) U.S. Geological Survey in cooperation with the U.S. Department of Agriculture, Natural Resources Conservation Service

Hazard Assessment and Determination

- USVI Soil Survey, US Department of Agriculture, Natural Resources Conservation
- Brabb, E.E. 1984. Landslide potential on St. Thomas, Virgin Islands, p.97-102. U.S. Geological Survey Open –File Report 84-762

Inventory Data (Assets)

- General Building Stock: Office of the Lt. Governor, Office of the Tax Assessor, Computer Mass Appraisal System Database and GIS Parcel Maps
- Critical Facilities and Infrastructure: VI Department of Property and Procurement, VITEMA

4.4.7 TSUNAMI

Hazard Description

A tsunami is a series of long waves generated in the ocean by a sudden displacement of a large volume of water. Underwater earthquakes, landslides, volcanic eruptions, meteor impacts, or onshore slope failures can cause this displacement. Most tsunamis originate in the Pacific Ocean associated with the high level of seismic activity present.

Tsunami waves can travel at speeds averaging 450 to 600 miles per hour. As a tsunami nears the coastline, its speed diminishes, its wavelength decreases, and its height increases greatly. Unusual heights have been known to be over 100 feet high. However, waves that are between 10 to 20 feet high can be very destructive and cause many deaths and injuries. An earthquake need not originate in the near proximity to a land mass to be destructive. Simply put, tsunamis are known to have immediate, intermediate and distant ranges. Destructive waves are known to travel over 1000 miles at alarming speeds. Of course, the closer the epicenter of an event to a land mass, the shorter the period of warning and preparation.

After a major earthquake or other tsunami-inducing activity occurs, a tsunami could reach the shore within a few minutes. From the source of the tsunami-generating event, waves travel outward in all directions in ripples. As these waves approach coastal areas, the time between successive wave crests varies from 5 to 90 minutes. The first wave is usually not the largest in the series of waves, nor is it the most significant. One coastal community may experience no damaging waves while another may experience destructive deadly waves. Some low-lying areas could experience severe inland inundation of water and deposition of debris of more than 1,000 feet inland.

Nature of the Hazard

Due to the historical record of earthquakes in the region, it is considered reasonable to expect that tsunamis would be generated as well, and the historic record bears this out (see Disaster History below). It is important to note that the sites for tsunami generation are likely to be very close to the coast and so warning time is very short. Therefore, the types of strategies that will be more effective focus on proper siting of structures as opposed to implementing warning systems.

However, in 2000, the University of Puerto Rico established a tsunami warning system for both Puerto Rico and the U S Virgin Islands. The efforts to strengthen its reliability and effectiveness have increased, especially since the major event in the Pacific Basin in 2004 that affected Indonesia, W Thailand, Sri Lanka, SE India. The warning system has an estimated response time of twenty minutes after an earthquake event. But the close proximity of the Puerto Rican Trench and the Anegada Fault, a devastating tsunami could occur before warning is issued. Researchers estimate that should a strong tsunami occur in the northern Caribbean region, the increase in population within the potentially affected zone, 35,5 million people could be affected by such an event.

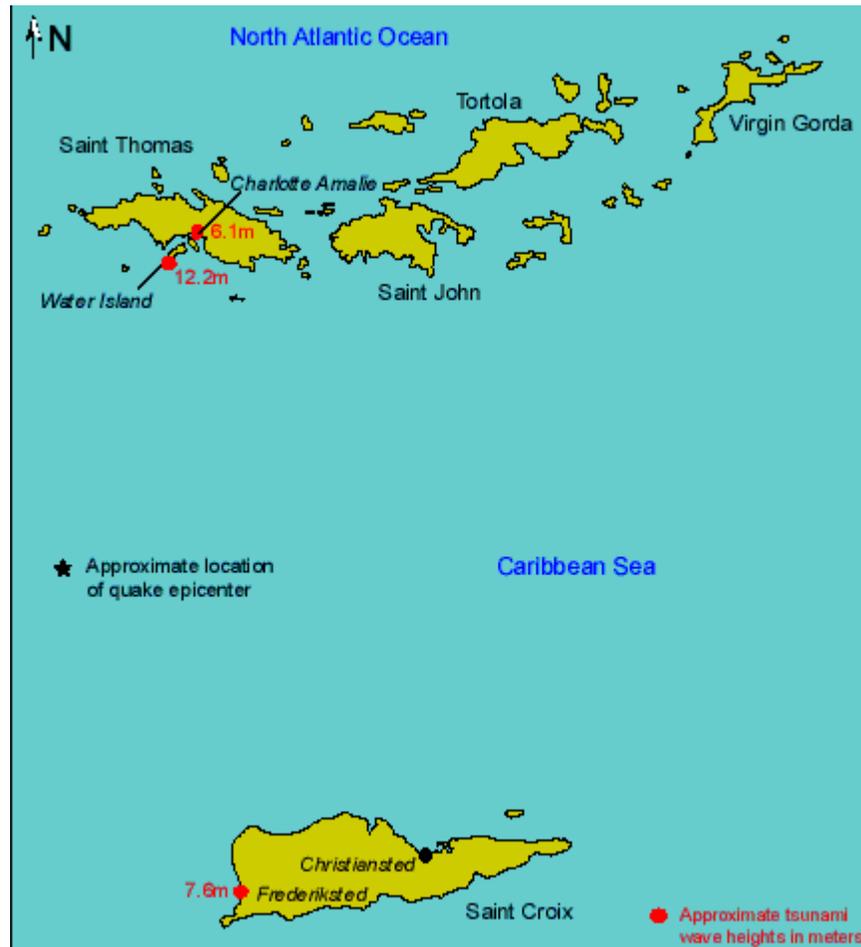
Tsunamis had a dramatic impact on the US Virgin Islands, when in 1867, a magnitude 7.5 earthquake occurred in the Anegada Trench. Two tsunami waves struck Charlotte Amalie, ten minutes apart. Both waves struck the harbor as a large recession of water, followed by a bore, which eyewitness accounts

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describe as a 6 meter wall of water. The waves destroyed many boats anchored in the harbor, leveled the town's iron wharf, and either flooded out or destroyed all buildings located along the waterfront area. The tsunami produced an estimated 2.4 meters of runup at Charlotte Amalie, and a maximum 75 meters of landward inundation. Frederiksted, in St. Croix was also struck by two tsunami waves, that same day, although of lesser magnitude, estimated at 7.6 meters high.

Figure 4.19 illustrates the projected epicenter of the 1867 earthquake in relation to St. Thomas and St. Croix.

FIGURE 4.19 *Projected Epicenter of the 1867 Earthquake*



Hazard Location, Extent and Distribution

Tsunami hazard areas are all low lying, relatively flat coastal areas. Tsunami hazard areas in US Virgin Islands are depicted in Figures 4.20, 4.21 and 4.22. Tsunami impacts will vary in the Virgin Islands. This is due to several factors including the offshore and near shore coastal topography (not considered in the tsunami hazard map developed in this study), vegetation and level and type of development. High waves will have only a serious impact, however, if the shoreline is low enough to be susceptible to flooding.

On St. Thomas, like St. John, the coastal areas are intensively developed. Charlotte Amalie and Cruz Bay are urbanized and have extensive infrastructure and road networks and are considered the most vulnerable areas to the tsunami hazard. On St. John, waterfront development, particularly port facilities and commercial development on the water such as shopping centers and hotels along the coastline could be affected by a tsunami. Both islands have secondary locations, Red Hook on St. Thomas and Coral Bay on St. John that are vulnerable to a tsunami. Both of these locations have experienced significant

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development in the past three years creating a potential for considerable property damage and possible loss of life.

In St. Thomas, cruise ships are highly vulnerable to tsunamis. In a recent paper given to the NSF Caribbean Tsunami Workshop, San Juan, March 30-31, 2004, Roy A. Watlington of the University of the Virgin Islands, indicated that on a three cruise ship day in St. Thomas, between 8:00 and 10:00 am as many as 12,000 tourists and crew may disembark to engage in recreational activities. The preferred activities of visitors, which include swimming at beaches, visits to the Coral World aquarium, sailing and boat sightseeing, keep them confined to tsunami prone coastal areas. Since the business district of Charlotte Amalie is also exposed to a tsunami, those visitors who elect to frequent the many stores, are also at risk. Furthermore, the report cites that several critical facilities are prone to tsunamis. These facilities include Virgin Islands Government offices (legislature, courts, and executive offices), electricity/desalination plants of the Water and Power Authority, the airport, port facilities and several schools.

The physiographic composition of St. Croix is vastly different from the previous two islands. The result is a landscape with much less topographic relief than St. Thomas and St. John. Nevertheless, it has two urban areas, Christiansted and Frederiksted that are particularly exposed to tsunami hazard. The town of Frederiksted suffered major damage from the 1867 tsunami, but not to the extent experienced on St. Thomas. Watlington, 1984 cites that on St. Croix several critical facilities are prone to tsunamis. These facilities include the electricity/desalination plant of the Water and Power Authority, HOVENSA (a large oil refinery), and the airport.

FIGURE 4.20 *Tsunami Hazard Map, St. Thomas*

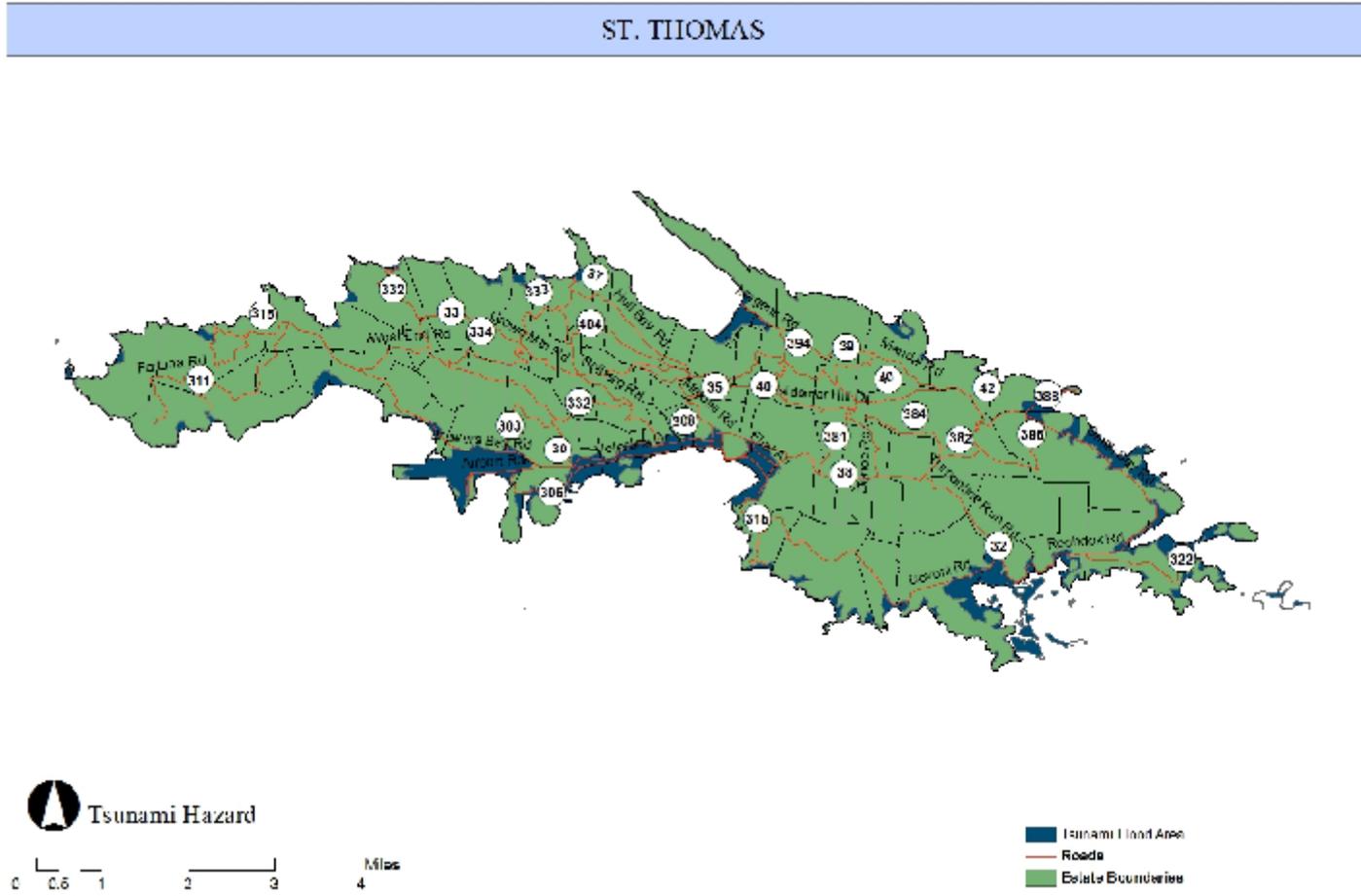


FIGURE 4.21 *Tsunami Hazard Map, St. Croix*

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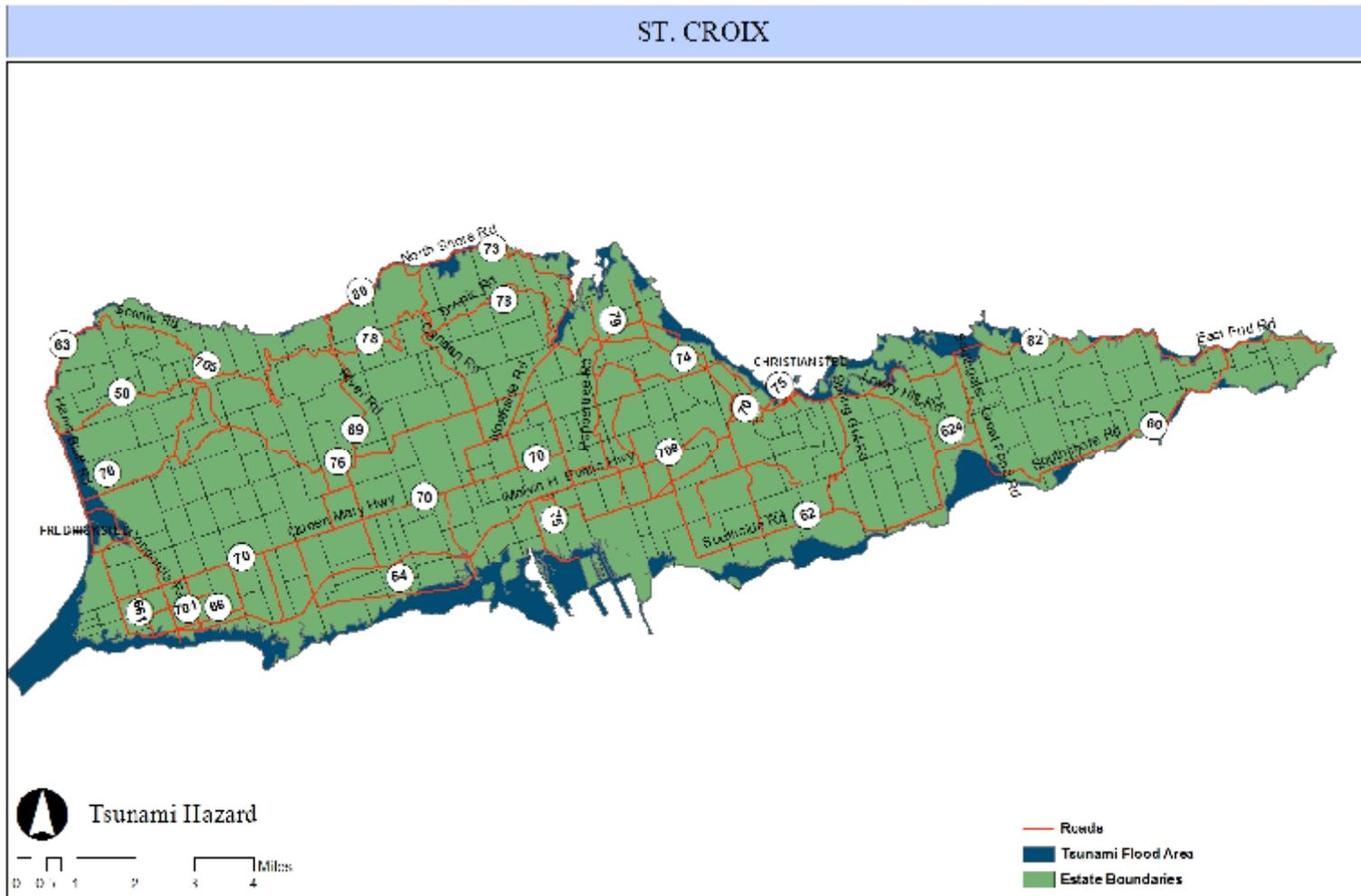
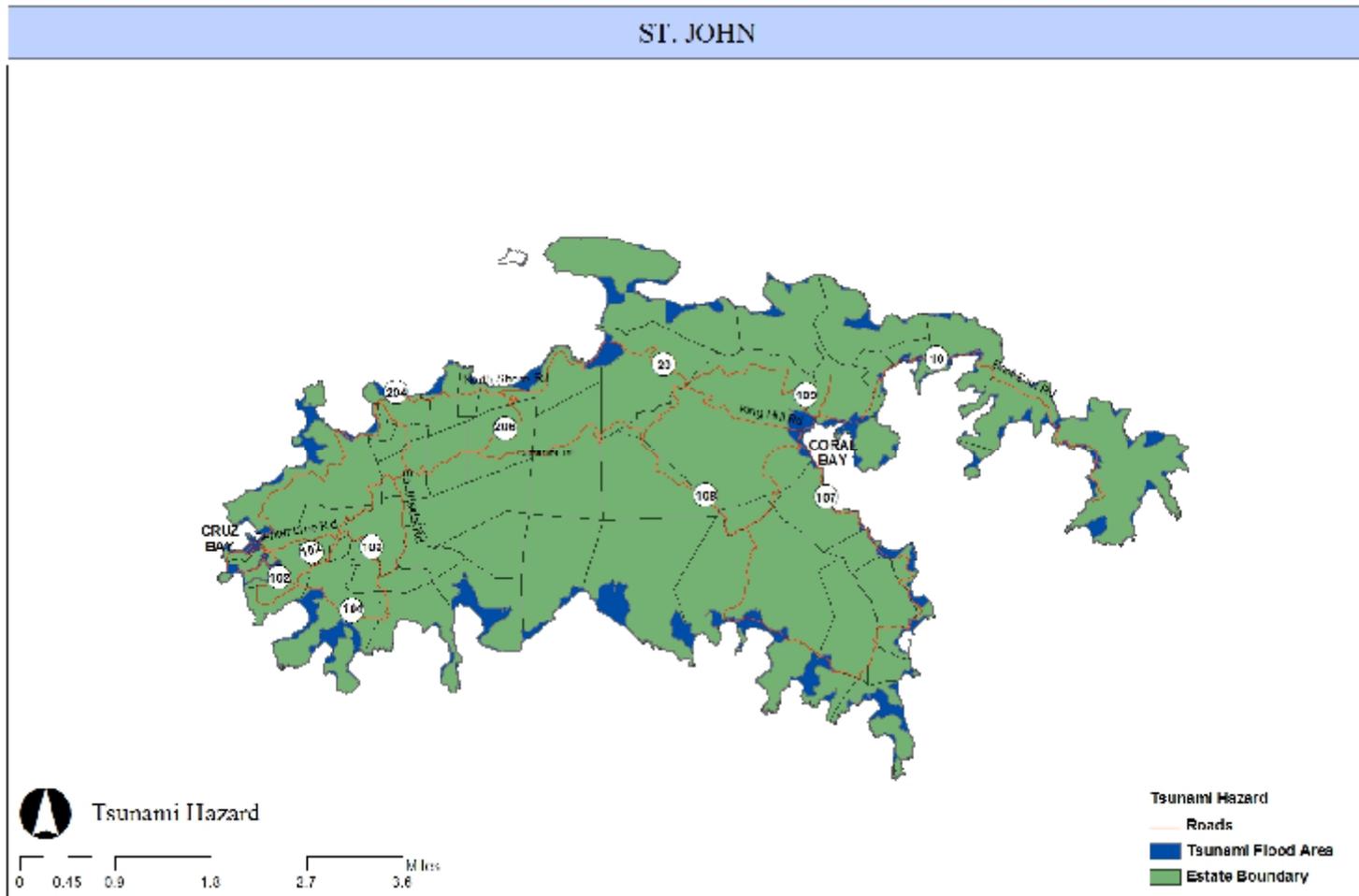


FIGURE 4.22 *Tsunami Hazard Map, St. John*

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Disaster History

Tom Parsons and Eric Geist¹² identify 116 individual observations of tsunami run ups in excess of 0.5 meters since 1530 (Caribbean-wide). Of these events, 14 tsunamis have been reported from Puerto Rico and the Virgin Islands (Lander et al., submitted). 30 tsunamis caused significant damage including reports of as many as 9,600 fatalities, which can be attributed to underwater earthquakes and tsunamis combined. 1,922 deaths are confirmed as being specifically related to tsunamis during the last 150 years. The following are events recorded for the Virgin Islands:

- May 7, 1842. Tsunami hit St. John. Maximum wave height was estimated to be 3 meters.
- Eyewitness reports of the 1868 St. Croix tsunami give a maximum wave height of over 20 feet in Frederiksted.
- A 1918 M 7.5 earthquake resulted in a tsunami that killed at least 116 people in northwestern Puerto Rico. A run up of about 20 feet has been documented by mapping, and sedimentary evidence for at least two earlier tsunamis in the area has been cited.

Hazard Frequency and Magnitude

In crude terms, based on a record of approximately 100 recorded tsunamis in the Caribbean over the last 500 years, on average, one tsunami should be expected somewhere in the basin every 5 years. Conversely, Tom Parsons and Eric Geist, in a regional tsunami probability study conducted in 2009 estimate that the 30-year probability of a tsunami with run up greater than or equal to 0.5 m at Charlotte Amalie is 18%. This combines the probability estimate from the historic catalog with numerical modeling results. The numerical model is based on a coarse grid and not geographically specific, but provides a good indicator of hazard frequency and magnitude.

Data Sources, Models and Methodologies

Tsunami

- Based on oral communication with Tsunami hazard expert, Professor Roy Watlington, UVI
- USGS U.S. Geological Survey, "Earthquakes and Tsunamis in Puerto Rico and the U.S. Virgin Islands", Fact Sheet FS-141-00, 2001
- University of California Tsunami Research Group (<http://www.usc.edu/dept/tsunamis/>)
- Parson, T and Geist, E (2009): Pure and Applied Geophysics, Vol. 165, 2089-2116

Tsunami Hazard Assessment and Determination

¹² Database of Caribbean Tsunami observations with runup ≥ 0.5 meters. Sources NOAA n-line database and Lander 2003.

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- The tsunami hazard maps used in this study were developed based on estimates of a historical event, the tsunami of 1867. The estimated maximum wave height of the tsunami of 1867 was 7 meters.
- Wave height estimates were intersected with a digital elevation model to develop tsunami inundation maps. These maps are based on a historical tsunami scenario and expert interviews. Inundation maps may have no significant bearing on any actual tsunami event and should not be used during a real tsunami event.
- GIS overlay techniques were utilized to identify structures in the inundation areas. Flood depths were not estimated.
- Database of Caribbean Tsunami observations with run up ≥ 0.5 meters. Sources NOAA n-line database and Lander 2003.

Inventory Data (Assets)

- General Building Stock: Office of the Lt. Governor, Office of the Tax Assessor, Computer Mass Appraisal System Database and GIS Parcel Maps
- Critical Facilities and Infrastructure: VI Department of Property and Procurement, VITEMA

4.4.8 WILDFIRE

Hazard Description

A wildfire is an undesirable, uncontrolled burning of grasslands, brush or woodlands. According to the National Weather Service, more than 100,000 wildfires occur in the United States each year. About 90% of these wildfires are started by humans (i.e., campfires, debris burning, smoking, etc.); the other 10% are started by lightning. Wildfires, by definition, occur in areas where development is sparse and as a result often begin unnoticed and spread quickly.

The potential for wildfire depends upon surface fuel characteristics, weather conditions, recent climate conditions, topography and fire behavior. Fuels are defined as anything that fire can and will burn, and are the combustible materials that sustain a wildfire. Typically, this is the most prevalent vegetation in a given area. Weather is one of the most significant factors in determining the severity of wildfires. The intensity of fires and the rate with which they spread is directly related to the wind speed, temperature and relative humidity. Climatic conditions such as long-term drought also play a major role in the number and intensity of wildfires, and topography is important because the slope and shape of the terrain can change the rate of speed at which fire travels.

There are four major types of wildfires, they are:

- Ground fires burn in natural litter, duff, roots or sometimes even highly-organic soils. Once started they are very difficult to control, and some ground fires may even rekindle after being extinguished.

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- Surface fires burn in grasses and low shrubs (up to 4' tall) or in the lower branches of trees. They have the potential to spread rapidly, and the ease of their control depends upon the fuel involved.
- Crown fires burn in the tops of trees, and the ease of their control depends greatly upon wind conditions.
- Spotting fires occur when burning embers are thrown ahead of the main fire, and can be produced by crown fires as well as wind and topographic conditions. Once spotting fires begin, the fire will be very difficult to control.

Nature of the Hazard

In the US Virgin Islands, the pattern of development in which structures are mixed in with or next to flammable vegetation, increases the territory's susceptibility to wildfires. The US Virgin Islands is considered to have a mixed wildland/urban interface where structures and other human development meet or intermingle with undeveloped vegetative lands.

On the islands of St. Thomas and St. John the wildland/urban intersection usually occurs in areas where homes developed are in steep vegetated areas. Furthermore, access to these areas is made difficult by the steep and narrow roadways. On St. Croix, residential and commercial structures are intermingled with grasslands and/or scrublands. Many of the wildfires on St. Croix tend to be caused by persons burning garbage or clearing their land for cultivation. These wildfires tend to occur in the dry season and spread for hundreds of areas across sparsely populated lands.

Hazard Location, Extent and Distribution

Because high-resolution data was not readily available to accurately identify the degree of wildfire hazard throughout the US Virgin Islands, a precise analysis to determine the geographic extent for the wildfire hazard could not be performed. Instead an approximate analysis mapping was utilized to identify general areas throughout the islands that could be prone to Wildfire (See Figures 4.22, 4.23 and 4.24).

It is necessary to note that historically fires have been man-caused, and limited primarily to St. Croix, and have spread over hundreds of acres.

FIGURE 4.23 *Wildfire Hazard Map, St. Thomas*

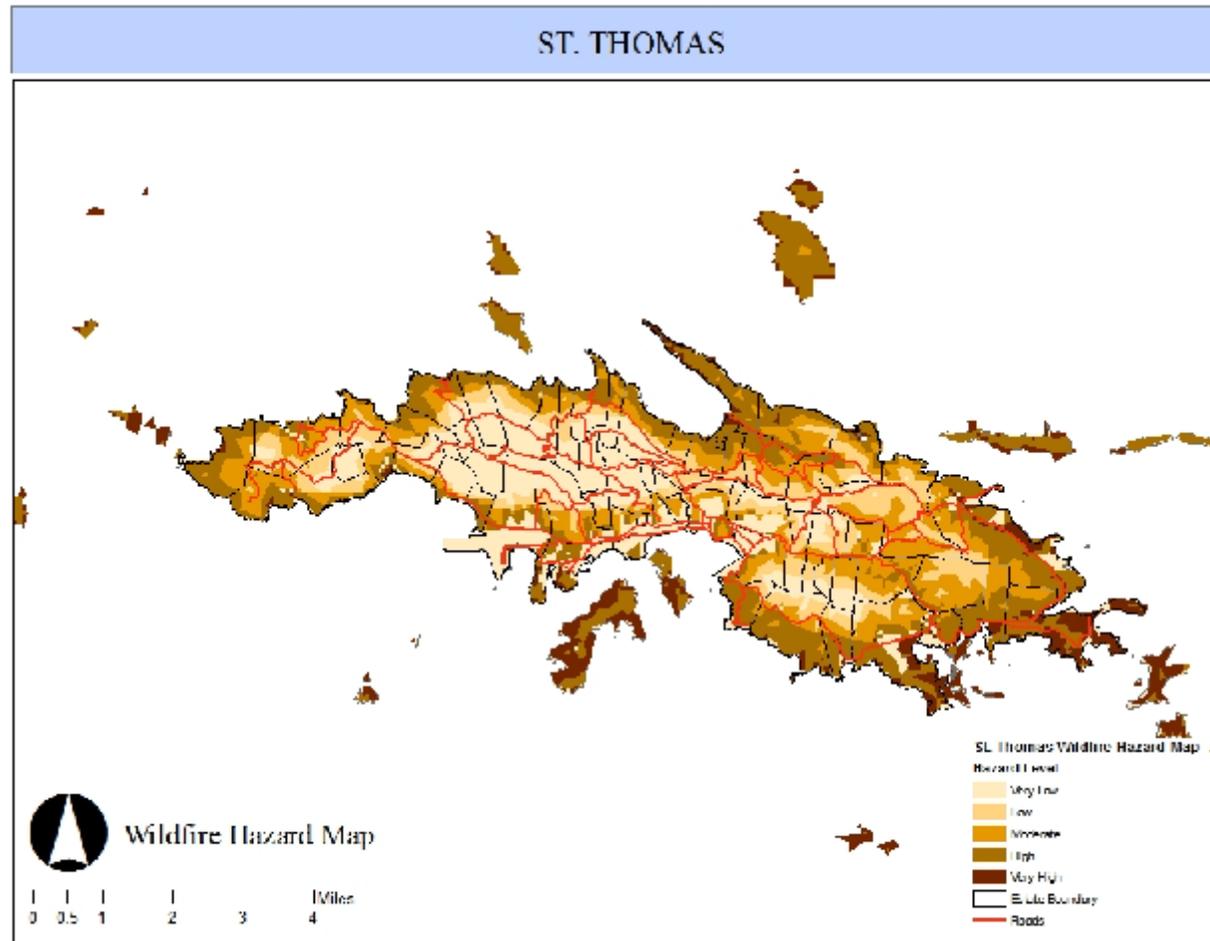
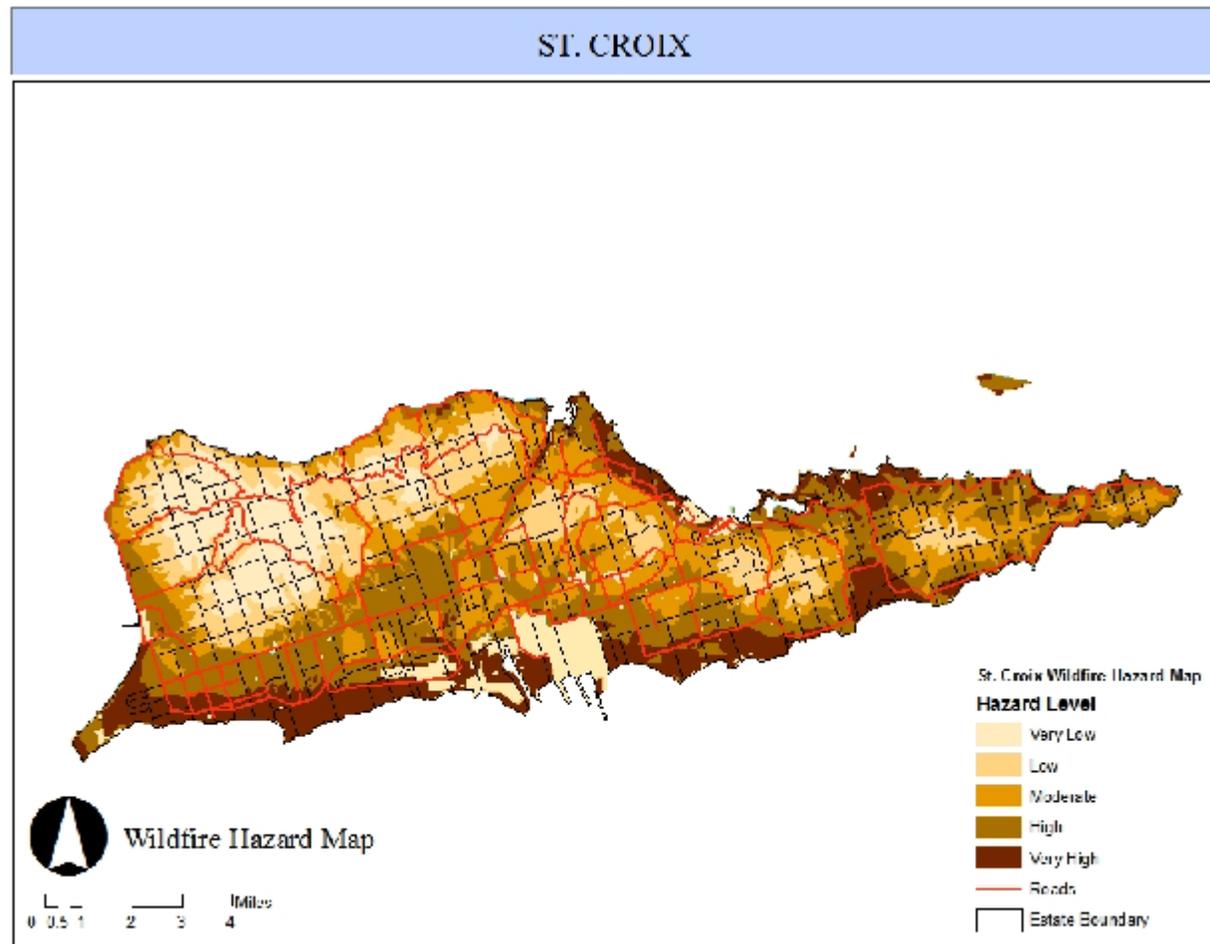


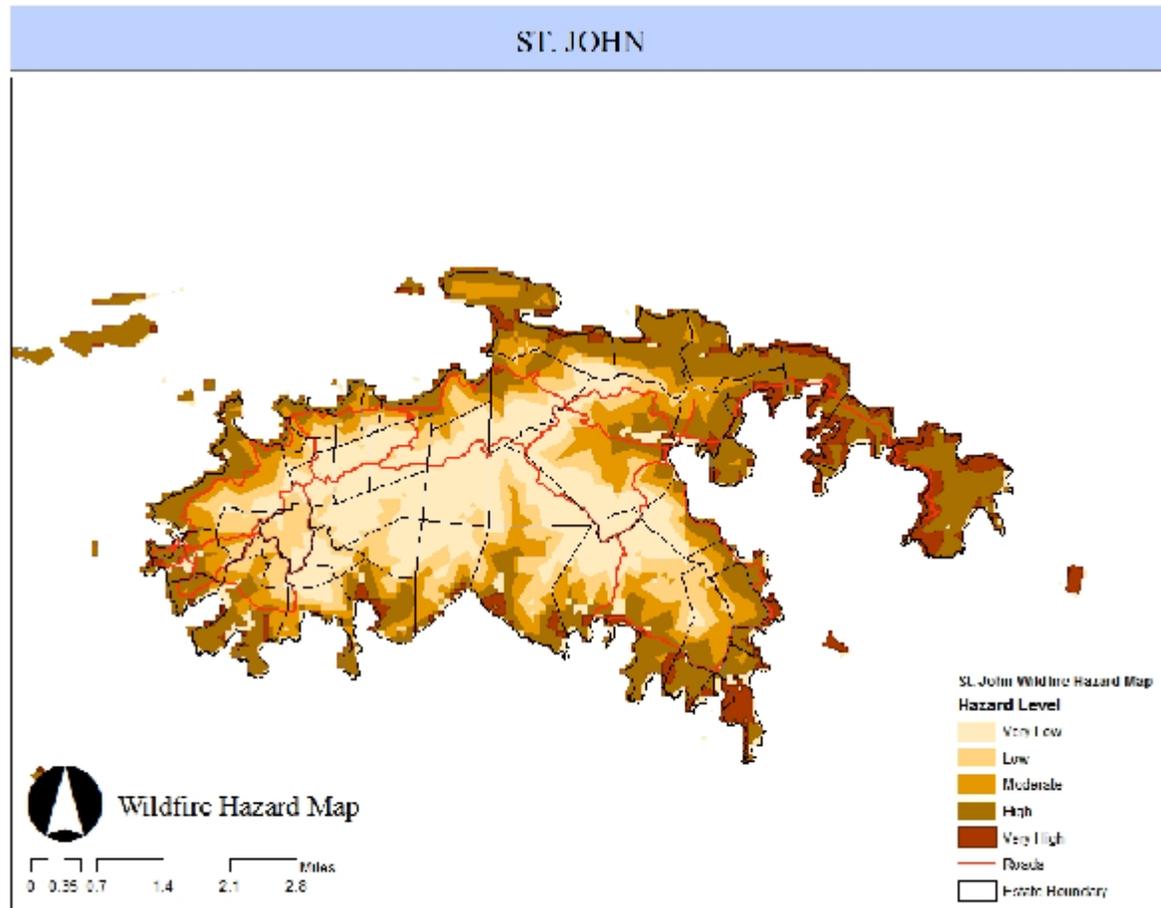
FIGURE 4.24 *Wildfire Hazard Map, St. Croix*

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FIGURE 4.23 Wildfire Hazard Map, St. John



Disaster History

The National Climatic Data Center record indicates that there have been only 18 confirmed wild/forest fires in the Territory between 2000 and 2010. All of these events were reported on St. Croix. Below are descriptions taken from the National Climatic Data Center (NOAA's on-line database):

1. April 14, 2000: Approximately 100 acres were burnt by brush fires fueled by dry, windy conditions in St. Croix western end hillsides. The fires began in Calquohoun and spread to cover a broad area in William's Delight, Queen Louise and Estate Mountain. No homes were destroyed and nobody was injured.
2. March 13, 2000. Brush fires affected about 600 acres of land in Lowry Hill and Tide Village in East End. No damage was reported to homes, structures and nobody was injured. The cause of fire was unknown but arson was suspected.
3. March 18, 2001. Brush fires affected about 100 acres near Mount Welcome and Recovery Hill. No damages were reported on structures, homes or people. The suspected cause of the fire was an abandoned car that someone set afire.
4. March 29, 2001. A brush fire formed at King Still Area across the Centerline Road. The fire affected a nearby elementary school with smoke. Four students were taken to the Hospital with respiratory difficulties. All of them were unharmed.
5. April 2, 2001. Brush fires affected about 215 acres of land in Recovery Welcome, Peter's Farm and a section just east of Gallows Bay. No damages were reported on homes, structure or affected any people. The cause of these fire was unknown, but arson was suspected in Gallows Bay.
6. March 13, 2003. Brush fires fueled by strong winds scorched hundreds of acres on St Croix, at Estates Bethlehem, Calquohoun, Cobble, and Lowry Hill. The extremely dry conditions appeared to have spawned multiple fires. Several telephone poles were damaged, and some livestock may have perished. About 60 acres of pasture and brush were lost in Estate Lowry Hill.
7. April 3, 2003. A brush fire was reported near Grassy Point in St Croix. It was burning up in open terrain and hills. A substantial number of acres were burned. Lack of rainfall could have been a contributing factor.
8. March 4, 2005. A brush fire scorched more than 300 acres of vegetation near South Sore cafe in Estate Petronelli. Several utility poles were damaged.

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9. March 8, 2005. More than 15 acres of brush was scorched when a fire crept over an open field between Estates Mon Bijou and Calquohoun.
10. March 11, 2011. A brush fire on the east end of the island consumed more than one 100 acres of parched vegetation near Grape Tree Bay. The fire damaged several utility poles.
11. March 13, 2005. Brush fires fueled by brisk winds scorched hundred of acres on St. Croix. Fires were in estates Bethlehem, Calquohoun and Cobble. The fire damaged several telephone poles and some livestock could have perished.
12. April 13, 2005. Two brush fires developed on the west end of St. Croix, in a field next to Williams's Delight. Morev than 40 acres burned.
13. April 21, 2005. A massive brush fire was reported on the East End. The fire erupted near Tide Village and quickly spread to hillsides surrounding Lowry Hill and Estate Boetzberg. The fire consumed more than 200 acres of hillside and pastureland.
14. March 8, 2007. A large brush fire burnt more than 800 acres near Castle Nugent, Lowry Hill and Estate Sight on Saint Croix's East End.
15. March 14, 2007. A brush fire scorched four acres of grassland near HaPenny on the island's south shore.
16. March 19, 2007. A brush fire scorched more than 100 acres in an open field in Estate Concordia east of Frederiksted.
17. March 28, 2007. A brush fire scorched 40 acres at Estate Granard.
18. April 14, 2010. A brush fire broke out on Saint Croix's south shore to the west of Howard Wall Boy Scouts facility. More than 50 acres of pasture and dry vegetation were consumed.

Hazard Frequency and Magnitude

The historic average occurrence of wildfires in the US Virgin Islands serves as the best value for predicting future expected recurrence. Based on the limited data, US Virgin Islands can expect at least one (1) wildfire event per year. Such predictions are limited by the number of years for which data was available and the recorded damages per event. Therefore, an thorough understanding of magnitude of wildfire events is very limited.

4.5 INVENTORY OF ASSETS

For the Plan Update, VITEMA utilized a methodology that was consistent with FEMA Publication 386-2, "State and Local Mitigation Planning How-To Guide, Understanding Your Risks—Identifying Hazards and Estimating Losses" (FEMA 2001). This methodology is the same that was utilized for the development of the 2008 Plan. It includes:

- Estimate or count the total number of buildings, value of buildings, and population in your community.
- Determine the proportion of buildings, the value of buildings, and the population in your community or state that are located in hazard areas, and
- Calculate the proportion of assets located in hazard areas.

4.5.1 INVENTORY DATA COLLECTION

Specific assets evaluated for this Plan Update include population, buildings, and critical facilities, including infrastructure. General inventory information was collected from the Office of the Lieutenant Governor's Tax Assessors Office and was used to classify the general building stock. Site specific data was also gathered from VITEMA and the Department of Property and Procurement and used to classify critical facilities and infrastructure. The data utilized in this Plan was aggregated from the 2005 and 2008 Plans and contain estimates of the price and quantities of structures used for residential and commercial purposes in the U.S. Virgin Islands. The aggregation of data and all estimates of structure costs used price indices for housing and construction costs. Annual data sets were derived from publicly available data from the Bureau of Economic Analysis (BEA).

Detailed spatial and non-spatial local data were gathered, compiled, and analyzed in a Geographic Information System (GIS). These data are discussed below under the following categories:

- General Building Stock
- Critical Facilities and Infrastructure

General Building Stock

Local tax assessor information was used to develop a detailed inventory of the built environment in the US Virgin Islands. Specifically, the Virgin Islands Tax Assessors Office (Division of the office of the Lt. Governor), provided their parcel maps and property tax valuation database. The database has been updated and was reevaluated. The OLG data was found to be consistent with tax lot information and could be used to identify use of parcel and/or building.

Since the 2008 Plan Update, the Virgin Islands Tax Assessors Office (Division of the office of the Lt. Governor), have made revisions to the property valuations throughout the entire Territory of the Virgin Islands. This revised database was not made available to VITEMA, and as a result, the same database that was utilized during the 2008 Update was utilized to categorize the built environment.

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The OLG database; however, had certain limitations related to structure classification. Field surveys were eliminated from the budget and not conducted during this Plan Update. The field investigations that were conducted during the 2005 and 2008 Plan Update were deemed to be satisfactory to determine the distribution of different building types and to gather structural information for each occupancy class.

In this Update, and in order to conduct basic analyses and gather information that would be useful to determine general loss estimates, structural categories remained the same as in the 2008 Plan Update. The ten (10) model building types remain consistent with field investigations conducted during this Plan Update (details in Appendix G), these include:

- Low Rise Wood Frame Dwelling,
- Mid-rise Wood Frame Dwelling,
- Low Rise Reinforced Concrete Dwelling,
- Mid Rise Reinforced Concrete Dwelling,
- Low Rise Steel Building,
- Mid Rise Steel Building,
- Low Rise Un-reinforced Masonry Building,
- Mid Rise Un-reinforced Masonry Building,
- Low Rise Reinforced Masonry Building, and
- Mid Rise Reinforced Masonry Building

The distribution of particular building types for each estate boundary for each island was then updated. This facilitated an understanding of the distribution of model building types for a specific occupancy class, at the estate level, for each island.

This analysis provided a basis to estimate the total number of buildings and to aggregate replacement and content values for model building types.

Territorial Facilities and Infrastructure

There were two (2) changes in the inventory of critical facilities for this Plan Update. These include the removal of the VITEMA building on St. Croix, and the addition of the new VITEMA Emergency Operations Center on St. Thomas. Facilities such as schools, police and fire stations, and hospitals, are known as “critical facilities.” Infrastructure is separated into two distinct classes that have substantially different damage and loss characteristics: (1) transportation systems (key roads, ports, airports) and (2) utility infrastructure (electric power stations, potable water treatment plants, wastewater treatment plants, water pumps). The following three-part definition of critical facilities and infrastructure shall apply:

Critical Facilities

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Critical facilities are those facilities that provide services to the community and should be functional after a hazard event. They include:

- Government buildings necessary for continuity of operations,
- Hospitals,
- Police stations,
- Fire stations,
- Schools, and
- Homes for the ageing.

Transportation Infrastructure

Transportation Infrastructure are facilities that enable the movement of goods, particularly emergency relief supplies. They include:

- Marine Facilities, and
- Airports.

Utilities and Infrastructure

Utilities and Infrastructure are facilities that, if damaged, could have far-reaching consequences for the environment. They include:

- Electrical Power Generating Plants,
- Water Treatment Plants,
- Wastewater Treatment Plants,
- Potable Water Pumps, and
- Water Tanks.

This list of facilities was developed by VITEMA and cross referenced to the Office of Homeland Security's Critical Infrastructure Plan during the 2008 Plan Update. A detailed listing of critical facilities was provided to VITEMA for this update. This list was referenced with information maintained by the Department of Property and Procurement.

The detailed site investigation to collect important structural information that was conducted during the 2005 and 2008 Plan were found to be adequate. Therefore, site visits of critical facilities were not undertaken for this Plan Update. Instead, information gathered from VITEMA was used to update Inventory information.

The 2011 Plan has categorized facilities and infrastructure by their structural characteristics relevant to vulnerability to the prominent hazards identified in the study. In this Plan, like the 2008 Plan, replacement and content values for facilities were determined using the FEMA guideline of content value as a percentage of building replacement value. In the 2011 Plan Update, facility values were updated utilizing a compounded inflation factor for the three year period.

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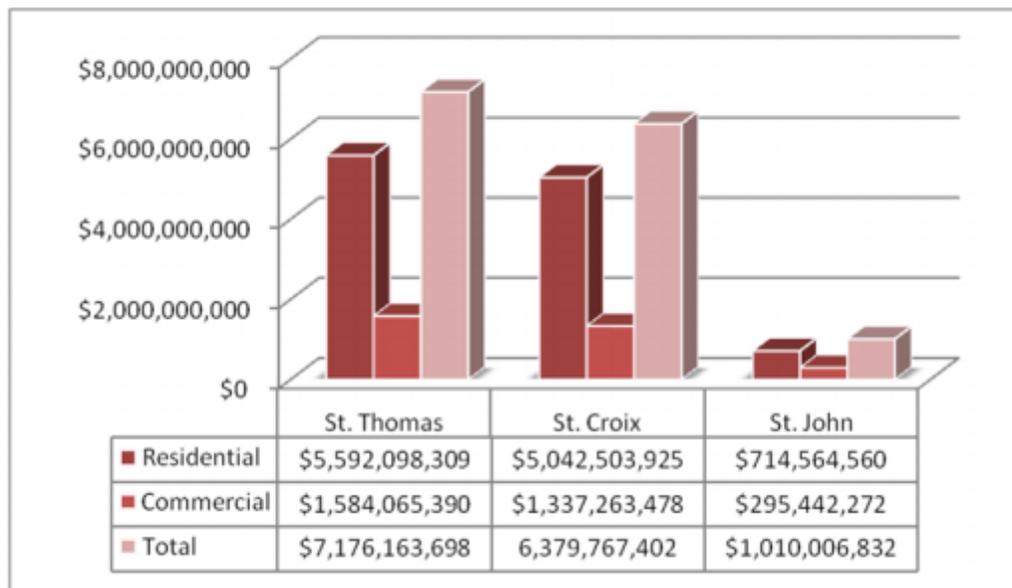
4.5.2 EXPOSURE VALUES

Exposure, as applied in this section of the Plan Update, means, the total amount of property value that are vulnerable to severe loss in the occurrence of a natural hazard event. Exposure is used to quantify the potential financial loss in the event of a natural hazard. Values shown include average building values, structural values (replacement costs), “content value,” and total value.

General Building Stock

Figure 4.24 shows the average estimated value of individual buildings by occupancy class. Exposure values are based on data gathered at the Office of Lieutenant Governor’s office and field investigations. The total inventory value for residential and commercial buildings is \$13 billion, which represents an increase of approximately a \$1 billion dollars since 2008.

FIGURE 4.24 *Building Stock Values by Occupancy Class for US Virgin Islands*



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Table 4.9 presents the estimated number of buildings and their dollar value by occupancy class, for each island in the Territory.

TABLE 4.9 Inventory of General Building Stock¹³

Building Occupancy Class	Number of Buildings 2011	Estimated	Estimated	Total Value
		Aggregate	Aggregate	
		Replacement Cost	Content Value	
St. Thomas				
Residential	22,751	\$3,730,676,594	\$1,861,421,714	\$5,592,098,309
Commercial	2,128	\$792,032,695	\$792,032,695	\$1,584,065,390
Total	23,857	4,522,709,289	2,653,454,409	\$7,176,163,698
St. Croix				
Residential	21,419	\$4,345,185,803	\$697,318,122	\$5,042,503,925
Commercial	813	\$639,945,356	\$697,318,122	\$1,337,263,478
Total	22,232	4,985,131,159	1,394,636,244	6,379,767,402
St. John				
Residential	2,188	\$478,104,128	\$236,460,432	\$714,564,560
Commercial	79	\$236,460,432	\$58,981,840	\$295,442,272
Total	2,267	714,564,560	295,442,272	\$1,010,006,832

For this Plan Update, there was an increase in the number of private structures and commercial on all three islands. The prolonged housing downturn on the US mainland has had an effect on the US Virgin Islands housing market in terms of fewer transactions of houses (down 23 percent since 2004) and condominiums (down 46 percent since 2004), but its impact has not been witnessed in house prices or construction costs. Overall total home values have remained fairly constant.

On St. John, several “high end” residential structures were erected which contributed to this upsurge. The number of residential structures has increased by 46, with an increased valuation of over \$66 million. The commercial building stock increased by 2 structures with an added value of over \$149 million. Of the three major islands, St. John exhibits the largest increase in value in terms of cost of structures.

St. Croix, however, had an increase in the number of both residential and commercial structures. The value of residential property increased by 21% or by \$886 million. Commercial property also

¹³ Single family dwellings are a subset of the total residential occupancy class. Total values include the sum of residential and commercial occupancy classes.

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increased by about the same amount (23 percent). The number of residential structures has increased by 451 and the number of commercial properties has increased by 17. Historically construction costs on this island are less than in other areas resulting in a lower valuation of the building stock.

On St. Thomas, the number of residential structures has increased by a total of 479 and the corresponding total valuation has increased by \$971 million. Likewise the commercial building number has increased by 45, but the total value increased by 19% (\$247 million). The total valuation of privately held real property is the highest on St. Thomas compared to the other two major islands of the Virgin Islands.

Territorial Facilities and Infrastructure

Table 4.10 shows the estimated value of critical facilities and infrastructure in primary categories. Precise valuation information was not readily available from VITEMA or Department of Property and Procurement at the time of the Plan Update; therefore, the values presented in the section are a close approximation of the actual value of these important structures. The valuation of these facilities for this Update was based on the estimated area of the structures and an inflation factor of 1.13 for the three year period. This inflation factor was developed through data supplied by the U.S. Department of Commerce, Bureau of Economic Analysis.

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TABLE 4.10 Estimated Value of Critical Facilities and Infrastructure

Facility	St. Thomas		St. Croix		St. John	
	# of Facilities in Class	Total Exposure	# of Facilities in Class	Total Exposure	# of Facilities in Class	Total Exposure
Critical Facilities						
Police Stations	5	12,465,771	6	62,409,350	2	4,232,415
Fire Stations	5	7,632,269	5	9,079,146	2	4,746,000
Emergency Response	1	6,339,740	N/A		1	5,036,571
Hospital/ Medical Clinic	5	93,867,045	3	133,193,329	2	17,228,782
Government Buildings	11	115,982,295	12	118,556,952	3	12,888,821
Shelters	8	121,014,906	11	169,722,337	5	51,393,929
Transportation Infrastructure						
Marine Ports	4	25,503,146	5	9,718,000	1	2,825,000
Airport	1	22,012,987	1	56,500,000	N/A	N/A
Utilities						
Electrical Power Generating Plants	1	50,119,536	1	50,850,000	1	15,255,000
Water Treatment Plants Wastewater Treatment Plants	5	60,521,406	36	107,803,428	4	32,828,750
Potable Water Pumps Water Tanks						

4.6 VULNERABILITY ASSESSMENT

This section of the Plan Update facilitates an understanding of the proportion of buildings, the value of buildings, and the population located in hazard areas. VITEMA utilized information from the Hazard Identification and Profile information (i.e. wind speed, flood depth, etc.) to assess the vulnerability parameters (specific damage and loss characteristics) of each asset identified.

Vulnerable subgroups of the population for each island were determined using the Census 2000 data. For this Plan Update, population projections for 2011 were prepared accounting for annual growth rate of roughly -.08% (CIA Fact Book). This is lower than growth rate that was utilized in the 2008 Plan Update and is considerably lower than the estimated growth rate for the period 2000-

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2010. The annual growth rate was applied for two years 2008 and 2009, to estimate population for 2010.

Once the population was projected, the vulnerability analysis looked first at social impacts. The social analysis identified the number of people less than 18 years of age and the number of people over 65 years of age. These two demographic subgroups help define the territory's social vulnerability as they are the most likely to need assistance during and/or after a hazard event. A series of GIS hazard overlay queries were performed to indicate where the people reside within the territory relative to hazards.

Following, the vulnerability assessment was used to estimate potential losses to each hazard. The estimation of how many buildings that are susceptible to hazard related damage are based on either the location of buildings to a particular hazard (i.e. flood zone, earthquake ground shaking level) or based on hazard intensity expressed across each of the Territory's major islands (i.e. wind speed). The pursuant tables identify the number of buildings and value that are exposed to a certain level of hazard intensity. The extent and severity of damage to structural and nonstructural components of a building is described by one of five damage states:

- Very Low, (no, or negligible damage)
- Low, (easily repairable damage mainly to part of nonstructural components and/or contents)
- Moderate, (considerable, yet repairable damage to mainly non-structural components)
- High (considerable damage to both structural and non-structural components), and
- Very High (that the extent of damage is too much to be repaired; the facility has to be demolished and replaced).

The qualitative vulnerability ratings relate to a percentage of damage for each model building type across each island. The damage estimation methods for critical facilities and infrastructure are identical to those utilized to estimate damage with general building stock, except that classification or grouping of facilities was not needed and performed on a structure by structure basis.

4.6.1 DROUGHT

This section discusses the population and the proportion and value of buildings located in areas affected by a drought. It also provides an estimate of proportion of assets located in areas that are susceptible to drought.

Social Impacts

Table 4.30 shows an estimate of the affected population and area (in square kilometers) as indicators of the social vulnerability of each island. Two special needs population segments are broken out by hazard areas: the number of people less than 18 years of age and the number of people over 65 years of age.

TABLE 4.11 Social Impacts (Drought)

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Island Jurisdiction	Total Population	Less than 18 Years of Age in Hazard Area	% Less than 18 Years of Age in Hazard Area	Over 65 Years of Age in Hazard Area	% Over 65 Years of Age in Hazard Area
St. Thomas	54,842	8,977	16%	2,211	4%
St. Croix	57,041	8,364	15%	2,060	4%
St. John	4,497	935	21%	230	5%

Physical and Economic Impacts

- In this Plan Update, economic vulnerability relates to the extent of dollar exposure of its buildings that are susceptible to a hazard. The findings of the vulnerability assessment for this Plan Update indicate that there are 10,921 residential structures exposed to this hazard on St. Thomas and 766 commercial structures. On St. Croix, there are 9,210 residential structures and 187 commercial structures exposed to this hazard, while on St. John the total number of residential properties exposed is 1335 and 11 commercial structures.
- On St. Thomas, approximately 48% percent of the residential building stock and 35% of the commercial building stock is considered to be vulnerable drought. Of this percentage, approximately 22% of the residential building stock is of high vulnerability and the remaining 26% is of very high vulnerability to a drought event. Commercial structures are not considered to be vulnerable to drought events with 35% of the commercial stock being exposed to the hazard, none of which are classified as very high.
- On St. Croix, approximately 43% percent of the residential building stock and 23% of the commercial building stock is considered to be vulnerable to drought. Of this percentage, approximately 34% of the residential building stock is of medium vulnerability, 15% of the residential building stock is of high vulnerability, and the remaining 28% is of very high vulnerability to drought. None of the commercial building inventory is of medium vulnerability, none has high or very high vulnerability rating to a drought event.

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- On St. John, approximately 61% percent of the residential building stock and 14% of the commercial building stock is considered to be vulnerable to a drought hazard. Of this percentage, approximately 26% of the residential building stock is of medium vulnerability, 28% of the residential building stock is of high vulnerability, and the remaining 33% is of very high vulnerability to a drought event. None of the commercial building inventory is of medium vulnerability, none has high or very high vulnerability rating to a drought event.

The tables below show potential dollar exposure to drought hazard on St. Thomas, St. Croix and St. John.

TABLE 4.12 Estimated Drought Exposure and Vulnerability (St. Thomas)

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	48%	13%	23%	16%	26%	22%
No. of Residential	10,921	1,368	5,123	3,735	5,987	5,057
Value of Residential	\$2,684,207,188	\$336,140,190	\$604,462,622	\$440,651,613	\$706,353,069	\$596,599,694
% of Commercial	36%	36%	64%	0	0	0
No. of Commercial	766	277	489	0	0	0
Value of Commercial	\$570,263,540	\$205,928,501	\$364,335,040	\$0.00	\$0.00	\$0.00

TABLE 4.13 Estimated Drought Exposure and Vulnerability (St. Croix)

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	43%	9%	14%	34%	15%	28%
No. of Residential	9210	801	114	38	6	2
Value of Residential	\$2,168,276,688	188,514,396	26,759,060	9,042,993	1,377,385	386,845
% of Commercial	23%	41%	61%	0	0	0
No. of Commercial	187	76	47	0	0	0
Value of Commercial	\$307,570,600	125,824,336	76,588,726	0	0	0

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TABLE 4.14 Estimated Drought Exposure and Vulnerability (St. John)

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	61%	2%	12%	26%	28%	33%
No. of Residential	1335	23	159	343	375	435
Value of Residential	\$435,884,382	7,509,853	52,021,377	111,865,518	122,582,704	141,904,930
% of Commercial	14%	14%	86%	0%	0%	0%
No. of Commercial	11	2	9	0	0	0
Value of Commercial	\$41,361,918	5,908,845	35,453,073	0	0	0

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Critical Facilities

The tables below highlight the results of the vulnerability assessment of each state-owned or operated facility to the earthquake hazard. Results define the potential exposure to Territorial Facilities and Infrastructure for the island of St. Thomas, St. Croix and St. John.

TABLE 4.16 Estimated Drought Exposure and Vulnerability, Critical Facilities and Infrastructure (St. Thomas)

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	5	2			2	1	12,465,771
Fire Stations	5	3	2				7,632,269
Emergency Response	1					1	6,339,740
Hospital, Clinics, and special needs	5	4		1			93,867,045
Government Buildings	11	9		9	9		115,982,295
Shelters	5	2	1		1	1	121,014,906
Transportation Infrastructure							
Marine Ports	4	4					25,503,146
Airport	1	1					22,012,987
Utilities							
Electrical Power Generating Plants	1	1					50,119,536
Sewage Treatment Plant	1			1			60,521,406
Water Treatment Plant	1		1				
WAPA Tanks	1			1			
Pumping Station	1	1					

Appendix G provides detailed Vulnerability and Loss Estimate calculations for each facility.

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TABLE 4.17 Estimated Drought Exposure and Vulnerability, Critical Facilities and Infrastructure (St. Croix)

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	6	3	2		1		62,409,350
Fire Stations	5	3		2			9,079,146
Emergency Response	N/A						N/A
Hospital/ Medical Clinic	3	3					133,193,329
Government Buildings	12	6			2	4	118,556,952
Shelters/Special Needs	11	3			5	3	169,722,337
Transportation Infrastructure							
Marine Ports	5	5					9,718,000
Airport	1	1					56,500,000
Utilities							
Electrical Power Generating Plants	1	1					50,850,000
Sewage Pumps	14	9				5	107,803,428
Wastewater Treatment Plant	1	1					
Water Treatment Plant	1	1					
Water Pumps	8	1	4	3			

Appendix G provides detailed Vulnerability and Loss Estimate calculations for each facility.

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TABLE 4.17 *Estimated Drought Exposure and Vulnerability, Critical Facilities and Infrastructure (St. John)*

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	2	1		1		2	4,232,415
Fire Stations	2	1					4,746,000
Emergency Response	1						5,036,571
Hospital/ Medical Clinic	2			1		1	17,228,782
Government Buildings	3	3					12,888,821
Shelters/Special Needs	5	1		2		2	51,393,929
Transportation Infrastructure							
Marine Ports	1	1					2,825,000
Airport	N/A						N/A
Utilities							
Electrical Power Generating Plants	1	1					15,255,000
WAPA Desalinization Plant	1	1					32,828,750
WAPA Water Tank	1	1					
Sewage Treatment Plant	1	1					
Potable Water Tank	1	1					

Appendix G provides detailed Vulnerability and Loss Estimate calculations for each facility.

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4.6.2 EARTHQUAKE

This section discusses the population and the proportion and value of buildings located in areas affected by an earthquake hazard. It also provides an estimate of proportion of assets located in earthquake hazard areas.

Social Impacts

Table 4.30 shows an estimate of the affected population and area (in square kilometers) as indicators of the social vulnerability of each island. Two special needs population segments are broken out by hazard areas: the number of people less than 18 years of age and the number of people over 65 years of age.

TABLE 4.18 Social Impacts (Earthquake)

Island Jurisdiction	Total Population	Less than 18 Years of Age in Hazard Area	% Less than 18 Years of Age in Hazard Area	Over 65 Years of Age in Hazard Area	% Over 65 Years of Age in Hazard Area
St. Thomas	54,842	6,033	11%	1,645	3%
St. Croix	57,041	8,556	15%	1,711	3%
St. John	4,497	630	14%	180	4%

Physical and Economic Impacts

In this Plan Update, economic vulnerability relates to the extent of dollar exposure of its buildings. The findings of the vulnerability assessment for this Plan Update indicate that there was an increase of 437 residential properties exposed to this hazard on St. Thomas. On St. Croix, there was a decrease of 726 residential properties exposed to this hazard, while on St. John the total number of residential properties exposed decreased 590. On St. Thomas there were 1003 additional commercial properties exposed to this hazard. In St. Croix there was a decrease of 195 commercial properties exposed to this hazard. On St. John there were 37 less commercial properties exposed to this hazard.

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- On St. Thomas approximately 91% percent of the residential building stock and 96% of the commercial building stock is considered to be vulnerable to an earthquake event. Of this percentage, approximately 59% of the residential building stock is of high vulnerability and the remaining 41% is of very high vulnerability to an earthquake event. About 44% of the commercial building inventory is of high vulnerability to an earthquake and the remaining 56% of the inventory has a very high vulnerability to a seismic event.
- On St. Croix approximately 70% percent of the residential building stock and 84% of the commercial building stock is considered to be vulnerable to an earthquake event. Of this percentage, approximately 75% of the residential building stock is of medium vulnerability, 5% of the residential building stock is of high vulnerability, and the remaining 20% is of very high vulnerability to an earthquake event. About 73% of the commercial building inventory is of medium vulnerability, none has high vulnerability, and the remaining 27% of the inventory has a very high vulnerability to a seismic event.
- On St. John approximately 71% percent of the residential building stock and 85% of the commercial building stock is considered to be vulnerable to an earthquake event. Of this percentage, approximately 71% of the residential building stock is of medium vulnerability, 11% of the residential building stock is of high vulnerability, and the remaining 19% is of very high vulnerability to an earthquake event. About 32% of the commercial building inventory is of medium vulnerability to an earthquake, 20% of the stock is of high vulnerability, and the remaining 48% of the inventory has a very high vulnerability to a seismic event. St. John has construction on steep sloping ground, but most structures are more recent and better built due to economic reasons.

The tables below show potential dollar exposure to earthquake hazard on St. Thomas, St. Croix and St. John.

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TABLE 4.19 Estimated Earthquake Exposure and Vulnerability (St. Thomas)

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	91%	0.00	0.00	0.00	0.42	0.58
No. of Residential	20,704	0	0	0	9,550	13,202
Value of Residential	\$5,088,809,461	\$0	\$0	\$0	\$2,347,243,008	\$3,244,855,301
% of Commercial	96%	0.00	0.00	0.00	0.20	0.80
No. of Commercial	2,043	0	0	0	423	1,705
Value of Commercial	\$1,520,702,774	\$0	\$0	\$0	\$315,125,353	\$1,268,940,037

TABLE 4.20 Estimated Earthquake Exposure and Vulnerability (St. Croix)

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	70%	0%	0%	75%	5%	20%
No. of Residential	14,993	0	0	16,064	1,071	4,284
Value of Residential	3,529,752,747	0	0	2,647,314,561	176,487,637	705,950,549
% of Commercial	84%	0%	0%	73%	0%	27%
No. of Commercial	683	0	0	498	0	184
Value of Commercial	1,123,301,321	0	0	820,009,964	0	303,291,357

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TABLE 4.21 Estimated Earthquake Exposure and Vulnerability (St. John)

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	71%	0	0	0.71	0.11	0.19
No. of Residential	1,554	0	0	1,103	171	295
Value of Residential	507,340,838	0	0	360,211,995	55,807,492	96,394,759
% of Commercial	85%	0	0	0.32	0.2	0.48
No. of Commercial	67	0	0	21	13	32
Value of Commercial	251,125,931	0	0	80,360,298	50,225,186	120,540,447

Critical Facilities

The tables below highlight the results of the vulnerability assessment of each state-owned or operated facility to the earthquake hazard. Results define the potential exposure to Territorial Facilities and Infrastructure for the island of St. Thomas, St. Croix and St. John.

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TABLE 4.22 Estimated Earthquake Exposure and Vulnerability, Critical Facilities and Infrastructure (St. Thomas)

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	5	1			1	3	12,465,771
Fire Stations	5	1		1	1	2	7,632,269
Emergency Response				1			6,339,740
Hospital, Clinics, and special needs	5				4	1	93,867,045
Government Buildings	11			3		8	115,982,295
Shelters	5	1		1		3	121,014,906
Transportation Infrastructure							
Marine Ports	4	1		1		2	25,503,146
Airport	1	1					22,012,987
Utilities							
Electrical Power Plant						1	50,119,536
Sewage Treatment Plant	1				1		
Water Treatment Plant	1				1		60,521,406
WAPA Tanks	1					1	
Pumping Station	1				1		

Appendix G provides detailed Vulnerability and Loss Estimate calculations for each facility.

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TABLE 4.23 Estimated Earthquake Exposure and Vulnerability, Critical Facilities and Infrastructure (St. Croix)

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	6	1		3	1	1	62,409,350
Fire Stations	5	1			1	3	9,079,146
Emergency Response	1			1			N/A
Hospital/ Medical Clinic	3			2		1	133,193,329
Government Buildings	12			6	2	4	118,556,952
Shelters/Special Needs	11		1	3	1	6	169,722,337
Transportation Infrastructure							
Marine Ports	5	5					9,718,000
Airport	1			1			56,500,000
Utilities							
Electrical Power Plant	1				1		50,850,000
Sewage Pumps	14	3	3	6	2		107,803,428
Wastewater Treatment Plant	1				1		
Water Treatment Plant	1	1					
Water Pumps	8			4	2	2	

Appendix G provides detailed Vulnerability and Loss Estimate calculations for each facility.

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TABLE 4.24 Estimated Earthquake Exposure and Vulnerability, Critical Facilities and Infrastructure (St. John)

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	2		1		1		4,232,415
Fire Stations	2			1		1	4,746,000
Emergency Response	1			1			5,036,571
Hospital/ Medical Clinic	2	1				1	17,228,782
Government Buildings	3		1			2	12,888,821
Shelters/Special Needs	5			1	1	3	51,393,929
Transportation Infrastructure							
Marine Ports	1	1					2,825,000
Airport	N/A						N/A
Utilities							
Electrical Power Plant	1				1		15,255,000
WAPA Desalinization Plant	1			1			32,828,750
WAPA Water Tank	1				1		
Sewage Treatment Plant	1				1		
Potable Water Tank	1				1		

Appendix G provides detailed Vulnerability and Loss Estimate calculations for each facility.

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4.6.3 RIVERINE FLOODING

This section discusses the population and the proportion and value of buildings located in areas affected by a riverine flooding hazard. It also provides an estimate of proportion of assets located in riverine flooding hazard areas.

Social Impacts

Table 4.25 shows an estimate of the affected population and area (in square kilometers) as indicators of the social vulnerability of each island. Two special needs population segments are broken out by hazard areas: the number of people less than 18 years of age and the number of people over 65 years of age.

TABLE 4.25 Social Impacts (Riverine Flooding)

Island Jurisdiction	Total Population	Less than 18 Years of Age in Hazard Area	% Less than 18 Years of Age in Hazard Area	Over 65 Years of Age in Hazard Area	% Over 65 Years of Age in Hazard Area
St. Thomas	54,842	3,839	7%	1,097	2%
St. Croix	57,041	4,563	8%	1,141	2%
St. John	4,497	270	6%	45	1%

Physical and Economic Impacts

In this Plan Update, economic vulnerability relates to the extent of dollar exposure of its buildings. The findings of the vulnerability assessment for this Plan Update indicate that there was an increase of 111 residential properties exposed to this hazard on St. Thomas. On St. Croix there was a decrease of 125 residential properties exposed to this hazard, while on St. John the total number of residential properties exposed to this hazard decreased by 525. On St. Thomas there were 376 more commercial properties exposed to this hazard. On St. Croix there were 24 less commercial properties exposed to this hazard. On St. John there was a decrease of 6 commercial properties exposed to this hazard.

- On St. Thomas approximately 23% percent of the residential building stock and 36% of the commercial building stock is considered to be vulnerable to river flooding. Of this percentage, approximately 64% of the residential building stock is of medium vulnerability and the remaining 36% is of high vulnerability to river flooding. About 44% of the

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commercial building inventory has a low vulnerability to river flooding, and the remaining 56% of the inventory has a high vulnerability to such flooding.

- On St. Croix approximately 12% percent of the residential building stock and 10% of the commercial building stock is considered to be vulnerable to river flooding. Of this percentage, approximately 68% of the residential building stock is of medium vulnerability and the remaining 32% is of high vulnerability to river flooding. About 51% of the commercial building inventory has a low vulnerability to river flooding, and the remaining 49% of the inventory has a high vulnerability to such flooding.
- On St. John approximately 12% percent of the residential building stock and 10% of the commercial building stock is considered to be vulnerable to river flooding. Of this percentage, approximately 81% of the residential building stock is of medium vulnerability and the remaining 19% is of high vulnerability to river flooding. About 51% of the commercial building inventory has a moderate vulnerability to river flooding, and the remaining 49% of the inventory has a high vulnerability to such flooding.

TABLE 4.26 Estimated Riverine Flooding Exposure and Vulnerability (St. Thomas)

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	23%	0.00	0.00	0.47	0.53	0.00
No. of Residential	5,233	0	0	2,452	2,780	0
Value of Residential	\$1,286,182,611	\$0.00	\$0.00	\$602,800,565	\$683,382,046	\$0.00
% of Commercial	36%	0.00	0.00	0.20	0.80	0.00
No. of Commercial	766	0	0	152	614	0
Value of Commercial	\$570,263,540	\$0	\$0	\$113,445,127	\$456,818,413	0

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TABLE 4.27 *Estimated Riverine Flooding Exposure and Vulnerability (St. Croix)*

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	12%	0%	0%	68%	32%	0%
No. of Residential	2,570	0	0	1,748	822	0
Value of Residential	605,100,471	0	0	411,468,320	193,632,151	0
% of Commercial	10%	0%	0%	51%	49%	0%
No. of Commercial	81	0	0	41	40	0
Value of Commercial	133,726,348	0	0	68,200,437	65,525,910	0

TABLE 4.28 *Estimated Riverine Flooding Exposure and Vulnerability (St. John)*

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	24%	0%	0%	81%	19%	0%
No. of Residential	525	0	0	425	100	0
Value of Residential	171,495,494	0	0	138,911,351	32,584,144	0
% of Commercial	15%	0%	0%	44%	48%	0%
No. of Commercial	12	0	0	5	6	0
Value of Commercial	44,316,341	0	0	19,499,190	21,271,844	0

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It may be overly simplistic to determine flood vulnerability as a yes or no as per the location of the structure in or outside of the floodplain. Flood vulnerability for this Plan Update was determined using the 100-year flood zone as an indicator of the overall hazard. The digital version of these maps was derived from updated DFIRMS. However, the updated DFIRMS did not have Base Flood Elevations (BFE) for all mapped riverine areas.

Therefore, BFEs were utilized where present and a terrain model was utilized to infer flood elevations where the BFE data was absent. The resulting analysis utilized a GIS to generate a Triangular Irregular Network (TIN) of the water surface elevation. Using GIS overlay techniques, the terrain were subtracted from TIN (an intersection of the flood polygon with the terrain model) to determine an estimated depth of flooding.

This method was found to be suitable for estimating zones experiencing different flood depths within the 100-year flood area. The depth intervals were broken out into five categories of different flood depths between 4 to 25 feet to define the flood hazard as very low, low, moderate, high and very high. Therefore, your highest areas of vulnerability would be found in the center of the 100-year floodplain, where the depths are the greatest. In this Plan Update, most of the residential and commercial structures in the Territory were found to be in moderate to high flood hazard intensity. This indicates that most the building stock estimated to be vulnerable to flooding were within the defined 100-year floodplain.

The flood hazard information in this Plan Update was used to develop a **Severe Repetitive Loss Strategy (Appendix C)** for the Virgin Islands. Different from the 2008 Plan Update, general GIS maps that graphically show Special Flood Hazard Area (SFHA) were used to identify residential and commercial areas that experience repetitive flooding. Mapping of individual structures was not conducted during this Plan Update.

Critical Facilities

The following tables highlight the results of the vulnerability assessment of each state-owned or operated facility to the riverine flood hazard. Results define the potential exposure to Territorial Facilities and Infrastructure for the islands of St. Thomas, St. Croix and St. John.

The tables below show potential dollar exposure to Riverine flood hazard on St. Thomas, St. Croix and St. John.

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TABLE 4.29 Estimated Riverine Flooding Exposure and Vulnerability, Critical Facilities and Infrastructure (St. Thomas)

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	5	2			1	2	12,465,771
Fire Stations	5	2		1		2	7,632,269
Emergency Response	1	1					6,339,740
Hospital, Clinics, and special needs	5	3	1			1	93,867,045
Government Buildings	11	3		1	2	5	115,982,295
Shelters	5	3		1	1		121,014,906
Transportation Infrastructure							
Marine Ports	4	3		1			25,503,146
Airport	1	1					22,012,987
Utilities							
Electrical Power Plant							50,119,536
Sewage Treatment Plant	1				1		60,521,406
Water Treatment Plant	1				1		
WAPA Tanks	1	1					
Pumping Station	1	1					

Appendix G provides detailed Vulnerability and Loss Estimate calculations for each facility.

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TABLE 4.30 *Estimated Riverine Flooding Exposure and Vulnerability, Critical Facilities and Infrastructure (St. Croix)*

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	6	6					62,409,350
Fire Stations	5	5					9,079,146
Emergency Response	1	1					N/A
Hospital/ Medical Clinic	3	3					133,193,329
Government Buildings	12	9		1	1		118,556,952
Shelters/Special Needs	11	11				1	169,722,337
Transportation Infrastructure							
Marine Ports	5	5					9,718,000
Airport	1	1					56,500,000
Utilities							
Electrical Power Plant	1		1				50,850,000
Sewage Pumps	14	12	2				107,803,428
Wastewater Treatment Plant	1	1					
Water Treatment Plant	1		1				
Water Pumps	8	6	1	1			

Appendix G provides detailed Vulnerability and Loss Estimate calculations for each facility.

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TABLE 4.31 *Estimated Riverine Flooding Exposure and Vulnerability, Critical Facilities and Infrastructure (St. John)*

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	2	1			1		4,232,415
Fire Stations	2	2					4,746,000
Emergency Response	1	1					5,036,571
Hospital/ Medical Clinic	2	2					17,228,782
Government Buildings	3	2			1		12,888,821
Shelters/Special Needs	5	3				2	51,393,929
Transportation Infrastructure							
Marine Ports	1						2,825,000
Airport	N/A						N/A
Utilities							
Electrical Power Plant	1	1					15,255,000
WAPA Desalinization Plant	1	1					32,828,750
WAPA Water Tank	1	1					
Sewage Treatment Plant	1				1		
Potable Water Tank	1	1					

Appendix G provides detailed Vulnerability and Loss Estimate calculations for each facility.

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4.6.4 COASTAL FLOODING

This section discusses the population and the proportion and value of buildings located in areas affected by a coastal flood hazard. It also provides an estimate of proportion of assets located in coastal flood hazard areas.

Social Impacts

Table 4.32 shows an estimate of the affected population and area (in square kilometers) as indicators of the social vulnerability of each island. Two special needs population segments are broken out by hazard areas: the number of people less than 18 years of age and the number of people over 65 years of age.

TABLE 4.32 Social Impacts (Coastal Flooding)

Island Jurisdiction	Total Population	Less than 18 Years of Age in Hazard Area	% Less than 18 Years of Age in Hazard Area	Over 65 Years of Age in Hazard Area	% Over 65 Years of Age in Hazard Area
St. Thomas	54,842	1,097	2%	16	0.03%
St. Croix	57,041	1,141	2%	23	0.04%
St. John	4,497	90	2%	2	0.04%

Physical and Economic Impacts

In this Plan update economic vulnerability relates to the extent of dollar exposure of its buildings. The findings of the vulnerability assessment for this Plan Update indicate that there was an increase of 34 residential properties exposed to this hazard on St. Thomas. On St. Croix there was a decrease of 52 residential properties, while on St. John the total number of residential properties exposed decreased by 4. On St. Thomas the total number of commercial properties increased by 42. On St. Croix there were 5 less commercial properties exposed to this hazard and on St. John, there was a decrease of 4 commercial properties exposed to this hazard.

- On St. Thomas approximately 7% percent of the residential building stock and 4% of the commercial building stock is considered to be vulnerable to coastal flooding. Of this percentage, approximately 1% of the residential building stock is of medium vulnerability, 63% of the residential building stock is of high vulnerability, and the remaining 36% is of

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very high vulnerability to coastal flooding. About 4% of the commercial building inventory is of medium vulnerability to coastal flooding, 40% of the stock is of high vulnerability, and the remaining 56% of the inventory has a very high vulnerability to such flooding.

- On St. Croix approximately 5% percent of the residential building stock and 2% of the commercial building stock is considered to be vulnerable to coastal flooding. Of this percentage, approximately 1% of the residential building stock is of medium vulnerability, 76% of the residential building stock is of high vulnerability, and the remaining 24% is of very high vulnerability to coastal flooding. About 4% of the commercial building inventory is of medium vulnerability to coastal flooding, 67% of the stock is of high vulnerability, and the remaining 29% of the inventory has a very high vulnerability to such flooding.
- On St. John approximately 10% percent of the residential and commercial building stock are considered to be vulnerable to coastal flooding. Of this percentage, approximately 1% of the residential building stock is of medium vulnerability, 76% of the residential building stock is of high vulnerability, and the remaining 26% is of very high vulnerability to coastal flooding. About 4% of the commercial building inventory is of medium vulnerability to coastal flooding, 47% of the stock is of high vulnerability, and the remaining 49% of the inventory has a very high vulnerability to such flooding.

The tables below show potential dollar exposure to the coastal flooding hazard on St. Thomas, St. Croix and St. John.

TABLE 4.33 Estimated Coastal Flooding Exposure and Vulnerability (St. Thomas)

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	7%	0.00	0.00	0.02	0.45	0.53
No. of Residential	1,593	0	0	28	718	846
Value of Residential	\$391,446,882	0	0	6,905,433	176,555,608	207,985,840
% of Commercial	4%	0.00	0.00	0.01	0.19	0.80
No. of Commercial	85	0	0	1	16	68
Value of Commercial	\$63,362,616	\$0	\$0	\$808,636	\$11,796,378	\$50,757,601

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TABLE 4.34 Estimated Coastal Flooding Exposure and Vulnerability (St. Croix)

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	5%	0%	0%	1%	76%	24%
No. of Residential	1,071	0	0	11	814	257
Value of Residential	252,125,196	0	0	2,521,252	191,615,149	60,510,047
% of Commercial	2%	0	0	0.04	67%	29%
No. of Commercial	16	0	0	3	53	23
Value of Commercial	26,745,270	0	0	53,490,539	895,966,530	387,806,409

TABLE 4.35 Estimated Coastal Flooding Exposure and Vulnerability (St. John)

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	10%	0%	0%	1%	76%	23%
No. of Residential	219	0	0	2	166	50
Value of Residential	71,456,456	0	0	714,565	54,306,907	16,434,985
% of Commercial	10%	0	0	0.04	47%	49%
No. of Commercial	8	0	0	0	4	4
Value of Commercial	29,544,227	0	0	1,181,769	13,885,787	14,476,671

Critical Facilities

The following tables highlight the results of the vulnerability assessment of each state-owned or operated facility to the coastal flood hazard. Results define the potential exposure to Territorial Facilities and Infrastructure for the island of St. Thomas, St. Croix and St. John.

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TABLE 4.36 Estimated Coastal Flooding Exposure and Vulnerability, Critical Facilities and Infrastructure (St. Thomas)

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	5	5					12,465,771
Fire Stations	5	5					7,632,269
Emergency Response	1	1					6,339,740
Hospital, Clinics, and special needs	5	5					93,867,045
Government Buildings	11	11					115,982,295
Shelters	5	5					121,014,906
Transportation Infrastructure							
Marine Ports	4	4					25,503,146
Airport	1	1					22,012,987
Utilities							
Electrical Power Plant	1	1					50,119,536
Sewage Treatment Plant	1	1					60,521,406
Water Treatment Plant	1	1					
WAPA Tanks	1	1					
Pumping Station	1	1					

Appendix G provides detailed Vulnerability and Loss Estimate calculations for each facility.

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TABLE 4.37 Estimated Coastal Flooding Exposure and Vulnerability, Critical Facilities and Infrastructure (St. Croix)

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	6	6					62,409,350
Fire Stations	5	5					9,079,146
Emergency Response	1	1					N/A
Hospital/ Medical Clinic	3	3					133,193,329
Government Buildings	12	11				1	118,556,952
Shelters/Special Needs	11	11					169,722,337
Transportation Infrastructure							
Marine Ports	5	5					9,718,000
Airport	1	1					56,500,000
Utilities							
Electrical Power Plant	1	1					50,850,000
Sewage Pumps	14	14					107,803,428
Wastewater Treatment Plant	1	1					
Water Treatment Plant	1	1					
Water Pumps	8	8					

Appendix G provides detailed Vulnerability and Loss Estimate calculations for each facility.

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TABLE 4.38 Estimated Coastal Flooding Exposure and Vulnerability, Critical Facilities and Infrastructure (St. John)

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	2	2					4,232,415
Fire Stations	2	2					4,746,000
Emergency Response	1	1					5,036,571
Hospital/ Medical Clinic	2	2					17,228,782
Government Buildings	3	2				1	12,888,821
Shelters/Special Needs	5	5					51,393,929
Transportation Infrastructure							
Marine Ports	1	1					2,825,000
Airport	N/A						N/A
Utilities							
Electrical Power Plant	1					1	15,255,000
WAPA Desalinization Plant	1	1					32,828,750
WAPA Water Tank	1					1	
Sewage Treatment Plant	1					1	
Potable Water Tank	1	1					

Appendix G provides detailed Vulnerability and Loss Estimate calculations for each facility.

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4.6.5 HURRICANE WINDS

This section discusses the population and the proportion and value of buildings located in areas affected by a Hurricane Winds hazard. It also provides an estimate of proportion of assets located in Hurricane Winds hazard areas.

Social Impacts

Table 4.39 shows an estimate of the affected population and area (in square kilometers) as indicators of the social vulnerability of each island. Two special needs population segments are broken out by hazard areas: the number of people less than 18 years of age and the number of people over 65 years of age.

TABLE 4.39 Social Impacts (Hurricane Winds)

Island Jurisdiction	Total Population	Less than 18 Years of Age in Hazard Area	% Less than 18 Years of Age in Hazard Area	Over 65 Years of Age in Hazard Area	% Over 65 Years of Age in Hazard Area
St. Thomas	54,842	11,517	21%	2,742	5%
St. Croix	57,041	14,260	25%	2,852	5%
St. John	4,497	1,079	24%	270	6%

Physical and Economic Impacts

In this Plan update, economic vulnerability relates to the extent of dollar exposure of its buildings. The findings of the vulnerability assessment for this Plan Update indicate that there was a reduction of 12,286 residential properties exposed to this hazard on St. Thomas. On St. Croix, there were 8,996 residential properties exposed to the hazard, which represented a reduction of 436 properties. On St. John, there were 766 residential properties, which represented a reduction of 28 structures that are exposed high winds. On St. Thomas, there were 731 more commercial properties exposed to this hazard. While in St. Croix, there were 135 less commercial properties and a reduction of 15 commercial properties on St. John that were exposed to this hazard.

- On St. Thomas, approximately 54% percent of the residential building stock and 70% of the commercial building stock is considered to be vulnerable to hurricane winds. Of this percentage, 1% of the residential building stock is of low vulnerability to hurricane force winds, 94% is of medium vulnerability, and the remaining 5% is of high vulnerability to such winds. Nearly 4% of the commercial building inventory has a low vulnerability to

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hurricane force winds, and the remaining 96% of commercial building inventory has a medium vulnerability to such winds.

- On St. Croix, approximately 42% percent of the residential building stock and 58% of the commercial building stock is considered to be vulnerable to hurricane winds. Of this percentage, 83% of the residential building stock is of low vulnerability to hurricane force winds, 12% is of medium vulnerability, and the remaining 5% is of high vulnerability to such winds. Nearly 69% of the commercial building inventory has a low vulnerability to hurricane force winds, and the remaining 31% of the inventory has a medium vulnerability to such winds.
- On St. John, approximately 35% percent of the residential and commercial building stock are considered to be vulnerable to hurricane winds. Of this percentage, 86% of the residential building stock is of low vulnerability to hurricane force winds, 9% is of medium vulnerability, and the remaining 5% is of high vulnerability to such winds. Nearly 73% of the commercial building inventory has a low vulnerability to hurricane force winds, and the remaining 27% of the inventory has a medium vulnerability to such winds.

The tables below show potential dollar exposure to the hurricane hazard on St. Thomas, St. Croix and St. John.

TABLE 4.40 *Estimated Hurricane Exposure and Vulnerability (St. Thomas)*

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	54%	0%	1%	94%	5%	0%
No. of Residential	12,286	0	123	11548	614	0
Value of Residential	\$3,019,733,087	\$0	\$30,197,331	\$2,838,549,101	\$150,986,654	\$0
% of Commercial	70%	0%	1%	99%	0%	0%
No. of Commercial	1489	0	27	2101	0	0
Value of Commercial	\$1,108,845,773	\$0	\$20,215,896	\$1,563,849,493	\$0	\$0

TABLE 4.41 *Estimated Hurricane Exposure and Vulnerability (St. Croix)*

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Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	42%	0%	83%	12%	5%	0%
No. of Residential	8,996	0	7,467	1,080	450	0
Value of Residential	2,117,851,648	0	1,757,816,868	254,142,198	105,892,582	0
% of Commercial	58%	0%	69%	31%	0%	0%
No. of Commercial	471	0	325	146	0	0
Value of Commercial	1,337,263,478	0	922,711,800	414,551,678	0	0

TABLE 4.42 Estimated Hurricane Exposure and Vulnerability (St. John)

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	35%	0	0.86	0.09	0.05	0
No. of Residential	766	0	659	69	38	0
Value of Residential	250,097,596	0	215,083,933	22,508,784	12,504,880	0
% of Commercial	35%	0	0.73	0.27	0	0
No. of Commercial	28	0	20	7	0	0
Value of Commercial	103,404,795	0	75,485,500	27,919,295	0	0

Although there are no areas of the US Virgin Islands that are totally free from hurricane force winds, the vulnerability of each island's building inventory is quite different. The tables above indicate that the vulnerability of each island's building stock differs. Since vulnerability refers to the potential of the built environment to be damaged or destroyed, the number of certain model building types that are found throughout each island, e.g., single-family wood-frame building, may experience particular states of damage to the hurricane wind hazard (ranging from Very Low, Low, Moderate, High, to Very High).

On St. Thomas approximately 54% percent of the residential building stock and 70% of the commercial building stock is considered to be vulnerable to hurricane winds utilized in this study. The higher vulnerability to hurricane winds than the other two islands can be explained do with the

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general condition of its inventory, which has a significantly higher number of pre-code structures. The island also has higher population densities when compared to the other two islands. St. Thomas has a population density of more than 1714 persons per square mile, while the population density of St. Croix is 679 persons per square mile and 161 persons per square mile in St. John.

Critical Facilities and Infrastructure

The following tables highlight the results of the vulnerability assessment of each state-owned or operated facility to the Hurricane Wind hazard. Results define the potential exposure to Territorial Facilities and Infrastructure for the island of St. Thomas, St. Croix and St. John.

**TABLE 4.43 Estimated Hurricane Exposure and Vulnerability,
Critical Facilities and Infrastructure (St. Thomas)**

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	5			3	1		12,465,771
Fire Stations	5		1	2	2		7,632,269
Emergency Response	1		1				6,339,740
Hospital, Clinics, and special needs	5		1	2	2		93,867,045
Government Buildings	11		2	1	6	2	115,982,295
Shelters	5			1	4		121,014,906
Transportation Infrastructure							
Marine Ports	4	1	1	1	1		25,503,146
Airport	1		1				22,012,987
Utilities							
Electric Power Plant	1		1				50,119,536
Sewage Treatment Plant	1		1				60,521,406
Water Treatment Plant	1		1				
WAPA Tanks	1		1				
Pumping Station	1		1				

Appendix G provides detailed Vulnerability and Loss Estimate calculations for each facility.

**TABLE 4.44 Estimated Hurricane Exposure and Vulnerability,
Critical Facilities and Infrastructure (St. Croix)**

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Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	6		4	2			62,409,350
Fire Stations	5	1			1	3	9,079,146
Emergency Response	1		1				N/A
Hospital/ Medical Clinic	3			2		1	133,193,329
Government Buildings	12			6	2	4	118,556,952
Shelters/Special Needs	11		1	3	1	6	169,722,337
Transportation Infrastructure							
Marine Ports	5	4	1				9,718,000
Airport	1			1			56,500,000
Utilities							
Electrical Power Plant	1		1				50,850,000
Sewage Pumps	14	3	2	3	4	2	107,803,428
Wastewater Treatment Plant	1		1				
Water Treatment Plant	1		1				
Water Pumps	8		8				
Water Tanks	12	2	3	3	4		

Appendix G provides detailed Vulnerability and Loss Estimate calculations for each facility.

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TABLE 4.45 Estimated Hurricane Exposure and Vulnerability, Critical Facilities and Infrastructure (St. John)

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	2		1		1		4,232,415
Fire Stations	2		1		1		4,746,000
Emergency Response	1		1				5,036,571
Hospital/ Medical Clinic	2		1			1	17,228,782
Government Buildings	3		2		1		12,888,821
Shelters/Special Needs	5			2	3		51,393,929
Transportation Infrastructure							
Marine Ports	1		1				2,825,000
Airport	N/A						N/A
Utilities							
Electrical Power Plant	1		1				15,255,000
WAPA Desalinization Plant	1		1				32,828,750
WAPA Water Tank	1		1				
Sewage Treatment Plant	1		1				
Potable Water Tank	1	1					

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4.6.6 RAIN-INDUCED LANDSLIDES

This section discusses the population and the proportion and value of buildings located in areas affected by a rain-induced landslides. It also provides an estimate of proportion of assets located in areas that are susceptible to rain-induced landslides

Social Impacts

Table 4.46 shows an estimate of the affected population and area (in square kilometers) as indicators of the social vulnerability of each island. Two special needs population segments are broken out by hazard areas: the number of people less than 18 years of age and the number of people over 65 years of age.

TABLE 4.46 *Social Impacts (Rain-induced Landslide)*

Island Jurisdiction	Total Population	Less than 18 Years of Age in Hazard Area	% Less than 18 Years of Age in Hazard Area	Over 65 Years of Age in Hazard Area	% Over 65 Years of Age in Hazard Area
St. Thomas	54,842	9,351	17%	2,303	4%
St. Croix	57,041	3,501	6%	862	2%
St. John	4,497	1,534	34%	147	3%

Physical and Economic Impacts

In this Plan Update, economic vulnerability relates to the extent of dollar exposure of its buildings that are susceptible to this hazard. The findings of the vulnerability assessment for this Plan Update indicate that there are 11,376 residential structures and 809 commercial structures exposed to this hazard on St. Thomas. On St. Croix there are 3,855 residential structures and 146 commercial structures exposed to this hazard on St. Thomas. On St. John there are 853 residential structures and 29 commercial structures exposed to this hazard.

- On St. Thomas approximately 50% percent of the residential building stock and 38% of the commercial building stock is considered to be vulnerable rain-induced landslides. Of this percentage, approximately 13% of the residential building stock is of high vulnerability and the remaining 27% is of very high vulnerability to rain-induced landslide event. Commercial

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structures are considered to be less vulnerable to rain-induced landslide with the majority of structures falling into the very low and low susceptibility categories.

- On St. Croix approximately 18% percent of the residential building stock susceptible to landslide hazards. Of this percentage, approximately 17% of the residential building stock is of medium vulnerability, 13% of the residential building stock is of high vulnerability, and the remaining 5% is of very high vulnerability to rain-induced landslide. None of the commercial building inventory falls into the medium, high or very high vulnerability hazard rating for a rain-induced landslide.

- On St. John approximately 39% percent of the residential building stock and 37% of the commercial building stock is considered to be vulnerable to a rain-induced landslide. Of this percentage, approximately 24% of the residential building stock is of medium vulnerability, 27% of the residential building stock is of high vulnerability, and the remaining 12% is of very high vulnerability to a rain-induced landslide event. None of the commercial building inventory is of medium high or very high vulnerability rating to a rain-induced landslide event.

The tables below show potential dollar exposure to earthquake hazard on St. Thomas, St. Croix and St. John.

TABLE 4.47 Estimated Rain-Induced Landslide Exposure and Vulnerability (St. Thomas)

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	50%	5%	33%	22%	13%	27%
No. of Residential	11,376	613	3,733	2,479	1,424	3,126
Value of Residential	\$2,796,049,154	\$150,562,191	\$917,540,438	\$609,378,709	\$350,108,023	\$768,459,794
% of Commercial	38%	13%	87%	0	0	0
No. of Commercial	809	106	702	0	0	0
Value of Commercial	\$601,944,848	\$79,203,269	\$522,741,579	\$0	\$0	\$0

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TABLE 4.48 Estimated Rain-Induced Landslide Exposure and Vulnerability (St. Croix)

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	18%	46%	20%	17%	13%	5%
No. of Residential	3855	1,758	769	637	490	201
Value of Residential	\$907,650,706	413,810,321	181,114,475	149,872,462	115,440,595	47,412,853
% of Commercial	18%	70%	30%	0	0	0
No. of Commercial	146	102	44	0	0	0
Value of Commercial	\$240,707,426	167,765,782	72,941,644	0	0	0

TABLE 4.49 Estimated Rain-Induced Landslide Exposure and Vulnerability (St. John)

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	39%	15%	22%	24%	27%	12%
No. of Residential	853	126	192	201	230	105
Value of Residential	\$278,680,179	41,303,465	62,567,100	65,640,523	74,985,954	34,183,137
% of Commercial	37%	41%	59%			
No. of Commercial	29	12	17	0	0	0
Value of Commercial	\$109,313,641	44,316,341	64,997,300	0	0	0

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Critical Facilities

The tables below highlight the results of the vulnerability assessment of each state-owned or operated facility to the earthquake hazard. Results define the potential exposure to Territorial Facilities and Infrastructure for the island of St. Thomas, St. Croix and St. John.

TABLE 4.50 Estimated Rain-Induced Landslide Exposure and Vulnerability, Critical Facilities and Infrastructure (St. Thomas)

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	5	3	2				12,465,771
Fire Stations	5	3	2				7,632,269
Emergency Response	1	1					6,339,740
Hospital, Clinics, and special needs	5	4	1				93,867,045
Government Buildings	11	10	1				115,982,295
Shelters	5	2	1	1	1		121,014,906
Transportation Infrastructure							
Marine Ports	4	4					25,503,146
Airport	1	1					22,012,987
Utilities							
Electrical Power Generating Plants	1	1					50,119,536
Sewage Treatment Plant	1		1				60,521,406
Water Treatment Plant	1		1				
WAPA Tanks	1	1					
Pumping Station	1		1				

Appendix G provides detailed Vulnerability and Loss Estimate calculations for each facility.

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TABLE 4.51 *Estimated Rain-Induced Landslide Exposure and Vulnerability, Critical Facilities and Infrastructure (St. Croix)*

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	6	6					62,409,350
Fire Stations	5	5					9,079,146
Emergency Response	N/A						N/A
Hospital/ Medical Clinic	3	3					133,193,329
Government Buildings	12	11	1				118,556,952
Shelters/Special Needs	11	11					169,722,337
Transportation Infrastructure							
Marine Ports	5	5					9,718,000
Airport	1	1					56,500,000
Utilities							
Electrical Power Generating Plants	1	1					50,850,000
Sewage Pumps	14	14					107,803,428
Wastewater Treatment Plant	1	1					
Water Treatment Plant	1	1					
Water Pumps	8	5	3				

Appendix G provides detailed Vulnerability and Loss Estimate calculations for each facility.

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TABLE 4.52 Estimated Rain-Induced Landslide Exposure and Vulnerability, Critical Facilities and Infrastructure (St. John)

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	2	1	1				4,232,415
Fire Stations	2	1	1				4,746,000
Emergency Response	1	1					5,036,571
Hospital/ Medical Clinic	2	1	1				17,228,782
Government Buildings	3	2	1				12,888,821
Shelters/Special Needs	5	3	2				51,393,929
Transportation Infrastructure							
Marine Ports	1	1					2,825,000
Airport	N/A						N/A
Utilities							
Electrical Power Generating Plants	1	1					15,255,000
WAPA Desalinization Plant	1	1					32,828,750
WAPA Water Tank	1	1					
Sewage Treatment Plant	1	1					
Potable Water Tank	1	1					

Appendix G provides detailed Vulnerability and Loss Estimate calculations for each facility.

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4.6.7 TSUNAMI

This section discusses the population and the proportion and value of buildings located in areas affected by a tsunami hazard. It also provides an estimate of proportion of assets located in tsunami hazard areas.

Social Impacts

Table 4.53 shows an estimate of the affected population and area (in square kilometers) as indicators of the social vulnerability of each island. Two special needs population segments are broken out by hazard areas: the number of people less than 18 years of age and the number of people over 65 years of age.

TABLE 4.53 Social Impacts (Tsunami)

Island Jurisdiction	Total Population	Less than 18 Years of Age in Hazard Area	% Less than 18 Years of Age in Hazard Area	Over 65 Years of Age in Hazard Area	% Over 65 Years of Age in Hazard Area
St. Thomas	54,842	1,645	3%	548	1%
St. Croix	57,041	1,711	3%	570	1%
St. John	4,497	90	2%	45	1%

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Physical and Economic Impacts

In this Plan Update, economic vulnerability relates to the extent of dollar exposure of its buildings. The findings of the vulnerability assessment for this Plan Update indicate that there was an increase of 57 residential properties exposed to this hazard on St. Thomas. For St. Croix there were 73 less residential properties exposed to this hazard, while on St. John the total number of residential properties exposed decreased by 67. On St. Thomas there were 190 more commercial properties exposed to this hazard. On St. Croix, there were 7 less commercial properties, while on St. John there was a decrease of 4 commercial properties exposed to this hazard.

- All building types are equally vulnerable to a tsunami. No regular building structure can be built to withstand a tsunami, as it would not be economically or realistically feasible to do so, given the rare and random nature of this hazard. Of all buildings exposed to this hazard, approximately 40% of the residential building stock is of high vulnerability and the remaining 60% is of very high vulnerability to a tsunami event. The commercial buildings 20% are of high vulnerability and 80% fall in the very high category.
- Tsunamis can devastate development along coastlines, causing widespread property damage and loss of life. Both residential and commercial structures are considered to be equally vulnerable to the tsunami hazard. Tsunamis can cause significant loss of life, especially in low-lying harbors of Charlotte Amalie, Christiansted and Fredricksted.
- Tsunamis have the potential to have an enormous impact of the tourist industry. Cruise ships and their passengers are particularly exposed to this hazard, especially while in harbor.

The tables below show potential dollar exposure to earthquake hazard on St. Thomas, St. Croix and St. John.

TABLE 4.54 Estimated Tsunami Exposure and Vulnerability (St. Thomas)

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	12%	0	0	0	40%	60%
No. of Residential	2,730	0	0	0	1,092	1,638
Value of Residential	\$671,051,797	\$0	\$0	\$0	\$268,420,719	\$402,631,078
% of Commercial	22%	0	0	0	20%	80%
No. of Commercial	468	0	0	0	94	374
Value of Commercial	\$ 348,494,386	\$ -	\$ -	\$ -	\$ 69,698,877	\$ 278,795,509

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TABLE 4.54 *Estimated Tsunami Exposure and Vulnerability (St. Croix)*

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	7%	0	0	0	40%	60%
No. of Residential	1,499	0	0	0	600	900
Value of Residential	352,975,275	0	0	0	141,190,110	211,785,165
% of Commercial	3%	0	0	0	20%	80%
No. of Commercial	24	0	0	0	5	20
Value of Commercial	40,117,904	0	0	0	8,023,581	32,094,323

TABLE 4.55 *Estimated Tsunami Exposure and Vulnerability (St. John)*

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	8%	0	0	0	40%	60%
No. of Residential	175	0	0	0	70	105
Value of Residential	57,165,165	0	0	0	22,866,066	34,299,099
% of Commercial	8%	0	0	0	20%	80%
No. of Commercial	6	0	0	0	1	5
Value of Commercial	23,635,382	0	0	0	4,727,076	18,908,305

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Critical Facilities

Table 4.43 through 4.45 highlights the results of the vulnerability assessment of each state-owned or operated facility to the Tsunami hazard. Results define the potential exposure to Territorial Facilities and Infrastructure for the island of St. Thomas, St. Croix and St. John.

TABLE 4.56 Estimated Tsunami Exposure and Vulnerability, Critical Facilities and Infrastructure (St. Thomas)

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	5	4				1	12,465,771
Fire Stations	5	3				2	7,632,269
Emergency Response	1	1					6,339,740
Hospital, Clinics, and special needs	5	4				1	93,867,045
Government Buildings	11	4				7	115,982,295
Shelters	5	5					121,014,906
Transportation Infrastructure							
Marine Ports	4	1				3	25,503,146
Airport	1	1					22,012,987
Utilities							
Electrical Power Plant	1					1	50,119,536
Sewage Treatment Plant	1		1				60,521,406
Water Treatment Plant	1		1				
WAPA Tanks	1		1				
Pumping Station	1		1				

Appendix G provides detailed Vulnerability and Loss Estimate calculations for each facility.

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TABLE 4.57 Estimated Tsunami Exposure and Vulnerability, Critical Facilities and Infrastructure (St. Croix)

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	6	6					62,409,350
Fire Stations	5	5					9,079,146
Emergency Response	1	1					N/A
Hospital/ Medical Clinic	3	2				1	133,193,329
Government Buildings	12	11				1	118,556,952
Shelters/Special Needs	11	11					169,722,337
Transportation Infrastructure							
Marine Ports	5	1				4	9,718,000
Airport	1					1	56,500,000
Utilities							
Electrical Power Plant	1	1					50,850,000
Sewage Pumps	14	14					107,803,428
Wastewater Treatment Plant	1					1	
Water Treatment Plant	1	1					
Water Pumps	8	7					

Appendix G provides detailed Vulnerability and Loss Estimate calculations for each facility.

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TABLE 4.58 *Estimated Tsunami Exposure and Vulnerability, Critical Facilities and Infrastructure (St. John)*

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	2	1				1	4,232,415
Fire Stations	2	1				1	4,746,000
Emergency Response	1	1					5,036,571
Hospital/ Medical Clinic	2	2					17,228,782
Government Buildings	3	3					12,888,821
Shelters/Special Needs	5	1				1	51,393,929
Transportation Infrastructure							
Marine Ports	1					1	2,825,000
Airport	N/A						N/A
Utilities							
Electrical Power Plant	1					1	15,255,000
WAPA Desalinization Plant	1					1	32,828,750
WAPA Water Tank	1					1	
Sewage Treatment Plant	1	1					
Potable Water Tank	1	1					

Appendix G provides detailed Vulnerability and Loss Estimate calculations for each facility.

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4.6.8 WILDFIRE

This section discusses the population and the proportion and value of buildings located in areas affected by a rain-induced landslides. It also provides an estimate of proportion of assets located in areas that are susceptible to rain-induced landslides

Social Impacts

Table 4.59 shows an estimate of the affected population and area (in square kilometers) as indicators of the social vulnerability of each island. Two special needs population segments are broken out by hazard areas: the number of people less than 18 years of age and the number of people over 65 years of age.

TABLE 4.59 Social Impacts (Wildfire)

Island Jurisdiction	Total Population	Less than 18 Years of Age in Hazard Area	% Less than 18 Years of Age in Hazard Area	Over 65 Years of Age in Hazard Area	% Over 65 Years of Age in Hazard Area
St. Thomas	54,842	7,854	14%	1,935	3.53%
St. Croix	57,041	7,077	12%	1,743	3.06%
St. John	4,497	419	9%	103	2.29%

Physical and Economic Impacts

In this Plan Update, economic vulnerability relates to the extent of dollar exposure of its buildings that are susceptible to this hazard. The findings of the vulnerability assessment for this Plan Update indicate that there are 10,067 residential structures and 219 commercial structures exposed to this hazard on St. Thomas. On St. Croix, there are 10,067 residential structures and 575 commercial structures exposed to this hazard on St. Thomas. On St. John, there are 831 residential structures and 35 commercial structures exposed to this hazard.

- On St. Thomas approximately 42% percent of the residential building stock and 35% of the commercial building stock is considered to be vulnerable wildfires. Of this percentage, approximately 32% of the residential building stock is of high vulnerability and the remaining 11% is of very high vulnerability to wildfires. Commercial structures are considered to be less vulnerable to wildfires with the majority of structures falling into the very low and low susceptibility categories.

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- On St. Croix approximately 47% percent of the residential building stock susceptible to wildfire hazards. Of this percentage, approximately 26% of the residential building stock is of medium vulnerability, 30% of the residential building stock is of high vulnerability, and the remaining 16% is of very high vulnerability to wildfires. None of the commercial building inventory falls into the medium, high or very high vulnerability hazard rating for a rain-induced landslide.
- On St. John approximately 38% percent of the residential building stock and 44% of the commercial building stock is considered to be vulnerable to a wildfire. Of this percentage, approximately 18% of the residential building stock is of medium vulnerability, 30% of the residential building stock is of high vulnerability, and the remaining 8% is of very high vulnerability to wildfire hazard. None of the commercial building inventory is of medium high or very high vulnerability rating to a rain-induced landslide event.

The tables below show potential dollar exposure to earthquake hazard on St. Thomas, St. Croix and St. John.

TABLE 4.60 Estimated Wildfire Exposure and Vulnerability (St. Thomas)

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	42%	18%	17%	22%	32%	11%
No. of Residential	9555	1734	1650	2121	3017	1033
Value of Residential	\$2,348,681,290	\$426,264,917	\$405,527,705	\$521,246,469	\$741,675,354	\$253,966,845
% of Commercial	35%	51%	49%	0	0	0
No. of Commercial	754	388	366	0	0	0
Value of Commercial	\$561,001,575	\$288,515,096	\$272,486,479	\$0	\$0	\$0

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TABLE 4.61 Estimated Wildfire Exposure and Vulnerability (St. Croix)

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	47%	10%	17%	26%	30%	16%
No. of Residential	10067	1,051	176	46	14	2
Value of Residential	\$2,369,976,845	247,339,436	41,518,425	10,786,545	3,273,473	538,478
% of Commercial	27%	37%	63%	0	0	0
No. of Commercial	575	213	134	0	0	0
Value of Commercial	\$361,061,139	133,726,348	84,198,071	0	0	0

TABLE 4.62 Estimated Wildfire Exposure and Vulnerability (St. John)

Occupancy Class	Total Number of Buildings/ Percentage	Number, Percentage and Value of Buildings by Vulnerability Rating				
		Very Low	Low	Moderate	High	Very high
% of Residential	38%	26%	18%	18%	30%	8%
No. of Residential	831	217	150	149	252	63
Value of Residential	\$271,534,533	71,018,163	49,029,668	48,655,395	82,293,116	20,538,191
% of Commercial	44%	59%	41%	0	0	0
No. of Commercial	35	21	14	0	0	0
Value of Commercial	\$130,617,655	77,183,160	53,434,495	0	0	0

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Critical Facilities

The tables below highlight the results of the vulnerability assessment of each state-owned or operated facility to the earthquake hazard. Results define the potential exposure to Territorial Facilities and Infrastructure for the island of St. Thomas, St. Croix and St. John.

**TABLE 4.63 Estimated Wildfire Exposure and Vulnerability,
Critical Facilities and Infrastructure (St. Thomas)**

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	5	5					12,465,771
Fire Stations	5	2		2	1		7,632,269
Emergency Response	1	1					6,339,740
Hospital, Clinics, and special needs	5	4	1				93,867,045
Government Buildings	11	9		1	1		115,982,295
Shelters	5			3	2		121,014,906
Transportation Infrastructure							
Marine Ports	4	4					25,503,146
Airport	1	1					22,012,987
Utilities							
Electrical Power Generating Plants	1	1					50,119,536
Sewage Treatment Plant	1		1				60,521,406
Water Treatment Plant	1		1				
WAPA Tanks	1	1					
Pumping Station	1		1				

Appendix G provides detailed Vulnerability and Loss Estimate calculations for each facility.

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**TABLE 4.64 Estimated Wildfire Exposure and Vulnerability,
Critical Facilities and Infrastructure (St. Croix)**

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	6	3		2	1		62,409,350
Fire Stations	5	4	1				9,079,146
Emergency Response	N/A						N/A
Hospital/ Medical Clinic	3	1		1	1		133,193,329
Government Buildings	12						118,556,952
Shelters/Special Needs	11			3	8		169,722,337
Transportation Infrastructure							
Marine Ports	5	5					9,718,000
Airport	1	1					56,500,000
Utilities							
Electrical Power Generating Plants	1	1					50,850,000
Sewage Pumps	14	9		3	2		107,803,428
Wastewater Treatment Plant	1	1					
Water Treatment Plant	1	1					
Water Pumps	8	3		3	2		

Appendix G provides detailed Vulnerability and Loss Estimate calculations for each facility.

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**TABLE 4.65 Estimated Wildfire Exposure and Vulnerability,
Critical Facilities and Infrastructure (St. John)**

Facility	# of Facilities in Class	Vulnerability Rating					Total Exposure
		Very Low	Low	Moderate	High	Very High	
Critical Facilities							
Police Stations	2	1			1		4,232,415
Fire Stations	2	1			1		4,746,000
Emergency Response	1	1					5,036,571
Hospital/ Medical Clinic	2	1					17,228,782
Government Buildings	3	3					12,888,821
Shelters/Special Needs	5	4		1			51,393,929
Transportation Infrastructure							
Marine Ports	1	1					2,825,000
Airport	N/A						N/A
Utilities							
Electrical Power Generating Plants	1	1					15,255,000
WAPA Desalinization Plant	1	1					32,828,750
WAPA Water Tank	1			1			
Sewage Treatment Plant	1			1			
Potable Water Tank	1						

Appendix G provides detailed Vulnerability and Loss Estimate calculations for each facility.

4.7 LOSS ESTIMATES

This section of the Plan Update presents the “estimate of losses,” including: exposure, damage, and loss estimates analyzed on a hazard-by-hazard basis. The findings support local and regional planners’ understanding of the potential impacts of each hazard and enable a comparison of hazards by quantifying potential exposures impacts.

The loss estimates provided in this section were developed using available data, and the methodologies applied have resulted in an approximation of risk. These estimates should be used to understand relative risk from hazards and potential losses.

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However, it is important to understand that uncertainties are inherent in any loss estimation methodology, arising in part from incomplete scientific knowledge concerning natural hazards and their effects on the built environment. Uncertainties also result from approximations and simplifications that are necessary for a comprehensive analysis.

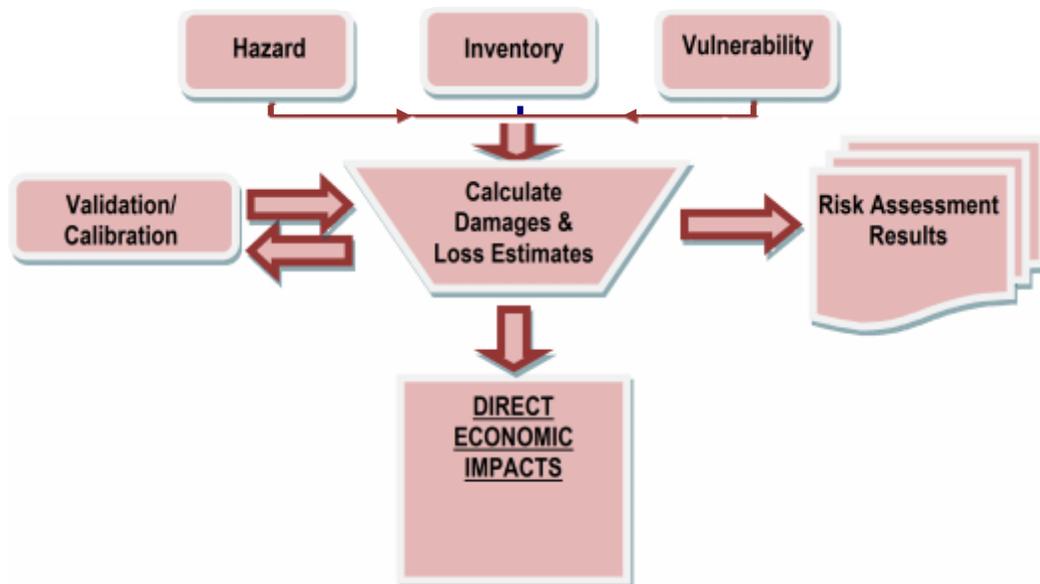
The risk assessment utilized for this Plan Update was parametric. The risk analyses are based on a comprehensive methodology that incorporates approaches for:

- Characterizing Hazards, understanding the nature of the hazards (i.e. level of ground shaking, wind speed, depth of flooding);
- Categorization of the built environment, understanding number, distribution, and value of assets (i.e. general buildings & critical facilities),
- Vulnerability Analysis, understanding the damage and loss characteristics of identified buildings, and
- Estimating damage and losses to buildings and critical facilities.

Figure 4.20 illustrates a conceptual model of the loss estimation methodology as applied for the US Virgin Islands Mitigation Plan.

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FIGURE 4.25 *Conceptual Model of Risk Assessment Methodology*



For each of the hazards (Earthquake, Riverine Flooding, Coastal Flooding, Hurricane Winds, and Tsunami) estimates were derived from calculating the number of buildings exposed to the hazard and the potential economic losses. The economic loss ratio is also provided, which is the percentage of the losses against the total value of all the structures within the Territory for a particular hazard.

Loss estimates associated with drought were not analyzed using a risk assessment methodology based on the same principals as described above. Instead, available historical data for each hazard are used and statistical evaluations are performed using manual calculations. The general steps used in this methodology are summarized below:

- Compile and analyze available data from national and local sources
- Verify data and conduct statistical analysis to relate historical patterns within the data to existing hazard models
- Develop model parameters based on data analysis, existing hazard models, and risk engineering judgment

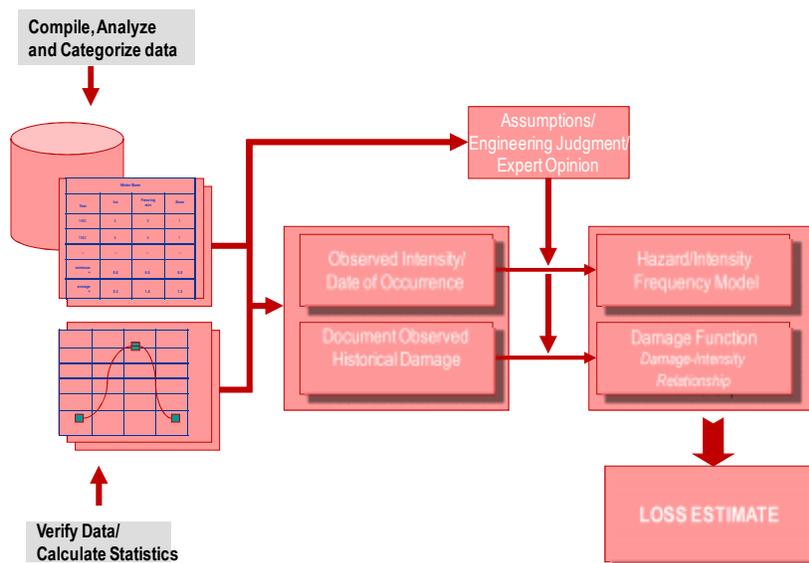
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The paucity of historic information that was available for these hazards necessitated the CIPA consultant team to try to ascertain the following:

- Analysis of frequency of hazard occurrence
- Analysis of intensity and/or damages parameters associated with hazard occurrence (for example, one drought event = \$ in estimated damages)
- Development of frequency curves expected damages
- Estimate losses

Figure 4.26 illustrates a conceptual model of the statistical risk assessment methodology as applied to the US Virgin Islands.

FIGURE 4.26: Conceptual Model of Statistical Risk Assessment Methodology



The risk assessment methodologies used in the Plan Update are standardized, meaning they have been applied to each island in the same way. Impacts presented in this study include only direct social economic losses because of data limitations and time constraints on the project; however these results represent the key impacts faced by US Virgin Islands.

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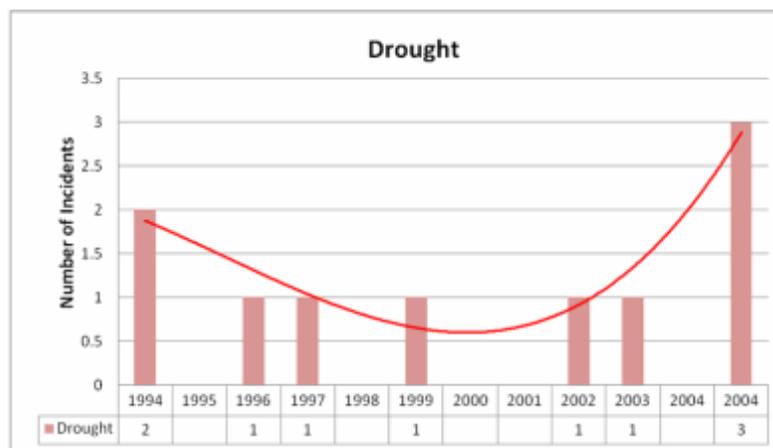
4.7.1 DROUGHT

This subsection of the risk assessment presents the “estimate of losses for drought hazard.

Estimated Losses: Economic Impact

Estimated losses for drought were aggregated for primary economic impacts that could impact the US Virgin Islands through regional economic loss. The primary economic impact was assumed to be increased costs associated with feeding cattle.

FIGURE 4.27 *Historical Droughts in US Virgin Islands, 2003-2007*



This figure was based regional historic drought data for Puerto Rico and the US Virgin Islands. Based on the available data and the assumptions provided above, the annual probability of observing a drought with an impact of \$200,000 on the US Virgin Islands estimated as 85%. Damage parameters from historic events in the US Virgin Island were used to develop this estimate.

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4.7.2 EARTHQUAKE

This subsection of the risk assessment presents the “estimate of losses,” including: exposure, damage, and loss estimates analyzed for the earthquake hazard.

Estimated Losses: General Building Stock

Damages and losses were estimated based on a 1000-year probabilistic ground shaking scenario. Property damage is summarized by general occupancy classes. The total damage for a 1000-year event was estimated to be \$5 billion for St. Thomas, \$4 billion for St. Croix and \$4635 million for St. John. This represents a \$3 billion increase in estimated losses for on St. Thomas since the 2008 Plan. Estimated losses for all islands increased.

TABLE 4.66 *Estimated Losses: General Building Stock for Earthquake Hazard*

Occupancy	No of Affected Buildings	Expected Losses	% Value
St. Thomas			
Residential	21,242	\$ 4,044,143,418	72%
Commercial	2,080	\$ 1,369,812,088	86%
Total	23,322	\$ 5,413,955,506	
St. Croix			
Residential	14,120	\$ 3,645,930,917	56%
Commercial	576	\$ 746,489,600	53%
Total	14,697	\$ 4,392,420,517	
St. John			
Residential	1,431	\$ 386,386,207	0.54
Commercial	70	\$ 76,830,370	0.65
Total	1,501	\$ 463,216,578	

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Estimated Losses: Critical Facilities and Infrastructure

Critical facilities and infrastructure losses for St. Thomas, St. Croix and St. John are highlighted in Table 4.67.

TABLE 4.67 *Estimated Losses: Critical Facilities and Infrastructure for Earthquake Hazard*

Facility	St. Thomas	St. Croix	St. John
Critical Facilities			
Police Stations	\$11,408,266	\$35,495,149	\$1,961,274
Fire Stations	\$26,752,748	\$6,141,995	\$2,745,285
Emergency Response	\$5,232,372	\$2,046,606	\$2,782,691
Hospital/ Medical Clinic	\$58,902,804	\$87,783,047	\$7,763,305
Government Buildings	\$85,630,364	\$90,213,147	\$7,254,143
Shelters/Special Needs	\$101,704,695	\$105,934,763	\$45,292,392
Transportation Infrastructure			
Marine Ports	\$5,656,208	\$300,913	\$28,060
Airport	\$22,010	\$25,312,386	#VALUE!
Utilities			
Electrical Power Generating Plants	\$25,530,985	\$36,172,053	\$11,648,207
Water Treatment Plants	\$36,784,419	\$13,214,709	\$1,732,628
Wastewater Treatment Plants	\$752,730	\$13,807,725	\$17,163,949
Pumps	\$244,100	\$13,617,258	--
Tanks	\$6,678,468	\$6,985,000	\$901,561

Detailed information on critical facilities identified to be high risk structures is included in Appendix J. These are defined as those expected to sustain damages exceeding 60% for any of the hazards considered.

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4.7.3 RIVERINE FLOODING

This subsection of the risk assessment presents the “estimate of losses,” including: exposure, damage, and loss estimates analyzed for the riverine flooding hazard.

Estimated Losses: General Building Stock

Property damage due to the riverine hazard is summarized in Table 4.46 by occupancy class. The total expected loss for a 100-year MRP is approximately \$945 million for St. Thomas, \$768 million for St. Croix and \$17million for St. John. This represents a \$700 million increase in estimated losses for the Territory.

TABLE 4.68 *Estimated Losses: General Building Stock for Riverine Flooding Hazard*

Occupancy	No of Affected Buildings	Expected Losses	% Value
St. Thomas			
Residential	11,089	\$ 655,626,344	0.12
Commercial	1,574	\$ 289,491,175	0.18
Total	12,663	\$ 945,117,519	
St. Croix			
Residential	3,660	\$ 618,081,641	0.09
Commercial	311	\$ 150,076,139	0.11
Total	3,971	\$ 768,157,780	
St. John			
Residential	309	\$ 15,718,980	0.02
Commercial	9	\$ 1,570,220	0.01
Total	318	\$ 17,289,200	

The estimated loss values are based on the count of buildings damaged as presented in the table above. Building counts are based on a geographic distribution of structures by occupancy class across estate boundaries.

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Estimated Losses: Critical Facilities and Infrastructure

Critical facilities and infrastructure losses for St. Thomas, St. Croix and St. John are highlighted in Table 4.69.

TABLE 4.69 *Estimated Losses: Critical Facilities and Infrastructure for Riverine Flooding Hazard*

Facility	St. Thomas	St. Croix	St. John
Critical Facilities			
Police Stations	\$1,824,997	\$699,258	\$2,025,525
Fire Stations	\$26,971,541	\$0	\$0
Emergency Response	\$0	\$0	\$0
Hospital/ Medical Clinic	\$3,715,058	\$0	\$0
Government Buildings	\$67,193,067	\$33,995,374	\$5,465,439
Shelters/Special Needs	\$45,668,562	\$6,732,992	\$19,923,308
Transportation Infrastructure	\$0	\$0	\$0
Marine Ports	\$1,771,587	\$0	\$28,250
Airport	\$0	\$0	#VALUE!
Utilities	\$0	\$0	\$0
Electrical Power Generating Plants	\$0	\$0	\$2,288,250
Water Treatment Plants	\$36,725,000	\$7,627,500	\$0
Wastewater Treatment Plants	\$775,041	\$0	\$18,362,500
Pumps	\$0	\$1,260,722	--
Tanks	\$0	\$427,549	\$0

Detailed information on critical facilities identified to be high risk structures is included in Appendix J. These are defined as those expected to sustain damages exceeding 60% for any of the hazards considered.

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4.7.4 COASTAL FLOODING

This subsection of the risk assessment presents the “estimate of losses,” including: exposure, damage, and loss estimates analyzed for the coastal flooding hazard.

Estimated Losses: General Building Stock

The total estimated property damages and losses for a Category 5 Storm Surge event is \$156 million for St. Thomas, \$78 million for St. Croix and \$26 million for St. John. Table 4.48 presents these results by occupancy class. This represents a \$108 million increase in estimated losses for the Territory since the 2008 Plan.

TABLE 4.70 *Estimated Losses: General Building Stock for Coastal Flooding Hazard*

Occupancy	No of Affected Buildings	Expected Losses	% Value
St. Thomas			
Residential	1,471	\$ 100,296,910	0.02
Commercial	501	\$ 55,997,070	0.04
Total	1,972	\$ 156,293,980	
St. Croix			
Residential	1,955	\$ 52,319,194	0.01
Commercial	274	\$ 26,256,719	0.02
Total	2,229	\$ 78,575,913	
St. John			
Residential	386	\$ 22,500,497	0.03
Commercial	3	\$ 4,123,048	0.03
Total	389	\$ 26,623,544	

The estimated loss values are based on the count of buildings damaged as presented in the table above. Building counts are based on a geographic distribution of structures by occupancy class across estate boundaries.

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Estimated Losses: Critical Facilities and Infrastructure

Critical facilities and infrastructure losses for St. Thomas, St. Croix and St. John are highlighted in Table 4.71.

TABLE 4.71 *Estimated Losses: Critical Facilities and Infrastructure for Coastal Flooding Hazard*

Facility	St. Thomas	St. Croix	St. John
Critical Facilities			
Police Stations	\$110,064	\$0	\$0
Fire Stations	\$11,488,031	\$0	\$0
Emergency Response	\$0	\$0	\$0
Hospital/ Medical Clinic	\$2,641,513	\$0	\$0
Government Buildings	\$5,335,031	\$3,295,080	\$7,531,612
Shelters/Special Needs	\$0	\$0	\$0
Transportation Infrastructure	\$0	\$0	\$0
Marine Ports	\$2,293,019	\$2,373,000	\$84,750
Airport	\$0	\$0	#VALUE!
Utilities	\$0	\$0	\$0
Electrical Power Generating Plants	\$11,006,493	\$0	\$12,204,000
Water Treatment Plants	\$0	\$8,136,000	\$0
Wastewater Treatment Plants	\$14,125,000	\$0	\$24,012,500
Pumps	\$0	\$313,738	--
Tanks	\$0	\$134,373	\$1,071,085

Detailed information on critical facilities identified to be high risk structures is included in Appendix J. These are defined as those expected to sustain damages exceeding 60% for any of the hazards considered.

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4.7.5 HURRICANE WIND

This subsection of the risk assessment presents the “estimate of losses,” including: exposure, damage, and loss estimates analyzed for the hurricane wind hazard.

Estimated Losses: General Building Stock

Property damage due to the wind-hurricane hazard is summarized in Table 4.46 by occupancy class. The total expected for a loss for a hurricane event with a 50year MRP is approximately \$3.6 billion for St. Thomas, \$1.8 billion for St. Croix and \$190 million for St. John. This represents a increase of \$2.3 billion in the Territory since the 2005 Plan.

TABLE 4.72 *Estimated Losses: General Building Stock for Hurricane Wind Hazard*

Occupancy	No of Affected Buildings	Expected Losses	% Value
St. Thomas			
Residential	14,347	\$ 2,699,007,980	0.48
Commercial	1,816	\$ 564,965,049	0.36
Total	16,163	\$ 3,263,973,029	
St. Croix			
Residential	8,777	\$ 1,508,195,711	0.23
Commercial	393	\$ 307,082,553	0.22
Total	9,170	\$ 1,815,278,264	
St. John			
Residential	745	\$ 163,596,725	0.23
Commercial	32	\$ 26,457,092	0.22
Total	777	\$ 190,053,817	

Because of differences in building construction, residential structures are more susceptible to wind damage. In using the damage counts for buildings, the number of buildings impacted should be interpreted loosely. Damage to a specific building can range from slight damage to total destruction; the total dollar damage estimates the overall impact to individual buildings at an aggregate level. The increase in construction cost, both commercial and residential, have increased the value of the building stock and thus estimated losses.

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Estimated Losses: Critical Facilities and Infrastructure

Critical facilities and infrastructure losses for St. Thomas, St. Croix and St. John are highlighted in Table 4.73.

TABLE 4.73 *Estimated Losses: Critical Facilities and Infrastructure for Hurricane Wind Hazard*

Facility	St. Thomas	St. Croix	St. John
Critical Facilities			
Police Stations	\$6,988,405	\$23,544,520	\$1,473,980
Fire Stations	\$24,822,463	\$5,368,538	\$2,051,099
Emergency Response	\$2,812,379	\$1,209,003	\$1,569,594
Hospital/ Medical Clinic	\$42,107,361	\$77,979,489	\$7,103,911
Government Buildings	\$69,917,479	\$66,905,304	\$4,926,322
Shelters/Special Needs	\$68,916,882	\$85,005,898	\$34,301,522
Transportation Infrastructure			
Marine Ports	\$8,270,463	\$620,585	\$75,131
Airport	\$8,202,416	\$23,324,320	n/a
Utilities			
Electrical Power Generating Plants	\$8,958,087	\$19,781,921	\$4,352,633
Water Treatment Plants	\$16,170,206	\$19,781,921	\$1,064,427
Wastewater Treatment Plants	\$301,049	\$7,658,785	\$7,846,963
Pumps	\$91,612	\$5,673,748	--
Tanks	\$2,477,983	\$1,722,508	\$488,441

Detailed information on critical facilities identified to be high risk structures is included in Appendix J. These are defined as those expected to sustain damages exceeding 60% for any of the hazards considered.

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4.7.6 RAIN-INDUCED LANDSLIDE

A deterministic approach was used to address the rain induced landslide hazard based on a worst-case scenario that assumed extensive to complete damage of structures during a landslide event.

Probability was not assigned to the rain-induced landslide hazard. Limited data and time needed to perform detailed mapping and statistical analysis go well beyond the scope of this study effort. The primary economic impact was assumed to be costs associated with infrastructure repair.

Based on the available data and the assumptions provided above, estimated impact of a rain-induced landslide is approximately \$500,000. Damage parameters from historic events in the US Virgin Islands were used to develop this estimate.

Estimated Losses: General Building Stock

The physical damage that could occur as a result of rain-induced landslide is summarized in Table 4.52. Estimated property damages and losses for the landslide hazard were aggregated across occupancy classes and are estimated to be \$1.3 billion for St. Thomas, \$8 million for St. Croix and \$123 million for St. John.

TABLE 4.74 Estimated Losses: General Building Stock for Rain-Induced landslide Hazard

Occupancy	No of Affected Buildings	Expected Losses	% Value
St. Thomas			
Residential	7,030	\$ 1,335,730,165	0.24
Commercial	0	\$ -	0.00
Total	7,030	\$ 1,335,730,165	
St. Croix			
Residential	1,328	\$ 8,208,417	0.002
Commercial	0	\$ -	0.00
Total	1,328	\$ 8,208,417	
St. John			
Residential	535	\$ 123,242,864	0.17
Commercial	0	\$ -	0.00
Total	535	\$ 123,242,864	

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Estimated Losses: Critical Facilities and Infrastructure

Critical facilities and infrastructure losses for St. Thomas, St. Croix and St. John are highlighted in Table 4.75.

TABLE 4.75 *Estimated Losses: Critical Facilities and Infrastructure for Rain-induced Landslide Hazard*

Facility	St. Thomas	St. Croix	St. John
Critical Facilities			
Police Stations	\$0	\$0	\$0
Fire Stations	\$0	\$0	\$0
Emergency Response	\$0	\$0	\$0
Hospital/ Medical Clinic	\$2,260,000	\$0	\$0
Government Buildings	\$0	\$0	\$0
Shelters/Special Needs	\$20,893,076	\$0	\$0
Transportation Infrastructure			
Marine Ports	\$0	\$0	\$0
Airport	\$0	\$0	\$0
Utilities			
Electrical Power Generating Plants	\$0	\$0	\$0
Water Treatment Plants	\$0	\$0	\$0
Wastewater Treatment Plants	\$0	\$0	\$0
Pumps	\$0	\$0	--
Tanks	\$0	\$0	\$0

SECTION FOUR RISK ASSESSMENT

4.7.7 TSUNAMI

Estimated Losses: General Building Stock

A deterministic approach was used to address the tsunami hazard based on a worst-case scenario that assumed extensive to complete damage within the Tsunami inundation area. Probability was not assigned to the tsunami hazard. Limited data and time needed to perform statistical analysis go well beyond the scope of this study effort. Therefore, while total damages were estimated, a return period is not applicable for the Tsunami hazard. The physical damage that could occur as a result of Tsunami is summarized in Table 4.52. Estimated property damages and losses for the tsunami hazard were aggregated across occupancy classes and are estimated to be \$1.1 billion for St. Thomas, \$786 million for St. Croix and \$99 million for St. John. This represents a \$739 million increase in estimated losses for on the Territory since the 2008 Plan.

TABLE 4.76 *Estimated Losses: General Building Stock for Tsunami Hazard*

Occupancy	No of Affected Buildings	Expected Losses	% Value
St. Thomas			
Residential	2,866	\$ 704,717,108	0.13
Commercial	532	\$ 398,300,996	0.25
Total	3,398	\$ 1,103,018,103	
St. Croix			
Residential	1,688	\$ 524,598,730	0.08
Commercial	149	\$ 261,998,197	0.19
Total	1,837	\$ 786,596,927	
St. John			
Residential	252	\$ 83,914,456	0.12
Commercial	10	\$ 15,908,495	0.13
Total	262	\$ 99,822,950	

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Estimated Losses: Critical Facilities and Infrastructure

Critical facilities and infrastructure losses for St. Thomas, St. Croix and St. John are highlighted in Table 4.77.

TABLE 4.77 *Estimated Losses: Critical Facilities and Infrastructure for Tsunami Hazard*

Facility	St. Thomas	St. Croix	St. John
Critical Facilities			
Police Stations	\$440,259	\$0	\$856,540
Fire Stations	\$44,631,331	\$0	\$968,572
Emergency Response	\$0	N/A	\$0
Hospital/ Medical Clinic	\$9,720,935	\$21,852,696	\$0
Government Buildings	\$81,573,751	\$3,478,140	\$12,399,875
Shelters/Special Needs	\$0	\$0	\$11,031,620
Transportation Infrastructure			
Marine Ports	\$9,172,078	\$6,819,550	\$240,125
Airport	0	\$50,850,000	N/A
Utilities			
Electrical Power Generating Plants	\$31,075,000		\$15,255,000
Water Treatment Plants	\$56,500,000	\$15,255,000	\$2,963,828
Wastewater Treatment Plants	\$1,192,370	\$22,600,000	\$0
Pumps	\$0	\$547,958	--
Tanks	\$0	\$213,775	\$1,217,142

Detailed information on critical facilities identified to be high risk structures is included in Appendix J. These are defined as those expected to sustain damages exceeding 60% for any of the hazards considered.

SECTION FOUR RISK ASSESSMENT

4.7.8 WILDFIRE

This subsection of the risk assessment presents the “estimate of losses for wildfires. Estimated losses for wildfires were aggregated for primary economic impacts that could impact the US Virgin Islands through economic loss.

Estimated Losses: General Building Stock

TABLE 4.78 *Estimated Losses: General Building Stock for Wildfire Hazard*

Occupancy	No of Affected Buildings	Expected Losses	% Value
St. Thomas			
Residential	6,171	\$ 605,424,189	0.11
Commercial	0	\$ -	0.00
Total	6,171	\$ 605,424,189	
St. Croix			
Residential	7,326	\$ 706,323,795	0.14
Commercial	0	\$ -	0.00
Total			
St. John			
Residential	464	\$ 157,465,209	0.22
Commercial	0	\$ -	0.00

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Estimated Losses: Critical Facilities and Infrastructure

Critical facilities and infrastructure losses for St. Thomas, St. Croix and St. John are highlighted in Table 4.79.

TABLE 4.79 *Estimated Losses: Critical Facilities and Infrastructure for Wildfire Hazard*

Facility	St. Thomas	St. Croix	St. John
Critical Facilities			
Police Stations	\$0	\$10,764,087	\$513,924
Fire Stations	\$754,275	\$1,110,225	\$0
Emergency Response	\$0	\$0	\$0
Hospital/ Medical Clinic	\$1,356,000	\$43,300,174	\$0
Government Buildings	\$0	\$0	\$0
Shelters/Special Needs	\$26,327,550	\$72,793,338	\$1,743,429
Transportation Infrastructure			
Marine Ports	\$0	\$0	\$0
Airport	\$0	\$0	\$0
Utilities			
Electrical Power Generating Plants	\$0	\$0	\$9,153,000
Water Treatment Plants	\$0	\$0	\$0
Wastewater Treatment Plants	\$0	\$13,560,000	\$0
Pumps	\$0	\$0	--
Tanks	\$4,039,750	\$0	\$0

4.8 LOSS ESTIMATION SUMMARY AND HAZARD RANKING

This section of the Plan Update, presents a summary of the loss estimates similar to that included in the 2008 Plan. This section is used to evaluate the risk between hazards facing USVI. To do so, one must understand that the risk from a hazard is relative to its return period. For the purposes of risk assessment, a return period has been selected for each hazard analysis.

To assist in evaluating the results of this study, a simple ranking methodology has been developed based on a comparison of the losses per year (i.e. aggregate losses/ return period) and the expected period of recovery following the hazard events considered for this study. Table 4.80 represents hazards that are a more pressing concern to the territory. This ranking provides information on hazards that the territory should focus on (i.e. hazards that require aggressive correction of deficiencies with community funding). This ranking is based on an expected loss per year for each hazard, simply calculated as the total expected losses (critical facilities, commercial and residential) divided by the Return Period of the selected event, representing the amount of capital the territory would have to set aside to cover the damages for such an event.

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TABLE 4.80 Hazard-by-Hazard Summary of Loss Estimates for US Virgin Islands

Hazard	Return Period (Years)	Critical Facility Losses	Residential Losses	Commercial Losses	Total Loss	Loss/Year	Dollar Loss Ranking
St. Thomas							
Drought	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Earthquake	1000	\$ 365,300,170	\$ 4,044,143,418	\$ 1,369,812,088	\$ 5,779,255,676	\$ 5,779,256	5
Riverine Flooding	100	\$ 184,644,853	\$ 655,626,344	\$ 289,491,175	\$ 1,129,762,372	\$ 11,297,624	4
Coastal Flooding	120	\$ 46,999,150	\$ 100,296,910	\$ 55,997,070	\$ 203,293,130	\$ 1,694,109	6
Hurricane	50	\$ 260,036,784	\$ 2,699,007,980	\$ 564,965,049	\$ 3,524,009,813	\$ 70,480,196	1
Rain-Induced Landslide	50	\$ 23,153,076	\$ 1,335,730,165	\$ -	\$ 1,358,883,241	\$ 27,177,665	3
Tsunami	500	\$ 252,950,724	\$ 704,717,108	\$ 398,300,996	\$ 1,355,968,827	\$ 2,711,938	5
Wildfire	10	\$ 32,477,575	\$ 605,424,189	\$ -	\$ 637,901,764	\$ 63,790,176	2
St. Croix							
Drought	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Earthquake	1000	\$ 437,024,752	\$ 3,645,930,917	\$ 746,489,600	\$ 4,829,445,269	\$ 4,829,445	4
Riverine Flooding	100	\$ 50,743,395	\$ 618,081,641	\$ 150,076,139	\$ 818,901,175	\$ 8,189,012	3
Coastal Flooding	120	\$ 14,252,191	\$ 52,319,194	\$ 26,256,719	\$ 92,828,103	\$ 773,568	7
Hurricane	50	\$ 338,576,539	\$ 1,508,195,711	\$ 307,082,553	\$ 2,153,854,804	\$ 43,077,096	1
Rain-Induced Landslide	50	\$ -	\$ 208,929,531	\$ -	\$ 208,929,531	\$ 4,178,591	5
Tsunami	500	\$ 172,467,119	\$ 524,598,730	\$ 261,998,197	\$ 959,064,046	\$ 1,918,128	6
Wildfire	10	\$ 141,527,823	\$ 4,868,439	\$ -	\$ 146,396,262	\$ 14,639,626	2
St. John							
Drought	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Earthquake	1000	\$ 99,273,496	\$ 386,386,207	\$ 76,830,370	\$ 562,490,073	\$ 562,490	6
Riverine Flooding	100	\$ 48,093,272	\$ 15,718,980	\$ 1,570,220	\$ 65,382,473	\$ 653,825	4
Coastal Flooding	120	\$ 44,903,947	\$ 22,500,497	\$ 4,123,048	\$ 71,527,491	\$ 596,062	5
Hurricane	50	\$ 65,254,024	\$ 163,596,725	\$ 26,457,092	\$ 255,307,841	\$ 5,106,157	1
Rain-Induced Landslide	50	\$ -	\$ 123,242,864	\$ -	\$ 123,242,864	\$ 2,464,857	3
Tsunami	500	\$ 44,932,703	\$ 83,914,456	\$ 15,908,495	\$ 144,755,653	\$ 289,511	7
Wildfire	10	\$ 11,410,353	\$ 59,836,779	\$ -	\$ 71,247,132	\$ 7,124,713	2

This ranking mechanism allows not only a ranking for each hazard, but a weight factor for each hazard to compare the relative economic losses to the community. The expected loss per year of

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Return Period can allow each jurisdiction individually to prioritize their hazards on an individual basis, and also allows the territory as a whole to determine which hazard most affects them as a whole.

The Recovery Ranking Table was not developed for this Plan Update. The paucity of data for certain hazards would lead to inclusive findings and would be misleading to gauge recovery efforts. Instead the potential dollar loss rankings are summarized in Table 4.81. It shows that the dollar loss for the VI as a whole is greatest for hurricanes and wildfires.

TABLE 4.81 Summary of Hazard Rankings for USVI

Hazard	St. Thomas	St. Croix	St. John
Drought	N/A	N/A	N/A
Earthquake	5	4	6
Riverine Flooding	4	3	4
Coastal Flooding	6	7	5
Hurricane	1	1	1
Rain-Induced Landslide	3	5	3
Tsunami	5	6	7
Wildfire	2	2	2

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